

OECD Reviews of Innovation Policy

# KOREA





OECD Reviews of Innovation Policy

# Korea



# ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of 30 democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities takes part in the work of the OECD.

OECD Publishing disseminates widely the results of the Organisation's statistics gathering and research on economic, social and environmental issues, as well as the conventions, guidelines and standards agreed by its members.

*This work is published on the responsibility of the Secretary-General of the OECD. The opinions expressed and arguments employed herein do not necessarily reflect the official views of the Organisation or of the governments of its member countries.*

Corrigenda to OECD publications may be found on line at: [www.oecd.org/publishing/corrigenda](http://www.oecd.org/publishing/corrigenda).

© OECD 2009

---

You can copy, download or print OECD content for your own use, and you can include excerpts from OECD publications, databases and multimedia products in your own documents, presentations, blogs, websites and teaching materials, provided that suitable acknowledgment of OECD as source and copyright owner is given. All requests for public or commercial use and translation rights should be submitted to [rights@oecd.org](mailto:rights@oecd.org). Requests for permission to photocopy portions of this material for public or commercial use shall be addressed directly to the Copyright Clearance Center (CCC) at [info@copyright.com](mailto:info@copyright.com) or the Centre français d'exploitation du droit de copie (CFC) [contact@cfcopies.com](mailto:contact@cfcopies.com).

---

## *Foreword*

This review of Korea's Innovation Policy is part of a series of OECD country reviews of innovation policy.<sup>\*</sup> The review was requested by the Korean authorities, represented by the Ministry of Education, Science and Technology (MEST), and was carried out by the OECD Directorate for Science, Technology and Industry (DSTI) under the auspices of the Committee for Scientific and Technological Policy (CSTP).

The review draws on a background report commissioned by the Korean authorities,<sup>\*\*</sup> and on the results of a series of interviews with major stakeholders in Korea's innovation system. The review was drafted by Michael Keenan (Country Review Unit, DSTI, OECD) and Ron Johnston (consultant to the OECD, Professor at the University of Sydney), with contributions from and under the supervision of Jean Guinet (Head, Country Review Unit, DSTI, OECD).

This review owes much to STEPI researchers, particularly Kong-Rae Lee, for organising a series of interviews in Korea, and to Korean government officials, in particular Hae-Joo Moon, Pan-Sick Hwang, Jin-Hun Bae, Joo-Han Kim and Tae-Young Kim for their guidance and for feedback on early drafts of the review. Yong-Nam Jung (Institute for Information Technology Advancement) also arranged interviews for the OECD team. An interim report prepared by the OECD and presented at a policy forum in Seoul in January 2008 benefited from comments by and the participation of Dieter Ernst (East-West Center, Honolulu). Finally, the review also benefited significantly from the insights of Korean OECD colleagues, namely Tae-Seog Oh and Dong-Hoon Oh.

---

<sup>\*</sup> See [www.oecd.org/sti/innovation/reviews](http://www.oecd.org/sti/innovation/reviews).

<sup>\*\*</sup> The background report was prepared by a team of Korean experts and edited by Kong-Rae Lee of the Science and Technology Policy Institute (STEPI) on behalf of MEST. The team's experts were Tae-Kyung Sung (Jeonju University), Woo-Sung Lee (STEPI), Sangwon Ko (Korea Information Society Development Institute) and Jung-Tae Hwang (STEPI).



## *Table of Contents*

|                                                                                 |            |
|---------------------------------------------------------------------------------|------------|
| <b>Introduction: Korean Innovation Policy in a Time of Economic Crisis.....</b> | <b>7</b>   |
| <b>Overall Assessment and Recommendations .....</b>                             | <b>13</b>  |
| Main strengths and weaknesses of Korea’s innovation system.....                 | 14         |
| Strategic tasks and guiding principles .....                                    | 17         |
| Recommendations .....                                                           | 19         |
| <b><i>Évaluation générale et recommandations.....</i></b>                       | <b>31</b>  |
| <i>Forces et faiblesses principales du système d’innovation coréen.....</i>     | <i>32</i>  |
| <i>Missions stratégiques et principes directeurs .....</i>                      | <i>36</i>  |
| <i>Recommandations .....</i>                                                    | <i>38</i>  |
| <b>Chapter 1. Performance and Framework Conditions for Innovation .....</b>     | <b>51</b>  |
| 1.1. Macroeconomic performance.....                                             | 51         |
| 1.2. Structural features .....                                                  | 58         |
| 1.3. Framework conditions for innovation .....                                  | 72         |
| 1.4. Performance in science, technology and innovation .....                    | 74         |
| <b>Chapter 2. Main Features of the Innovation System .....</b>                  | <b>87</b>  |
| 2.1. Large national firms .....                                                 | 87         |
| 2.2. SMEs and new technology-based firms .....                                  | 111        |
| 2.3. Government research institutes .....                                       | 124        |
| 2.4. Higher education institutions.....                                         | 138        |
| 2.5. Human capital .....                                                        | 145        |
| 2.6. System linkages.....                                                       | 165        |
| Notes .....                                                                     | 172        |
| <b>Chapter 3. Government Innovation Policy .....</b>                            | <b>173</b> |
| 3.1. Introduction to Korean innovation policy .....                             | 173        |
| 3.2. Policy-making institutions.....                                            | 178        |
| 3.3. STI policy and governance.....                                             | 184        |
| 3.4. Research funding.....                                                      | 195        |
| 3.5. HRST policy.....                                                           | 218        |
| 3.6. Knowledge diffusion and linkages .....                                     | 231        |
| 3.7. Improving the framework conditions for innovation .....                    | 236        |
| 3.8. Internationalisation.....                                                  | 245        |
| 3.9. Regionalisation.....                                                       | 251        |
| Notes .....                                                                     | 258        |
| <b>References.....</b>                                                          | <b>259</b> |



## Introduction

### Korean Innovation Policy in a Time of Economic Crisis

The research for this review, as well as much of its drafting, was carried out before the global financial crisis and the earlier commodity price shock had started to take their toll on Korea's economic growth. An obvious question to ask, therefore, is whether the analyses and recommendations contained in this review are still relevant. This introduction seeks to answer this question by first sketching out the new economic environment for Korean innovation policy. It goes on to consider some of the challenges facing the Korean innovation system before concluding with a set of guiding principles for innovation policy. As will be apparent, these guiding principles are well aligned with, and in fact reinforce, much of the analysis and many of the recommendations highlighted in various parts of this review.

#### *Innovation and the economic crisis*

With its heavy dependence on oil and other commodity imports and its export-oriented manufacturing economy, Korea was hard hit in 2008 by rising commodity prices and steep declines in demand for its goods in international markets. The Bank of Korea has reported the economy's first year-on-year decline in quarterly growth since the Asian financial crisis of 1997-98, with GDP falling 3.4% in the fourth quarter of 2008 against a year earlier. Exports slumped by 12% in the same period, with semiconductor shipments especially suffering, while manufacturing output was also down 12%. These figures are clearly disturbing, with few prospects for improvement until a worldwide economic recovery begins to take hold.

In the meantime, corporate profits continue to be squeezed, which in turn results in declining growth in investment. Investments in R&D and innovation are unlikely to be immune from these pressures. Indeed, longitudinal analysis shows that investments in R&D and innovation are pro-cyclical and thus rise and fall in line with GDP growth. The major reason is that such investments, more than most other types, are financed from cash flow, which contracts, along with demand, in times of recession. Furthermore, investments by banks, markets, venture capitalists and the like are sensitive to the business cycle, and this exacerbates the shortage of investment funding for innovation. The crisis is also increasing unemployment levels. With falling demand in Korea's export-oriented high-technology industries, mass layoffs of skilled human resources are a growing threat.

### *Policy responses – past, present and future*

These developments present serious challenges to innovation policy, particularly as the business sector accounts for one of the highest proportions of national R&D spending in the OECD area and employs three-quarters of all researchers. A significant part of this activity and the jobs it supports are under threat as the economic crisis deepens. Korea has faced similar challenges before, most notably during the Asian financial crisis of the late 1990s, which led to significant down-scoping and downsizing by large firms. That crisis was characterised by mass layoffs of highly skilled personnel and large reductions in corporate R&D spending. The response of the Korean government was to increase public R&D budgets, in order to offset declines in corporate R&D spending. But it also promoted the development of a technology-based SME sector. This involved putting in place a co-ordinated mix of policy measures, including: regulations (the government used the crisis as an opportunity to overhaul regulations and to create a more positive environment for venture start-ups and their growth); venture financing (government-backed venture funds and tax incentives to investors); and research support (*e.g.* R&D funding, tax waivers, tariff exemption for R&D equipment, and military service exemptions for researchers).

These measures fuelled a rapid expansion in the number of corporate R&D labs (which numbered about 3 000 at the time of the crisis and reached about 9 000 by 2001). SMEs accounted for 95% of the increase. On the eve of the crisis, there were around 100 “venture firms” in Korea. By the end of 1999, there were over 5 000, and by the end of 2001, they numbered over 11 000. The long-term effects of these measures have been striking. In 1997, SME spending accounted for just 12% of total business R&D, but by 2006, it had increased to 24%. Of course, this success cannot be explained by policy intervention alone. The worldwide shift to a digital economy and the rapid growth of information and communications technology provided exceptional business opportunities for those with technology and ideas – notably researchers laid off by large Korean firms. Nevertheless, without the government’s intervention, it is difficult to see how this could have occurred.

The causes of the crisis facing Korea today are quite different from those that shaped the previous crisis. Yet the effects are likely to be rather similar in some respects, with deep cuts in business R&D and innovation activity a real possibility, along with mass layoffs of researchers and other highly skilled human resources. Until now, the Korean government has responded to the crisis with a broad range of policy measures, including macroeconomic stimulus and regulatory reform. New measures for science and innovation have not figured prominently in this stimulus package, although some of the stimuli and reforms that have been announced may have a positive bearing on innovation. The Korean government’s efforts in the regard, like those of other OECD governments, have, understandably, sought to deal with the immediate threat of financial and economic collapse, with longer-term growth prospects a secondary concern. Furthermore, the Korean government had already committed itself to considerable expansion of the science base before the crisis took hold. This included proposals for sizeable injections of new funding, construction of new research and innovation infrastructures, and a renewed emphasis on developing a green economy. In this sense, Korea was somewhat ahead of the curve, with many other OECD governments only now – in the midst of the economic crisis – making similar commitments.

Nonetheless, several challenges directly related to science and innovation lie ahead, most notably the ability to manage an STI landscape marked by expected declines in business R&D and innovation activity, and a concomitant depreciation of human capital as a result of rising unemployment levels. Direct government spending on R&D will only partly offset these developments and a broader perspective will be required, with, for example, a focus on development of appropriate new skills and on new firm creation. There are also risks that some of the necessary reforms highlighted in this review will be postponed, which could ultimately hamper progress towards a sustainable recovery.

### ***Guiding principles for innovation policy***

Against this background, the following guiding principles should inform innovation policy interventions:

- At the political level, it is important to maintain a steadfast commitment to existing proposals for expanding science and innovation, as this will lay the ground for sustainable recovery in the post-crisis era. Ensuring that economic stimulatory measures take account of the longer term will be important in this regard, as this will provide a natural “policy space” for science and innovation to feature prominently on political agendas.
- From a shorter-term perspective, implementation of certain policy measures and programmes should be accelerated as part of a wider package of stimulatory measures. These should be carefully selected to maximize the short-term impact on demand, but also to minimise the risk of wasting public money by rushing projects that require more time to plan and implement. Moreover, the use of existing programmes and agencies should be favoured as they do not require the long lead times needed for new programmes and agencies to become effective.
- With levels of BERD expected to fall, public funding should be selectively used to increase direct support to firms’ R&D, while taking care to minimise the crowding out of private investment that would have occurred anyway. Again, existing programmes and agencies are probably best placed to funnel such expenditure increases. Furthermore, rises in direct funding of firm R&D should be used, wherever reasonably possible, to deepen and extend interactions between the public and private sectors. Such public-private partnerships increase the resilience of R&D efforts as their financing can be rebalanced over the business cycle.
- Innovative clusters often involve such public-private partnerships and offer important platforms for organising complementarities and mutual exchanges between new and established firms and public-sector knowledge producers (universities, GRIs, etc.). The government should target such agglomerations as they provide an important conduit for reaching new and small players directly through the funding of existing (“shovel-ready”) projects.
- Public procurement of innovative goods and services may further increase in importance as a stimulant to innovation. The government should, wherever possible, accelerate and expand its programmes in this area, many of which could usefully involve public-private partnerships.

- At the same time, a short-term focus on existing programmes and industries should not compromise the necessary shift towards a more balanced portfolio of support measures that broaden Korea's industrial specialisation over the longer term. Certainly, some compromise is necessary to cushion the immediate effects of the crisis, as there are trade-offs between short-term impacts and long-term benefits and between support to existing firms and activities and promotion of new firms and activities. But adopting a balanced scorecard approach, which should see significant investments directed towards green investments and services innovation, will be important for achieving long-term prosperity.
- A particular danger is that challenges such as educational reform and gender mainstreaming will slip down the STI policy agenda. This should be avoided, as such reforms are necessary for the long-term health and sustainability of the Korean innovation system. Furthermore, the crisis intensifies the need for more closely linked policy making between the various ministries and agencies responsible for innovation policy. This is especially the case for the two wings of MEST, which still seem to function in separate spheres, and for closer co-ordination between MEST and MKE.
- Finally, layoffs and unemployment of the highly skilled will be an inevitable consequence of the downturn. To prevent human capital lying idle and depreciating during the crisis, the government should bolster its entrepreneurship policies to aid new business start-ups. Furthermore, flexible approaches to lifelong learning – for the employed as well as the unemployed – should be further encouraged.

In summary, the imperative for the Korean government is to maintain its strong commitment to research and innovation, to keep to its reform agenda, and to navigate a course that balances short-term and long-term considerations in an appropriate manner during this time of crisis.

### ***Review outline***

This review is divided into three main chapters. Chapter 1 reviews Korea's innovation performance and examines structural features of the Korean economy, recent macroeconomic performance and the framework conditions for innovation. While the chapter highlights many positive aspects of Korea's performance, it also points to a number of imbalances, including the traditional dominance of the chaebol in research and innovation, the productivity gap between services and manufacturing, the diversity in levels of regional economic development, and the relatively low levels of internationalisation in the economy. A final section assesses Korean performance in science, technology and innovation and benchmarks it against the performance of leading OECD economies.

Chapter 2 presents the main features of the Korean innovation system, beginning with an overview of the role of large firms and SMEs in innovation and their performance. The chapter then turns to the public sector, assessing the contribution and performance of the GRIs and HEIs. The second part of the chapter moves from an assessment of system actors to consideration of a few chosen elements of the system. A first is human resources for science and technology and issues of supply and demand. A second is the linkages between the various actors of the Korean innovation system, which are assessed in terms of their strength and coherence.

In light of the characterisation and assessment of the first two chapters, Chapter 3 considers the appropriateness and performance of Korean innovation policy. It begins with a short history of Korean innovation policy, highlighting the issues that dominate the contemporary policy agenda. The main policy-making institutions are then described, together with an examination of the way policy is co-ordinated and governed. The various funding programmes for research are then discussed, as is Korean HRST policy. This is followed by consideration of more demand-side policies. The final sections of the chapter take a spatial perspective by considering policy efforts aimed at promoting the internationalisation and regionalisation of science and innovation.



## Overall Assessment and Recommendations

Korea has performed exceptionally well over the last few decades in its efforts to catch up with the world's leading economies, and it has instigated waves of industrial upgrading to become a world leader in some of the most high-technology industries. Historically, the Korean form of catch-up was shaped by strong state leadership, a state-controlled banking system, and the dominance of the *chaebol* – large, highly diversified, family-owned companies. Substantial increases in capital and labour, driven by the highest rate of business investment in the OECD area, a growing population, a long working-hours culture, and rising participation in the labour force, were the main drivers of growth.

In the wake of the Asian financial crisis of 1997-98 – which hit Korea particularly hard – the catch-up model was revised, with significant restructuring of the *chaebol* and a reduced leadership role for the state. The economy rebounded, the recovery was swift, and today, Korea's per capita income is around 70% of the OECD average. The *chaebol* succeeded in accessing and exploiting international markets and sources of technology in order to achieve the export-driven economic growth which has seen Korea transform a trade deficit of USD 3 billion in 1997 into a trade surplus of USD 33 billion in 2006. Moreover, the proportion of high- and medium-high-technology products among Korea's exports has grown sharply since the early 1990s, owing to the development of substantial technological capabilities in a number of high-technology areas. Korean firms now have the largest world market share in DRAM semiconductors, TFT-LCD and CDMA cellular phones.

This success has few parallels around the world. Yet, at the same time, Korea is entering a new and critical phase in its development and there are few guarantees of continuing success. With the growth of labour and capital inputs already slowing, continued convergence to the OECD average based on input-based growth will become more difficult. Furthermore, with the lowest fertility rates in the OECD area and increasing competition from newly industrialising countries, especially China, Korea faces new challenges. More than ever, sustaining economic growth will depend upon boosting innovation.

Korean innovation policy seeks to accelerate the shift from a “catch-up” to a “creative” innovation system, as articulated in the 2004 Implementation Plan for the National Innovation System. The catch-up model centred upon large-scale strategic technology development with government-affiliated research institutes and large global conglomerates taking the leading role. It has not been conducive to the creation of innovative start-ups, to technology transfer, or to building basic research capabilities, all of which are increasingly important as Korea moves towards knowledge frontiers. The creative model instead relies upon greatly increased spending on R&D – by both the public and private sectors – and upon attempts to improve knowledge flows and technology transfer across the system. Under this model, innovation policy also seeks to

address regional imbalances in the national economy, with a rich portfolio of programmes designed to develop innovation capacities outside of the Seoul metropolitan region.

While this shift in innovation policy appears broadly appropriate, it is worth recalling that earlier policy goals – articulated in various policy statements stretching back to the 1990s – were broadly similar. In other words, while there has been a general awareness of the general direction in which the innovation system needs to move, certain lock-ins hamper its evolution. These include the still dominant role of the chaebol, despite efforts to improve the innovation capacity of SMEs; an over-emphasis on short-term, industrially oriented research at the expense of longer-term, fundamental research; a 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. None of these problems is easy to resolve quickly, particularly as many are legacies of past successes. However, if Korea is to achieve full convergence with the leading OECD economies, the Korean government will need to redouble efforts to shift the innovation system to a more creative mode.

### **Main strengths and weaknesses of Korea's innovation system**

It is important to take specific aspects of Korea's history, geopolitical features, and cultural and institutional characteristics into account when assessing the current state of the innovation system and when determining the feasibility of policy responses to new challenges and opportunities:

- In a relatively short time, Korea has changed from a backward agricultural economy into one of the world's most modern industrial economies. This transformation has been underpinned by a strong, mobilising national vision which is widely shared by government, business and the population at large.
- Korea occupies a unique geopolitical position between two economic superpowers which have presented both opportunities and threats throughout its history. This influences the Korean psyche – as has the continuing division of the Korean peninsula – and encourages a strong sense of independence and self-sufficiency. Perceived external opportunities and threats are implicitly mobilised to strengthen the drive to meet the development challenge.
- Korea has few natural resources and is heavily dependent upon imports for energy and raw materials. Thus, one of the main driving forces behind Korea's transformation has been investment in human capital. A socio-cultural eagerness for education, rooted in longstanding Confucian educational values, has contributed to strong demand for education.

### ***Analysis of strengths, weaknesses, opportunities and threats***

#### ***Main strengths***

- *Strong commitment from the outset to technology-based economic development.* There has been strong support from successive governments as well as a national consensus on the importance of science, technology and innovation (STI) as drivers of future socioeconomic growth.

- *High levels of gross domestic expenditure on R&D (GERD).* GERD amounted to a little under USD 30 billion in 2006, or 3.23% of GDP, one of the highest levels in the world.
- *High levels of business enterprise expenditure on R&D (BERD).* The private sector is by far the biggest R&D player, accounting for around three-quarters of Korean GERD.
- *A highly educated labour force.* In international assessments of school education, Korea ranks very high in reading, mathematics and science. More than any other country, Korea has ensured that virtually all students complete secondary education, and has moved towards universal tertiary education.
- *Strong willingness to learn from failures and to learn from others.* Korea has benefited from accelerated learning owing to its openness to learn from failure and its ability to assess policy options based upon international good practices.
- *Good and improving framework conditions for innovation.* In the wake of the Asian financial crisis, the Korean government introduced strong competition policy and further liberalised product and labour markets, thereby improving the conditions for innovation.
- *High degree of interest in science and technology.* Korean society is a ready adopter of new leading-edge technologies, and more young people study for science and engineering degrees in Korea than in any other OECD country.
- *Large firms that are internationally competitive.* Several leading Korean chaebol, such as Samsung, Hyundai Motors and LG, have become important transnational corporations with operations across the globe and leading-edge technologies.
- *Exceptional fast-followers.* Korean industry is renowned for its ability to combine opportunities in fast-moving markets and rapid technological change.
- *Capability to produce talent.* Korea has an exceptionally large number of talented people in the arts, sciences and sport.
- *Strong ICT infrastructure.* Korea has one of the world's highest rates of broadband penetration and is rolling out one of the world's most advanced mobile communications networks. This has created domestic demand, which in turn has led to the development of new industries.

### *Main weaknesses*

- *Nascent but still lagging capacities to conduct fundamental research.* Korea is a relative newcomer to fundamental research and needs to bolster its capacities in this area, particularly in the university sector. Universities employ around 70% of all doctorates in Korea, yet account for just 10% of Korean spending on research.
- *System linkages.* As in most OECD countries, system linkages in Korea could be stronger. However, mutual distrust and a lack of understanding between the government research institutes (GRIs) and the universities inhibit the development of closer and mutually beneficial linkages.

- *Teaching styles.* High school curricula place too much emphasis on preparation for the national university entrance exam and rely heavily on rote learning. This leaves little room for creative thinking and the emergence of an exploratory spirit.
- *Tertiary education offerings.* With a few notable exceptions, universities are comprehensive rather than specialised. As a result, many courses are mediocre at best and do not challenge students sufficiently.
- *Under-utilisation of female labour.* At around 30%, the graduation rate of women in science and engineering (S&E) is close to the OECD average. However, women make up only 13% of Korean researchers, the lowest level in the OECD.
- *Weak performances in the services sector.* Services currently make a very marginal contribution to aggregate productivity growth in Korea, although they account for around half of Korean GDP and more than 60% of employment.
- *Relatively weak SMEs.* Korea's economic growth has been led by the chaebol. This industrial structure offered some advantages during rapid catch-up but has left a legacy of relatively weak SMEs.
- *Unbalanced regional development.* Economic activities in Korea are concentrated in the Seoul metropolitan area. This creates serious geographical imbalances in the national economy.
- *Weak international linkages.* Very little R&D carried out in Korea is financed from abroad, linkages with foreign firms and institutions are relatively weak, and few foreign researchers and students come to Korea to work or study. This suggests that Korea may not draw sufficiently on the growing global stock of knowledge.
- *Limited policy co-ordination.* As most government ministries have their own research policies and funding programmes, co-ordination of the Korean government's interventions and activities has proven difficult. The problem has been compounded by strong rivalries between the main ministries, which have resulted in some duplication of policies and programmes and insufficient inter-ministerial co-operation.
- *Legacy of dirigisme.* While the national innovation system (NIS) concept has been adopted to frame Korean innovation policy, many policies and programmes remain mission-oriented rather than diffusion-oriented. Selection and targeting of strategic industries and technologies still receive high priority while measures to upgrade the innovation system are given less attention.

### *Threats and opportunities*

- *Continuing high dependency on natural resource imports, particularly hydrocarbons.* Korea is the world's fourth largest importer of oil, so that its economy is highly sensitive to oil price fluctuations. Growing uncertainties surrounding supply and prices may cause serious problems, at least in the short term, but might also usefully spur the development of new technologies that could ultimately form a basis for export-oriented growth.

- *Competition from China and other newly industrialising countries.* Korea is increasingly challenged by China in many industries in which it currently enjoys competitive advantages. At the same time, Korea has benefited significantly from economic development in China and other newly industrialising economies. Thus, potential threats could become opportunities by providing new markets for Korean exports and manufacturing, spurring domestic industrial upgrading, and accelerating a shift towards the development of a more knowledge-intensive economy.
- *Low fertility rates and an ageing society.* Korea's fertility rate, the lowest in the OECD area, is likely to halve the current potential GDP growth rate by 2030, and it will lead to an elderly society. This demographic pressure could be channelled to increase productivity and to improve female workforce participation rates.
- *Regional geopolitical developments.* The uncertain direction of such developments, particularly as regards North Korea, creates a sense of unease in the region.
- *Over-specialisation.* The heavy concentration of R&D and innovation activities in a few economic sectors, particularly ICTs, contributes to a dualism in the Korean economy and may not provide a broad enough base to promote convergence to income levels in the most advanced OECD countries.
- *International trade environment.* Korea is heavily dependent upon exports for economic growth and would be affected by major disturbances in the international trading system, as a result, for example, of a major economic recession or increased protectionism.
- *Growing Korean diaspora.* Many graduate students are choosing to remain overseas – particularly in the United States – after completing their PhDs, partly because of fewer opportunities for post-doctoral positions in Korea. There is a risk that many will never return to Korea and constitute a growing brain drain. However, as Korean science continues to progress, there should be more job opportunities in Korea. The time spent by young scientists overseas will then prove an investment for Korea. Those who remain overseas can also constitute a useful resource for collaboration.
- *Technological change.* Korea has been adept at exploiting technical change, particularly in the ICT sector, but will need to further develop its capacities to catch emerging technology waves, for example, in nanotechnology and biotechnology.

## Strategic tasks and guiding principles

The main strategic task of Korea's innovation policy is to achieve convergence with the more advanced OECD economies. It needs to achieve this in the context of declining fertility rates and increased competition from newly industrialising countries, particularly China. Korean innovation policy therefore needs to accelerate the shift of the innovation system away from a catch-up to a more creative model, by supporting more fundamental research in diverse domains, raising the innovative and absorptive capacities of SMEs, and better linking up to international sources of knowledge. In accomplishing these tasks, policy should follow certain guiding principles:

- *International openness.* Korea needs to improve its research system's international openness in order to better access global knowledge pools. It has targeted programmes to deal with this, but internationalisation should be part of most policies dealing with science, technology and innovation.
- *Diversification.* Much of Korea's recent growth has been due to its development and exploitation of ICTs. Korea should seek to further diversify its economy by exploiting new growth engines offered by biotechnology, nanotechnology and other emerging areas of science and technology while strongly building upon existing strengths.
- *Shift from economic development programmes towards more public and generic research.* Korea has caught up with the most technologically advanced countries and has moved towards technological frontiers. It is therefore time to shift from high levels of public support for industrial R&D towards more public and welfare-oriented R&D. Moreover, this shift should be taken as an opportunity to increase the levels of fundamental research carried out in Korea.
- *Incorporating a long-term perspective when assessing the costs and benefits of public R&D funding.* Policy makers and other innovation actors should better appreciate that the returns to investment in fundamental research may be largely intangible – and embodied – and will take a considerable time to accrue. This also makes it very difficult to convincingly account for the full spectrum of benefits, at least in the short term.
- *Balancing competition with the development of co-operation and trust.* A growing convergence in the types of research and innovation being conducted by different research performers means that distinctive core competencies and complementarities are less clear-cut. This has led to greater competition between research performers, as well as a lack of trust, probably at the expense of greater co-operation. Competition is no bad thing, but it should be better balanced with co-operation, particularly between the GRIs and universities.
- *Systematic and evolutionary approach to the promotion of innovation.* A clear overall strategy should inform policies that affect the dynamics and efficiency of innovation processes. Such policies should adapt to changes in the global environment and respond to the evolving needs of actors in innovation. They should help to improve the performance of the innovation system and sub-systems through continuous monitoring and assessment rather than define in advance an optimal innovation structure.
- *Comprehensive approach to fostering innovation beyond support for R&D and high technology.* To enhance innovation capabilities throughout the economy, including in non-R&D-based activities, innovation policy should avoid too close a focus on R&D and high technology. Non-technological or “soft” innovation – notably in the SME sector, which has particularly weak innovation capabilities – offers considerable opportunities for boosting productivity and income growth. Moreover, the “servicification” of manufacturing and the increasing technological component of services mean that both the manufacturing and services sectors need common capabilities to increase their knowledge intensity.

- *Gender mainstreaming.* Given the demographic shifts facing Korea in the near future, it will be imperative to increase female participation rates in science and technology in order to maintain economic growth. The Korean government should follow the example of OECD member governments that have introduced a “gender mainstreaming” dimension into all of their policies.
- *Co-ordination in policy.* Achieving policy and programme coherence is a difficult challenge for governments, which are generally not well organised to deal with cross-cutting policy issues such as innovation. This means viewing government intervention in terms of the so-called policy mix.
- *Participatory governance of S&T.* As Korean S&T moves towards knowledge frontiers, it takes on new responsibilities and challenges that will require a dialogue with society. This should be embodied in a new form of participatory governance, in which scientists and governments engage in a genuine dialogue with citizens on S&T developments.

## Recommendations

In light of these strategic tasks and guiding principles, and in the context of Korea’s strengths, weaknesses, opportunities and threats, this review makes a number of policy recommendations.

### *Improve inter-ministerial co-ordination of innovation policy*

An important challenge for the Korean government is to improve co-ordination among the many ministries and agencies with a stake in R&D, and more broadly, innovation. Previous Korean governments put in place quite elaborate mechanisms to deal with this issue. These seem to have had some success – though problems undoubtedly remained – but were largely abolished by the new government in 2008 in favour of ministerial consolidation. This consolidation could go only so far and two super-ministries now have the greatest influence on innovation policy in Korea, *i.e.* MEST, which is responsible for the public science base and education; and MKE, which is responsible for industrial technology R&D and cluster policy.

- *Build a strong working relationship between MEST and MKE.* Given the ministerial separation of public science and education from industrial R&D, the Korean government should take steps to ensure a fruitful working relationship between MEST and MKE. While more space needs to be provided for fundamental research – as argued throughout this review – it is also paramount that the public science base does not become decoupled from an industrial R&D agenda.
- *Ensure that science and innovation remain prominent on political agendas.* Within MEST and MKE, it will be important to ensure that the science, technology and innovation agenda is not crowded out by other pressing (and often more short-term) policy issues. This is a real potential concern in MEST, as international experience has shown that the coupling of science with education often results in neglecting the former when the more politically contentious issue of education demands greater policy attention.

In addition to horizontal co-ordination, vertical lines of co-ordination and accountability are important for effective innovation policy. Five research councils have been created for this purpose (recently reduced to three by the new administration), but their role has been rather limited. Moreover, the assignment of individual GRIs to different research councils seems to be somewhat arbitrary.

- *Reconsider the purpose and functioning of the research councils.* The Korean government should consider reorganising them, perhaps along more disciplinary lines, or possibly merging them into a single body, with a view to increasing their strategic capability.

### ***Redefine the roles of research performers***

The traditional roles of the government research institutes and universities have been evolving over the last couple of decades and some degree of convergence has been occurring. The GRIs were originally established to accelerate the adoption and adaptation of technology by Korean firms, while the universities were concerned primarily with teaching. In terms of the role of the universities in research, there remains a significant mismatch between research spending and human resource capabilities – the universities have almost 70% of all Korean doctorates, but perform just 10% of Korean research.

- *Tackle the mismatch between human resources and research spending in universities.* This should be done urgently, for example, by increasing R&D spending and/or providing incentives to encourage more doctorates to work in the private sector or GRIs.
- *Nurture closer relationships between universities and GRIs.* It is clear that there is still some way to go before Korea's universities become research power-houses. The funding of research centres and plans to attract leading foreign scientists to set up research groups will surely make useful contributions, but reaching that goal will take considerable time. A supplementary strategy might be the development of closer relationships between the universities and the GRIs, as this might offer an accelerated path to raising the research capacities of the universities. Such relationships could range from relatively loose co-operation to full mergers between institutions. The Korean government should review the benefits and feasibility of such options, drawing upon international experiences in developing such relations.
- *Ensure that research spending increases in the universities do not create ivory towers.* The government is broadly right to increase the number of small, non-mission-oriented grants available, as this will benefit the individual researchers and small groups commonly found in universities and should allow for carrying out more curiosity-driven research. However, the availability of such grants should not substitute for the more mission-oriented research currently performed in universities. Simply put, Korean university researchers (with a few notable exceptions) need to become more active in research, and any additional research funding should translate into more research being carried out.

While there is a high degree of consensus on the need to enhance universities' research intensity, the role of the GRIs is still much debated. Several alternative (and non-exclusive) future orientations – each with its pros and cons – have been proposed: *i)* supporting technological development in SMEs; *ii)* moving away from industrially oriented R&D and towards public and welfare research; *iii)* concentrating on platform technologies; *iv)* leading Korea's shift towards more fundamental research; and

v) working in areas of interdisciplinary and fusion research. In addition, various options for the institutionalisation of the GRIs are regularly discussed. These range from merging and breaking up different institutes to revising their ministerial location. More radical proposals are also sometimes discussed, including privatisation and merger with universities.

- *Acknowledge the variety of GRIs when planning reforms.* There is a great deal of variety among the GRIs, with different types of organisations facing different issues which require different policy responses. The government should be sensitive to these differences when formulating policy *vis-à-vis* the GRIs and should consider the future of each institute on a case-by-case basis.
- *Expect the GRIs to play a multiplicity of roles.* The GRIs should not be pigeon-holed into performing a single function even if this gives the appearance of overall system untidiness. Rather, they can play multiple roles in innovation systems, something that policy should acknowledge.
- *Learn from international experience to strengthen relationships between GRIs and universities.* Different models of university-GRI co-existence are to be found around the world and adoption of any of these would need to be suitably adapted to the Korean context.
- *Make access to GRIs (and other public) research infrastructure more open.* Large-scale public research facilities and equipment are frequently criticised for being ineffectively and inefficiently used. These infrastructures should be more widely opened up to both public- and private-sector research actors.

### ***Understand the benefits of fundamental research***

With limited resources available during Korea's catch-up phase, the government carefully targeted certain areas and sought tangible (often short-term) returns from its investments in R&D. With the large budget increases recently announced for fundamental research, expectations on returns to investment need to shift. Although it appears to be appreciated that a turn to more fundamental research is unlikely to provide immediate, tangible returns, research performers are nevertheless under pressure to demonstrate early outcomes from their R&D activities, particularly as these results have become important assessment criteria in national evaluation efforts. The substantial growth in public R&D investment has been accompanied by dramatic increases in GRIs' and universities' rates of scientific publication and patenting in recent years. However, there is suspicion that some of this growth is due to over-publication and over-patenting, as evidenced by the marginal growth in citation rates and relatively low levels of technology transfer.

- *Better reflect the varied contribution of R&D in national evaluation efforts.* To minimise unwanted behaviour, such as over-patenting, national evaluations should better appreciate the varied contributions that higher education institutions and GRIs make to innovation. The scope and effects – both intended and unintended – of the elaborate programme evaluation arrangements rolled out over the last three to four years should now be reviewed.

- *Make greater use of the Korean diaspora in the national evaluation system.* While Korea makes extensive use of expert review panels in its evaluations, international reviewers are rare owing to language barriers. Greater use of English might help, but perhaps more reasonably, the growing Korean diaspora might bring a useful international dimension to the review process.

The technological progress of firms – particularly the chaebol and high-technology SMEs – helps drive the need for more fundamental research, but the need is also due to the growth and maturity of Korea's scientific endeavours and the demand for more sophisticated infrastructure and greater levels of support. Many of these demands are legitimate, given that investment in research infrastructure that makes it possible to carry out more fundamental research can have real benefits for Korea's socioeconomic development. However, the validity and value to Korea of such investments should be considered carefully on a case-by-case basis.

- *Carefully assess proposals for large research infrastructures to ensure their appropriateness and adaptability.* Calls for large new infrastructures should be judged on their merits, bearing in mind that many OECD countries with a longer history of funding and conducting fundamental research have sometimes had difficulties in ensuring the relevance of such research.
- *Recognise the strategic nature of much fundamental research.* Fundamental research should not be solely equated with curiosity-driven research. In fact, fundamental research is often carried out in the context of strategic missions. In many instances, an *ex ante* assessment of the contribution of fundamental research to a mission should be possible, even if there are practical difficulties in measuring its contribution *ex post*.

### ***Promote innovation in the business sector***

The Korean government provides relatively generous tax credits to firms that conduct R&D. On top of this, direct government research funding accounts for around 5% of BERD – an average figure for OECD countries. However, more than 50% of government research spending in the public sector is directed at industrial development – one of the highest levels in the OECD. The government is also active in implementing policies and programmes that deal with a broader range of innovation-related issues, such as venture financing, skills development, industry-academic collaboration, and cluster agglomeration. However, government policy intervention needs to be sensitive to two important divides in the innovation performance of the Korean business sector: first, the divide between the chaebol and SMEs; and second, the divide between manufacturing and services.

On the first divide, SME innovation performance still falls far short of that of the chaebol. This may improve in future, as the amount of R&D carried out by SMEs grew almost fivefold from 1997 to 2006 and now amounts to almost one-quarter of Korean BERD. Government incentive schemes, including R&D funding, tax waivers, tariff exemption for R&D equipment, and military service exemption for researchers, have fuelled much of this rapid expansion. The chaebol are also playing a more supportive role in the development of a vibrant SME sector. This is because supplier companies have had to substantially enhance their R&D capabilities in order to meet the increased technological demands of chaebol working at the technological frontier. Furthermore, as the chaebol continue to source technologies internationally, Korean SMEs are looking to

reduce their dependency on a single chaebol and to diversify their customer base. To succeed, they need to be internationally competitive. But emerging Chinese competition means that Korean firms have less scope to rely upon price competitiveness and have to improve the functionality and quality of their products; this obliges them to innovate.

- *Continue support for innovation efforts in SMEs while acknowledging the limits of public intervention.* The target of government support for firm innovation has shifted away from large firms and towards SMEs, a shift that would seem to be broadly appropriate. The government has had some success in supporting the development of SME capability, as well as in improving the conditions for innovative start-up companies. Government policy should continue along this path, while taking into account the limits and opportunities offered by wider Korean industrial dynamics.
- *Further streamline the various schemes on offer to support innovation by SMEs.* Many policies and programmes are targeted at SMEs, and the government now directly funds more research in SMEs than in large firms. However, the schemes on offer should be further streamlined as their number and scope cause confusion.

In terms of the divide between manufacturing and services, productivity growth in manufacturing has soared in recent years but continues to stagnate in services. The services sector accounted for just 7% of BERD in 2006, one of the lowest rates in the OECD. A productive and competitive services sector is important to underpin the performance of the manufacturing sector. Yet, consulting services, which are widely regarded as important to innovation, are poorly developed in Korea, largely on account of an industrial structure dominated by the self-contained chaebol and a domestic market for services relatively closed to international competition.

- *Consider ways in which innovation in services might be enhanced.* The Korean government should implement new policies and programmes that specifically target innovation in the services sector as a means of broadening the basis for future socioeconomic growth.

### ***Broaden areas of specialisation***

There appears to be a degree of lock-in in Korean R&D, as evidenced by the large role played by ICT and physical engineering in research specialisation and scientific publication. This situation is aligned with, and contributes to, Korea's current industrial strengths, particularly as much public research spending is still directed at industrial R&D. However, Korea needs to diversify its competitive advantage through investments in new knowledge-intensive fields with high-growth potential.

- *Strike a better balance between supporting existing industrial champions and new growth engines.* MEST has announced its intention to decrease the proportion of public funding of R&D in ICT and manufacturing engineering and to make more money available to areas like bioscience, nanotechnology, space science, etc. However, since much of the public research budget originates in mission-oriented ministries (especially MKE), MEST's ability to enact such a shift is limited. Improved co-ordination across government will be required to ensure that a better balance between fields can be attained.

- *Formulate a set of more welfare-oriented “grand challenges” for research.* These should be used to diversify away from over-investment in relatively short-term industrially oriented research, and could also fit well with the targeted approach familiar to Korean R&D.
- *Increase the use of small grants to diversify the research base.* Diversification efforts should be sensitive to the funding needs of the individual researcher or small research groups in universities, who would prefer small grant funding in order to build up their research capacities. These investments need not be restricted to bottom-up funding schemes but can be extended to top-down managed programmes as well.
- *Promote innovation in services as a future key growth engine.* As highlighted elsewhere, special attention should be given to supporting innovation in services, which is already Korea’s largest employer by far yet suffers from low levels of productivity.

### ***Improve the contribution of tertiary education to innovation***

Education and skills development have been at the heart of Korea’s success in transforming itself into a leading industrial economy. However, the education system that has developed over the years now needs to adapt to the new challenges facing Korea. The focus of this transformation lies in tertiary education and a better balance between the supply of and demand for graduates with the particular skills and knowledge required to meet economic and societal needs. Overall, there are too many people with bachelor’s degrees and too few technicians and people with postgraduate qualifications in high-technology fields. Moreover, the strong and overly rigid hierarchy of Korean universities has a powerful influence on success in careers and social status. Unfortunately, the resulting competition for places in the leading universities has not led to differentiation and specialisation but to a system in which universities generally offer the same broad profile of academic programmes. Moreover, the system is overly geared towards young people, and there is insufficient flexibility in course design that would allow for greater participation of older age groups.

- *Continue policy efforts that encourage universities to specialise.* The government has sought to raise standards by encouraging higher education institutions (HEIs) to specialise, preferably in fields in which graduates are likely to find local employment opportunities (not least to ease the pressure on Seoul). This runs counter to the expansionary tendencies of many institutions, but would seem to be the right policy and should therefore be continued and even extended more aggressively.
- *Provide incentives to help make courses responsive to the skills needs of Korean business and society.* Korean firms currently indicate one of the highest levels of dissatisfaction with the quality of graduates. However, many HEIs are now increasingly working with firms and local governments on the redesign of curricula and all should be encouraged to do so. This enhances their receptiveness to demand signals and helps raise standards.

- *Ensure that competition among HEIs is based upon reliable information about the results and performance of their faculties and/or departments.* The 2008 introduction of the University Information Disclosure System – with information on graduate employment rates, enrolment rates, full-time faculty rates, scholarship provision, research achievements, curricular operation and school management – is a welcome development. However, assessments that centre on individual departments or faculties should also be developed so as to make known the specialised strengths of HEIs.
- *Use periodic assessment of faculty and/or departmental research performance to reinforce the link between research and graduate education.* Large numbers of postgraduate students in Korea are trained in faculties that do not engage extensively in research. To address the problem of the resulting lack of connection between research and education, departmental or faculty research should be assessed, so that prospective students and funding agencies have access to good information on their research strengths and quality.
- *Raise the status of vocational training awards and the institutions in which they can be earned.* As the strong demand for bachelor's degrees is unlikely to diminish soon, consideration should be given to making awards for vocational training equivalent to bachelor's degrees.
- *Offer further incentives to education providers to develop more flexible lifelong learning programmes.* University and junior college courses should be made more flexible to allow learners to study part-time while in employment. At the same time, employers and employees should be encouraged to engage in lifelong learning activities.

### ***Improve female participation rates in science and engineering***

Simply from an economic perspective and given imminent demographic shifts, there is an urgent need to get more women into science and engineering careers. 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. Comprehensive government policy in this area is relatively new but is wide-ranging and reflects a high degree of international learning. In addition to programmes aimed at attracting more females to S&E careers, recruitment targets have been set for some parts of the public sector, along with favourable point systems for research project selection. There are signs that these policies are having some effect, but progress is rather slow and from a low base.

- *Introduce gender mainstreaming across all areas of S&T policy.* This will demonstrate the Korean government's seriousness about giving female participation in S&T the highest priority.
- *Provide a mix of regulations and incentives to encourage the private sector to utilise and support women in S&T.* With most researchers employed by the private sector, there are limitations on direct government interventions to support women in S&T. Accordingly, a mix of regulation and incentives should be considered, including measures such as affirmative action quotas, tax incentives, and the subsidisation of childcare facilities.

- *Use the diversification of R&D efforts as an opportunity to bring more women into S&T.* The move to broaden R&D efforts from ICTs and machine engineering to biosciences, medical sciences and environmental sciences should be used as an opportunity to increase female participation rates, as these fields tend to be more female-friendly than the traditional engineering fields in which Korea has so far been most active.

### ***Improve labour mobility in the research system***

A fundamental weakness of the research system concerns labour mobility, which is low in volume and unidirectional. This is partly due to the dualistic nature of the labour market; but the high status afforded to university staff is also a factor and has resulted in an internal brain drain from the GRIs (and to a lesser extent, firms) to universities, with very little movement in the opposite direction. The resulting lack of labour circulation tends to hamper knowledge diffusion throughout the innovation system.

- *Consider ways of further enhancing the status of GRIs so that they are considered as attractive as universities as places to work.* The prospect of increasing convergence in the working conditions of the GRIs and universities – regarding issues such as job security, career paths and pensions – could make the GRIs once again relatively attractive places in which to work and might increase labour mobility. However, as long as the status of GRIs is perceived to be lower than that of universities, movement to the GRIs is likely to remain low. The government should therefore enhance the status of the GRIs, for example, through investments in leading-edge facilities and flagship projects.

### ***Decentralise innovation policy in the interests of more balanced growth***

Regions and city-regions perhaps offer one of the best levels at which to develop productive innovation system linkages. However, there are no significant technology-driven regional clusters beyond the Seoul macro-cluster. This concentration of S&T resources was taken for granted during Korea's rapid industrialisation process but is being questioned in the framework of the government's push for balanced development. Korea needs a variety of policy programmes in order to address regional innovation deficits, including measures that promote partnerships among regional innovation actors, which until recently have been relatively weak. Accordingly, a mix of policy measures – from public agencies at both national and regional levels – has been enacted to support or build regional innovation systems. These efforts are, however, fragmented and insufficiently co-ordinated. Much of the problem arises from the fact that many regional programmes are centrally administered by national agencies rather than by the regions themselves. This makes co-ordination at regional level difficult and has prevented the development of a stronger regional planning and implementation capacity.

- *Devolve greater responsibility to regions for the design and delivery of regional innovation policy.* 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, with much responsibility for design and delivery devolved to the regions themselves. This responsibility should be accompanied by a system of accountability to ensure policy appropriateness and efficiency and to facilitate inter-regional policy learning.

- *Conduct a bottom-up strategic audit of regional innovation programmes.* Within the context of greater devolution, there is need for a strategic audit of the various regional innovation initiatives enacted by different agencies, and efforts should be made to further develop planning and implementation capacities in the regions.

The Korean government has also sought to engineer the development of a knowledge-intensive cluster around the Daedeok Science Town complex – recently renamed the Daedeok Innopolis. Whether Daedeok can transform itself from a science cluster into an innovation cluster is still an open question, though early signs are promising. Perhaps more controversially, the government is seeking to nurture smaller science-driven clusters in other regions which have in some cases previously performed little science.

- *Understand the long-term nature of investments and returns on regional innovation systems.* It is clear that even with government intervention, building research capability in a region will take considerable time to bear fruit. This is not to say that such investments should not be made; rather, such investments should be given due time to show their benefits.
- *Ensure that an innovation agenda lies at the core of any science-based investments intended to promote regional development.* Without this, the government risks building “cathedrals in the desert”, *i.e.* centres of research excellence that bring few benefits to the local economy.

### ***Maximise benefits from the internationalisation of R&D***

In recent years, as R&D has become increasingly internationalised, it has become important for countries to open up to and engage in global knowledge production networks. The Korean R&D system is considered to have been relatively closed to internationalisation: few foreign scientists work in Korea, few foreign research centres are located in Korea, and the levels of international research co-operation are low. However, in other respects, the Korean R&D system has been highly internationalised from its earliest days, when the newly established GRIs depended for their research personnel upon enticing Korean scientists back from the United States. This labour mobility has continued to the present day, with many Koreans choosing to study overseas for their doctorates, and increasingly for their bachelor’s and master’s degrees, before returning to Korea to work. The recent acceleration of this outward mobility – Korea has more students studying in the United States than any other country – is a growing concern, since many choose not to return to Korea, at least not right away. Some derive a brain drain scenario from this and point to the need to improve research and education opportunities in Korean universities. Others view such developments more positively as increasing Korea’s internationalisation through a process of brain circulation.

The Korean government rightly wants to reduce the risks associated with outward mobility by encouraging inward mobility. It is redoubling its efforts to improve the internationalisation of its S&T base and has recently enacted several policy initiatives that seek to promote international R&D collaboration, attract foreign R&D centres, and attract human resources in the form of students and skilled researchers to study and work in Korea. The scale and scope of planned investments (*e.g.* for the newly announced World Class University initiative) and the targets being set (*e.g.* numbers of foreign students) demonstrate a suitable ambition, albeit against the current situation of low levels of co-operation, low international investment in the country’s R&D, and few foreign researchers

and students in Korea. If these policy initiatives meet their goals, considerable progress will have been made in the internationalisation of Korean R&D.

- *Take advantage of wider system changes to enhance the internationalisation of Korean R&D indirectly.* These changes include a shift towards more fundamental research, since much international scientific co-operation is in areas of fundamental research, and stronger university research capacity, a possible major nexus of international co-operation and exchange.
- *Continue to invest in overseas R&D facilities.* The Korean chaebol have invested quite heavily in overseas R&D facilities, particularly in the United States, Europe, Russia and, increasingly, China. Similar, though more modest, links have been established by a few public-sector research institutes. All of these are likely to further enhance the links of Korean research and innovation to global knowledge networks and should continue to be nurtured.
- *Improve co-ordination between the internationalisation policies and programmes of MEST and MKE.* Where possible, policies and programmes should be rationalised to avoid overlaps and to fill gaps.

**Summary table: SWOT analysis of the Korean innovation system**

| Strengths                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Opportunities                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Strong, mobilising national vision</li> <li>• High growth rates in GDP</li> <li>• Strong government support for innovation and R&amp;D</li> <li>• Good and improving framework conditions for innovation</li> <li>• High ratio of gross domestic expenditure on R&amp;D (GERD) to business enterprise expenditure on R&amp;D (BERD)</li> <li>• Highly educated workforce</li> <li>• Good supply of human resources for science and technology (HRST)</li> <li>• Ready early adopters of new technologies</li> <li>• Strong ICT infrastructure</li> <li>• Exceptionally fast followers</li> <li>• Strong and internationally competitive firms</li> <li>• Learning society with a capacity to learn from failures and international good practices</li> <li>• Capability to produce world-class talents</li> </ul> | <ul style="list-style-type: none"> <li>• Geopolitical positioning in one of the most dynamic regions of the world</li> <li>• Free trade agreements</li> <li>• Globalisation, including of R&amp;D</li> <li>• Growing Korean S&amp;T diaspora</li> <li>• Developments in S&amp;T (technological change), particularly information technology, nanotechnology, biotechnology and environmental technology – and their possible fusion</li> <li>• Growth of China and other newly industrialising economies, both in the region and worldwide, offering new markets for Korean exports</li> </ul> |
| Weaknesses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Threats                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <ul style="list-style-type: none"> <li>• Underdeveloped fundamental research capabilities and weak research capacity in universities</li> <li>• Weak linkages between GRIs and institutions of higher education</li> <li>• In education, rote learning, overemphasis upon university entrance exam, and crippling cost of private education</li> <li>• Underutilisation of female labour</li> <li>• Low productivity in the services sector</li> <li>• Relatively weak SME sector</li> <li>• Legacy of dirigisme which hampers the development of a diffusion-oriented innovation policy</li> <li>• Unbalanced international linkages</li> <li>• Uneven development across regions and sectors</li> <li>• Small domestic market (compared to China, Japan, United States)</li> <li>• Policy co-ordination problems between ministries</li> </ul>           | <ul style="list-style-type: none"> <li>• Low fertility rates and an ageing society</li> <li>• Arrival of strong new competitors in fields in which Korea excels, e.g. ICTs, particularly from China</li> <li>• Geopolitical developments in the region</li> <li>• Disruption in the supply of imported natural resources and energy upon which the Korean economy is highly dependent</li> <li>• Global economic outlook and its consequences for export-oriented economies</li> </ul>                                                                                                         |



## Évaluation générale et recommandations

En l'espace de quelques décennies, les efforts déployés par la Corée pour rattraper les principales économies mondiales ont produit des résultats exceptionnels, grâce à plusieurs vagues de modernisation du tissu industriel, qui ont permis au pays de devenir aujourd'hui un leader mondial dans certains des secteurs de très haute technologie. Le modèle de rattrapage économique de la Corée s'est longtemps caractérisé par le rôle dirigeant des pouvoirs publics, un système bancaire contrôlé par l'État et la domination du secteur industriel par les *chaebol* – ces grandes entreprises familiales très diversifiées. L'accumulation du capital et l'augmentation du volume de travail – rendues possibles par le taux d'investissement productif le plus fort de la zone OCDE et l'accroissement de la participation au marché du travail d'une population croissante et d'une culture laborieuse – ont été les principaux moteurs de la croissance coréenne.

La crise financière asiatique de 1997-1998, qui a touché la Corée particulièrement durement, a entraîné un infléchissement du modèle de rattrapage, notamment une restructuration profonde des *chaebol* et une réduction du rôle de l'État. La reprise a été rapide et l'économie a rebondi. Aujourd'hui, la Corée jouit d'un niveau de revenu par habitant de l'ordre de 70 % de la moyenne de l'OCDE. Les *chaebol* ont su accéder aux marchés étrangers et aux sources de technologie internationales pour alimenter une croissance portée par les exportations qui a permis à la Corée de transformer un déficit commercial de 3 milliards d'USD en 1997 en un excédent de 33 milliards d'USD en 2006, et de voir la proportion des produits à intensité technologique moyenne et moyenne/haute parmi ses exportations fortement progresser depuis le début des années 90. Ces évolutions reflètent le développement de capacités technologiques importantes dans un certain nombre de secteurs intensifs en recherche ; les entreprises coréennes détiennent maintenant leurs plus grosses parts de marché dans les semi-conducteurs pour mémoire RAM dynamique, la technologie LCD-TFT et les téléphones mobiles CDMA.

Cette réussite est presque sans équivalent dans le monde, mais la Corée entre désormais dans une phase délicate de son développement, où les chances de succès durable sont plus incertaines. Il va devenir plus difficile de poursuivre la convergence vers la moyenne de l'OCDE grâce à une croissance fondée sur l'accroissement de la quantité de facteurs de production, dont le ralentissement est d'ailleurs déjà notable. En outre, avec les taux de fécondité les plus bas de l'OCDE et une concurrence accrue des nouvelles économies industrielles, en particulier la Chine, la Corée doit faire face à de nouveaux défis. Plus que jamais, il lui faudra, pour soutenir sa croissance économique, stimuler l'innovation.

La politique de l'innovation en Corée vise à accélérer la transition d'un modèle « de type rattrapage » vers un système d'innovation « de type créatif » – ainsi qu'il est énoncé que le « Plan d'action pour le système d'innovation national » de 2004. La stratégie de rattrapage était axée sur un développement à grande échelle des technologies stratégiques, le rôle moteur étant tenu par des instituts de recherche parapublics et de grands conglomérats industriels. Elle n'a pas été propice aux nouvelles entreprises innovantes ou au

transfert de technologies, ou bien encore au renforcement des capacités de recherche fondamentale, qui sont de plus en plus vitales à mesure que l'innovation en Corée s'effectue plus près des frontières de la connaissance. Le système de type créatif requiert lui un accroissement sensible des dépenses de R-D – tant par le secteur public que par le secteur privé – et une amélioration des flux de connaissances et le transfert de technologies dans l'ensemble du système. L'objectif est également que la politique de l'innovation contribue à résorber les déséquilibres régionaux, à l'aide de toute une série de programmes destinés à renforcer les capacités d'innovation en dehors de la région métropolitaine de Séoul.

Si cette nouvelle orientation de la politique de l'innovation semble globalement appropriée, il convient de noter que des intentions plus ou moins analogues ont déjà été exprimées dans des déclarations de politique générale dès les années 90. En d'autres termes, la direction générale dans laquelle le système d'innovation doit évoluer est connue, mais certains « verrous » freinent cette évolution, notamment la position toujours dominante des *chaebol* en dépit des mesures prises pour renforcer les capacités d'innovation des PME, l'importance excessive accordée à une recherche de court terme à visée industrielle, au détriment de la recherche fondamentale à plus long terme, des capacités de recherche peu développées à l'université, une productivité en perte de vitesse dans les services, une internationalisation relativement faible du système de recherche et une sous-utilisation d'une partie de la force de travail, en particulier des femmes. Aucun de ces blocages n'est facile à desserrer rapidement, notamment parce que nombre d'entre eux incarnent des réussites du passé. Mais si la Corée veut parvenir comme elle le souhaite à rejoindre le camp des économies les plus avancées de l'OCDE, les autorités devront redoubler d'efforts pour orienter le système d'innovation vers un mode plus « créatif ».

## Forces et faiblesses principales du système d'innovation coréen

Il est important de prendre en compte des aspects spécifiques de l'histoire du pays, des facteurs géopolitiques et des caractéristiques culturelles et institutionnelles afin d'évaluer la situation actuelle du système d'innovation et de déterminer la faisabilité des réponses possibles aux nouveaux défis et opportunités de la part des pouvoirs publics :

- En un laps de temps relativement court, la Corée est passée d'une économie agricole attardée à l'une des économies industrielles les plus modernes du monde. Cette transformation a été inspirée par une vision nationale forte et mobilisatrice, largement partagée par les autorités, les entreprises et la population au sens large.
- La Corée occupe une position géopolitique unique, entre deux superpuissances économiques qui lui ont apporté des possibilités comme des menaces tout au long de son histoire. Cette situation – tout comme la division de la péninsule coréenne – influence le psychisme national et alimente une forte volonté d'indépendance et d'autosuffisance de la population, pour qui les possibilités et menaces que recèle l'environnement étranger sont perçues implicitement comme autant de raisons pour œuvrer toujours plus en faveur du développement.
- La Corée possède peu de ressources naturelles et dépend largement des importations pour son approvisionnement en énergie et ses matières premières. L'un des principaux moteurs de la transformation du pays a donc été l'investissement dans le capital humain. L'empressement socioculturel de la population pour l'éducation, qui s'explique par des valeurs confucéennes profondément enracinées

dans la société, a contribué à une forte demande sociale adressée au secteur de l'enseignement.

### *Analyse des points forts, des faiblesses, des opportunités et des menaces*

#### *Atouts principaux*

- *Dès le départ, un engagement fort au service d'un développement économique fondé sur les technologies* : il y a eu un soutien franc de la part des gouvernements successifs ainsi qu'un consensus national quant à l'importance de la science, de la technologie et de l'innovation (STI) en tant que moteurs de la croissance socio-économique.
- *Des niveaux élevés de dépense intérieure brute de R-D (DIRD)* : la Corée a dépensé près de 30 milliards d'USD dans la R-D en 2006, soit 3.23 % du PIB, l'un des niveaux les plus élevés au monde.
- *Des niveaux élevés de dépense intérieure brute de R-D du secteur des entreprises (DIRDE)* : le secteur privé est de loin le principal acteur de la R-D, puisqu'il représente les trois quarts environ de la DIRDE en Corée.
- *Une main-d'œuvre hautement qualifiée* : dans les évaluations internationales de l'enseignement scolaire, la Corée se classe dans le groupe de tête en compréhension de l'écrit, en mathématiques et en sciences. Plus qu'aucun autre pays, la Corée est parvenue à ce que la quasi-totalité de ses élèves achèvent leurs études secondaires et tend désormais vers un niveau de formation supérieure pour tous.
- *La volonté de tirer les leçons de ses échecs et d'apprendre des autres* : la Corée a bénéficié d'un apprentissage accéléré des bonnes pratiques grâce à sa capacité de tirer parti des échecs et celle d'évaluer les actions possibles de politique à la lumière de l'expérience internationale.
- *De bonnes conditions-cadres pour l'innovation et qui vont en s'améliorant* : après la crise financière asiatique, les autorités coréennes ont instauré une politique de la concurrence solide et ont poursuivi la libéralisation des marchés des produits et du travail, établissant ainsi des conditions de plus en plus propices à l'innovation.
- *Un intérêt marqué pour les sciences et les technologies* : la société coréenne adopte très facilement les nouvelles technologies de pointe et les jeunes Coréens qui poursuivent des études scientifiques et d'ingénierie sont en pourcentage de leur classe d'âge plus nombreux que partout ailleurs dans l'OCDE.
- *De grandes entreprises solides et compétitives sur le plan international* : plusieurs grands *chaebol* coréens, tels que Samsung, Hyundai Motors et LG, sont devenus des sociétés transnationales importantes qui opèrent partout dans le monde et maîtrisent des technologies de pointe.
- *Une réactivité exceptionnelle* : l'industrie coréenne est réputée pour sa capacité de conjuguer les opportunités offertes par des marchés en rapide évolution avec le changement technologique.
- *La capacité de révéler les talents* : la Corée compte un nombre remarquablement élevé de personnes talentueuses dans les arts, les sciences et les sports.

- *Une infrastructure des TIC solide* : la Corée a l'un des taux de pénétration du haut débit les plus élevés au monde et possède l'un des réseaux de communications mobiles les plus avancés, ce qui alimente la demande intérieure, qui à son tour contribue au développement de nouveaux secteurs d'activités.

### *Faiblesses principales*

- *Des capacités de recherche fondamentale croissantes mais toujours nettement insuffisantes* : la Corée ne s'est aventurée que relativement récemment sur le terrain de la recherche fondamentale et doit encore renforcer ses capacités dans ce domaine, en particulier dans le secteur universitaire. Les universités emploient 70 % environ de tous les titulaires de doctorat en Corée, mais ne représentent paradoxalement que 10 % à peine des dépenses du pays dans la recherche.
- *Les liens au sein du système d'innovation* : comme dans la plupart des pays de l'OCDE, les relations entre les acteurs du système d'innovation pourraient être plus étroites en Corée, mais un manque de compréhension et une défiance réciproque entre les instituts de recherche publics et les universités empêchent l'établissement de liens plus étroits et mutuellement avantageux.
- *Les styles d'enseignement* : les programmes de l'enseignement secondaire sont exagérément conçus pour faciliter la préparation à l'examen national d'entrée à l'université, et s'appuient trop sur l'apprentissage par cœur, qui laisse peu de place à l'originalité et à la curiosité.
- *L'offre dans l'enseignement supérieur* : la plupart des universités, à quelques exceptions notables près, ont une vocation généraliste et proposent peu de domaines de spécialisation. Ainsi, de nombreux programmes sont, au mieux, médiocres, et peu stimulants pour les étudiants.
- *Une sous-utilisation de la main-d'œuvre féminine* : avec un pourcentage tournant autour de 30 %, le taux de femmes diplômées en sciences et en ingénierie est proche de la moyenne de l'OCDE, mais les femmes ne représentent que 13 % des chercheurs coréens, c'est-à-dire le taux le plus bas de l'OCDE.
- *Un secteur tertiaire relativement peu performant* : à l'heure actuelle, les services contribuent de manière très marginale à la croissance de la productivité globale en Corée, alors qu'ils représentent la moitié environ du PIB coréen et plus de 60 % de l'emploi.
- *Des PME relativement fragiles* : la croissance économique du pays s'est appuyée sur les *chaebol*. Cette structure industrielle a offert certains avantages pour un rattrapage économique rapide mais a contribué à produire des PME relativement fragiles.
- *Un développement régional déséquilibré* : les activités économiques en Corée sont très concentrées dans la région métropolitaine de Séoul, ce qui crée de sérieux déséquilibres géographiques au sein de l'économie nationale.
- *Des liens internationaux insuffisamment développés* : très peu des activités de R-D menées en Corée sont financées à l'étranger, les liens avec les entreprises et établissements étrangers sont relativement faibles et peu de chercheurs et d'étudiants étrangers viennent en Corée pour travailler ou étudier, ce qui signifie que la Corée

ne puise sans doute pas suffisamment dans le fonds de connaissances croissant à l'échelle mondiale.

- *Une coordination déficiente des politiques* : la plupart des ministères ayant leurs propres politiques de recherche et programmes de financement, il se révèle difficile pour le gouvernement coréen de coordonner ses interventions et ses actions. Les problèmes de coordination sont en outre aggravés par une rivalité exacerbée entre les principaux ministères, qui entraîne un chevauchement des politiques et des programmes ainsi qu'un manque de coopération interministérielle.
- *L'héritage du dirigisme* : si l'idée d'un système d'innovation national s'est imposée pour modeler la politique de l'innovation en Corée, la plupart des actions et des programmes demeurent axés sur les missions et non sur la diffusion. La sélection et le ciblage de secteurs et de technologies stratégiques sont toujours considérés comme prioritaires, tandis que les mesures visant à améliorer le fonctionnement du système d'innovation dans son ensemble retiennent moins l'attention.

### *Menaces et opportunités*

- *Une dépendance toujours forte aux importations de ressources naturelles, en particulier les hydrocarbures* : la Corée est le quatrième importateur mondial de pétrole, de sorte que son économie est très vulnérable aux fluctuations du prix du pétrole. L'incertitude grandissante autour de l'approvisionnement et des prix pourrait causer de sérieux problèmes, du moins à court terme, mais pourrait également motiver la mise au point de nouvelles technologies, qui pourraient en définitive consolider la base d'une croissance tournée vers l'exportation.
- *La concurrence de la Chine et d'autres économies industrielles nouvelles* : la Corée est de plus en plus concurrencée par la Chine dans nombre des secteurs où elle exploite actuellement ses avantages comparatifs. D'un autre côté, la Corée tire déjà largement parti du développement économique de la Chine et d'autres économies industrielles nouvelles. Les menaces potentielles pourraient ainsi se transformer en opportunités et offrir des marchés nouveaux aux exportations manufacturières coréennes, favorisant ainsi la modernisation du tissu industriel national et accélérant le passage à une économie davantage axée sur le savoir.
- *Des taux de fécondité faibles et une population vieillissante* : la Corée affiche le taux de fécondité le plus bas de l'OCDE, ce qui entraînera le vieillissement de la société et devrait diviser par deux le taux de croissance potentiel actuel du PIB d'ici 2030. Cette évolution démographique pourrait être mise à profit pour améliorer la productivité et rehausser le taux d'activité des femmes.
- *Les évolutions géopolitiques régionales* : il est encore difficile de discerner quels chemins elles prendront, notamment en ce qui concerne la Corée du Nord, ce qui génère un sentiment d'incertitude dans la région.
- *Une spécialisation excessive* : la concentration importante des activités de R-D et d'innovation dans quelques secteurs économiques seulement, en particulier les TIC, se traduit par une forme de dualisme économique de la Corée et pourrait ne pas offrir une base suffisamment large pour promouvoir la convergence vers les niveaux de revenu des pays de l'OCDE les plus avancés.

