CHANGING STRATEGIES FOR BUSINESS R&D AND THEIR IMPLICATIONS FOR SCIENCE AND TECHNOLOGY POLICY IN KOREA

PHASE 1 REPORT

Foreword

This report on *Changing Strategies for Business R&D and Their Implications for Science and Technology Policy in Korea* summarizes the results of Phase 1 of a joint project undertaken by the OECD and the Science and Technology Policy Institute (STEPI) in Korea to better understand how recent changes in the Korean economic and business environment have affected the R&D strategies in Korean firms and, in turn, how science, technology and innovation policies can be improved to strengthen business R&D and innovation in Korea. The effort is linked to a project being conducted under the auspices of the OECD's Working Party on Innovation and Technology Policy on emerging patterns of public and private financing of business R&D, which will include analyses of R&D financing trends in several OECD countries.

Phase 1 of the joint OECD-STEPI project is aimed at developing the analytical framework for the project and an implementation plan. The work was facilitated by a visit by OECD staff and a consultant to Korea, during which meetings were held with government officials and R&D executives from Korean firms. Phase 2 of the project will contain most of the data-gathering and analysis and result in a final report. This Phase 1 report was prepared by Jerry Sheehan of the OECD's Science and Technology Policy division, with assistance from Ki-Joon Jung, of the OECD's Science and Technology Policy division and Luke Georghiou, director of the Center for Policy Research in Engineering, Science and Technology at the University of Manchester, UK, who served as a consultant to the OECD. STEPI provided financial support for the project, which also benefited from valuable comments, suggestions and guidance from Jong Guk Song, Jung Won Lee and Sung Chul Chung at STEPI.

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Introduction and overview

1. There are many indications that business strategies for research and development (R&D) have changed significantly over the recent years across the OECD: business R&D expenditures grew rapidly together with R&D alliances, co-operative R&D, and patent licensing activities. The share of SMEs in industrial R&D and business funding for university research have also increased significantly. There may be various reasons behind these changes, but many attribute the recent changes in business R&D to such factors as the globalisation of business activities, the growth of corporate venture capital, and the emergence of new technologies. Such changes have potentially far-reaching implications for science and technology (S&T) policy, in that new patterns of business R&D may imply compensatory changes in government policy as the rationale for certain forms of government support may have weakened while that for others has strengthened.

2. Korean industries are no exception. Considerable evidence suggests that Korean business enterprises are redirecting their R&D efforts in response to changing business environments, both domestic and international. In addition to the factors cited above, reforms in corporate governance and financial institutions, among other forces, are motivating Korean business enterprises to change their strategies for R&D. Change in corporate governance have modified decision-making processes in many of the large enterprises, in particular, chaebol[1] companies. Financial reforms affected the financing strategies of enterprises, which in turn brought about significant changes in investment activities, including R&D. Even though the nature of the changes has yet to be examined, one cannot deny that the changes will have far-reaching and profound implications for S&T policy. This is particularly true in Korea, because Korea relies on private business enterprises for more than 70% of its R&D investment.

3. The Korean government has strong interest in the study on Emerging Patterns of Public and Private Financing of R&D that was initiated by the OECD Working Party on Innovation and Technology Policy in June 2001. It seeks co-operation with the OECD in conducting a study on the same issues in a Korean setting. Basic questions that the proposed study pursues to answer are:

1. What are the major factors behind the recent changes in business R&D strategies in Korea? What are the key features of the changes?

2. What are the major policy issues to consider in promoting and facilitating business R&D in Korea under the changing policy environments? What specific policy actions are required?

As Phase I of this project, the OECD Secretariat (with the assistance of a consultant) agreed to work with the Korean government to specify in greater detail the scope of the study and develop an analytical framework and a plan for its implementation. This process was facilitated by an early mission to Korea to discuss the specific concerns/interests of the Korean government and conduct a preliminary set of interviews with Korean firms. A review of existing data and literature describing patterns of R&D investments of Korean firms was also undertaken to provide a solid basis from which to launch further investigations.

4. This document summarises the results of the Phase I effort and provides a framework for guiding the subsequent phases of the project. It *1)* reviews the changing patterns of R&D across the

[1] A Korean word meaning "business group."

OECD to highlight significant factors for further examination in a Korean context; *2)* identifies recent trends in the performance of business R&D in Korea, as well as in government policy to support business R&D and innovation; and *3)* discusses the methodological approaches being undertaken in other country-level studies of business R&D, in conjunction with the TIP project on this topic.

The changing context for business investments in R&D

5. At the aggregate level, available statistics indicate growing business investments in R&D, as well as the emergence of a more diversified business R&D system in many OECD countries. Business R&D performance is not limited to large manufacturing firms, but is found in a wider range of large and small firms in both manufacturing and services. As a result, governments will need to find ways to better support a more heterogeneous mix of R&D-performing organisations and to ensure necessary linkages among them. They will also have to find ways to avoid crowding out the growing R&D expenditures of a more diverse set of private-sector institutions.

Growing levels of business R&D spending

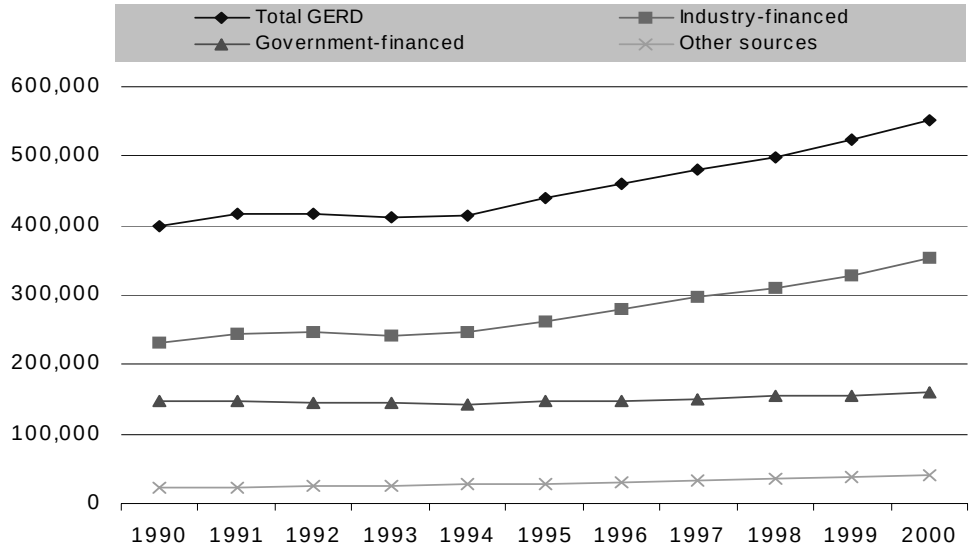
6. Aggregate statistics show that business R&D fared well in the OECD region in the last decade, with both industry financing of R&D and industry performance of R&D posting gains. Between 1990 and 2000, industry funding of R&D rose 53% in real terms, from approximately USD 230 billion to more than USD 350 billion (Figure 1). Total business enterprise expenditures on R&D (BERD) – a measure of R&D performed in the business sector – grew by 39% in real terms during this period, from USD 276 billion to USD 385 billion.[2] In contrast, direct government funding of R&D grew by only 8.4% in real terms between 1990 and 2000, from USD 147 billion to USD 159 billion.[3] As a result, government represents a declining share of R&D financing in most OECD countries. Government funding for R&D declined from 37% of total OECD funding for R&D to less than 30% in the 1990s, continuing a trend that stretches back at least to 1981. This change implies that businesses play a much larger role in directing innovation activities and that governments must find more effective ways leveraging private sector R&D in order to meet social and economic objectives.

2. Such R&D is financed largely with industry funds, but also with contributions from government and other national sources.

3. In the European Union and the United States, government R&D funding was lower in 2000 than in 1990, despite slight increases in the late 1990s. This trend reflects both a reduction in defence-related expenditures and fiscal restraint in the United States and several large European economies.