- *Le contexte des échanges internationaux* : la Corée est largement tributaire des exportations pour sa croissance économique et serait donc vulnérable à toute perturbation majeure du système commercial international, causée par exemple par des récessions économiques profondes ou par un renforcement du protectionnisme.
- *Une diaspora toujours plus nombreuse* : de nombreux étudiants en post-licence choisissent de rester à l'étranger – en particulier aux États-Unis - après avoir obtenu leur doctorat, en partie parce qu'il leur est plus difficile d'obtenir un poste de post-doctorat en Corée. Le risque est que beaucoup ne reviennent jamais en Corée, ce qui pourrait se solder par une fuite croissante des cerveaux. Cela dit, le secteur scientifique coréen continue à progresser et devrait donc offrir davantage de débouchés. Le temps que passent les jeunes Coréens à l'étranger aura alors été un investissement pour la Corée, et ceux qui restent à l'étranger pourraient également constituer une source de collaboration utile.
- *Le changement technologique* : la Corée parvient parfaitement à exploiter le changement technologique, en particulier dans le secteur des TIC, mais elle devra renforcer encore ses capacités pour tirer parti des technologies émergentes, telles que les nanotechnologies et les biotechnologies.

## Missions stratégiques et principes directeurs

La principale mission de la politique de l'innovation de la Corée est de parvenir à la convergence avec les pays de l'OCDE plus avancés. Cet objectif doit être atteint alors que le taux de fécondité est en recul et que la concurrence s'accroît avec les nouvelles économies industrielles, en particulier la Chine. La mission plus spécifique de la politique de l'innovation doit donc être d'accélérer le passage d'un système d'innovation de type rattrapage à un modèle plus créatif, en soutenant la recherche fondamentale dans un plus grand nombre de domaines, en renforçant les capacités d'innovation et d'absorption des PME et en établissant des liens plus solides avec des sources de connaissances à l'échelle internationale.

Pour remplir ces missions, la politique de l'innovation doit reposer sur les principes directeurs suivants :

- *L'ouverture internationale* : la Corée doit ouvrir davantage son système de recherche au plan international afin de pouvoir mieux puiser dans les réservoirs de connaissances mondiaux. Des programmes ciblés ont été mis en place pour améliorer la situation, mais l'internationalisation devrait faire partie intégrante de la majorité des politiques ayant trait à la science, la technologie et l'innovation.
- *La diversification* : la croissance récente de la Corée s'appuie en grande partie sur le développement et l'exploitation des TIC. La Corée devrait chercher à diversifier son économie en exploitant les nouveaux moteurs de croissance offerts par les biotechnologies, les nanotechnologies et d'autres domaines scientifiques et technologiques nouveaux, tout en tirant le meilleur parti possible de ses atouts existants.
- *Le rééquilibrage du soutien public en faveur d'une recherche à visée publique et générique plutôt qu'à visée purement économique* : la Corée ayant « rattrapé » les pays les plus avancés au plan technologique et cherchant désormais à progresser en repoussant les frontières du savoir-faire technologique, il est temps pour la politique d'innovation de faire une place plus grande aux activités de R-D visant le

public et le bien-être en se consacrant moins exclusivement à la promotion de la R-D industrielle. Cette transition aurait aussi le mérite d'accroître les niveaux de recherche fondamentale menée en Corée.

- *L'adoption d'une perspective à long terme pour l'évaluation des coûts et des avantages du financement de la R-D publique* : il serait souhaitable que les décideurs publics et les autres acteurs de l'innovation prennent pleinement en compte le fait que les bénéfices des investissements dans la recherche fondamentale peuvent être en grande partie immatérielles – très variés dans leur nature et pour partie inséparables d'autres retombées de l'innovation – et qu'il faudra beaucoup de temps pour les percevoir pleinement.
- *L'équilibre entre concurrence et développement de la coopération et de la confiance* : La convergence des types de recherche et d'activités d'innovation menés par les différents acteurs rend moins évidente l'identification de leurs compétences clés respectives et de leurs complémentarités. Cela a encouragé une concurrence plus vive entre ces acteurs, assortie d'un manque de confiance, sans doute au détriment d'une coopération plus étroite. La concurrence entre les principaux types d'acteurs du système d'innovation n'est pas une mauvaise chose en soi, mais elle doit être mieux équilibrée avec la coopération, notamment entre les instituts de recherche publics et les universités.
- *Une approche systémique et évolutionniste de la promotion de l'innovation* : une stratégie globale claire devrait inspirer l'ensemble des politiques ayant une incidence sur la dynamique et l'efficacité des processus d'innovation. Ces politiques doivent s'adapter à l'évolution du contexte mondial et répondre aux nouveaux besoins des acteurs de l'innovation. Elles doivent également contribuer à l'amélioration des performances du système d'innovation et de ses composantes en s'appuyant sur des mécanismes de suivi et d'évaluation continus plutôt qu'en se fixant pour objectif d'établir une structure optimale prédéfinie du système d'innovation.
- *Une approche globale de la promotion de l'innovation, au-delà du soutien à la R-D et aux hautes technologies* : pour renforcer les capacités d'innovation dans l'ensemble de l'économie, y compris dans les activités non fondées sur la R-D, il faut éviter une politique de l'innovation à trop focalisée sur la R-D et la haute technologie. L'innovation non technologique ou « *soft* » – notamment dans le secteur des PME, dont les capacités d'innovation sont particulièrement faibles – offre de très grandes possibilités pour stimuler la productivité et la croissance des revenus. En outre, la tertiarisation du secteur secondaire et la part technologique croissante des services impliquent que les secteurs secondaire et tertiaire ont besoin de capacités communes pour s'engager plus avant sur la voie d'une économie de la connaissance.
- *La prise en compte des questions d'égalité hommes-femmes* : compte tenu de l'évolution démographique de la Corée, il sera crucial d'accroître les taux d'activité des femmes dans les secteurs scientifiques et technologiques. Les autorités coréennes devraient suivre l'exemple d'autres pays membres de l'OCDE qui ont choisi d'intégrer les questions d'égalité hommes-femmes dans l'ensemble de leurs politiques.
- *La coordination des politiques* : il est difficile pour les gouvernements d'assurer la cohérence de leurs politiques et programmes, car ils sont généralement mal

organisés pour traiter des questions transversales telles que l'innovation. Il faut pour cela envisager l'intervention publique comme un dosage équilibré (« *policy mix* ») des différents instruments d'action disponibles.

- *La gouvernance participative en science et technologie* : à mesure que la Corée repousse les limites de la connaissance, elle prend de nouvelles responsabilités et relève de nouveaux défis qui appellent un dialogue avec la société. Ce dialogue devrait s'inscrire dans le cadre d'un nouveau système de gouvernance participatif en science et technologie, qui permette aux scientifiques et aux autorités d'entretenir un dialogue réel avec les citoyens à propos des nouveaux développements en science et en technologie.

## Recommandations

À la lumière de ces missions stratégiques et de ces principes directeurs, et en considérant les forces et les faiblesses du système d'innovation en Corée ainsi que les opportunités et les menaces qui se présentent à lui, cet Examen présente un certain nombre de recommandations pour l'action publique.

### *Améliorer la coordination interministérielle de la politique de l'innovation*

L'une des tâches importantes du gouvernement coréen est d'améliorer la coordination entre les nombreux ministères et agences intervenant dans la R-D et, plus généralement, l'innovation. Les gouvernements précédents ont mis en place des mécanismes assez élaborés pour répondre au problème de la coordination, mécanismes qui semblent avoir eu quelque succès – bien que des difficultés demeurent manifestement – mais qui ont dans leur majorité été supprimés par le nouveau gouvernement en 2008 dans un mouvement général de consolidation ministérielle. Toutefois, cette consolidation ne va pas se poursuivre indéfiniment et il restera toujours deux « super-ministères » qui ont une influence majeure sur la politique de l'innovation en Corée, à savoir le Ministère de l'éducation, de la science et de la technologie (MEST), qui est chargé de la science et de l'éducation publiques, et le Ministère de l'économie du savoir (MKE), responsable de la R-D et de la politique des pôles de technologie industrielle.

- *Établir des relations de travail solides entre le MEST et le MKE.* Compte tenu de la séparation ministérielle entre la science et l'éducation publiques d'une part, et la R-D industrielle d'autre part, le gouvernement coréen doit veiller à ce que le MEST et le MKE entretiennent des relations de travail fructueuses. S'il est manifestement nécessaire d'accorder plus de place à la recherche fondamentale sans visée industrielle, ainsi qu'il est préconisé dans cet examen, il est également essentiel que le système scientifique public ne se retrouve pas isolé de la R-D industrielle.
- *Veiller à ce que les sciences et l'innovation restent au premier plan des préoccupations politiques.* Au sein de chaque ministère élargi, il faudra également s'assurer que les questions relatives à la science, à la technologie et à l'innovation ne sont pas reléguées derrière d'autres plus pressantes à court terme. C'est un risque réel au MEST, car l'expérience internationale montre que lorsqu'on associe science et éducation, la première est souvent négligée au profit de la seconde, qui, plus épineuse d'un point de vue politique, demande une attention constante plus grande de la part des pouvoirs publics.

Outre une coordination de type horizontal, il est important d'établir des mécanismes de coordination et de pilotage verticaux afin d'obtenir une bonne mise en œuvre de la politique de l'innovation adoptée. Cinq conseils de recherche (CR) ont été créés à cet effet (depuis peu réduits à trois par le nouveau gouvernement), mais leur rôle est assez limité. En outre, l'affectation de chaque institut public de recherche à tel ou tel CR semble quelque peu arbitraire.

- *Réexaminer l'objectif et le fonctionnement des CR.* Le gouvernement coréen devrait envisager une réorganisation des CR, peut-être davantage en fonction des différentes disciplines, ou leur regroupement éventuel au sein d'une même entité afin de renforcer leurs capacités stratégiques.

### ***Redéfinir les rôles des acteurs de la recherche***

Les rôles traditionnels des instituts de recherche publics et des universités ont perdu progressivement de leur pertinence depuis une vingtaine d'année sous l'effet d'un certain degré de convergence de leurs missions respectives. Les instituts de recherche publics ont été créés à l'origine pour accélérer l'adoption et l'adaptation des technologies de pointe par les entreprises coréennes, alors que les universités avaient pour mission essentielle l'enseignement. S'agissant du rôle des universités dans la recherche, il demeure un décalage important entre les dépenses de recherche et les capacités en ressources humaines : les universités accueillent près de 70 % des titulaires de doctorat coréens, mais ne représentent que 10 % de la recherche nationale.

- *Corriger le décalage entre la quantité de ressources humaines et le montant des dépenses de recherche de l'université.* Il s'agit là d'une tâche urgente, qui peut exiger une hausse des dépenses de R-D et/ou des incitations plus puissantes pour encourager un plus grand nombre de titulaires de doctorat à travailler dans le secteur privé ou dans des instituts de recherche publics.
- *Établir des liens plus étroits entre les universités et les instituts de recherche publics.* Il y a de toute évidence encore des progrès à faire avant que les universités coréennes ne deviennent des acteurs majeurs de la recherche. Le soutien financier aux centres de recherche et les plans visant à attirer des scientifiques étrangers éminents afin de former des groupes de recherche de premier plan apporteront sans doute des contributions précieuses, mais mettront beaucoup de temps à porter leurs fruits. Une stratégie supplémentaire consisterait à établir des relations plus étroites entre les universités et les instituts de recherche publics, ce qui pourrait accélérer le renforcement des capacités de recherche des universités. Ces liens pourraient être de différente nature, des plus relativement informels, ou au contraire prendre la forme d'un regroupement total entre les organismes. Les autorités coréennes devraient étudier les avantages et à la faisabilité de ces solutions, en s'inspirant des initiatives étrangères de rapprochement entre établissements d'enseignement supérieur et organismes de recherche publics.
- *Veiller à ce que l'accroissement des dépenses dans la recherche universitaire n'engendre pas des « tours d'ivoire ».* Les pouvoirs publics ont de bonnes raisons d'accroître le nombre des petites subventions accordées à des projets non liés à des missions spécifiques, dans la mesure où cela bénéficiera aux chercheurs isolés et aux petits groupes souvent présents dans les universités, et où cela pourrait encourager une recherche davantage mue par la curiosité. Toutefois, l'existence de ces subventions ne doit affaiblir les activités de recherche davantage orientées sur

des missions. Autrement dit, les chercheurs des universités coréennes (à quelques exceptions notables près) doivent se consacrer plus activement à la recherche, et tout financement supplémentaire dans ce domaine doit se traduire par un développement effectif des activités réelles de recherche.

Si l'on s'accorde généralement sur la nécessité de renforcer la recherche à l'université, le rôle des instituts de recherche publics fait toujours débat. Plusieurs axes nouveaux (et non exclusifs) – chacun avec ses avantages et ses inconvénients – ont été proposés, notamment i) soutenir le développement technologique des PME, ii) passer d'une R-D de type industriel à une recherche tournée vers le public et le bien-être, iii) se concentrer sur les technologies de plateforme, iv) mener l'effort national de renforcement de la recherche fondamentale, et v) mettre l'accent sur des domaines de recherche interdisciplinaires et transversaux. Parallèlement à ces axes nouveaux, différentes options concernant la structure des instituts de recherche publics sont régulièrement étudiées. Elles vont du regroupement ou de la division de différents instituts jusqu'à la révision de leur tutelle ministérielle. Des propositions plus radicales sont aussi parfois évoquées, notamment la privatisation et le regroupement avec les universités.

- *Prendre en compte la diversité des instituts de recherche publics dans la planification des réformes.* Les instituts de recherche publics sont très différents les uns des autres, ils font face à différents défis, qui demandent des actions adaptées. Les pouvoirs publics devraient tenir compte de cette diversité dans la formulation de leur politique à l'égard des instituts de recherche publics, et devrait étudier l'avenir de chaque institut au cas par cas.
- *Attendre des instituts de recherche publics qu'ils remplissent de multiples rôles.* Les instituts de recherche publics ne doivent pas être cantonnés à une seule fonction – même si cela se traduit par plus de complexité du système national de recherche. Ils ont au contraire de multiples rôles à jouer dans le système d'innovation, ce qui doit être pris en compte dans la politique dans ce domaine.
- *S'inspirer des initiatives étrangères visant à renforcer les liens entre instituts de recherche publics et universités.* Différents modèles de coexistence entre instituts de recherche publics et universités ont été appliqués dans le monde et leur adoption éventuelle doit être correctement adaptée au contexte coréen.
- *Ouvrir davantage l'accès aux instituts de recherche publics (et aux autres infrastructures de recherche publiques).* L'utilisation de grands équipements et installations de recherche publics est souvent critiquée pour son manque d'efficacité et de rentabilité. Ces infrastructures doivent être plus largement ouvertes aux acteurs de la recherche du secteur public comme du secteur privé.

### ***Comprendre les avantages de la recherche fondamentale***

Disposant de ressources limitées pendant la phase de rattrapage économique, les autorités coréennes ont pris soin de cibler certains domaines et ont cherché à obtenir des retombées concrètes (et souvent à court terme) de leurs investissements en R-D. Toutefois, les hausses budgétaires importantes en faveur de la recherche fondamentale qui ont été annoncées récemment doivent s'accompagner d'attentes différentes quant aux retombées de cet investissement croissant. S'il semble admis que le développement de la recherche fondamentale ne produira sans doute pas de retombées tangibles immédiates, des pressions s'exercent néanmoins sur les acteurs de la recherche pour qu'ils obtiennent rapidement des résultats – en particulier dans la mesure où ceux-ci sont devenus des

critères d'évaluation importants à l'échelle nationale. La forte progression des investissements en R-D publique a permis aux instituts de recherche publics et aux universités d'augmenter très largement le nombre d'articles scientifiques publiés et de brevets déposés ces dernières années. Cependant, il est à craindre qu'une partie de cette progression soit due à un excès de publications et de dépôt de brevets, comme l'indiquent la croissance marginale des taux de citation d'articles et la faiblesse relative des taux de transfert de technologies.

- *Mieux refléter les multiples contributions de la R-D dans les évaluations nationales.* Pour limiter autant que possible les comportements non souhaitables, tels que le dépôt abusif de brevets, les diverses contributions que les établissements d'enseignement supérieur et les instituts de recherche publics apportent en faveur de l'innovation devraient mieux transparaître dans les évaluations nationales. C'est pourquoi la portée et les effets – attendus ou imprévisibles – des dispositifs complexes d'évaluation des programmes appliqués depuis trois ou quatre ans devraient maintenant être révisés.
- *Mobiliser davantage la diaspora coréenne dans le système d'évaluation national.* La Corée fait appel à de nombreux panels d'examen par des experts pour ses évaluations, mais ne fait appel que rarement à des experts étrangers à cause de la barrière de la langue. Cette situation pourrait s'améliorer par un emploi plus étendu de l'anglais, mais aussi peut-être plus simplement par le recours à la diaspora coréenne grandissante, qui apporterait une dimension internationale utile au processus d'examen.

Le besoin des entreprises – en particulier les *chaebol* et les PME de haute technologie - constitue un puissant motif de développement de la recherche fondamentale en Corée, mais ce n'est pas le seul. La nécessité de ce développement découle également de la dynamique propre du secteur scientifique, qui a atteint maintenant un niveau de maturité important et réclame des infrastructures plus élaborées et des niveaux de soutien plus importants. Nombre de ces demandes sont justifiées car des investissements dans certaines infrastructures scientifiques nécessaires à la recherche fondamentale pourraient contribuer significativement au développement socio-économique du pays. Toutefois, certaines pourraient ne servir que les intérêts du milieu scientifique et doivent être étudiées avec soin.

- *Évaluer avec minutie les projets relatifs à de grandes infrastructures de recherche afin de déterminer leur légitimité et leur adaptabilité aux besoins évolutifs.* Les demandes de grandes infrastructures nouvelles doivent être rigoureusement examinées, en gardant à l'esprit que de nombreux pays de l'OCDE ayant une plus grande expérience du financement et de la conduite de la recherche fondamentale ont parfois eu du mal à s'assurer de la pertinence des travaux de recherche associés.
- *Reconnaître le caractère stratégique d'une grande partie de la recherche fondamentale.* La recherche fondamentale ne doit pas être assimilée à une démarche uniquement motivée par la curiosité. De fait, les travaux de recherche fondamentale sont souvent menés dans le cadre de missions stratégiques. Dans bien des cas, il devrait être possible d'évaluer ex ante la contribution que peut apporter la recherche fondamentale à telle ou telle mission, même s'il est difficile de mesurer sa contribution a posteriori.

### *Promouvoir l'innovation dans le secteur des entreprises*

Les pouvoirs publics ont prévu des crédits d'impôt relativement généreux pour les entreprises qui poursuivent des activités de R-D. En outre, les financements publics directs représentent 5 % environ de la DIRDE – un chiffre moyen pour les pays de l'OCDE. Cependant, plus de 50 % des dépenses de l'État dans la recherche publique sont axés sur le développement industriel – l'un des niveaux les plus élevés de l'OCDE. Les autorités cherchent également à mettre en œuvre des politiques et des programmes portant sur un éventail plus large de questions liées à l'innovation, entre autres le financement d'entreprise, l'amélioration des compétences, la collaboration entre entreprises et universités et les pôles d'activité. L'intervention publique doit toutefois tenir compte de deux « clivages » importants concernant les résultats des entreprises coréennes en matière d'innovation : premièrement, le clivage entre les *chaebol* et les PME, et deuxièmement, celui entre le secteur manufacturier et les services.

En ce qui concerne le premier point, les performances des PME en matière d'innovation arrivent toujours loin derrière celles des *chaebol*. Il est possible que cela s'améliore à l'avenir, puisque le volume des activités de R-D menées par les PME a été multiplié par cinq entre 1997 et 2006 et qu'il s'élève aujourd'hui à près d'un quart de la DIRDE coréenne. Les mesures d'incitation de l'État, notamment le financement de la R-D, les exonérations fiscales, l'exonération des droits de douane sur les équipements de R-D et l'exemption du service militaire pour les chercheurs, entrent pour une large part dans cette rapide expansion. Les *chaebol* jouent également un rôle de soutien plus important en faveur d'un secteur des PME dynamique, car leurs fournisseurs ont dû renforcer sensiblement leurs capacités de R-D afin de répondre aux besoins technologiques accrus des *chaebol* travaillant sur des technologies de pointe. En outre, les *chaebol* continuant de se procurer des technologies à l'extérieur, les PME coréennes cherchent à réduire leur dépendance vis-à-vis d'un seul *chaebol* et à diversifier leur clientèle. Pour y parvenir, elles doivent être compétitives au plan international. Cependant, face à la nouvelle concurrence de la Chine, les entreprises coréennes peuvent moins s'appuyer sur la compétitivité des prix et doivent améliorer la fonctionnalité et la qualité de leurs produits – ce qui les oblige à innover encore davantage.

- *Continuer à soutenir l'innovation au sein des PME tout en reconnaissant les limites de l'intervention publique.* Le soutien public à l'innovation, qui concernait en premier lieu les grandes entreprises, se tourne désormais davantage vers les PME – une nouvelle orientation qui semble globalement justifiée. Les pouvoirs publics sont parvenus dans une certaine mesure à renforcer les capacités des PME, ainsi qu'à rendre les conditions plus propices aux nouvelles entreprises innovantes. Ils doivent poursuivre leurs efforts, tout en tenant compte des limites et des possibilités qu'offre la dynamique industrielle globale du pays.
- *Poursuivre la rationalisation des divers programmes de soutien à l'innovation dans les PME.* Les politiques et les programmes relatifs aux PME sont très nombreux, et les autorités financent désormais directement plus de travaux de recherche dans les PME que dans les grandes entreprises. Toutefois, il serait souhaitable de rationaliser encore davantage les programmes proposés car leur nombre et leurs champs d'application sont source de confusion.

Le second clivage concerne le secteur manufacturier et celui des services. La productivité dans le secteur manufacturier a fortement progressé ces dernières années, alors qu'elle continue de stagner dans les services. Le secteur tertiaire représentait à peine 7 % de la DIRDE en 2006, l'un des taux les plus faibles de l'OCDE. Il est important

d'avoir un secteur tertiaire productif et compétitif pour soutenir les performances du secteur manufacturier. Pourtant, les services de conseil, qui sont généralement considérés comme importants pour l'innovation, sont peu développés en Corée, notamment à cause d'une structure industrielle dominée par les *chaebol* « autonomes » et d'un marché intérieur des services relativement fermé à la concurrence étrangère.

- *Imaginer des solutions pour favoriser l'innovation dans les services.* Les pouvoirs publics devraient mettre en œuvre des politiques et des programmes nouveaux spécifiquement ciblés sur l'innovation dans le secteur tertiaire, en vue d'élargir l'assise de la croissance socio-économique future.

### ***Étendre les domaines de spécialisation***

Il existe un certain degré d'inertie dans l'orientation sectorielle des activités de R-D en Corée, comme le montrent la forte spécialisation de la recherche et des publications scientifiques autour des TIC et du génie physique. Cette spécialisation correspond aux atouts industriels actuels de la Corée, et n'est donc pas surprenante, d'autant moins que la grande part des dépenses publiques de recherche est toujours consacrée à la R-D industrielle. Cependant, la Corée doit diversifier ses avantages concurrentiels par des investissements dans de nouveaux domaines à forte intensité de savoir et ayant un potentiel de croissance élevé.

- *Établir un meilleur équilibre entre le soutien aux secteurs phares bien établis et aux « nouveaux vecteurs » de la croissance.* Le MEST a annoncé son intention de réduire la proportion des financements publics de R-D allouée aux TIC et au génie industriel, et de consacrer plus d'argent à des secteurs tels que les sciences du vivant, les nanotechnologies, les sciences spatiales, etc. Toutefois, étant donné qu'une large part du budget public de recherche provient de ministères ayant des missions sectorielles (notamment le MKE), l'influence du MEST sur une évolution de cette nature semble limitée. Une meilleure coordination dans l'ensemble de l'administration sera nécessaire pour s'assurer qu'un meilleur équilibre entre les disciplines peut être obtenu.
- *Définir les « grands défis » auxquels devra s'adresser une recherche davantage orientée vers le bien-être.* L'existence de ces défis devrait motiver une diversification des investissements de recherche et se traduire en de nouvelles priorités dont la poursuite pourrait se prêter à l'approche ciblée souvent employée pour la R-D en Corée.
- *Accroître le recours à de petites subventions afin de diversifier la recherche.* Les efforts de diversification doivent tenir compte des besoins de financement des chercheurs isolés ou des petits groupes de recherche des universités actifs dans les domaines concernés, pour lesquels des petites subventions peuvent particulièrement bien adaptées. Ces investissements ne doivent pas nécessairement être consentis dans le cadre de mécanismes de financement ascendants (« *bottom-up* ») et peuvent également l'être au sein de programmes gérés de manière descendante (« *top-down* »).
- *Promouvoir l'innovation dans les services – un vecteur de croissance essentiel à l'avenir.* Ainsi qu'il a déjà été souligné par ailleurs, il convient de soutenir l'innovation dans le secteur tertiaire, qui est déjà de loin le premier employeur en Corée et souffre de niveaux de productivité faibles.

### *Accroître la contribution de l'enseignement supérieur à l'innovation*

Ce sont l'éducation et l'amélioration des compétences qui ont permis à la Corée de devenir une grande économie industrielle. Cependant, le système éducatif qui s'est développé au fil des années doit aujourd'hui s'adapter aux nouveaux défis auxquels le pays doit faire face. Au cœur de cette évolution se trouve l'enseignement supérieur, où il est nécessaire d'améliorer l'adéquation entre l'offre et la demande de diplômés ayant des compétences et des connaissances répondant aux besoins de l'économie et de la société. Il y a, de manière générale, trop de diplômés au niveau licence et trop peu de techniciens et de diplômés au niveau post-licence dans les domaines de haute technologie. En outre, la hiérarchie très visible et excessivement rigide des universités coréennes conditionne fortement la réussite professionnelle et le statut social. Malheureusement, la concurrence exacerbée pour l'entrée dans les universités les mieux cotées n'a pas entraîné une différenciation et spécialisation au sein du système éducatif mais s'est traduit au contraire par une uniformisation, les universités étant nombreuses à proposer les mêmes types de cursus. Par ailleurs, le système est trop exclusivement au service des jeunes gens et n'est pas assez souple pour proposer des programmes qui favoriseraient une participation plus nombreuse d'apprenants plus âgés.

- *Poursuivre les actions encourageant les universités à se spécialiser.* Les pouvoirs publics cherchent à relever les niveaux en encourageant les universités à se spécialiser, de préférence dans des domaines où les diplômés ont plus de chances de trouver un emploi au niveau local (en particulier pour atténuer la pression sur Séoul). Cette démarche va à contre-courant de l'expansion non viable vers laquelle tendent de nombreuses universités, mais semble être la bonne marche à suivre et doit donc être poursuivie, voire étendue plus activement.
- *Offrir de nouvelles incitations afin que les cursus universitaires répondent aux besoins en personnel qualifié des entreprises coréennes et de la société.* Dans une comparaison internationale, les entreprises coréennes montrent l'un des niveaux d'insatisfaction les plus élevés quant à la qualité des diplômés. De nombreux établissements d'enseignement supérieur sont en train de relever leur niveau et travaillent de plus en plus avec des entreprises et les autorités locales en vue de réviser les programmes pour les rendre plus réactifs à l'évolution de la demande.
- *Veiller à ce que la concurrence entre les établissements d'enseignement supérieur s'appuie sur des informations fiables concernant les résultats et le fonctionnement de leurs facultés et/ou départements.* La mise en place en 2008 du système d'information universitaire – qui comprend des renseignements sur les taux d'emploi des diplômés, les taux d'inscription, la proportion d'enseignants à temps plein, l'offre de bourses, les résultats scientifiques, le fonctionnement des programmes et la gestion des écoles – est une initiative fort opportune à cet égard. Cependant, une évaluation supplémentaire de chaque département ou faculté devrait également être mise au point, ce qui permettrait de mettre mieux en lumière les atouts spécifiques des établissements d'enseignement supérieur.
- *Effectuer une évaluation régulière des résultats de la recherche au sein des facultés et/ou des départements afin de renforcer les liens entre la recherche et la formation post-licence.* De nombreux étudiants post-licence en Corée sont formés dans des facultés peu actives dans le domaine de la recherche, ce qui signifie que le lien étroit entre recherche et enseignement est brisé. Pour résoudre ce problème, il conviendrait d'évaluer les travaux de recherche menés au sein des départements

ou des facultés, de sorte que les étudiants éventuels et les bailleurs de fonds disposent des informations requises pour un choix éclairé.

- *Rehausser le statut des diplômes de formation professionnelle et celui des établissements où ils peuvent être obtenus.* Comme la forte demande en diplômes de licence ne devrait pas diminuer dans l'immédiat, il conviendrait d'envisager de revaloriser les brevets professionnels en les rendant équivalents à des diplômes de licence.
- *Offrir de nouvelles incitations aux prestataires d'enseignement afin qu'ils élaborent des programmes de formation tout au long de la vie plus souples.* Les programmes des universités et des « *junior colleges* » devraient être plus flexibles et permettre aux apprenants d'étudier à temps partiel tout en continuant à travailler. Parallèlement, les employeurs et les salariés devraient être davantage incités à s'investir dans des activités de formation tout au long de la vie.

### ***Augmenter les taux d'activité des femmes en science et en ingénierie***

D'un point de vue strictement économique, il est urgent que plus de femmes travaillent dans les sciences et l'ingénierie, étant donné l'évolution démographique prévisible de la Corée. Les taux d'obtention de diplôme des femmes dans ces secteurs sont proches de la moyenne de l'OCDE, mais nombre d'entre elles ne parviennent pas à trouver un emploi dans ce domaine. Les pouvoirs publics ne se sont attaqués à ce problème qu'assez récemment mais leurs initiatives sont de portée large et mettent à profit les expériences de l'étranger. Outre les programmes visant à attirer plus de femmes vers des carrières scientifiques et d'ingénieur, des objectifs de recrutement ont été fixés dans certaines parties du secteur public, ainsi que des systèmes favorables à points pour la sélection des projets de recherche. Certains éléments semblent indiquer que ces mesures ont des effets, mais les progrès sont plutôt lents et partent d'un niveau faible.

- *Prendre en compte les questions d'égalité hommes-femmes à tous les niveaux de la politique scientifique et technologique.* Cela montrera la détermination du gouvernement coréen à accorder la priorité la plus haute à la présence des femmes dans ces secteurs.
- *Conjuguer réglementation et incitations afin de pousser le secteur privé à employer plus de femmes dans les domaines scientifiques et technologiques.* La plupart des chercheurs étant employés par le secteur privé, il y a des limites à l'intervention directe des autorités. C'est pourquoi une combinaison de réglementation et d'incitations devrait être envisagée, notamment des mesures telles que des quotas en faveur des femmes, des incitations fiscales et des subventions pour les structures de garde d'enfants.
- *Mettre à profit la diversification des efforts de R-D pour favoriser une présence accrue des femmes dans les domaines scientifiques et technologiques.* Le recul relatif des TIC et de l'ingénierie des machines au profit des sciences du vivant, des sciences médicales et des sciences de l'environnement doit être mis à profit pour accroître les taux d'activité des femmes, dans la mesure où ces disciplines semblent plus propices aux femmes que les secteurs dans lesquels la Corée a été la plus active jusqu'à présent.

### ***Améliorer la mobilité professionnelle au sein du système de recherche***

La mobilité de la main-d'œuvre constitue l'une des faiblesses fondamentales du système de recherche : elle est à la fois faible en volume et unidirectionnelle. Cela tient en partie au dualisme du marché du travail, mais le haut statut accordé au personnel universitaire joue également et entraîne progressivement une « fuite des cerveaux » interne à partir des instituts de recherche publics (et, dans une moindre mesure, des entreprises), les mouvements inverses étant très peu nombreux. Le manque de circulation de la main-d'œuvre qui en résulte a tendance à gêner la diffusion des connaissances au sein du système d'innovation.

- *Étudier des moyens de rehausser le statut des instituts de recherche publics de sorte qu'ils soient considérés comme des lieux de travail aussi intéressants que les universités.* Si les conditions de travail dans les instituts de recherche publics se rapprochaient davantage de celles dans les universités – en termes de sécurité de l'emploi, d'évolution de carrière et de pension de retraite par exemple – cela pourrait permettre aux premiers de redevenir des employeurs plus attractifs et encouragerait sans doute la mobilité de la main-d'œuvre. Cependant, le statut des instituts de recherche publics étant considéré comme moins prestigieux que celui des universités, la mobilité vers les instituts risque de rester modeste. Les pouvoirs publics devraient donc redorer l'image des instituts de recherche publics, par exemple en investissant dans des équipements de pointe et des projets phares.

### ***Décentraliser la politique de l'innovation pour une croissance plus équilibrée***

Les régions et les régions urbaines constituent peut-être l'un des meilleurs niveaux pour établir des relations productives au sein du système d'innovation. Cependant, il n'existe pas de pôles technologiques importants au-delà du « macropôle » de Séoul. Cette concentration des ressources scientifiques et technologiques semblait aller de soi pendant le processus d'industrialisation rapide de la Corée, mais elle est désormais remise en question, les pouvoirs publics souhaitant promouvoir un développement plus équilibré géographiquement. La Corée doit mettre en œuvre différents programmes d'action pour combler des manques d'innovation au plan régional, notamment des mesures encourageant les partenariats entre les acteurs régionaux de l'innovation, qui étaient récemment encore peu développés. En conséquence, une série de mesures – mises en œuvre dans diverses agences publiques à l'échelle nationale comme dans les régions – a été adoptée afin de soutenir/renforcer les systèmes d'innovation régionaux. Cependant, ces efforts sont fragmentés et manquent de coordination. Le problème est essentiellement dû au fait que de nombreux programmes régionaux sont gérés au niveau central par des agences nationales et non par les régions elles-mêmes. La coordination au niveau régional est ainsi compliquée et empêche le développement et l'enracinement de capacités de planification et de mise en œuvre plus solides.

- *Donner plus de responsabilités aux régions pour la conception et l'application de la politique d'innovation régionale.* Les politiques actuellement distinctes mais souvent enchevêtrées sur les pôles, la R-D, l'innovation régionale et l'éducation devraient être regroupées en une stratégie globale au service du développement économique régional, qui laisserait une grande marge de manœuvre aux régions elles-mêmes en matière de conception et d'application. Cette responsabilité devrait s'accompagner d'un système de contrôle permettant de veiller à l'adéquation et à l'efficacité de l'action, et permettant également de tirer plus facilement des leçons des politiques appliquées au niveau régional.

- *Mener un audit stratégique ascendant sur les programmes d'innovation régionaux.* Dans le contexte d'une décentralisation accrue des pouvoirs, il est nécessaire de réaliser un audit stratégique des diverses initiatives régionales en matière d'innovation prises par les différentes agences, ainsi que des efforts consentis pour renforcer les capacités de planification et de mise en œuvre dans les régions.

Le gouvernement coréen a également cherché à faire émerger un pôle d'activités à forte intensité de savoir autour de la cité de la science de Daedok – rebaptisée récemment Daedok Innopolis. La transformation de Daedok d'un pôle scientifique en un pôle de l'innovation n'est pas acquise, mais les premiers signes sont encourageants. Autre point peut-être davantage sujet à controverse, les autorités veulent encourager le développement de pôles scientifiques plus petits dans d'autres régions qui n'ont jusqu'à présent que peu d'activités de recherche.

- *Comprendre que les investissements et les retombées associés aux systèmes d'innovation régionaux s'inscrivent dans la durée.* Il est évident que même avec l'intervention de l'État, il faudra très longtemps pour que le renforcement des capacités de recherche d'une région porte ses fruits. Cela ne signifie pas renoncer à investir pour ce renforcement, mais plutôt admettre que les bénéfices attendus mettront du temps à se matérialiser pleinement. .
- Veiller à ce que l'innovation soit au cœur de tout investissement à visée scientifique destiné à promouvoir le développement régional. Sans cela, les pouvoirs publics risquent de bâtir des « cathédrales dans le désert », autrement dit des centres d'excellence scientifique comportant peu d'avantages pour l'économie locale.

### ***Tirer le meilleur parti possible de l'internationalisation de la R-D***

Ces dernières années, alors que la R-D s'est de plus en plus internationalisée, il est devenu important pour les pays de s'ouvrir et de participer à des réseaux mondiaux de production de savoir. Le système coréen de R-D est considéré à bien des égards comme relativement fermé à l'internationalisation : les scientifiques étrangers sont peu nombreux à travailler en Corée, il existe peu de centres de recherche étrangers dans le pays et la coopération internationale en matière de recherche n'est guère développée. Toutefois, sur d'autres aspects, le système de R-D coréen a toujours été très internationalisé, et ce, dès le début, lorsque les instituts de recherche publics nouvellement créés devaient débaucher des scientifiques coréens travaillant aux États-Unis pour étoffer leurs effectifs. Cette mobilité de la main-d'œuvre s'est poursuivie jusqu'à aujourd'hui, de nombreux Coréens choisissant de passer leur doctorat à l'étranger, et de plus en plus, leur licence et leur master, avant de retourner en Corée pour travailler. Néanmoins, l'accélération récente de cette mobilité vers l'extérieur (la Corée compte plus d'étudiants aux États-Unis qu'aucun autre pays) est une préoccupation grandissante, dans la mesure où de nombreuses personnes choisissent de ne pas retourner en Corée, du moins pas dans l'immédiat. Certains parlent de « fuite des cerveaux » et soulignent la nécessité d'améliorer les possibilités de recherche et d'enseignement dans les universités coréennes. D'autres considèrent ces évolutions de manière plus positive et y voient l'internationalisation de la Corée par un processus de « circulation des cerveaux ».

Les pouvoirs publics coréens souhaitent à juste titre réduire les risques associés à la mobilité vers l'extérieur en encourageant le mouvement inverse, vers la Corée. Ils redoublent d'efforts pour améliorer l'internationalisation de l'assise scientifique et technologique du pays et ont récemment adopté plusieurs plans d'action visant à i) promouvoir la collaboration internationale en matière de R-D ; ii) attirer des centres de R-D étrangers en Corée; iii) attirer des ressources humaines – étudiants et chercheurs qualifiés – afin qu'ils étudient et travaillent en Corée. L'ampleur et la portée des investissements prévus (par exemple, pour l'initiative qui vient d'être annoncée sur les Universités de classe mondiale) ainsi que les objectifs fixés (sur les effectifs d'étudiants étrangers, par exemple) montrent une réelle ambition. Si ces plans d'action atteignent leurs objectifs, des progrès considérables auront été faits en vue de l'internationalisation de la R-D coréenne.

- *Tirer parti des évolutions systémiques au sens large pour renforcer indirectement l'internationalisation de la R-D en Corée.* Ces évolutions concernent notamment i) l'accent mis sur la recherche fondamentale, dans la mesure où celle-ci est propice à de nombreuses coopérations scientifiques internationales, et ii) le renforcement des capacités de recherche universitaires, qui devraient devenir un axe majeur de la coopération et des échanges avec l'étranger.
- *Continuer d'investir dans des installations de R-D à l'étranger.* Les *chaebol* coréens investissent assez largement dans des installations de R-D à l'étranger, en particulier aux États-Unis, en Europe, en Russie et, de plus en plus, en Chine. Des relations similaires, bien que plus modestes, ont été établies par quelques instituts de recherche du secteur public. Tous ces efforts vont sans doute contribuer à renforcer les liens entre la recherche et l'innovation en Corée et les réseaux mondiaux de savoir, et doivent donc être poursuivis.
- *Améliorer la coordination entre les politiques et les programmes du MEST et du MKE en faveur de l'internationalisation.* Il conviendrait autant que possible de rationaliser les politiques et les programmes de manière à éviter les chevauchements et à combler les manques.

**Tableau récapitulatif : Le système d'innovation coréen – forces, faiblesses, opportunités et menaces**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Les forces</b></p> <ul style="list-style-type: none"> <li>• Une vision nationale articulée et mobilisatrice</li> <li>• Des taux élevés de croissance tendancielle du PIB</li> <li>• Un soutien public important à l'innovation et à la R-D</li> <li>• De bonnes conditions-cadres pour l'innovation et qui vont en s'améliorant</li> <li>• Des niveaux élevés de DIRD et de DIRDE en pourcentage du PIB</li> <li>• Une main-d'œuvre hautement qualifiée</li> <li>• Une offre de RHST de qualité</li> <li>• Une grande capacité d'adopter rapidement les nouvelles technologies</li> <li>• Une infrastructure des TIC solide</li> <li>• Une réactivité exceptionnelle face à la concurrence</li> <li>• Des entreprises solides et compétitives sur le plan international</li> <li>• La capacité de tirer les leçons des échecs et d'apprendre des autres</li> <li>• La capacité de produire des talents d'envergure mondiale</li> </ul>                                                                                                                                                                      | <p><b>Les opportunités</b></p> <ul style="list-style-type: none"> <li>• Un positionnement géopolitique dans l'une des régions les plus dynamiques du monde</li> <li>• Des accords de libre-échange</li> <li>• La mondialisation, y compris de la R-D</li> <li>• Une diaspora coréenne grandissante dans les secteurs scientifiques et technologiques</li> <li>• L'évolution scientifique et technologique, en particulier en informatique, dans les nanotechnologies, les biotechnologies et en ingénierie – et leur possible fusion</li> <li>• La croissance de la Chine et d'autres économies industrielles nouvelles, dans la région et ailleurs, qui offrent de nouveaux marchés pour les exportations coréennes</li> </ul> |
| <p><b>Les faiblesses</b></p> <ul style="list-style-type: none"> <li>• Des capacités de recherche fondamentale peu développées et des capacités de recherche modestes à l'université</li> <li>• Des liens peu développés entre les instituts de recherche publics et les établissements d'enseignement supérieur</li> <li>• Dans l'enseignement : apprentissage par cœur, trop d'importance accordée à l'examen d'entrée à l'université, et coûts exorbitants de l'enseignement privé</li> <li>• Une sous-utilisation des femmes dans la population active</li> <li>• Une productivité faible du secteur des services</li> <li>• Un secteur des PME relativement fragile</li> <li>• L'héritage du dirigisme, qui gêne l'élaboration d'une politique de l'innovation orientée vers la diffusion</li> <li>• Des liens internationaux déséquilibrés</li> <li>• Un développement inégal selon les régions et les secteurs</li> <li>• Un marché intérieur relativement modeste (comparé à la Chine, au Japon et aux États-Unis)</li> <li>• Des problèmes de coordination des politiques entre les ministères</li> </ul> | <p><b>Les menaces</b></p> <ul style="list-style-type: none"> <li>• Des taux de fécondité faibles et une population vieillissante</li> <li>• L'arrivée de concurrents redoutable dans les domaines où la Corée excelle, tels que les TIC, en particulier la Chine</li> <li>• Les incertitudes géopolitiques dans la région</li> <li>• Les perturbations des importations de ressources naturelles et d'énergie, dont l'économie coréenne est fortement dépendante</li> <li>• Les perspectives économiques mondiales et leurs conséquences pour les économies tournées vers l'exportation</li> </ul>                                                                                                                              |



## Chapter 1

### Performance and Framework Conditions for Innovation

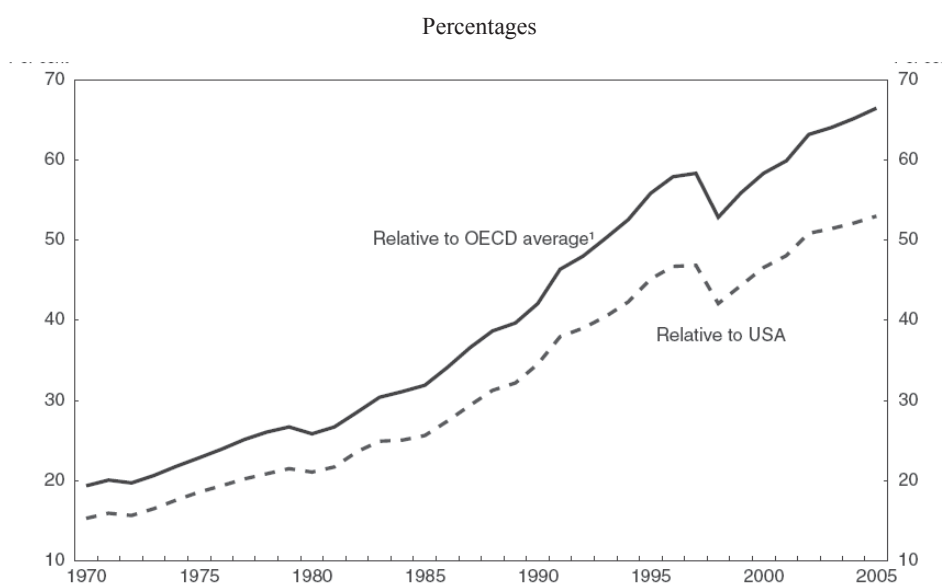
*This chapter first reviews Korea's macroeconomic performance, with its above-average OECD-area economic growth and sustained shift towards high-technology production. It then considers the structural features of the Korean economy: the unique role of the chaebol, the position of SMEs, the productivity gap between manufacturing and services, regional economic imbalances, and relatively low levels of internationalisation. It then turns to an examination of the framework conditions for innovation: the business environment, competition policy, and product and labour market conditions. A final section assesses and benchmarks Korea's performance in science, technology and innovation (STI), with a focus on indicators such as research spending, publication and patenting rates, and human resource capacity.*

#### 1.1. Macroeconomic performance

In its efforts to catch up with the world's leading economies, Korea has performed exceptionally well over the last few decades by instigating waves of industrial upgrading to become a world leader in some of the most high-technology industries. Historically, the catch-up process was shaped by strong state leadership, a state-controlled banking system, and the dominance of the *chaebol* – Korea's large, highly diversified, family-owned conglomerates. The growth of Korea's GDP to around 70% of the average OECD GDP per capita income (see Figure 1.1) can be attributed to export-driven economic growth as the chaebol have accessed and exploited international markets and international sources of technology.

##### 1.1.1. Growth of GDP

Historically, Korea's growth can be largely 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 has begun to slow, continued convergence to the OECD average through input-based growth will become more difficult. Sustaining high growth will increasingly depend upon boosting innovation, which will in turn feed productivity growth.

**Figure 1.1. Convergence of Korea's per capita income to the OECD average, 1970-2005**

1. The OECD average is based on 26 countries (excluding the Slovak Republic, Poland, the Czech Republic and Hungary) from 1970 to 1990, on 29 countries (excluding the Slovak Republic) from 1991 to 1992, and on all 30 member countries from 1993 to 2005.

Source: OECD (2007), *OECD Economic Surveys: Korea*, OECD, Paris.

As Table 1.1 shows, the Korean economy's growth rate has slowed since the beginning of the decade, although it has expanded at an annual rate of 4.3% since 2002, one of the highest rates in the OECD area. Growth in private consumption, gross fixed capital formation and total domestic demand have all declined. These trends are interpreted in Korea as the warning signs of a weakening in the growth potential of the economy. However, such signs of decline need to be put into perspective, since the deceleration during the past four years has been exaggerated by several factors that artificially boosted growth from 1998 to 2002 (OECD, 2007a):

- The economy bounced back sharply from the 1997 crisis and deep recession of 1998.
- The worldwide ICT boom accelerated growth around the turn of the century.
- As the impact of the ICT boom faded, it was replaced by another bubble – in household credit – that drove private consumption until it burst in 2002. The weaker contribution of private consumption to output growth during the past four years – less than one percentage point a year compared to more than four points from 1998 to 2002 – is explained by the difficulty households faced in repairing their balance sheets following the credit card bubble in 2002.

**Table 1.1. Economic growth trends in Korea, 1998-2006**

|                               | Average annual growth rates |         | Contribution to growth |         |
|-------------------------------|-----------------------------|---------|------------------------|---------|
|                               | 1998-2002                   | 2002-06 | 1998-2002              | 2002-06 |
| Private consumption           | 8.2                         | 1.5     | 4.4                    | 0.8     |
| Government consumption        | 3.8                         | 4.3     | 0.5                    | 0.5     |
| Gross fixed capital formation | 6.7                         | 2.7     | 2.0                    | 0.8     |
| Stock building                | ..                          | ..      | 0.8                    | 0.0     |
| Total domestic demand         | 8.0                         | 2.3     | 7.7                    | 2.1     |
| Exports                       | 10.8                        | 14.1    | - 0.5*                 | 2.1*    |
| Imports                       | 12.6                        | 13.1    | 13.1                   |         |
| GDP                           | 7.2                         | 4.3     | 4.3                    | 4.2     |

\* Indicates contribution of net exports.

Source: OECD (2007), *OECD Economic Surveys: Korea*, OECD, Paris.

### **1.1.2. International trade**

Export growth has continued to soar, transforming a trade deficit of USD 3 billion in 1997 into a trade surplus of USD 33 billion in 2006. This resilient export performance made Korea the world's tenth largest exporting country and thirteenth largest importing country in 2006, and reflects the fact that Korean firms are competitive in international markets, despite the appreciation of the won during this period, as Korean firms have improved the quality of their products, but have also shifted towards more knowledge-intensive products, and have thus been less sensitive to exchange rate fluctuations (OECD, 2007a). This shift is confirmed by Table 1.2, which shows that the proportion of high- and medium-high-technology products among Korea's exports has grown sharply since the early 1990s in parallel with a similar decline in low-technology products, such as textiles and food.

Table 1.2 also shows the revealed comparative advantage (RCA) indices of different Korean sectors, a measure of their international competitiveness. The RCA indices of high-technology and medium-high-technology sectors increased significantly, while the indices of medium-low-technology sectors (with the exception of shipbuilding and repair) declined, implying a loss in competitive advantage. Clearly, the low-technology industries that profited from low wages are rapidly losing their competitive advantage to Chinese industries not only in international markets but also in the domestic market (see Box 1.1).

Table 1.2. Composition of Korea's exports, 1992 and 2004

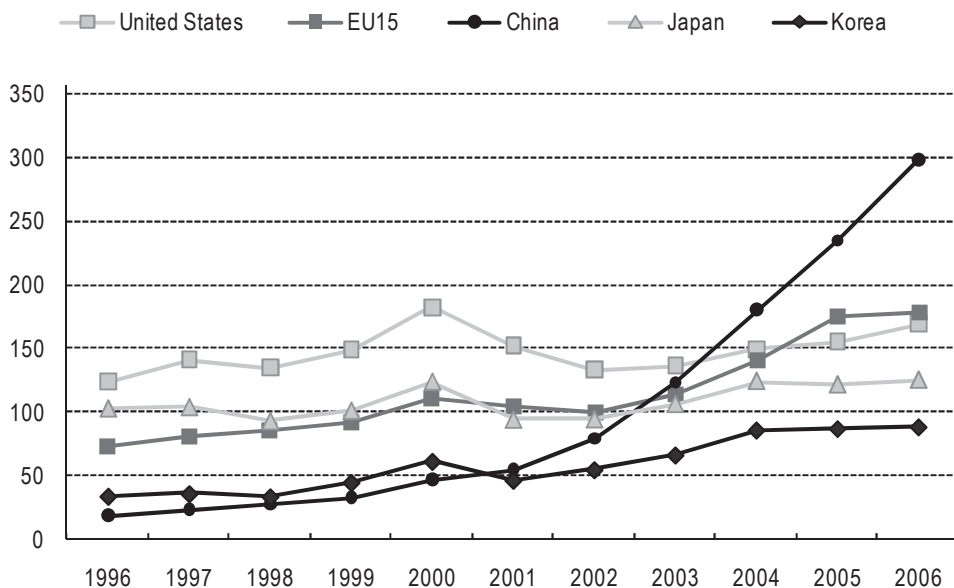
|                                           | Share (%)   |             | Revealed comparative advantage |             |
|-------------------------------------------|-------------|-------------|--------------------------------|-------------|
|                                           | 1992        | 2004        | 1992                           | 2004        |
| <b>Manufacturing</b>                      |             |             |                                |             |
| <b>High technology and products</b>       | <b>25.8</b> | <b>39.2</b> | <b>1.33</b>                    | <b>1.63</b> |
| Aircraft and spacecraft                   | 0.9         | 0.2         | 0.28                           | 0.11        |
| Pharmaceuticals                           | 0.4         | 0.3         | 0.26                           | 0.11        |
| Computers and office products             | 4.0         | 9.0         | 0.91                           | 1.73        |
| Semiconductors and electronic valves      | 10.6        | 11.0        | 3.62                           | 2.30        |
| Radio, TV and communication equipment     | 8.5         | 15.3        | 2.31                           | 3.19        |
| Precision, medical and optical instrument | 1.3         | 2.4         | 0.39                           | 0.65        |
| <b>Medium-high technology</b>             | <b>20.4</b> | <b>35.2</b> | <b>0.60</b>                    | <b>1.10</b> |
| Electrical machinery                      | 2.2         | 3.2         | 0.59                           | 0.77        |
| Chemical products                         | 7.2         | 10.2        | 0.99                           | 1.26        |
| Motor vehicle and trailer                 | 5.8         | 13.6        | 0.50                           | 1.33        |
| Other transport equipment                 | 0.2         | 0.2         | 0.35                           | 0.29        |
| Home appliance and machinery equipment    | 3.0         | 8.0         | 0.46                           | 0.91        |
| <b>Medium-low technology</b>              | <b>18.7</b> | <b>17.3</b> | <b>1.45</b>                    | <b>1.43</b> |
| Shipbuilding and repair                   | 5.4         | 6.4         | 5.77                           | 8.45        |
| Coke and petroleum products               | 0.2         | 0.1         | 0.30                           | 0.20        |
| Rubber and plastic products               | 2.8         | 2.4         | 1.15                           | 0.96        |
| Non-metallic mineral products             | 0.8         | 0.6         | 0.52                           | 0.44        |
| Basic and fabricated products             | 9.7         | 7.7         | 1.30                           | 1.12        |
| <b>Low technology</b>                     | <b>31.6</b> | <b>8.8</b>  | <b>1.44</b>                    | <b>0.49</b> |
| Textile, apparel and footwear             | 25.4        | 6.1         | 2.99                           | 0.92        |
| Food, beverages and tobacco               | 2.1         | 1.1         | 0.35                           | 0.20        |
| Wood and paper products                   | 1.0         | 0.6         | 0.22                           | 0.19        |
| Other misc. manufacturing products        | 3.2         | 1.0         | 1.03                           | 0.35        |
| <b>Non-manufacturing</b>                  | <b>1.5</b>  | <b>0.4</b>  | <b>0.18</b>                    | <b>0.03</b> |

Source: OECD (2007), *OECD Economic Surveys: Korea*, OECD, Paris.

### Box 1.1. The rise of China

Korea has benefited significantly from China's economic development. Strengthening economic ties have made China Korea's largest export market, accounting for 21% of total Korean exports in 2006. The trade relationship has been underpinned by Korea's foreign direct investment (FDI) in China. Indeed, China accounted for nearly a quarter of Korea's total stock of overseas FDI in 2005 and 36% in the manufacturing sector. At the same time, Korea is increasingly challenged by China in many industries in which it currently enjoys a competitive advantage. For example, China is now the leading exporter of information and communication technology (ICT) products (Figure 1.2). China's growing presence in more high-technology industries is encouraged by its growing investment in R&D, which increased at an average annual rate of 18% between 2000 and 2005, well above the rate of 6.9% in Korea and the OECD average of 3.6%.

**Figure 1.2. Exports of ICT goods between 1996 and 2006 (USD billions in current prices)**



Note: Data for the EU exclude intra-EU trade.

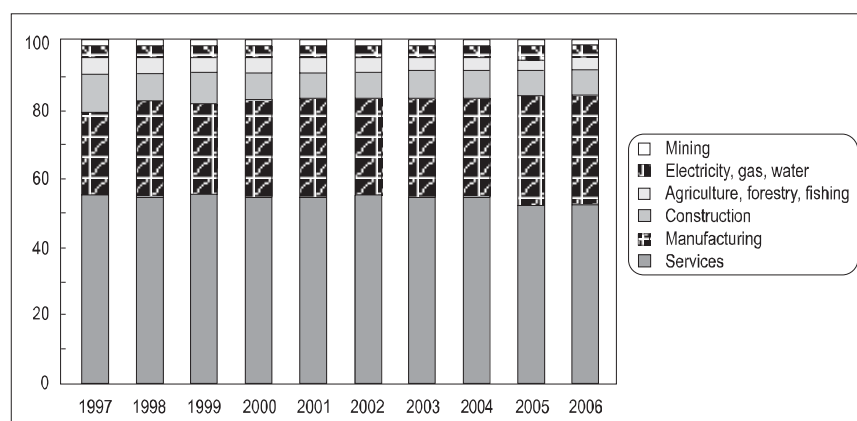
Source: Joint OECD-UNSD ITCS and the UN COMTRADE database, June 2008, cited in OECD (2008), *OECD Reviews of Innovation Policy: China*, OECD, Paris.

### 1.1.3. Composition of economic activities

As Korean industry has become more knowledge-intensive and shifted to high-technology sectors, some economic activities have declined in importance. As Figure 1.3 shows, agriculture, forestry and fishing, mining and construction each account for a smaller share of Korean GDP than they did a decade ago, while manufacturing has continued to soar, to account for almost 30% of GDP in 2006, up from 22% in 1997. This amounts to an annual increase of 7% and bucks the trend towards a decline in manufacturing in many advanced economies. Interestingly, the share of services has barely changed, decreasing slightly from 51.3% in 1997 to 48.9% in 2006.

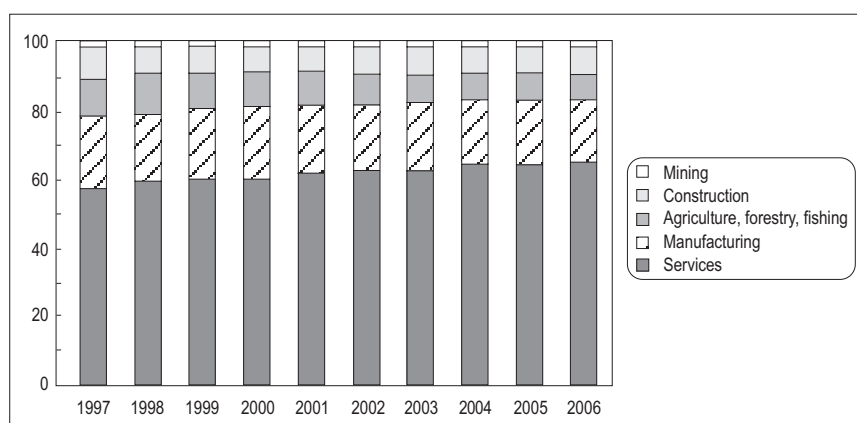
Around two-thirds of employment in the Korean economy is in services (Figure 1.4), a significantly higher proportion than the sector's contribution to GDP. By contrast, despite its growing share of GDP, manufacturing accounts for a declining share of employment, down from 21.4% in 1997 to 18.0% in 2006. This suggests that Korean manufacturing firms facing fierce international competition have reduced their number of employees in a bid to increase productivity levels. The services sector seems to have absorbed most of the people who have exited the manufacturing sector. Nevertheless, the decline in manufacturing jobs has affected the labour market, as too few positions are available to absorb new graduates.

**Figure 1.3. Trends in the composition of GDP, by sector, 1997-2006**



Source: National Statistical Office (2007), *Major Statistics of the Korean Economy*, National Statistical Office, Seoul.

**Figure 1.4. Trends in the composition of employment, by sector, 1997-2006**



Source: National Statistical Office (2007), *Major Statistics of the Korean Economy*, National Statistical Office, Seoul.

As Table 1.3 shows, the high-growth industries include refined petroleum products (8.9%), rubber & plastics products (10.6%), basic metals (10.0%), assembling metal products (7.9%), machinery (8.0%), TV and communication equipment (13.5%), motor cars and trailers (9.2%), other transport equipment (7.9%) and recycling industry (13.0%).

**Table 1.3. Composition of gross output in Korean manufacturing industry, 1997, 2000, 2005**

KRW billions

| Manufacturing sectors                     | 1997    | %    | 2000    | %    | 2005    | %    | AGR* |
|-------------------------------------------|---------|------|---------|------|---------|------|------|
| Total                                     | 434 895 | 100  | 564 834 | 100  | 848 484 | 100  | 7.7  |
| Food products and beverages               | 31 426  | 7.2  | 37 434  | 6.6  | 48 264  | 5.7  | 4.9  |
| Tobacco products                          | 4 195   | 1.0  | 3 696   | 0.7  | 2 764   | 0.3  | -4.5 |
| Textiles                                  | 21 314  | 4.9  | 26 033  | 4.6  | 21 944  | 2.6  | 0.3  |
| Wearing apparel and fur articles          | 10 314  | 2.4  | 9 458   | 1.7  | 12 351  | 1.5  | 2.0  |
| Tanning and dressing of leather           | 5 108   | 1.2  | 5 508   | 1.0  | 4 205   | 0.5  | -2.1 |
| Wood and cork                             | 3 320   | 0.8  | 3 172   | 0.6  | 4 394   | 0.5  | 3.2  |
| Pulp, paper and paper products            | 10 247  | 2.4  | 13 410  | 2.4  | 14 722  | 1.7  | 4.1  |
| Publishing, printing and recording        | 7 866   | 1.8  | 9 804   | 1.7  | 12 664  | 1.5  | 5.4  |
| Coke, refined petroleum products          | 28 038  | 6.4  | 40 158  | 7.1  | 60 425  | 7.1  | 8.9  |
| Chemicals and chemical products           | 41 681  | 9.6  | 56 038  | 9.9  | 79 318  | 9.3  | 7.4  |
| Rubber & plastics products                | 15 222  | 3.5  | 21 465  | 3.8  | 37 599  | 4.4  | 10.6 |
| Non-metallic mineral products             | 17 034  | 3.9  | 16 983  | 3.0  | 23 005  | 2.7  | 3.4  |
| Basic metals                              | 35 204  | 8.0  | 44 591  | 7.9  | 82 797  | 9.8  | 10.0 |
| Assembly of metal products and outfits    | 19 972  | 4.6  | 20 309  | 3.6  | 39 666  | 4.7  | 7.9  |
| Machinery and out fits                    | 36 287  | 8.3  | 42 414  | 7.5  | 72 226  | 8.5  | 8.0  |
| Office, calculation, accounting machinery | 13 313  | 3.1  | 26 349  | 4.7  | 7 969   | 0.9  | -5.5 |
| Electrical machinery                      | 15 627  | 3.6  | 21 595  | 3.8  | 30 065  | 3.5  | 7.5  |
| Television and communication equipment    | 44 973  | 10.3 | 79 414  | 14.0 | 140 470 | 16.6 | 13.5 |
| Medical, precision and optical machinery  | 4 803   | 1.1  | 5 132   | 0.9  | 8 692   | 1.0  | 6.8  |
| Motor cars and trailers                   | 44 181  | 10.2 | 53 889  | 9.5  | 97 894  | 11.5 | 9.2  |
| Other transport equipment                 | 16 997  | 3.9  | 18 715  | 3.3  | 33 592  | 4.0  | 7.9  |
| Furniture                                 | 7 100   | 1.6  | 8 378   | 1.5  | 11 439  | 1.3  | 5.4  |
| Recycling                                 | 672     | 0.2  | 891     | 0.2  | 2 020   | 0.2  | 13.0 |

\* AGR indicates annual average growth rates.

Source: National Statistical Office (2006), *Report on Mining and Manufacturing Survey*, National Statistical Office, Seoul.

These trends show Korea to be a manufacturing-led economy, which depends for much of its value added on manufacturing. They also point to an opportunity to increase economic growth through productivity gains in the services sector, which accounts for a smaller proportion of GDP than in advanced countries. As will be discussed in later sections, Korean services lag those of advanced countries, particularly in knowledge-intensive services such as finance, insurance, medical services, business services, etc.

## 1.2. Structural features

This section briefly recalls the history of Korean economic development and highlights the important role played by large industrial conglomerates – the *chaebol*. It then discusses four structural “imbalances” in the Korean economy: the “dual economy” of large and small firms; the yawning productivity gap between manufacturing and services; unbalanced regional development; and the economy’s relatively low levels of internationalisation. Each of these is further discussed in later chapters.

### 1.2.1. Brief history of Korea’s economic development

Korea’s early industrial strategy was based on growing import-substitution industries, starting with subsistence agriculture, such as rice, and labour-intensive light manufacturing sectors, such as textiles, footwear and bicycles. Korea had a comparative advantage in inexpensive skilled labour, but it had neither the technological capability nor local capital to establish and operate production systems. The technological deficit was addressed by promoting technology transfer from overseas, linked with the strengthening of domestic capacity to absorb and improve on the transferred technology. Contrary to popular belief, foreign direct investment (FDI) played an important role in technology transfer during the 1960s and early 1970s (Ernst, 2000), but other mechanisms were later exploited, particularly original equipment manufacturer (OEM) production arrangements.

A shortage of foreign exchange and a strong commitment to economic independence led to a policy that relied on long-term loans, rather than FDI, to finance industrial development. These loans were made directly to the Korean government which then allocated them for investments in selected industries. This led to a significant import of foreign capital goods and turn-key plant, which were later reverse-engineered in order to acquire the necessary technologies (Chung, 2006). The selection and assimilation of appropriate technologies required a moderate local R&D capability and S&T infrastructure, which was addressed by establishing the Ministry of Science and Technology (MoST) and the Korea Institute of Science and Technology (KIST) in the 1960s. As a result, with progressive local capital accumulation and investment in primary education, Korea achieved a gradual move up the value-added chain towards more sophisticated products.

In the mid-1970s, Korea moved, in a highly targeted fashion, into heavy industries such as chemicals and shipbuilding, at the same time working to improve technology absorption and promoting research to meet industry needs. This targeting operated in the framework of largely protectionist policies designed to deny foreign companies access to the Korean market. The government also played a key role in developing a domestic R&D capability by establishing ten industry-oriented government research institutes (GRIs) in areas such as machinery, electronics, chemistry and shipbuilding.

By the 1980s new challenges had emerged, as Korean industries found it more difficult to compete in international markets owing to their reliance on imported technologies and an increasingly expensive domestic labour force. At the same time, a small number of large Korean firms had become potential competitors in international markets, making foreign companies increasingly reluctant to transfer technologies to Korea. To compete, Korea would have to develop an indigenous base for research and innovation (Bartzokas, 2007). Thus, the policy focus moved to structural adjustment, technology-intensive industrial development and strengthening of the national S&T capability. The gradual opening of domestic markets forced Korean firms to improve their technological capabilities through technology transfer from abroad and investment in their own R&D. There was also a move to liberalise the control of investment inflows and to seek access to more advanced technology through FDI.

Korea continued to pursue high-value-added manufacturing in the 1990s by promoting local high-technology innovation. Korean companies drew on the skilled labour force resulting from the government's expansion of the higher education system to expand their R&D capabilities. This setting of innovation policy remained in place until the storm clouds leading up to the 1997 Asian financial crisis began to gather. Domestic wage rises and the appreciation of the won resulted in chronic current account deficits and led to reforms in the financial markets. However, the Korean model had fundamental weaknesses, particularly with respect to the chaebol, which had diversified beyond their financial and technological capabilities. The economic reform package agreed with the International Monetary Fund (IMF) required opening up the national economy to international competition and technology flows, higher standards of corporate governance, and microeconomic adjustments to achieve greater productivity growth in both the public and private sectors.

In 1998, the new government launched major reforms in four areas: the public sector, the financial sector, the chaebol and the labour market. In particular, it committed to a transition to an advanced knowledge-based economy in which domestic innovation would thrive, thereby enhancing overall productivity and sustaining economic growth. The new knowledge-based development strategy was based on the “four pillars of the knowledge economy” framework developed by the Knowledge for Development (K4D) programme of the World Bank (see Box 1.2).

#### **Box 1.2. The four pillars of the knowledge economy**

- *An economic incentive and institutional regime* that provides good economic policies and institutions, which promote efficient allocation of resources and stimulate creativity and incentives for the efficient creation, dissemination and use of existing knowledge.
- *An educated and skilled labour force* that continuously upgrades and adapts skills to create and use knowledge efficiently.
- *An effective innovation system* of firms, research centres, universities, consultants and other organisations that keeps up with the knowledge revolution, taps into the growing stock of global knowledge, and assimilates and adapts new knowledge to local needs.
- *A modern and adequate information infrastructure* that facilitates the effective communication, dissemination, and processing of information and knowledge.

*Source:* World Bank (2006), *Korea as a Knowledge Economy: Evolutionary Process and Lessons Learned*, World Bank, Washington, DC.

There is strong evidence that Korea has successfully weathered the storm and established a sound framework for a globally competitive and innovative economy. Today, Korea has achieved a substantial technological capability in some high-technology areas, such as information and telecommunications, semiconductors and LCDs, steel, shipbuilding and automobiles. It has the largest world market shares in the high-technology electronic industries of DRAM semiconductors, TFT-LCD and CDMA cellular phones.

### 1.2.2. The role of the chaebol in Korea's industrialisation

Korea has a diversified industrial structure, a legacy of waves of industrial development from light industries to heavy industries to high-technology industries. Furthermore, because the chaebol tended to diversify into several industries, there are now large competing companies in major sectors such as ICTs, shipbuilding and automobiles. Some of these firms have become world leaders (see Table 1.4). For example, Korea became the fifth largest automobile producer in 2005, its shipbuilding industry is the largest in the world, and Korean steel companies are major innovators. But the most striking success story has undoubtedly been the Korean ICT industry, which has performed exceptionally well in terms of competitiveness and globalisation in a relatively short period of time on the back of strong exports.

**Table 1.4. Major Korean companies and industries**

| Company        | Major arm                            | Industries                                                |
|----------------|--------------------------------------|-----------------------------------------------------------|
| <b>Samsung</b> | Samsung Electronics                  | Semiconductors – DRAM, SRAM; LCD panels, mobile phones    |
|                | Samsung Heavy Industries             | Shipbuilding                                              |
|                | Samsung Engineering and Construction | High-rise buildings, roads, railways, power stations      |
| <b>SK</b>      | SK Energy                            | Petrochemicals                                            |
|                | SK Teletech                          | CDMA mobile phone systems                                 |
| <b>LG</b>      | LG Electronics                       | LCD and plasma panels, mobile phones, consumer appliances |
| <b>Hyundai</b> | Hyundai Motor Corp                   | Motor vehicles                                            |
|                | Hyundai Heavy Industries             | Shipbuilding                                              |
|                | Hynix                                | Semiconductors                                            |
| <b>Hanjin</b>  | Hanjin Shipping                      | Container transport and shipping                          |
| <b>POSCO</b>   |                                      | Steelmaking                                               |

The chaebol are defined as business groups in which one parent company (holding company), owned by a family or extended family, controls subsidiaries in various industries, with large subsidiaries occupying oligopolistic positions in the respective industries (Haggard *et al.*, 2003). This definition emphasises three distinct structural elements – a governance structure of family dominance, an organisational structure based on a holding company controlling legally independent firms, *i.e.* multi-subsidaries rather than multi-divisions, and a diversified business structure encompassing many discrete products and services. However, there is no standard model. Some chaebol are one large corporation, while others have broken up into loosely connected groups of separate companies sharing a common name. Box 1.3 provides a basic explanation of the ownership and control model commonly employed by the chaebol.

**Box 1.3. Ownership and control of the chaebol**

As Korean business groups grew, entrepreneurs afraid of losing control changed the ownership structure from direct ownership to interlocking ownership. Interlocking ownership means that the chaebol family owns a nuclear company and/or an intermediary, which in turn has interlocking ownerships with member companies. This kind of structure gives the chaebol families the ability to control affiliated firms with a small share of the companies' equity. [...] In 1995 chaebol families only controlled on average 10% of the outstanding capital, but the average interlocking ownership of about 33% gave them an ownership control share of 43% on average (Chung *et al.*, 1997). Even if the minority shareholders collectively own more than 50% they do not have control because they are largely fragmented and until recently the rights of minority shareholders have been weak. [...] The chaebol ownership structure can be seen as a pyramid in which the owner family controls assets that vastly exceed their own investment. This is done by holding controlling interests in companies that hold controlling interest in other companies which in turn control other firms, and so on.

Source: Karlsson (2006), "Chaebol Characteristics: A Post Asian Crisis Study", Working Paper, Växjö University, Växjö.

**Table 1.5. Korean chaebol and numbers of affiliate firms, 2004**

| Business group           | Number of affiliates |
|--------------------------|----------------------|
| Samsung                  | 63                   |
| LG                       | 46                   |
| Hyundai Motor            | 28                   |
| Hanjin                   | 23                   |
| Lotte                    | 36                   |
| Hanwha                   | 31                   |
| Hyundai Heavy Industries | 6                    |
| Kumho Asiana             | 16                   |
| Doosan                   | 22                   |
| Dongbu                   | 22                   |
| Hyundai                  | 7                    |
| LG Cable                 | 12                   |
| Tong Yang                | 16                   |
| Daelim                   | 12                   |
| Hyosung                  | 16                   |
| Dong Kuk Steel Mill      | 8                    |
| Kolon                    | 31                   |
| Hyundai Department Store | 17                   |
| KCC                      | 10                   |
| Hansol                   | 11                   |
| Hyundai Development      | 12                   |
| Dongyang Chemical        | 19                   |

Source: Karlsson (2006), "Chaebol Characteristics: A Post Asian Crisis Study", Working Paper, Växjö University, Växjö.

The origins of many of the larger chaebol can be traced to the period after Japanese colonialism, when some Korean businessmen obtained the assets of Japanese firms. All started small and had a fairly chequered history in their early years. However, Korean governments from 1961 to 1987 actively supported their operations through successive strategies and policies, as a means of pursuing the government's industrialisation objectives, and the companies, as well as the national economy, prospered. Table 1.5 lists the Korean business groups defined as chaebol during the period 1998-2004.

#### **Box 1.4. The chaebol and the Asian financial crisis**

Unlike previous economic disruptions, which had been triggered by external shocks such as oil crises, the 1997 crisis stemmed from fundamental structural weaknesses in the Korean institutions that support national innovation. The state had sufficient power to pick “winners” and it mobilised and allocated resources to them to meet ambitious developmental goals, thereby achieving phenomenal industrial growth in the early decades. However, this approach eventually led to corruption and collusion between the state and big businesses and to mismanagement of the financial sector and serious misallocation of resources. The chaebol relied heavily on state protection and diversified beyond their financial and technological capabilities. Lack of transparency and accountability in the economic system was also a serious problem. As a result, the trade balance of payments declined from a surplus of USD 7.6 billion in 1987 to a deficit of USD 20.6 billion in 1996 and foreign debt increased from USD 31.7 billion in 1990 to USD 156 billion in 1997 (Kim, 2001, p. 1).

In fact, one-quarter of the chaebol did not earn enough to meet the interest payments on their loans. They were therefore a major target for reform, in particular with regard to the ownership and control patterns that resulted in non-transparent governance. It was argued, particularly by the IMF, that the close connections between government, big business and the banks had created an inefficient financial sector and a highly leveraged corporate sector which lacked effective market discipline. In response, the government announced a number of requirements for corporate restructuring, including a focus on core businesses, the reduction of debt-to-equity ratios to below 200% by the end of 1999, the dismantling of cross-credit guarantees among subsidiaries, management transparency, and greater management accountability.

To meet these requirements, chaebol had to sell off many of their unprofitable businesses to foreign firms. Hyundai, for example, decided to focus on five core businesses: automobiles, electronics, construction, heavy industry and financial services. Samsung concentrated on four core businesses: electronics, finance, trade and services. LG announced that its main business segments would be chemicals/energy, electronics/telecommunications, services and finances. Daewoo went bankrupt in the middle of restructuring. Other smaller chaebol also undertook major restructuring of their businesses (Kim, 2001).

In addition, listed companies were required to appoint outside directors to make the board of directors more independent in their supervision of top management. Within the first year, 752 listed companies had assigned outside directors, though there is considerable anecdotal evidence that many were not truly independent. In fact, there is considerable debate about the extent to which the chaebol have reformed their governance since the financial crisis. Karlsson (2006), on the basis of a detailed empirical study of all firms listed on the Korea Stock Exchange during the period 1996-2004, found no evidence that chaebol are more diversified than other firms. However, there was little evidence of a decline, after 1998, in debt financing or interlocking ownership.

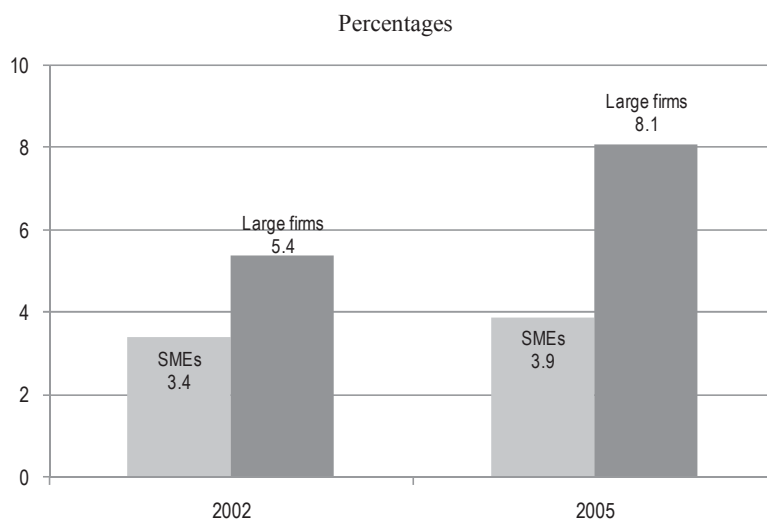
The chaebol have therefore been central to Korea's economic development. However, a number of problems due to their pyramidal ownership structures have been identified: the controlling shareholder can secure control rights without the corresponding cash flow rights, which means that the controlling owner is protected from losing power; top management positions are often retained by family members; even if resources are efficiently managed and allocated within a group controlled by a family, the group may still be inefficient; and, if only a few families control productive assets in an economy, *i.e.* have market power in both the goods and capital markets, this can result in

undesirable economic costs. These problems became particularly evident during the Asian financial crisis (see Box 1.4) when several chaebol were forced into bankruptcy while those that remained in business were obliged to reform their structures and practices. In the wake of the Asian financial crisis, both the chaebol and the Korean economy recovered rapidly.

### 1.2.3. Persisting dual economy: small firms and the chaebol

The dominance in the Korean economy of the chaebol and other large business groups, in terms of their proportion of GDP, is well known. However they also have a strong influence on the smaller companies that supply them with goods and services. In general, small companies have only survived by providing products and services to the chaebol. This has led to some growth in skills and capacity but little innovation. Furthermore, cultural and job security concerns limit the flow of personnel from large firms to smaller entrepreneurial firms, while the large chaebol firms can and do hire some of the most talented employees of small and medium-sized enterprises (SME), and thus frustrate capability building. This situation makes it exceedingly difficult to assemble and retain the management and technical teams necessary to build an entrepreneurial start-up (Suh, 2000, cited in Sohn and Kenney, 2007). Accordingly, as Figure 1.5 shows, the profitability of large firms continues to rise, while the profitability of SMEs continues to lag behind.

**Figure 1.5. Profitability by firm size, 2002 and 2005**



Source: OECD (2007), *OECD Economic Surveys: Korea*, OECD, Paris.

Nevertheless, recent years have seen steady growth in the number of SMEs (SMBA, 2004). The Asian financial crisis led many experienced managers to leave their jobs and set up new SMEs, and the government also introduced many new schemes and incentives to promote new enterprises. The result was an impressive growth in the number of SMEs, though growth has since stalled (see Box 1.5). The factors that enabled the growth of SMEs in the past are increasingly disappearing due to rapid changes in the global economic environment: large enterprises' global outsourcing strategies; the emergence of strong competitors with cost advantages (especially China); shortening product life cycles; and fierce competition brought on by market liberalisation (OECD, 2005a). Such changes in the business environment are weakening SMEs' growth potential, profitability and investment in facilities.

**Box 1.5. SMEs in Korea**

In Korea SMEs are defined as enterprises employing fewer than 300 personnel. As of 2004, Korea had approximately 3 million SMEs, including 84 000 medium-sized enterprises (50-300 employees), 230 000 small enterprises (10-50 employees) and 2.68 million micro-enterprises (fewer than 10 employees). As the main component of the Korean economy, SMEs represent 99.8% of all enterprises, and 86.5% of total employment (see table below). By sector, services dominate as in other OECD countries, accounting for 86% of firms and two-thirds of employment. By contrast, manufacturing accounts for only 11% of firms and 28% of employment, with construction and agriculture, forestry, fishing and mining making up the remainder.

|                                       | 1998  | 1999  | 2000  | 2001  | 2002  | 2003  | 2004  |
|---------------------------------------|-------|-------|-------|-------|-------|-------|-------|
| <b>Number of firms (millions)</b>     | 2.63  | 2.78  | 2.87  | 2.88  | 2.96  | 3.00  | 3.00  |
| <b>Number of employees (millions)</b> | 10.18 | 10.83 | 11.53 | 11.65 | 11.98 | 12.04 | 12.04 |

Source: SMBA website ([www.smba.go.kr/smba/main/english/index.jsp](http://www.smba.go.kr/smba/main/english/index.jsp)), accessed February 2008.

An analysis of the major supplier firms to the chaebol provides an interesting insight into their influence and the characteristics of the supplier companies (Table 1.6). While the number of supplier companies has been growing slowly, it has declined quite sharply in the electronic industry. Smaller companies, with a turnover of less than KRW 200 billion (approximately USD 210 million), constitute the majority (almost two-thirds) of suppliers and an even higher proportion (in excess of 75%) in the electronics industry. At the same time, none of these companies can be considered small, indeed some are quite large. More detailed characteristics are provided in Table 1.7.

**Table 1.6. Chaebol supplier firms with turnover of more than KRW 100 billion, 2004-06**

| Year        | Company turnover<br>(KRW billions) | Number of<br>companies | Electronics<br>industry | Automotive<br>industry | Machinery<br>industry | Materials<br>industry |
|-------------|------------------------------------|------------------------|-------------------------|------------------------|-----------------------|-----------------------|
| <b>2004</b> | 100-200                            | 29                     | 20                      | 6                      | 1                     | 2                     |
|             | 200-300                            | 11                     | 2                       | 2                      | 1                     | 6                     |
|             | 300-1 000                          | 4                      | 2                       | 1                      | 0                     | 1                     |
|             | >1 000                             | 2                      | 0                       | 1                      | 0                     | 0                     |
|             | <b>Total</b>                       | <b>45</b>              | <b>24</b>               | <b>10</b>              | <b>2</b>              | <b>9</b>              |
| <b>2005</b> | 100-200                            | 31                     | 14                      | 5                      | 2                     | 10                    |
|             | 200-300                            | 9                      | 3                       | 4                      | 0                     | 2                     |
|             | 300-1 000                          | 8                      | 3                       | 4                      | 0                     | 1                     |
|             | >1 000                             | 1                      | 0                       | 1                      | 0                     | 0                     |
|             | <b>Total</b>                       | <b>49</b>              | <b>20</b>               | <b>14</b>              | <b>2</b>              | <b>13</b>             |
| <b>2006</b> | 100-200                            | 34                     | 12                      | 9                      | 2                     | 13                    |
|             | 200-300                            | 10                     | 5                       | 2                      | 1                     | 2                     |
|             | 300-1 000                          | 8                      | 1                       | 4                      | 1                     | 2                     |
|             | >1 000                             | 1                      | 0                       | 1                      | 0                     | 0                     |
|             | <b>Total</b>                       | <b>53</b>              | <b>16</b>               | <b>16</b>              | <b>4</b>              | <b>15</b>             |

Source: Private communication, Kwang H. Lee, STEPI, 2008.

Strong producer-user interactions are an essential source of innovation and technology utilisation and need to be promoted. However, there are barriers to interactive learning among Korean firms. For instance, firms that are part of a chaebol group may be reluctant to interact with firms from another chaebol group. Also, interactive learning between large and small firms is impeded by the low level of competitiveness of small firms. To overcome this, the government attempted in the 1990s to encourage innovation by small firms through collaborative R&D with the GRIs and universities. However, success seems to have been limited, particularly if compared to similar efforts in Chinese Taipei.

**Table 1.7. Chaebol supplier firms with turnover of more than KRW 100 billion (2004-2006)**

| Year | Industry     | Average turnover<br>(KRW billions) | Average no. of<br>employees | Average R&D<br>investment<br>(KRW billions) | Average R&D<br>intensity<br>(%) |
|------|--------------|------------------------------------|-----------------------------|---------------------------------------------|---------------------------------|
| 2004 | Electronics  | 184.2                              | 493                         | 8.0                                         | 4.3                             |
|      | Automotive   | 299.1                              | 788                         | 12.2                                        | 4.5                             |
|      | Machinery    | 163.4                              | 367                         | 5.2                                         | 3.5                             |
|      | Materials    | 224.3                              | 424                         | 3.2                                         | 1.6                             |
|      | <b>Total</b> | <b>216.8</b>                       | <b>539</b>                  | <b>7.8</b>                                  | <b>3.8</b>                      |
| 2005 | Electronics  | 208.0                              | 514                         | 12.6                                        | 6.2                             |
|      | Automotive   | 337.7                              | 790                         | 10.4                                        | 3.0                             |
|      | Machinery    | 119.7                              | 350                         | 3.7                                         | 3.1                             |
|      | Materials    | 217.5                              | 437                         | 3.8                                         | 2.2                             |
|      | <b>Total</b> | <b>244.0</b>                       | <b>566</b>                  | <b>9.2</b>                                  | <b>4.1</b>                      |
| 2006 | Electronics  | 195.0                              | 504                         | 14.5                                        | 8.3                             |
|      | Automotive   | 311.9                              | 704                         | 9.7                                         | 3.5                             |
|      | Machinery    | 213.2                              | 387                         | 5.6                                         | 2.6                             |
|      | Materials    | 200.7                              | 444                         | 3.7                                         | 2.1                             |
|      | <b>Total</b> | <b>233.1</b>                       | <b>539</b>                  | <b>9.3</b>                                  | <b>4.7</b>                      |

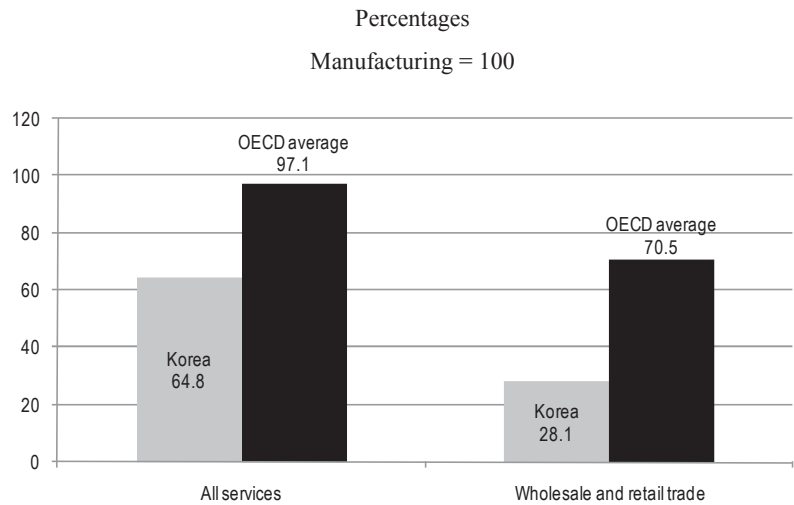
Source: Private communication, Kwang H. Lee, STEPI, 2008.

#### **1.2.4. Manufacturing and services**

In contrast to many other OECD countries, the services sector in Korea currently makes a very marginal contribution to aggregate productivity growth. Yet, services account for around half of Korean GDP and more than 60% of employment. More attention to innovation in the services sector will help broaden the basis for future growth. At the same time, a productive and competitive services sector also helps to underpin the performance of the manufacturing sector (Pilat and Hoffman, 2004). Promising services include the cultural industries (TV and movies, gaming, etc.), which have shown spectacular growth in recent years; business services, which show above average growth; and social services, which have a great deal of potential as Korea's society ages and social safety nets increase. However, services innovation in Korea is relatively weak compared to most leading economies, and service industries suffer from low productivity

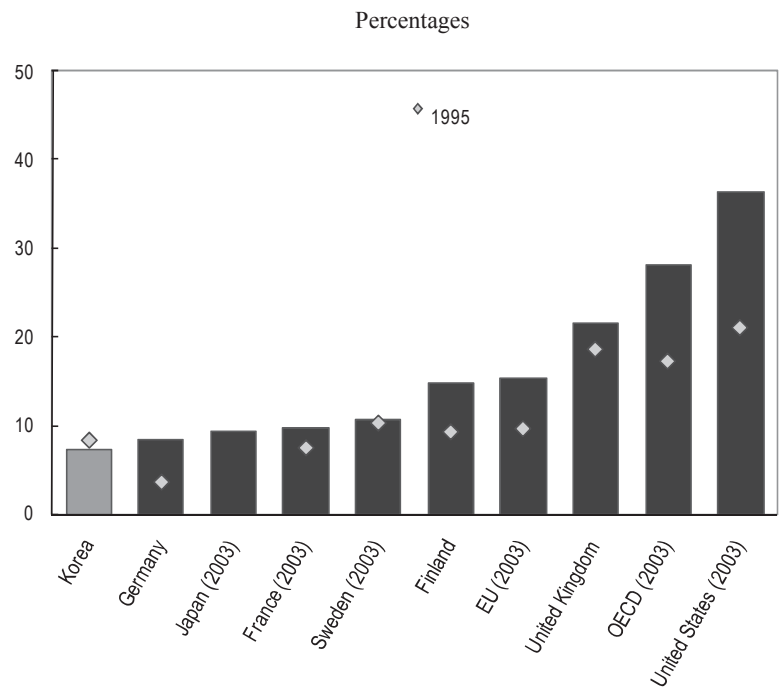
levels (Figure 1.6). Moreover, the share of services in business R&D is also relatively low (Figure 1.7), though this is probably mostly due to the powerful performance of the large manufacturing firms in recent years.

Figure 1.6. Productivity in Korean services, 2003



Source: OECD (2007), *OECD Economic Surveys: Korea*, OECD, Paris.

Figure 1.7. Share of services in business R&D, 2004



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

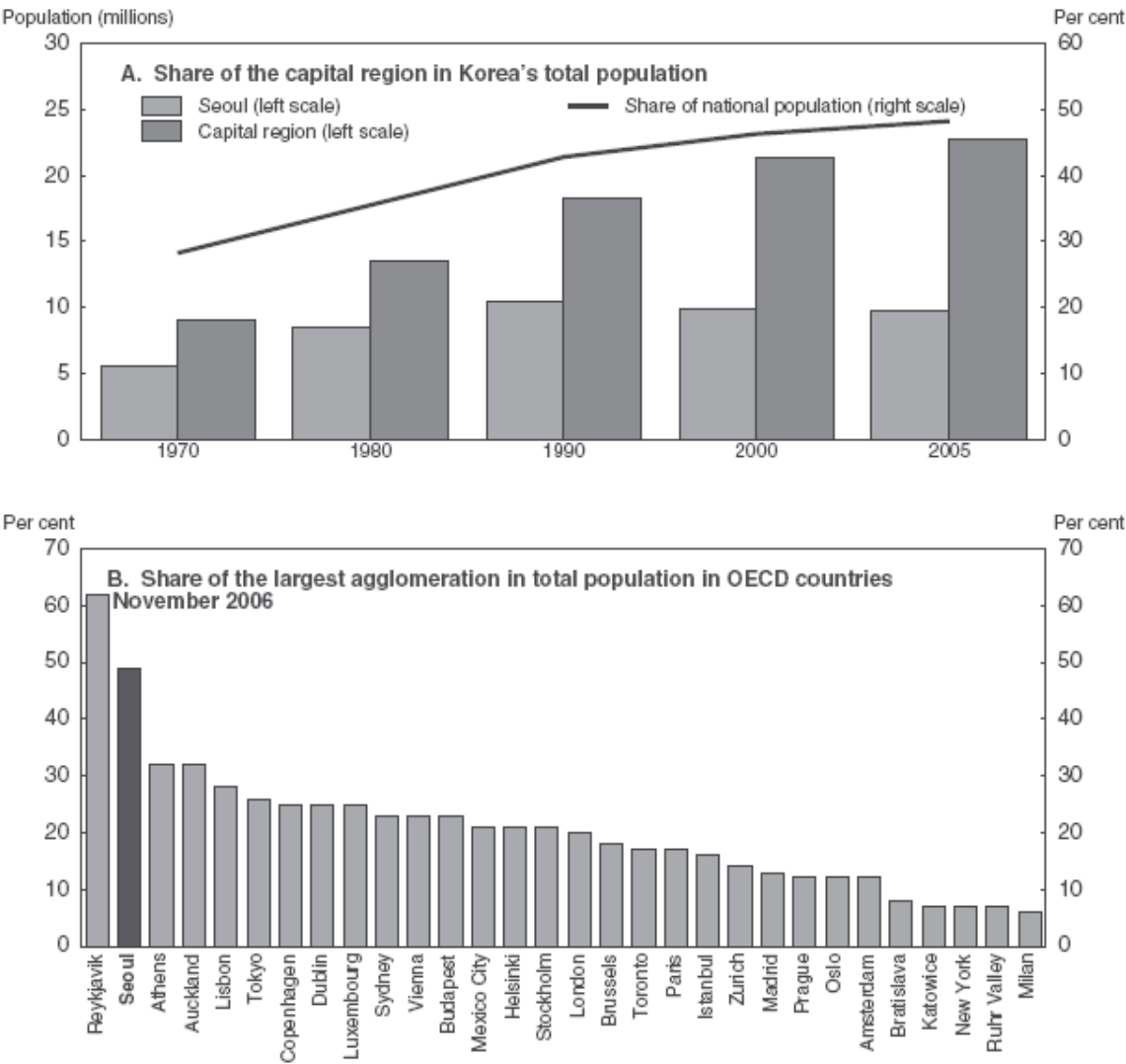
According to a study by Lee *et al.* (2002), knowledge-intensive business services (KIBS) are underdeveloped in Korea and represented 1.8% of industrial sales in 2002, only a slight increase from 1.6% in 1996. Among the KIBS, sales of computer-related services expanded rapidly at an annual rate of 35.5% in 1996-2000, while R&D services and business services (including consultancy) grew annually by 8.2 and 5.7%, respectively. Sales in technical services, which include construction technology and “engineering, science and technology services”, actually fell on average by 1.5% a year over the same period. R&D services, business services and technical services are traditional KIBS which interact closely with manufacturing firms in process or product innovation. This shows that traditional KIBS directly relevant to innovation grow relatively slowly, in contrast to computer-related services. All of this reflects the fact that consulting services, which are regarded as important to the innovation process, are poorly developed in Korea.

### ***1.2.5. Regional imbalances***

Economic activity in Korea is largely concentrated in the Seoul metropolitan area, thereby creating serious geographical imbalances in the national economy. Today, the capital region has become one of the world’s largest urban agglomerations with a population of 22.8 million, and its share of Korea’s population has risen from 28% in 1970 to almost half (Figure 1.8). Korea has 16 regions, seven of which are metropolises. The remaining nine provinces differ significantly in their degree of economic development. Kyonggi province, which is close to Seoul, has developed strongly, and the eastern regions, especially Kyongbuk and Kyongnam, are more developed than the western ones, such as Chonnam, Chonbuk, Gangwon and Chungbuk.

One simple, though admittedly crude, measure of the strength of innovation capacity in each region is the distribution of innovation “actors” (Chung, 2005). Table 1.8 shows the number of public research institutes, universities (public and private) and company research units in each region as of 2006. As the data show, the Seoul metropolitan area accounts for around 40% of public research institutes and universities and almost two-thirds of company research units. Although the government has launched initiatives in other parts of the country, such as the construction of a new government administrative city and “innovation cities” and “enterprise cities”, in order to boost development, the lack of innovation resources or assets across Korea is seen as the greatest barrier to more effective regional economic development through innovation.

Figure 1.8. Concentration in the Seoul metropolitan area, 1970-2005



Source: OECD (2007), *OECD Economic Surveys: Korea*, OECD, Paris.

**Table 1.8. R&D-performing units by sector of performance and region, 2006**

In units and percentages

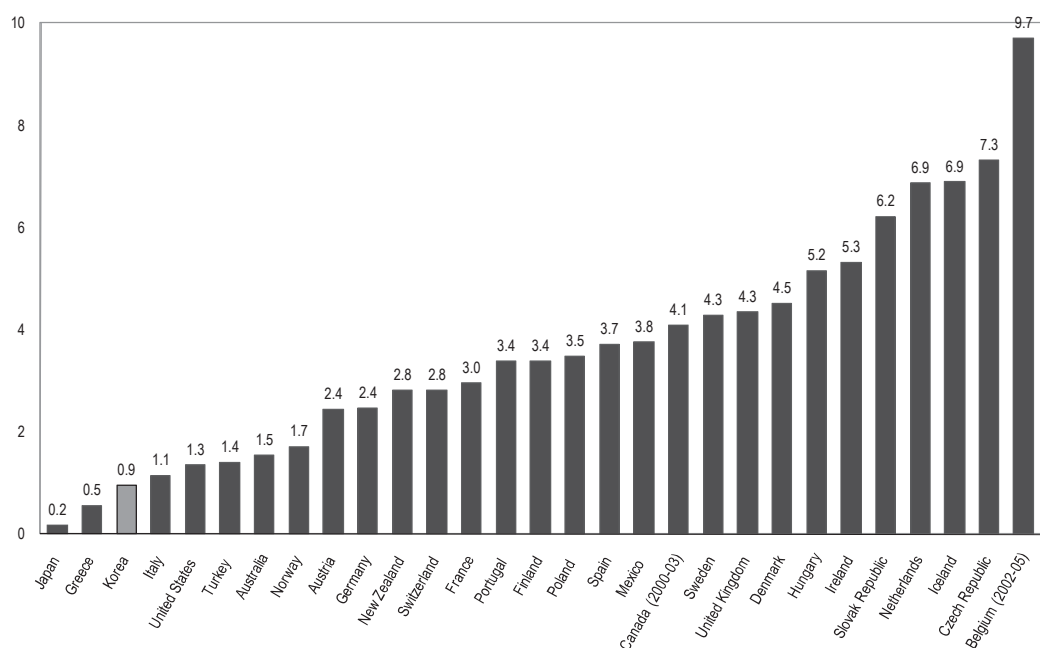
| Region                          | Sector of performance |                           |                  |                 |
|---------------------------------|-----------------------|---------------------------|------------------|-----------------|
|                                 | Research institutes   | Universities and colleges | Companies        | Total           |
| Seoul metropolitan area         | 89<br>(40.46)         | 115<br>(39.12)            | 6 491<br>(62.57) | 6 695<br>(61.5) |
| Pusan                           | 10<br>(4.55)          | 19<br>(6.46)              | 437<br>(4.21)    | 466<br>(4.28)   |
| Taegu                           | 7<br>(3.18)           | 11<br>(3.74)              | 373<br>(3.60)    | 391<br>(3.59)   |
| Kwangju                         | 7<br>(3.18)           | 13<br>(4.42)              | 223<br>(2.15)    | 243<br>(2.23)   |
| Taejon                          | 19<br>(8.64)          | 18<br>(6.12)              | 501<br>(4.83)    | 538<br>(4.94)   |
| Ulsan                           | 2<br>(0.91)           | 2<br>(0.68)               | 152<br>(1.47)    | 156<br>(1.43)   |
| Gangwon                         | 12<br>(5.45)          | 14<br>(4.76)              | 128<br>(1.23)    | 154<br>(1.41)   |
| Chungbuk                        | 10<br>(4.55)          | 15<br>(5.10)              | 363<br>(3.50)    | 388<br>(3.56)   |
| Chungnam                        | 8<br>(3.64)           | 19<br>(6.46)              | 457<br>(4.41)    | 484<br>(4.45)   |
| Chonbuk                         | 15<br>(6.82)          | 16<br>(5.44)              | 169<br>(1.63)    | 200<br>(1.84)   |
| Chonnam                         | 12<br>(5.45)          | 10<br>(3.40)              | 155<br>(1.49)    | 177<br>(1.63)   |
| Kyongbuk                        | 7<br>(3.18)           | 25<br>(8.50)              | 349<br>(3.36)    | 381<br>(3.50)   |
| Kyongnam                        | 17<br>(7.73)          | 13<br>(4.42)              | 543<br>(5.23)    | 573<br>(5.26)   |
| Cheju                           | 5<br>(2.27)           | 4<br>(1.36)               | 33<br>(0.32)     | 42<br>(0.39)    |
| <b>R&amp;D-performing units</b> | <b>220</b>            | <b>294</b>                | <b>10 374</b>    | <b>10 888</b>   |

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.

### 1.2.6. Low levels of internationalisation and FDI

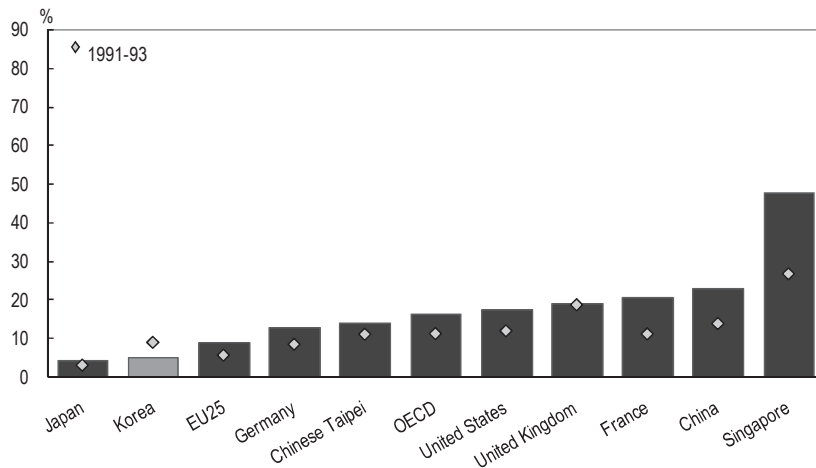
Globalisation through FDI, international trade and international movements of labour is a key driver of economic growth. Although Korea has become more integrated in the world economy over the past decade, it still ranks low in terms of import penetration, the stock of inward FDI relative to GDP and foreign workers as a share of the labour force. After increasing in the wake of the 1997 Asian financial crisis, as a result of the liberalisation of barriers and the restructuring of the corporate and financial sectors, the stock of FDI inflows amounted to 11.5% of GDP in 2002. Nevertheless, it was still the sixth lowest in the OECD area, and inflows of FDI have declined during the past few years, both in absolute terms and as a share of world flows (OECD, 2007a). As Figure 1.9 shows, FDI inflows averaged 0.9% of GDP from 2000 to 2005, the third lowest level in the OECD.

**Figure 1.9. FDI inflows to OECD countries as a percentage of GDP, average, 2000-05**



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

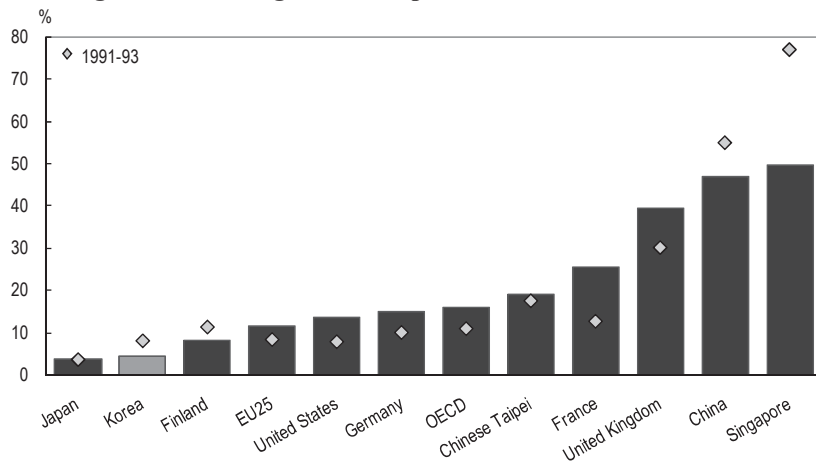
Figure 1.10 shows that domestic ownership of inventions made abroad remains low (as in Japan). Less surprising, given the relatively low levels of FDI in Korea, foreign ownership of domestic inventions is also low (Figure 1.11) and suggests a degree of insularity relative to the OECD average. Outside of the major firms, Korea's R&D system is even less well connected. Very little R&D carried out in Korea is financed from abroad, linkages with foreign firms and institutions are relatively weak, and few foreign researchers and students come to Korea to work or study, a sign that Korea may not draw sufficiently on the growing global stock of knowledge. The language barrier and the emphasis on more proprietary industrial research may have contributed to the low level of international R&D activities; the situation appears to be similar to that of Japan.

**Figure 1.10. Domestic ownership of inventions made abroad,<sup>1</sup> 2001-03**

1. Share of patent applications to the European Patent Office (EPO) invented abroad in total patents owned by country residents.

*Note:* Patent counts are based on the priority date, the applicant's country of residence, using simple counts.

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

**Figure 1.11. Foreign ownership of domestic inventions, 2001-03**

*Note:* Patent counts are based on the priority date, the applicant's country of residence, using simple counts.

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

### 1.3. Framework conditions for innovation

Favourable framework conditions enable and facilitate innovation. The macro-economic framework, the general business environment, the intensity of competition, and product and labour market regulations – all of which are shaped by institutional and cultural factors – are of key importance to a country's innovative performance.

#### 1.3.1. Macroeconomic framework and business environment

The macroeconomic framework is on the whole positive and the commitment to a “participatory society” has promoted a transparent regulatory regime. Unemployment is low, as is inflation despite the rise in oil prices. Korea's fiscal position remains sound, with little public debt and government expenditures at only 29% of GDP, the lowest ratio in the OECD area (OECD, 2007a).

On the downside, starting a business in Korea is relatively complicated, costly and time-consuming: in this area, Korea ranks 26<sup>th</sup> in the OECD and 110<sup>th</sup> in the world (World Bank, 2008). In particular, the minimum capital requirement to start a business is about three times income per capita, compared to an OECD average of only 38%. Such regulations weaken entrepreneurship, a key driver of innovation.

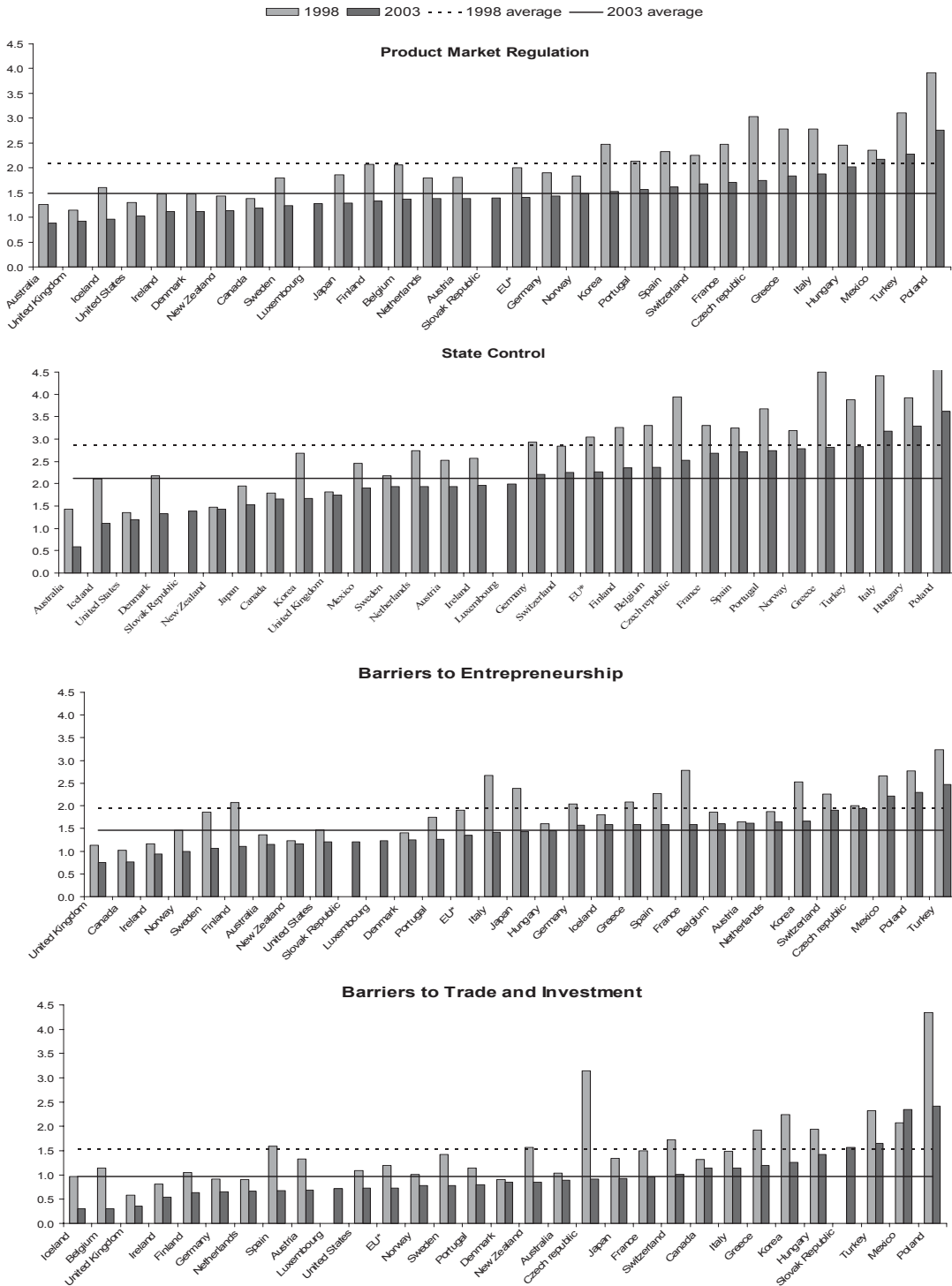
#### 1.3.2. Competition policy and product and labour market regulation

Commitment to market principles at the highest political level has provided strong support for competition policies, reform of the financial sector and corporate governance, and for opening markets to trade and lowering barriers to foreign investment. Significant progress has been achieved in terms of shifting the focus of the Korea Fair Trade Commission (KFTC) towards core competition problems and increasing its ability to enforce competition policy (OECD, 2007c).

Product market competition is a driver of productivity growth, either directly or indirectly through its positive impact on innovation, at least until a certain intensity of competition is reached (Aghion *et al.*, 2005). There are indications that some features of the regulatory system may impede product market competition. Accordingly, the OECD has developed a system of indicators on product market regulation (Conway *et al.*, 2005):

- State control of economic activities, including indicators on public ownership and involvement in business operations.
- Barriers to entrepreneurship, encompassing indicators on regulatory and administrative opacity, administrative burden on start-ups and barriers to competition.
- Barriers to trade and investment, including indicators on explicit barriers to trade and investment and other barriers (regulatory barriers).

As Figure 1.12 shows, Korean product market regulation was among the strongest in the OECD area in 1998 but has since declined to a level close to the OECD average. State control has also markedly declined and remains a little below the OECD average. Barriers to entrepreneurship and to trade and investment remain above the OECD average, as discussed above. Progress in reforming regulatory policies has played an important role in the speed and strength of Korea's recovery.

Figure 1.12. Regulation, 1998 and 2003<sup>1</sup>

\* EU15 (simple average).

1. Sorted by 2003 values. The scale of indicators is 0-6 from least to most restrictive of competition.

Source: Conway *et al.* (2005), "Product Market Regulation in OECD Countries, 1998 to 2003", Economics Department Working Paper No. 419, OECD, Paris.

Labour market flexibility is also an important factor in economic growth. Korea's labour market is relatively rigid, and strong opposition to dismissals hampers labour flexibility (OECD, 2007c). The employment protection accorded to regular workers has encouraged the hiring of non-regular workers who now account for a third of Korea's labour force. These workers are paid 20 to 27% less than regular workers, after adjustment for characteristics such as age or experience. A third of these workers are not covered by any work-related social insurance system. This has probably also contributed to the rise in income inequality.

## 1.4. Performance in science, technology and innovation

Korea's commitment to investment in STI is impressive and has undoubtedly underpinned much of the country's recent economic growth. This section outlines patterns of R&D spending, comparing Korea to other leading science and technology (S&T) countries. In particular, it explores levels of gross domestic expenditure on R&D (GERD) and business enterprise expenditure on R&D (BERD); the sites of R&D performance; the number of Korean researchers and their regional distribution; and the "productivity" of S&T. The fact that this section benchmarks Korea against leading S&T countries (with a considerably higher GDP) rather than with OECD countries with a similar level of GDP bears witness to the progress Korea has realised.

### 1.4.1. R&D spending

Korea spent a little under USD 30 billion on R&D in 2006, which puts GERD at 3.23% of GDP, one of the highest levels in the world (Table 1.9 and Figure 1.13). Korea has also had one of the fastest annual rates of growth of GERD in recent years, far exceeding that of the G7 countries, albeit considerably below that of China (Figure 1.14), and has set an ambitious medium-term GERD target of 5% of GDP. Nonetheless, as a medium-sized country, Korea's R&D expenditure is dwarfed by that of the United States (which spends twelve times as much) and Japan (which spends more than five times as much) though is rapidly catching up with the level of expenditure in the United Kingdom.

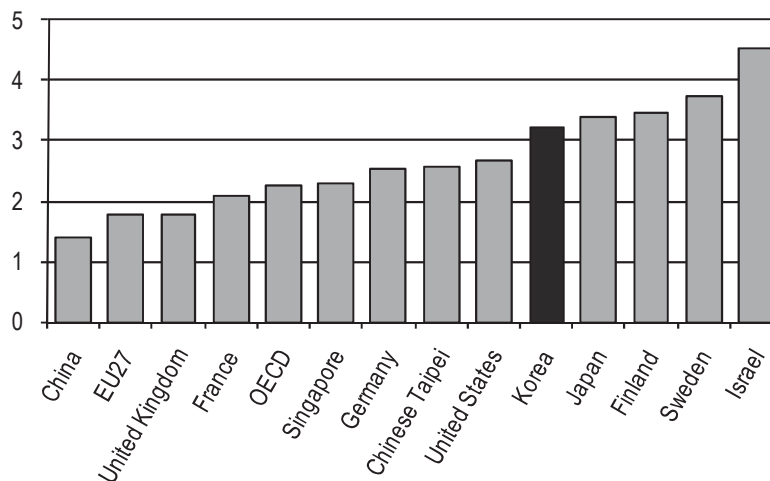
Table 1.9 also shows that the private sector is by far the biggest investor in R&D, accounting for around three-quarters of Korean expenditure. This was not always the case, with the private sector only outspending the public sector in the last 25 years (Figure 1.15). The annual growth rate of business R&D is around twice the OECD average, and Korean BERD is now among the highest in the world and is indicative of the emergence of Korean leaders in industrial technology, especially in information and communication technologies, automobiles, shipbuilding, and steel. Despite its impressive growth, Korean private-sector investment represents only about one-quarter of that of Japanese firms and a mere tenth of that of US business in absolute terms (Table 1.10). Moreover, Korean growth rates significantly lag those of China.

**Table 1.9. Total R&D expenditure by major countries**

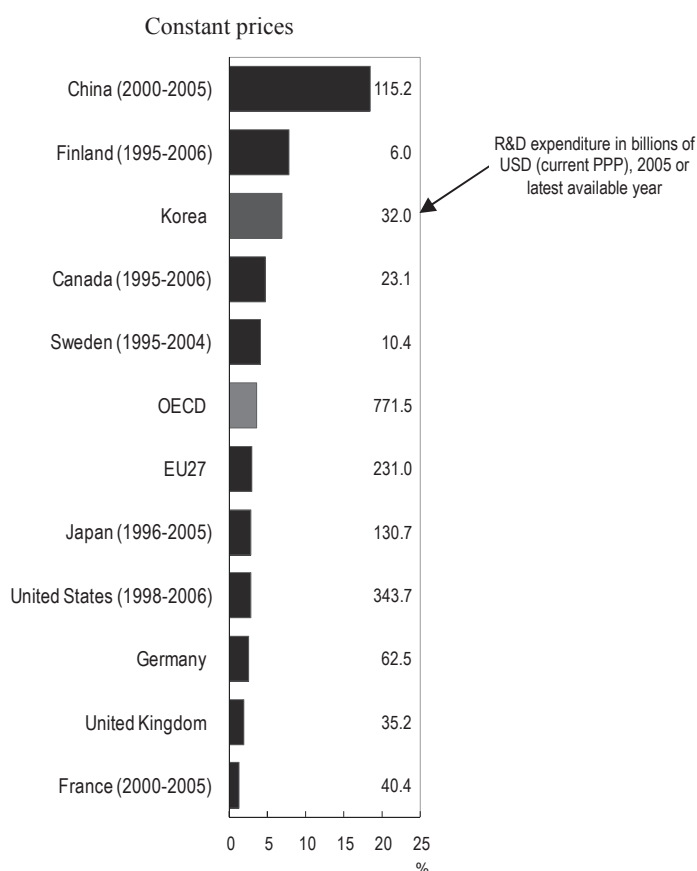
|                                                     |                     | Korea<br>(2006) | United<br>States<br>(2006) | Japan<br>(2005) | Germany<br>(2006) | France<br>(2006) | United<br>Kingdom<br>(2005) | China<br>(2006) |
|-----------------------------------------------------|---------------------|-----------------|----------------------------|-----------------|-------------------|------------------|-----------------------------|-----------------|
| R&D expenditure (USD millions)                      |                     | 28 619.0        | 343 747.5                  | 151 269.6       | 73 049.8          | 47 648.9         | 39 571.1                    | 37 663.8        |
| R&D expenditure based on a value of 1.0 for Korea   |                     | 1.0             | 12.0                       | 5.3             | 2.6               | 1.7              | 1.4                         | 1.3             |
| Ratio to GDP (%)                                    |                     | 3.23            | 2.62                       | 3.33            | 2.51              | 2.12             | 1.78                        | 1.43            |
| R&D expenditure per person (USD)                    |                     | 592.6           | 1 146.5                    | 1 183.9         | 886.9             | 754.0            | 657.1                       | 28.7            |
| R&D expenditure by source of funds <sup>1</sup> (%) | Government & public | 24.3            | 35.1                       | 23.5            | 28.7              | 40.1             | 38.7                        | 24.7            |
|                                                     | Private             | 75.4            | 64.9                       | 76.1            | 67.6              | 52.5             | 42.1                        | 69.1            |
|                                                     | Foreign             | 0.3             | 0.0                        | 0.4             | 3.8               | 7.3              | 19.2                        | 1.6             |

1. Data on R&D funding sources for Germany and France are based on 2005.

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.

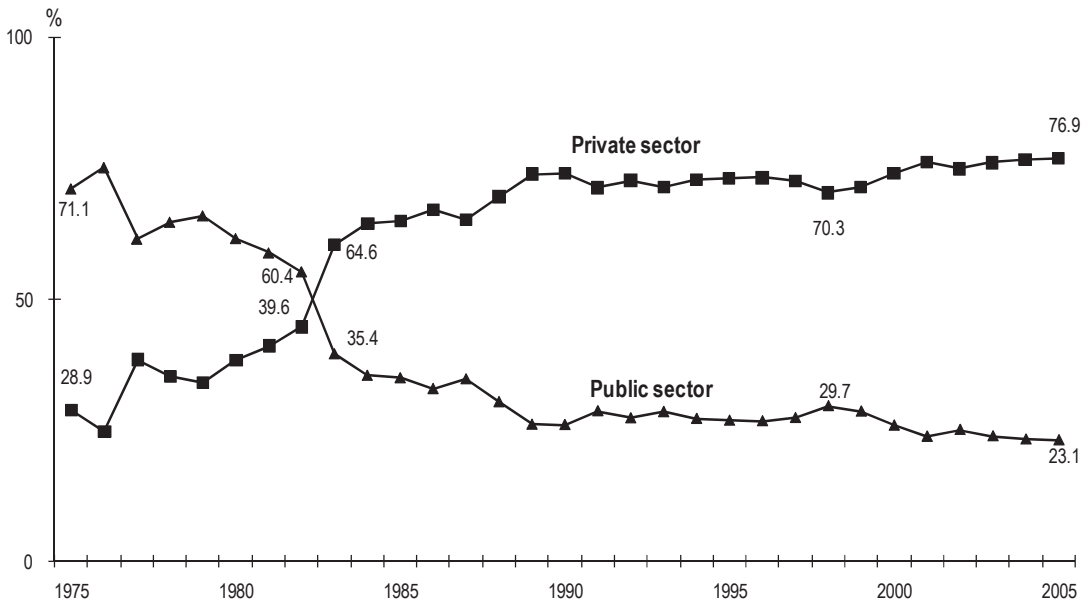
**Figure 1.13. R&D intensity (gross domestic expenditure on R&D as a percentage of GDP), 2006 or latest available year**

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

**Figure 1.14. Evolution of gross domestic expenditure on R&D, average annual growth rates, 1995-2005**

Source: OECD, Main Science and Technology Indicators, April 2007.

As Korea has caught up with the most technologically advanced countries and moved towards technological frontiers, it has faced a greater need to conduct more fundamental research. This has led to a gradual, but discernible, shift in the types of R&D it carries out. As Table 1.11 shows, there has been an increase in basic research, from 13.6% of total spending in 1999 to 15.2% in 2006. Given the considerable increases in total R&D spending over this time, basic research investment has in fact jumped from KRW 1.63 trillion to KRW 4.14 trillion in just seven years. A similar scale increase has been observed in experimental development, which now accounts for 65.0% of spending, compared to 60.7% in 1999. At the same time, the share of applied research spending has declined, from 25.7% of the total in 1999 to 19.9% in 2006. Table 1.12 shows that recent Korean figures are closely comparable to those seen in Japan and not too far from those in the United States.

**Figure 1.15. Trends in the composition of R&D expenditure by the private sector, 1975-2005**

Source: MoST and KISTEP (2006), *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 1.10. Trends in business R&D in selected countries**

| Country        | Business enterprise R&D intensity, 2006 | Growth of business R&D, 1996-2006<br>Annual average growth rate (year 2000 USD PPP) | Business R&D expenditure, 2006<br>USD billions (current PPP), |
|----------------|-----------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------|
| China          | -                                       | 25.7                                                                                | 61.7                                                          |
| Finland        | 4.0                                     | 7.9                                                                                 | 4.2                                                           |
| Japan          | 3.6                                     | 3.9                                                                                 | 107.1                                                         |
| Korea          | 3.6                                     | 7.9                                                                                 | 27.7                                                          |
| United States  | 3.0                                     | 3.4                                                                                 | 247.7                                                         |
| Germany        | 2.8                                     | 3.6                                                                                 | 46.6                                                          |
| OECD           | 2.4                                     | 3.9                                                                                 | 570.6                                                         |
| France         | 2.3                                     | 1.8                                                                                 | 26.2                                                          |
| United Kingdom | 1.7                                     | 1.9                                                                                 | 21.9                                                          |
| EU27           | 1.8                                     | 3.5                                                                                 | 154.4                                                         |

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

**Table 1.11. R&D expenditure by research stage, 1999-2006**

KRW hundred millions and percentages

| Section     | 1999    | 2000    | 2001    | 2002    | 2003    | 2004    | 2005    | 2006    |
|-------------|---------|---------|---------|---------|---------|---------|---------|---------|
| Total       | 119 218 | 138 485 | 161 105 | 173 251 | 190 687 | 221 853 | 241 554 | 273 457 |
| (%)         | (100.0) | (100.0) | (100.0) | (100.0) | (100.0) | (100.0) | (100.0) | (100.0) |
| Basic       | 16 255  | 17 461  | 20 250  | 23 732  | 27 568  | 33 994  | 37 068  | 41 433  |
| (%)         | (13.6)  | (12.6)  | (12.6)  | (13.7)  | (14.5)  | (15.3)  | (15.3)  | (15.2)  |
| Growth rate | 2.5     | 7.4     | 16.0    | 17.2    | 16.2    | 23.2    | 9.0     | 11.8    |
| Applied     | 30 652  | 33 701  | 40 759  | 37 636  | 39 740  | 47 121  | 50 341  | 54 301  |
| (%)         | (25.7)  | (24.3)  | (25.3)  | (21.7)  | 20.8    | (21.2)  | (20.8)  | (19.9)  |
| Growth rate | 7.6     | 9.9     | 20.9    | - 7.7   | 5.6     | 18.6    | 6.8     | 7.9     |
| Development | 72 311  | 87 323  | 100 096 | 111 882 | 123 361 | 140 738 | 154 144 | 177 723 |
| (%)         | (60.7)  | (63.1)  | (62.1)  | (64.6)  | (64.7)  | (63.5)  | (63.8)  | (65.0)  |
| Growth rate | 4.8     | 20.8    | 14.6    | 11.8    | 10.3    | 14.1    | 9.5     | 15.3    |

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 1.12. R&D expenditure by research stage (2006 or latest available year)**

Percentages

|                      | Basic research | Applied research | Experimental development |
|----------------------|----------------|------------------|--------------------------|
| France (2003)        | 24.1           | 36.2             | 39.7                     |
| United States (2004) | 18.7           | 21.3             | 60.0                     |
| Japan (2005)         | 14.3           | 22.8             | 62.9                     |
| Korea (2006)         | 15.2           | 19.9             | 65.0                     |

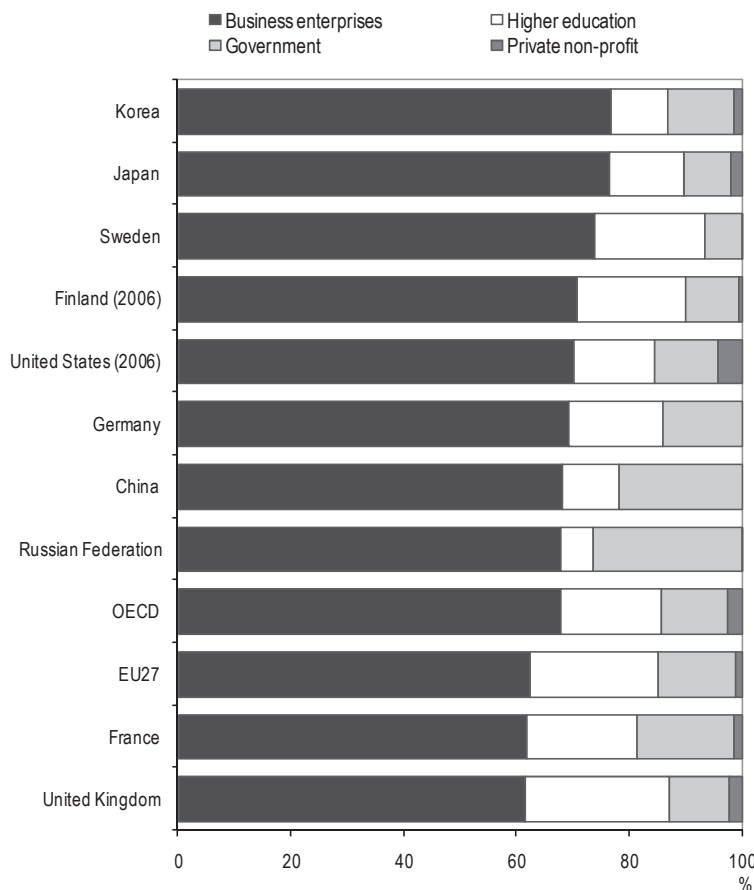
Source: MoST and KISTEP (2007), *Report on the Survey of Research and Development in Science and Technology*, Ministry of Science and Technology and Korea Institute of Science and Technology Evaluation and Planning, Seoul.

### 1.4.2. R&D performers

As already discussed, Korean business is by far the largest investor in R&D and unsurprisingly conducts the majority of R&D in Korea. In fact, as it conducts slightly more than it pays for itself, the public sector also contributes to Korea's BERD (Table 1.13). It is also interesting to compare Korea's situation with that of other countries. Figure 1.16 shows that the proportion of R&D performed in the Korean business sector is high by international standards, with the Japanese picture the most comparable. However, most striking is the comparatively low level of R&D expenditure in universities. Korean spending in this sector 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 GRIs were originally established to accelerate technology adoption and adaptation by Korean firms and universities were concerned primarily with teaching. It is only in recent years that the government has sought to strengthen the research capacities of universities, a long-term undertaking that will require a number of significant changes. Table 1.13 also shows that the evolution of expenditure in the public sector over the last decade has been less kind to the GRIs than to the universities. The former have seen their budgets increase by more than 50%, but their share of total expenditure has fallen by more than a quarter. By contrast, research expenditures in universities have almost doubled over the same period, although their expenditure levels are still only about three-quarters of those of the GRIs, which remain the main performers of public-sector research.

**Figure 1.16. R&D by sector of performance (as a percentage of the national total), 2005 or latest available year**



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

**Table 1.13. Korea's R&D expenditure structure, by performers, 1997-2006**

KRW hundred millions and percentages

| Year | Total       |       | Government research institutes |       | Universities |       | Private companies |       |
|------|-------------|-------|--------------------------------|-------|--------------|-------|-------------------|-------|
|      | Expenditure | Ratio | Expenditure                    | Ratio | Expenditure  | Ratio | Expenditure       | Ratio |
| 1997 | 121 858     | 100.0 | 20 689                         | 17.0  | 12 716       | 10.4  | 88 453            | 72.6  |
| 1998 | 113 366     | 100.0 | 20 994                         | 18.5  | 12 651       | 11.2  | 79 721            | 70.3  |
| 1999 | 119 218     | 100.0 | 19 792                         | 16.6  | 14 314       | 12.0  | 85 112            | 71.4  |
| 2000 | 138 485     | 100.0 | 20 320                         | 14.7  | 15 619       | 11.3  | 102 547           | 74.0  |
| 2001 | 161 105     | 100.0 | 21 602                         | 13.4  | 16 768       | 10.4  | 122 736           | 76.2  |
| 2002 | 173 251     | 100.0 | 25 526                         | 14.7  | 17 971       | 10.4  | 129 754           | 74.9  |
| 2003 | 190 687     | 100.0 | 26 264                         | 13.8  | 19 327       | 10.1  | 145 097           | 76.1  |
| 2004 | 221 853     | 100.0 | 29 646                         | 13.4  | 22 009       | 9.9   | 170 198           | 76.7  |
| 2005 | 241 554     | 100.0 | 31 929                         | 13.2  | 23 983       | 9.9   | 185 642           | 76.9  |
| 2006 | 273 457     | 100.0 | 34 971                         | 12.8  | 27 219       | 10.0  | 211 268           | 77.3  |

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.

### 1.4.3. Human resources

With the growth of R&D budgets, the number of researchers in Korea has almost doubled to reach more than a quarter of a million in the ten years to 2006 (Table 1.14). In terms of full-time equivalents (FTE), there are approximately 200 000 researchers, giving Korea 8.3 researchers per 1 000 labour force. This figure is higher than in the major European economies, though still a little short of the proportion in the United States and Japan. At the same time, Korean expenditure per researcher has grown in recent years although it remains well below the levels in Europe, Japan and the United States (Table 1.15). This variance can be largely accounted for by lower costs in Korea rather than by inferior equipment.

**Table 1.14. Number of Korean researchers, 1997-2006**

| Year | Total researchers (head count) | Total researchers per 1 000 labour force (full-time equivalent) |
|------|--------------------------------|-----------------------------------------------------------------|
| 1997 | 138 438                        | 4.7                                                             |
| 1998 | 129 767                        | 4.3                                                             |
| 1999 | 134 568                        | 4.6                                                             |
| 2000 | 159 973                        | 4.9                                                             |
| 2001 | 178 937                        | 6.1                                                             |
| 2002 | 189 888                        | 6.2                                                             |
| 2003 | 198 171                        | 6.6                                                             |
| 2004 | 209 979                        | 6.7                                                             |
| 2005 | 234 702                        | 7.6                                                             |
| 2006 | 256 598                        | 8.3                                                             |

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 1.15. Number of researchers in major countries**

|                       | Researchers<br>(FTE) | Researchers per<br>1 000 labour force<br>(FTE) | Researchers per<br>10 000 population<br>(FTE) | Expenditure per<br>researcher<br>(USD) |
|-----------------------|----------------------|------------------------------------------------|-----------------------------------------------|----------------------------------------|
| Korea (2006)          | 199 990              | 8.3                                            | 41.4                                          | 143 102                                |
| United States (2005)  | 1 394 682            | 9.3                                            | 47.0                                          | 232 644                                |
| Japan (2005)          | 704 949              | 10.6                                           | 55.2                                          | 214 582                                |
| Germany (2006)        | 279 800              | 6.7                                            | 34.0                                          | 261 079                                |
| France (2005)         | 204 484              | 7.4                                            | 32.6                                          | 222 947                                |
| United Kingdom (2005) | 180 450              | 6.1                                            | 30.0                                          | 219 291                                |
| Finland (2006)        | 40 411               | 15.1                                           | 76.7                                          | 178 846                                |
| China (2006)          | 1 223 756            | 1.6                                            | 9.3                                           | 30 777                                 |

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.

#### **1.4.4. Regional dimension**

As mentioned in Section 1.2, Korea suffers from unbalanced growth, with the Seoul metropolitan area dominating the economy. This has become a pressing political concern, with successive governments initiating a variety of policies and programmes to help redress the situation (see Chapter 3, section 3.9). Some of these efforts have centred on promoting innovation and, to a lesser extent, investments in science and technology, but they face an uphill task: the historical development of S&T in Korea has mirrored developments in other parts of the economy, leaving a legacy of concentration in the capital region. As Table 1.16 shows, almost two-thirds of Korean researchers work in the Seoul metropolitan area, most of them in companies. Even discounting the private sector, almost half of all researchers in higher education institutions (HEIs) and around 40% in public research organisations (PROs) work in and around Seoul. Taejon is the region with the next highest number of researchers, mostly on account of deliberate government policies to locate PROs in Daedeok Science Town. Even so, this region has less than 8% of the total.