Figure 1 Gross expenditures on R&D in the OECD region, 1990-2000

Millions of constant 1995 PPP dollars



Source: OECD, Main Science and Technology Indicators, June 2002.

7. These statistics, however, mask significant variation in the distribution of R&D growth across OECD countries and industry sectors:

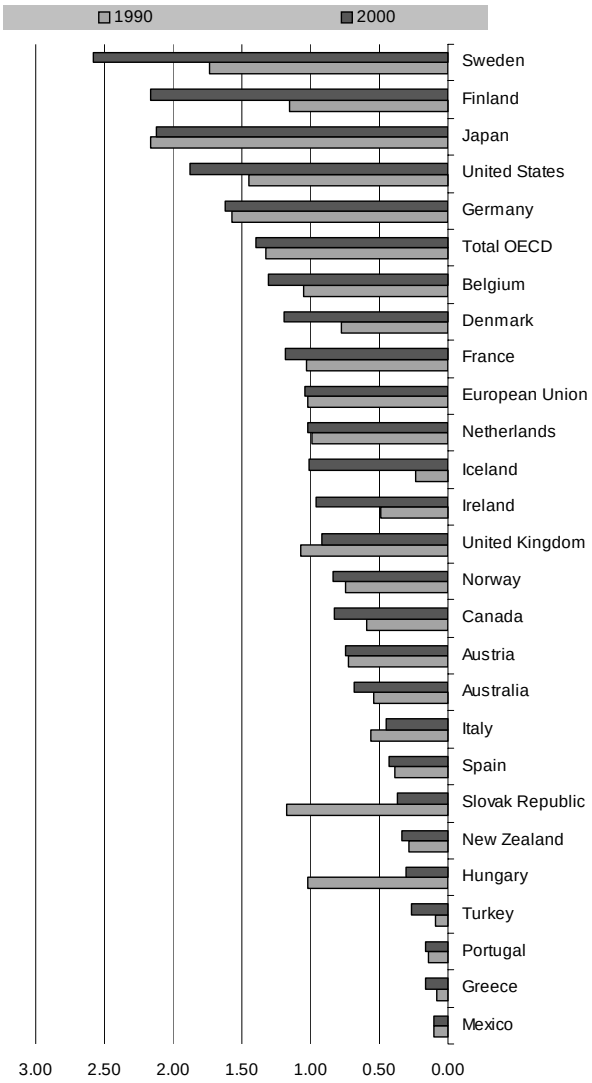
- *National differences*. In the European Union, industry R&D spending averaged just 1 percent of GDP in 2000, a figure virtually unchanged from 1993 and considerably below that of other OECD countries, including Japan, Sweden, and the United States (Figure 2). In Australia, Italy, and the United Kingdom, industry funding for R&D declined in real terms and as a share of GDP during the course of the decade. Firms in the European Union also lagged companies in Japan, the United States, and the Nordic countries in R&D performance. Australia, France, Italy, and the United Kingdom saw declines in BERD as a percentage of GDP.[4] Understanding the factors that underlie these differences is important in determining how governments can best encourage growth in business R&D--in particular in industry-financed business R&D.

- *Sectoral differences*. Growth in business R&D was driven disproportionately by high-technology industries, such as ICT and pharmaceuticals, and the service sector (Figure 3). In Finland, where total business expenditures on R&D (BERD) more than doubled between 1990 and 1998, approximately three-quarters of the increase came from the ICT, pharmaceuticals, and service sectors—60% from ICT alone. Ireland and the Netherlands saw service sector R&D increase at an average rate of more than 20% a year in the 1990s, with Japan and the United States posting gains of between 5% and 10% annually.

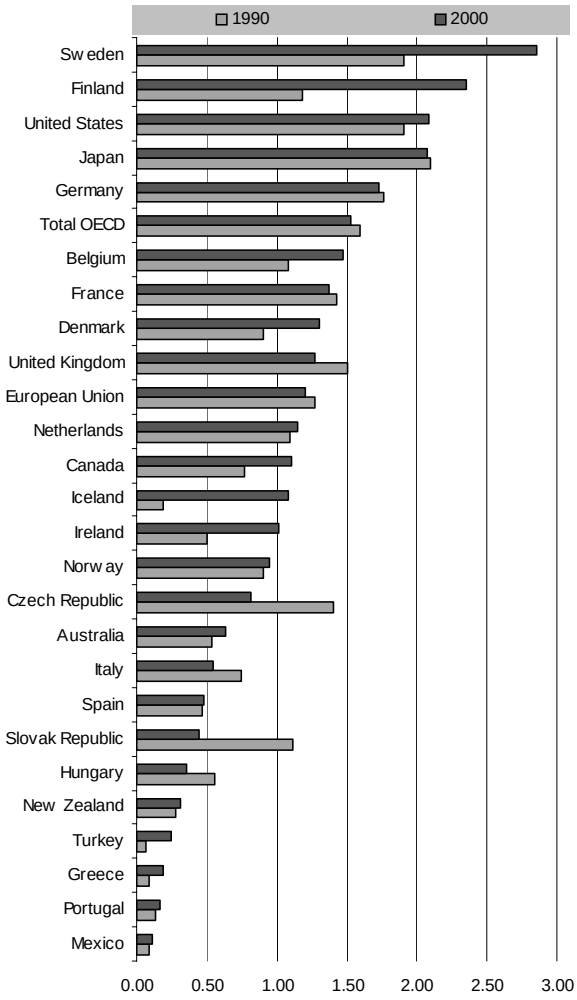
4. In the case of France and the United Kingdom, sharp declines in government funding of business R&D, especially of defence-related R&D, contributed significantly to the overall decline.

Figure 2 National trends in industry-financed and business-performed R&D relative to GDP, 1990-2000[1]

Industry-financed R&D as a percentage of GDP



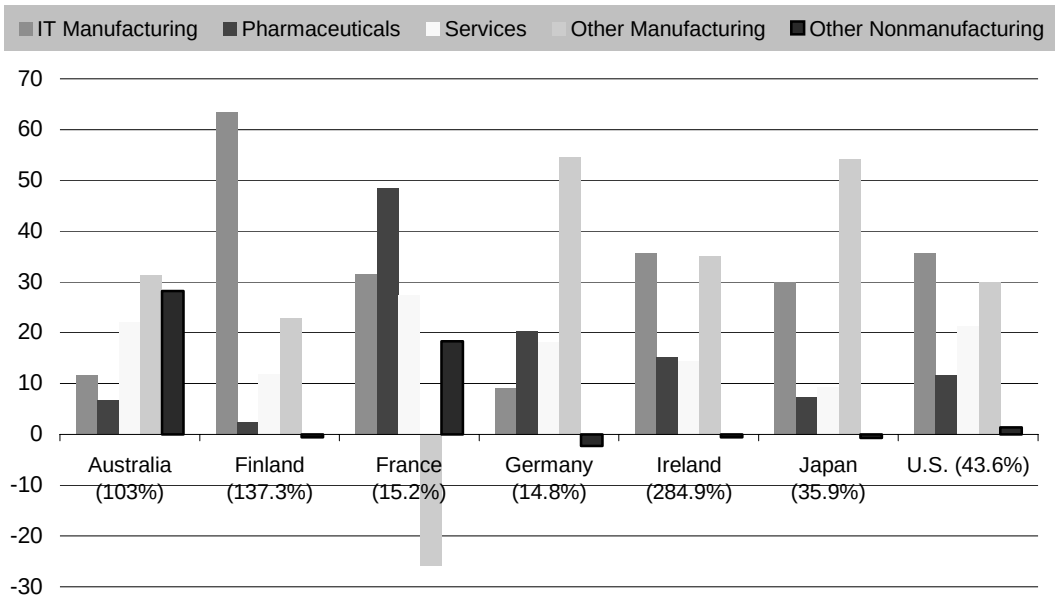
Business-performed R&D as a percentage of GDP



1. Nearest available year.
Source: OECD, MSTI Database, June 2002.

Figure 3 Distribution of the growth in business R&D between 1990 and 1998[1] in select OECD countries by industry

Percentage of total increase in BERD



1. Nearest available years.
Note: Information technology manufacturing includes office, computing and accounting machines, communications equipment and electronic components. The decline in R&D in other manufacturing industries in France derives from steep reductions in defence expenditures (OST, 2000).
Source: OECD ANBERD Database, June 2002.