Not surprisingly, resources tend to follow researchers, so that around two-thirds of R&D expenditure goes to the capital region (Table 1.17). Taejon follows, at just over 11%. This is slightly higher than the proportion of researchers (8%) on account of the expensive facilities at many of the PROs in Daedeok.

**Table 1.16. R&D researchers by sector of performance and region, 2006**

In headcount and percentages

| Region                                 | Sector of performance |                           |                    |                   |
|----------------------------------------|-----------------------|---------------------------|--------------------|-------------------|
|                                        | Research institutes   | Universities and colleges | Companies          | Total             |
| Seoul metropolitan area                | 6 873<br>(40.97)      | 32 879<br>(49.87)         | 124 206<br>(71.42) | 163 958<br>(63.9) |
| Pusan                                  | 324<br>(1.93)         | 4 286<br>(6.50)           | 3 038<br>(1.75)    | 7 648<br>(2.98)   |
| Taegu                                  | 226<br>(1.35)         | 2 163<br>(3.28)           | 2 487<br>(1.43)    | 4 876<br>(1.90)   |
| Kwangju                                | 94<br>(0.56)          | 2 418<br>(3.67)           | 1 924<br>(1.11)    | 4 436<br>(1.73)   |
| Taejon                                 | 6 671<br>(39.78)      | 5 061<br>(7.68)           | 8 095<br>(4.65)    | 19 827<br>(7.73)  |
| Ulsan                                  | 15<br>(0.09)          | 405<br>(0.61)             | 3 178<br>(1.83)    | 3 598<br>(1.40)   |
| Gangwon                                | 234<br>(1.40)         | 3 719<br>(5.64)           | 813<br>(0.47)      | 4 766<br>(1.86)   |
| Chungbuk                               | 263<br>(1.57)         | 1 773<br>(2.69)           | 2 851<br>(1.64)    | 4 887<br>(1.90)   |
| Chungnam                               | 335<br>(2.00)         | 2 530<br>(3.84)           | 8 476<br>(4.87)    | 11 341<br>(4.42)  |
| Chonbuk                                | 267<br>(1.59)         | 3 174<br>(4.81)           | 1 181<br>(0.68)    | 4 622<br>(1.80)   |
| Chonnam                                | 244<br>(1.45)         | 813<br>(1.23)             | 1 216<br>(0.70)    | 2 273<br>(0.89)   |
| Kyongbuk                               | 275<br>(1.64)         | 3 847<br>(5.84)           | 2 553<br>(4.80)    | 12 471<br>(4.86)  |
| Kyongnam                               | 838<br>(5.00)         | 2 553<br>(3.87)           | 7 944<br>(4.57)    | 11 335<br>(4.42)  |
| Cheju                                  | 112<br>(0.67)         | 302<br>(0.46)             | 146<br>(0.08)      | 560<br>(0.22)     |
| <b>R&amp;D researchers (headcount)</b> | <b>16 771</b>         | <b>65 923</b>             | <b>173 904</b>     | <b>256 598</b>    |

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 1.17. R&D expenditure and ratio by sector of performance and region, 2006**

KRW millions and percentages

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

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.

### 1.4.5. STI productivity

There is concern in Korea that although the intensity of R&D investment is among the world's highest, it is not being matched by performance. To explore these R&D efficiency concerns, two common indicators of performance – scientific publications and patents – can be considered. Table 1.18 shows that the number of scientific publications doubled in the six years to 2005 and now amounts to more than 2% of the global total, placing Korea in 14<sup>th</sup> place. Still, Korea lags behind the leading scientific countries in number of articles per million population (Figure 1.17). The fact that so much R&D is conducted in the private sector may partly account for this, given relatively weak incentives to publish in open scientific journals.

Korea has also improved its citations per paper ranking (30<sup>th</sup> in the world in 2005; see Figure 1.18 for a cross-country comparison), a markedly lower ranking than that the number of papers published. There are several reasons for disparities between publication and citation rates, including database and language biases and the differences in publication behaviour in different scientific fields. But even if these are taken into account, it is likely that many Korean scientists fail to publish ground-breaking original research that might be cited by their international peers.

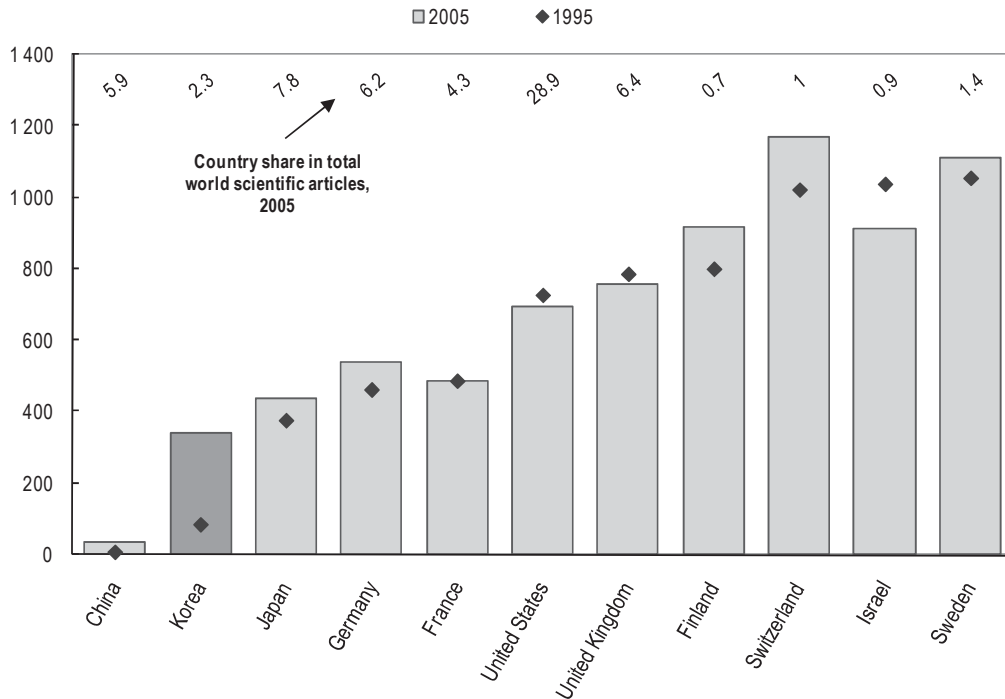
At the same time, Korea shows a steady rise in the number of triadic patents filed, surpassing both the United Kingdom and France (Table 1.19). The number of triadic patent families per million population is one of the highest in the OECD, and even higher than that of the United States. Despite these impressive figures, there are Korean concerns over relatively low levels of patent exploitation, which are discussed in later sections of this report.

In a more ambitious econometric study exploring the impacts of R&D on economic performance, Shin *et al.* (2006) found that the Korean R&D stock appeared to represent around 30% of Korea's economic growth for the period 1990-2004 (Table 1.20), an increase on the contribution of 23% for the period 1971-89. Unsurprisingly, capital appeared to be the most significant contributor to Korean economic growth for the same period, as the importance of labour steadily declined. The study also found that the efficiency of Korea's R&D investment was 0.187 for the period 1990-2004, an increase from 0.137 for 1971-89. Accordingly, the study's authors argue that the efficiency of Korea's R&D investment has been on a par with the OECD average since the 1990s.

**Table 1.18. Korea's scientific publications, 1999-2007**

|                             | 1999   | 2000   | 2001   | 2002   | 2003   | 2004   | 2005   | 2007   |
|-----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Number of papers published  | 11 324 | 12 472 | 14 892 | 15 863 | 18 791 | 19 294 | 23 048 | 25 494 |
| World share                 | 1.27   | 1.39   | 1.61   | 1.71   | 1.85   | 1.96   | 2.02   | 2.17   |
| World rank                  | 16     | 16     | 15     | 14     | 14     | 14     | 14     | 12     |
| Average citations per paper | 1.88   | 2.01   | 2.18   | 2.39   | 2.63   | 2.80   | 3.04   | 3.27   |
| World rank                  | 34     | 35     | 34     | 33     | 30     | 29     | 30     | 30     |

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

**Figure 1.17. Scientific articles per million population, 2005**

Source: OECD, Main Science and Technology Indicators, April 2008; National Science Foundation (2008), Science and Engineering Indicators 2008.

**Table 1.19. Economies' share of triadic patent families, 2006<sup>1</sup>**

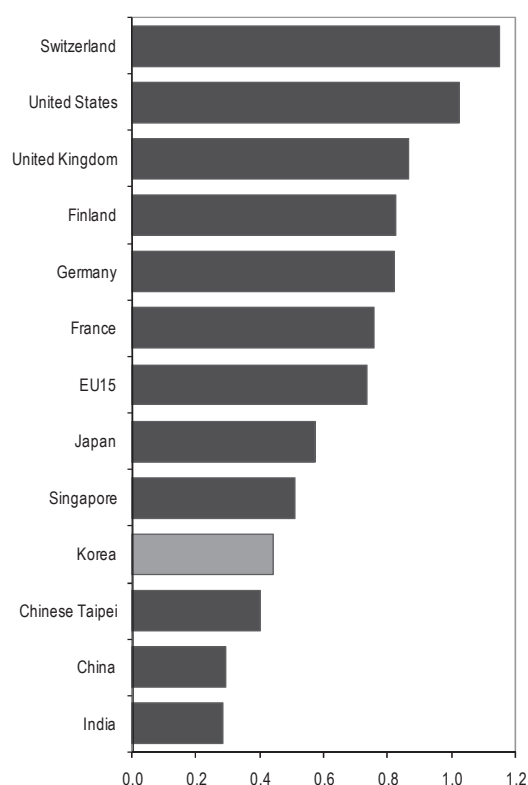
|                | 2006        | 1996        | Average annual growth rate,<br>1996-2006 | Triadic patent families<br>per million population, 2006 <sup>2</sup> |
|----------------|-------------|-------------|------------------------------------------|----------------------------------------------------------------------|
| United States  | 30.91       | 33.07       | 2.1                                      | 53.3                                                                 |
| Japan          | 27.51       | 27.13       | 2.9                                      | 111.1                                                                |
| Germany        | 11.96       | 14.09       | 1.1                                      | 74.9                                                                 |
| <b>Korea</b>   | <b>5.40</b> | <b>0.82</b> | <b>24.1</b>                              | <b>57.7</b>                                                          |
| France         | 4.85        | 5.49        | 1.5                                      | 39.5                                                                 |
| United Kingdom | 3.22        | 4.24        | 0.0                                      | 27.4                                                                 |
| China          | 0.94        | 0.06        | 35.6                                     | 0.3                                                                  |
| Finland        | 0.66        | 0.91        | -0.4                                     | 64.7                                                                 |
| India          | 0.26        | 0.04        | 25.4                                     | 0.1                                                                  |
| Chinese Taipei | 0.23        | 0.10        | 12.1                                     | 5.9                                                                  |

Note: Patent counts are based on the earliest priority date, the inventor's country of residence and fractional counts.

1. Patents filed at the European Patent Office (EPO), the US Patent & Trademark Office (USPTO) and the Japan Patent Office (JPO) which protect the same invention. Data from 1998 onwards are OECD estimates.

2. 2005 instead of 2006 for China, Chinese Taipei and India.

Source: OECD, Patent Database, October 2008.

**Figure 1.18. Relative prominence of cited scientific literature, 2003**

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

**Table 1.20. Contribution of the R&D stock to Korea's economic growth, 1971-2004**

Percentages

|                           | 1971-1989 |              | 1990-2004 |              | 1971-2004 |              |
|---------------------------|-----------|--------------|-----------|--------------|-----------|--------------|
|                           | Growth    | Contribution | Growth    | Contribution | Growth    | Contribution |
| Labour                    | 2.22      | 29.1         | 1.17      | 20.4         | 1.75      | 25.9         |
| Capital                   | 3.24      | 42.5         | 2.58      | 45.0         | 2.95      | 43.4         |
| Total factor productivity | 2.16      | 28.4         | 1.98      | 34.6         | 2.08      | 30.7         |
| R&D stock                 | 1.77      | <b>23.3</b>  | 1.74      | <b>30.4</b>  | 2.07      | <b>30.6</b>  |
| Real growth rate          | 7.62      | 100          | 5.73      | 100          | 6.79      | 100          |

Source: Shin *et al.* (2006), *Effects of R&D Investment on Economic Growth and Income Distribution*, Ministry of Science and Technology, Seoul.

In summary, this set of performance data seems to suggest that Korea is making steady progress in transitioning to a more knowledge-intensive developmental trajectory. Progress might be slower than some would like, but it should be acknowledged that many of the investments and reforms that embody transition typically take several years to achieve their desired impacts. Furthermore, indicators such as publication and patent counts can only ever provide a partial picture and care needs to be taken when using them for purposes of comparison.

## Chapter 2

### Main Features of the Innovation System

*This chapter describes the key actors in the Korean innovation system. It begins with an account of the role and performance of large national firms, in many respects the main players in Korean innovation. It then considers the role and performance of small and medium-sized enterprises (SMEs), an increasingly important sector for Korean innovation performance. It then turns to public-sector actors, starting with government research institutes (GRIs), which have played a crucial role in Korea's ability to move into high-technology sectors. Next, it considers Korean universities, which have played a modest though increasingly important role in research, but have been crucial for the mass education of young Korean adults. In terms of a key factor, human resources for science, technology and innovation, the chapter looks at the demand for skills and examines how overall arrangements for education and training are geared to meeting this demand. Finally, it discusses linkages between the various actors in the system with a view to assessing their strengths and overall coherence.*

#### 2.1. Large national firms

As Chapter 1 has shown, large national firms have played a dominant role in Korea's economic development. Their dominance extends across several industrial sectors, so that while Korea is perhaps best known around the world for its information technology (IT) and electronics industries, it is also a major player in several others. For instance, Korea became the fifth largest automobile producer in 2005, its steel companies have some of the best facilities in the world (and POSCO is the world's third largest steel manufacturer), and its shipbuilding industry dominates world markets. By 2006, the five largest Korean firms by revenue were Samsung (USD 158 billion), SK (USD 76 billion), LG (USD 61 billion), Hyundai Motors (USD 30 billion), and POSCO (USD 27.5 billion).

This section looks more closely at some of these large companies before exploring the model of catch-up followed by the leading *chaebol* (Korea's large family-owned conglomerates), particularly its consequences for contemporary innovation strategy and its impacts on Korea's industrial ecology. It then examines Korea's continuing heavy dependence on technology imports, although the situation is improving owing to significant R&D investments by the *chaebol*, which have grown over the last decade and shifted towards more basic research. This phenomenon and the increased levels of patenting by Korean industry are discussed. Finally, Korean firms' exploitation of emerging technologies is briefly reviewed.

### 2.1.1. Korea's large business groups

The **Samsung Group** is Korea's largest chaebol. Its numerous businesses include Samsung Electronics, the world's largest electronics company, Samsung Heavy Industries, one of the world's biggest shipbuilders, and Samsung Engineering and Construction, a major construction contractor. As the world's fifth largest transnational corporation, Samsung had revenues of USD 158 billion in 2006 and accounts for more than 20% of Korea's total exports.

Compared to other major Korean companies, Samsung survived the Asian financial crisis of the late-1990s relatively unharmed. Samsung Electronics was spun off from the Samsung Group and has since come to dominate the group and the worldwide semiconductor business. It expanded production dramatically to become the world's largest manufacturer of DRAM chips (see Box 2.1), flash memory, and optical storage drives and aims to become the world's top manufacturer of 20 products by 2010. It is already one of the world's leading manufacturers of liquid crystal displays and next generation mobile phones. Samsung has worked hard to establish industry standards, organising an in-house Technological Standardisation Committee in 2001 and operating a Standardisation Office with 300 employees. The company has placed particular emphasis on trying to standardise emerging technologies or products, such as MPGE-4/7 (for next-generation mobile communication), DVD, memory, DMB and WiBro. WiBro, which has been developed jointly by Samsung Electronics, Intel and Motorola, gained the international standardisation qualification from the International Telecommunication Union in 2007.

#### Box 2.1. Samsung's DRAM technology development strategy

Samsung Electronics' strategy to develop DRAM (dynamic random access memory) can be divided into three periods. In the first, from entry to the development of 64K DRAM chips, the company depended on external resources for the necessary core technologies. In the second period, leading up to the development of the 256K DRAM, reliance on externally acquired technologies remained high. In the third period, when the 1M DRAM was developed, the role of internally acquired technologies became crucial.

*Stage 1.* To secure the required technologies, Samsung Electronics focused on purchasing technologies from overseas where possible. In particular, it imported the core and most difficult technologies, *i.e.* design and wafer fabrication technologies, from overseas: 64K DRAM design technology from Micron Technology and Zytex (United States), and wafer process technology from Sharp (Japan). It also continued to accumulate technologies and experience with the manufacture of semiconductors following its takeover of Korea Semiconductor Co. in the mid-1970s and manufactured home appliances. As Samsung Electronics began to manufacture home appliances, it accumulated the mass-production technology and know-how for standardised products that constitute the core element of DRAM competitiveness. These accumulated technologies and knowledge served as a crucial basis for DRAM assembly technology.

*Stage 2.* As for 64K DRAM, Samsung imported the design technology for 256K DRAM from Micron Technology. However, drawing on its experience in the development of 64K DRAM, Samsung adopted an approach based on externally acquired wafer fabrication and assembly technologies. For this purpose, Samsung explored the literature on 256K DRAM production processes and technological specifications, received technology training from technology exporters and technological advice from external experts.

*Stage 3.* The external acquisition of design technology was conducted through examination of technical information from advanced firms, reverse engineering, and careful analysis of other DRAM designs. At the same time, it continued to develop wafer fabrication and assembly technologies using internally accumulated knowledge. In addition, to shorten the time frame for the commercialisation of new products, Samsung undertook the construction of mass-production lines and engaged in joint development of equipment in consultation with equipment manufacturers.

*Source:* STEPI (2002), *Changing Strategies for Business Innovation and the Implication for S&T Policy*, Science and Technology Policy Institute, Seoul.

Samsung Electronics has developed a very strong network of R&D collaborators across Korea, which includes: SMEs in Seoul, Daejeon and Gyeonggi; government research institutes (GRIs): the Korea Institute of Science and Technology (KIST), the Korea Electronics Technology Institute (KETI) and the Korea Automotive Technology Institute (KATECH); and universities: Seoul, Seoul National, Hongik, Yonsei, Sogang, Hanyang, POSTECH, Kyungpook, Kookmin, Pusan, Konkuk, Inha, Sungkyunkwan, Korea, Incheon, Aju and Ewha. It has also initiated collaborations with a number of US companies, but it is frequently noted that its traditional management style will need to change significantly in order to operate effectively in the necessarily open form of these alliances.

The Hyundai Group underwent massive restructuring following the 1997 Asian financial crisis and the founder's death in 2001. Today, many companies bearing the Hyundai name are legally unrelated, with each company having a different chairman. Two of these groups are considered here: the Hyundai Motor Company and Hynix Semiconductor.

The Hyundai Motor Company (HMC), a division of the Hyundai Kia Automotive Group, is Korea's largest and the world's sixth largest car manufacturer. Hyundai operates the world's largest integrated manufacturing facility in Ulsan; it is capable of producing 1.6 million units annually. In 1998 Hyundai acquired rival Kia Motors. In 2000, the company established a strategic alliance with DaimlerChrysler and severed its partnership with the Hyundai Group. Hyundai has manufacturing plants in the United States, China, India and Turkey. Its major R&D is conducted at the Namyang Technology Research Centre but it also has R&D centres in Detroit, Los Angeles and Irvine in the United States, Frankfurt in Germany, and Chiba in Japan.

HMC progressively built up its technology capacity through technology imports and internal capability development over three decades, moving from manufacture for the local market to a focus on exports. In the catch-up phase, when the focus was on assembly and models for the domestic market, there was significant effort to build capabilities through links to external technology sources and internal technology accumulation. The Korean automobile industry, however, remains weak in generic and core technologies, in the parts industry, in flexible manufacturing systems, and in quality. The industry is still catching up with the leading companies' technologies through international co-operative R&D.

In achieving its present strategic capability, HMC's approach to internal R&D shifted focus from problem solving to basic research, and technology sources have changed from advanced car makers to specialised services firms in component technologies. In addition to reverse engineering and developing imported technology, it has formed alliances with major car manufacturers to access emerging technologies. For example, HMC plans to commercialise a hydrogen-fuelled car through co-operative R&D with International Fuel Cells of the United States and has already developed GDI (gasoline direct injection) with Mitsubishi of Japan. In addition, the organisation has been restructured from a traditional hierarchical model to one in which authority is delegated to middle management and *ad hoc* teams are established to address specific issues as they emerge (see Table 2.1).

**Table 2.1. Characteristics of HMC's technology accumulation process**

|                                       | Catch-up                                              | Towards strategic capability                                 |
|---------------------------------------|-------------------------------------------------------|--------------------------------------------------------------|
| <b>Acquisition sources</b>            | Advanced automaker                                    | ► Specialised technology service firm                        |
| <b>Introduced technology content</b>  | Collection and integration technology                 | ► Segmented element technology                               |
| <b>Level of introduced technology</b> | Technology during the consolidation period            | ► Technology under development                               |
| <b>Type of organisation</b>           | Flexible organisation; frequent organisational change | ► 'Hypertext' organisation; operation of <i>ad hoc</i> teams |

Source: STEPI (2002), *Changing Strategies for Business Innovation and the Implication for S&T Policy*, Science and Technology Policy Institute, Seoul.

Hynix Semiconductor Inc., which spun off from the Hyundai Group in 2001, is the world's sixth largest semiconductor company, focusing on DRAM and flash memory chips, and the second largest manufacturer of memory chips. In 2006, a global manufacturing network was established with the construction in China of Hynix-ST Semiconductor Inc., a wholly owned manufacturing subsidiary. In 2007, its turnover rose by 32% to USD 8 billion.

In 2006 Hynix demonstrated its technological leadership over other chipmakers, when it became the first company to receive Intel validation for 512Mb DDR2 products, developed with 80 nanometre technology, and for 1Gb DDR2 products with 66 nanometre technology. The competitive edge for Hynix is the refresh rate of its 80 nanometre DRAM products, which is more than double that of its competitors' products.

It has also initiated an enterprise-wide innovation system called RTIP (Real Time, Interactive & Parallel). The emphasis is on teams working in parallel and with external suppliers and effective communication with internal and external partners. Previous innovation programmes tended to take a bottom-up approach, assuming that innovation would flow from incremental adjustments to a given work environment. RTIP, however, is much more transformational. It is about fundamentally changing how work is done and information is shared. It is about joining the entire Hynix organisation together as a networked community with common goals and the ability to get things done (Hynix, 2007).

LG, established in 1947, now operates through some 36 affiliates in three main industries – electronics and consumer appliances, chemicals, and telecommunications. The company has more than 72 000 employees in more than 120 overseas operations, including 77 subsidiaries and marketing units around the world. LG Electronics is the world's largest producer of CDMA handsets, DVD players, optical storage devices, air conditioners, canister vacuum cleaners and microwave ovens. In 1999, it launched its first foray into the US consumer electronics market by purchasing a recognised American company, Zenith Corporation. In 2003, it launched a comprehensive holding company, LG Corp; it was the first major Korean corporation to introduce a holding company structure which separates its investment and business divisions. LG was previously primarily known for its low-cost home appliances, such as air conditioners and refrigerators, but the conglomerate now has its sights set on becoming one of the world's top three consumer electronics companies by 2010. Like Samsung, LG is also seeking to

establish industry standards, focusing upon standardisation in mobile communication, DTV, home network, DRM (digital rights management), wireless networks, etc.

### 2.1.2. From catch-up to leadership

The overarching strategic goal of the latecomer firm and of its country is to catch up with industrially advanced firms in industrially advanced countries. It is its catch-up situation which creates the critical strategic framework and justifies practices and perspectives that may have to be abandoned or modified once catch-up has been accomplished – practices such as targeting, government-induced collaboration, and collective risk reduction through public facilitation (Mathews, 2001). Catch-up can be characterised in terms of enhancement of technological capabilities (both deepening and broadening) and enhancement of access to or linkage with customers in advanced markets (see Box 2.2). During much of Korea's catch-up phase, access to global markets and knowledge was mainly driven by the chaebol. These have enhanced their technological capabilities via technical licensing arrangements with foreign firms, imports of capital goods and components, and exporting through OEM, ODM and OBN (see Box 2.3).

#### Box 2.2. Sequence of steps for establishing high-technology industries

According to Mathews (2001), all high-technology industries successfully created in East Asia have followed a general sequence of steps:

- Step 1. *Preparing the ground*: ensuring that skills, knowledge, contacts and companies are established.
- Step 2. *Seeding/implantation*: technology acquisition and resource leverage, leading to adaptation and improvement.
- Step 3. *Propagation*: financial resources, enterprise development, product development and infrastructure support to encourage firms to take up the new technologies.
- Step 4. *Sustainability*: deepening industry structures, R&D capabilities, and social structures of innovation.

The process is then extended through a new round of seeding, propagation and sustainability, with the newly created technological capabilities serving as the platform for the next.

#### Box 2.3. OEM, ODM and OBM

OEM. *Original equipment manufacturer*: a producer that provides a product to its customers, who proceed to modify or bundle it before distributing it to their customers, *i.e.* one company uses a component of another company in its product, or sells the product of another company under its own brand.

ODM. *Original design manufacturer*: a company that manufactures a product which ultimately will be branded by another firm for sale. Such companies allow the brand firm to produce the product without having to engage in the organisation or running a factory. A primary attribute of this business model is that the ODM owns and/or designs in-house the products that are branded by the buying firm.

OBM. *Original brand manufacturer*: a company that designs and conducts R&D for new products; it also organises, distributes and uses its own brand names and captures post-production value added.

Ernst (2000) describes Korea's catch-up in the electronics industry as based upon a narrow specialisation on commodity-type products, such as semiconductors and liquid crystal displays (LCDs). Its success was less due to Korea's strength in R&D than on its capacity to raise sufficient funding to invest in mass production facilities. Only the chaebol had this capacity, as they enjoyed privileged access to investment capital. They therefore came to dominate Korea's sales and exports and were able to recruit the best workers, technicians, engineers and managers. Their dominance squeezed out the possibility of the emergence of a dynamic SME sector; this continues to have consequences for component and supplier industries in Korea and contributes to a large technology trade deficit (see below). The extreme degree of concentration in a handful of chaebol still distinguishes the Korean electronics industry from that of Japan, where none of the big electronics groups comes close to achieving the overwhelming dominance found in Korea.

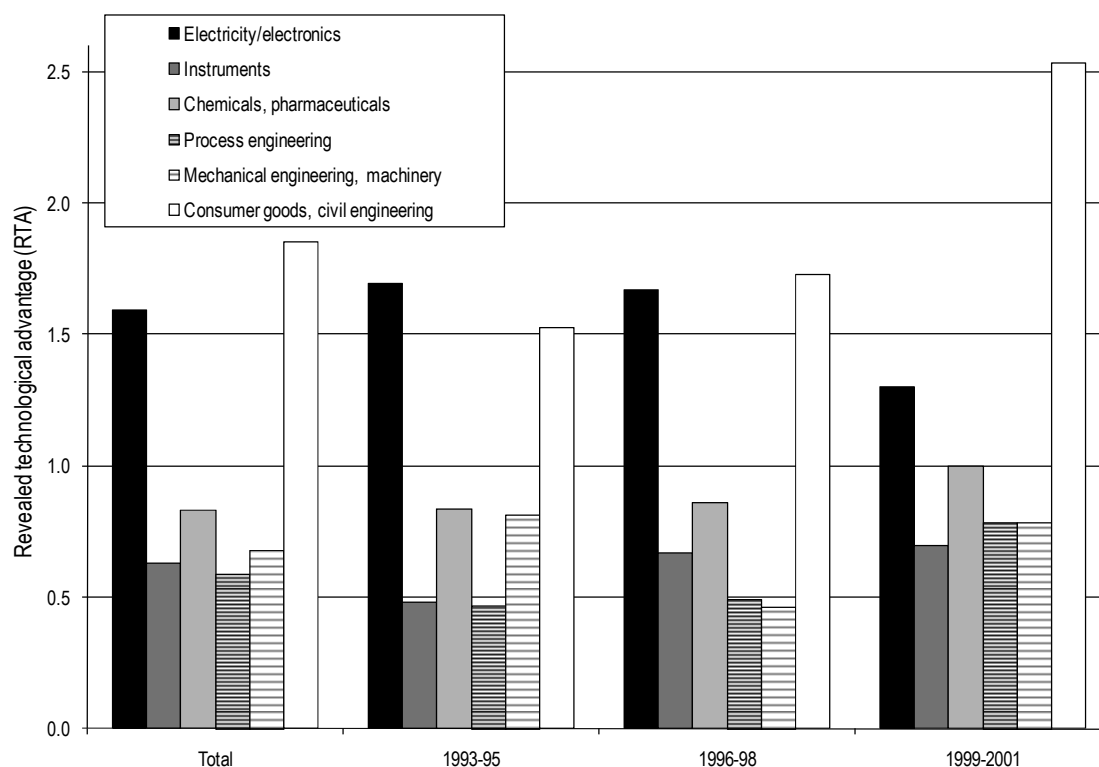
Historically, the narrow specialisation in commodity-type products provided insufficient pressure to improve the domestic knowledge base, which in turn proved a constraint on improving specialisation. At a result, once a chaebol reached the limits of "easy" expansion of capacity and market share for a particular product, it tended to move on to a new product group that promised rapid market expansion. Such "octopus-like" diversification also proved detrimental to capability formation and knowledge deepening (Ernst, 2000). The Asian financial crisis curtailed much of this kind of expansion, as the chaebol were forced to concentrate upon a limited number of core businesses. This led them to greatly expand their in-house R&D capacity over the last decade, with the result that they are now genuine world leaders in several product and technology lines. As the data in Figure 2.1 show, Korean industry has been increasing its technological advantage across a broad spectrum of industries, most notably in consumer electronics.

Thus, the growth and technological progress of Korean manufacturing has been led by the rapid productivity growth of large firms in the electronics and automobile industries (Woo, 2003), which have moved well beyond the catch-up phase. Particularly in the electronics industry, they have moved from global export production bases for software and hardware to commercially viable innovations and standards. In doing so, they have reduced, to a significant extent, their dependence upon sub-contracting, licensing and OEM. Furthermore, by investing in R&D labs, they have strengthened their R&D capacity, accumulated new process engineering technologies, and broadened the range of export products in which they occupy a world leadership position (Hobday *et al.*, 2004).

On this evidence, it would appear that the leading Korean chaebol have made a successful transition from fast followers to leaders. However, it would be a mistake to view these firms as occupying leadership positions across the board. Instead, they offer a portfolio of products, some of which are technologically advanced and others less so. Many firms in many product areas have yet to reach the innovation frontier and even the leading chaebol continue to produce large volumes of products under sub-contracting and licensing agreements. Indeed, besides the substantial additional risks and costs of increased R&D and original new product development associated with choosing an innovation leadership strategy, Korean firms would risk challenging their traditional sub-contracting partners in the United States and Japan who, fearing direct competition from their Korean suppliers, might withdraw from OEM and licensing arrangements (see Box 2.4). Thus, corporate innovation strategies tend to focus on the needs of specific products (or closely related product families) rather than the firm in its entirety, and

typically embody a mix of leadership, “followership” and latecomer positions according to their product portfolios (Hobday *et al.*, 2004).

**Figure 2.1. Index of revealed technological specialisation<sup>1</sup> for Korea (1993-2001)**



1. This index relates the relative share of a technology in a country/firm to the share this technology has in all countries/national wide. A value >1 indicates that the technology is over-represented in the country/firm compared to the rest of the world/economy and thus indicates a strong position in that technology.

Source: Dachs *et al.* (2007), “The Technological Competencies of Korea’s Firms: A Patent Analysis”, in J. Mahlich and W. Pascha (eds.), *Innovation and Technology in Korea: Challenges of a Newly Advanced Economy*, Springer, Heidelberg.

#### Box 2.4. Pros and cons of OEM

OEM arrangements have proven to be one of the most cost-effective methods for acquiring core capabilities in production and investment, providing the supplier with a high volume of business, which makes possible the realisation of scale economies. The often tedious and gruelling qualification process that any potential supplier has to complete successfully in order to compete for 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. OEM arrangements, however, can also have substantial drawbacks. For example, a firm may become so locked into an OEM arrangement that it is hindered from developing its own independent brand name recognition and marketing channels. Furthermore, profit margins are substantially lower in OEM sales than in own brand name sales, which in turn makes it difficult for suppliers to muster the capital needed to invest in R&D that might eventually lead to the introduction of new products.

Source: Ernst (2000), “Catching Up and Post-Crisis Industrial Upgrading: Searching for New Sources of Growth in Korea’s Electronics Industry”, East-West Center Working Paper, No. 2 March 2000, East-West Center, Honolulu.

In fact, beyond the chaebol, much Korean industry still remains in the imitative mode, with R&D efforts oriented towards exploitation of mature and advanced technologies for market expansion in selected areas. This is not necessarily a bad thing: innovation should not be confused with a sole focus upon leading-edge high technology, and many, if not most, firms can benefit from exploitation of existing technologies (not to mention non-technological forms of innovation such as organisational change). However, there are limits to this approach, particularly because of the emergence of powerful new competitors in China (see below).

There are also lingering concerns about the readiness of Korean firms to adopt leadership positions given the management style they have traditionally followed. According to Kim (2001), Koreans typically believe a firm's success rests largely with the top manager's personal skills. This fostered a management style in the chaebol that in some ways resembled a military bureaucracy, in that it was hierarchical and centrally controlled. However, it was relatively less formalised than a military bureaucracy, meaning that firms could adapt to changes once they were decided at the top. While such organisations were well suited to imitative reverse engineering and production-oriented tasks during the catch-up era, the limitations of this command-control management style are now well recognised in Korea, particularly for the pursuit of higher levels of innovation. Yet, it has become apparent that while the formal organisational structure can be readily changed, it is more difficult and time consuming to change the behaviour and attitudes of managers and employees.

### ***2.1.3. Korean industrial ecology***

Given their dominance, the strategies of the chaebol have determined the overall product mix and capabilities of Korean industry. This dominance is widely considered to have had a somewhat negative effect on SMEs that supply parts and components and engage in complementary support activities. Although formally independent, most of these firms are tightly integrated into the vertical production networks of the chaebol. Furthermore, as sub-contractors tend to work for only one manufacturer they are locked into a fairly closed production network controlled by a particular chaebol and their very limited decision-making autonomy has significantly limited their attempts to improve their international competitiveness (Ernst, 2000).

This is well illustrated by the dual structure of the Korean electronics industry, in which large conglomerates play a leading role in both domestic and global markets but other groups of companies have weak technological competences (Woo, 2003). This weakness affects the chaebol, which are unable to obtain capital goods technology and key components in Korea and must therefore depend upon US and Japanese suppliers. The result is a high import cost structure (see Box 2.5).

This dual structure is also found in the automobile industry, as firms such as HMC are poorly supported by the local capital goods and components industry and rely heavily on foreign imports. At the same time, many Korean component suppliers are very dependent upon final auto assemblers such as HMC for orders, and almost all production is targeted at the domestic market. The strategy of such businesses has been to copy, develop and improve – a well-tested fast-follower strategy that focuses upon quality, price and rapid delivery rather than product sophistication. However, such companies now face a challenge: the fast-follower strategy – quickly reproducing and improving on new products – has worked in the past but the capacity for low-cost product imitation may soon be challenged by large players with similar strategies, for example from China

(Hobday *et al.*, 2004). Korean suppliers are vulnerable to such competition, since they are weak in areas such as independent technological development, purchasing and sales, and the capability to collect information on global market trends, for which they mostly rely upon “parent” companies. Because they pay considerably lower wages than the final auto assemblers (owing to pressures from the large conglomerates to cut costs), it has become increasingly difficult to attract highly skilled labour (Woo, 2003; see also section 2.6). Furthermore, the perception in Korea is that western and Japanese firms are becoming less inclined to license their technologies, which, if accurate, would close off some possibilities for imitation. At the same time, there are all the usual risks and difficulties of becoming a product creator as well as uncertainty over who the customers might be for such products in the Korean market (Hobday *et al.*, 2004).

### **Box 2.5. Korean capital goods technology**

To make the transition to leadership, latecomer firms need access to advanced, usually foreign, capital goods technology in order to design and manufacture new products. In some cases, this access requires deep technological knowledge of the capital goods and systems in question. For example, leading foreign manufacturers of microprocessors and automobiles work continually with high-technology specialist capital goods producers in advance of new product development in order to ensure design for manufacture or “produceability”. For the leading companies in Korea, moves to develop radically new products would require more intense and direct collaboration with foreign suppliers of capital goods and the designers of key components. This would in turn require a greater physical presence in Korea of capital goods makers and greater capabilities on the part of Korean manufacturers to shape the development of new capital goods. At the moment, most physical equipment has to be imported from foreign industry leaders through agents in Korea or small subsidiaries of major companies.

In electronics, automobiles and other manufacturing sectors, leading Korean firms point to weaknesses in the local supply of capital goods and related technologies. For example, to move towards a full-service, supply-chain approach, the automotive industry has only a few domestic Korean suppliers that are able to meet its quality, technology and service requirements. As the chaebol move into more sophisticated designs for global markets, they need to collaborate with and rely upon the producers of the highest-technology capital goods. In the automotive and electronics industries, as the chaebol approach technology frontiers, they tend to source globally in search of the suppliers of the most advanced technology. This involves forming difficult arm’s length partnerships with foreign capital goods producers (mostly Japanese, but also some US suppliers), relegating local producers to low technology fields and small niches. The latter find it increasingly difficult to compete with the capability and R&D spending of international competitors. Furthermore, they tend to have a “credibility” problem even if they are able to master the technology because they lack the foreign suppliers’ strong reputation. As a result, many have resigned themselves to lower-technology options for which they have proven advantages in terms of price and quality. At the same time, these local producers feel threatened by the emergence of cheaper capital goods and component suppliers from China and see themselves as “sandwiched” between lower-cost regional producers and high-technology foreign leaders.

*Source:* Hobday *et al.* (2004), “Approaching the Innovation Frontier in Korea: The Transition Phase to Leadership”, *Research Policy*, Vol. 33.

### **2.1.4. Technology trade**

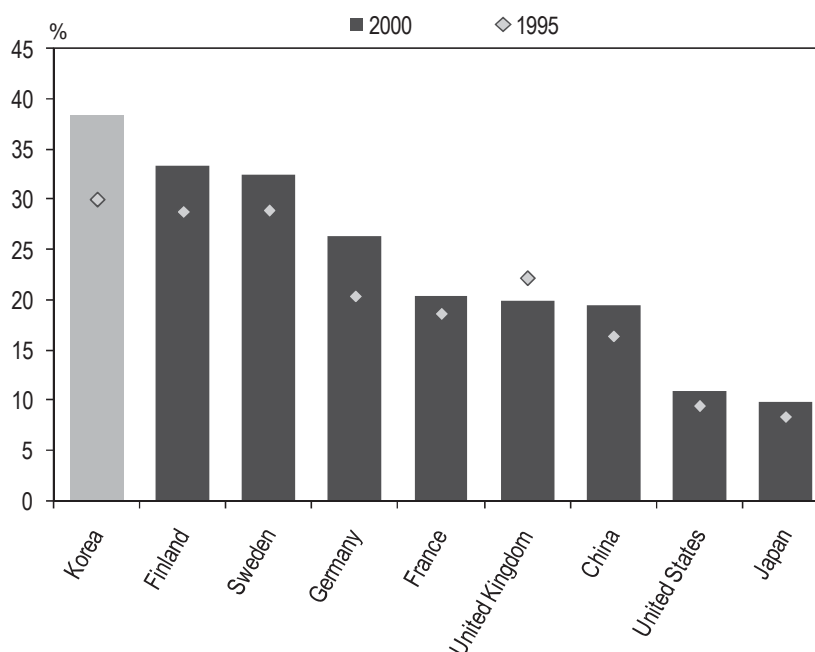
Given such reliance upon overseas technology suppliers, it is not surprising that the domestic market for technology trade – worth around USD 3 billion in 2005 – is about half the size of the market for foreign technology trade (Table 2.2). Around 90% of domestic transactions are business-to-business, with the remaining 10% involving technology transfers from public research organisations (PROs) and universities to businesses. The latter are discussed below.

Table 2.2. Size of Korea's technology market, 2005

|                | Market size (USD millions) |        |       |
|----------------|----------------------------|--------|-------|
|                | Type                       | Amount | Total |
| Domestic trade | Business-to-business       | 2 700  | 3 000 |
|                | Government-to-business     | 300    |       |
| Foreign trade  | Technology import          | 4 500  | 6 000 |
|                | Technology export          | 1 500  |       |

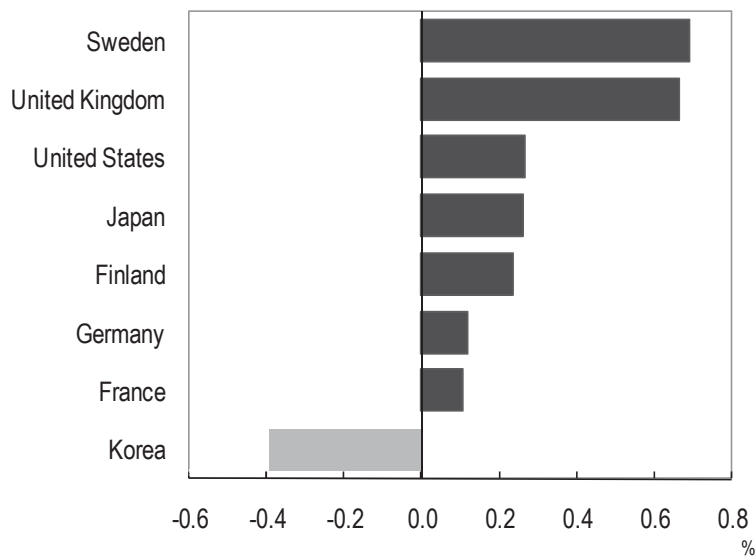
Source: Korea Technology Transfer Centre, cited in Ilshin (2007), "Venture Capital in Korea", presentation to the OECD Country Review Unit, October 2007, Seoul.

Figure 2.2 confirms the high dependency of Korean firms on foreign technologies: the level of import content of Korean exports is the highest among the leading industrial countries and around three times higher than for Japanese exports. This coincides with a substantial technology trade deficit, as shown in Figure 2.3, which also indicates the (often substantial) technology trade surpluses of other leading economies. The data seem to imply that Korea's technological capabilities are far below those of Japan and other developed countries and that Korean firms still rely heavily upon foreign technologies for their products and processes. In other words, Korea would still seem to have some catching up to do to gain technological parity with the leading economies.

Figure 2.2. Import content of exports, 1995<sup>1</sup> and 2000

1. Data for China 1997.

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

**Figure 2.3. Technology balance of payments as a percentage of GDP, 2005<sup>1</sup>**

1. Data for France and Korea 2003.

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

However, care must be taken when interpreting the data. First, sectors such as electrical machinery, radio/television and communication equipment, and office, accounting and computing machinery are known for the high import content of their exports, owing to the international division of labour in production of parts and components and final assembly. These are precisely the industries in which Korea has a strong presence. Second, an examination of recent technology trade trends presents a more positive picture. As Table 2.3 shows, while the technology trade deficit has slowly risen in absolute terms, the annual growth rate of technology exports has outstripped that of technology imports by more than four to one. Indeed, the trend data would seem to indicate that Korea is on the path to developing internationally competitive technological capabilities.

**Table 2.3. Trends in Korea's technology trade, 1999-2006**

USD millions

|                        | 1999   | 2000   | 2001   | 2002   | 2003   | 2004  | 2005   | 2006   | AGR  |
|------------------------|--------|--------|--------|--------|--------|-------|--------|--------|------|
| Technology trade (A+B) | 2 879  | 3 263  | 3 262  | 3 359  | 4 052  | 5 564 | 6 150  | 6 735  | 12.9 |
| Technology exports (A) | 193    | 201    | 619    | 638    | 816    | 1 416 | 1 625  | 1 897  | 38.6 |
| Technology imports (B) | 2 686  | 3 063  | 2 643  | 2 721  | 3 236  | 4 148 | 4 525  | 4 838  | 8.7  |
| Balance (A-B)          | -2 493 | -2 862 | -2 024 | -2 083 | -2 420 | -2732 | -2 900 | -2 941 | -    |

Note: AGR indicates average annual growth rate (%).

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

The rapid growth of technology exports no doubt reflects Korea's strengthened technological capability, particularly in manufacturing, which has been underpinned by heavy investments in in-house R&D. But the picture is more complex, as indicated by a breakdown of its technology import and export figures. As Table 2.4 shows, the United States is the largest recipient of Korean royalty payments, followed at some distance by Japan. In fact, over recent years, royalty payments to Japan have remained quite stable, while those to the United States have increased markedly. Korea also seems to be broadening its technology sourcing, with France, Germany and "other countries" accounting for more than a quarter of total royalties paid in 2006.

**Table 2.4. Technology import royalties paid by Korea, 1995-2006**

USD millions

| Country       | 1995         | 2000         | 2001         | 2002         | 2003         | 2004         | 2005         | 2006         |
|---------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| United States | 962          | 1 819        | 1 484        | 1 609        | 1 838        | 2 424        | 2 734        | 3 016        |
| Japan         | 695          | 527          | 392          | 403          | 468          | 478          | 584          | 515          |
| Germany       | 79           | 101          | 120          | 133          | 153          | 148          | 144          | 170          |
| France        | 31           | 153          | 57           | 76           | 120          | 240          | 204          | 236          |
| Others        | 181          | 463          | 590          | 501          | 658          | 857          | 860          | 901          |
| <b>Total</b>  | <b>1 947</b> | <b>3 063</b> | <b>2 643</b> | <b>2 721</b> | <b>3 236</b> | <b>4 147</b> | <b>4 525</b> | <b>4 838</b> |

Source: KOITA (2007), *Industrial Technology White Book*, Korea Industrial Technology Association, Seoul.

In contrast, China is the main recipient of Korea's technology exports, with around 35% of the technology export royalties received by Korea in 2006 (Table 2.5). The United States is the second largest purchaser of Korean technology, accounting for more than one-quarter of the total, with other countries accounting for less than 5% each. Taken together, these figures show that Korea remains heavily dependent upon US and Japanese technologies, with technology imports around ten times greater in value than exports. The growth rate in Korean technology exports to both countries certainly outstrips the growth rate in technology imports, but from a very low base. It is therefore likely to take Korea a considerable amount of time at best to achieve balanced technology trade with both countries. Furthermore, the rapid growth in technology exports to China is a sign of the latter's rapid industrialisation and the important part played by Korean firms in that process. In many ways, these figures confirm Korea's position as economically "sandwiched" between a rapidly growing China, which is quickly moving up the product ladder, and Japan, which retains a comparative advantage in a number of advanced industries.

By type of technology, only technology trade related to machinery recorded a surplus in 2005 (Figure 2.4). By contrast, information technologies recorded the largest deficit. While electrical/electronics and communication technologies also recorded a large deficit, their exports are relatively large, signalling a high degree of intra-technology trade.

Table 2.6 summarises technology trade in 2005 by firm size. Technology imports, technology exports, and the resulting trade deficit are all dominated by large companies. While SMEs accounted for 9.6% of total technology exports and 18.1% of total technology imports, this trend is changing, with SMEs' technology imports and exports increasing at a faster rate than those of large companies.

**Table 2.5 Technology import royalties received by Korea, 1995-2006**

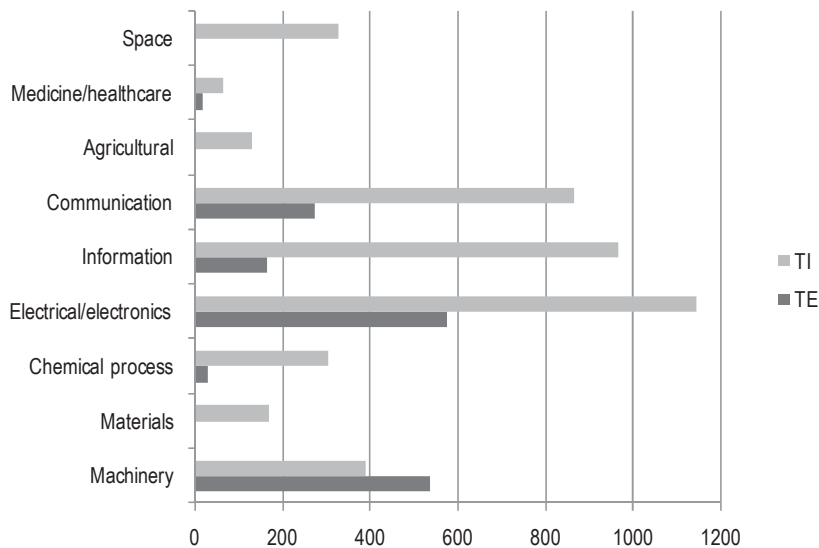
USD millions

| Country       | 1995       | 2000       | 2001       | 2002       | 2003       | 2004         | 2005         | 2006         |
|---------------|------------|------------|------------|------------|------------|--------------|--------------|--------------|
| China         | 18         | 80         | 186        | 182        | 262        | 377          | 719          | 666          |
| United States | 1          | 11         | 197        | 96         | 115        | 230          | 285          | 516          |
| Indonesia     | 5          | 12         | 1          | 61         | 60         | 67           | 80           | 77           |
| Japan         | 4          | 1          | 32         | 33         | 52         | 67           | 63           | 58           |
| Others        | 84         | 97         | 203        | 266        | 326        | 675          | 478          | 580          |
| <b>Total</b>  | <b>112</b> | <b>201</b> | <b>619</b> | <b>638</b> | <b>816</b> | <b>1 416</b> | <b>1 625</b> | <b>1 897</b> |

Source: KOITA (2007), *Industrial Technology White Book*, Korea Industrial Technology Association, Seoul.

**Figure 2.4. Value of technology imports (TI) and exports (TE) by technology type, 2005**

USD millions



Source: MoST (2006a), *Report on the Survey of Research and Development in Sciences and Technology*, Ministry of Science and Technology.

**Table 2.6. Technology trade by firm size, 2005**

USD millions

|                    | Technology exports | Technology imports | Balance  |
|--------------------|--------------------|--------------------|----------|
| <b>Large firms</b> | 1 439.3            | 3 692.6            | -2 253.3 |
| <b>SMEs</b>        | 156.5              | 818.5              | -662     |

Source: MoST (2006a), *Report on the Survey of Research and Development in Sciences and Technology*, Ministry of Science and Technology.

A survey of Korean firms by the Ministry of Science and Technology (MoST) reveals the reasons for firms to engage in technology trade (Table 2.7). There are few surprises in terms of technology imports. The information on technology exports is perhaps more interesting, since it indicates that profit maximisation is the main motive for technology exports. This suggests that Korean technology is internationally competitive, with foreign firms increasingly willing to purchase it.

**Table 2.7. Results of a survey of Korean firms' main motives for technology trade**

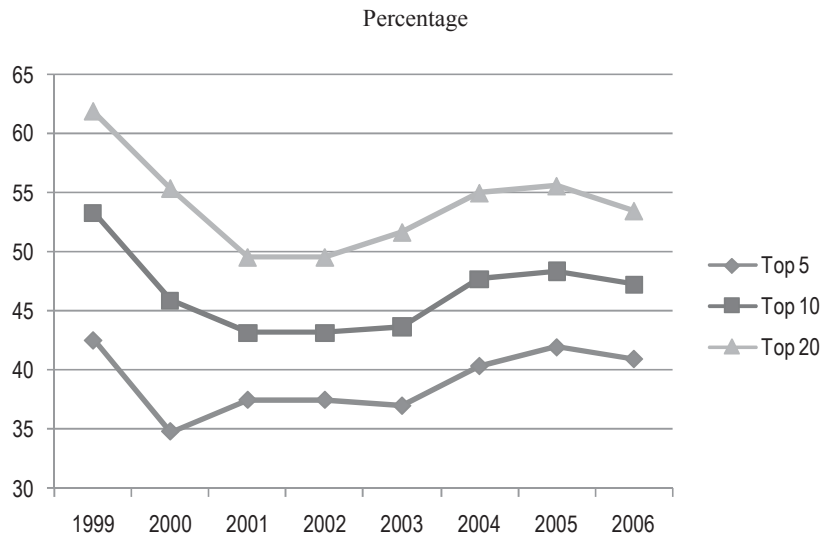
| <b>Technology exports</b><br>(692 survey responses)              |       | <b>Technology imports</b><br>(558 survey responses) |       |
|------------------------------------------------------------------|-------|-----------------------------------------------------|-------|
| Maximising profit through technology sales                       | 43.6% | Acquiring competing technologies                    | 34.9% |
| Entering foreign market by technology sales                      | 35.4% | Entering new business                               | 18.6% |
| Co-operating in business with foreign buyers                     | 10.0% | Shortening R&D period                               | 17.7% |
| Accompanying the exports of parts, equipments, and raw materials | 5.2%  | Avoiding development difficulty                     | 10.9% |
| Accompanying plant exports                                       | 3.3%  | Decreasing development cost                         | 9.0%  |
| Decreasing management cost                                       | 1.9%  | Averting R&D risk                                   | 7.5%  |
| Others                                                           | 0.6%  | Others                                              | 1.3%  |

Source: MoST (2006a), *Report on the Survey of Research and Development in Sciences and Technology*, Ministry of Science and Technology.

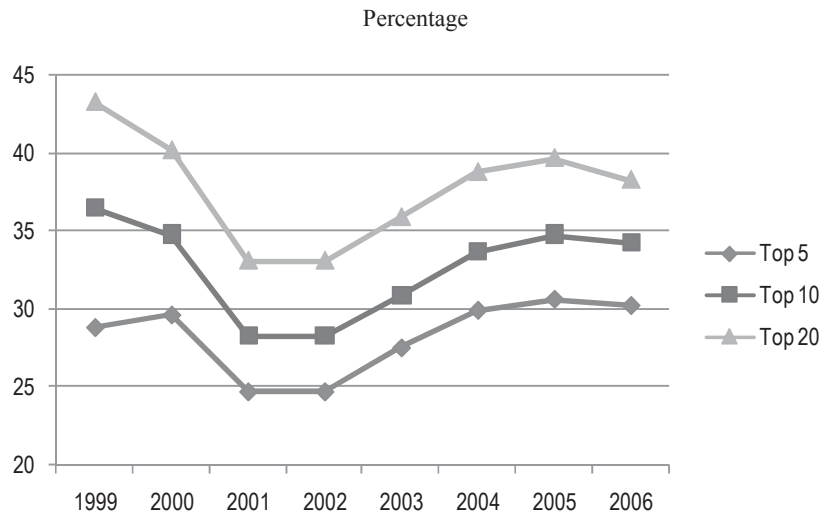
### 2.1.5. R&D activities

Many OECD governments, particularly in Europe, are struggling to get their firms to spend more on R&D and look at Korean levels of business enterprise expenditure on R&D (BERD) with some envy. However, while there is international consensus that firms should be the source of most R&D spending, there are concerns in Korea that the levels are too high and that market downturns could result in immediate and drastic falls in the support for R&D (in fact, this happened during the Asian financial crisis in the late 1990s, when firms cut their R&D budgets, sometimes sharply). This risk is perhaps greater in Korea because of the concentration of BERD in a handful of large firms. As Figure 2.5 shows, the top five firms in terms of R&D expenditure in 2006 accounted for more than 40% of Korean BERD, a figure that has remained largely unchanged over the last decade. A single firm, Samsung Electronics, accounts for more than half of this expenditure. The top ten firms accounted for 47.3% of expenditure and the top 20 for 53.5%, a marked decrease in share over the last decade.

Figure 2.6 shows the concentration in number of researchers, with the top five firms accounting for around 30% of the total, a slight increase over the last decade, while the top ten account for 34.3% and the top 20 for 38.3%, a decrease in share over the last decade. Perhaps unsurprisingly, these figures largely mirror those for R&D expenditure, although expenditures are about a third higher than would be expected given the numbers of researchers. This suggests that the top-spending firms invest more resources per researcher than smaller investors.

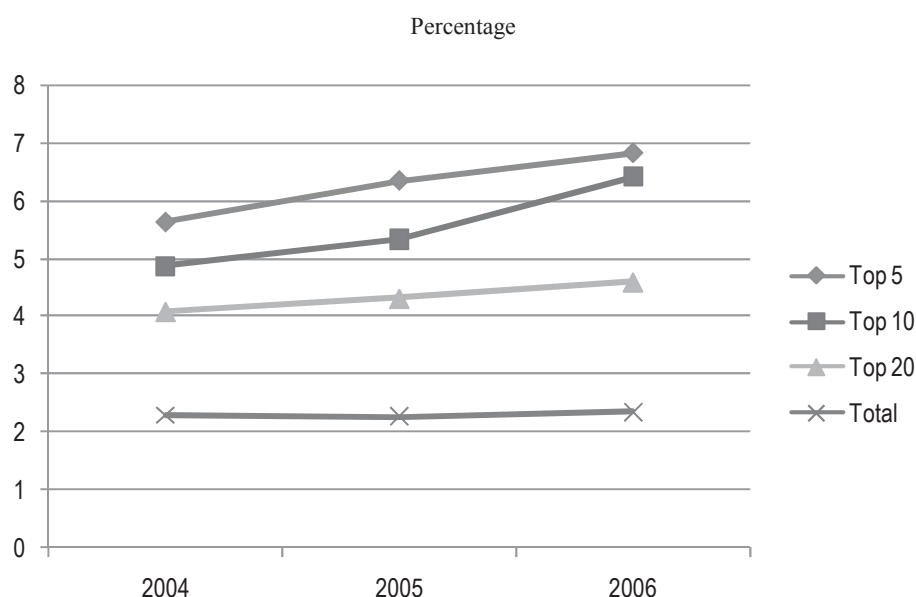
**Figure 2.5. Concentration of BERD, 1999-2006**

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.

**Figure 2.6. Concentration of company researchers, 1999-2006**

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.

In recent years, large Korean firms have devoted a greater proportion of their income to R&D expenditure. As Figure 2.7 shows, the most recent years have seen large increases, and in 2006 the top five companies had an R&D expenditure-to-sales ratio of 6.84, up from 5.64 in 2004. Similar scale increases are also evident in the top ten and top 20 firms. However, as this is not the case for Korean firms as a whole, it highlights a growing divergence between the largest firms, which increasingly operate at technological frontiers, and the remainder of Korean industry, much of which remains largely engaged in imitative catch-up.

**Figure 2.7. Recent trends in the ratio of R&D expenditure to sales in top companies, 2004-06**

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.

Overall, large firms accounted for 76% of R&D expenditure in 2006 (Table 2.8), but somewhat less than their 88% in 1997 on the eve of the Asian financial crisis. Korea is not an exception in this respect, as the concentration of R&D in large firms is even stronger in some other advanced and bigger countries, such as the United States, Japan and Germany. The main difference is the extreme concentration of private R&D spending in a small number of large firms, which suggests that the chaebol continue to control the key assets and capabilities of Korea's innovation system, so that science and technology decisions are overwhelmingly shaped by their strategies. While the government has had some success in supporting the development of SME capabilities, as well as in improving competitive conditions for innovative start-ups (see Chapter 3, section 3.6), the continuing dominance of large firms in this area risks perpetuating Korea's dualistic industrial structure (Ernst, 2000).

**Table 2.8. R&D expenditure by firm size, 2001-06**

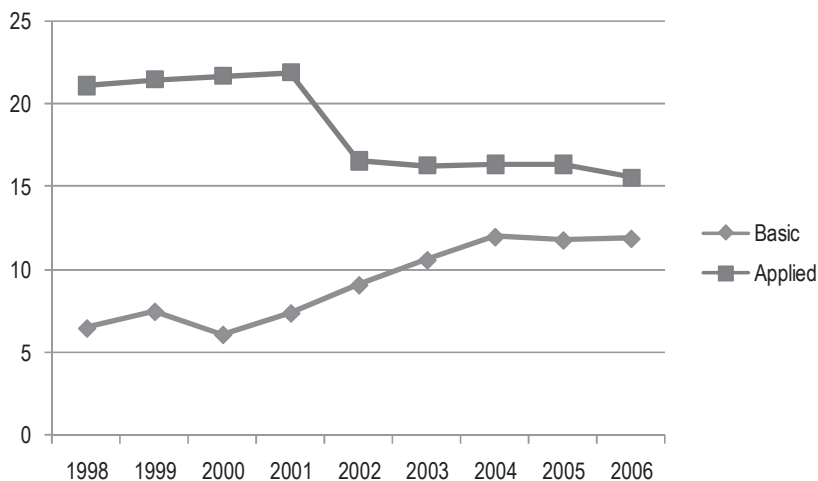
KRW millions and percentages

|                    | 2001               | 2002               | 2003                | 2004                | 2005                | 2006                |
|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|---------------------|
| <b>Large firms</b> | 8 736 966<br>(71%) | 9 337 066<br>(72%) | 11 084 236<br>(76%) | 13 464 089<br>(79%) | 14 642 880<br>(79%) | 16 021 718<br>(76%) |
| <b>SMEs</b>        | 3 536 613<br>(29%) | 3 638 287<br>(28%) | 3 425 427<br>(24%)  | 3 555 721<br>(21%)  | 3 921 363<br>(21%)  | 5 105 062<br>(24%)  |
| <b>Total</b>       | 12 273 579         | 12 975 354         | 14 509 663          | 17 019 811          | 18 564 243          | 21 126 780          |

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.

Not only has private-sector R&D expenditure soared in recent years, its nature has changed as well. As Figure 2.8 shows, the share of basic research has almost doubled, from 6.5% in 1998 to around 12% since 2004. The proportion of experimental development has remained static over the same period, while the share of applied research has declined, accounting for just over 15% of private sector R&D expenditure in 2006. The shift may have two main drivers. First, private-sector R&D is heavily concentrated 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. Second, at the other end of the scale, SMEs and “venture companies” have also contributed to increases in basic research expenditures. Though starting from a low base, their basic research expenditures increased by more than 60% in 2006 compared to the previous year (Table 2.9). The overall result is that the private sector now accounts for the largest volume of basic research in Korea, spending around 50% more than the public sector (Figure 2.9). Given that private-sector investments in basic research are highly sensitive to industrial shocks and business cycles, Korea’s commitment to basic research is perhaps more fragile than in the leading economies in which the public sector tends to conduct a larger share of such research.

**Figure 2.8. Percentage of firms’ total R&D expenditure on basic and applied research, 1998-2006**



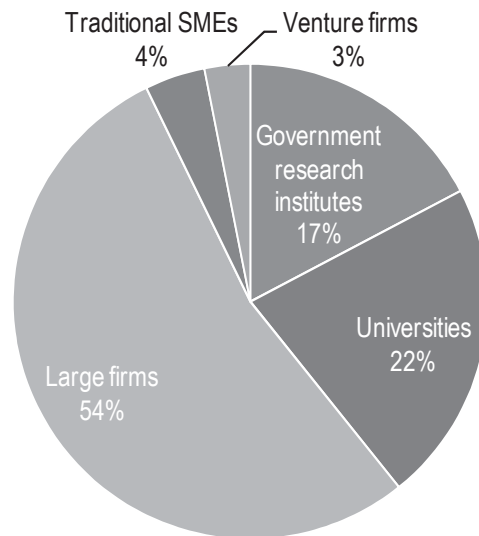
Source: MoST and KISTEP (2007), *Report on the Survey of Research and Development in Science and Technology*, Ministry of Science and Technology and Korea Institute of Science and Technology Evaluation and Planning, Seoul.

**Table 2.9. Expenditure on basic research by sector of performance, 2005-06**

KRW hundred millions and percentages

| Section                    | 2005           |               | 2006           |               | Increase/decrease |              | Growth rate (%) |             |
|----------------------------|----------------|---------------|----------------|---------------|-------------------|--------------|-----------------|-------------|
|                            | Total          | Basic         | Total          | Basic         | Total             | Basic        | Total           | Basic       |
| Public research institutes | 31 929         | 6 845         | 34 971         | 7 167         | 3 042             | 322          | 9.5             | 4.7         |
| Universities               | 23 983         | 8 338         | 27 219         | 9 092         | 3 236             | 754          | 13.5            | 9.0         |
| Companies                  | 185 642        | 21 885        | 211 268        | 25 173        | 25 625            | 3 288        | 13.8            | 15.0        |
| Large                      | 146 429        | 20 026        | 160 217        | 22 182        | 13 788            | 2 156        | 9.4             | 10.8        |
| Small and medium-sized     | 19 911         | 1 055         | 25 031         | 1 705         | 5 120             | 650          | 25.7            | 61.6        |
| Venture                    | 19 302         | 804           | 26 019         | 1 287         | 6 717             | 483          | 34.8            | 60.1        |
| <b>Total</b>               | <b>241 554</b> | <b>37 068</b> | <b>273 457</b> | <b>41 433</b> | <b>31 903</b>     | <b>4 364</b> | <b>13.2</b>     | <b>11.8</b> |

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.

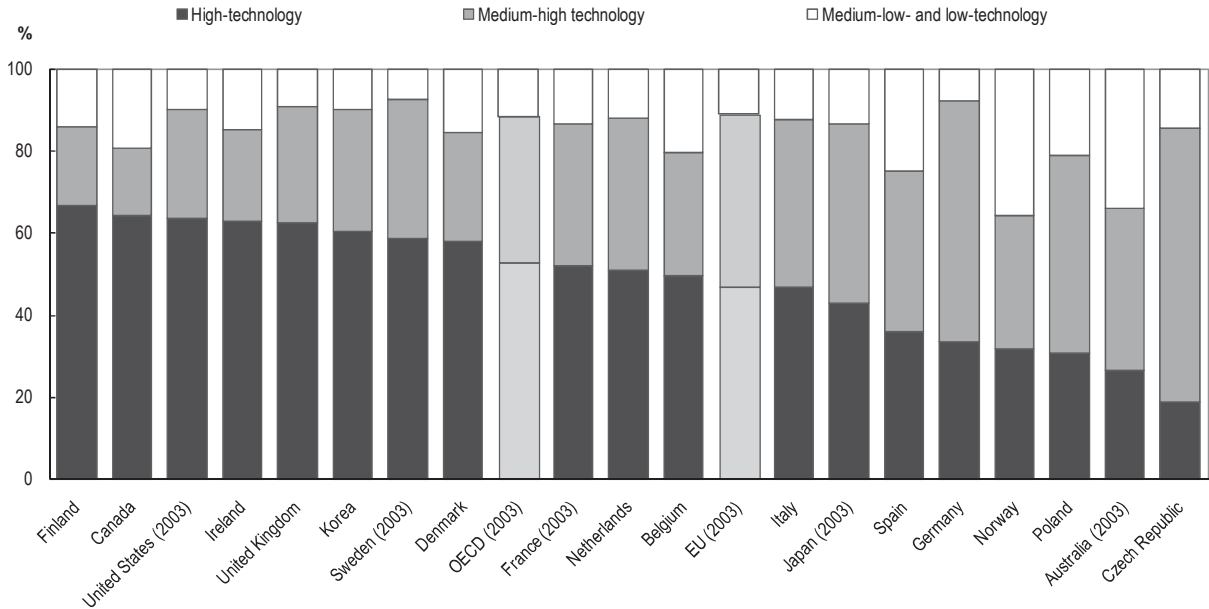
**Figure 2.9. Share of total basic research performed by public and private sector actors, 2006**

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.