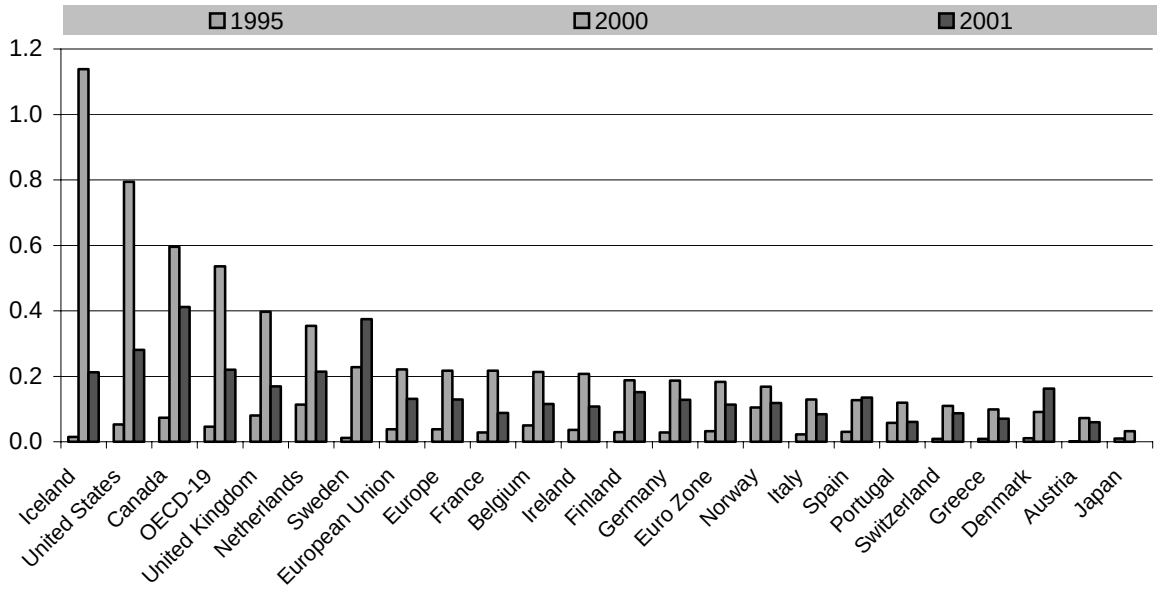
The role of venture capital

8. Rapid growth of venture capital during the late 1990s contributed to the rise in private-sector investment in R&D. While the United States had the largest venture capital sector with over USD 103 billion invested in venture funds in 2000, many Member countries saw their venture capital markets grow 30% or more between 1995 and 2000 before tumbling in 2001 (OECD, 2000b) (Figure 5).[5] Venture capital finances R&D indirectly by supporting new technology-based firms that conduct significant amounts of R&D. Increased venture capital funding has helped spur increases in the share of business R&D conducted by SMEs. In the United States, for example, SMEs were responsible for more than one-third of the growth in business R&D between 1995 and 1998, with R&D expenditures of the smallest firms increasing most quickly. This trend reflects a significant reduction in the scale and scope of activity needed to successfully develop a number of emerging technologies, especially in the areas of ICT and biotechnology (Pavitt, 2000). Despite the significant downturn in venture capital investments in 2001, they remain well above their levels of the mid-1990s and are likely to remain a significant source of financing for new technology-based firms.

5 . Countries differ in the relative share of venture capital that supports seed investments versus later stage expansion of business and in the industry sectors that receive funding, but a considerable amount of venture capital is directed toward ICT and biotechnology.

Figure 4. Venture capital expenditures in the OECD

Early and expansion stage venture capital as a % of GDP



Source: OECD, based on various sources.

9. Together, these trends indicate the emergence of a more diversified business R&D system in many OECD countries, a system characterised by an expanded set of R&D-funding and performing organisations. Business R&D performance is no longer limited to large manufacturing firms, but is rooted in a wider range of large and small firms in all sectors of the economy. This shift may have significant implications for government policy. Without significant increases in government R&D spending, governments will need to find ways to better support a more heterogeneous mix of R&D-performing organisations and to ensure necessary linkages among them. They will also have to find ways to avoid crowding out growing R&D expenditures by a more diverse set of private-sector institutions. Efforts will be needed to refine processes used to select projects to support, and governments may alter the balance of funding among different R&D performers and types of projects (e.g., allocating more R&D resources to basic research, even if it implies redirecting government R&D funds away from the business sector and toward universities and government laboratories). They may also see a need to increase use of measures, such as tax credits, that can better reach a growing number of SMEs, and to use various forms of public/private partnership to allow governments to share R&D costs with industry and that can help improve public and private returns to R&D.

Reorganising business R&D

10. As important as the overall changes in patterns of business R&D has been the restructuring of R&D processes within firms themselves, in particular within large, multinational corporations. Despite the increased role of small start-up firms, large firms continue to wield considerable influence over patterns of innovation. In the late 1990s, large firms (*i.e.*, those with more than 500 employees) accounted for 93 percent of all business R&D in Japan, 81 percent in the United States, 78 percent in

the European Union, and 74 percent in Nordic countries. They also exert considerable influence over the R&D programmes of firms in their supplier networks.

11. Many large firms have restructured their R&D operations to improve the linkages between their R&D programmes and their overall strategic objectives. The implications of these changes were perhaps most pronounced in centralised corporate research labs, which perform the most fundamental research in the business sector. The results of research conducted in such labs have often been difficult for parent firms to appropriate, and numerous examples exist of technologies being brought to market by competitors who did not conduct the original R&D.

12. Firms have experimented with a range of reforms that strive to provide researchers in such labs with sufficient freedom to explore new scientific and technological opportunities with uncertain outcomes while ensuring that the labs contribute to profitability. Elements of the restructuring include (Chesbrough 2000b; Coombs 2001):

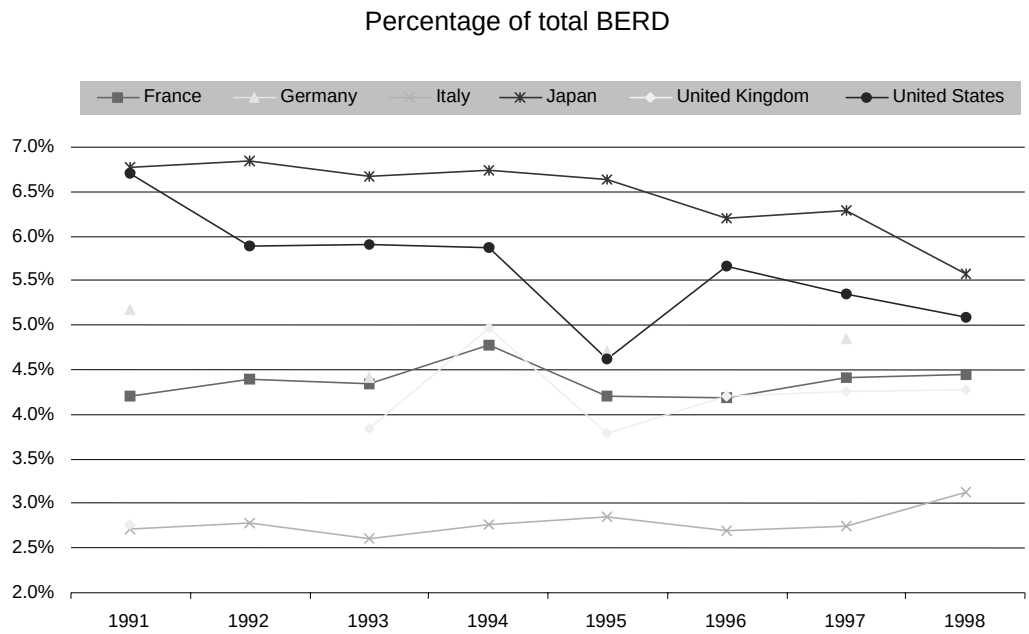
- *New funding models.* Funding of internal research laboratories relies less on central funding and more on mixed models in which researchers receive some financial support from product divisions.