Figure 2.10 shows that business R&D expenditure in Korea is heavily focused upon high-technology industries. The distribution of R&D expenditures among industries reflects the strong overall concentration on certain products and technological fields. Thus, the electronic parts industry plays a dominant role, followed by the automobile industry and the audio/video/communication equipment industry. By contrast, other R&D-intensive industries, such as pharmaceuticals or instruments, are weak (Figure 2.11).

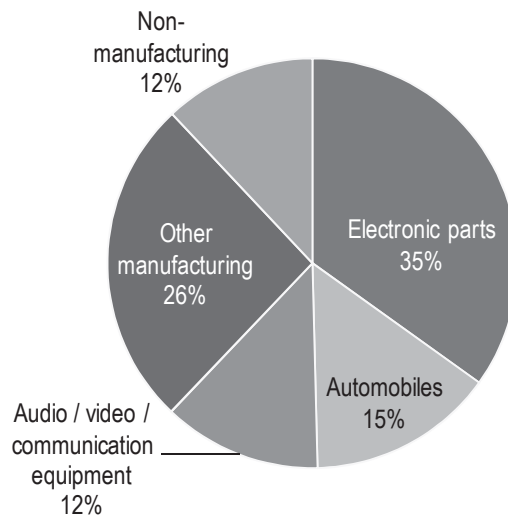
The concentration of R&D in a few sectors contributes to the dualism of the Korean economy and may not provide a broad enough base to promote the convergence to the income levels of the most advanced OECD countries (OECD, 2005a).

**Figure 2.10. Share of business R&D in the manufacturing sector by technological intensity, 2004**



Source: OECD, ANBERD database, June 2007.

**Figure 2.11. Composition of Korean BERD by industry, 2004**



Source: Hemmert (2007), "The Korean Innovation System: From Industrial Catch-Up to Technological Leadership?", in J. Mahlich and W. Pascha (eds.), *Innovation and Technology in Korea: Challenges of a Newly Advanced Economy*, Springer, Heidelberg.

KOITA (2000) and STEPI (2005) have examined some of the bottlenecks facing Korean firms in the performance of R&D. As Table 2.10 shows, the KOITA survey results are coloured by the situation after the 1997 economic crisis, with unavailability of finance, poor linkages (both inside and outside the firm) and the challenges of restructuring looming large among responses. By contrast, the bottlenecks identified in the more recent STEPI survey have seen a shift that reflects the constraints and risks associated with increasing leadership positions in R&D. The top constraint identified was excellent R&D personnel, while the risks associated with leading-edge R&D and innovation, including failure, imitation, competition and regulation, were all highlighted. This is quite a change in the space of a few years, but also a good indication of the real progress many firms have achieved.

**Table 2.10. Bottlenecks to innovation by firms, ranked by significance**

| KOITA survey (2000)                                              | STEPI survey (2005)                     |
|------------------------------------------------------------------|-----------------------------------------|
| 1. Financing R&D expenditure                                     | 1. Excellent R&D personnel              |
| 2. Failure to commercialise R&D results                          | 2. High R&D risk                        |
| 3. Unexpected transfer of key R&D personnel                      | 3. Large R&D expenditure                |
| 4. Inefficient co-operation with other departments within a firm | 4. Easy imitation by competitors        |
| 5. Poor external network system (with universities)              | 5. Deficient technological information  |
| 6. Heavy burden of restructuring                                 | 6. Financing R&D expenditure internally |
| 7. Depressed atmosphere due to restructuring                     | 7. Severe competition                   |
| 8. Little interest of chief executive officer in R&D             | 8. Deficient business service           |
| 9. Others                                                        | 9. Institutional regulation             |

Source: KOITA (2000), *Industrial Technology White Book*, Korea Industrial Technology Association, Seoul, and STEPI (2005), *Report on the Korean Innovation Survey 2005: Manufacturing Sector*, Science and Technology Policy Institute, Seoul.

Finally, a significant part of Korean BERD is spent via large private R&D institutes operating relatively independently of their parent companies, *e.g.* LG-Elite, an LG Group R&D institute, and the Samsung Advanced Institute of Technology (SAIT), which employ thousands of scientists and engineers. Other large corporations with significant internal R&D centres in their prime business units include KT Corp., SK Group, Hyundai Motors and Hynix. There are concerns in the literature about continuing reliance on the central corporate lab model, which in many countries has tended to be replaced or at least integrated within a network model able to access highly advanced technology from many sources around the world (Hobday *et al.*, 2004). Ernst (2000) suggests that a bias for centralised R&D organisations also reinforces the weak domestic linkages among the different actors involved in the process of technology generation and diffusion. This is said to apply particularly to linkages between large manufacturing companies and their component suppliers. It is beyond the remit of this review to explore the organisation of Korean corporate R&D and its relative pros and cons, but it is clear that the leading chaebol are increasing their international technology networking in countries such as the United States, the United Kingdom, Russia, Japan and China (see Box 2.6).

### Box 2.6. Overseas R&D centres of the leading chaebol, 2005

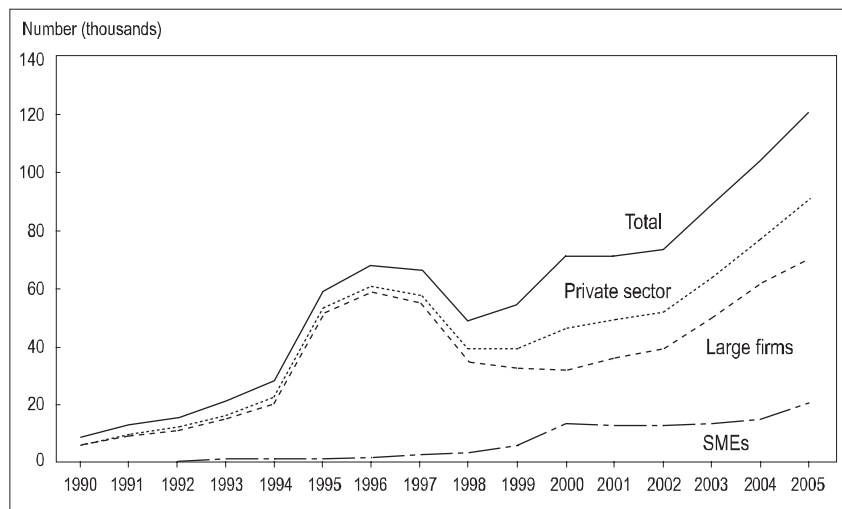
The Korea Industrial Technology Association (KOITA) reports that Korean firms had set up around 60 overseas R&D centres by 2005. Three Korean global corporations have been particularly prominent in setting up overseas R&D centres from the mid-1990s onwards:

1. Samsung Electronics operates ten overseas R&D centres around the world in addition to 40 or so in Korea. The first overseas centre was set up in the United Kingdom in 1991, with subsequent centres established in Russia (1993), Israel (1997), Japan (1997) and the United States (1997). More recently, Samsung has opened three R&D centres in China.
2. LG Electronics has opened an even larger number of overseas R&D centres that deal with aesthetic design, collect technical information, develop software and develop specific technologies. The geographical distribution of LG's R&D centres mainly focuses on China (four centres), the United States (three centres), and Japan (two centres). These outposts monitor technological change at the frontier, seek opportunities to develop strategic alliances with foreign firms, and develop state-of-the-art products through advanced R&D.
3. Finally, Hyundai Motors has also built an overseas network of R&D centres to tap into advanced technology and design. Of its five centres, three are located in the United States.

### 2.1.6. Firms' patenting behaviour

Figure 2.12 shows the innovative performance of Korean firms measured in terms of domestic patent applications. On the whole, the number of patents applied for by the private sector has increased rapidly over the last 15 years, mostly on account of the activities of large firms. However, the pattern has changed since the 1997 Asian financial crisis. First, the relationship between total domestic patent applications and private-sector patent applications has weakened because the share of patents applied for by other actors, such as GRIs and universities, has increased. Second, the number of patents applied for by SMEs increased markedly in 2000 when thousands of new “venture firms” were established (see section 2.3). SME patenting has continued to grow steadily to reach 20 597 patent applications in 2005.

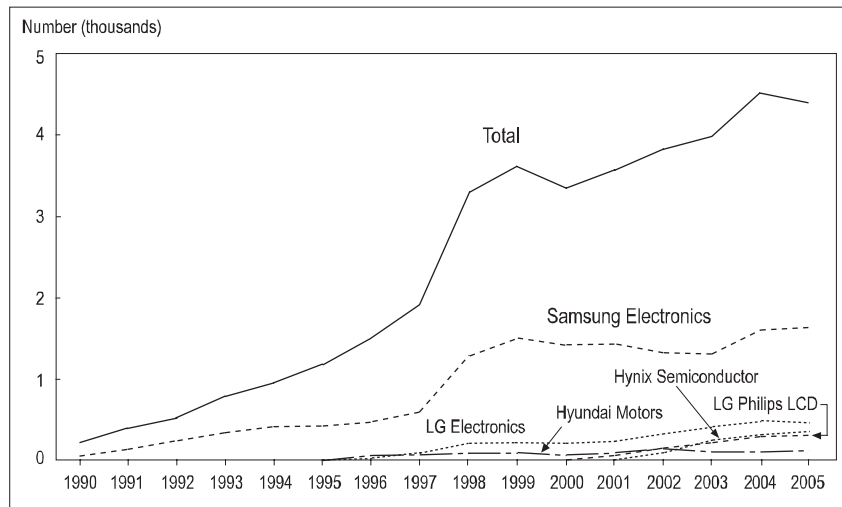
Figure 2.12. Domestic patent applications by firm size, 1990-2005



Source: KIPO (2006), *Patent Trends in Korea 2006*, Korea Industrial Property Office, Seoul.

Similarly, the number of Korean patents granted by the US Patent & Trademark Office (USPTO) has increased rapidly (Figure 2.13). Samsung Electronics, LG Electronics, Hynix Semiconductor, LG Philips LCD, and Hyundai Motors have led the growth in US patenting, but the international patenting of Korean SMEs remains weak.

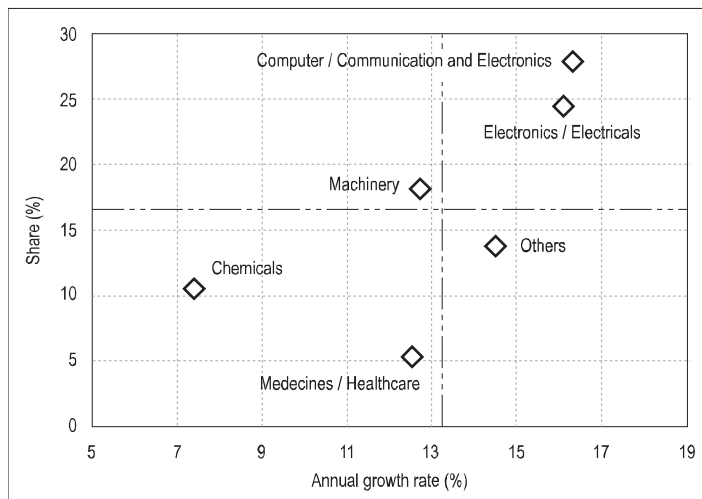
**Figure 2.13. Korean patents granted by the USPTO, 1990-2005**



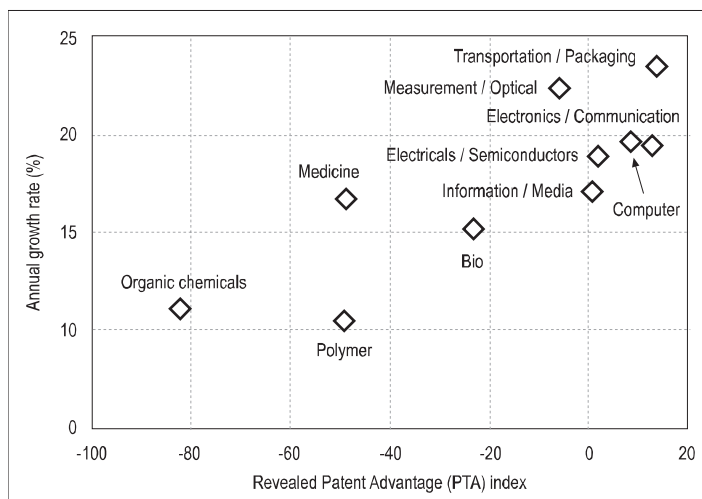
Source: KIPO (2006), *Patent Trends in Korea 2006*, Korea Industrial Property Office, Seoul.

In terms of patenting behaviour by Korean industry over the 15 years to 2005, the leaders have been computer and communication and the electronics and electrical industries (Figure 2.14). By contrast, the medicine and healthcare and the chemicals industries patent relatively little. The machinery industry has a higher than average share of patents, but the annual growth rate in patenting activity is below average. Finally, other sectors, including textiles, construction, consumer products, food and beverages, printing, agricultural products, lighting products, and paper, while they account for a smaller than average share of patents, nevertheless all recorded above average annual growth. The lighting products, construction and printing industries led the growth.

Figure 2.15 plots the RPA (revealed patent advantage) index against the average annual growth rate of patent applications. As expected, the results mirror those of industrial sectors, with electrical, semiconductor, electronics, communication and computer technologies recording high performances in both RPA and annual growth rates. However, transport and packaging technologies recorded the strongest performance. Chemicals, medicine and biotechnology all recorded below average RPA indices and annual growth rates.

**Figure 2.14. Patents by industry, 1990-2005**

Source: KIPO (2006), *Patent Trends in Korea 2006*, Korea Industrial Property Office, Seoul.

**Figure 2.15. Patents by technology, 1990-2005**

Source: KIPO (2006), *Patent Trends in Korea 2006*, Korea Industrial Property Office, Seoul.

### 2.1.7. Exploitation of emerging technologies

As the BERD data seem to suggest, Korean firms are now working at the frontier in several technological areas which include emerging technologies, such as nanotechnology and biotechnology. For example, Korea's large electronics and automobile corporations are active in the development and practical application of nanotechnology products. Many have established nanotechnology research centres and in some cases have already brought products to the market. Samsung developed the world's first 38" colour CNT-FED (carbon nanotube field emission display) prototype and has commercialised it, while Iljin Nano Tech has begun mass-producing carbon nanotubes (Wieczorek, 2007). Table 2.11 presents Korea's major successful nanotechnology companies.

**Table 2.11 Korea's major successful nanotechnology companies**

| Type of development      | Items                | Developer                                 | Major features                                       |
|--------------------------|----------------------|-------------------------------------------|------------------------------------------------------|
| Creation of architecture | CNT-FED              | Iljin Nanotech                            | Next generation display architecture                 |
|                          | NAND flash memory    | Samsung Electronics & Hynix Semiconductor | More applicable than DRAM                            |
| Parts and equipment      | ALD equipment        | Jusung Engineering Co.                    | Core process equipment for nano-scale semiconductors |
|                          | OLED panel           | Samsung SDI                               | Upgraded mobile display parts                        |
| New materials            | Nano                 | SilverStar Corporation                    | Diverse uses for consumer products                   |
|                          | Silicon Resin Powder | Nano Tech                                 | Nano-size minute particles                           |

Source: Lee and Suh (2006), *The Characteristics of Technological Innovation in the Nanotechnology-based Industrial Goods Producers*, Science and Technology Policy Institute, Seoul.

Korean firms are also beginning to take leading positions in biotechnology. It is estimated that there are more than 600 biotechnology companies in Korea of which some 170 R&D companies and 430 sales companies. Of these, 61% work in biopharmaceuticals and the rest in areas such as bio-foods, bio-chemicals, bio-environments, bio-energy and resources, bio-process and bio-equipment, and bio-electronics and bioinformatics.<sup>1</sup> Table 2.12 lists some major successful biotechnology companies, including those listed on the KOSDAQ (Korean Securities Dealers Automated Quotations) stock exchange. They can be grouped into three types according to their R&D and innovation activities: *i)* large firms, such as LG Life Sciences and CJ, which perform all innovation-related activities themselves, including R&D, production and marketing; *ii)* pharmaceutical companies, such as Dong-A Pharmaceutical Co., Chong Kun Dang Pharm. and Samyang Genex Corporation, which specialise in specific fields; and *iii)* SMEs or venture firms, such as Bioneer and Viomed, which have expanded their businesses through the development of new technologies. Many of these firms are accredited by the Korean Biotech Venture Association (KOBIOVEN), which helps build networks and capacity.

**Table 2.12 Korea's major successful biotechnology companies**

| Applied fields            | Technologies                 | Companies                                                                                                |
|---------------------------|------------------------------|----------------------------------------------------------------------------------------------------------|
| Medicine and therapy      | Development of new medicines | LG Life Science, CJ, Dong-A Pharmaceutical, Chong Kun Dang Pharm., Crystal Genomics Incorporation, C-TRI |
|                           | Cell therapy                 | Cellontech, Binex Co., CreaGene                                                                          |
|                           | Gene therapy                 | Viromed, Welgene Inc.                                                                                    |
| Agriculture               | GMO, food flavouring         | Nexgen, Easy Bio System                                                                                  |
| Environment               | Microorganisms               | Inbionet, Dae Sung Microbiological Labs. Co.                                                             |
| Equipment and information | Analysis and culture         | Bioneer, Dae Han Biolink Co., KoBio Tech                                                                 |
|                           | Generic technologies         | Proteogen, Genexel, Bioneer, Istech                                                                      |

Source: Cho *et al.* (2005), *Next Generation Technology Innovation Method for Fostering Korea's Future Strategic Industries*, STEPI, Seoul.

## 2.2. SMEs and new technology-based firms

As discussed in the previous section, Korea's catch-up model has been dominated by the chaebol and has largely neglected SMEs. Indeed, the chaebol-dominated industrial structure which created economies of scale and scope and opportunities for substantial cross-subsidisation 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 (see Box 2.7).

### Box 2.7. The role of SMEs in Korea and Chinese Taipei

The pervasive role that the chaebol have played as engines of growth and industrial transformation sets Korea apart from Chinese Taipei, where SMEs have been the main sources of industrial development. In Korea, most SMEs continue to focus on imitation based on reverse engineering. This has led to relatively inefficient learning when compared to Chinese Taipei, where SMEs were exposed early to apprentice-like learning arrangements with large firms, both foreign and domestic. These relationships have significantly strengthened the flexibility of Chinese Taipei's SMEs, enabling them to shift rapidly from relatively simple to increasingly complex forms of international sub-contracting.

Source: Ernst (2000), "Catching Up and Post-Crisis Industrial Upgrading: Searching for New Sources of Growth in Korea's Electronics Industry", East-West Center Working Paper, No. 2 March 2000, East-West Center, Honolulu.

There is, however, evidence that the position of Korean SMEs has slowly begun to improve in recent years. The following considers trends in R&D expenditure and discusses venture firms and their funding by venture capital. Finally, attention is given to innovation in the services sector, which is dominated by SMEs.

### 2.2.1. R&D expenditure in SMEs

As Table 2.13 shows, 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. A further point of interest is the amount of R&D expenditure spent per researcher. With large firms spending around USD 16 billion on approximately 100 000 researchers in 2006, their expenditure per researcher is almost 2.5 times greater than the amount spent by SMEs. This can probably be explained, in part, by the expensive facilities built by the large firms, but the fact that SME salaries are almost half those in the leading chaebol is undoubtedly a significant explanatory factor.

**Table 2.13. Evolution of R&D expenditures and researcher numbers (head count), 1997-2006**

|                    | R&D expenditure<br>(KRW billions and as a percentage of sales) |                   |                    |                    | Number of researchers<br>(doctoral level) |                   |                   |                    |
|--------------------|----------------------------------------------------------------|-------------------|--------------------|--------------------|-------------------------------------------|-------------------|-------------------|--------------------|
|                    | 1997                                                           | 2000              | 2003               | 2006               | 1997                                      | 2000              | 2003              | 2006               |
| <b>SMEs</b>        | 1 090.2<br>(2.82)                                              | 2 106.4<br>(3.14) | 3 425.4<br>(3.57)  | 5 105.1<br>(2.10)  | 17 703<br>(474)                           | 36 494<br>(1 543) | 52 332<br>(2 291) | 74 875<br>(6 573)  |
| <b>Large firms</b> | 7 755.1<br>(2.07)                                              | 8 148.2<br>(1.81) | 11 084.2<br>(2.05) | 16 021.7<br>(2.22) | 56 990<br>(3 613)                         | 57 839<br>(3 878) | 71 698<br>(5 562) | 99 029<br>(15 814) |

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 2.14 shows that the recent spectacular growth of R&D activities in Korean SMEs can be accounted for by growth in both the “traditional” SME sector and the so-called “venture firm” sector (see below). 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.

**Table 2.14. Status of R&D expenditure and number of researchers by company type, 2004-06**

KRW millions and head count

|                           | 2004                |                 | 2005                |                 | 2006                |                 |
|---------------------------|---------------------|-----------------|---------------------|-----------------|---------------------|-----------------|
|                           | Expenditure         | Researchers     | Expenditure         | Researchers     | Expenditure         | Researchers     |
| <b>Large corporations</b> | 13 464 089<br>79.1% | 79 910<br>59.5% | 14 642 880<br>78.9% | 91 514<br>59.3% | 16 021 718<br>75.8% | 99 029<br>56.9% |
| <b>SMEs</b>               | 1 890 242<br>11.1%  | 28 683<br>21.4% | 1 991 126<br>10.7%  | 30 619<br>19.8% | 2 503 113<br>11.8%  | 36 055<br>20.7% |
| <b>Venture businesses</b> | 1 665 479<br>9.8%   | 25 707<br>19.1% | 1 930 237<br>10.4%  | 32 173<br>20.9% | 2 601 949<br>12.3%  | 38 820<br>22.3% |
| <b>Total</b>              | 17 019 811          | 134 300         | 18 564 243          | 154 306         | 21 126 780          | 173 904         |

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.

Several factors contribute to this turnaround in the R&D activities of SMEs, some of which are further explained below. One important change in the wake of the Asian financial crisis is that the chaebol now play a more supportive role in the development of a vibrant SME sector. As the chaebol have moved to technological leadership positions, supplier companies have had to substantially enhance their R&D capabilities in order to meet increased technological demands. To illustrate this, Table 2.15 shows the dramatic growth in R&D investment, particularly in the electronics industry, by some of the top chaebol suppliers. In most cases, these dramatic increases in R&D expenditure coincide with remarkable increases in financial performance. An example of a Samsung-driven cluster of SMEs in the mobile telecommunications sector is briefly described in Box 2.8.

**Table 2.15. Characteristics of top chaebol suppliers**

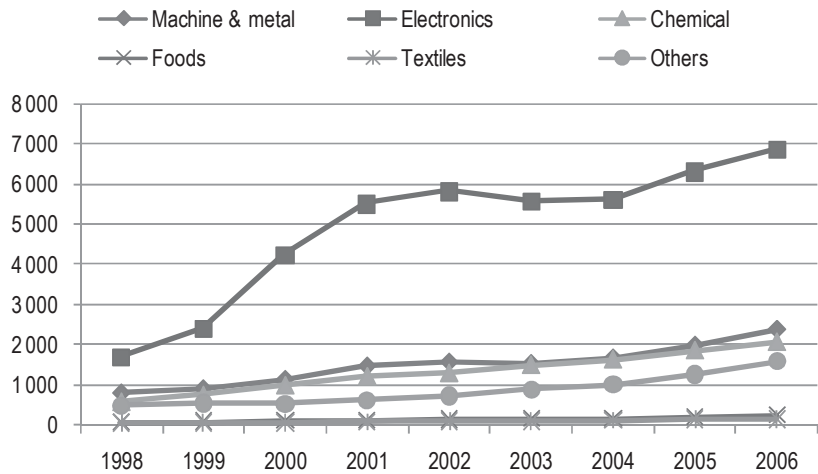
| Industry           | Company                 | Year established | R&D intensity 2001 | R&D intensity 2006 | Turnover 2001 (KRW 100 million) | Turnover 2006 (KRW 100 million) | Growth rate (%) |
|--------------------|-------------------------|------------------|--------------------|--------------------|---------------------------------|---------------------------------|-----------------|
| <b>Electronics</b> | MTEK-Vision             | 1999             | 19.2               | 28.9               | 36                              | 1 186                           | 3 169           |
|                    | Jusung                  | 1995             | 228.6              | 21.2               | 499                             | 1 210                           | 143             |
|                    | Aceteq                  | 1980             | 12.9               | 10.9               | 805                             | 1 032                           | 28              |
|                    | PSK Inc.                | 1990             | 11.0               | 9.1                | 130                             | 1 289                           | 895             |
|                    | Corelogic               | 1988             | 42.1               | 7.8                | 13                              | 1 902                           | 14 272          |
|                    | KCTech                  | 1987             | 9.8                | 6.4                | 3 618                           | 9 459                           | 161             |
|                    | Seoul Semi-conductors   | 1987             | 6.8                | 6.3                | 428                             | 1 838                           | 330             |
|                    | Homecast                | 2000             | 4.6                | 6.2                | 164                             | 1 010                           | 517             |
|                    | Humax Digital           | 1989             | 3.7                | 5.8                | 3 151                           | 6 559                           | 108             |
|                    | Elentec                 | 1982             | 1.5                | 4.7                | 1 105                           | 1 672                           | 51              |
|                    | Inzi-display            | 1992             | 4.9                | 4.7                | 325                             | 2 089                           | 542             |
|                    | Dongjin                 | 1967             | 1.4                | 4.5                | 1 596                           | 2 266                           | 42              |
| <b>Auto</b>        | JYSolutech              | 1984             | 2.2                | 7.5                | 791                             | 1 743                           | 120             |
|                    | Saeronauro              | 1999             | 6.3                | 6.2                | 494                             | 1 063                           | 115             |
|                    | Samsung Climate Control | 1954             | 2.9                | 4.6                | 980                             | 1 029                           | 5               |
|                    | DRB                     | 1945             | 2.9                | 4.2                | 1 403                           | 1 703                           | 21              |
| <b>Materials</b>   | SSCP Corp               | 1985             | 6.1                | 6.6                | 586                             | 1 587                           | 171             |

Source: Private communication, Kwang H. Lee, STEPI, 2008.

Box 2.8. Gumi mobile cluster

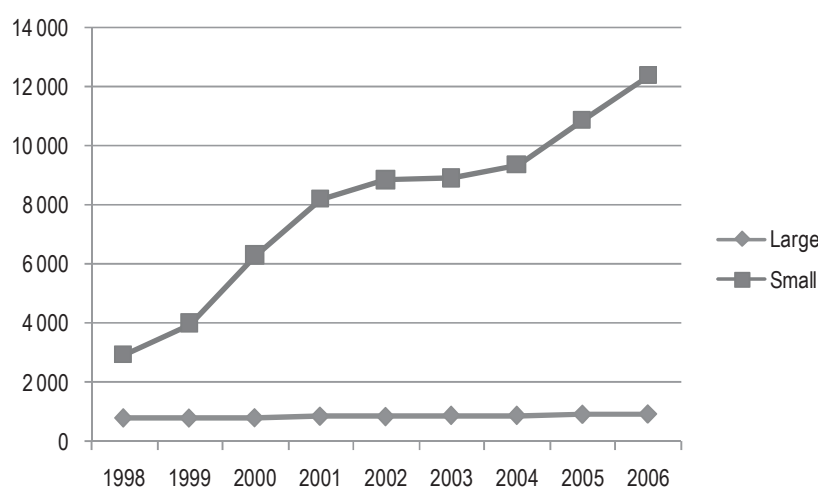
A particular case of the influence of a major chaebol in driving supplier and associated companies is provided by the rapid development since 2000 of a mobile telecommunication cluster in Gumi (Lee, 2006). The region has more than 350 mobile companies which produce more than 90% of total mobile sales. The major force behind the cluster formation was the outsourcing strategy of Samsung Electronics. Technological and market uncertainties have led Samsung to expand its outsourcing. Its sharp expansion of telecommunications sales in the global market (a 65.4% increase in the two years from 2002 to 2004) has driven the rapid expansion of the local agglomeration of mobile companies. Most of the contract suppliers have accumulated core technologies through their Samsung contracts. However, recognising their vulnerability to sudden changes at Samsung, they have also sought to develop independent strategies and customers.

Figure 2.16. Number of industrial research institutes by sector, 1998-2006



Source: KOITA (2007), *Status and Problems of Foreign Invested Firms' R&D in Korea*, Korea Industrial Technology Association, Seoul.

Figure 2.17. Number of industrial research institutes by firm size, 1998-2006



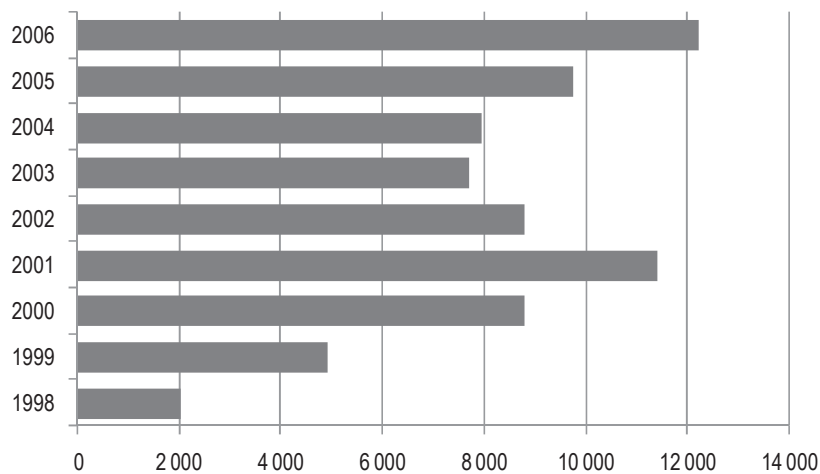
Source: KOITA (2007), *Status and Problems of Foreign Invested Firms' R&D in Korea*, Korea Industrial Technology Association, Seoul.

The growth in SMEs' share of business expenditure on R&D has naturally led to the establishment of many more industrial (private-sector) research "institutes" in recent years. In the early 1980s, Korea had fewer than 60 such institutes, but as a result of various government incentives, there were a few thousand by the eve of the Asian financial crisis. In 1998, there were 800 industrial research institutes in large firms and almost 3 000 in SMEs. A little under half of the total was from the electronics industry, and a little over one-fifth from the machine and metals industry. The immediate aftermath of the Asian financial crisis saw a major upsurge in the establishment of industrial research institutes, with the number almost doubling from 1999 to 2001 to just over 9 000. The electronics industry was especially active, with the number of research institutes growing more than threefold over the three years from 1998 to 2001 and accounting for around two-thirds of the total increase during this period (Figure 2.16). Virtually all of the increase was accounted for by new research labs set up by SMEs (Figure 2.17). Incentive schemes, including R&D funding, tax waivers, tariff exemption for R&D equipment, and military service exemption for researchers fuelled much of the rapid expansion (see Chapter 3, section 3.6). Over the following few years, growth stabilised, but picked up again in 2005, and by 2006, Korea had just over 13 000 industrial research institutes (in 2008, they exceeded 15 000, a sign of continuing healthy growth). The latest surge is more broadly based than the previous one, with all industries seeing notable increases in the establishment of research labs.

### 2.2.2. *Venture firms*

One of the most notable phenomena in the Korean economy in the late 1990s was the emergence of the "venture company". A venture company can be generally defined as an early-stage innovative SME. However, there is a more specific legal definition for a Korean venture company, as the government enacted "Special Measures on the Promotion of Venture Companies" in 1997 to promote venture start-ups. According to this law, a venture company is defined as an SME: *i*) in which a venture capital firm (VCF) has invested; or *ii*) which has a relatively large R&D expenditure as a percentage of sales; or *iii*) whose business stems from technology, such as a patent.

The growth in the number of venture companies was catalysed by the down-scoping and down-sizing of the chaebol in the context of the Asian financial crisis and received further impetus from various government incentives (see Box 2.9 for factors contributing to the growth of venture companies). Their number increased from a mere 100 on the eve of the Asian financial crisis to around 5 000 by the end of 1999 (Kim, 2001). During much of 2000 and 2001, their number increased at a rate of more than 250 a month to over 11 000 by the end of 2001 (Figure 2.18). However, this growth surge was short-lived, as the bursting of the "Internet bubble" in 2001 and the general economic slowdown in Korea during 2002 led to the closure of many companies. Furthermore, in 2002, the Korean government tightened the qualification rules for venture companies, which also contributed to their decline in number. The number of venture companies started to increase again as of 2005 and exceeded 12 000 in 2006.

**Figure 2.18. Number of venture companies, 1998-2006**

Source: SMBA website ([www.smba.go.kr/smba/main/english/index.jsp](http://www.smba.go.kr/smba/main/english/index.jsp)), accessed November 2007.

### Box 2.9. Background for venture companies' growth

Five major factors allowed venture companies to flourish in the late 1990s in Korea:

1. *Economic restructuring* in the aftermath of the Asian financial crisis in 1997 provided the economic environment in which venture companies could flourish. Economic development since the 1960s had promoted large companies by concentrating resources into long-term capital-intensive industries. However, the financial crisis in 1997 witnessed a shift towards SMEs and away from large companies.
2. The *shift to a digital economy* and rapid growth of ICTs laid the foundation for many venture companies to start and grow. As the information and communications industry involved the development of many new technologies, it provided business opportunities for people with technology and ideas and this led to venture start-ups.
3. The *increased funding for venture capital and expansion of the KOSDAQ* provided the funds necessary for venture companies to be established and to grow. Increased funding for venture capital was essential for venture companies to thrive.
4. The *success of venture companies and venture capital* put an end to the idea that it is difficult to succeed only with technology. Early instances of successful venture companies and venture capital sparked a chain reaction in venture start-ups and venture investment.
5. The *government's strong venture promotion policies* created a favourable regulatory environment for venture companies and provided them with support. When promoting its venture policies the government overhauled and relaxed regulations to create an environment for venture start-ups and their growth (see Chapter 3, section 3.6).

Source: MoCIE website, accessed November 2007.

By industry, the manufacturing sector accounts for around 70% of venture companies, the software industry for the second largest share at around 20%, followed by the R&D service industry with around 4%. Funding is a difficult issue for venture companies, with more than half the firms recently surveyed by the Ministry of Commerce, Industry and Energy (MoCIE) reporting financial difficulties and only 14% indicating their financial status to be good. As Table 2.16 shows, a decreasing number of venture companies are underpinned by venture capital; the vast majority (84%) qualify for venture company status because they are a business with new technology. Accordingly, most companies surveyed by MoCIE – around 86% – have research centres or departments dedicated to research, and more than half indicated that their technologies are unique or the world's most advanced.

**Table 2.16. Trends in the status of venture companies, 2002-06**

| Classification                      | 2002            | 2003            | 2004            | 2005            | 2006            |
|-------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Venture capital (rate)              | 1 124<br>(12.8) | 718<br>(9.3)    | 442<br>(5.5)    | 330<br>(3.4)    | 301<br>(2.8)    |
| R&D business (rate)                 | 1 325<br>(15.1) | 1 483<br>(19.3) | 1 416<br>(17.8) | 1 425<br>(14.6) | 1 421<br>(13.3) |
| Business with new technology (rate) | 6 329<br>(72.1) | 5 501<br>(71.4) | 6 109<br>(76.7) | 7 977<br>(82.0) | 8 974<br>(83.9) |
| Total                               | 8 778           | 7 702           | 7 967           | 9 732           | 10 696          |

Source: SMBA website ([www.smba.go.kr/smba/main/english/index.jsp](http://www.smba.go.kr/smba/main/english/index.jsp)), accessed November 2007.

**Table 2.17. Number of spin-offs from university and research institutes as of August 2007**

| From universities |     |          |     | From research institutes |     |          |       |
|-------------------|-----|----------|-----|--------------------------|-----|----------|-------|
| Region            | No. | Region   | No. | Region                   | No. | Region   | No.   |
| Seoul             | 161 | Incheon  | 9   | Seoul                    | 400 | Incheon  | 56    |
| Pusan-Ulsan       | 35  | Kangwon  | 12  | Pusan-Ulsan              | 54  | Kangwon  | 13    |
| Taegu-Kyongbuk    | 56  | Chungbuk | 10  | Taegu-Kyongbuk           | 94  | Chungbuk | 28    |
| Kwangju-Chonnam   | 39  | Chonbuk  | 26  | Kwangju-Chonnam          | 61  | Chonbuk  | 16    |
| Taejon-Chungnam   | 52  | Kyongnam | 17  | Taejon-Chungnam          | 225 | Kyongnam | 48    |
| Kyonggi           | 62  | Chju     | 3   | Kyonggi                  | 390 | Chju     | 1     |
| Total             | 482 |          |     | Total                    |     |          | 1 386 |

Source: SMBA website ([www.smba.go.kr/smba/main/english/index.jsp](http://www.smba.go.kr/smba/main/english/index.jsp)), accessed November 2007.

Coinciding with the growth of venture companies, there have been determined efforts to facilitate the formation of spin-off ventures from universities and GRIs, with some degree of success. As Table 2.17 shows, as of August 2007, 482 ventures had been spun off from universities and 1 386 from GRIs. A specific example of a spin-off firm from Seoul National University is provided in Box 2.10.

**Box 2.10. SNU Precision Co Ltd: A successful start-up company**

SNU Precision Co Ltd was established in 1998, based on expertise in nano-metrology and nano-inspection systems at Seoul National University. The company's product range encompasses: two-dimensional measurement and inspection systems, including microscope video systems, gear measuring systems and wafer inspection systems; three-dimensional measurement and inspection systems, including interscan series, atomic force microscopes and conoscopic hologram microscopes; fibre-optic inspection systems, including ferrule inspection systems, defect inspection systems and interscan systems; automatic calibrators, including automatic volumetric error calibrators; and medical vision systems. It has 130 employees, and had sales of KRW 34 billion in 2006. It has developed as follows:

February 1998: Foundation of SNU Precision Co., Ltd., the first venture firm of Seoul National University.

February 2000: Registered as venture company.

July 2000: Established R&D institute.

December 2000: Established a fully owned subsidiary, SNU-YANJI Inc., in China.

March 2001: Developed and exported Ferrule Inspection System to the United States, Chinese Taipei, China.

April 2001: Concluded a contract for the supply of automation facilities to Samsung Corning Micro-optics.

July 2001: Funded by US KTB Network and KDB Capital.

August 2001: Developed and exported 3D surface profiling system (SIS-1000) to the United States and Chinese Taipei.

October 2001: Established a half-owned subsidiary, SNU-USA Inc, in the United States.

January 2002: Selected best venture company in Korea.

June 2002: Successful fundraising from Korean Development Bank.

August 2002: Supplied PS Inspection System to Major LCD manufacturers such as LG Philips, AUO, CMO, Hannstar, AMTC, Shintek, NEC, DNP, ACTI, SVA, BOE, CPT.

April 2004: World Market Share No.1 (Korea/Chinese Taipei/Japan/China).

January 2005: KOSDAQ listing.

March 2005: Korea IB Grand Prix (Best KOSDAQ Listed Company).

June 2005: Provider of 7G PSIS System to LG Philips-LCD and Samsung Electronics.

**2.2.3. SME financing and venture capital**

Korean SMEs have had difficulty borrowing from traditional lenders, largely on account of information asymmetry between lending financial institutions and borrowing SMEs and a lack of tangible collateral to secure creditors' confidence. For this reason the Korean government has been directly and broadly involved in SMEs' financing activities, *e.g.* through credit guarantees and policy loans. These are discussed in Chapter 3; the remainder of this section is devoted to venture capital funding.

With the designation of venture company status, SMEs are eligible for investments from venture capital firms (VCFs) and limited partnerships funds (LPFs). Generous tax incentives have been provided to investors in VCFs and LPFs, including 70-100% equity guarantees on investments in certain venture businesses. On account of these generous terms, the Korean venture capital market grew dramatically in the wake of the Asian financial crisis. Starting from a negligible base in the early 1990s, it almost tripled between 1998 and 2001. The market has since contracted, with just over 600 firms benefiting from venture capital funding in 2006 for a total investment of around USD 750 million. This is down from a peak in 2000, when almost 2 000 firms benefited from more than USD 2 billion (Figures 2.19 and 2.20). At the same time, the number of VCFs declined, from a peak of 147 in 2001 to 104 in 2006, while the number of venture capital funds declined to 350 from a peak of 430 in 2003 (see Figures 2.21 and 2.22).

These figures appear discouraging, but must be seen in the context of an unsustainable “bubble” in the KOSDAQ, which resulted in a crash in 2001-02. Since then, the venture capital market has stabilised and in some respects consolidated.

In 2006, the investors in these venture capital funds included government (24.0%), firms and individuals (22.6%), financial institutions (17.8%), pensions (16.9%), venture capitalists (14.3%) and others (4.4%). Thus, the major sources of venture capital funds are still government and firms/individuals. The role of financial institutions and pension funds remains limited when compared to the situation in Europe and North America. In 2006, almost 40% of venture capital funds were directed to ICTs, by far the biggest beneficiary. However, investment in this industry is on a clear downward trend, from almost 60% of total investment in 2001 to 50% in 2003 and to below 40% in 2006. The entertainment industry was the second biggest beneficiary, followed by the traditional manufacturing sector and biotechnology (Figure 2.23). As Figure 2.24 shows, a major portion of venture capital goes to venture firms that are more-than three years old, with just under a third to early-stage firms (less than three years old). This is comparable to figures in other parts of the world.

As Figure 2.25 shows, Korean venture capital funds reap their investments mostly through initial public offerings (IPOs), in stark contrast to the situation in the United States, where such investments are mostly realised through mergers and acquisitions (M&A). This is because the total M&A market is relatively small in Korea, amounting to only 2.9% of market capitalisation in 2005, well below the United States (6.9%), France (7.4%), Germany (9.4%) and the United Kingdom (9.9%) (OECD, 2007a). The full development of Korea’s venture capital sector has also been disadvantaged by a relatively undeveloped shareholder culture.

There are two further important concerns related to the venture capital system (OECD, 2005a):

- *Potential mismatches in demand and supply for venture capital over the long term.* There is a risk of mismatches in the demand for and supply of venture capital if the entrepreneurial sector provides insufficient investment opportunities, resulting in an excess of venture funds chasing too few start-ups. Private equity would then be concentrated on later-stage investments and traditional industrial sectors, with far less impact on potential growth. Thus, a key priority is to create an environment that encourages the supply of investment-ready SMEs.
- *Need to further privatise the venture capital system.* The role of the public sector as a source of venture capital should be gradually phased out, as in other OECD countries. Among other measures, this is likely to require regulatory change and incentives for institutional investors to play a fuller part in venture capital markets.

**Figure 2.19.**  
**Number of invested companies**

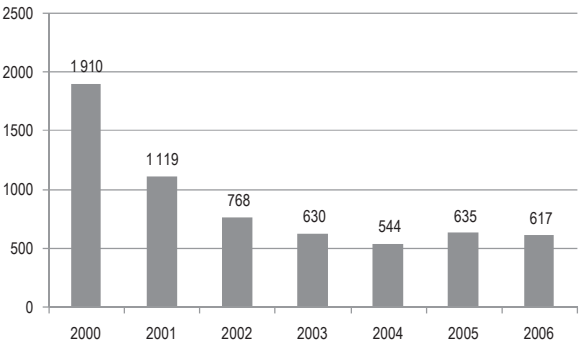


**Figure 2.20. Amount invested**  
**KRW billions**

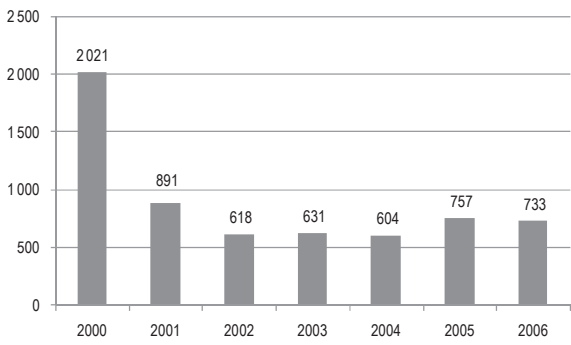


**Figure 2.21.**  
**Number of venture capital companies**

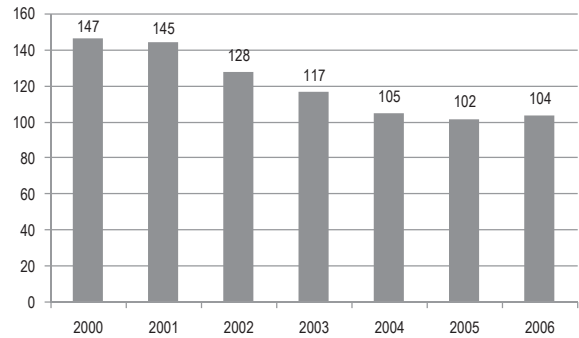


**Figure 2.22.**  
**Number of venture capital funds**

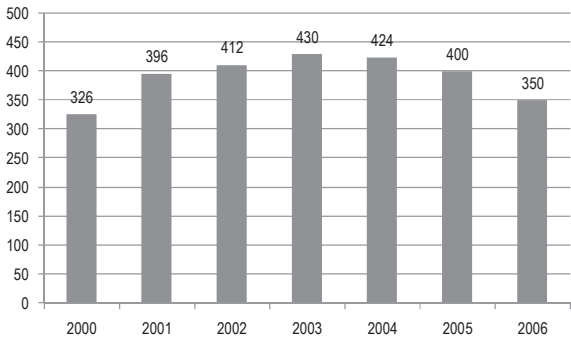


**Figure 2.23. VC investment by industry, 2006**  
Percentages (100% = KRW 733.3 billion)

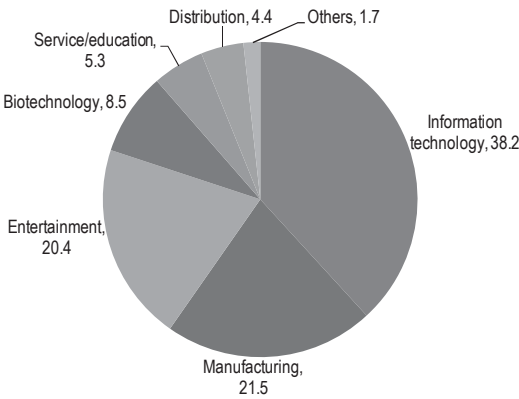
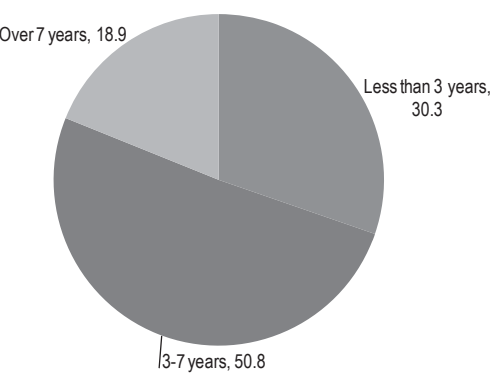
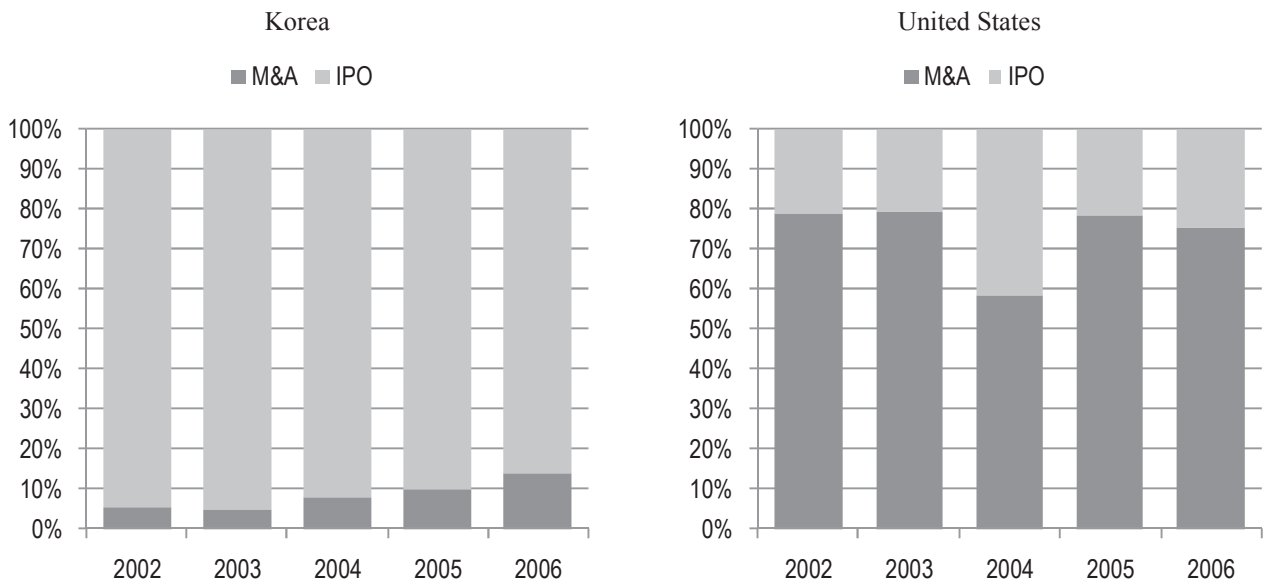


**Figure 2.24. Investment by stage, 2006**  
Percentages (100% = KRW 733.3 billion)



Source: SMBA statistics, cited in Ilshin (2007), “Venture Capital in Korea”, presentation to the OECD Country Review Unit, October 2007, Seoul.

**Figure 2.25. Exit by type in Korea and the United States, 2002-06**

Source: Korean Venture Capital Association, cited in Ilshin (2007).

Source: US National Venture Capital Association, cited in Ilshin (2007).

The KOSDAQ was established in 1996 to promote the access of SMEs to equity funding through easier entry requirements and less stringent operating obligations than the Korea Stock Exchange (KSE). In the wake of the Asian financial crisis, the KOSDAQ experienced a boom, followed by the technology market crash that led to a 90% fall in the stock price index in 2001-02. The market capitalisation of KOSDAQ has since recovered, as shown in Table 2.18, although the number of IPOs has continued to decline. By 2006, more than 80% of venture company IPOs were from companies backed by venture capital, indicating the importance of KOSDAQ for venture capitalists to realise their investments.

**Table 2.18. Trends in the KOSDAQ market, 2001-06**

|                                                          | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|----------------------------------------------------------|------|------|------|------|------|------|
| Number of listed companies <sup>1</sup>                  | 721  | 843  | 879  | 890  | 918  | 963  |
| Total market capitalisation <sup>1</sup> (KRW trillions) | 51.8 | 37.4 | 37.4 | 31.1 | 70.9 | 72.1 |
| Number of IPOs                                           | 171  | 153  | 71   | 52   | 70   | 56   |
| Number of IPOs of venture companies (A)                  | 134  | 105  | 58   | 37   | 61   | 43   |
| Number of IPOs of VC-backed venture companies (B)        | 73   | 53   | 36   | 28   | 49   | 35   |
| B / A (%)                                                | 54   | 50   | 62   | 76   | 80   | 81   |

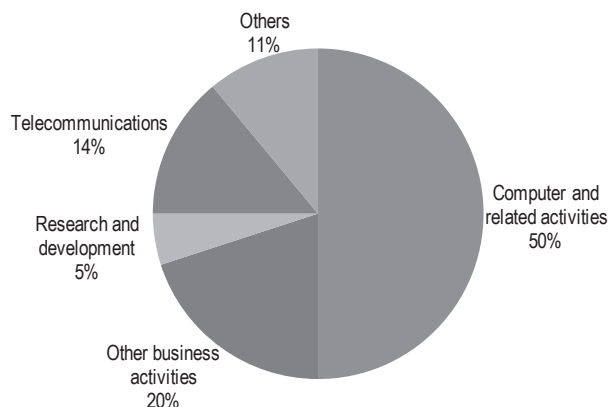
1. As of each year end.

Source: KVCA; Korean Stock Dealers Association, cited in Ilshin (2007).

### 2.2.4. Innovation in services

By industry, the services sector accounted for around 7% of BERD in 2006, one of the lowest rates in the OECD area, though not too far from the proportions seen in other exported-oriented, manufacturing economies, such as Japan, Germany and Sweden. Around three-quarters of this R&D was performed by the business services industry, which includes computer and related activities, research and development, and other business activities (Figure 2.26).

**Figure 2.26. BERD performed in service industries**



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

#### Box 2.11. Innovation in services

Boosting innovation in service industries is central to improving the performance of the services sector. The sector has traditionally been seen as less innovative than manufacturing and as playing only a supportive role in the innovation system. As a result, national innovation policies have paid scant attention to services, and service firms have not been active participants in government-sponsored innovation programmes. Recent work confirms, however, that services are more innovative than previously thought; indeed, in some areas, they are more innovative than the average manufacturing industry. In fact, knowledge-intensive business services play an increasingly dynamic and pivotal role in the knowledge-based economy.

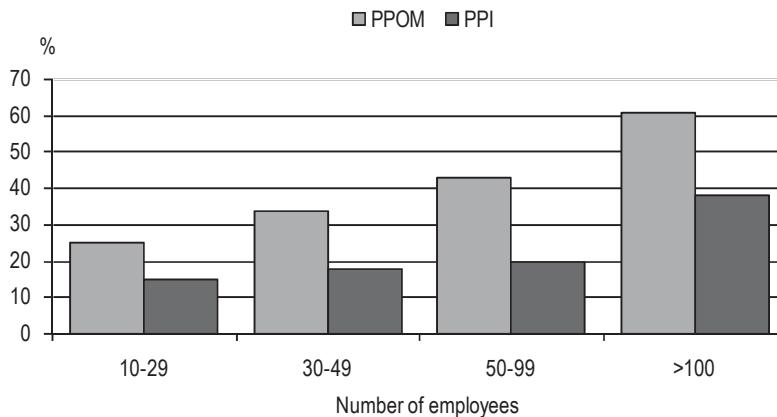
Innovation surveys suggest that service firms innovate for many of the same reasons as manufacturing firms: to increase market share, to improve service quality and to expand product or service range. However, how innovation occurs in the services sector is less well understood. Compared to manufacturing, most innovations in services appear to be non-technical and result from small, incremental changes in processes and procedures that do not require much formal R&D. Developing policy to support innovation in the services sector may therefore require new policies and programmes.

Source: Tamura *et al.* (2005), "Promoting Innovation in Services", in OECD (2005), *Enhancing the Performance of the Services Sector*, OECD, Paris.

R&D statistics provide only a partial picture, however, since most innovation in services appears to be non-technical and to result from small, incremental changes in processes and procedures that do not require much formal R&D (see Box 2.11). Innovation surveys are therefore better at capturing the nature of innovation activities and have been used widely around the world, including in Korea. The results of the most recent Korean innovation survey of services firms (STEPI, 2006) show that 17% of those surveyed carried out product or process innovation (PPI) during the 2003-05 period. If

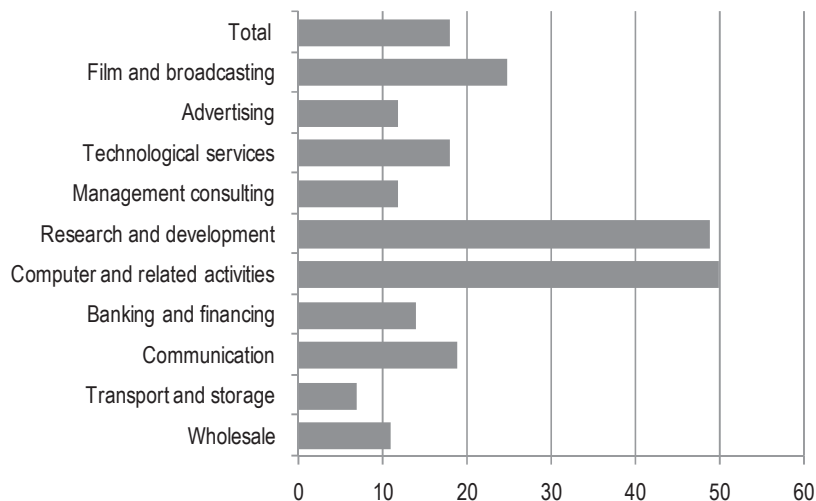
non-technological innovation, *i.e.* organisational and management innovation, is included (PPOM – product, process, organisational and management), the figure rises to 29%. In comparison, a similar survey of the manufacturing sector for the period 2002-04 (see STEPI, 2005) shows that 43% of firms engage in product and process innovation, but the figure reaches 48% when non-technological innovation is also included. Services therefore seem to be much less innovative than manufacturing. The gap is unusually wide by international standards: for instance, innovation survey data for European Union countries (CIS-4 for 2002-04) show that 37% of EU27 service firms and 42% of manufacturing firms were innovative.

**Figure 2.27. Innovation activities in the Korean services sector by firm size**



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

**Figure 2.28. Innovation activities in the Korean services sector by industry**



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

Figure 2.27 shows that the proportion of innovative enterprises increases significantly with the size of the enterprise, a pattern that is seen in innovation surveys around the world.<sup>2</sup> By industry, as seen in Figure 2.28, computer and related activities and research

and development are most active in technological innovation. The degree of innovation in traditional service industries such as wholesale, transport and storage; advertising; and banking and finance are lower than the average of the total services sector. The most serious barriers to technological innovation are the uncertainty of market demand, followed closely by lack of funds, excessive cost, and illegal copying of innovations (STEPI, 2006).

## 2.3. Government research institutes

By budget expenditure, the GRIs are the largest performers of research in the public sector, although their leading position is increasingly challenged by universities. They have played a significant part in the technological upgrading of Korean industry over the last four decades and have shown themselves in most cases able to adapt to fast-changing conditions. However, further reform and adaptation of the GRIs is on the political agenda and necessitates understanding of their current and potential contribution to the Korean innovation system. This section starts by describing the different public research organisations operating in Korea, before describing the development of the GRIs and their funding. Next, the continuing debate over the appropriate role of the GRIs in the wider innovation system is discussed, as is their attractiveness to prospective employees in the competitive labour market. Finally, the performance of the GRIs is reviewed, with reference to measures of academic publications, patent applications, and technology transfer.

### 2.3.1. Types of Korean public research organisations

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

- *Government-sponsored research institutes (GRIs)* – these are semi-autonomous research centres established by the Korean government. There are 100 GRIs in all, 52 of which are associated with the humanities and social sciences. While they operate with the financial assistance of the government, they are independent, non-governmental organisations operating under the provisions of the Law for the Creation and Promotion of the Government Research Institutes (1999). GRI researchers are therefore not civil servants. The largest GRIs fall directly or indirectly (through two research councils) under the Ministry of Education, Science and Technology (MEST) and the Ministry of Knowledge Economy (MKE). This section focuses on them.
- *National labs* – these are fully financed by the central government, which employs the research staff directly. There are currently 53 national labs, many of which are operated by the Ministry for Food, Agriculture, Forestry and Fisheries for the purpose of developing agricultural, fishery and food technology and technological capabilities in these areas.
- *Local government-sponsored research institutes* – these are autonomous organisations financially supported by local governments. The majority are involved in planning and linking local innovation actors to boost technological innovation in regions, and as such do not do scientific research themselves. There are 38 such organisations across Korea.

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

**Table 2.19. Distribution of public research organisations in Korea, 2004**

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

Source: Lee and Choi (2004), *Strategy to Manage Public R&D Institutes for Building-up Open Regional Innovation systems*, Science and Technology Policy Institute, Seoul.

Table 2.19 provides a summary of the various PROs in Korea. In terms of size and scope of activities, the GRIs are the most important and these are discussed further in this section.

### **2.3.2. Historical development of the GRIs**

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

In the 1970s, a number of specialised research institutes were established to keep pace with the rise in industrial sophistication and diversity. Each institute aimed to develop capabilities in strategic areas such as shipbuilding, geo-science, electronics, telecommunications, energy, machinery, chemicals, etc., in order to serve the growing needs of the private sector. The GRIs relied upon contract funding from enterprises and the government and were therefore relatively autonomous. According to Kim (2001), the capabilities developed by the GRIs strengthened the bargaining power of local enterprises, helping them to acquire increasingly sophisticated foreign technology and to develop competing technologies locally. Perhaps most importantly, the GRIs generated experienced researchers who then migrated to corporate R&D centres. In this sense, the GRIs spearheaded both technology development and human capital formation (Yim and Kim, 2005).

However, by the 1980s, Korean firms were criticising the research support being provided by the GRIs as failing to meet their needs. At the same time, the government believed that many “specialised satellite institutes” under related ministries were too small to achieve economies of scale and that this resulted in overlap and frequent duplication of research efforts (Yim and Kim, 2005). The government therefore consolidated 15 GRIs under various ministries into nine large research institutes under MoST, with the aim of upgrading and strengthening Korean research capability. It was thought that this restructuring would improve the managerial efficiency of GRIs by centralising management responsibility under the authority of a single ministry.

The Korean government was also keen for industry to perform a greater share of R&D so as to develop its own technological capacity. Thus, in addition to consolidating the number of GRIs, the government initiated national R&D programmes (NRDP) in 1982 to provide funding for the GRIs to collaborate with industry on areas of strategic research and technological development. This extra funding helped the GRIs to increase their research activities, but throughout the 1980s and 1990s, their performance continued to be criticised by government and business alike. Criticisms centred upon apparent duplication of research domains, poor R&D project management, and perceived low R&D productivity levels. According to Yim and Kim (2005), these problems can be attributed to a lack of consensus among the relevant government departments and GRI managers on the role and missions of GRIs, and to excessive government monitoring and control. It may also be argued that both business and government had overly high expectations of the contributions that the GRIs could reasonably make. Nevertheless, to boost research efficacy and productivity, from 1991 the GRIs were subject to regular evaluations of their performance, and in 1996 a contractual project-based management system (PBS) was introduced to replace the lump-sum system then in operation (see Box 2.12).

#### **Box 2.12. The project-based system (PBS)**

In 1996, the government changed its research funding system from a lump-sum system to a project-based system (PBS) in order to increase research productivity. Before the introduction of PBS, the manpower costs of GRI researchers were supported from the government budget and GRIs charged only direct research costs to each project. Under the PBS, GRIs have to charge manpower costs to research projects and must compete with universities and industries to obtain contract research. On the positive side, the PBS has contributed to the creation of a competitive R&D funding system for creative researchers and to the diffusion of the customer relationship and price concept in government R&D. However, the PBS has also received criticism. First, GRI researchers have been forced to shift their research focus away from basic research projects to short-term application-oriented projects as they seek more research contracts to cover their manpower costs. Second, PBS has encouraged greater use of cheaper temporary researchers at GRIs. Research budgets have been insufficient to cover the costs of permanent and experienced researchers so that the GRIs have had to rely upon MA or PhD students for much of their research manpower. As of 2002, 50% of GRI researchers were in irregular employment, including temporarily hired students.

*Source:* Yim and Kim (2005), “The Evolutionary Responses of Korean Government Research Institutes in a Changing National Innovation System”, *Science, Technology and Society*, Vol. 10, No. 1.

During the 1980s and 1990s, the number of GRIs continued to grow and there was further reorganisation through mergers and break-ups. Nevertheless, GRIs began to lose their once-dominant role, with industry quickly becoming the largest R&D funder and performer by the mid-1980s and with the universities also gradually catching up over time. Several analysts have explored some of the reasons for this relative decline. For instance, according to Linsu Kim (2001), because the GRIs were under the bureaucratic

control of the government, the environment creative individuals need to flourish had been stifled and they were less dynamic than their counterparts in corporate labs. He also pointed to the difficulties facing GRIs for retaining competent researchers, as many moved either to academic institutions for prestige and freedom or to corporate R&D laboratories for better economic conditions (see section 2.5).

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

The system underwent further change in 2004, when the then new government moved the three science and technology-based research councils from the Office of the Prime Minister to MoST. This move was part of a broader set of measures to strengthen a revamped MoST (see Chapter 3, section 3.3) and saw the biggest GRIs come under MoST's jurisdiction.

### ***2.3.3. Funding of GRIs***

The proportion of government support in total R&D expenditure differs by type of research field, research institute and historical dependency. Roughly speaking, around half of the GRIs' budget comes from a government core grant (Table 2.20), 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. Reflecting the government's emphasis upon funding more fundamental research, it is perhaps unsurprising to see that the GRIs under the supervision of the Korea Research Council of Fundamental Science & Technology (KRCF) enjoyed the largest budget increases overall in 2007 (up 16% on 2006). However, overall, the GRIs have benefited from the smallest increases in R&D spending over the last decade or so, with universities and firms accounting for an ever-increasing share of Korean R&D.

**Table 2.20. Government core grant to GRIs under the three<sup>1</sup> S&T research councils**

KRW millions

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

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

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

### 2.3.4. What role for the GRIs?

In spite of the reforms of recent decades, the role the GRIs should play in the Korean innovation system is still widely discussed. There remains a sense that they are not as effective and efficient as they could be. Indeed, according to the opening lines of the page devoted to GRIs on the MoST/MEST website,<sup>3</sup> “there have been grave concerns regarding research effectiveness and operational efficiency of the GRIs’ R&D activities”. It is clear that for many, these concerns remain, but whether they are justified or not is open to question. The main problem – stretching back perhaps 30 years – has been a lack of consensus on the role that the GRIs should play in the innovation system. Korea is hardly alone in this uncertainty, as the role of PROs has been called into question across the OECD area in recent decades (see Box 2.13). Yet, PROs remain extremely important players in national research systems, and especially in Korea where university research still remains relatively weak. Because they have been poorly studied, PROs have often been victims of stereotypes and of policy fashions (Larédo, 2008), and Korean GRIs are no exception in this regard (Lee, Kong-Rae, 2007). In fact, PROs vary widely, with different types of organisations facing different issues that require different policy responses. This observation also applies to Korean GRIs, and more attention should be paid to this sort of differentiation.

#### Box 2.13. Public research organisations under pressure

Changes in government missions over the past several decades have necessitated adjustments in the structure, organisation and roles of non-university public research organisations. The role of PROs has already diminished relative to universities in terms of R&D performance, in part because of reductions in the defence budgets of many larger OECD members and further restructuring of national science systems in response to changing priorities for mission-oriented research. Several OECD members have undertaken reforms of their PROs, but this restructuring is far from complete in most countries. Questions remain regarding the organisational and institutional changes that are needed to improve their ability to respond flexibly to evolving societal objectives over the long term and the respective roles of government laboratories and universities in the public research system.