- *Links to the market*. More explicitly links are established between research programmes and market needs, whether by researchers working more closely with customers or through more elaborate research planning processes.

- *Re-organising staff*. Organisational structures based on traditional academic disciplines are being replaces by problem- or product-oriented structures. Incentive plans are rewarding researchers and research managers for both quality research and contributions to business performance.

13. These types of changes have arguably helped firms improve the returns from their R&D investments, but they have also raised concern among policy makers regarding their implications for industry support of long term, fundamental research. Data on business performance of R&D show that the share of business R&D allocated to basic research fell in the United States and Japan between 1991 and 1998 while increasing modestly in Italy and France—two countries that saw overall declines in BERD during this timeframe (Figure 5). A number of surveys (*e.g.*, IRI 2001) and interviews with business executives (Chesbrough 2000a) provide further evidence that businesses have cut back on basic research.

Figure 5. Share of BERD allocated to basic research in selected OECD countries



Source: OECD, MSTI database, June 2002.

14. Nevertheless, there are clearly incentives for firms in industries like ICT and pharmaceuticals to pursue R&D that will generate pioneering innovations. The high degree of network externalities in the ITC industry and the strong first-mover advantages in pharmaceuticals allow market leaders to reap significant rewards from new products and services, thereby creating increased incentives for industry to invest in innovative R&D projects. Accordingly, US firms indicate growing interest in R&D related to new business areas even as interest in basic research is declining (IRI, 2000), but they may be relying more on outside organisations (*e.g.*, universities and start-ups) for more fundamental advances that stimulate radical innovation.

Linking internal and external R&D efforts

15. A significant aspect of the restructuring of business R&D has been a conscious attempt on behalf of many firms to open up their R&D systems to integrate them better with external sources of technology. The objective of this approach is to increase the flow of ideas through the company, both to make researchers aware of external developments of interest to the firm and to speed subsequent innovation processes. This approach may allow firms to outsource some of their R&D activities, but more importantly, it can enable them to take advantage of a wider range of technological inputs.

16. Firms report that they increasingly outsource research to R&D service organisations and that more frequently partner with universities and national laboratories to develop technology (Chesbrough 2001a). Consistent with these statements, the share of industry R&D funding used to finance research conducted in universities—though still very small—more than doubled in the OECD between 1981 and 1999, driven mostly by gains in the European Union and United States. Several countries also report increases in the R&D expenditures of firms in the R&D services sector and in the amount of industrial R&D contracted to outside organisations. Such figures do not measure the considerable interaction that occurs between industry and public research organisations (*i.e.*, universities and

government labs) in the form of joint research programmes and licenses for public research results, both of which occur can without measurable transfers of R&D funds.[6]

17. Small technology-based firms (*e.g.*, high-tech start-ups) have also become a growing source of new technology. Such firms are often more effective than large companies at commercialising radical innovations that open new product markets because: (1) they can satisfy their need for revenue growth by concentrating on markets that are initially small; (2) they tend not to have an installed base of customers who discount the value of new technology (which is often inferior in some important dimensions to existing technologies); and (3) they do not have to worry about cannibalising existing product lines (Christenson, 1997). Nevertheless, the R&D programmes of new technology-based firms are smaller and more targeted than those of large, R&D-intensive firms. High-technology start-ups may therefore serve more as a way of complementing than replacing the broader, long-term R&D portfolios of some larger high-technology firms.

18. While large firms finance some R&D in small firms and license the results of such work, other mechanisms, such as corporate venture capital (CVC) funds and mergers and acquisitions (M&As) have become increasingly popular for financing and appropriating the results of start-up R&D:

- *Corporate venture capital (CVC)* funds allow large firms to invest in start-up firms to gain a window on new technologies, stimulate development of complementary technologies, or encourage broader use of the investor's technology by establishing a *de facto* standard (Cohen 2000). The number of companies world-wide with CVC programmes jumped from 49 in 1996 to approximately 350 in 2000.[7] Total CVC investments in the United States climbed to USD 9.5 billion in 1999, or more than 15 percent of total venture capital spending in the United States (CEB, 2000).[8] Such investments were subsequently scaled back as the economy entered a downturn, but many firms continued to invest at a smaller scale in new technology based firms, with a greater share of investments reportedly being made outside the United States.

- *Mergers and acquisitions (M&As)* allow large firms to appropriate technology developed in small firms, even if they did not finance the R&D. While firms engage in M&As for many reasons other than to access technology, the increasing numbers of small, R&D-intensive firms acquired by large high-technology firms indicates the growing importance of technology sourcing in such decisions. Firms can choose between developing a particular technology in-house or acquiring it on the open market through a merger or acquisition. M&A activity has declined significantly since 2000, but remains an important element in firms' R&D strategies.

19. Together, these various forms of inter-firm co-operation allow businesses to nurture and benefit from the development of a wide range of new technologies without committing internal R&D resources to them. They represent a different type of outsourcing than the sponsored research

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6 . For a brief discussion of industry-science relations and relevant indicators, see chapter 5 in OECD (2000) and OECD (2001a).

7 . Data from *The Corporate Venturing Report* as cited in Silverman (2000). Cited figures figure does not include companies that take minority equity stakes in start-up firms on an *ad hoc* basis-

8 . CVC funds are not limited to U.S. firms. A number of European and Japanese companies including Alcatel, France Telecom, Hitachi, Novartis, Philips, Siemens, and SmithKlineBeecham have CVC funds.

described above. Outsourcing implies the transfer of R&D to R&D performers outside the firm, with a commensurate decline in internal R&D. Current modes of technology sourcing may result less in a reduction of in-house R&D than in a change in allocation of internal R&D funding. Companies may dedicate increasing R&D resources to those activities in which managers believe they have the greatest capability. Rather than weakening (or hollowing out) the R&D capabilities of large firms, external sourcing may increase the efficiency of business R&D and innovation systems overall—by allowing a wider range of organisations to concentrate their R&D efforts in areas of relative strength.

20. From a policy perspective, the increasing collaboration among firms and between researchers in industry, universities, and government labs also demands greater attention to policies that foster the exchange of knowledge among innovating organisations in the public and private sectors. Government can support such linkages in numerous ways, such as by funding collaborative research programmes, promoting the licensing of technology from public research organisations (*e.g.*, as with the Bayh-Dole Act in the United States), removing unnecessary obstacles to co-operation between researchers in the public and private sectors (*e.g.*, rules governing public sector employees), and enhancing the mobility of researchers between these sectors. Competition policies also need to be re-examined to ensure that they allow for necessary forms of inter-firm co-operation while creating a competitive business environment.

Globalisation

21. By virtually all measures, industrial R&D has become more global. Existing statistics indicate that the share of R&D financed by foreign sources increased throughout the OECD in the last decade and now stands between 3% and 7% in most countries. Japan and Austria represent two ends of the spectrum in terms of globalisation. In Japan R&D funding from abroad remained at only 0.4% of total R&D funding in 1995. In Austria the reported share of funding from abroad increased from 2.6% to 20.1% of GERD between 1993 and 1998—the highest in the OECD.[9] These figures do not necessarily include R&D expenditures by foreign affiliates, which can also be large. Many major technological companies have R&D facilities located outside their home countries.[10] Almost two-thirds of BERD in Hungary and Ireland was financed by foreign multinationals in 1997, as was one-third of BERD in Canada, Spain, and the United Kingdom. Sweden and the United States reported 16% and 12%, respectively.

22. The motivations for foreign R&D investments appear to be changing, with implications for the patterns of investment. Traditionally, investments in foreign affiliates were made to allow multinational firms to better tailor products to local market needs, often following the globalisation of manufacturing and marketing functions. Increasingly, investments in foreign R&D facilities appear to be motivated by the desire to tap into centres of scientific and technical excellence, a trend that pushes investments toward locations such as Silicon Valley and Cambridge, United Kingdom (Sachwald, 2000). Other investments are made to access inexpensive labour (such as in the software industry) or lower regulatory hurdles (as in the medical devices and pharmaceuticals industries) (COC 1998; CFR, 1998). They also allow large firms to accelerate R&D programmes by having scientists and engineers working on common projects in different locations 24 hours a day.

9 . It should be noted that data on R&D funding from abroad is among the most difficult for countries to report and are subject to changing definitions over time. Time series data and international comparisons must therefore be interpreted with caution.

10 . A survey by EIRMA in 1997 found that 60% of the 23 major firms surveyed had established foreign R&D facilities. Cited in Weil (2000).

23. Globalisation raises numerous issues for policy makers and business executives. Countries hoping to use foreign direct investments to boost employment, economic output, and R&D spill-overs continue to seek ways to attract multinational investment, such as through tax incentives or an educated workforce. Countries that are already highly internationalised (*e.g.*, smaller northern European countries) are more interested in reinforcing innovative strengths and maintaining their niche in the global environment. Large, technologically advanced countries tend to be more concerned about minimising the leakage of technology abroad while remaining attractive bases for industrial research (OECD, 1999). Globalisation of R&D can also make firms aware of the lack of co-ordination between policies and programmes at the national, regional, and international levels. Similarly, as small firms become more tightly integrated into global innovation networks and global markets, they find they must develop the capacity to accommodate different needs of markets and regulatory bodies.

Business R&D in Korea

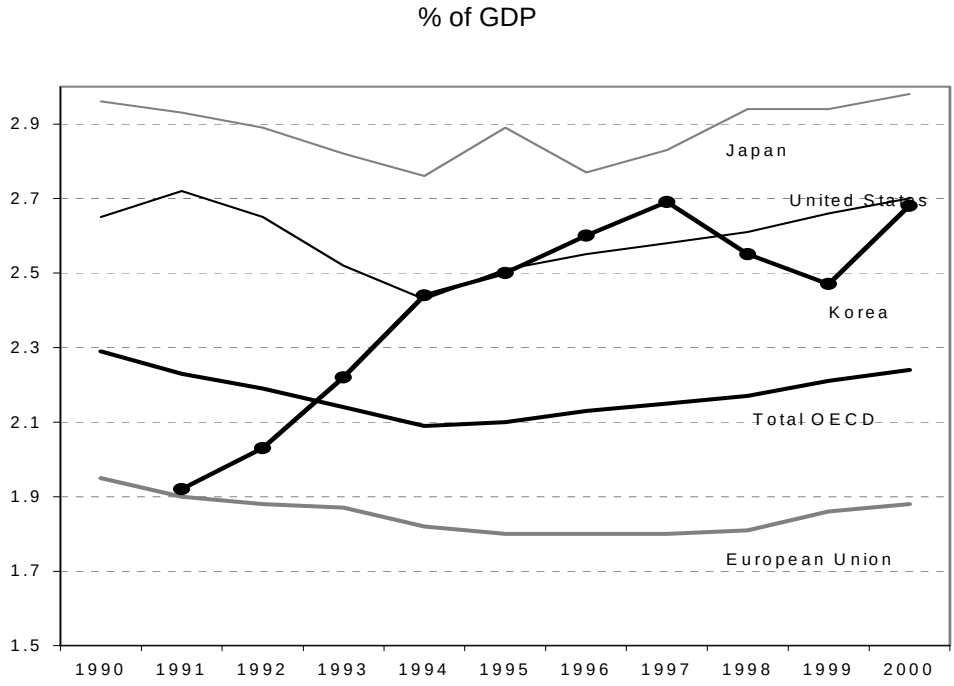
24. Business R&D has undergone significant changes over the past decade. These changes appear to have been influenced by a number of factors, including new technological developments, changes in the economic environment, including the financial crisis of the late 1990s, and government policy. While business R&D expenditures appear to have recovered from the effects of the financial crisis, more subtle changes in business R&D strategies may have occurred. Additional research will be needed to better understand the scale and scope of these changes and the ways in which government policy might adjust to better accommodate them.

Changing patterns of R&D investment in Korean

25. Korea's expenditures on R&D grew significantly during the 1990s. Gross expenditures on R&D (GERD) more than doubled in real terms from USD 7.6 billion in 1991 to USD 17.5 billion in 2000. Its R&D intensity (GERD as a share of GDP) rose from 1.9% to 2.7% of GDP (Figure 6). In doing so, it moved up from the 9th to 5th most R&D intensive country in the OECD, just ahead of the United States, and from the 8th to 6th most R&D investing country in the OECD by surpassing Canada and Italy. Growth in R&D expenditure was paralleled by an increase in the number of researchers. The number of full-time equivalent (FTE) researchers grew from 72,607 in 1991 to 108,370 in 2000, which at the same time brought about an increase in the number of researchers per thousand in the workforce from 3.8 to 5.2.[11] This figure remains significantly below OECD average, which reached 6.4 researchers per thousand in the workforce in 1999.

11 . Researchers statistics for 1991 are from national sources while those for 2000 are from OECD, Main Science and Technology Indicators, Vol 2002/1..