While government laboratories have made numerous contributions to industrial innovation and economic growth, econometric analysis suggests that the effects of publicly funded R&D on productivity growth are larger in countries that devote more of their public research budget to universities than to government labs (Guellec and van Pottelsberghe de la Potterie, 2001). This reflects the fact that in some countries the very nature of the R&D missions entrusted to government labs limits the generation of economic spillovers, but additional structural impediments also appear to be in place. Although their size and research portfolios are diverse, public labs in a number of countries face common problems relating to ageing staff, blurred missions and relative isolation from the mainstream of knowledge exchange and the education system. Government labs do not generally participate in training students who can transfer knowledge to industry, and the disciplinary nature of many labs can impede their attempts to conduct research in emerging interdisciplinary areas. They may nevertheless play a critical role in providing government ministries with impartial, long-term, in-depth and interdisciplinary expertise which is important to their mission and which cannot be suitably obtained from the university system (Senker, 2000).

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

Thus, in the context of a rapidly evolving innovation system and industry’s development of its own R&D capabilities, the purpose of the GRIs is not as clear-cut as it once was. At the same time, the Korean government has begun to favour the strengthening of R&D capabilities in universities, which are considered the “natural” sites of skills development and knowledge transfer. Pressures to reform the GRIs have resulted in a succession of changes in their governance systems, creating a near-permanent sense of

uncertainty and even crisis in many institutes. This has served to undermine the stability required for conducting long-term fundamental research, something that governments have often failed to take into account (Lee, Kong-Rae, 2007). To their credit, policy makers in MoST/MEST have recently tried to be sensitive to this danger and have consequently not sought to introduce radical new reforms that might further lower morale.

Clearly, the GRIs are in a difficult position. They were the main recipients of public R&D funding when universities conducted relatively little R&D. However, as the R&D capabilities of universities and firms have increased, some convergence has begun, with all actors conducting similar sorts of research (see section 2.6). Accordingly, many in industry argue that the GRIs should now focus primarily on fundamental research whereas many university researchers argue that the GRIs should return to their original purpose of supporting technology adoption and adaptation by Korean firms (but rather than the chaebol, the GRIs should assist SMEs which typically lack the capabilities or resources to conduct their own research). Whether the GRIs face such a stark choice is an open question, and there are few reasons to believe that they should focus on just one type of activity at the expense of others. Moreover, as highlighted above, the GRIs are not identical and each institute has its own history and accumulated competencies. Sensitivity to these is required in any future reforms.

Nevertheless, the GRIs would appear to be squeezed between two constituencies with a strong sense of their identity. Before exploring the positioning issue further, however, it is worth reviewing the direction in types of research performed by the GRIs. As Table 2.21 shows, the trend has been away from basic research (down from 26.7% of the total in 1998 to just 20.5% in 2006) towards more experimental development (up from 38.0% in 1998 to 43.7% in 2006), while the proportion of applied research has remained largely unchanged at around 35%. Closer examination of the data shows that most of this shift occurred in the first few years after the Asian financial crisis and that the current picture stabilised in 2003 (in fact, the current proportion of basic research stabilised in 2001). These figures seem to suggest that the GRIs are positioning themselves primarily to develop new technologies. But there are questions concerning whether the GRIs are best placed to bring these technologies to the market; it is widely believed that this is best done by the private sector.

**Table 2.21. R&D expenditure by research stage in research institutes**

KRW millions and percentages

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

Source: MoST and KISTEP (2007), *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.

Another issue to take into account is the fact that the GRIs conduct much of the “big science” carried out by the public sector and universities cannot match their facilities. This is not an unusual situation in many countries and international experience suggests that PROs often carry out fundamental research that would be impossible to conduct in universities (see Box 2.14 for an example from Germany). However, if the GRIs are to conduct more fundamental research, it is likely that the current project-based system will need to be revised. Originally introduced to improve the efficiency and performance of GRIs, the PBS has improved R&D management and performance through the use of competitive tendering. However, there have also been some less desirable effects:

- First, PBS has been detrimental to the stability needed to foster more fundamental research (since many projects are more mission-oriented and relatively short-term).<sup>4</sup>
- Second, it has encouraged GRIs to apply for a wide spectrum of projects as they compete for funding. The loss of focus has contributed in part to the identity crisis in many GRIs.
- Finally, it has seen a vast expansion in the use of temporary contract labour (for example, at the Korean Research Institute for Bioscience and Biotechnology [KRIBB], special service interns outnumbered regular employees by almost 2:1 in 2006). Although the use of temporary contracts gives the GRIs some flexibility, it also makes them less attractive destinations for researchers (see below).

#### **Box 2.14. Max Planck Society for the Advancement of Sciences (MPG)**

The MPG is an example of good practice for the funding of basic research outside the higher education sector. Its research institutes carry out basic research in all fields of science. The MPG focuses on new and promising research that universities have difficulty accommodating, either owing to the fact that the interdisciplinary character of such research does not fit into universities’ organisational framework or because the costs for personnel and facilities are beyond the universities’ resources. Other research is performed in joint projects between the Max Planck Society and universities. Such co-operation will be intensified in the future. In terms of funding, 95% comes from the public sector and only 5% from other sources (members’ contributions, donations, own income). Public money comes without any strings attached. The Society is completely autonomous in choosing its research priorities, managing its staff, etc.

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

Although some research collaboration occurs already (see Box 2.15), there is no doubt that there is much greater scope for such co-operation between GRIs and universities. This is hampered by the mutual distrust of the two sectors: the universities view themselves as more academically valid and the GRIs see themselves as the public sector’s main source of research with the necessary experience, competencies, equipment and relevance. This distrust and lack of understanding and respect creates problems for developing closer and mutually beneficial linkages.

**Box 2.15. The KIST-academia collaborative education programme**

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

*Source:* KIST (2007), Korea Institute of Science and Technology brochure.

In a further twist to the trend towards convergence between research performers, the GRIs have also got together to found a university – the University of Science and Technology (UST) – which focuses upon hands-on multidisciplinary training, a missing gap in much Korean higher education (see Box 2.16).

**Box 2.16. The University of Science and Technology**

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

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

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

*Source:* UST website ([www.ust.ac.kr/eng](http://www.ust.ac.kr/eng)), accessed February 2008.

**2.3.5. Employment conditions**

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

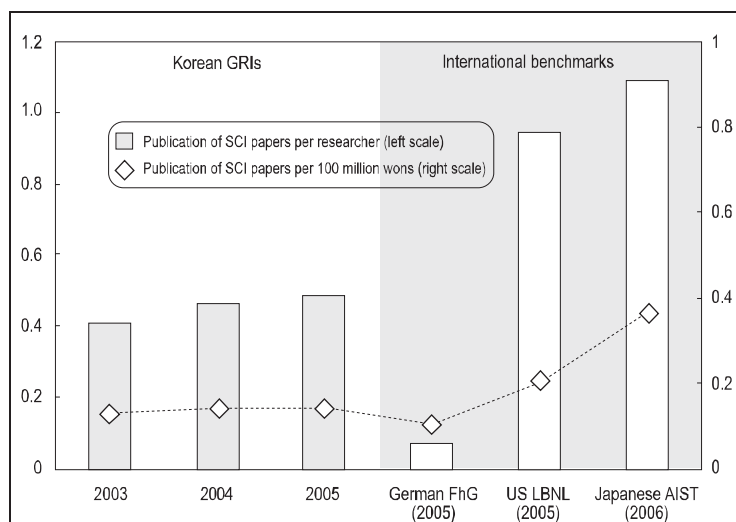
In the last three or four years, however, the GRIs have enjoyed a modicum of stability as they have focused their attention on a set of core research areas (for example, through the Top Brand Project initiative, in which GRIs identify a small number of fields in which they aim to achieve leadership positions in the short to medium term). The PBS continues

to be improved and it has recently been announced that GRIs will in future benefit from more core funding, with as much as 70% of staff costs being met in this way by 2012 as compared to 40% or so in 2007. The tenure system is also being expanded, and the number of researchers earning in excess of USD 100 000 a year was expected to exceed 1 000 in 2007. Finally, the new government has also announced that it intends to set aside KRW 200 billion by 2013 to cover the pensions of GRI researchers.<sup>5</sup> In parallel to these developments in the GRIs, the universities are becoming less comfortable places to work, as professors are increasingly expected to meet performance targets and in some institutions (*e.g.* KAIST) to teach in English. Therefore, some convergence in working conditions between GRIs and universities appears likely, which could make the GRIs once again relatively attractive places in which to work.

### 2.3.6. GRI performance

Under the research councils, the GRIs have recently improved their performance in terms of publications and patent applications (Lee, Chul-Won, 2007). For example, SCI publications per researcher increased from 0.407 in 2003 to 0.465 in 2004 and to 0.489 in 2005, a significant rise in a short space of time. As Figure 2.29 shows, these numbers are higher than those of the Fraunhofer Society's institutes in Germany (although the latter undertake more applied research and may be less active in academic publishing than institutes engaged in more fundamental research), though considerably lower than those of the Lawrence Berkeley National Laboratory (LBNL) in the United States and the National Institute of Advanced Industrial Science and Technology (AIST) in Japan. The results are similar when using SCI publications per KRW 100 million spent.

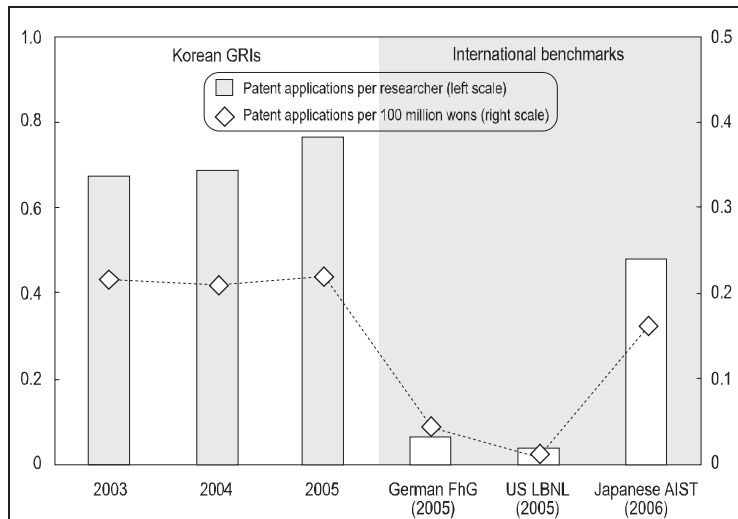
**Figure 2.29. SCI publications by GRIs (2003-05) and international benchmarks**



Source: Lee, Chul-Won (2007), "Challenges and Issues to Upgrade Government-Sponsored Research Institutes in Science and Technology in Korea", paper presented at the Annual Conference of the Korean Society for Innovation Management and Economics, 20-21 July, Jeju Island.

In terms of patent applications, the performance of the GRIs appears to exceed that of PROs in developed countries. As shown in Figure 2.30, patent applications per researcher increased from 0.6754 in 2003 to 0.765 in 2005, figures that are much higher than those of the Fraunhofer institutes, the LBNL or AIST (as the LBNL undertakes largely fundamental research, its relatively low performance on this measure is not unexpected). A comparison based on patent applications per KRW 100 million shows a similar trend. Furthermore, GRIs made 3 158 patent applications in 2006 (Table 2.22), more than US GRIs (1 790) and Canadian government research institutes including universities (1 307).

**Figure 2.30. Patent applications of GRIs (2003-05) and international benchmarks**



Source: Lee, Chul-Won (2007), “Challenges and Issues to Upgrade Government-Sponsored Research Institutes in Science and Technology in Korea”, paper presented at the Annual Conference of the Korean Society for Innovation Management and Economics, 20-21 July, Jeju Island.

Applying for patents is one thing, but transferring technologies and possibly earning royalty income is quite another and is often a better measure of performance. In terms of technology transfer rates, Table 2.22 shows that Korea underperforms the United States and Canada but seems to do better than Japan. Around 30% of Korean GRI patents were transferred in 2006, compared to 37.5% in US PROs. The figures for Canada are probably even better, but because they have been combined with university figures, this cannot be demonstrated with certainty. More positively, the GRIs performed considerably better than Korean universities, which saw only 13.6% of their technologies transferred. Overall, these figures indicate that Korean PROs have more difficulty commercialising their R&D than their counterparts in North America.

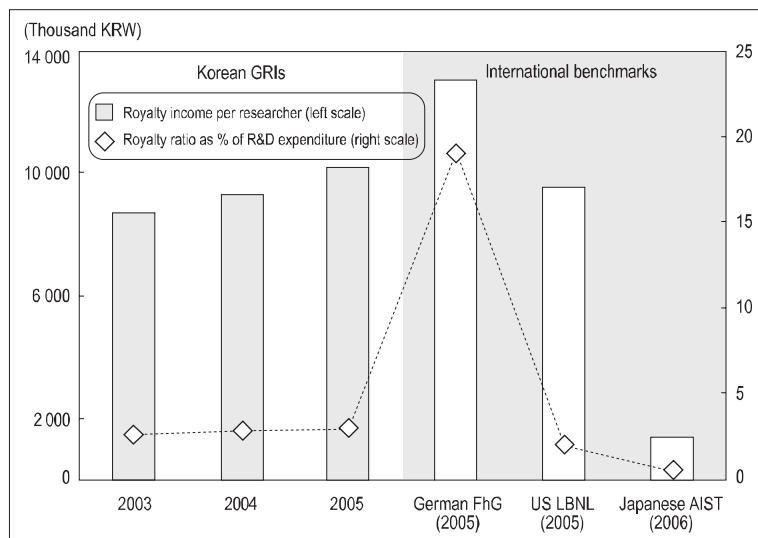
Royalty income figures provide one indicator of the “quality” of technology transfer. As Table 2.22 shows, Korea again underperforms the United States and Canada (figures for Japan are not available). While Korean GRIs earned USD 53.3 million from 951 technology transfers, US PROs were able to earn USD 346 million from just 671 transfers. The picture is even worse for Korean universities, which earned a meagre USD 3.2 million from 629 technology transfers compared to more than USD 1 billion earned by US universities from around 4 000 transfers. These figures indicate that the values of technologies transferred from Korean PROs are lower than those of their North American counterparts.

**Table 2.22. International comparison of technology transfer among public sector research performers, 2006**

| Performance indicators                         | Korea |       |       | United States |       |        | Japan         | Canada        |
|------------------------------------------------|-------|-------|-------|---------------|-------|--------|---------------|---------------|
|                                                | Univ. | GRI   | Total | Univ.         | GRI   | Total  | (Univ. + GRI) | (Univ. + GRI) |
| Number of technologies patented (2006)         | 4 616 | 3 158 | 7 774 | 15 002        | 1 790 | 16 792 | 8 725         | 1 307         |
| Number of technology transfers                 | 629   | 951   | 1 580 | 4 087         | 671   | 4 758  | 1 171         | 544           |
| Ratio of technology transfers (%)              | 13.6  | 30.1  | 20.3  | 27.2          | 37.5  | 28.3   | 13.4          | 41.6          |
| Yearly royalty income (USD millions)           | 3.2   | 53.3  | 56.5  | 1 088         | 346   | 1 435  | n/a           | 43.3          |
| Yearly R&D expenditure (USD millions)          | 2 200 | 2 964 | 5 164 | 37 162        | 4 082 | 41 244 | 47 200        | 3 127         |
| Number of employees per commercialisation unit | 4.8   | 3.6   | 4.2   | 8.65          | 6.1   | 8.2    | 14.3          | 8.3           |

Source: Lee, Chul-Won (2007), “Challenges and Issues to Upgrade Government-Sponsored Research Institutes in Science and Technology in Korea”, paper presented at the Annual Conference of the Korean Society for Innovation Management and Economics, 20-21 July, Jeju Island.

Figure 2.31 shows that the Korean situation is gradually improving, however, with royalty income per GRI researcher climbing from around KRW 8 million in 2003 to around KRW 10 million in 2005. The royalty ratio as a percentage of R&D expenditure has shown a similar trend over the same period. This performance is comparable to that of the LBNL in the United States (although as Figure 2.30 shows, the latter patents far less than Korean GRIs) and far exceeds the performance of AIST in Japan. But the GRIs have some way to go to catch up with the German Fraunhofer institutes, which earn the equivalent of almost 20% of their total R&D expenditure in royalty income (on the basis of a fraction of the patent applications made by Korean institutes).

**Figure 2.31. Royalty income of GRIs**

Source: Lee, Chul-Won (2007), “Challenges and Issues to Upgrade Government-Sponsored Research Institutes in Science and Technology in Korea”, paper presented at the Annual Conference of the Korean Society for Innovation Management and Economics, 20-21 July, Jeju Island.

To summarise, Korean GRIs have improved their performance in recent years, in terms both of number of publications and returns from commercialisation of their R&D efforts. However, given the level of patenting activity, they should be doing much better. There are several possible explanations for the relatively weak performance indicated by technology transfer rates and royalty income levels:

- First, technology markets are less developed in Korea than in North America, owing to their relatively weak institutionalisation. However, the effects are unlikely to be large enough to account for the significant differences in commercialisation of their technologies.
- Second, compared to North America, there is relatively weak interest on the part of local firms in adopting new technologies from GRIs, particularly among SMEs (see section 2.2). Even among larger firms, there appears to be a growing preference to conduct research in house and to reduce reliance on the GRIs for fear of “knowledge leakage”.
- A third explanation may lie in the GRIs and universities themselves, as they may be insufficiently geared to offer their R&D for exploitation. However, the Korean government has placed much emphasis on the commercialisation of R&D and the channels for transferring public research results are various, such as technology transfer agreements, direct creation of venture firms, technical consulting, training of engineers and technicians, and so on. Because of the income-generating opportunities and in order to promote technology transfer, most GRIs have set up commercialisation units, although these remain comparatively small. As Table 2.22 indicates they employ on average 3.6 persons, fewer than Korean universities (4.8) and considerably fewer than in Japan, Canada and the United States. This is perhaps surprising given the relatively large size of the patent stock held by the GRIs, but it may be because many of the patents are in fact of little commercial interest to Korean firms.
- Finally, it seems certain that Korean GRIs and universities are patenting excessively, as evidenced by the very rapid rise of Korea in the patent rankings over the last decade (see Chapter 1, section 1.4). The government has set very ambitious performance targets for the public sector research base, many of which are quantitative in nature. These include publication and patenting targets. As researchers have struggled to meet these targets, they have tended to patent discoveries that might not otherwise have been patented (because of the low likelihood of commercial exploitation). As a result, Korean institutes hold a large body of patents, many of which are unlikely ever to be exploited.

This final point is significant for two reasons: first, failing to acknowledge that this sort of behaviour is happening risks misdiagnosing the problem to be tackled by policy interventions. Some improvements in R&D commercialisation can certainly be achieved through measures such as better technology market institutionalisation and enhancement of the GRIs’ commercialisation units, but the main issue is the fact that much of the intellectual property held by institutions is in fact unsuitable for commercial exploitation. This situation can be changed only by modifying the way research is carried out (*e.g.* through greater collaboration with research users) and/or altering the patenting behaviour of researchers so that they patent more in line with realistic expectations of commercialisation.

The second reason concerns the use of quantitative indicators to measure the performance of the GRIs. Performance indicators invariably change the behaviour of those who are to be held accountable – sometimes in ways intended by policy makers (*e.g.* researchers pay more attention to the commercial potential of their research), but often in unintended ways as well (*e.g.* researchers over-patent). The problem with many performance indicators is that they tend to focus only upon those things that are directly measurable quantitatively and miss many (often more essential) intangible effects. In this sense, performance indicators tend to be blunt instruments of control, which, if not used appropriately, can adversely distort the behaviour of those who are accountable and can have undesirable effects on the system being monitored. Such distortions can be minimised by a good understanding of the system being monitored and wide agreement on an appropriate set of performance indicators which are sufficiently sensitive to the various nuances inherent to the system. As Box 2.17 would seem to suggest, however, this agreement does not yet seem to exist in Korea.

#### **Box 2.17. ETRI and measuring intellectual capital**

The following text is taken from the foreword of a report published by ETRI on measuring intellectual capital and illustrates well the pressures facing Korean PROs in demonstrating their effectiveness:

“From time to time government-supported organisations in Korea have been criticised both internally and externally, as it is not easy to identify performance for all long-term investments. Therefore it has almost become a liability for such organisations to acknowledge their performance in various sectors and demonstrate how they are planning future core competencies.

“In 21st century knowledge and information societies, peoples’ abilities and attitudes are paramount; the power of the system and the quality of relationships people build will ultimately become a source of future success. Absorbing these trends to measure and manage intellectual capital helps us not only to identify knowledge as a new growth engine in Korean society, but also to lay stepping stones to transform local workplaces into knowledge creation institutions.

“At this moment in time the most influential forces for social change and development are individuals and organisations with knowledge and information generating capabilities. This recent and persisting trend is rooted in the fact that the paradigm has radically shifted to an information or knowledge-based society. Despite this major transformation, the value of research institutes as centres of knowledge creation in our society is still being evaluated from the perspectives of the Industrial Age.

“What is it that interferes with the transformation of perspectives? In my view, there is no consensus on research performance evaluation criteria. Until recently, tangible outputs such as publications, patents, royalties and so on have been accorded prime significance. Unfortunately, it has not been acknowledged that R&D produces other types of value, *viz.* the enhanced capability of researchers, knowledge accumulation and learning from experience, knowledge diffusion to related industries, and reputation building, to name just a few.

“To overcome these shortcomings, since 2004 ETRI has been conducting research focused on modelling intellectual capital, which is composed of human capital, structural capital, and relational capital. ETRI’s IC report is the first fruit cultivated from these efforts. Within the organisation the intention of publishing ETRI’s IC Report is to acknowledge the true means for long-term competitiveness. Externally, we would like to inform more people that the real value of research institutes lies in the sum of intangible intellectual capital rather than tangible assets. Finally, we sincerely hope that our efforts will facilitate government initiatives to ascertain where national core competencies and social welfare come from. Hopefully, the new perspective, ignited from our efforts, will lead to concrete policies with an emphasis on intellectual capital.”

*Source:* ETRI (2005), *Intellectual Capital Report 2004*, Electronics and Telecommunications Research Institute, Daejeon.

**Box 2.18. Goals of the various higher education institutions**

*Two-year colleges:* to educate students about specialised knowledge and skills to foster talents able to fulfil specialised positions in society.

*Technical colleges:* to teach the necessary skills and knowledge to students so they may contribute to various industries, to provide opportunities for higher learning to students, and to foster talent in industrial sectors so that the country and society can benefit.

*Colleges of education:* to foster knowledgeable teachers for primary education.

*Open universities:* to give the public opportunities for higher education through various media, further open education, and thus contribute to lifelong learning.

*Technical universities:* to form a workforce with specialised knowledge and applicable skills by providing the opportunity to continually learn and practise specialised vocational knowledge and theories in the workplace.

*Source:* KEDI (2006), background report in support of the *OECD Review of Tertiary Education*.

**2.4. Higher education institutions**

There are many types of higher education institutions (HEIs) in Korea, including universities, two-year colleges, and specialised institutions such as industrial colleges, education colleges and technical colleges (see Box 2.18). There are also HEIs under the jurisdiction of provincial governments or government agencies other than the MEST (KEDI, 2006). In all, 212 universities currently run four-year undergraduate courses, of which 41 are national, 2 public and 169 private. Between them, they operate 147 graduate schools which are associated with research activities.

In addition, two-year colleges are active in training technicians and also carry out some research. They account for about 40% of students in tertiary education. As in many other countries, these institutions exist to prepare middle-level manpower and technicians. The fields of study include a range of occupations in engineering, health including nursing, business and law, and education. Compared to the universities, a larger fraction of colleges and college enrolments are in private institutions, which are more reliant on tuition fees and less on government funding. They also do not receive government funding for research, as some universities do (Grubb *et al.*, 2006).

It is important to understand the contributions that HEIs make to innovation. All too often, policy attention is too focused upon the production of codified knowledge through research and its subsequent diffusion and exploitation through various “third-stream” activities and industry-academic linkages. However, the innovation studies literature makes clear that the most significant contribution of HEIs to innovation lies in the creation of embodied capabilities through teaching and research training activities. Accordingly, the remainder of this section considers the role of Korean HEIs in providing tertiary education, in conducting research, and in commercialising the results of research.

**2.4.1. Education activities**

The expansion of tertiary education in Korea over the past two decades has been incredibly rapid and astonishingly impressive in many ways (Grubb *et al.*, 2006). More than any other country, Korea has ensured that virtually all students complete secondary education and has moved toward universal tertiary education, with more than 80% of young people attending universities or junior colleges, by far the largest proportion in the OECD area. A socio-cultural eagerness for education in Korea, rooted in long-standing

Confucian educational values, has contributed to this great demand for tertiary education. Figure 2.32 shows that since 1980, there has been an almost five-fold increase in the number of students enrolled at universities. This growth is mirrored by increased enrolments in junior colleges over a similar period (see Figure 2.33), although the last five years or so have seen numbers steadily decrease (enrolments peaked in 2001).

**Figure 2.32. Number of enrolled university students**

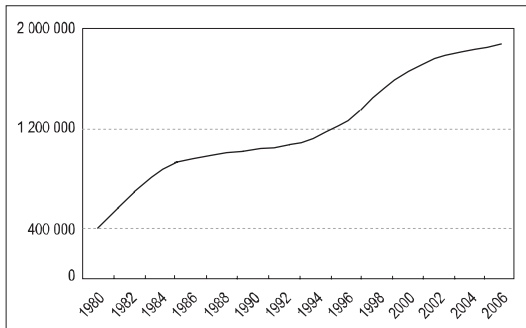


**Figure 2.33. Number of enrolled junior college students**

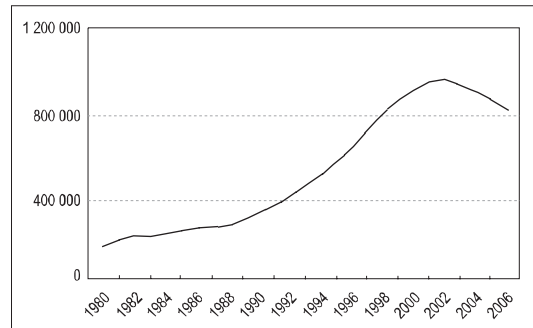


**Figure 2.34. Ratio of students to university faculty**

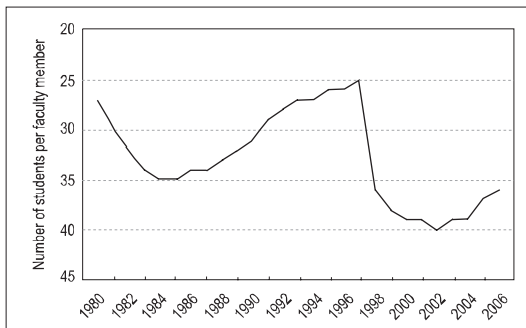


**Figure 2.35. Ratio of students to junior college faculty**

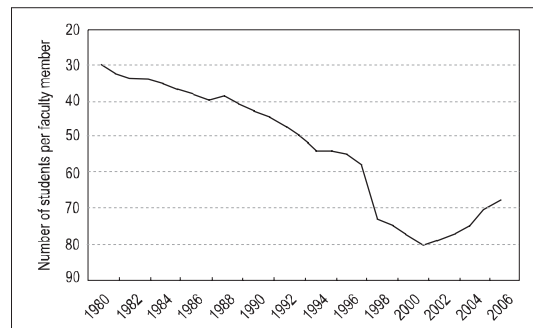


**Figure 2.36. Number of graduate students**

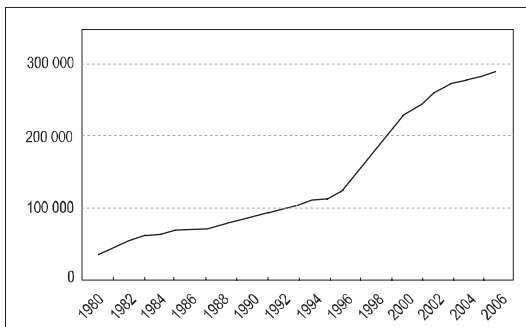
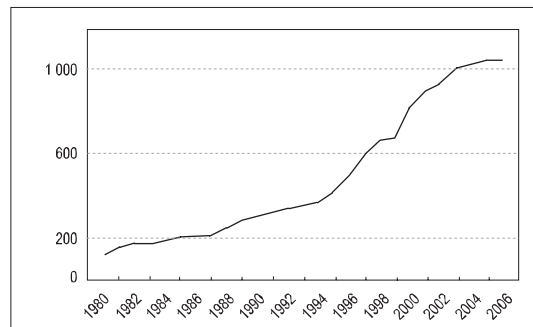


**Figure 2.37. Number of graduate schools**



Source: MoE Statistics (2007).

Accordingly, over the last decade, the number of universities in Korea has continued to increase. Most universities, with a few notable exceptions (*e.g.* KAIST and POSTECH), are comprehensive, providing teaching in a broad range of sciences, social sciences, the humanities and professional subjects such as engineering and business. This has led to criticisms that many universities look alike, that regional universities fail to take advantage of regional differences, and that the university system as a whole provides relatively little choice to students. In fact, by far the main distinguishing factor among the universities is their well-known ranking, with virtually all Koreans agreeing on the top ten universities in the country. However, in a recent international review of Korean tertiary education (Grubb *et al.*, 2006), the reviewers were not convinced that the highest-status universities are necessarily of the highest quality. The problem is the ranking approach itself, which is crude by international standards and is even unofficial in Korea. A better system would acknowledge the differences between universities and apply different ranking systems that highlight performance relating to a variety of university functions. Moreover, a better assessment approach would be centred on individual departments rather than applied crudely to entire universities. This is because departments within universities typically vary in their quality. Without departmental assessment, there is no systematic way for students to learn about such variation.

Perhaps unsurprisingly, this situation has some damaging side effects. To begin with, efforts to build strong departments in lower-ranked universities are less likely to be rewarded with an increase in high-calibre student applications, simply on account of the university's overall perceived status. At the same time, departments that may not be the best in their field can nevertheless attract the best students because of their location in a high-status university. Furthermore, because the vast majority of high-status universities tend to be in and around the metropolitan Seoul area, provincial colleges and universities – which constitute over 60% of HEIs in Korea – have great difficulty in attracting students, and their graduates find it more difficult to secure employment (KEDI, 2006).<sup>6</sup> This contributes to imbalanced growth. But perhaps the most damaging side effect of the current ranking of universities concerns its impact on secondary education and the sacrifices made by both parents and students to try to gain access to high-status institutions. This important issue is explored in some detail in section 2.6.

In contrast to the universities, the number of junior colleges has remained relatively stable since the mid-1990s. As Figure 2.33 shows, the number of enrolments continues to decline, and it is expected that some junior colleges will have to merge to survive (this has already started to happen, though still on a modest scale). Lower birth rates are partly responsible for this, and many universities are certain to face similar pressures in the near future. However, the pressure on junior colleges has been further exacerbated by an increasing tendency for universities to offer a broader range of courses, including those that were previously offered exclusively by junior colleges. As there is a near-universal preference for universities over junior colleges – on account of their perceived higher status – the junior colleges are losing students to universities in their traditional markets. This is in some ways ironic, since the junior colleges have shown a greater tendency to innovate in their teaching than universities. In many (though not all) universities, teaching is dominated by a Confucian tradition of information transfer from master to student, with learning largely limited to lectures. By contrast, many junior colleges employ a variety of teaching methods, including team-teaching, project-based learning and workshops, providing students with the skills to question and criticise that employers want in a modern economy. Here again, status is not necessarily the same as quality (Grubb *et al.*, 2006).

It is not only the prevailing teaching methods that are under fire when it comes to questions of quality. The “massification” of tertiary education over the last two decades has also led to a substantial increase in the student-teacher ratio both in universities (Figure 2.34) and in junior colleges (Figure 2.35), as HEI expenditures and staff numbers have failed to keep up with increased student enrolments. For instance, from 1980 to 2006 period, the student-teacher ratio rose from 29:1 to 68:1 in colleges and from 27:1 to 36:1 in universities, compared to an OECD average of 17:1. A sharp increase in the student-teacher ratio of universities coincides with the Asian financial crisis of the late 1990s, when many staff were laid off. The worsening student-teacher ratio is often seen as a sign of falling standards in Korean HEIs, as larger classes are often equated with a reduction in the quality of teaching. However, in a system dominated by information transfer and lecture, it probably makes little difference whether there are 30 students in a class or 300. Only when teaching shifts to other forms of pedagogy does the student-teacher ratio matter (Grubb *et al.*, 2006), so this may be more of an issue for the junior colleges than for the universities.

With the increase in competition for jobs among an ever-growing number of graduates, many young people seek postgraduate qualifications to obtain a competitive edge. Many Koreans travel abroad for such qualifications – particularly to the United States (see section 2.6) – but the home market for postgraduate degrees has also grown spectacularly over the last two decades, with an eight-fold increase since 1980 (Figure 2.36). Currently, around 15% of enrolments are for PhD degrees, and the rest for master’s degrees. As Figure 2.37 shows, the increase in the number of postgraduate degree enrolments has been matched by similar growth in the number of graduate schools, with more than 1 000 operating in 2006. However, this is not all good news. As a recent international review of Korean tertiary education noted, more than half of HEI-directed research funding goes to the top 20 universities (see Table 2.23), but “large numbers of postgraduate students in Korea are trained in second-tier universities where the faculty is not engaged extensively in research, meaning that the close connection between research and education is broken. In effect, non-research institutions are preparing the next generation of researchers, and this is surely not the optimal form of training” (Grubb *et al.*, 2006). The authors suggest that one solution would be to limit PhD training to institutions, or departments within institutions, with demonstrated research strengths.

#### **2.4.2. Research activities**

Table 2.23 lists the top 20 research universities in Korea in terms of research income. National universities dominate, along with KAIST, POSTECH and GIST, which were specifically established to focus on graduate schools in science and technology.

**Table 2.23. Twenty largest universities by R&D expenditure in Korea, 2005**

| Rank | University                     | Amount (USD million) | Share (%) |
|------|--------------------------------|----------------------|-----------|
| 1    | Seoul National University      | 219.97               | 12.2      |
| 2    | KAIST                          | 84.85                | 4.7       |
| 3    | POSTECH                        | 69.80                | 3.9       |
| 4    | Yonsei University              | 66.94                | 3.7       |
| 5    | Hanyang University             | 52.92                | 2.9       |
| 6    | Korea University               | 51.13                | 2.8       |
| 7    | Kyungpook National University  | 44.24                | 2.5       |
| 8    | Pusan National University      | 39.37                | 2.2       |
| 9    | Sungkyunkwan University        | 37.68                | 2.1       |
| 10   | Chonnam National University    | 34.67                | 1.9       |
| 11   | Chonbuk National University    | 30.30                | 1.7       |
| 12   | Inha University                | 27.46                | 1.5       |
| 13   | Chungnam National University   | 24.43                | 1.4       |
| 14   | Chungbuk National University   | 23.47                | 1.3       |
| 15   | GIST                           | 23.22                | 1.3       |
| 16   | Gyeongsang National University | 21.84                | 1.2       |
| 17   | Kyunghee University            | 21.56                | 1.2       |
| 18   | Ajou University                | 20.31                | 1.1       |
| 19   | Konkuk University              | 19.43                | 1.1       |
| 20   | Ewha Women's University        | 18.84                | 1.0       |
|      | Other universities             | 871.73               | 48.3      |
|      | Total                          | 1 750.98             | 100.0     |

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

Around 65 000 researchers were employed by universities in 2005 (Table 2.24). They represent just over one-quarter of all researchers employed in Korea and about four times more than in the GRIs, despite the latter's higher research expenditures. In fact, universities employ around 70% of all PhDs in Korea, yet account for only around 10% of Korean spending on research. This is partly because many PhDs in universities choose not to undertake research. In addition, the R&D facilities of most universities are less well equipped and their research teams are less well organised than the GRIs. As Table 2.24 shows, R&D expenditure per university researcher is about one-quarter that of researchers in GRIs. The government has recently recognised that mobilising the pool of latent research capacity in universities will be essential if Korea is to achieve technological parity with the leading economies (see Chapter 3). However, given that research capabilities depend upon gradual knowledge accumulation through active research, the historical under-investment in university researchers is likely to hinder their skills development over time and may slow government efforts to strengthen the overall performance of university research in the future.

**Table 2.24. Allocation of researchers and R&D expenditures among sectors of performance, 2005**

|                                                                     | Universities      | GRI               | Industries         | Total             |
|---------------------------------------------------------------------|-------------------|-------------------|--------------------|-------------------|
| <b>Researchers</b><br>(Head count)                                  | 64 895<br>(27.6%) | 15 501<br>(6.6%)  | 154 306<br>(65.7%) | 234 702<br>(100%) |
| <b>Researchers holding PhDs</b><br>(Head count)                     | 40 229<br>(69.4%) | 7 452<br>(12.9%)  | 10 261<br>(17.7%)  | 57 942<br>(100%)  |
| <b>R&amp;D expenditure</b><br>(KRW 100 million)                     | 23 983<br>(9.9%)  | 31 929<br>(13.2%) | 185 642<br>(76.9%) | 241 554<br>(100%) |
| <b>Government-financed R&amp;D expenditure</b><br>(KRW 100 million) | 18 244<br>(32.6%) | 29 167<br>(52.0%) | 8 637<br>(15.4%)   | 56 048<br>(100%)  |
| <b>R&amp;D expenditure per researcher</b><br>(KRW 1 000)            | 36 956            | 154 718           | 120 308            | 102 920           |

Source: MOST and KISTEP (2006), *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.

As Table 2.25 shows, the proportion of experimental development performed in universities has increased markedly at the expense of a relative decline in basic research. The pattern is similar to that in the GRIs and is symptomatic of a growing convergence in the types of research performed by Korean research actors (though the figures have stabilised over the last few years). Despite this apparent shift, the number of papers in SCI publications by Korean universities increased 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).

**Table 2.25. R&D expenditure by research stage in universities and colleges, 1998-2006**

KRW millions and percentages

|      | Total R&D expenditure | Basic research |      | Applied research |      | Experimental development |      |
|------|-----------------------|----------------|------|------------------|------|--------------------------|------|
| 1998 | 1 265 074             | 507 261        | 40.1 | 427 539          | 33.8 | 330 274                  | 26.1 |
| 1999 | 1 431 421             | 491 402        | 34.3 | 479 440          | 33.5 | 460 579                  | 32.2 |
| 2000 | 1 561 865             | 661 562        | 42.4 | 475 685          | 30.5 | 424 618                  | 27.2 |
| 2001 | 1 676 777             | 679 826        | 40.5 | 498 455          | 29.7 | 498 496                  | 29.7 |
| 2002 | 1 797 096             | 666 130        | 37.1 | 596 213          | 33.2 | 534 753                  | 29.8 |
| 2003 | 1 932 663             | 695 638        | 36.0 | 634 122          | 32.8 | 602 903                  | 31.2 |
| 2004 | 2 200 886             | 736 761        | 33.5 | 760 983          | 34.6 | 703 142                  | 31.9 |
| 2005 | 2 398 284             | 833 799        | 34.8 | 825 172          | 34.4 | 739 313                  | 30.8 |
| 2006 | 2 721 874             | 909 221        | 33.4 | 876 798          | 32.2 | 935 855                  | 34.4 |

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.

### 2.4.3. Commercialisation activities

In terms of research and innovation, many current policy frameworks see HEIs (especially universities) as places where new scientific and technological principles are discovered. The issue then becomes how well these discoveries are transformed into innovations. This kind of focus leads to an emphasis on the problem of commercialisation for HEIs and on a policy focus on intellectual property rights, patenting and technology transfer from HEIs. Against this backdrop, Korean universities have shown an increase in their patenting activities over recent years. Table 2.26 shows an almost tenfold increase for the period 1997-2005 in the total number of patent applications by the ten universities that lead in patenting, as well as a diversification in the types of universities making them (ten years ago, applications were mostly confined to the technical universities of KAIST and POSTECH, but this is no longer the case).

**Table 2.26. Patent applications of leading patenting universities in Korea, 1997-2005**

| University                | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004  | 2005  | Total |
|---------------------------|------|------|------|------|------|------|------|-------|-------|-------|
| KAIST                     | 110  | 158  | 186  | 189  | 182  | 175  | 195  | 245   | 300   | 1 740 |
| POSTECH                   | 46   | 51   | 67   | 82   | 102  | 116  | 102  | 111   | 106   | 783   |
| Seoul National University | 6    | 13   | 16   | 24   | 22   | 53   | 152  | 210   | 278   | 774   |
| GIST                      | 13   | 37   | 40   | 83   | 62   | 47   | 73   | 75    | 74    | 504   |
| Inha University           | 11   | 16   | 24   | 28   | 33   | 40   | 79   | 80    | 127   | 438   |
| Korea University          | 0    | 2    | 27   | 31   | 31   | 27   | 59   | 80    | 180   | 437   |
| Hanyang University        | 0    | 0    | 0    | 2    | 26   | 51   | 96   | 81    | 162   | 418   |
| Yonsei University         | 0    | 1    | 1    | 9    | 16   | 26   | 79   | 82    | 126   | 340   |
| Sungkyunkwan University   | 0    | 1    | 0    | 3    | 33   | 34   | 48   | 62    | 131   | 312   |
| Kyungpook National Univ.  | 1    | 0    | 0    | 1    | 6    | 10   | 21   | 48    | 73    | 160   |
| Total top 10              | 187  | 279  | 361  | 452  | 513  | 579  | 904  | 1 074 | 1 557 | 5 906 |

Source: KIPO (2006), *Patent Trends in Korea 2006*, Korea Industrial Property Office, Seoul.

Along with the increase in patenting activities, many Korean universities, encouraged by the government, have established technology licensing offices (TLOs). There were 25 TLOs in Korean universities in 2003 and 69 in 2005 (KRF, 2006). Though the number of TLOs has continuously increased, 78% employs fewer than five people and so may be playing a limited role in transferring the R&D results of universities. The average royalty income of university TLOs from technology transfers jumped from KRW 15.1 million in 2003 to KRW 24.1 million in 2004 and to KRW 47.9 million in 2005. Although the amounts are relatively small, they nevertheless show a marked increase over a short period of time.

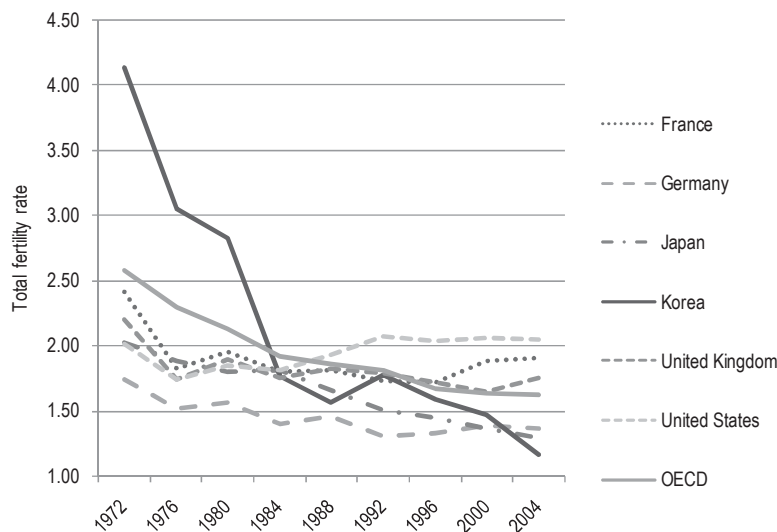
## 2.5. Human capital

Over the last 50 years, Korea has transformed itself from a backward agricultural economy into one of the most modern economies in the world. One of the main driving forces behind this transformation has been a growing population and investment in human capital. This section first discusses a major crisis set to affect Korea over coming decades – its falling birth rate and ageing society – and points to the need to bring more women into the workforce and to increase lifelong learning opportunities. It then provides a brief outline of the Korean education system, followed by a more detailed account of the secondary and tertiary education systems. Within this context, broad patterns in the supply of and demand for human resources are considered, after which the issues of lifelong learning, gender imbalances and labour mobility are discussed.

### 2.5.1. Low fertility rates

Korea's 2005 total fertility rate of 1.08 was the lowest in the OECD (Figure 2.38). In the long run, such a rate will lead to a decline in the number of workers and will weaken the economy's growth potential. According to the Korea Development Institute, the low fertility rate will pull down Korea's potential GDP growth rate from 5% currently to 3.6% by 2020 and 2.3% in 2030. In addition, the low birth rate will trigger fiscal problems such as the funding of the national pension plan by a much smaller domestic labour pool.

**Figure 2.38. Total fertility rates in a selection of OECD countries, 1972-2004**

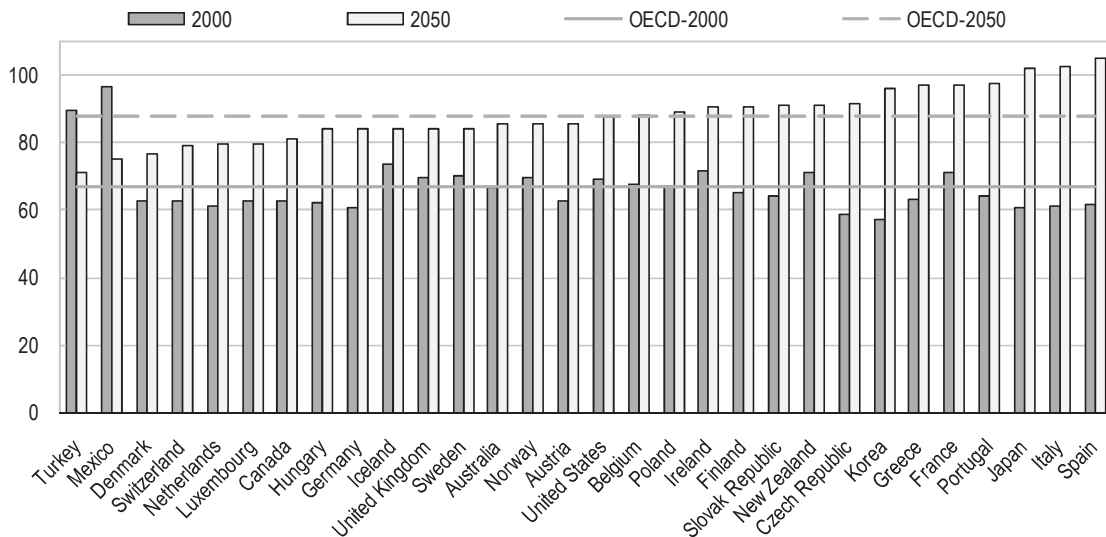


Source: OECD (2006), *Society at a Glance*, OECD, Paris.

A number of economic and social changes have contributed to the declining fertility rate. Most recently, the 1997 Asian financial crisis left an indelible imprint on employment. As companies underwent painful restructuring, they jettisoned their tradition of lifetime employment. Job seekers now face a job market that gives prominence to two-to-three-year contracts rather than more secure, full-time employment. As a result, young adults delay marriage and children on account of the fragile labour atmosphere (Choi and Kim, 2007).

Korea's economically productive population aged 15 to 64 will decrease after peaking in 2016 at 36.19 million. The percentage of people aged 25 to 49 will decrease from 59.6% in 2005 to 44.4% in 2050 (Figure 2.39). Meanwhile, people over age 50 in the economically productive population are forecast to surge from 20.5% in 2005 to 40.9% in 2050 (see Table 2.27). This has major implications for increasing levels of employment – particularly of women – and for lifelong learning, as workers remain in the workforce for longer periods.

**Figure 2.39. Share of population under 20 or over 64 as a percentage of the population aged 20 to 64**



Source: OECD (2006), *Society at a Glance*, OECD, Paris.

**Table 2.27. Outlook for the economically productive population**

|                   | 2000   | 2007   | 2010   | 2020   | 2030   | 2050   |
|-------------------|--------|--------|--------|--------|--------|--------|
| Total (thousands) | 33,702 | 34,912 | 35,611 | 35,506 | 31,229 | 22,424 |
| Aged 15 to 24 (%) | 22.8   | 18.9   | 18.3   | 15.6   | 13.1   | 14.7   |
| Aged 25 to 49 (%) | 58.8   | 59.2   | 56.7   | 50.9   | 49.5   | 44.4   |
| Aged 50 to 64 (%) | 18.4   | 22.0   | 25.0   | 33.5   | 37.4   | 40.9   |

Note: The shares are the shares of the economically productive population.

Source: National Statistical Office, *Outlooks on Future Population*, November 2006, cited in Choi and Kim (2007), "Korea's Plunging Birth Rate: Causes and Policy Suggestions", Issue Paper 01/07, Samsung Economic Research Institute, Seoul.

### 2.5.2. The Korean education system

Korea has a single-track 6:3:3:4 system which provides six years of compulsory primary education, three years of middle school and three years of high school, followed by two or four years at college or university. Attendance at primary and middle school is compulsory. Universal education was achieved at the primary level by 1970 and at the lower secondary school level by 1985. The rate of advancement from high school to

university now exceeds 80%. Pre-school education has also been expanded in the past few years, and almost 40% of children attend nursery school (OECD, 2005a).

This expansion has been achieved with a relatively low level of public expenditure on education: at 4.4% of GDP in 2004, somewhat below the OECD average of 5.0% (Table 2.28). This level of public expenditure is not without consequences: Korea has the least favourable ratio of teachers to students at primary and secondary level in the OECD area and hence the largest classes. Furthermore, to make up for the shortfall in public spending, private spending on education is one of the highest in the OECD area. This has equity implications, with those who can afford private tuition more likely to secure a place in a top-ranked university. This is discussed further below.

**Table 2.28. Expenditure on educational institutions as a percentage of GDP, by source of funds and level of education, 2004**

|                     | Primary, secondary and post-secondary non-tertiary education |                      |            | Tertiary education  |                      |            | Total all levels of education |                      |            |
|---------------------|--------------------------------------------------------------|----------------------|------------|---------------------|----------------------|------------|-------------------------------|----------------------|------------|
|                     | Public <sup>1</sup>                                          | Private <sup>2</sup> | Total      | Public <sup>1</sup> | Private <sup>2</sup> | Total      | Public <sup>1</sup>           | Private <sup>2</sup> | Total      |
| Denmark             | 4.2                                                          | 0.1                  | 4.3        | 1.8                 | 0.1                  | 1.8        | 6.9                           | 0.3                  | 7.2        |
| Finland             | 3.9                                                          | n                    | 3.9        | 1.7                 | 0.1                  | 1.8        | 6.0                           | 0.1                  | 6.1        |
| France              | 3.9                                                          | 0.2                  | 4.1        | 1.2                 | 0.2                  | 1.3        | 5.7                           | 0.4                  | 6.1        |
| Germany             | 2.8                                                          | 0.6                  | 3.5        | 1.0                 | 0.1                  | 1.1        | 4.3                           | 0.9                  | 5.2        |
| Japan               | 2.7                                                          | 0.3                  | 2.9        | 0.5                 | 0.8                  | 1.3        | 3.5                           | 1.2                  | 4.8        |
| <b>Korea</b>        | <b>3.5</b>                                                   | <b>0.9</b>           | <b>4.4</b> | <b>0.5</b>          | <b>1.8</b>           | <b>2.3</b> | <b>4.4</b>                    | <b>2.8</b>           | <b>7.2</b> |
| Sweden              | 4.5                                                          | n                    | 4.5        | 1.6                 | 0.2                  | 1.8        | 6.5                           | 0.2                  | 6.7        |
| United Kingdom      | 3.8                                                          | 0.6                  | 4.4        | 0.8                 | 0.3                  | 1.1        | 5.0                           | 1.0                  | 5.9        |
| United States       | 3.7                                                          | 0.4                  | 4.1        | 1.0                 | 1.9                  | 2.9        | 5.1                           | 2.3                  | 7.4        |
| Israel              | 4.4                                                          | 0.3                  | 4.7        | 1.1                 | 0.9                  | 1.9        | 6.6                           | 1.8                  | 8.3        |
| <b>OECD average</b> | <b>3.6</b>                                                   | <b>0.3</b>           | <b>3.8</b> | <b>1.0</b>          | <b>0.4</b>           | <b>1.4</b> | <b>5.0</b>                    | <b>0.7</b>           | <b>5.7</b> |

1. Including public subsidies to households attributable for educational institutions, as well as including direct expenditure on educational institutions from international sources.

2. Net of public subsidies attributable for educational institutions.

Source: OECD (2007), *Education at a Glance*, OECD, Paris.

### 2.5.3. Secondary education

The OECD's Programme of International Student Assessment (PISA) examines, through tests and surveys of 15-year-olds, how well individual national education systems are doing in equipping their young people with essential skills. The latest round of PISA, carried out in 2006, shows Korean performance to be generally outstanding. Korea appears close to the top of the rankings in reading and mathematics, and ranks high on the science scale as well (OECD, 2007e).

Unlike many traditional assessments of student performance in science, PISA is not limited to measuring students' mastery of specific science content. Instead, it measures the capacity of students to identify scientific issues, explain phenomena scientifically and use scientific evidence as they encounter, interpret, solve and make decisions in life situations involving science and technology. This is important, since if students learn merely to memorise and reproduce scientific knowledge and skills, they risk being prepared mainly for jobs that are disappearing from labour markets in many countries. For today's global economy, students need to be able to solve problems for which there are no clear rule-based solutions and also to communicate complex scientific ideas clearly and persuasively (OECD, 2007e).

Table 2.29 shows how Korea compares to some of the leading economies along these dimensions. First, Korea has one of the highest mean science scores, but performs comparatively less well than in reading and mathematics, where it regularly tops the PISA rankings. Considering Korean students' competency levels, they excel in using scientific evidence but perform less well in explaining phenomena scientifically. Only one other country, France, shows a similar pattern, which has been attributed to a curriculum that emphasises scientific reasoning as well as the analysis of data and experiments. The situation would seem to be similar in Korea, where particular emphasis is placed on analysing tables, graphs and experimental results (OECD, 2007e).

PISA also looks at student performance scores on questions that indicate students' science competencies at one of six proficiency levels. While basic competencies are generally considered important for the absorption of new technology, high-level competencies are critical for the creation of new technology and innovation. For countries near the technology frontier, this implies that the share of highly educated workers in the labour force is an important determinant of economic growth and social development. There is also mounting evidence that individuals with high-level skills generate relatively large externalities in terms of knowledge creation and utilisation, compared to an "average" individual (OECD, 2007e). On average across OECD countries, 1.3% of 15-year-olds reached Level 6 of the PISA 2006 science scale, the highest level. These students consistently identify, explain and apply scientific knowledge, and knowledge about science, in a variety of complex life situations. A total of 9% were proficient at least to Level 5, showing that they had a well-developed capacity for scientific enquiry and were able to combine knowledge and insight appropriately in scientific tasks. Despite overall good performance, just 1.1% of Korean students fall into the Level 6 proficiency category, a little under the OECD average. However, 9.2% of Korean students achieved Level 5 proficiency, compared to an OECD average of 7.7%.

Table 2.29. PISA science scale performance for a selection of countries

|                    | Science score | Performance difference between the combined science scale and each scale |                                     |                           |                         |                 |                |                  |
|--------------------|---------------|--------------------------------------------------------------------------|-------------------------------------|---------------------------|-------------------------|-----------------|----------------|------------------|
|                    |               | Competency                                                               |                                     |                           | Content                 |                 |                |                  |
|                    |               | Identifying scientific issues                                            | Explaining phenomena scientifically | Using scientific evidence | Knowledge about science | Earth and space | Living systems | Physical systems |
| Canada             | 534           | -2.6                                                                     | -3.6                                | 7.1                       | 2.8                     | 5.8             | -4.0           | -5.5             |
| Finland            | 563           | -8.4                                                                     | 2.8                                 | 4.1                       | -5.6                    | -9.0            | 10.5           | -3.6             |
| France             | 495           | 3.9                                                                      | -14.1                               | 15.8                      | 12.2                    | -32.6           | -5.3           | -13.0            |
| Germany            | 516           | -5.9                                                                     | 3.4                                 | -0.3                      | -3.9                    | -5.4            | 8.2            | 0.5              |
| Japan              | 531           | -9.3                                                                     | -4.1                                | 13.0                      | 0.2                     | -1.1            | -5.2           | -1.0             |
| <b>Korea</b>       | <b>522</b>    | <b>-3.1</b>                                                              | <b>-10.5</b>                        | <b>16.3</b>               | <b>4.4</b>              | <b>10.8</b>     | <b>-23.9</b>   | <b>7.6</b>       |
| United Kingdom     | 515           | -1.0                                                                     | 1.9                                 | -1.2                      | 1.8                     | -10.2           | 10.6           | -6.4             |
| United States      | 489           | 3.2                                                                      | -2.8                                | -0.4                      | 3.3                     | 15.1            | -2.1           | -3.7             |
| Hong Kong, China   | 542           | -14.4                                                                    | 7.0                                 | 0.2                       | -0.6                    | -17.1           | 15.4           | 3.3              |
| Macao, China       | 511           | -20.8                                                                    | 9.2                                 | 0.7                       | -5.9                    | -4.9            | 14.2           | 6.7              |
| Russian Federation | 479           | -16.6                                                                    | 3.8                                 | 1.4                       | -4.5                    | 2.0             | 10.5           | -0.2             |
| Chinese Taipei     | 532           | -23.8                                                                    | 12.7                                | -0.6                      | -7.0                    | -3.2            | 16.9           | 13.0             |

Note: The science performance scales have been constructed such that the average student score in OECD countries is 500 points.

Source: OECD (2007), *PISA 2006: Science Competencies for Tomorrow's World*, OECD, Paris.

In terms of content, Korean students perform well in knowledge *about* science. As for knowledge *of* science, Table 2.29 shows the results for three content areas: “Physical systems”, “Living systems”, and “Earth and space systems”. Here, Korea shows larger differences in performance between content areas than any other country participating in PISA, scoring very highly in “Earth and space systems” and “Physical systems”, but coming out at just below the OECD average in “Living systems”. It is interesting to note that this disparity reflects a similar general bias in the strengths and weaknesses of Korean S&T (see Chapter 3, section 3.4).

In spite of the overall impressive PISA performance, there is widespread public discontent in Korea regarding the education system. The high and rising reliance on private tutoring in the primary and secondary levels is widely regarded as a social disease that imposes a number of costs. It has its roots in the fierce competition for prestigious university places. The value of an education at an elite university puts pressure on students to get high scores on the university entrance exam, the College Scholastic Aptitude Test (CSAT), and parents who can afford it feel duty-bound to maximise their children’s chances through extensive private tuition. It has been estimated that expenditure on this extra schooling accounts for some 5% of all consumer spending by private households (OECD, 2005a). It goes without saying that the high proportion of private financing of education undermines equity goals, since the children of wealthier parents start out with better prospects.

But the burden does not fall on household expenditures alone. The high school curriculum is tailored to prepare for the CSAT (see Box 2.19); it relies heavily on rote learning and leaves little room for the creative thinking and exploratory spirit which are essential for S&T education. The result is that while Korea's total spending on education is one of the highest in the OECD area – because of the very high private spending on education as a share of GDP – much of this investment is inefficient and wasteful. Reform of the university entrance system would therefore seem to be a key starting point for improving the quality of secondary education.

#### **Box 2.19. The College Scholastic Aptitude Test**

The competition to get into the “best” universities is fierce, and secondary school students typically work an additional four to six hours a day in tutoring schools (if their parents can afford them) to improve their score on the university admission test, the College Scholastic Aptitude Test (CSAT). With a few notable exceptions, such as Seoul National University, the CSAT often counts for 70% of the overall selection for colleges and universities, with the student's high school record contributing only 10%. It is therefore not surprising that the CSAT and tutoring schools are so important – more important than high school itself.

Over-reliance on a single, national admissions test, in a status-driven culture, not only places disproportionate burdens on the lives of young people during their formative years but also distorts the distribution of talent within the society and across the labour market. Some students end up taking courses for which they have little interest or aptitude, while others who have the potential to excel in their careers start off too often, regrettably, with a sense of failure. If instead universities and colleges could control their own admissions policies, they might develop specialities that would give prospective students more options from which to choose.

One question, then, is whether changes in tertiary education, such as changes in admissions procedures, might reduce the pressures on secondary education. If there were more varied ways to gain admission to universities and colleges, and the influence of the CSAT was reduced to 33% or less, the CSAT would not be as crucial. Universities might add additional criteria to their admissions procedures, including various kinds of experience during secondary education, accomplishments other than academic accomplishments, and extra-curricular activities, so that the CSAT would not be so dominant.

*Source: Grubb et al. (2006), “Thematic Review of Tertiary Education: Korea Country Note”, Directorate for Education, OECD, Paris.*

#### **2.5.4. Tertiary education**

The hierarchy of universities has a powerful influence in determining success in one's career and social status (KEDI, 2006). The most important positions in government, business and even academia are monopolised by graduates of selective and prestigious universities. Such graduates are preferentially hired not because of the perceived quality of education they have received, but because they are judged to be inherently smart because they have passed the very competitive entrance exam to these universities and can “get things done” through informal connections with their university's alumni in important positions. Critics argue that such a system obstructs fair competition among institutions, so that national competitiveness is ultimately compromised. It also exacerbates the problems outlined above concerning the CSAT.

Government spending for tertiary education is quite low by international standards, while private spending is high at nearly four times the OECD average (see Table 2.28). This reflects the pattern of growth since 1980, which has seen tertiary education expand through the opening of new institutions whose activities have been funded by parents (and other private sources, such as churches and corporations). Thus, the enormous increase in tertiary enrolments has been achieved without a substantial increase in public funding (Grubb et al., 2006), with the proportion of private co-payments for tertiary

education standing at around 78%, one of the highest levels in the OECD area (OECD, 2007d). Students studying at college or university pay high fees, and only loans – not grants – are available for children from poorer families.

According to a recent international review of Korean education conducted for the OECD:

“One way to view the current state of tertiary education in Korea is that the basic building blocks are now in place – the universities, colleges, and other specialized institutions with the capacity to enrol substantial proportions of new generations of students. However, the overall challenge for the next several decades is to take these institutions and form them into a coherent system responsive to the needs of parents and prospective students, to employers, and to the social purposes of education.” (Grubb *et al.*, 2006)

#### **Box 2.20. Challenges for Korean tertiary education**

*The match with labour markets.* While it is often asserted that more individuals need to be schooled to meet the challenges of competition and growth, there is evidence that the rapid expansion of tertiary education has resulted in over-education. In addition, there are substantial complaints, particularly from employers, that the skills of graduates do not match the skills required in the labour force.

*Quality.* Virtually everyone in Korea agrees that expansion has resulted in lower quality. However, no one agrees about how to recognise or measure quality, so there is little agreement on what to do about it.

*The quality of teaching and learning.* A particular dimension of quality involves the nature of teaching. Most Korean education has been concerned largely with information transfer, but many Koreans have recognised that conventional lecture-dominated teaching is not a good way to prepare for entrepreneurs, creative thinkers and new perspectives on Korea’s role in a changing world. Current efforts to change teaching and learning appear relatively weak and isolated.

*Governance and regulation.* The expansion of Korean education has occurred largely through expansion of nominally private institutions, but the relatively tight control from MoE has led to institutions that sometimes lack sufficient autonomy and flexibility. A more developmental conception of regulation – one designed to develop the capacities of tertiary institutions, rather than rely on bureaucratic norms to control their actions – probably requires a different approach, and a different type of government agency.

*The role of tertiary education in R&D.* A persistent question concerns the role of tertiary institutions in R&D – a topic that concerns much of this innovation policy review.

*Equity in tertiary education.* The expansion of tertiary education has taken place with little thought for equity issues, understood as equity among social classes (or income groups) and equity between men and women. On the one hand, expansion may have enhanced equity, by increasing opportunities for tertiary education. On the other, the extreme differentiation of tertiary education in Korea, with intense pressure to get into the best universities, has created new forms of inequality.

*Regional equity and the domination of Seoul.* Equity in Korea also takes the form of a regional imbalance, as most young Koreans seem to want to migrate to Seoul while the government would like to see the population, and employment, more evenly spread throughout the country.

*Globalising pressures.* Particularly for a country like Korea, which operates in an open economy, the effect of a globalising world and economy has been powerful. However, the implications specifically for tertiary education are unclear.

*Creating a system of tertiary education.* Because the expansion of tertiary education has happened so quickly, there is now a case for paying increased attention to ways of creating a coherent system of inter-related institutions.

*Source:* Grubb *et al.* (2006), “Thematic Review of Tertiary Education: Korea Country Note”, Directorate for Education, OECD, Paris.

The authors go on to identify several challenges facing tertiary education in Korea (see Box 2.20), most of which are dealt with in various parts of this report. Among them are concerns about quality. The sharp expansion in the number of students attending university has apparently been accompanied by a decline in the quality of tertiary education – a common claim regarding fast-expanding tertiary education systems in many OECD countries. Furthermore, Korean firms regularly complain about the standard of graduates entering the employment market (another common complaint across the OECD area), arguing that curricula are outdated and in need of renewal. At the same time, students in many universities appear to do relatively little work, and there is a prevailing view that university students, after the pressures of the CSAT, do not work very hard (Grubb *et al.*, 2006). In addition, Korean universities' investments in facilities, including equipment for scientific experimentation, are relatively low; this has a detrimental effect on the training of new researchers. The consequences of these conditions are further explored below.

### 2.5.5. Broad patterns in the supply of and demand for human resources

Throughout Korea's industrialisation process, an adequate supply and mobilisation of qualified S&T human resources have been the foundation of industrial and S&T policy. As Figure 2.40 shows, the number of researchers per thousand total employment was above the OECD and the EU27 average in 2005. Owing to the dominance of the business sector in R&D spending, the vast majority of these researchers are employed in firms (see Table 2.30). However, universities are by far the largest employers of PhDs (Table 2.31), although they account for just 10% of Korean gross domestic expenditure on R&D (GERD). This would seem to suggest a significant mismatch between research spending and capabilities and points to the need to enhance R&D spending in universities and/or provide greater incentives to encourage more PhDs to work in the private sector or GRIs.