Figure 6. R&D expenditures in select OECD countries, 1990-2000

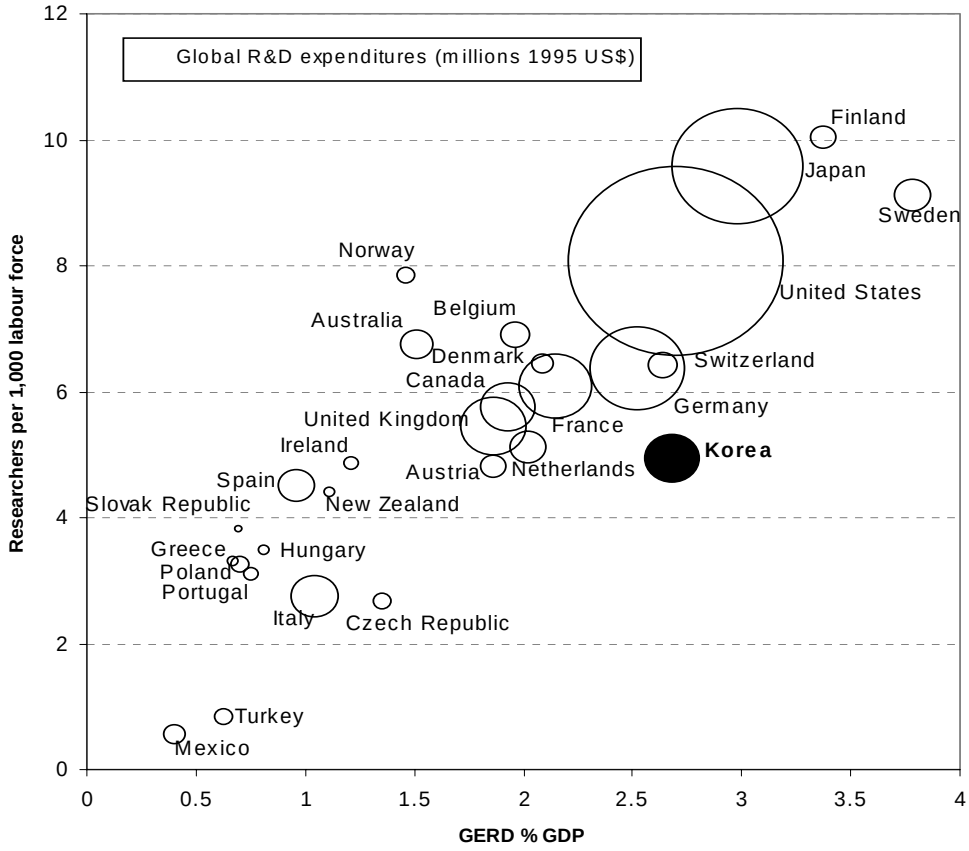


Source: OECD, MSTI database, October 2002

26. The financial crisis in Korea took a significant but short-lived toll on Korean R&D. Total R&D expenditures dropped from USD 15.6 billion to USD 13.8 billion between 1997 and 1998, and R&D intensity declined to less than 2.5% of GDP in 1999. Nevertheless, by 2000, R&D spending exceeded its pre-crisis value and R&D had recovered to its pre-crisis value. The R&D workforce followed a similar trend: the number of FTE researchers dropped from 102 660 in 1997 to 92 541 in 1998, but recovered to 108 370 by 2000. Most recent figures put Korean R&D expenditures on par with those of France, Italy, and the United Kingdom, and its R&D intensity just below that of the United States. The number or FTE researchers remains low compared to Korea's R&D expenditures (Figure 7).

Figure 7. R&D expenditures and researcher population across the OECD, 2000[1]

GERD in millions of 1995 USD



1. Or closest available year
Source: OECD, MSTI Database, June 2002.

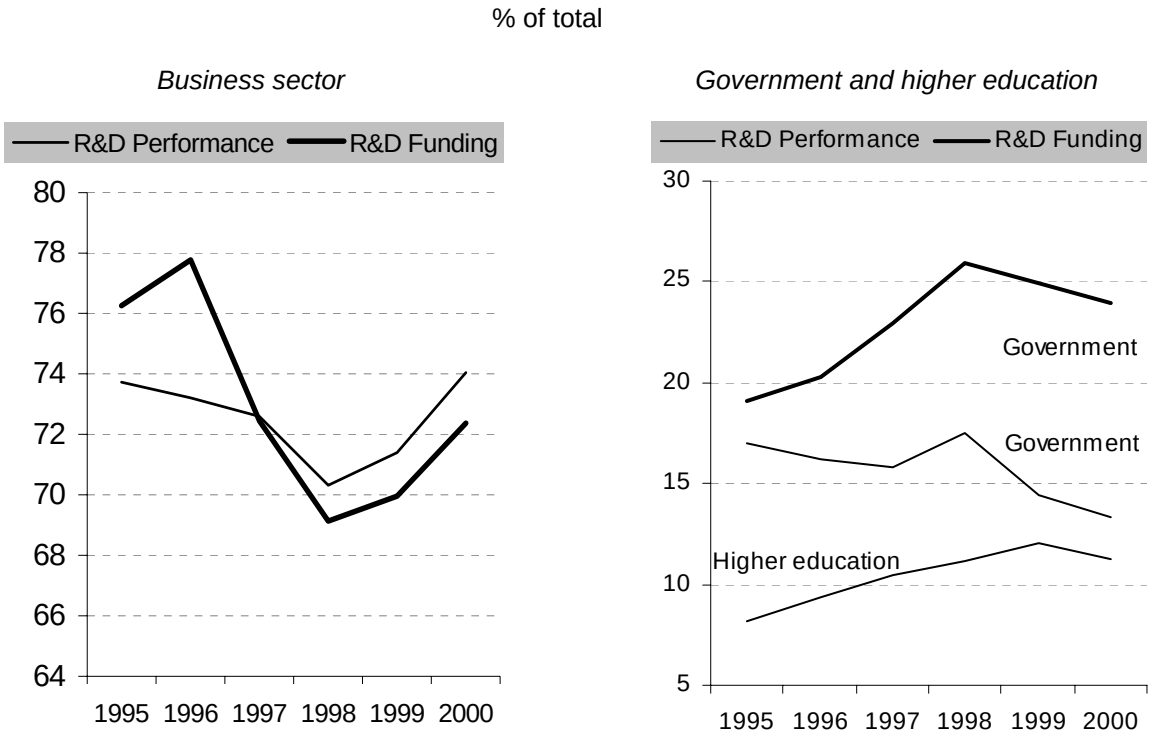
27. As with other countries with high levels of R&D intensity, Korean R&D is financed and performed overwhelmingly by the business sector, although the business sector's share has declined since the financial crisis. The share of GERD financed by industry peaked at 78% in 1996, dipped below 70% during the financial crisis, and returned to 72% by 2000 (Figure 8). This figure is the highest in the OECD, equalled only by Japan.[12] Business R&D performance followed a similar, but more muted pattern, declining from 74% to 70% between 1995 and 1997, and recovering to 74% in 2000—a share lower than only the United States and Sweden.[13] In real terms, Korean BERD grew from USD 9.5 billion in 1995 to USD 11.3 billion in 1997, before declining to USD 9.7 billion in 1998. By 2000 BERD had more than recovered to USD 12.9 billion. The distribution of researchers is also skewed toward industry, reflecting the R&D expenditure. In 2000, 66.3% of Korean researchers

12 . On average, OECD countries have 64% of GERD financed by industry.

13 . Government financed R&D increased from 19% to 24% of total GERD during this period, although government-performed R&D declined from 17% to 13% of total GERD. The share of GERD performed by the higher education sector increased from 8% to 12% of the total.

were employed in the business enterprise sector.[14] This figure is among the highest in the OECD—far in excess of the 50% figure characteristic of the European Union in 1999 and matched only by Japan (65.3% in 1999) and the United States (82.5% in 1997).

Figure 8 Performance and funding of Korean R&D, 1995-2000



1. Amounts financed by the Higher Education sector are small.
Source: OECD, MSTI database, June 2002.

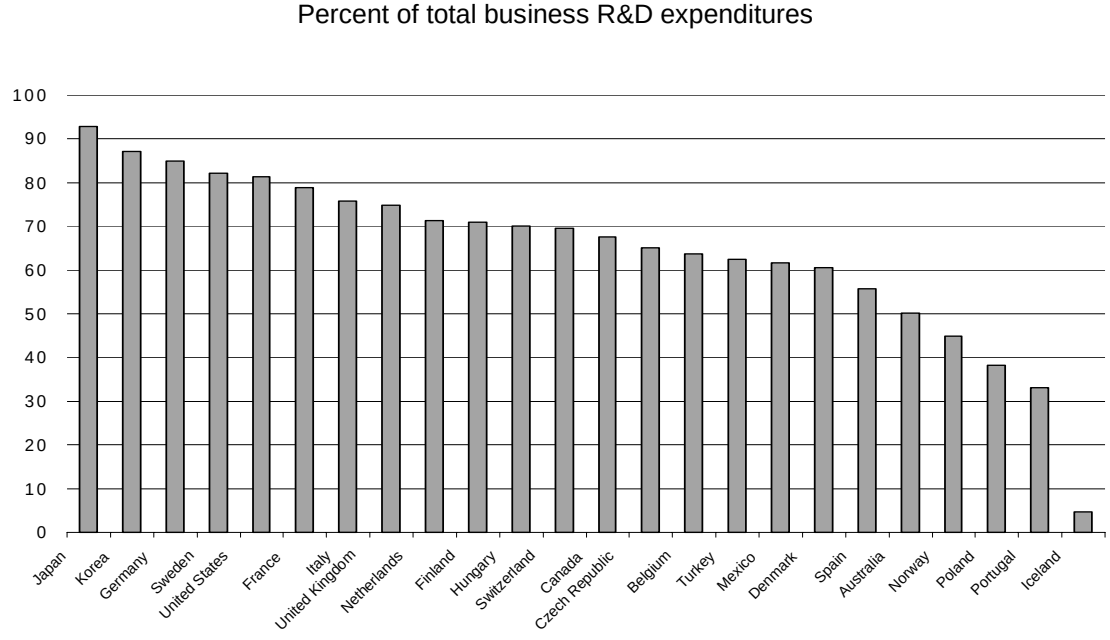
28. Korea spends less than most other R&D intensive countries on basic research, a partial reflection of the large role of industry in the R&D system. Basic research expenditures were equal to 0.35% of GDP in 2000, compared to more than 0.4% in Switzerland, France, Sweden, the United States, Germany, and Denmark. As a share of GERD, expenditures on basic research ranged between 12.5% and 14.0% in the 1990s,peaking in 1998. The government intends to increase the share of basic research in Korean R&D funding in coming years by strengthening its support for basic research and university R&D.

29. Korean business R&D is concentrated in large firms. As of 1997, 87% of Korean business R&D was performed by firms with 500 or more employees (Figure 9). It is typical of countries with high R&D intensities to have a high concentration of business R&D in large firms, but Korea is second only to Japan, where 93% of BERD is performed in large firms, and is several percentage points ahead of the United States, which had 81% in 1999. Moreover, in 2000, the five largest R&D performing firms in Korea accounted for 35% of the total BERD and 30% of total researchers

14 . As of 2000, 21.8% of Korean researchers were employed in higher education sector, and 11.9% were employed in government labs, public research institutes, or private non-profit research institutes.

employed in industry. The top 20 companies accounted for 55% of BERD and 40% of researchers. Many of these large firms are/were chaebol, which have been the target of reforms in the post-financial crisis environment. The government is attempting to increase the role of small and medium sized enterprises (SMEs) in business R&D performance.

Figure 9. Share of R&D performed by large firms (500 or more employees)



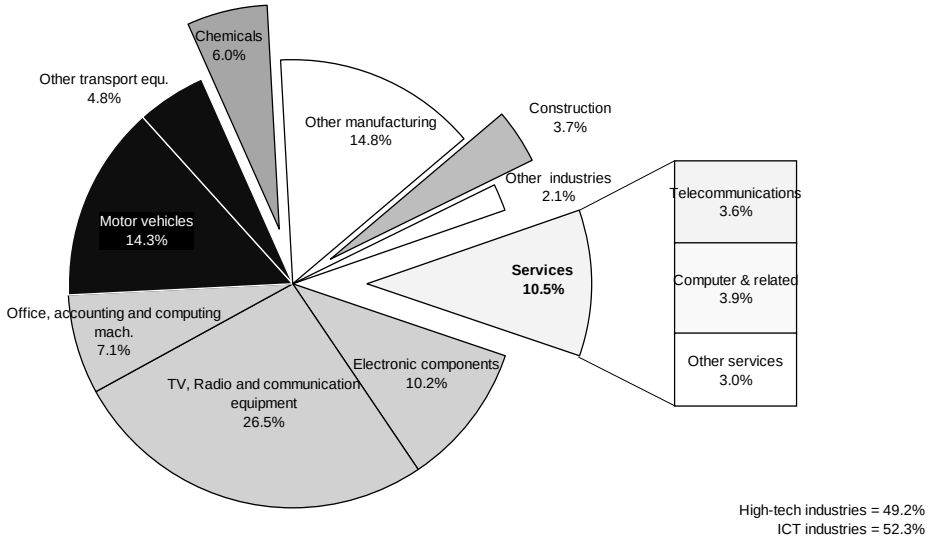
Source: OECD R&D database

30. Business R&D in Korea is also concentrated in high-technology industries.[15] Moreover, the concentration in high-technology industries has increased over time. Between 1995 and 2000, the share of Korean business R&D performed in high-technology sectors grew from 37% to 49%, and the share of researchers in high-technology sectors grew to more than 44% of total industry researchers. The bulk of high-technology R&D is performed in the ICT sector. In 2000, almost 44% of Korean business R&D was performed in the ICT manufacturing industries: office, computing, and accounting machines; TV, radio, and communications equipment, and electronic components (Figure 10). The TV, radio, and communications equipment alone comprised more than one-quarter of Korean business R&D, and computer and telecommunications services contributed another 7.5% of business R&D. While Finland invests a higher share of its business R&D in communications and electronic components, no other country invests a larger share of its business R&D in the ICT sector than Korea.

15. The OECD defines high-technology industries as pharmaceuticals (ISIC 2423); office and computing machinery (ISIC 30); radio, TV and communication equipment (ISIC 32); medical, precision and optical equipment (ISIC 33); and aircraft and spacecraft (ISIC 353).

Figure 10. Korean business R&D by sector of performance, 2000

Percentage of total business R&D expenditure.



Source: OECD, Basic S&T databases, June 2002.

Changing business strategies for R&D

31. Statistical data is not sufficient to determine whether business strategies for R&D have changed significantly in Korean firms and whether any such changes mirror those seen in other OECD countries. This is an area in which additional research is needed. Preliminary interviews conducted in Phase 1 of this study provided some insight into changes in the R&D strategies and R&D management in large Korean firms. These interviews with R&D executives in a large Korean firm revealed that in the firm interviewed:

- *R&D funding is increasing*—Since the financial crisis, R&D funding had increased in the company. Increases were continuing into 2002 despite the global economic slowdown, and the company was attempting to double R&D expenditure per researcher over the next few years.

- *R&D more closely linked to business needs*—Approximately half of the research funding in the central research laboratory of this firm was provided in the form of a lump sum payment, with the remainder coming in the form on contract-based research for specific projects requested by product divisions. Priorities for that portion of the research that was financed as a lump sum are set in accordance with a long-term strategy that identifies future areas of importance to the company, but that are linked to existing businesses and corporate capabilities.

- *Fundamental research is of growing importance*—The firm's technology strategy is shifting its emphasis from applied research and development toward more fundamental research as the company shifts from being a technology-follower to a technology leader.

- *Outsourcing of R&D is increasing*—In conjunction with the shift toward more fundamental research, the firm is working more closely with universities and provides significant levels of funding for university research. This work is increasingly related to scientific rather than engineering fields. A corporate venture capital unit has also been established. Outsourcing seems to be related to the increased role of science in driving innovation and the need to keep abreast of developments in a wider range of fields.

- *Public policy has influenced business R&D strategies*—Reforms instituted by Korea's Fair Trade Commission and the Financial Supervisory Commission in response to the financial crisis spurred changes in the funding structure of the research lab. Previously, central research was funded entirely in a lump-sum fashion, but now consists of a mix of lump-sum and project-based funding. Korean tax policy has affected the structure of the research lab, which is organised not an independent research institution, but as a grouping of several research laboratories that are part of other product divisions. Korean R&D programmes also had an impact as government financing of nanotechnology research also encouraged the firm to begin research programmes in that area.

32. Conducting similar interviews with a larger number of firms would provide additional insight into changing business R&D strategies and confirm whether the trends identified in this preliminary interview are widespread throughout the Korean business sector. In addition, future work could attempt to determine how such patterns vary across industry sectors and firm sizes (e.g., large firms versus SMEs).

The influence of government policy

33. As the interview described above suggests, public policy has had an important influence on business R&D patterns in Korea. In keeping with a innovation systems framework of analysis, the policies of interest range from those specifically aimed at boosting business R&D to those aimed at increasing the capabilities of the science sector, those aimed at stimulated R&D in SMEs and new technology-based firms (NTBFs), and changes in corporate governance.