**Table 2.30. Number of researchers by sector of performance, 1997-2006**

Head count and percentages

|      | Total       |       |             | Public research institutes |       |             | Universities |       |             | Companies   |       |             |
|------|-------------|-------|-------------|----------------------------|-------|-------------|--------------|-------|-------------|-------------|-------|-------------|
|      | Researchers | Ratio | Growth rate | Researchers                | Ratio | Growth rate | Researchers  | Ratio | Growth rate | Researchers | Ratio | Growth rate |
| 1997 | 138 438     | 100.0 | 4.5         | 15 185                     | 11.0  | -2.2        | 48 588       | 35.1  | 7.2         | 74 665      | 53.9  | 4.9         |
| 1998 | 129 767     | 100.0 | -6.3        | 12 587                     | 9.7   | -17.1       | 51 162       | 39.4  | 5.3         | 66 018      | 50.9  | -11.6       |
| 1999 | 134 568     | 100.0 | 3.7         | 13 986                     | 10.4  | 11.1        | 50 151       | 37.3  | -2.0        | 70 431      | 52.3  | 6.7         |
| 2000 | 159 973     | 100.0 | 18.9        | 13 913                     | 8.7   | -0.5        | 51 727       | 32.3  | 3.1         | 94 333      | 59.0  | 33.9        |
| 2001 | 178 937     | 100.0 | 11.9        | 13 921                     | 7.8   | 0.1         | 53 717       | 30.0  | 3.8         | 111 299     | 62.2  | 18.0        |
| 2002 | 189 888     | 100.0 | 6.1         | 14 094                     | 7.4   | 1.2         | 57 634       | 30.4  | 7.3         | 118 160     | 62.2  | 6.2         |
| 2003 | 198 171     | 100.0 | 4.4         | 14 395                     | 7.3   | 2.1         | 59 746       | 30.1  | 3.7         | 124 030     | 62.7  | 5.1         |
| 2004 | 209 979     | 100.0 | 6.0         | 15 722                     | 7.5   | 9.2         | 59 957       | 28.5  | 0.4         | 134 300     | 64.0  | 8.3         |
| 2005 | 234 702     | 100.0 | 11.8        | 15 501                     | 6.6   | -1.4        | 64 895       | 27.6  | 8.2         | 154 306     | 65.7  | 14.9        |
| 2006 | 256 598     | 100.0 | 9.3         | 16 771                     | 6.5   | 8.2         | 65 923       | 25.7  | 1.6         | 173 904     | 67.8  | 12.7        |

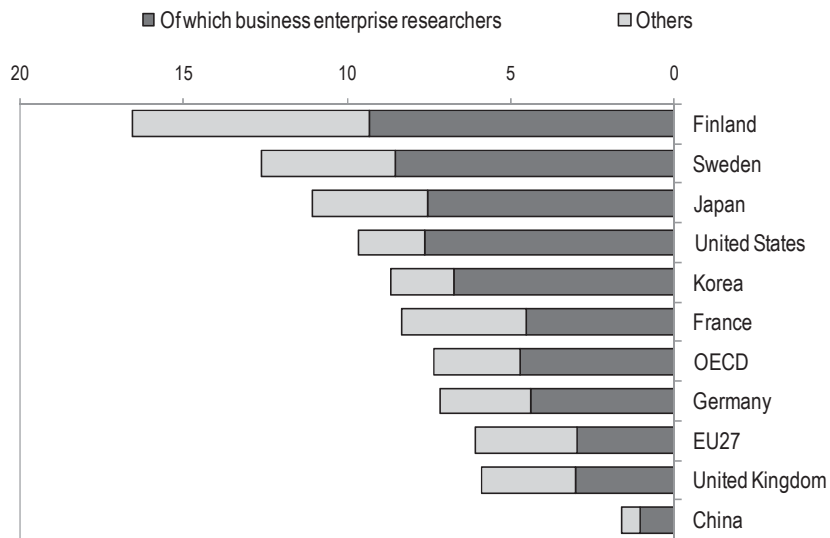
Source: MoST and KISTEP (2007), *Report on the Survey of Research and Development in Science and Technology*, Ministry of Science and Technology and Korea Institute of Science and Technology Evaluation and Planning, Seoul.

**Table 2.31. The distribution of researchers by degree, 2006**

Headcount and percentages

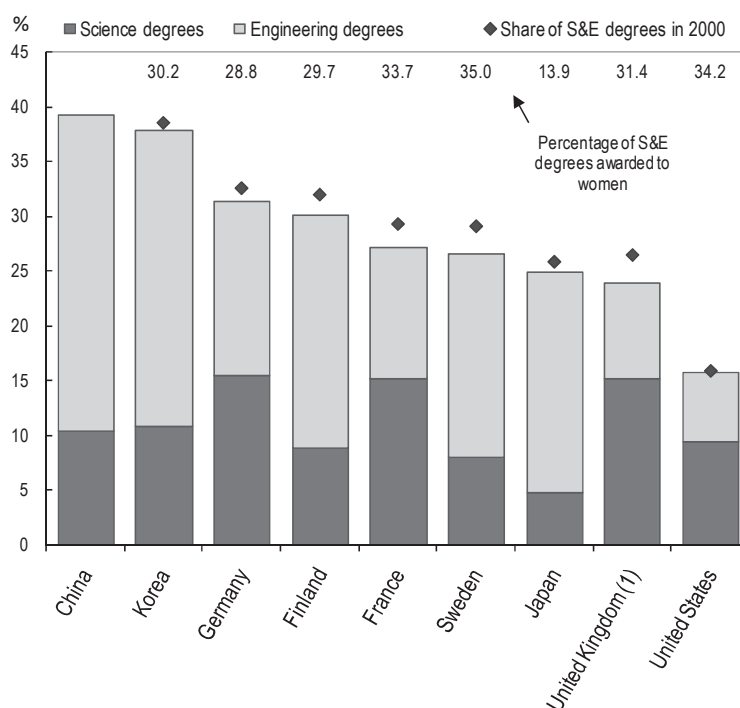
|                 | Public research institutes | Universities     | Companies        | Total   |
|-----------------|----------------------------|------------------|------------------|---------|
| <b>PhD</b>      | 8 083<br>(13.5)            | 40 256<br>(67.1) | 11 674<br>(19.5) | 60 013  |
| <b>Master</b>   | 6 887<br>(8.3)             | 22 878<br>(27.4) | 53 615<br>(64.3) | 83 380  |
| <b>Bachelor</b> | 1 579<br>(1.6)             | 1 835<br>(1.8)   | 98 008<br>(96.6) | 101 422 |
| <b>Others</b>   | 222<br>(1.9)               | 954<br>(8.1)     | 10 607<br>(90.0) | 11 783  |

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.

**Figure 2.40. Researchers per thousand total employment, 2006 or nearest available year**

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

The generally impressive increases in researcher numbers have been achieved by a remarkable record in expanding student enrolments at all levels of schooling. Furthermore, Korea produces among the highest numbers of science and engineering (S&E) graduates as a proportion of the total, although there has been a slight decline in recent years, albeit less so than in many other leading industrial economies (Figure 2.41). The graduation rate of women in these subjects is also close to the OECD average at around 30%, though the data in Figure 2.41 would seem to suggest that many fail to take up employment in the field.

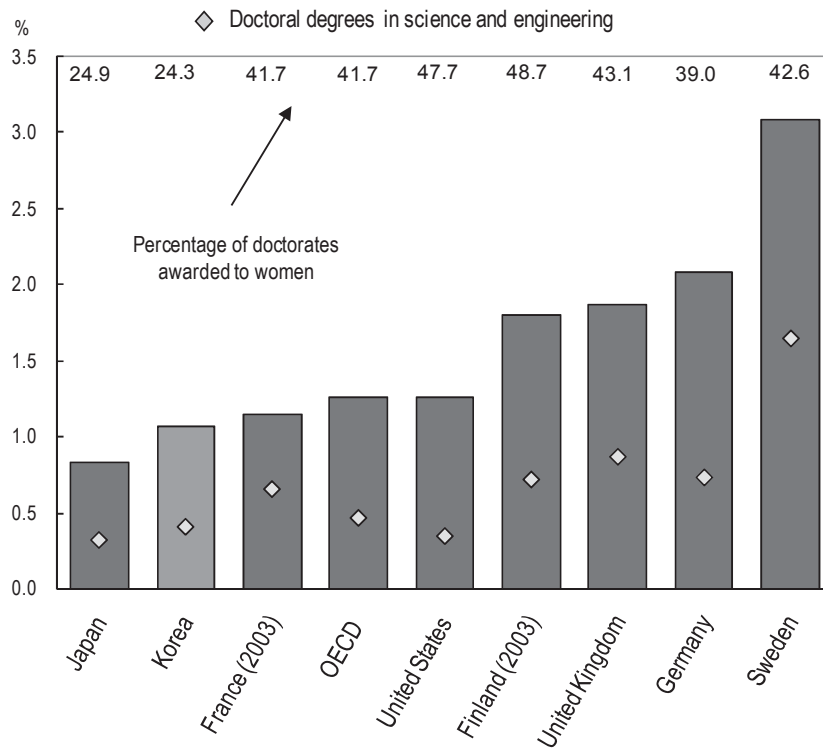
**Figure 2.41. Science and engineering degrees as a percentage of total new degrees, 2005**

1. 2003 data for the United Kingdom are used.

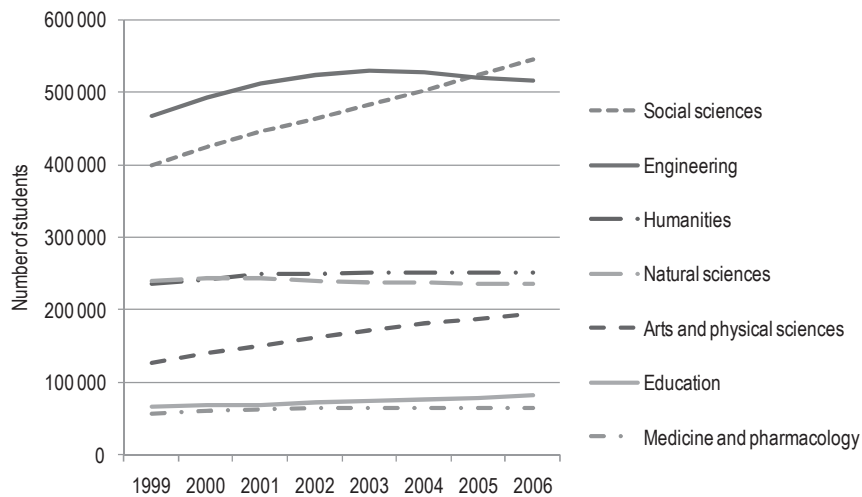
Source: OECD, Education database, September 2007.

Figures for graduation rates at doctoral level are perhaps less impressive, with Korea below the OECD average, although Japan performs even less well (Figure 2.42). The number of doctorates awarded to women is also the lowest among the leading industrial countries. As discussed below, many Koreans choose to study overseas for their doctorates, so these figures are likely to significantly under-estimate the total number of Koreans graduating with PhDs. However, decreasing return rates mean that these overseas PhDs may not be the resource they once were, an issue further discussed below.

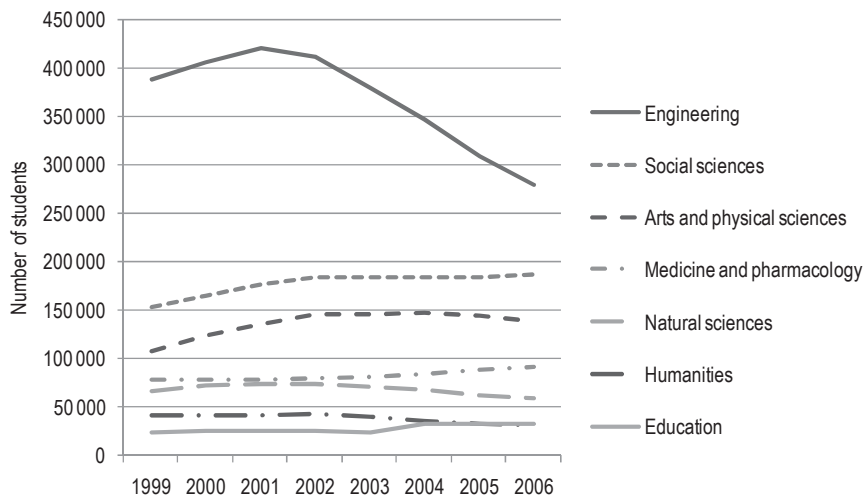
The most recent data from the Ministry of Education (up to 2006) suggests that the situation in science and engineering degrees is rapidly worsening (Figures 2.43 and 2.44). The falls in engineering enrolments are especially pronounced in junior colleges. There has also been a slight decline in the number of enrolments in natural sciences. The social sciences and humanities are increasingly popular, particularly in the universities, with the number of social science enrolments surpassing the number of engineers for the first time in 2005. There have also been slight increases in enrolments in medicine and pharmacology.

**Figure 2.42. Graduation rates at doctorate level, 2004**

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

**Figure 2.43. University enrolments by field, 1999-2006**

Source: Ministry of Education statistics.

**Figure 2.44. Junior college enrolment by field, 1999-2006**

Source: Ministry of Education statistics.

### Box 2.21. Explanations for the growing disinterest in science and engineering

Ryoo (2004) has analysed the economic roots of the increasing tendency of Korean high-school students to reject S&E fields in tertiary education. The study compared the performance of science and engineering graduates in the labour market with that of other graduates by analysing the Korean Labour and Income Panel Study (KLIPS) data from 1998 to 2002. It found that the unemployment rate of S&E graduates is slightly higher than that of non-S&E graduates, though the differences are negligible. Furthermore, the analysis showed that the relative economic position of S&E graduates measured in terms of employment quality is not significantly different from that of non-S&E graduates. However, the study did show that S&E graduates earn relatively low wages and self-employment income. Moreover, the relative income of the top 5% of S&E graduates has been declining in recent years. The study concluded that the main reasons for avoiding S&E fields are the low relative incomes of the average S&E graduate as well as the increasingly lower relative income of the most able S&E graduates, coupled with the increasing compensating differential required for S&E jobs.

In a further study, Park (2004) has analysed the causes of the decline in applications for S&E courses. Compared to graduates in the social sciences and humanities, the study found that S&E graduates have a higher risk of suffering redundancy and lower levels of remuneration throughout their careers. S&E graduates start with lower wages than their counterparts in social sciences and humanities when they enter the job market, and this persists until the 15th year of their careers. Furthermore, because S&E graduates have a higher risk of redundancy, they suffer from greater job insecurity. Interestingly, rapid technological progress and the risks of knowledge obsolescence are, among others, a major cause of job instability for S&E graduates.

A sample of academic work examining these enrolment trends is summarised in Box 2.21. Perceptions of relatively low remuneration and unfavourable working conditions would seem to be contributing to a decline in interest in S&E degrees. Similar trends – and their causes – can be observed in most OECD countries, so the situation in Korea is hardly unusual. On the other hand, these trends are a cause for continuing concern among S&T policy makers in Korea. The question is whether these concerns are well founded. On the face of it, such declines would certainly seem to be worrying, but it might reasonably be argued that Korea has perhaps been producing too many engineering

graduates in recent years and that some readjustment is in fact overdue. Indeed, when compared to other leading industrial manufacturing economies, such as Germany, Japan and Sweden, Korea still produces a far larger proportion of engineering graduates, even when recent declines are taken into account. The picture is slightly different for the natural sciences, in which the proportion of enrolments is lower than in some leading industrial countries (Germany, France and the United Kingdom), though on a par with Japan and the United States. The situation will need to be carefully monitored, though declines in enrolments to date remain relatively small. Perhaps of greater concern than a potential quantitative shortage is the quality of students in science and engineering, as shown by their CSAT scores. These have been declining as more able students are attracted to social sciences, business, law, education and medicine.

Besides international benchmarking, the economy's demand for S&E graduates is also a useful guide for gauging whether perceptions of crisis in the supply of S&E graduates are in fact justified. According to the Korean Educational Development Institute (KEDI), the leading educational research institute in Korea, there is an imbalance in the supply of and demand for human resources, in terms of university qualifications and the fields covered. Overall, there are too many people with bachelor's degrees and too few with master's or doctoral degrees in high-technology fields (KEDI, 2006). The latter point would seem to be supported by data from the Korean Ministry of Labour (see Table 2.32), which show a growing shortage of technical manpower since 2004.<sup>7</sup> The shortage is much greater for SMEs than the industry average on account of sharp increases in wage differentials by firm size (see Table 2.33). In other words, the shortage of technical personnel in SMEs is likely caused by SMEs' inability to pay competitive wages rather than by strong demand for technical manpower.

**Table 2.32. Shortage of technical personnel, 2004-07**

Percentages

|                       | 2004 | 2005 | 2006 | 2007 |
|-----------------------|------|------|------|------|
| Total                 | 2.5  | 3.1  | 2.7  | 3.2  |
| Shortage rate of SMEs | 3.7  | 5.0  | 5.3  | 5.0  |

*Notes:* Technical personnel here is defined as the following occupations according to OES (Korean Employment Classification of Occupations): Natural and Life Science Professionals (042), Natural and life Science associate professionals (044), Mechanical Engineer (151), Metal and Materials Engineers (161), Electric and Electronic Engineers (191), Computer and Telecommunication Engineers (201), Computer and Information System professionals (202).

*Source:* Korean Ministry of Labour, *Labour Demand Survey*, various years.

**Table 2.33. Average wage levels of SMEs relative to those of large firms, manufacturing sector, 1990, 1995, 2000-05**

|                                 | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---------------------------------|------|------|------|------|------|------|------|------|
| Relative wage level of SMEs (%) | 66.2 | 64.3 | 55.5 | 55.4 | 55.7 | 54.8 | 52.2 | 51.5 |

*Note:* Average wage level of large firm = 100.

*Source:* Korean National Statistical Office, *Report on Mining and Manufacturing Survey*, various years.

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 junior colleges, while there are too many individuals with bachelor's degrees who cannot find appropriate employment. The latter point is supported by figures from KEDI (2006), which show that only about two-thirds of new graduates of universities and junior colleges find employment within six months of graduating. Changes in recruiting practices and higher student expectations are blamed for the resulting high unemployment rates. With so much competition for jobs, university and college graduates have lost their former privileged status in the labour market and now compete with workers with qualifications from vocational high schools (OECD, 2005b). This has led to a drop in wage differentials based on educational levels. For example, until the mid-1980s, the average wage of college graduates was 2.3 times greater than that of high school graduates, but since the early 1990s, it has stayed at around 1.5 times greater. The average wage of junior college graduates, which used to be 1.5 times greater than that of high school graduates in the 1980s, dropped to only 1.024 times greater by 2004. Given these narrowing wage differentials and high unemployment rates, it would seem that the choice of tertiary education can be explained by a deeply rooted respect for knowledge, a Confucian cultural heritage, and the elitism associated with college education.

To conclude, complaints about the mismatches of skills are quite varied in their origin and in their solutions:

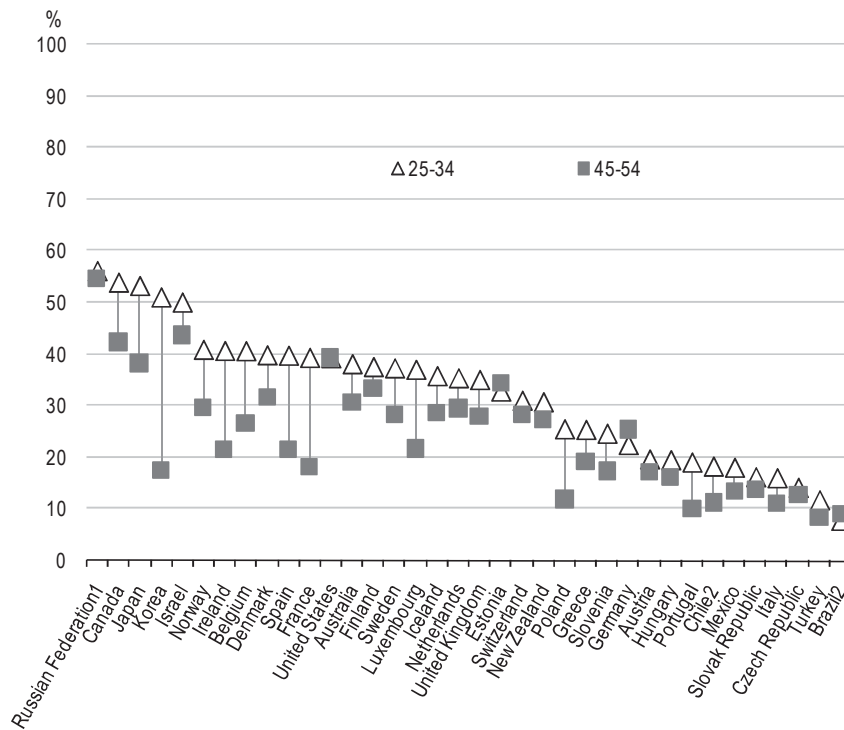
“Some seem to arise from student misunderstanding of what jobs require, and then the solution is better information to students. Some arise from educational institutions having rigid staffing structures and being resistant to change and, particularly, failing to recognize the competencies required in modern work, and the solution is for employers and education providers to confer about the requirements of modern work. Sometimes the solution should come from employers themselves, developing certain skills on their own, or creating internships and other forms of work-based learning. In some cases, like shortages of workers in unpleasant jobs, the real solution should come from the demand side and increasing wages. And more might be done through financial incentives that encourage responsiveness to changing circumstances on the part of higher education institutions. Like many other issues in Korean education, the problem of mismatches is not a single issue, but a series of somewhat different issues requiring different solutions.” (Grubb *et al.*, 2006)

### 2.5.6. Lifelong learning

The marked expansion of higher education in the past few decades has led to major differences in educational attainment of successive generations (see Figure 2.45). The Korean education system is strongly geared to young people, with the participation of the younger generation above the OECD average; in older age groups, participation is well below the OECD average (see Table 2.34). These figures are a reflection of the delay in investing in adult education, the causes of which are twofold. First, when industrialisation began, Korea needed large numbers of less skilled workers, since it initially entered the global market with simple products. At that time Koreans did not have the same education opportunities as the current generation. Second, significant population growth (from 25.8 million in 1961 to 48 million in 2003) meant that it was easy to improve the skills structure of the working population via the change in generations. This has worked

well until recently, but with a sharp drop in the birth rate, annual employment growth is set to decline, irrespective of any increases that might occur in the employment rate. This means that further technological and economic change will be increasingly dependent on continuing education and training for those already in employment (OECD, 2005b).

**Figure 2.45. Percentage of population by age group that has attained at least tertiary education, 2005**



1. Data for Russian Federation 2003.

2. Data for Chile and Brazil 2004.

Source: OECD (2007), *Education at a Glance*, OECD, Paris.

**Table 2.34. Enrolment rates of full-time and part-time students in public and private institutions, by age, 2005**

Percentages

|                           | 15-19       | 20-29       | 30-39      | 40 and over |
|---------------------------|-------------|-------------|------------|-------------|
| <b>Korea (2005)</b>       | <b>85.6</b> | <b>27.3</b> | <b>2.0</b> | <b>0.5</b>  |
| Korea (2001) <sup>1</sup> | 79.3        | 25.0        | 1.6        | 0.3         |
| Finland                   | 87.5        | 42.6        | 13.1       | 3.0         |
| Germany                   | 88.8        | 28.2        | 2.5        | 0.1         |
| Sweden                    | 87.3        | 36.4        | 13.3       | 3.0         |
| United Kingdom            | 78.5        | 29.0        | 15.8       | 7.8         |
| United States             | 78.6        | 23.1        | 5.2        | 1.4         |
| <b>OECD average</b>       | <b>81.5</b> | <b>24.9</b> | <b>6.0</b> | <b>1.6</b>  |

1. Korean data for 2001 taken from OECD (2003), *Education at a Glance 2003*, OECD, Paris.

Source: OECD (2007), *Education at a Glance 2007*, OECD, Paris.

The Korean government has recognised this problem and has in recent years sought to promote the participation of adults in formal education. But progress is slow, owing in part to the continuing emphasis upon full-time degree programmes in the Korean education system, although these are generally ill suited to the needs of adults already in employment (Grubb *et al.*, 2006). Furthermore, the dualistic nature of the Korean labour market inhibits the possibility of a far greater uptake of education by those in employment, as explained in Box 2.22.

#### **Box 2.22. Dualism in the Korean labour market**

The 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 (see Table 2.33). 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. This division in the labour market, the lack of mobility prospects for irregular workers and workers in SMEs, and the seniority-based wage system, all mean that there is little financial incentive for many workers to invest in their own human capital.

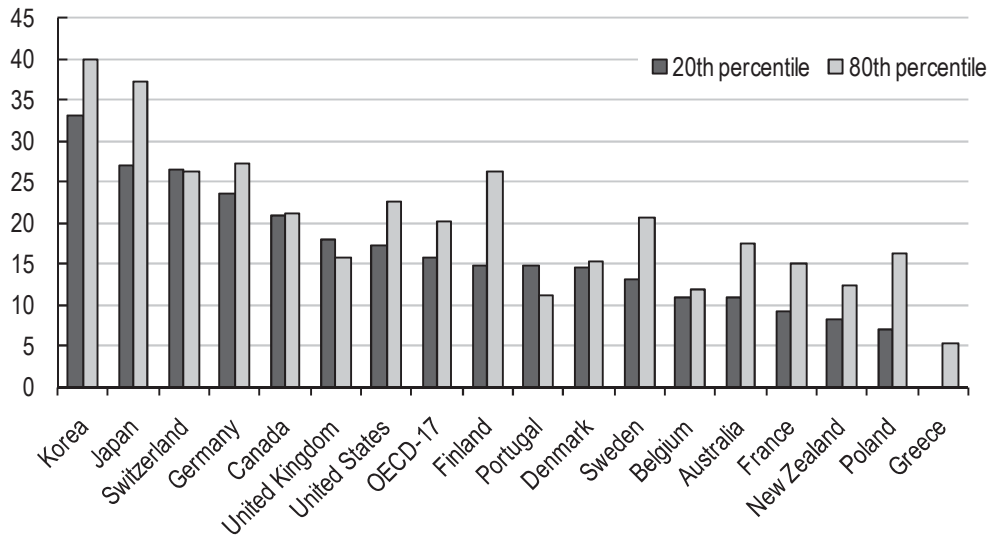
*Source:* OECD (2005), *Thematic Review of Adult Learning: Korea Country Note*, OECD, Paris.

#### **2.5.7. Gender imbalance**

The female employment rate is also relatively low at 52.5% compared to an OECD average of 56.1%. In all OECD countries except Korea, women with university level educational attainment have higher rates of participation in the labour force than those with lower levels. In 2004, 57% of women with university education participated in the labour force compared with 59% of women who had only compulsory education (OECD, 2007f). An important reason for this trend in Korea lies in traditional family values, with women remaining at home. Well-qualified men can normally earn a wage which allows them to finance the traditional family model. Since highly qualified Korean women tend to marry well-qualified men, they are more likely to adopt the traditional family model (OECD, 2005b).

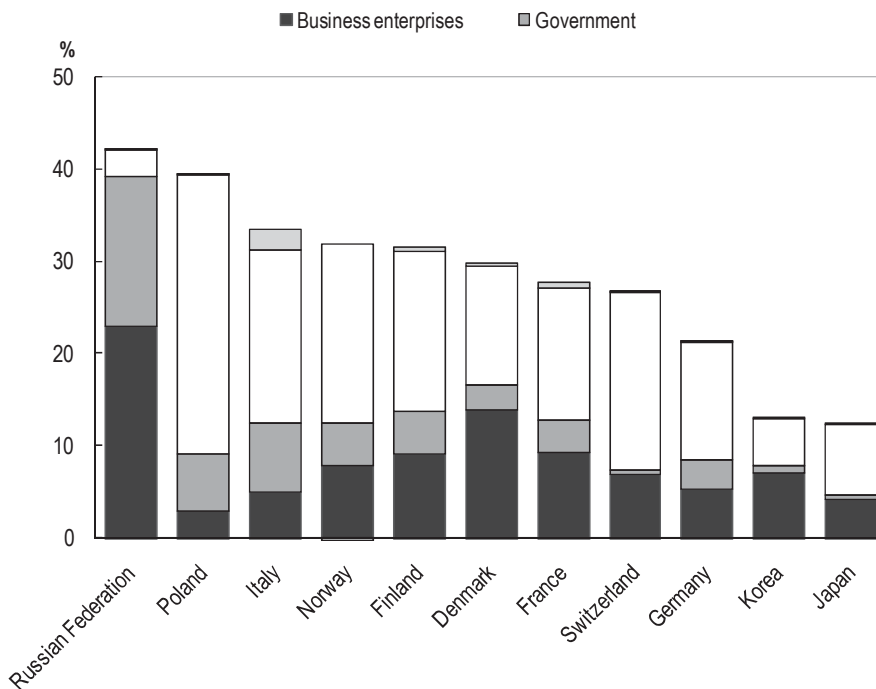
However, another important reason for the low activity rate among well-qualified women lies in the duality of the labour market (see Box 2.22), which manifests itself most clearly in the significant gender wage gap. As Figure 2.46 shows, while there are still wage differentials between women and men 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 advancement) and a long working-hours culture.<sup>8</sup> These are structural problems in the economy that will be difficult to solve, but there is a clear need for increased levels of female employment, as the Korean labour force is projected to decline in future (OECD, 2005b).

**Figure 2.46. Gender gap in full-time earnings at the top and bottom of the earnings distribution, 2003 or latest available year**



Source: OECD (2006a), *Society at a Glance*, OECD, Paris.

**Figure 2.47. Women researchers by sector of employment, as a percentage of total researchers, 2006**



Note: 2005 instead of 2006 for Denmark, Germany and Norway; 2004 for Switzerland.

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

Korea also has one of the lowest proportions of women researchers (see Figure 2.47), at 13% in 2006 (Table 2.35). The sector with the largest proportion of female researchers is higher education (around 20%), with business enterprises the lowest (around 10%). These figures can no doubt be attributed to some of the more generic reasons for low female participation rates discussed above. However, in addition, the fact that Korea's human resources in science and technology (HRST) are heavily biased towards the traditionally less female-friendly engineering professions clearly contributes to these low levels. As Table 2.36 shows, more than 90% of researchers are working in engineering, an area that has by far the lowest female participation rates at a meagre 8%.

**Table 2.35. The distribution of researchers by gender and sector of performance, 2006**

Head count and percentages

|                               | Male    |            | Female |            |
|-------------------------------|---------|------------|--------|------------|
|                               | Number  | Percentage | Number | Percentage |
| Public research organisations | 14 122  | 84.2       | 2 649  | 15.8       |
| Universities                  | 52 879  | 80.2       | 13 044 | 19.8       |
| Companies                     | 155 915 | 89.7       | 17 989 | 10.3       |
| Total                         | 222 916 | 86.9       | 33 682 | 13.1       |

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 2.36. The distribution of researchers by gender and major field, 2006**

Head count and percentages

|                                | Male    |            | Female |            |
|--------------------------------|---------|------------|--------|------------|
|                                | Number  | Percentage | Number | Percentage |
| Natural science                | 26 911  | 76.4       | 8 328  | 23.6       |
| Engineering                    | 169 909 | 91.9       | 14 988 | 8.1        |
| Medical science                | 11 851  | 68.1       | 5 540  | 31.9       |
| Agriculture, forestry, fishery | 6 063   | 85.0       | 1 069  | 15.0       |
| Others                         | 8 182   | 68.5       | 3 757  | 31.5       |
| Total                          | 222 916 | 86.9       | 33 682 | 13.1       |

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.

### 2.5.8. *Labour mobility*

There is generally little labour mobility in Korea. Some of the reasons have already been discussed and concern the dualistic nature of the labour market, particularly the divide between regular and non-regular workers and between large firms and SMEs. In the context of innovation, a further issue of concern is the relative lack of HRST mobility between universities, GRIs and industry, which tends to hamper knowledge diffusion throughout the innovation system. There are cultural reasons for this, including the perceived status of certain types of jobs and institutions (for example, working in a university is highly regarded and few people leave once they enter the academic system). Working conditions can also contribute to such perceptions, with weak pension provision and the need to compete for funding a major disincentive for many to move to GRIs from a more comfortable existence in a university. Taken together, these conditions mean that GRIs and firms have experienced an internal “brain drain” to the universities, with very little movement in the opposite direction.

Another aspect of HRST mobility concerns migration into and out of Korea. The rapidly growing demand for highly skilled workers and growing concerns about ageing populations have translated into a global competition for talent. A major challenge for Asian nations has been the creation of domestic employment opportunities, through either foreign direct investment (FDI) or investment by national governments and indigenous businesses, to enable career paths to be pursued back home, thus transforming a potential “brain drain” into an actual “brain gain” (Lazonick, 2007). This challenge is especially acute for Korea, with 13 scholars (university researchers or teachers) in the United States per 100 university researchers in Korea, a rate far higher than in the leading OECD economies. Moreover, the average annual growth rate in the number of scholars working abroad is the highest in the world at almost 10% over the last decade or so (see Table 2.37).

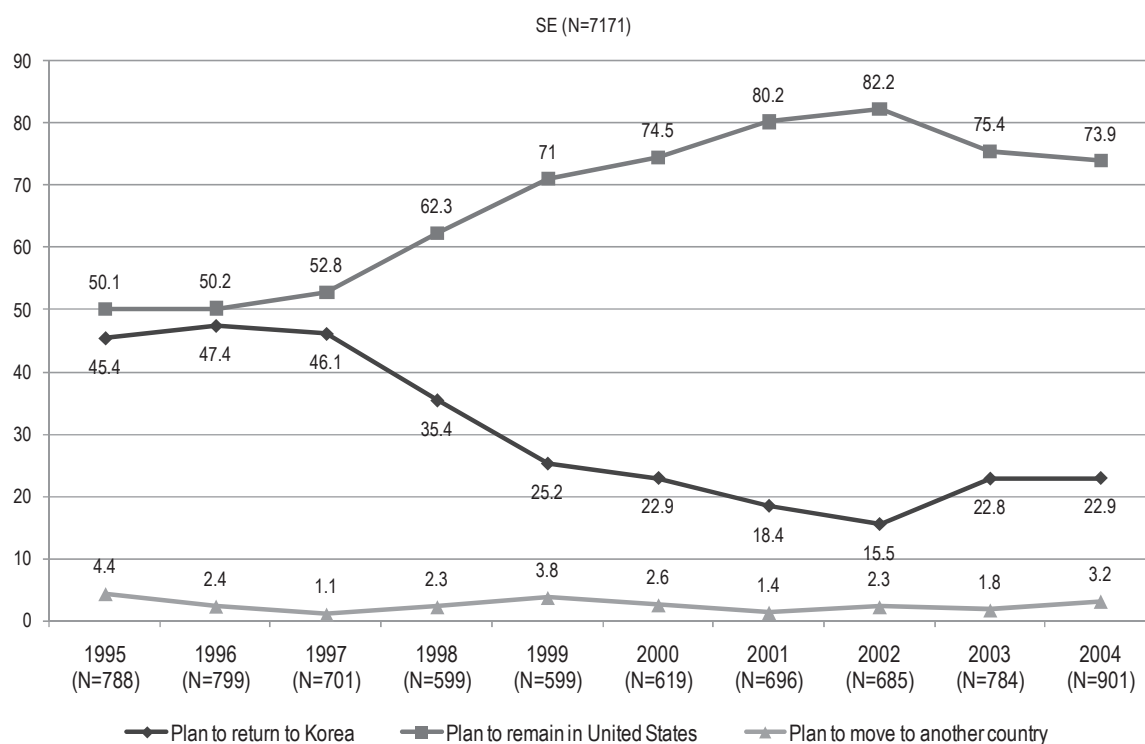
Furthermore, it has been reported that there were over 100 000 students from Korea in the United States in 2007, more than from any other country and well ahead of the former No. 1, India.<sup>9</sup> Many are studying postgraduate courses in science and engineering and therefore offer great potential to further boost HRST in Korea. But this potential may not be realised, at least not in the short term, since the number of doctoral students returning to Korea after graduation has dramatically declined over the last decade (see Figure 2.48), 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. Preliminary findings seem to point to the following: higher quality research and work environments in the United States; lack of suitable post-doc positions in Korea, especially in universities; and better conditions in the United States to raise and educate children. Some derive a brain drain scenario from this and point to the need to improve research and education in Korean universities. A more positive view is that Korea is becoming more internationalised through a process of “brain circulation”.

**Table 2.37. Growth in foreign scholars, by economy of origin, average annual growth rate, 1995-2006**

| Country                 | Average annual growth rate<br>1995-2006 | Number of scholars in the United States<br>per 100 university researchers in the<br>economy of origin <sup>1</sup> |
|-------------------------|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <b>Korea</b>            | <b>9.9</b>                              | <b>13.0</b>                                                                                                        |
| India                   | 7.7                                     | n.a                                                                                                                |
| China                   | 6.1                                     | n.a                                                                                                                |
| Russia                  | 5.6                                     | 8.2                                                                                                                |
| Chinese Taipei          | 3.3                                     | 5.8                                                                                                                |
| France                  | 3.1                                     | 3.0                                                                                                                |
| <b>OECD (1995-2004)</b> | <b>3.1</b>                              | <b>n.a</b>                                                                                                         |
| Sweden (1995-2005)      | 2.8                                     | 1.7                                                                                                                |
| United Kingdom          | 2.0                                     | n.a                                                                                                                |
| EU25 (1995-2004)        | 1.7                                     | n.a                                                                                                                |
| Germany                 | 1.4                                     | 2.8                                                                                                                |
| Japan                   | 0.8                                     | 1.9                                                                                                                |
| Finland (1995-2004)     | -2.9                                    | 1.6                                                                                                                |

1. 2005 for Japan and Korea; 2004 for France and Germany; 2003 for Sweden; 2002 for other economies.

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

**Figure 2.48. Postgraduate plans of Korean recipients of doctorate from US universities in science and engineering fields, 1995-2004**

Source: NSF (2004), *Survey of Earned Doctorates*, US National Science Foundation.

At the same time, 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, 2007a). The Korean government is providing preferential treatment and incentives to attract highly skilled foreign workers, measures which are described in Chapter 3.

## 2.6. System linkages

It is important both to develop capabilities and opportunities in research actors and to pay attention to the linkages between them. Accordingly, over the last two decades, governments across the OECD area have reframed their S&T policies with a view to strengthening systems of innovation. This has led policy makers to consider the relationships and linkages between different players in innovation systems: firms, universities and government research institutes. This section reviews the state of Korean innovation system linkages on the basis of funding and technology transfer statistics. It begins with a discussion of research convergence, which tends to have implications for the degree of complementarity and co-operation across research systems.

### 2.6.1. Convergence and competition

The evidence shows that a high rate of complementarity between public- and private-sector R&D improves innovation performance, with each actor performing relatively distinct functions essential to the operation of the innovation system. Furthermore, complementary assets and capabilities are more conducive to co-operation between innovation actors. This complementarity clearly exists in all OECD countries, including Korea, but is also under pressure from the tendency for research performers' research activities to converge.

This convergence is well-illustrated by the evolution of research performed in Korean industry, HEIs and the GRIs (based on *Frascati Manual* definitions, OECD, 2002). It is apparent from the data that the growth in the proportion of basic research spending in Korea in recent years is entirely accounted for by significant budget increases in companies, where the share of investment in basic research almost doubled from 6.5% of BERD in 1998 to 11.9% in 2006 (see Figure 2.8 in section 2.1). By contrast, the proportion of spending on basic research has fallen in both the GRIs (from 26.7% in 1998 to 20.5% in 2006 – see Table 2.21 in section 2.3) and HEIs (from 40.1% in 1998 to 33.4% in 2006 – see Table 2.25 in section 2.4). Similarly, the overall decline in the proportion of applied research carried out in Korea can be entirely accounted for by shifting research portfolios in companies, where only 15.6% of research was classified as “applied” in 2006 compared to 21.1% in 1998. While the proportions of applied research in GRIs and HEIs have remained relatively constant, the proportions of experimental development carried out in these organisations increased markedly – from 38.0% in 1998 to 43.7% in 2006 in GRIs, and from 26.1 to 34.4% in HEIs over the same period.

These figures can be explained by two important developments: first, several large Korean companies have reached the technological frontier in their sectors and have recognised the need to conduct more basic research in order to compete successfully. At the same time, more SMEs and venture companies are investing in basic research than previously. As a result, Korean firms are now by far the major investors in basic research in

Korea, spending around 50% more in absolute terms than the GRIs and HEIs combined. The second development concerns the pressures on GRIs and HEIs to commercialise the fruits of their research, which has led them to focus increasingly upon experimental development.

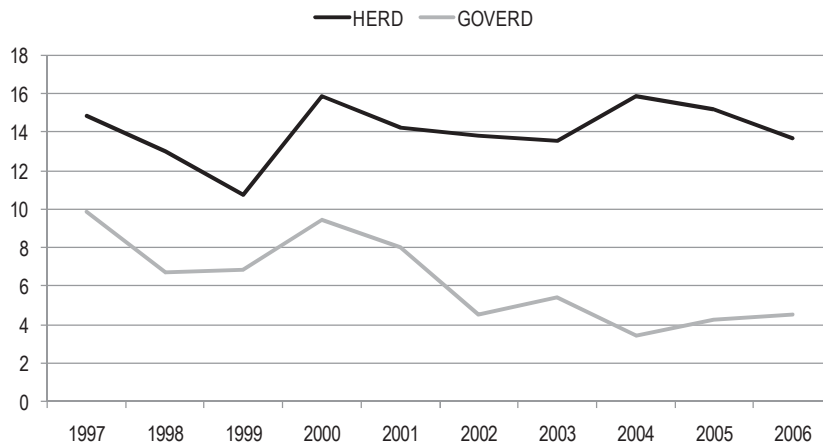
It would be too much to characterise these shifts as a reversal of the traditional roles of research system actors, particularly as GRIs and HEIs still spend a higher proportion of their R&D budgets on basic research than firms and the latter spend a higher proportion of their R&D on experimental development than the public sector. These figures are nevertheless symptomatic of the growing convergence of research performers in Korea. As a result, their complementarities are less clear-cut, and this has been a factor not only in the GRIs' identity crisis, but has also contributed to greater competition between research performers, as well as a lack of trust, probably at the expense of greater co-operation.

### ***2.6.2. The strength of system linkages***

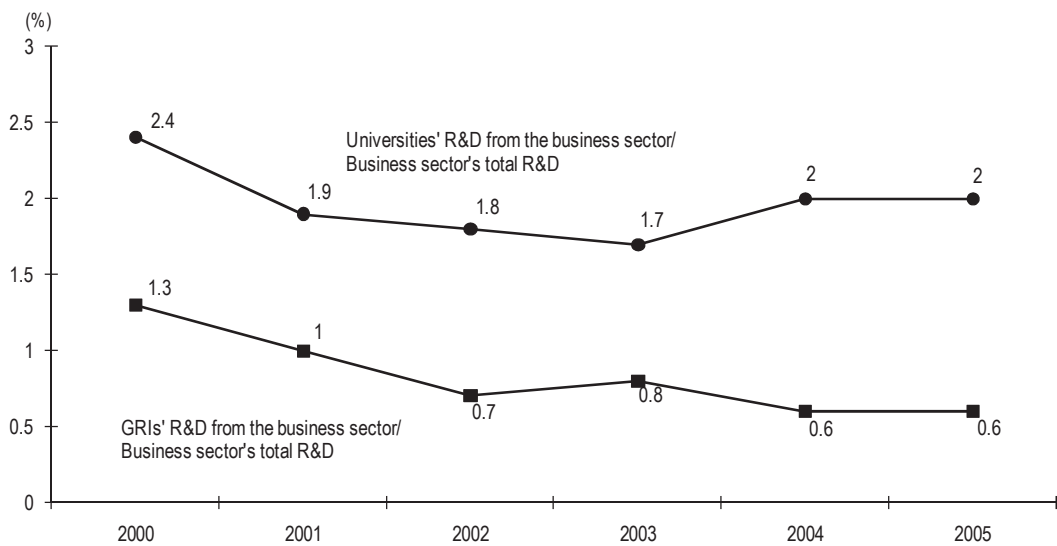
Korea has a rich and successful history of public-private partnerships (P/PPs) in technology and product development. For example, the well-known technologies TDX, DRAM and TICOM were all developed by R&D consortia involving GRIs and private firms. Furthermore, many Korean government funding programmes require the building of such consortia – more than one-third of the government's R&D funding is funnelled through industry-HEI/GRI co-operative programmes (see Chapter 3). Despite these impressive figures and Korea's history of collaboration, the industry-academia-government interface is widely considered by Koreans to be weak and the level of R&D collaboration between public and private research to be insufficient. How is this perception to be explained?

Here, it is worth considering the levels of expenditures by industry on research performed in HEIs and GRIs and the levels of government funding to industry. Both are useful measures for examining shifting collaborative arrangements and for international benchmarking. Figure 2.49 shows that the proportion of government intramural expenditure on R&D (GOVERD) (essentially, R&D carried out in the GRIs) funded by the private sector has more than halved since 2000 (from 9.5% to just 4.5%). Figure 2.50 also confirms this trend, showing that businesses spent just 0.6% of their R&D spending in the GRIs in 2005 (compared to 1.3% in 2000). Yet, comparing these latest figures to international benchmarks, Korea is a middle performer, with a much higher proportion of business funding of GOVERD than the United States and Japan, but only about half the level of Germany and the United Kingdom (Figure 2.51). Thus, perceptions of weakness in relations between industry and the GRIs are probably informed by history, as the GRIs played a much more prominent role in Korea's industrialisation process in earlier times.

The situation of industry funding of higher education expenditure on R&D (HERD) is somewhat different. As Figure 2.49 shows, the proportion of HERD funded by industry has remained roughly flat over the ten years to 2006 and stands at 13.7%, three times the figure for GOVERD. At the same time, while Figure 2.50 shows a decline in the share of business-funded R&D performed in HEIs, it is slight (from 2.4% in 2000 to 2.0% in 2005); industry spends more than three times as much in HEIs as in GRIs. Moreover, international comparison shows the percentage of HERD funded by industry to be one of the highest in the OECD area (see Figure 2.52), while the share of business-funded R&D performed in HEIs – at 2% in 2005 – also compares favourably internationally.<sup>10</sup> Thus, R&D collaboration between industry and HEIs would seem to be relatively strong and stable, something that new government funding directed at the HEI sector should remain sensitive to.

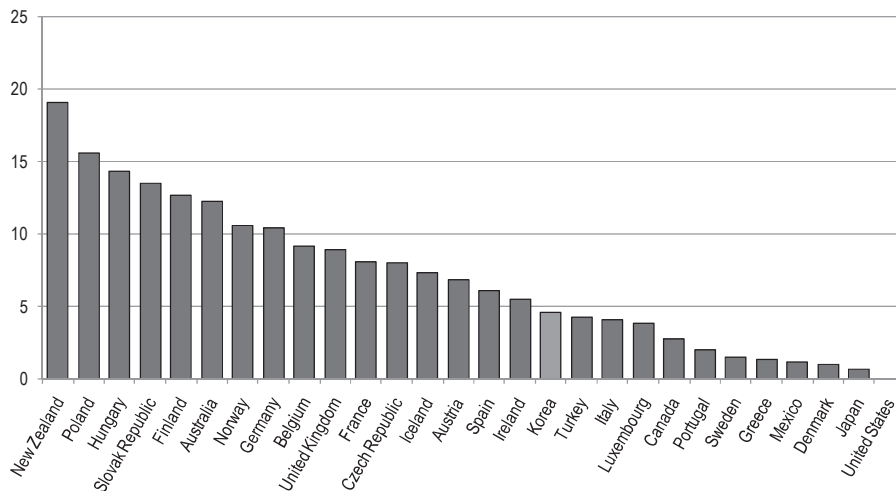
**Figure 2.49. Percentage of GOVERD and HERD funded by business in Korea, 1997-2006**

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

**Figure 2.50. Proportion of business-funded R&D received by universities and GRIs, 2000-05**

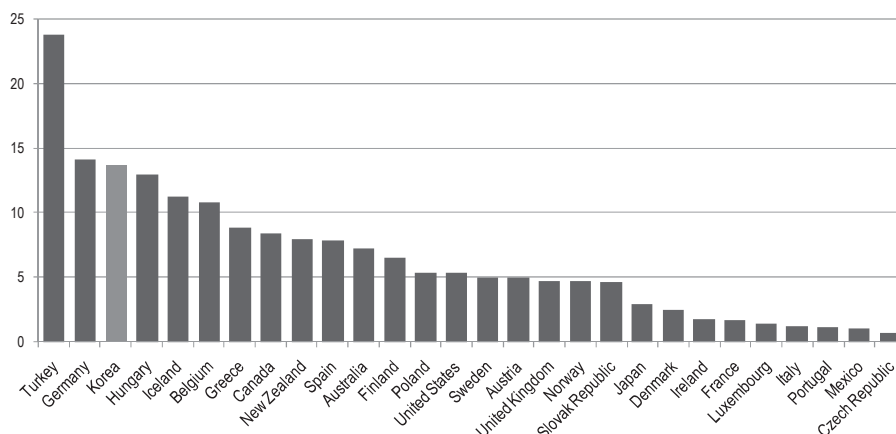
Source: KISTEP database.

**Figure 2.51. Business-financed R&D in the government sector (2006 or nearest available year), as a percentage of GOVERD**



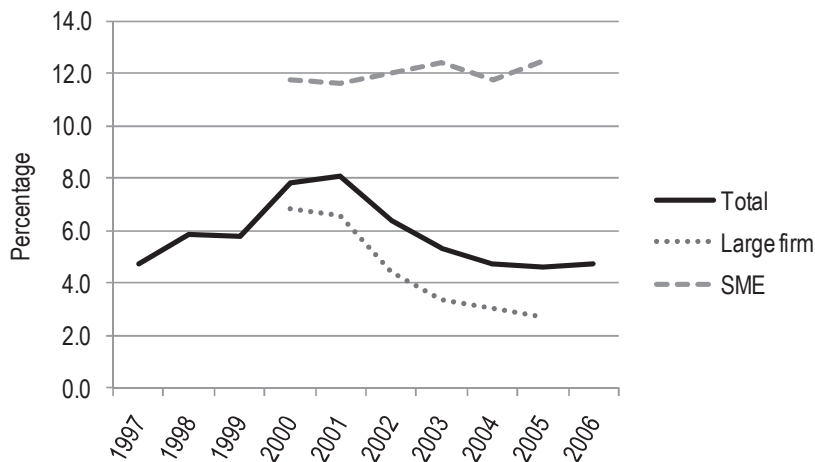
Source: OECD, Main Science and Technology Indicators, October 2008.

**Figure 2.52. Business-financed R&D in HEIs (2006 or nearest available year), as a percentage of HERD**



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

In terms of government-funded research performed in business enterprises, Figure 2.53 shows that this has hovered at around 5% in recent years. In the wake of the Asian financial crisis of the late-1990s, the government increased its financing of BERD, but this has since fallen back. Much of the recent decline can be accounted for by relative and absolute declines in the amount of R&D subsidies awarded to large firms. For example, in 2001, large firms received more than USD 600 million in R&D subsidies (accounting for 6.6% of large firm BERD), but by 2005, this had dropped to around USD 450 million (amounting to around 2.7% of large firm BERD). By contrast, the subsidies awarded to SMEs continue to increase, keeping pace with these firms' own increased spending on R&D. Thus, in 2000, SMEs benefited from a subsidy of around USD 265 million (11.7% of SME BERD), which increased to around USD 500 million by 2005 (representing 12.5% of SME BERD), thereby exceeding the funding made available to large firms.

**Figure 2.53. Korean government-financed R&D in business, as a percentage of BERD, 1997-2006**

Source: KISTEP database and OECD, Main Science and Technology Indicators, April 2008.

These figures are important from a system linkages perspective because a large proportion of government spending on R&D is funnelled through public-private partnerships (P/PPs). As Table 2.38 shows, in 2006, co-operative R&D accounted for 57.7% of the total national R&D expenditure. At the same time, the share of P/PPs, including industry-university, industry-GRIs, and industry-university-GRIs, stood at 37%, a remarkably high figure. Thus, R&D subsidies to industry very often come with conditions requiring collaboration with the public sector, thereby enhancing system linkages. Viewed in this way, the absolute and relative decline of subsidies received by large firms might be interpreted as a weakening of their ties to the public sector research base – a concern sometimes aired by those interviewed in the course of this review. On the other hand, the growth of subsidies to SMEs, as well as the apparent recent strengthening of industry-GRI links (see Table 2.38) may be cause for optimism.

**Table 2.38. Types of P/PPs in terms of R&D expenditure, 2005-06**

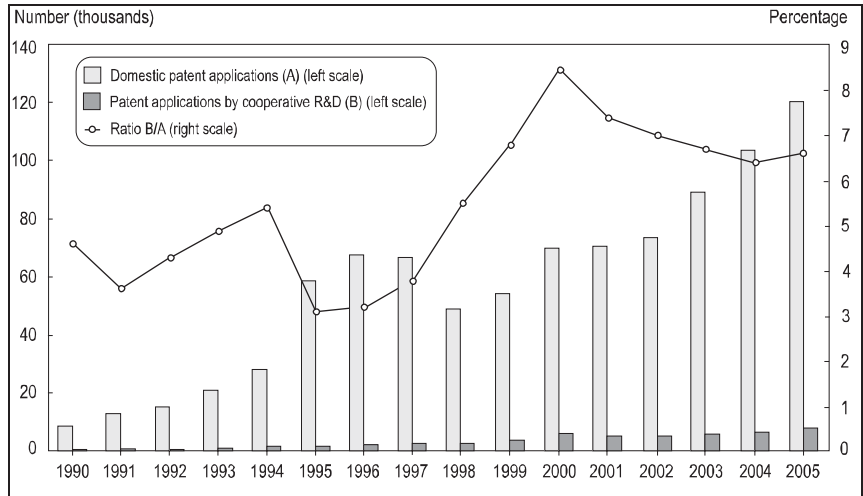
| Type of partnership | 2005         |              | 2006         |              |
|---------------------|--------------|--------------|--------------|--------------|
|                     | KRW billions | %            | KRW billions | %            |
| Industry-HEI        | 748          | 11.8         | 796          | 11.3         |
| Industry-GRI        | 452          | 7.1          | 739          | 10.5         |
| Industry-HEI-GRI    | 1 069        | 16.9         | 1 066        | 15.2         |
| <b>Sum: P/PPs</b>   | <b>2 270</b> | <b>35.8</b>  | <b>2 602</b> | <b>37.0</b>  |
| Other partnerships  | 1 466        | 23.1         | 1 450        | 20.6         |
| No partnership      | 2 602        | 41.1         | 2 976        | 42.3         |
| <b>Total</b>        | <b>6 339</b> | <b>100.0</b> | <b>7 029</b> | <b>100.0</b> |

Note: "Other partnerships" includes industry-industry, GRI-GRI, HEI-HEI and GRI-HEI partnerships.

Source: KISTEP database.

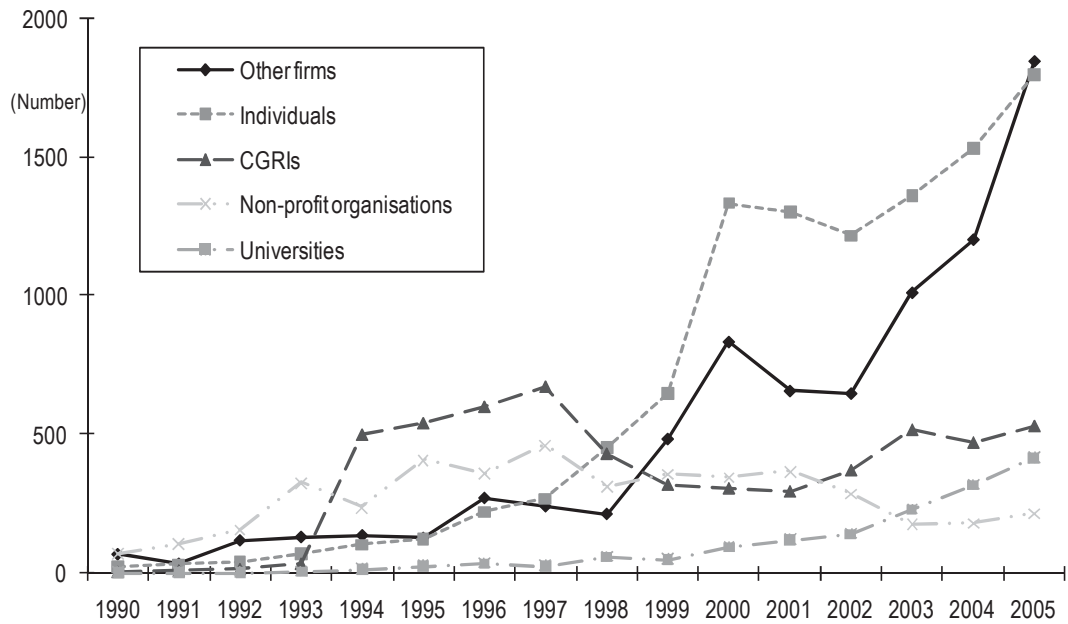
Another means of assessing system linkages is to examine patenting behaviour. Just over 6% of domestic patent applications in 2005 emerged from co-operative R&D partnerships, with the vast majority accounted for by firm-firm and firm-individual co-operation (Figure 2.54). The data point to a lower level of co-operation between firms and the public-sector research base, although co-operation between firms and universities has grown markedly over the last few years from a very low base (Figure 2.55).

Figure 2.54. Ratio of co-operative R&D to total patent applications, 1990-2005



Source: KIPO (2006), *Patent Trends in Korea 2006*, Korea Industrial Property Office, Seoul.

Figure 2.55. Domestic patent applications arising from firms' co-operative R&D, 1990-2005



Source: KIPO (2006), *Patent Trends in Korea 2006*, Korea Industrial Property Office, Seoul.

A further indicator of linkages in the innovation system concerns rates of technology transfer, particularly from the public to the private sector. Table 2.39 shows that the rate of technology transfer from GRIs and universities has increased markedly in recent years, reaching 30% in the case of GRIs and almost 10% in universities by 2005, owing to new policy schemes, such as the operation of public technology transfer consortia and the designation of TLOs at universities and at GRIs. A 2006 survey conducted by MoCIE shows that 90% of technology transfer by P/PPs was channelled through technology licences, with only 7% realised through direct sales and 3% through technological alliances.

**Table 2.39. Technology transfer from the public sector, 2002, 2004-05**

|              | ~ 2002 |             |      | 2004   |             |      | 2005   |             |      |
|--------------|--------|-------------|------|--------|-------------|------|--------|-------------|------|
|              | Owned  | Transferred | %    | Owned  | Transferred | %    | Owned  | Transferred | %    |
| GRIs         | 17 384 | 3 003       | 17.3 | 21 822 | 5 499       | 25.0 | 23 335 | 6 993       | 30.0 |
| Universities | 5 496  | 258         | 4.7  | 13 644 | 1 121       | 8.2  | 18 878 | 1 761       | 9.3  |

Note: % = transferred/owned.

Source: MoCIE (2006), *A Survey on the Technology Transfer of Public Research Institutes*, Ministry of Commerce, Industry and Energy, Seoul.

Finally, besides research and technological development, there is also some collaboration in teaching. The GRIs and HEIs already engage in some co-operation for the training of postgraduate students, as discussed above. In addition, there is some collaboration between HEIs and industry, although this could be developed much further. According to a recent review of education policy (Grubb *et al.*, 2006), colleges appear to be more closely related to employers than universities. It is more common for colleges to set up partnerships with local firms, particularly SMEs, and they often offer customised training, in which firms pay for short-term training adapted or customised to their purposes.

## Notes

1. Austrade, [www.austrade.gov.au/Biotechnology-to-Korea/default.aspx](http://www.austrade.gov.au/Biotechnology-to-Korea/default.aspx), accessed 7 April 2008.
2. Eurostat (2008) provides the following “explanation”: “It should be borne in mind that in the Community Innovation Survey (CIS), small enterprises have at least 10 employees. Self-employed entrepreneurs and very small enterprises are not covered by the CIS [or by the Korean Innovation Survey]. This does not mean that these enterprises are not actively innovating, but they may not innovate in the same way and for this reason are not comparable with larger enterprises. Research and development (R&D) are essential for innovation in new goods and services. A certain size is necessary if an enterprise is to be continuously active in R&D. Many SMEs cannot pay one or more employees to work full-time on R&D. The problem with an R&D employee is that he or she does not necessarily produce something that can be sold in the short run. Many technical products need long years of research.”
3. MEST website (<http://english.mest.go.kr>), accessed August 2008.
4. On the other hand, the GRIs are major players in some of the government’s more long-term, strategic research programmes, including the 21st century frontiers programme.
5. As reported in *The Korea Times*, 20 March 2008.
6. These institutions may also have problems attracting high-quality faculty. According to KEDI (2006), “although tertiary institutions in Korea do not have much difficulty filling faculty positions, some institutions find it hard to procure a long-term supply of professors of high quality primarily because of financial reasons. Currently, many tertiary institutions are facing financial difficulties as the number of enrolled students declines, leading to less tuition income. Regional universities and junior colleges are especially vulnerable to financial difficulties and are more likely to find it difficult to secure quality faculty members.”
7. Before 2004, the “Labour Demand Survey” used KSCO (Korean Standard Classification of Occupation) rather than OES. Accordingly, statistics on shortage rates before 2004 are not comparable with statistics after 2004.
8. Almost 90% of the male workforce spends over 40 hours a week at work as compared with the OECD average of 76%. Although fewer (77%) Korean women work over 40 hours a week, this is significantly higher than the OECD average of 49% (OECD, 2007f).
9. The 103 394 Korean students studying in the United States at the end of 2007 accounted for 14% of the foreign students in the country. The share has been steadily increasing, up 12.6% at the end of 2005 from the previous year, 10.5% in 2006, and another 10.3% in 2007. India ranked second, followed by China, Japan and Chinese Taipei.
10. The shares of business-funded R&D performed in HEIs in some leading economies are as follows: 0.5% in Japan; 0.6% in France; 1.1% in the United States; 2.7% in the United Kingdom; and 3.4% in Germany (all figures are for 2006). Figures based upon OECD Main Science and Technology Indicators 2008/1.

## 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**

|                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Imitation</b>      | <ul style="list-style-type: none"> <li>Foundation of KIST (1966), MoST (1967)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                               |
| 1960s                 | <ul style="list-style-type: none"> <li>The S&amp;T promotion act (1967)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 1970s                 | <ul style="list-style-type: none"> <li>Establishment of GRIs (1970s) in the areas of machinery, shipbuilding, chemicals, marine science, electronics</li> <li>Tax credit for R&amp;D investment (1974)</li> <li>Development of human resources for R&amp;D (KAIST)</li> </ul>                                                                                                                                                                                                                          |
| <b>Transformation</b> | <ul style="list-style-type: none"> <li>National R&amp;D programme (NRDP, 1982)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                              |
| 1980s                 | <ul style="list-style-type: none"> <li>Establishment of Daedeok Science Town</li> <li>Promotion of private firms' research: financial and tax incentives to stimulate R&amp;D investments (reduction of tax for technology-based start-ups (1982); tax credit for technology and manpower development expense)</li> </ul>                                                                                                                                                                              |
| <b>Innovation</b>     | <ul style="list-style-type: none"> <li>Promotion of university-based research Science Research Centres</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                      |
| 1990s onwards         | <ul style="list-style-type: none"> <li>Five-year plan for innovation (1997)</li> <li>Establishment of the National Science and Technology Council (1999)</li> <li>S&amp;T vision 2025 (1999)</li> <li>First National Technology Roadmap (2001)</li> <li>New organisation of MoST(2004) – Deputy prime minister, establishment of the Office of the Ministry of Science, Technology and Innovation (OSTI)</li> <li>Launch of the Ministry of Education, Science and Technology (MEST) (2008)</li> </ul> |

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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Strong, mobilising national vision</li> <li>• High growth rates in GDP</li> <li>• Strong government support for innovation and R&amp;D</li> <li>• Good and improving framework conditions for innovation</li> <li>• High ratio of gross domestic expenditure on R&amp;D (GERD) to business enterprise expenditure on R&amp;D (BERD)</li> <li>• Highly educated workforce</li> <li>• Good supply of human resources for science and technology (HRST)</li> <li>• Ready early adopters of new technologies</li> <li>• Strong ICT infrastructure</li> <li>• Exceptionally fast followers</li> <li>• Strong and internationally competitive firms</li> <li>• Learning society with a capacity to learn from failures and international good practices</li> <li>• Capability to produce world-class talents</li> </ul> | <ul style="list-style-type: none"> <li>• Geopolitical positioning in one of the most dynamic regions of the world</li> <li>• Free trade agreements</li> <li>• Globalisation, including of R&amp;D</li> <li>• Growing Korean S&amp;T diaspora</li> <li>• Developments in S&amp;T (technological change), particularly information technology, nanotechnology, biotechnology and environmental technology – and their possible fusion</li> <li>• Growth of China and other newly industrialising economies, both in the region and worldwide, offering new markets for Korean exports</li> </ul> |
| Weaknesses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Threats                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <ul style="list-style-type: none"> <li>• Underdeveloped fundamental research capabilities and weak research capacity in universities</li> <li>• Weak linkages between GRIs and institutions of higher education</li> <li>• In education, rote learning, overemphasis upon university entrance exam, and crippling cost of private education</li> <li>• Underutilisation of female labour</li> <li>• Low productivity in the services sector</li> <li>• Relatively weak SME sector</li> <li>• Legacy of dirigisme which hampers the development of a diffusion-oriented innovation policy</li> <li>• Unbalanced international linkages</li> <li>• Uneven development across regions and sectors</li> <li>• Small domestic market (compared to China, Japan, United States)</li> <li>• Policy co-ordination problems between ministries</li> </ul>           | <ul style="list-style-type: none"> <li>• Low fertility rates and an ageing society</li> <li>• Arrival of strong new competitors in fields in which Korea excels, e.g. ICTs, particularly from China</li> <li>• Geopolitical developments in the region</li> <li>• Disruption in the supply of imported natural resources and energy upon which the Korean economy is highly dependent</li> <li>• Global economic outlook and its consequences for export-oriented economies</li> </ul>                                                                                                         |

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.

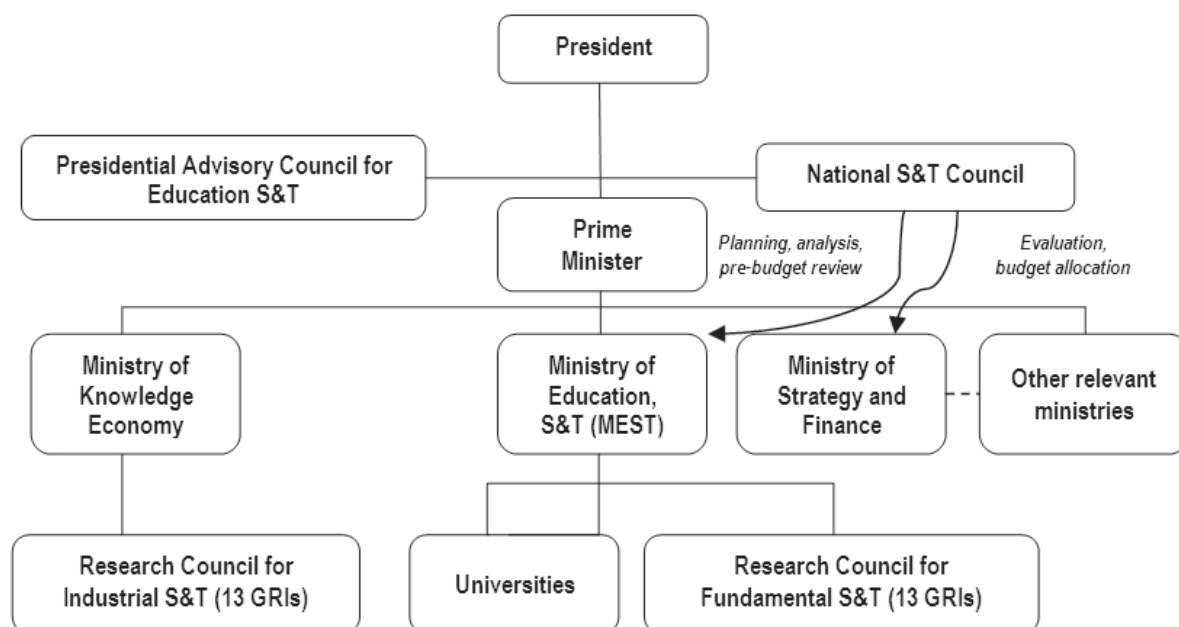
*Source: World Bank (2000), Republic of Korea: Transition to a Knowledge-Based Economy, World Bank, Washington, DC.*

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.

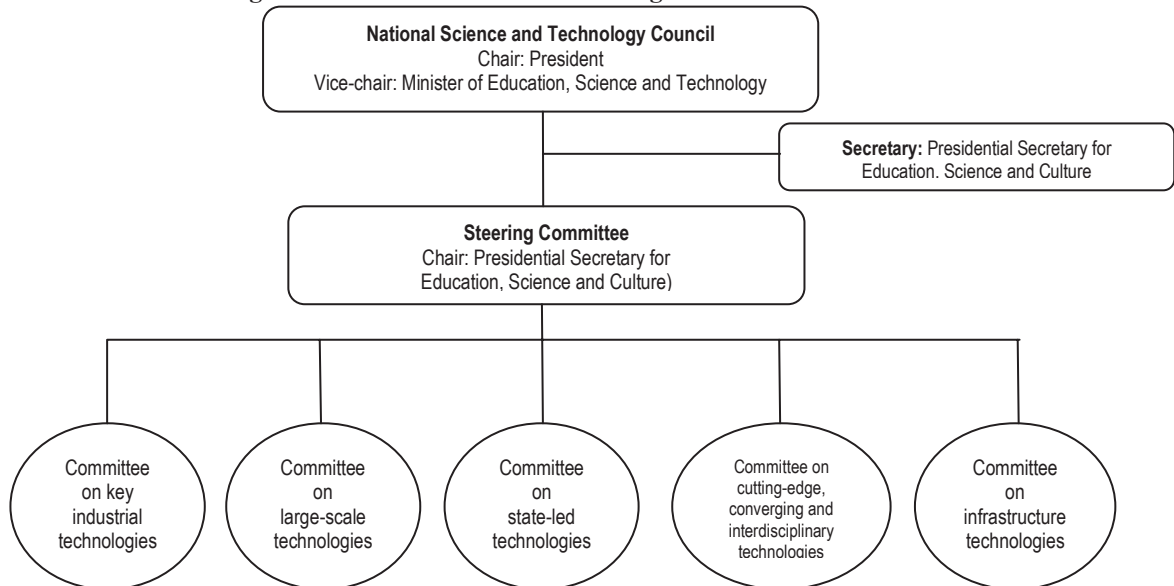
**Box 3.2. The five sub-committees of the PACST**

- 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).<sup>1</sup> 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         |
| <b>Total</b> |                | <b>65 154</b> | <b>100.0</b> | <b>70 827</b> | <b>100.0</b> | <b>77 996</b> | <b>100.0</b> |

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:<sup>2</sup>

- 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 commercialisation.
- 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

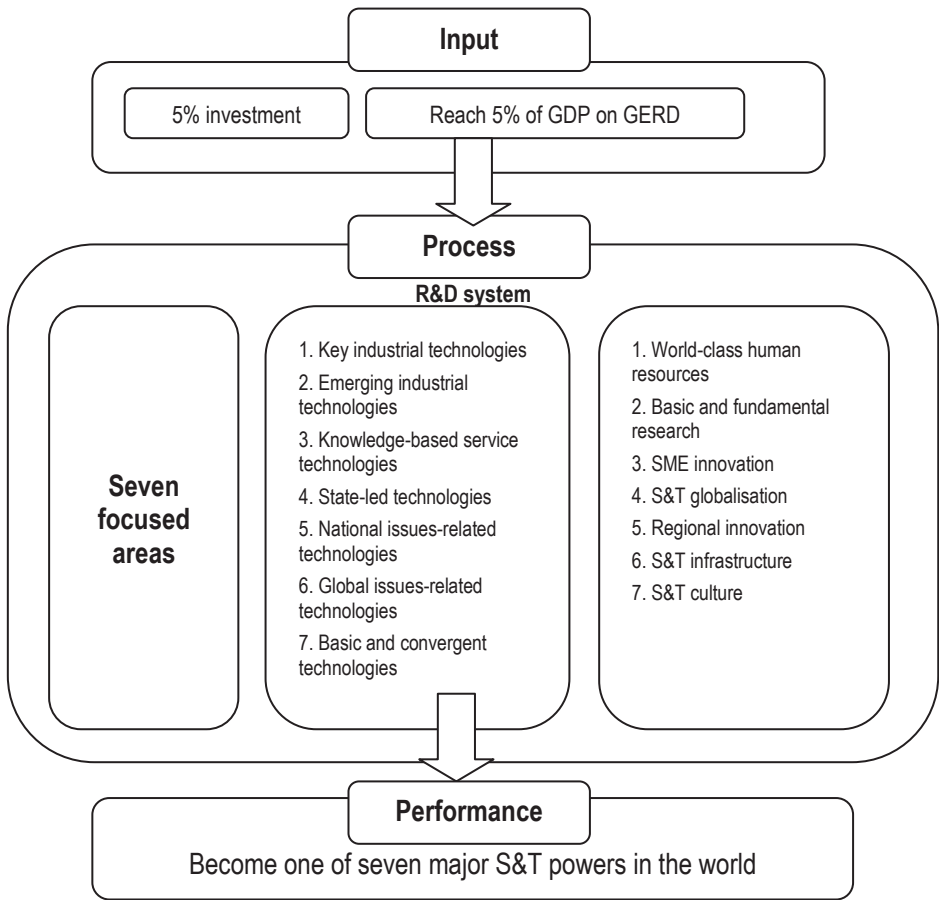
innovation system. This reflected the government's view that the Korean economy had reached technological frontiers in several areas (particularly in the ICT sector) and that the innovation system needed to be transformed to better incorporate aspects of innovative and creative technological development. 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,<sup>3</sup> a further 40% from MoST, and the remaining 20% from the S&T

community and the private sector.<sup>4</sup> 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.<sup>5</sup> 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.<sup>6</sup> 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 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     |
|----------------|------------|
| <b>Korea</b>   | <b>9.5</b> |
| Sweden         | 6.2        |
| United States  | 5.7        |
| <b>OECD</b>    | <b>3.9</b> |
| 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<br>Public technology<br>Welfare technology                                                                                                                                                                           |
| R&D programmes for industrial technology                | Short-term industrial technology<br>Mid- and long-term industrial technology                                                                                                                                                                      |
| R&D infrastructure                                      | International co-operation<br>Development of human resources<br>Regional R&D centres of excellence<br>R&D facilities and equipments                                                                                                               |
| Support for public research institutes                  | National laboratories (three sub-groups)<br>Government-supported research institutes for basic technology<br>Government-supported research institutes for industrial technology<br>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.

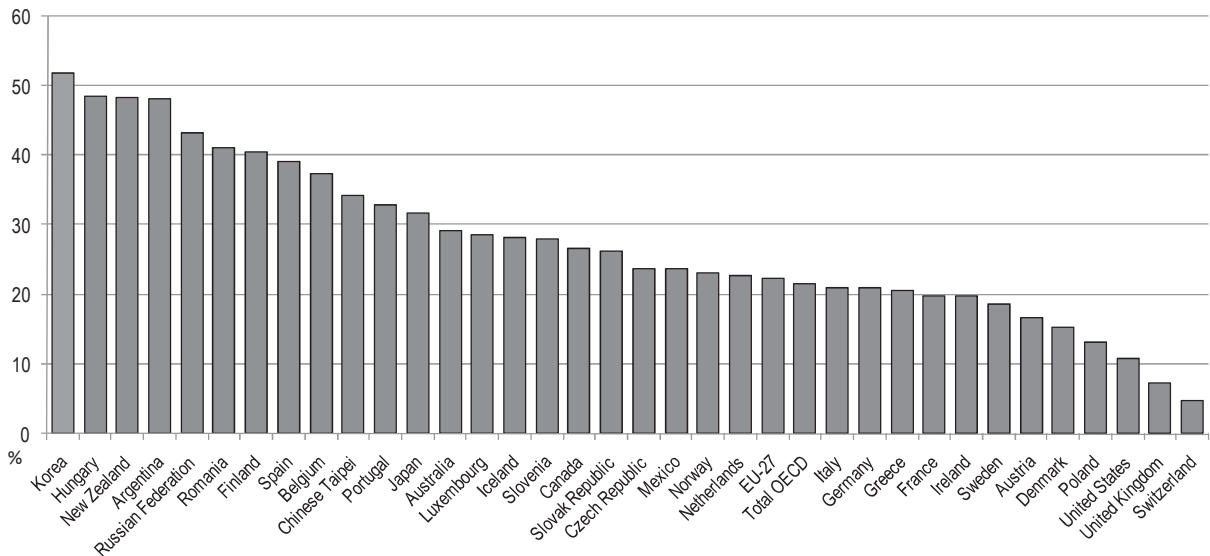
While the KISTEP classification of R&D programmes is useful, it will not be used to structure the analysis that follows. Instead, this section begins with a discussion of the government's continuing drive to increase the proportion of fundamental research carried out and describes some of the main programmes. 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.<sup>7</sup> 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.

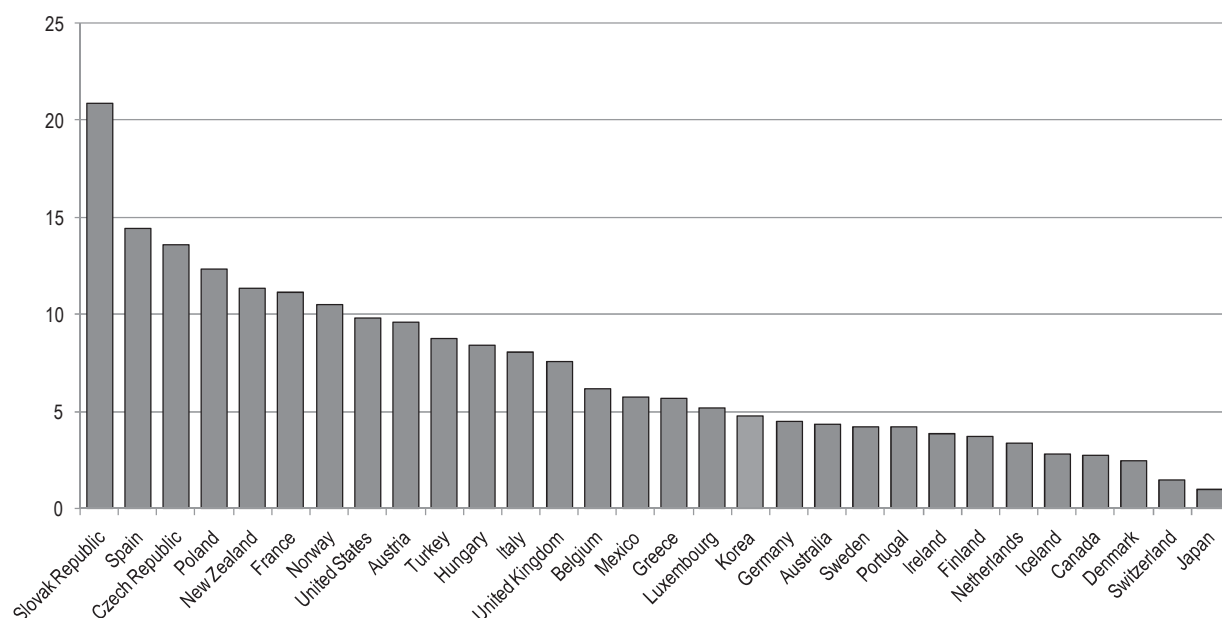
These investments are to be welcomed, though it will be important for the Korean government not to equate basic research with curiosity-driven basic research alone. While the latter has an important role to play – and has been largely neglected in Korea so is in need of strengthening – it is also wise 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.<br>Secure source technologies for hybrid and fuel-cell vehicles.<br>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.<br>Build a new ship model equipped with advanced IT technologies.                                                                                      |
| Semiconductors      | Maintain status as the world’s largest memory chip producer.<br><br>Enhance competitiveness of non-memory chip sector. | (In the memory sector)<br>Develop new memory chip technologies; secure advanced technologies in equipment and material industries.<br><br>(In the non-memory sector)<br>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.<br>Increase supply of insufficient steel materials.                                                                                                                                                      |
| General machines    | Secure advanced technologies to stimulate production and exports.                                                      | Develop core technologies for localisation of general machines.<br>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.<br>Produce new types of textiles such as green textiles.                                                                                                                                                                       |
| Parts and materials | Obtain source technologies.                                                                                            | Develop technologies for imported parts and materials.<br>Construct business-friendly infrastructure.                                                                                                                                                                 |

Source: MKE website ([www.mke.go.kr/language/eng](http://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                     | Manufacturing robot                         | Increasing or Integrating series of products<br>(4→4) |
|                                           | Cleaning & secure robot                     | Individual serve robot                      |                                                       |
|                                           | IT-based intelligent robot                  | Professional service robot                  |                                                       |
|                                           | Network-based humanoid                      | Network robot                               |                                                       |
| Future vehicle                            | Hybrid car                                  | Hybrid car                                  | No change<br>(3→3)                                    |
|                                           | Fuel cell vehicle                           | Fuel cell vehicle                           |                                                       |
|                                           | Intelligent vehicle                         | Intelligent vehicle                         |                                                       |
| Next-generation cell                      | Second battery                              | Second battery                              | Adjusting series of products<br>(2→2)                 |
|                                           | Fuel cell                                   | Capacity                                    |                                                       |
| Display                                   | LCD, PDP, OLED                              | LCD, PDP, OLED                              | No change                                             |
| Next-generation semiconductor             | SoC                                         | SoC                                         | Decreasing or Integrating series of products<br>(6→4) |
|                                           | Semiconductor equipment                     | Nano process                                |                                                       |
|                                           | Nano semiconductor                          | Memory,                                     |                                                       |
|                                           | SiC semiconductor                           | IT SoC IP                                   |                                                       |
|                                           | IT SoC IP                                   |                                             |                                                       |
|                                           | IT SoC, designing SoC CAD                   |                                             |                                                       |
| Digital TV/broadcast                      | DTV receiver                                | DTV receiver                                | No change<br>(2→2)                                    |
|                                           | DMB terminal                                | DMB terminal                                |                                                       |
| Next-generation mobile telecommunications | Wibro/4 generation mobile telecommunication | Wibro/4 generation mobile telecommunication | Decreasing or Integrating series of products<br>(5→4) |
|                                           | Next-generation- fusion mobile assistant    | Next-generation- fusion mobile assistant    |                                                       |
|                                           | Ubiquitous sensor network                   | Ubiquitous sensor network                   |                                                       |
|                                           | Tele-matrix high-tech system                | Tele-matrix system                          |                                                       |
|                                           | Tele-matrix system loaded on vehicle        |                                             |                                                       |
| Intelligent home network                  | Home platform                               | Home platform                               | Changing product's name or adjusting groups<br>(4→4)  |
|                                           | Middleware                                  | Ubiquitous home networking                  |                                                       |
|                                           | Intelligent electronic appliance            | Intelligent electronic appliance            |                                                       |
|                                           | Home networking                             | Wire/wireless home networking               |                                                       |
| Digital content/SW solution               | Creating content                            | Next-generation online game                 | Changing product's name or adjusting groups<br>(6→5)  |
|                                           | Securing & distributing content             | Digital images,                             |                                                       |
|                                           | Producing content                           | Intelligent SW                              |                                                       |
|                                           | Middleware                                  | Free software-based system                  |                                                       |
|                                           | Basic SW                                    | SW                                          |                                                       |
|                                           | Application SW                              | Information securing SW                     |                                                       |
| Bio Pham./equipment                       | Hetero-organ producing pig clone            | Hetero-organ producing pig clone            | No change<br>(5→5)                                    |
|                                           | Bio-chip for analysis/ diagnosis            | Bio-chip for analysis/ diagnosis            |                                                       |
|                                           | Drug delivery system                        | Drug delivery system                        |                                                       |
|                                           | Cellular therapy                            | Cellular therapy                            |                                                       |
|                                           | New bio-medicine                            | New bio-medicine                            |                                                       |
| 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<br>2. Next-generation shipbuilding and offshore-platform technology<br>3. Intelligent production system technology<br>4. High-precision micro-machining and instrumentation control technology<br>5. Next-generation network technology<br>6. Mobile Internet and 4G mobile communication technology<br>7. Non-memory semiconductor technology<br>8. Next-generation semiconductor equipment and process technology<br>9. Next-generation display technology                                                                                         | 1. Intelligent automotive technology<br>2. Next-generation production process and equipment technology<br>3. Next-generation memory semiconductor technology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Emerging critical technologies       | 10. Cancer diagnosis and treatment technology<br>11. Drug discovery and development technology<br>12. Clinical testing technology<br>13. Medical apparatus development Technology<br>14. Stem-cell Technology<br>15. Proteomics and Metabolics Applied Technology<br>16. Technology of Identification of Drug Target and Drug Candidate<br>17. Brain Science Research and Brain Disease Diagnosis and Treatment Technology<br>18. Next-generation System Software Technology<br>19. Next-generation high performance computing Technology<br>20. Next-generation Human-Computer Interaction Technology | 4. Biomaterials and process technology<br>5. Conservation of marine resources and utilisation technology of marine biotechnology<br>6. Regulation technology of cellular function<br>7. Genomics applied technology<br>8. Application and analysis technology of biomedical information<br>9. Gene therapy technology<br>10. Oriental medicine and treatment technology<br>11. Next-generation computing solution technology<br>12. Information security technology                                                                                                                                                                                                                                                                                                                                                                                   |
| Knowledge-based service technologies | 21. Converging contents and knowledge service technology<br>22. Advanced logistics technology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 13. Converging technology of communication and broadcasting                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| State-led technologies               | 23. Satellite development technology<br>24. Next-generation airplane development technology<br>25. Nuclear fusion technology<br>26. Next-generation nuclear reactor technology<br>27. Next-generation weapon development technology                                                                                                                                                                                                                                                                                                                                                                    | 14. High-rise building technology<br>15. Next-generation railroad system technology<br>16. Construction-based technology<br>17. Super-long bridge construction technology<br>18. Advanced transportation system technology<br>19. Advanced residence and education environment technology<br>20. Intelligent national geographic information system development technology<br>21. Satellite propulsion technology<br>22. Utilisation technology of satellite information<br>23. Planet exploration and space monitoring system development technology<br>24. Global navigation satellite system technology<br>25. Efficiency and safety enhancement technology of sea-air aviation<br>26. Utilisation technology of radiation and radioactive isotope<br>27. Nuclear fuel cycle technology<br>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<br>29. Human safety and risk evaluation technology<br>30. Food safety evaluation technology<br>31. Agricultural resources development and management technology<br>32. IT nano-device technology<br>33. High-efficiency energy management technology                                                                                                                                                                                                                                                                                                                                          | 29. Food resource utilisation and management technology<br>30. Insect pest and disease prevention and control technology<br>31. Applied technology of environment-friendly nano-materials<br>32. Nano-bio materials                                                                                                                                                                                                                                             |
| Global issues-related technologies   | 34. Hydrogen production and storage technology<br>35. Next-generation fuel cells & energy storage and conversion technology<br>36. New and renewable energy technology<br>37. Energy and resource exploration & development technology<br>38. Marine territory management technology<br>39. Marine environments maintenance technology<br>40. Atmospheric environmental improvement technology<br>41. Environment conservation and restoration technology<br>42. Water quality management and water resources protection technology<br>43. Climate change prediction and adaptation technology<br>44. Natural disaster prevention and management technology | 33. Next-generation superconductivity and power IT technology<br>34. Highly efficient technology for resource utilisation<br>35. Environmentally friendly process technology<br>36. Resource recycling and waste safe treatment technology<br>37. Integrated management and utilisation technology of environmental information<br>38. Life safety and anti-terror technology<br>39. Fire safety and future fire extinguishing equipment development technology |
| Basic and convergent technologies    | 45. Drug delivery technology<br>46. Biochip and biosensor technology<br>47. Intelligent robot technology<br>48. Nano-based functional materials technology<br>49. Nano-based convergent and composite materials technology<br>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 21<sup>st</sup> 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. 21<sup>st</sup> century frontier R&D programmes by year**

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

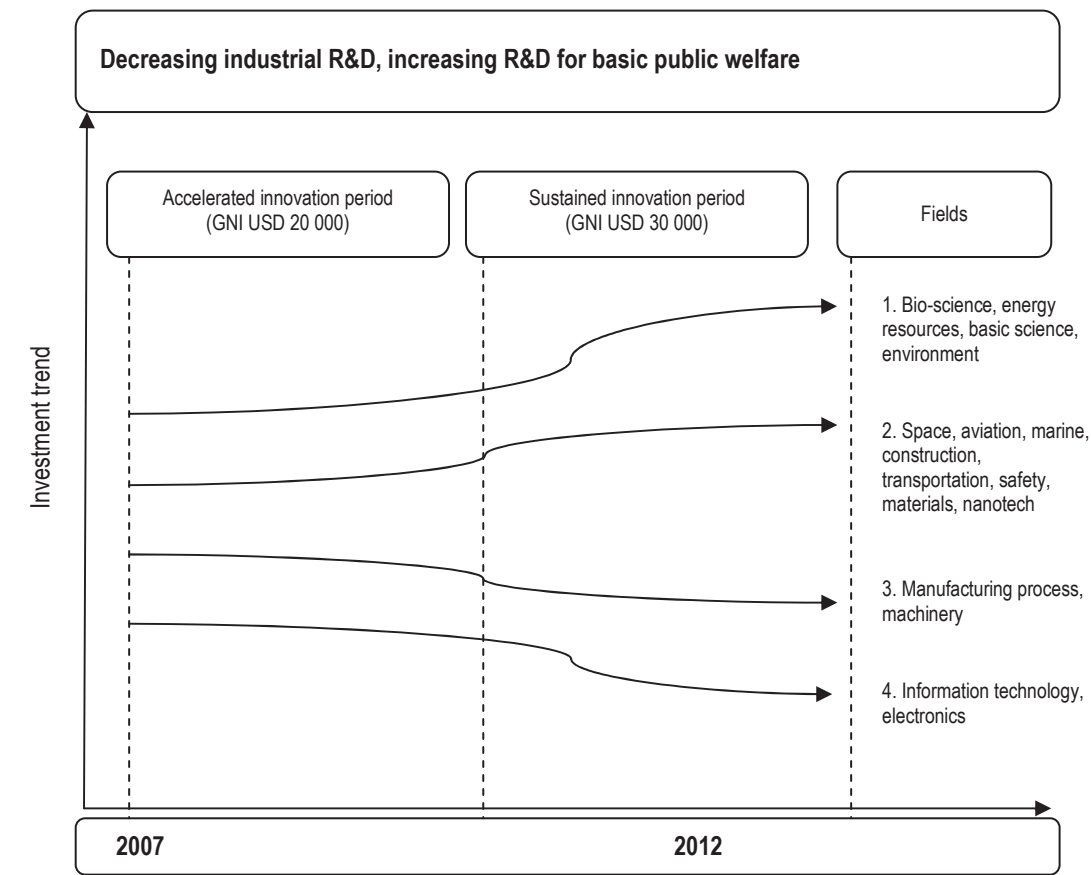
Source: MoST and KISTEP (2007), *Report on the Survey of Research and Development in Science and Technology*, Ministry of Science and Technology and Korea Institute of Science and Technology Evaluation and Planning, Seoul.

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 |

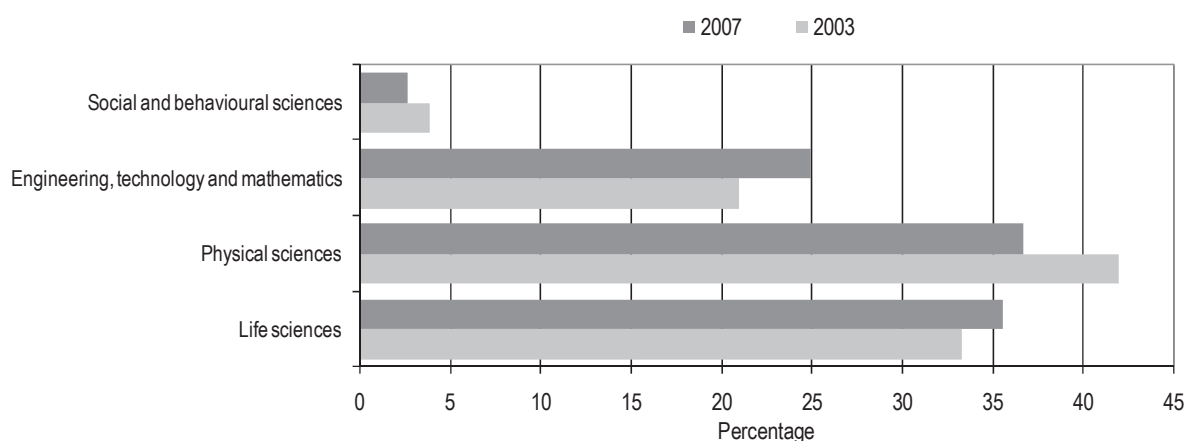
Source: MoST and KISTEP (2007), *Report on the Survey of Research and Development in Science and Technology*, Ministry of Science and Technology and Korea Institute of Science and Technology Evaluation and Planning, Seoul.

**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                             |
| <b>OECD</b>    | <b>51.8</b>   | <b>28.2</b>       | <b>10.7</b>                             | <b>9.3</b>                      |
| 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                             |
| <b>Korea</b>   | <b>33.3</b>   | <b>42.0</b>       | <b>21.0</b>                             | <b>3.9</b>                      |

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.

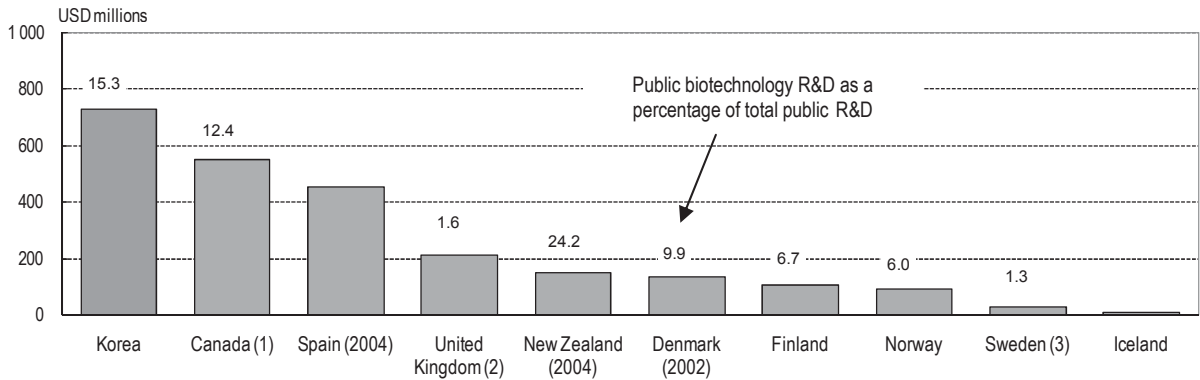
In addition to structural lock-ins, a lack of alignment between MEST’s stated aim of diversification and continuing strong support for ICT R&D might also be explained in part by the fact that much public support for R&D still flows through the mission-oriented ministries, including MKE. For example, 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.<sup>8</sup> 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 45<sup>th</sup> in terms of financial experts, compared to 11<sup>th</sup> for Hong Kong, China, and 15<sup>th</sup> 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.<sup>9</sup>

### ***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

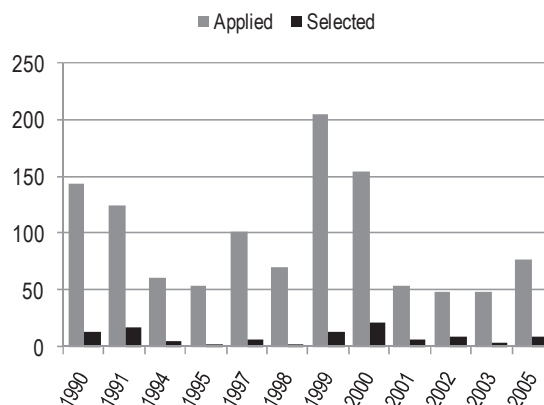
human resource profiles in Korean S&T. As Figure 3.9 shows, the competition for centre status is intense, but the rewards immense by university funding standards: each selected centre receives around USD 10 million over nine years; this provides a sound basis for establishing leading-edge research activities.

**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        |
| <b>Total</b>                        | <b>64</b>         | <b>48</b> | <b>113</b> | <b>100</b> |

Source: KOSEF website ([www.kosef.re.kr/english\\_new/](http://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.<sup>10</sup> 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.<sup>11</sup> 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 21<sup>st</sup> 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 “21<sup>st</sup> century creative network”, where science, art, culture and industries converge. It will be Korea's “21<sup>st</sup> 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,<sup>\*</sup> which is expected to facilitate the inward and outward international mobility of engineers.

<sup>\*</sup> 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

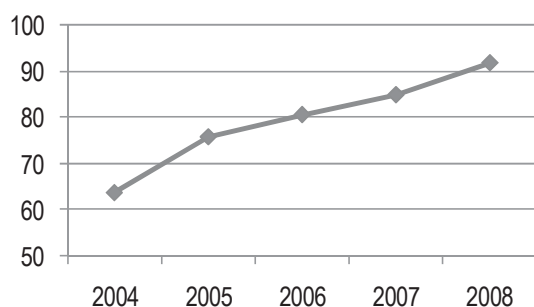
The prospect of falling student numbers (on account of shifting demographics), together with prospective students' preference for universities in and around the Seoul metropolitan area, has raised the question of the sustainability of several regional HEIs. Matters have not been helped by many HEIs' "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.

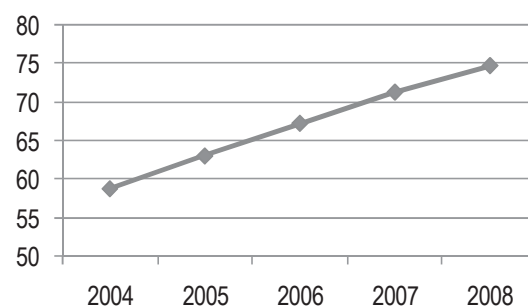
The NURI programme is set to invest a total of USD 1.3 billion over five years (2004-08). According to interim assessments, NURI shows visible progress in terms of facilitating local university specialisation, enhancing student competitiveness for employment, and fostering collaboration between universities, 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.

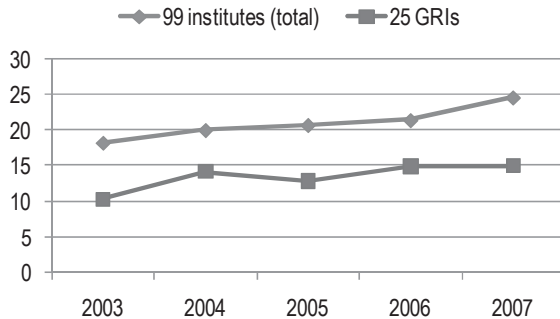
As part of the new legislation to improve the position of women in S&T, the National Institute for Supporting Women in Science and Technology (NIS-WIST) was established in 2004 and there are now a further four regional institutes in Korea. Its tasks include investigation and research in support of policies 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

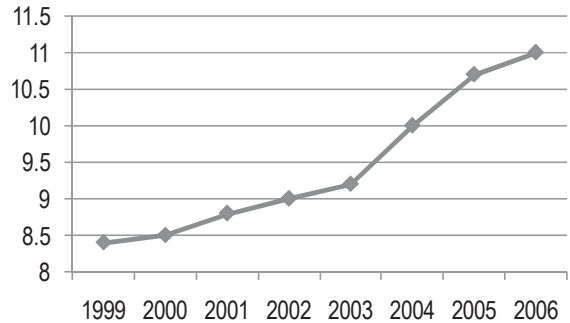
0.6%. After implementation of the programme, the rate of increase jumped threefold from 2003 to 2006. As of 2006, the ratio of the female faculty is still at a low 11.0% but the programme would seem to be having positive effects.

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



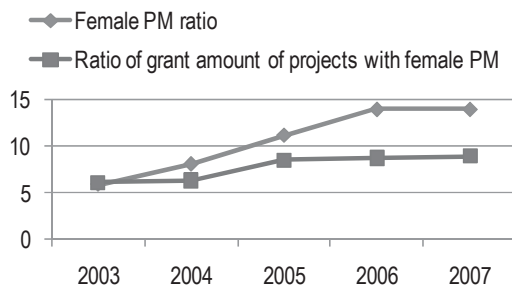
Source: NIS-WIST (2007), *Women in Science and Technology: Why and How Must They Be Supported?* Strategic Report, National Institute for Supporting Women in Science and Technology, Seoul.

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



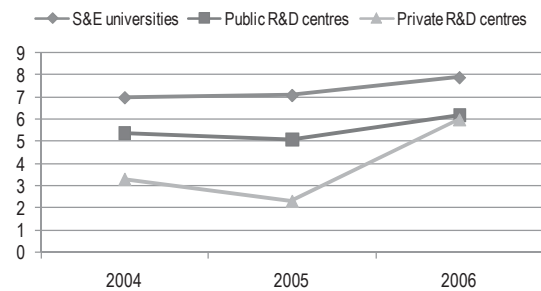
Source: NIS-WIST (2007), *Women in Science and Technology: Why and How Must They Be Supported?* Strategic Report, National Institute for Supporting Women in Science and Technology, Seoul.

**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 |
|--------------------|------------------------------------------------------------------------------------------|-------------------|
| <b>Fostering</b>   | 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              |
| <b>Utilisation</b> | 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              |
| <b>Support</b>     | 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                                                     | MEST              |
|                    | - Support Project for Fostering Outstanding Female Scientist                             |                   |
|                    | - Support Project for Enhancing Competitiveness of Outstanding Female Scientist          |                   |
|                    | 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                                                                                                                                              |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>MoST</b>  | <ul style="list-style-type: none"> <li>- Designation of national labs</li> <li>- Excellent research centres</li> <li>- Basic research centres for medical science</li> <li>- International co-operative R&amp;D</li> </ul>                                                                                                                                                                                                               | <ul style="list-style-type: none"> <li>- National core research centres</li> <li>- Support for foreign MA &amp; PhD</li> <li>- National research centres for mathematical science</li> <li>- Basic research centres for nanotechnology</li> <li>- Education centre for research personnel</li> </ul> | <ul style="list-style-type: none"> <li>- National S&amp;T information system</li> </ul>                                                                             | <ul style="list-style-type: none"> <li>- Business incubators of KAIST, CGRIs, etc.</li> </ul>                                                                         |
| <b>MoCIE</b> | <ul style="list-style-type: none"> <li>- Development of industrial technology</li> <li>- Building industrial technology base</li> <li>- Next-generation growth engine technologies</li> <li>- Nano cluster</li> <li>- Regional technology innovation</li> <li>- Fostering strategic industry of regions</li> <li>- New technology fusion</li> <li>- Designation of national lab</li> <li>- International co-operative R&amp;D</li> </ul> | <ul style="list-style-type: none"> <li>- Labour force for industrial technology</li> <li>- Industrially oriented university</li> <li>- Regional research centres (RRC)</li> <li>- Labour force for energy technology</li> </ul>                                                                      | <ul style="list-style-type: none"> <li>- Diffusion of R&amp;D outcomes</li> <li>- Support for leading TLOs</li> <li>- Development of dual use technology</li> </ul> | <ul style="list-style-type: none"> <li>- Technoparks</li> <li>- Specialised regional innovation</li> <li>- Business incubators for new technologies</li> </ul>        |
| <b>MIC</b>   | <ul style="list-style-type: none"> <li>- Development of strategic IT</li> <li>- Development of next-generation core IT</li> <li>- International co-operative R&amp;D</li> </ul>                                                                                                                                                                                                                                                          | <ul style="list-style-type: none"> <li>- Excellent research personnel</li> <li>- Specialised IT education</li> <li>- Global IT personnel</li> </ul>                                                                                                                                                  | <ul style="list-style-type: none"> <li>- Diffusion of R&amp;D outcomes</li> </ul>                                                                                   | <ul style="list-style-type: none"> <li>- Designation of new IT technologies</li> </ul>                                                                                |
| <b>SMBA</b>  | <ul style="list-style-type: none"> <li>- Industry-university-research co-operative technology development</li> <li>- Technology development with industries</li> </ul>                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>- Support for hiring young employees</li> <li>- Internships of SMEs</li> </ul>                                                                                                                                                                                | <ul style="list-style-type: none"> <li>- Support for commercialisation by SMEs</li> </ul>                                                                           | <ul style="list-style-type: none"> <li>- Business incubators</li> <li>- Graduate schools for new business</li> <li>- New technology-based business package</li> </ul> |
| <b>MoE</b>   | <ul style="list-style-type: none"> <li>- Support for core research institutes</li> <li>- International co-operative R&amp;D</li> </ul>                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                     |                                                                                                                                                                       |

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           |
| <b>Total</b>   | <b>116</b> | <b>108</b> | <b>164</b> | <b>188</b> | <b>169</b> | <b>256</b> | <b>1 001</b> |

Source: KTTC website ([www.kttc.or.kr/eng/main.asp](http://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](http://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.

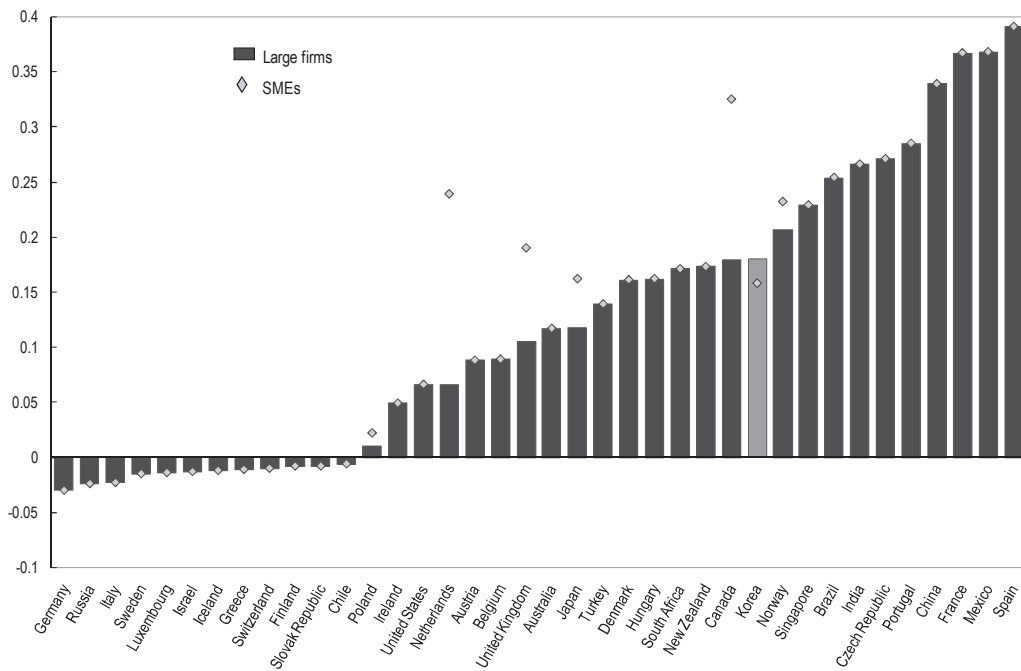
### 3.7. Improving the framework conditions for innovation

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<sup>1</sup> (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 Exemption 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**

|             |                                                                                                                                                                 |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1991</b> | 10% volume tax credit of R&D expenditure +10% incremental tax credit (large firm)<br>10% volume tax credit of R&D expenditure +15% incremental tax credit (SME) |
| <b>1992</b> | 5% volume tax credit of R&D expenditure +25% incremental tax credit (large firm)<br>10% volume tax credit of R&D expenditure +25% incremental tax credit (SME)  |
| <b>1993</b> | 5% tax credit of R&D expenditure (15% for SME) or 50% incremental tax credit                                                                                    |
| <b>1999</b> | Changed base periods from two previous years to four previous years in incremental tax credit                                                                   |
| <b>2001</b> | Only 50% incremental tax credit applied for large size firm                                                                                                     |
| <b>2003</b> | Only 40% incremental tax credit applied for large size firm                                                                                                     |
| <b>2004</b> | Reduced upper limit of corporate income tax rate to 10% from 12% for SME and to 13% from 15% for large firm                                                     |
| <b>2007</b> | Abolished reserve fund for R&D expenditure<br>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                             |
| <b>Sum</b>                                                            |                  |                                   |                                                                               | <b>1 160 414</b>                   |

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](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<br>(1974-86)                                                                                                                                                                                                                                                                                  | Growth phase<br>(1986-98)                                                                                                                                                                                                                                                                                                                                                                                         | Overshooting phase<br>(1998-2000)                                                                                                                                                                                                     | Consolidation phase<br>(2001-04)                                                                                                                                           | Turnaround phase<br>(2005- )                                                                                                                                                                                                                                                                                                              |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Korea Technology Advancing Corporation (KTAC) founded by Korea Institute of Science and Technology (KIST) in 1974</li> <li>• Three more new technology finance companies established under Financial Assistance to New Technology Businesses Act (1986)</li> </ul> | <ul style="list-style-type: none"> <li>• Support for Small and Medium Enterprise Establishment Act enacted in 1986</li> <li>• 12 venture capital companies (VCs) founded in 1986 and the number of VCs increased to 72 in 1998</li> <li>• Small and Medium Business Administration (SMBA) organised in 1996</li> <li>• Act on Special Measures for the Promotion of Venture Businesses enacted in 1997</li> </ul> | <ul style="list-style-type: none"> <li>• VCs proliferated and the number of VCs peaked at 147 in 2000</li> <li>• 194 venture capital funds (VC funds) were launched in 2000</li> <li>• VCs invested KRW 2 trillion in 2000</li> </ul> | <ul style="list-style-type: none"> <li>• The number of VCs decreased to 105 in 2004</li> <li>• The VC fund formation and VC investment significantly contracted</li> </ul> | <ul style="list-style-type: none"> <li>• Government implemented strong measures announced in December 2004 to reactivate venture ecosystem</li> <li>• Korea Fund of Funds with the target commitment of KRW 1 trillion was launched in 2005</li> <li>• The VC fund formation and VC investment significantly increased in 2005</li> </ul> |

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                                                                                                                                                                                                                                                                        |
|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Direct support</b>                     | Promote common criteria<br>Activate duty development                                                                                                                                          | Provide patent conflict legal structure<br>Operate patent attorney consulting centre<br>Grant rewards for reporting fake products                                                                                                | Produce patent technology trial products<br>Invest in Funds of Funds (venture capital)                                                                                                                                                                                             |
| <b>Directly supporting infrastructure</b> | Organise invention promotion events<br>Encourage inventions by women                                                                                                                          | Protect international intellectual property<br>Promote semiconductor arrangement design                                                                                                                                          | Evaluate value of patented technology<br>Operate Patent Technology Commercialisation Association                                                                                                                                                                                   |
| <b>Supporting infrastructure</b>          | Promote research on intellectual property<br>Research patented technology trends<br>Hold the Republic of Korea Trademark Exhibition<br>Promote creation of core semiconductor design property | Operate WIPO Korea Trust Fund<br>Send KIPO personnel to European Patent Office<br>Participate in free trade agreement IP negotiations<br>Construct traditional knowledge database<br>Manage and protect patented micro-organisms | Build and operate Patent Technology Transfer System<br>Establish the basis for patent product distribution and sales<br>Operate and improve patent information system<br>Build patent information database<br>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) |
|-------------------------------------------------------------|------------------------------------------------------------------------|------------------------------------------------|--------------------------------------------------------------------------|------------------------------|
| <b>MoST</b>                                                 | 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                        |
| <b>MoCIE</b>                                                | International Joint R&D Programme (1990- )                             | EUREKA                                         |                                                                          | 19 000                       |
|                                                             |                                                                        | Infrastructure of international industrial R&D |                                                                          |                              |
|                                                             |                                                                        | Hosting foreign R&D centre                     |                                                                          |                              |
| <b>Korea Food and Drug Administration</b>                   | International Co-operative Research Programme (2006- )                 | Safety-related OECD/WHO research               |                                                                          | 2 800                        |
| <b>Rural Development Administration</b>                     | International collaborative research programme on agriculture (1983- ) | International organisation related research    | Standards/regulation, developing countries, North Korea                  | 2 785                        |
| <b>Ministry of Education and Human Resource Development</b> | 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.<sup>12</sup> 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 abroad – 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**

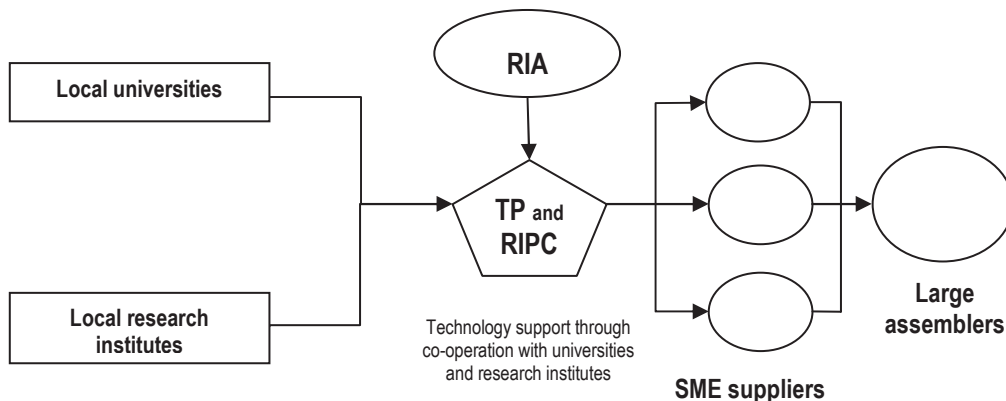
| City/province | Strategic industry            | City/province | Strategic industry                  |
|---------------|-------------------------------|---------------|-------------------------------------|
| Busan         | Harbour logistics             | Jeju          | Tourism                             |
|               | 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

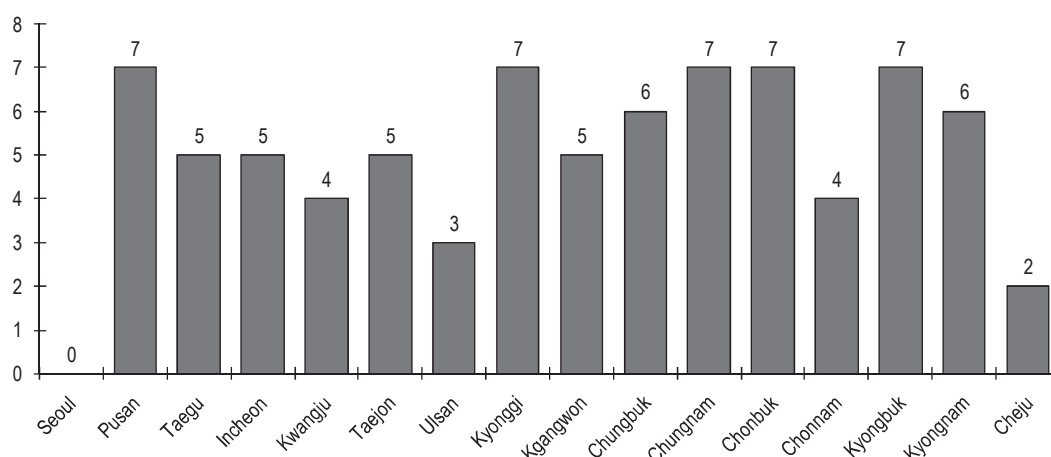


RIA: Regional innovation agency. TP: Techno-parks. RIPC: Regional industrial promotion centres.

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](http://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.

## References

- Aghion, P., N. Bloom, R. Blundell, R. Griffith and P. Howitt (2005), “Competition and Innovation: An Inverted-U Relationship”, *Quarterly Journal of Economics*, May, pp. 701-728.
- Bartzokas, A. (2007), “Monitoring and analysis of policies and public financing instruments conducive to higher levels of R&D investments: Country review Korea”, Policy Mix Project country case study, UNU-MERIT, Maastricht.
- Basri, E. (2008), “Enhancing the Role of Tertiary Education in Research and Innovation”, in OECD (2008), *Tertiary Education for the Knowledge Society*, Vol. 2, OECD, Paris.
- Cho, Hwang-Hee (2005), “Material for Discussion on Innovation Korea and Activation of University R&D”, STEPI, Seoul (in Korean).
- Cho, Hyun-Dae, Tae-Kyung Sung, and Dae-Hee Lee (2005), *Next Generation Technology Innovation Method for Fostering Korea’s Future Strategic Industries*, STEPI, Seoul.
- Cho, Hyun-Dae et al. (2006), *An Analysis of Innovation Infrastructure of the Korean Biotechnology Sector and Policy Recommendation*, STEPI, Seoul (in Korean).
- Cho, Hyun-Dae (2008), “Biotechnology R&D and Innovation in Korea: Status and Features”, Paper presented at the PICMET 2008 Conference “Technology Management for a Sustainable Economy”, July 27-31, Cape Town.
- Choi, Sook-Hee and Jung-Woo Kim (2007), “Korea’s Plunging Birth Rate: Causes and Policy Suggestions”, Issue Paper 01/07, Samsung Economic Research Institute, Seoul.
- Chung, Kae H., Hak-Chong Lee and Ku-Hyun Jung (1997), *Korean Management: Global Strategy and Cultural Transformation*, Walter de Gruyter, Berlin.
- Chung, Sung-Chul (2001), “The Research, Development and Innovation System in Korea”, in Larédo, P. and P. Mustar (eds.), *Research and Innovation Policies in the New Global Economy: An International Comparative Analysis*, Edward Elgar, Cheltenham.
- Chung, Sung-Chul (2006), “Harnessing the Potential of Science and Technology”, in STEPI (2006), *Knowledge-Based Economy*, Science and Technology Policy Institute, Seoul.
- Chung, Sun-Yang (2005), “Partnership in Korean Regional Innovation Systems”, unpublished paper.
- Conway P., V. Janod and G. Nicoletti (2005), “Product Market Regulation in OECD Countries, 1998 to 2003”, Economics Department Working Paper, No. 419, OECD, Paris.
- Dachs, B., J. Mahlich and G. Zahradnik (2007), “The Technological Competencies of Korea’s Firms: A Patent Analysis”, in J. Mahlich and W. Pascha (eds.), *Innovation and Technology in Korea: Challenges of a Newly Advanced Economy*, Springer, Heidelberg.
- Edler, J. and L. Georgiou (2007), “Public procurement and innovation—Resurrecting the demand side”, *Research Policy*, Vol. 36, pp. 949–963.
- Ernst, D. (2000), “Catching Up and Post-Crisis Industrial Upgrading: Searching for New Sources of Growth in Korea’s Electronics Industry”, East-West Center Working Paper, No. 2 March 2000, East-West Center, Honolulu.

- ETRI (2005), *Intellectual Capital Report 2004*, Electronics and Telecommunications Research Institute, Daejeon.
- European Commission (2005), *Public Procurement for Research and Innovation*, Expert Group Report, Directorate General for Research, September 2005, EUR 21793 EN, Office for Official Publications of the European Communities, Luxembourg.
- 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.
- Eurostat (2008), *Science, Technology and Innovation in Europe*, Office for Official Publications of the European Communities, Luxembourg.
- Grubb, W.N., R. Sweet, M. Gallagher and O. Tuomi (2006), "Thematic Review of Tertiary Education: Korea Country Note", July 2006, Directorate for Education, OECD, Paris.
- Guellec, D. and B. van Pottelsberghe de la Potterie (2001), "R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries", STI Working Paper, No. 2001/3, OECD, Paris.
- Haggard, S., Won-Hyuk Lim and Euy-Sung Kim (eds.) (2003), *Economic Crisis and Corporate Restructuring in Korea*, Cambridge University Press, Cambridge.
- Hemmert, M. (2007), "The Korean Innovation System: From Industrial Catch-Up to Technological Leadership?", in Mahlich, J. & W. Pascha (eds.), *Innovation and Technology in Korea: Challenges of a Newly Advanced Economy*, Springer, Heidelberg.
- Hobday, M., H. Rush and J. Bessant (2004), "Approaching the innovation frontier in Korea: the transition phase to leadership", *Research Policy*, Vol. 33, pp. 1433–1457.
- Hong, Yoo-Soo (2005), "Evolution of the Korean National Innovation System: Towards an Integrated Model", in OECD (2005), *Governance of Innovation Systems*, Vol. 2, OECD, Paris.
- Hynix (2007), *Hynix Annual Report 2007*, Hynix, Seoul.
- Ilshin (2007), "Venture Capital in Korea", Presentation to the OECD Country Review Unit, October 2007, Seoul.
- IMD (2008), *World Competitiveness Yearbook 2008*, International Institute for Management Development, Lausanne.
- International Science and Business Belt Task Force (2008), *International Science and Business Belt*, Presidential Transition Committee, Seoul.
- Johnston, R. (2003), "Clusters: A Review", in Department of Education, Science and Training (2003), *Mapping Australia's Science and Innovation System*, DEST, Canberra.
- Karlsson, J. (2006), "Chaebol Characteristics: A Post Asian Crisis Study", Working Paper, Växjö University, Växjö, Sweden.
- KDI (2007), *Survey on Financial Hub Policy*, Korea Development Institute, Seoul (in Korean).
- KEDI (2006), "OECD Thematic Review of Tertiary Education Country: Background Report for Korea", April 2006, Korean Educational Development Institute, Seoul.
- Kim, L. (2001), "Crisis, National Innovation, and Reform in South Korea", MIT Japan Program Working Paper, No. 2001/01.

- KIPO (2006), *Patent Trends in Korea 2006*, Korea Industrial Property Office, Seoul (in Korean).
- KIST (2007), Korea Institute of Science and Technology brochure.
- KOITA (2000, 2006), *Industrial Technology White Book*, Korea Industrial Technology Association, Seoul.
- KOITA (2007), *Status and Problems of Foreign Invested Firms' R&D in Korea*, Korea Industrial Technology Association, Seoul (in Korean).
- KRF (2006), *White Book on University-Industry Cooperation*, Korea Research Foundation, Seoul (in Korean).
- KRF BK21-Nuri Committee (2007), *Brain Korea 21*, Korea Research Foundation, Seoul.
- Larédo, P. (2008), “Some notes on ‘Non-University research organisations’”, Presentation to the OECD meeting on Steering and Funding of Research Institutions, Paris, 19 February 2008.
- Lazonick, W. (2007), “Foreign Direct Investment, Transnational Migration, and Indigenous Innovation in the Globalization of High-Tech Labor”, Revised version of paper presented at the International Forum of Comparative Political Economy of Globalization, September 1-3 2006, Renmin University of China, Beijing.
- Lee, Chul-Won (2007), “Challenges and Issues to Upgrade Government-Sponsored Research Institutes in Science and Technology in Korea”, paper presented at the Annual Conference of the Korean Society for Innovation Management and Economics, 20-21 July, Jeju Island.
- Lee, Jeong-Hyop (2006), “Overcoming the Legacies of the Developmental State Model: the Case of the Gumi Mobile Cluster”, Presentation at the KDI & World Bank Senior Policy Forum on Innovation Policies and Institutions for Knowledge Economy, 29 November-1 December, Seoul.
- Lee, Jeong Hyop and Hyung-Joo 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.
- Lee, Kong-Rae (2007), “An Essay on Government Policies to Manage Public R&D Institutes”, *Asian Journal of Technology Innovation*, Vol. 15, No. 1, pp. 21-34.
- Lee, Kong-Rae, Sang-Wan Shim, Byung-Seon Jeong and Jung-Tae Hwang (2002), *Knowledge-Intensive Service Activities in Korea's Innovation System*, Science and Technology Policy Institute, Seoul.
- Lee, Kong-Rae and Ji-Sun Choi (2004), *Strategy to Manage Public R&D Institutes for Building-up Open Regional Innovation systems*, Science and Technology Policy Institute, Seoul (in Korean).
- Lee, Kwang-Ho and Jung-Wha Suh (2006), *The Characteristics of Technological Innovation in the Nanotechnology-based Industrial Goods Producers*, Science and Technology Policy Institute, Seoul (in Korean).
- Lee, Mu-Shin, Byoung-Ho Son, and Ki-Yong Om (1996), “Evaluation of national R & D projects in Korea”, *Research Policy*, Vol. 25, pp. 805-818.
- Lim (2005), “Korea National System of Innovation”, in STEPI (2005), *Research Issues Derived from the Study of National Systems of Innovation of Small Advanced Nations*, Science and Technology Policy Institute, Seoul.

- Mathews, J. (2001), “National systems of economic learning: The case of technology diffusion management in East Asia”, *International Journal of Technology Management*, Vol. 22, Nos. 5/6, pp. 455-479.
- 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.
- MoCIE (2006), *A Survey on the Technology Transfer of Public Research Institutes*, Ministry of Commerce, Industry and Energy, Seoul.
- MoST (2006a), *Report on the Survey of Research and Development in Sciences and Technology*, Ministry of Science and Technology, Seoul (in Korean).
- MoST (2006b), *National R&D Programs 2006*, Ministry of Science and Technology, Seoul (in Korean).
- MoST (2006c), *Regional Science and Technology Yearbook 2005*, Ministry of Science and Technology, Seoul (in Korean).
- MoST (2007a), *Science and Technology Yearbook 2006*, Ministry of Science and Technology, Seoul.
- MoST (2007b), *Innovation for the Future: Science and Technology in Korea*, Ministry of Science and Technology, Seoul.
- MoST (2007c), *Korean Annual Report on Science and Technology 2006*, Ministry of Science and Technology, Seoul (in Korean).
- MoST and KISTEP (2006), *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 (in Korean).
- 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.
- National Science Foundation (2008), *Science and Engineering Indicators 2008*, US National Science Foundation.
- National Statistical Office (2006), *Report on Mining and Manufacturing Survey*, National Statistical Office, Seoul.
- National Statistical Office (2007), *Major Statistics of the Korean Economy*, National Statistical Office, Seoul.
- Nelson, R. (1993), *National Innovation Systems*, Oxford University Press, New York.
- 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.
- NIS-WIST (2008), *2007 Report on Women in Science and Engineering*, National Institute for Supporting Women in Science and Technology, Seoul.
- NSF (2004), *Survey of Earned Doctorates*, US National Science Foundation.
- NSTC (2006), *Survey and Analysis Report on 2006 National R&D Projects*, National Science and Technology Council, Seoul (in Korean).
- OECD (1996), *Reviews of National Science and Technology Policy – Republic of Korea*, OECD, Paris.

- OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, OECD, Paris.
- OECD (2003a), *Governance of Public Research*, OECD, Paris.
- OECD (2003b), *Education at a Glance 2003*, OECD, Paris.
- OECD (2005a), *OECD Economic Surveys – Korea*, OECD, Paris.
- OECD (2005b), *Thematic Review of Adult Learning: Korea Country Note*, OECD, Paris.
- OECD (2005c), *OECD Territorial Reviews: Busan*, OECD, Paris.
- OECD (2006a), *Society at a Glance*, OECD, Paris.
- OECD (2006b), *Science, Technology, and Industry Outlook 2006*, OECD, Paris.
- OECD (2007a), *OECD Economic Surveys – Korea*, OECD, Paris.
- OECD (2007b), *Science, Technology and Industry Scoreboard 2007*, OECD, Paris.
- OECD (2007c), *Korea: Progress in Implementing Regulatory Reform*, OECD Reviews of Regulatory Reform, OECD, Paris.
- OECD (2007d), *Education at a Glance 2007*, OECD, Paris.
- OECD (2007e), *PISA 2006: Science Competencies for Tomorrow's World*, OECD, Paris.
- OECD (2007f), *Babies and Bosses – Policies towards Reconciling Work and Family Life*, OECD, Paris.
- OECD (2007g), *Higher Education and Regions*, OECD, Paris.
- OECD (2007h), *Competitive Regional Clusters: National Policy Approaches*, OECD, Paris.
- OECD (2008a), *OECD Reviews of Innovation Policy – China*, OECD, Paris.
- OECD (2008b), *OECD Economic Surveys – Korea*, OECD, Paris.
- Oh, Dong-Hoon and Young-Jun Kim (2006), “Overall Coordination of Government-Funded Research and Development Programs in Korea”, *Journal of Multi-Disciplinary Evaluation*, Vol. 3, No. 5, pp. 153-170.
- Oh, Dong-Hoon and M. Cervantes (2007), “Evaluating Government R&D Programmes: Lessons from the Korean Experience”, internal OECD paper DSTI/STP/TIP(2007)7.
- Park, Sung-Jun (2004), “A Study of the Science and Engineering Avoidance Situation”, *Korean Journal of Labor Economics*, Vol. 27. No. 1, Korean Labor Economic Association, Seoul.
- Pilat, D. and A. Hoffman, (2004), “Competitiveness Challenges for OECD Economies: Lessons from the OECD Growth Project”, Paper presented at the KDI 33<sup>rd</sup> Anniversary Conference on Industrial Dynamism and Competitiveness in the East Asian Economies, 22-23 April, Seoul.
- Ryoo, Jaewoo (2004), “Labor Market Performance of the Science and Engineering Graduates and Its Recent Changes in Korea”, *Korean Journal of Labor Economics*, Vol. 27. No. 1, Korean Labor Economic Association, Seoul.
- Sawyer, A. (2005), “Reflections on providing tax incentives for research and development: New Zealand at the cross roads”, *Journal of Australian Taxation*, Vol. 8, No. 1, pp. 111-149.

- Senker, J. (2000), "Introduction", Special Issue on Changing Organisation and Structure of European Public Sector Research Systems, *Science and Public Policy*, Vol. 27, No. 6, pp. 394-396.
- Seong, Jieun and Wichin Song (2007), "Innovation Policy and Administration System in the Era of Post Catch-Up: The Case of Korea", Paper presented at the Science, Technology and Innovation Policy Conference, 19-20 October, Atlanta.
- Shin, Tae-Young, *et al.* (2006), *Effects of R&D Investment on Economic Growth and Income Distribution*, Ministry of Science and Technology, Seoul (in Korean).
- SMBA (2004), *Prosperity with Competitive and Innovative SMEs*, Small and Medium Business Administration, Seoul.
- Sohn, Dong-Won and Kenney, M. (2007), "Universities, Clusters and Innovation Systems: The case of Seoul, Korea", *World Development*, Vol. 35, pp. 991-1004.
- Song, Jong-Guk (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.
- STEPI (2002), *Changing Strategies for Business Innovation and the Implication for S&T Policy*, Science and Technology Policy Institute, Seoul.
- STEPI (2005), *Report on the Korean Innovation Survey 2005: Manufacturing Sector*, Science and Technology Policy Institute, Seoul.
- STEPI (2006), *Korean R&D Scoreboard*, Science and Technology Policy Institute, Seoul (in Korean).
- Suh, Joong-Hae (2000), "Korea's Innovation System: Challenges and a New Policy Agenda", INTECH United Nations University Working Paper, No. 2000-4, Maastricht.
- Tamura, S., J. Sheehan, C. Martinez and S. Kergroach (2005), "Promoting Innovation in Services", in OECD (2005), *Enhancing the Performance of the Services Sector*, OECD, Paris, pp. 113-177.
- UNCTAD (2005), *World Investment Report 2005: Transnational Corporations and the Internationalisation of R&D*, United Nations, New York and Geneva.
- Warda, J. (2007), "Generosity of Tax Incentives", Presentation at the TIP Workshop on R&D Tax Treatment in OECD Countries: Comparisons and Evaluations, 10 December, Paris.
- Wieczorek, I. (2007), "Nanotechnology in Korea – Actors and Innovative Potential", in Mahlich, J. & W. Pascha (eds.), *Innovation and Technology in Korea: Challenges of a Newly Advanced Economy*, Springer, Heidelberg.
- Woo, Cheon-Sik (2003), "Industrial Competitiveness of Korea: Methodology and Findings of KDI's 2003 Study", Korea Development Institute (KDI), Seoul.
- World Bank (2000), *Republic of Korea: Transition to a Knowledge-Based Economy*, World Bank, Washington, DC.
- World Bank (2006), *Korea as a Knowledge Economy: Evolutionary Process and Lessons Learned*, World Bank, Washington, DC.
- World Bank (2008), *Doing Business 2008*, World Bank, Washington, DC.
- Yim, Deok-Soon and Wang-Dong Kim (2005), "The Evolutionary Responses of Korean Government Research Institutes in a Changing National Innovation System", *Science, Technology and Society*, Vol. 10, No. 1, pp. 31-55.

OECD PUBLISHING, 2, rue André-Pascal, 75775 PARIS CEDEX 16  
PRINTED IN FRANCE  
(92 2009 04 1 P) ISBN 978-92-64-06722-6 – No. 56857 2009

# OECD Reviews of Innovation Policy

## KOREA

How are a country's achievements in innovation defined and measured, and how do they relate to economic performance? What are the major features, strengths and weaknesses of a nation's innovation system? How can government foster innovation?

The *OECD Reviews of Innovation Policy* offer a comprehensive assessment of the innovation system of individual OECD member and non-member countries, focusing on the role of government. They provide concrete recommendations on how to improve policies that affect innovation performance, including R&D policies. Each review identifies good practices from which other countries can learn.

Korea's exceptional economic success over the last half century has few parallels and has been driven in no small part by a firm commitment to innovation. Among its strengths, Korea has one of the highest rates of spending on R&D in the world, much of which is performed by private firms. It also has a highly educated labour force – as signalled by its impressive PISA performance and exceptionally high rates of tertiary level graduation – with a strong interest in science and technology. However, a number of bottlenecks persist that hamper Korea's economic convergence with the leading OECD economies. These include a relatively weak SME sector and weak performance in services, as well as lagging capacities to conduct leading-edge research in many areas. Furthermore, Korea faces numerous threats in the mid term, notably increased levels of competition from China and other newly-industrialising economies, the lowest fertility rate in the OECD and an ageing society, and a continuing high dependency on imports of natural resources, particularly hydrocarbons. In the shorter term, the economic crisis offers its own challenges, with the need for some policy adjustments to deal with expected falls in business investment in R&D and growing levels of unemployment among the highly skilled.

This report assesses the current status of Korea's innovation system and policies, and identifies where and how the government should focus its efforts to improve the country's innovation capabilities.

More information about the *OECD Reviews of Innovation Policy* series is available at [www.oecd.org/sti/innovation/reviews](http://www.oecd.org/sti/innovation/reviews).

The full text of this book is available on line via this link:  
[www.sourceoecd.org/scienceIT/9789264067226](http://www.sourceoecd.org/scienceIT/9789264067226)

Those with access to all OECD books on line should use this link:  
[www.sourceoecd.org/9789264067226](http://www.sourceoecd.org/9789264067226)

**SourceOECD** is the OECD online library of books, periodicals and statistical databases. For more information about this award-winning service and free trials ask your librarian, or write to us at **SourceOECD@oecd.org**.