Corporate governance

34. A number of policy changes were instituted in the wake of the financial crisis in order to improve corporate governance in the non-banking sector. These policies, promulgated by Koreas Financial Supervisory Commission (FSC) and Fair Trade Commission (FTC) were not aimed at altering business R&D strategies, but appear to have had indirect effects. The main objectives of the policy changes, which were introduced in 1998, were to *1)* increase accountability; *2)* eliminate cost guarantees between enterprises; *3)* improve the financial status of enterprises; *4)* build on core the competence of enterprises; and *5)* enhance transparency. Policies therefore restricted cross-investments among chaebol affiliates and undue transactions within business groups. The effect of these changes was most pronounced among the chaebol: fifteen of the top 30 chaebol were eliminated after financial crisis by splitting into separate companies that operate independently (e.g., Hyundai split into separate automotive, shipbuilding, steel, and semiconductor corporations).

35. Such changes have potential implications for business R&D. Firms are believed to have focussed their R&D in areas of competence and have limited the extent to which they invest in different industry sectors. This change is expected to force a narrowing of research agendas within large firms to concentrate more on strategic business areas. In addition, the law now restricts the

investment of chaebols in affiliated companies to 25 percent of their net assets. Some exceptions are made for *1)* venture investment in new industries like biotechnology, environmental technology, and information technology—technological areas that are stipulated by law; and *2)* investments in core area (e.g., large telecommunications firms can invest in other telecommunications firms). Companies wishing to co-operate on R&D need to register with the FTC in order to receive authorisation in advance, which provides protection from violations of competition law.

Promotion of R&D in SMEs and new technology-based firms

36. Stimulating R&D in SMEs and NTBFs is also a priority of the Korean government. A number of programmes have been established to support various aspects of this objective, including support for venture capital financing. Korea's Small and Medium Business Administration (SMBA) operates three programmes that aim directly at support for R&D and R&D-intensive firms:

- *Technological innovative programme*—This programme, which began in 1997 provides financing of approximately USD 50 000 to support innovation projects in about 1 000 SMEs per year

- *Co-operative development programme*—This programme, started in 1993, supports co-operative R&D between SMEs and government research institutions (GRIs). It tends to attract very small companies with just 20 to 30 employees that have few technical facilities or PhD-level researchers. The programme provides funding of approximately USD 250 000 to the GRI to finance research in support of SMEs that submit proposals. About 2 500 companies take part in the programme, as do 200 universities and other GRIs.

- *Technology construction support programme*—This programme supports business incubation programmes at GRIs and regional institutes. There are now 300 such incubators in Korea, with about 15 start-up firms apiece.

37. While the Phase 1 work did not provide an opportunity to evaluate the effectiveness of these or other programmes, interviews with one successful technology-based SME provided an illustrative example. The firm DGI, a small digital printing company located north of Seoul has participated in a range of SMBA programmes to build its R&D capabilities. The firm reported that it originally had no engineering or R&D staff and that its main product, a drafting machine, could be easily reverse-engineered by competitors. It therefore launched a collaborative project with a local GRI to develop a microprocessor-based drafting tool. The firm continued to build on this start and has since developed an inkjet plotter. It now has an R&D division with 14 people, which accounts for 15% of the firm's staffing. Growth of the R&D staff was facilitated by other changes in government policy that waived military service requirements for technical staff members who work in the firm for five years. The firm's sales have expanded rapidly, and it competes in several international markets. The firm credits its R&D capability—and the intellectual property it generates—for this success. It also credits other support programmes offered by the Korean government, especially those that provide assistance with business plan and market development.

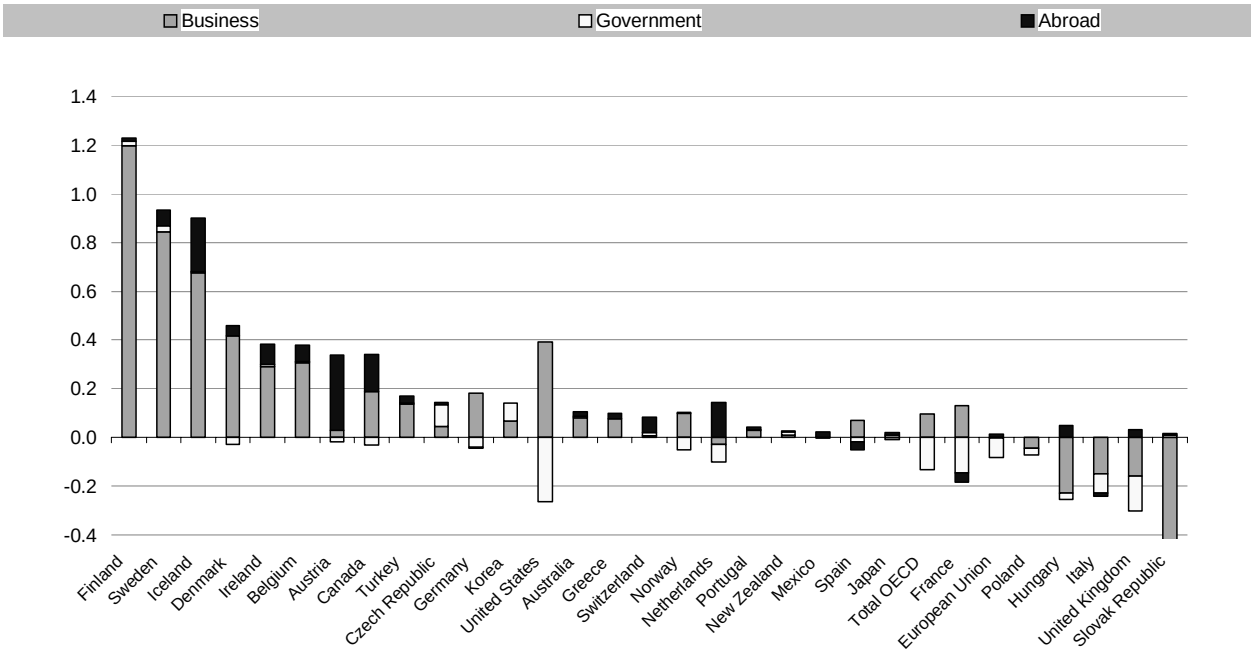
Direct financing of business R&D

38. Direct financing of business R&D also appears to have driven increases in BERD. Korea is among a few countries in which both the government and business made a significant contribution to

increase in BERD during the 1990's (Figure 11). It should be also noted, that the government made an extraordinary efforts to increase the share of R&D related budget in the total government budget. As a result, the share grew from 3.2% in 1995 to 4.4% in 2001, and a significant portion of the increase supported industry R&D either directly or indirectly.

Figure 11. Increase in BERD intensity by source of funds, 1990-2000[1]

Percentage point increase in BERD as a share of GDP



1. Nearest available years.
Source: OECD MSTI database, May 2002.

39. Government financing of business R&D comes from multiple sources in Korea, primarily the Ministry of Science and Technology (MOST) and the Ministry of Commerce, Industry and the Economy (MOCIE). The main focus of policy for both MOST and MOCIE since 1997 has been to support development of particular technologies that have been identified by the National Science and Technology Council as critical to Korean industry: *1)* information and communications technology; *2)* biotechnology; *3)* nanotechnology; *4)* environmental technology; *5)* content/cultural technology; and *6)* space technologies. These six technologies currently account for about half of total government R&D funding.

40. MOCIE has primary responsibility for industrial technology and traditionally aimed its R&D financing at specific industry sectors rather than enabling technologies. In the new technology areas, MOCIE funding is aimed more at development and application than research and attempts to build on Korean industry's strengths in information technology (e.g., by financing R&D on information technology-related aspects of biotechnology or nanotechnology). MOCIE's R&D funding is growing rapidly, and it encourages the formation of consortia of firms and public sector research organisations, many of which are led by large firms. MOCIE provides cost sharing for industrial partnerships and consortia, with the degree of cost-sharing depending on several factors, such as the size of the firm.

Large firms may be expected to provide 50% of the funds for a research project, while small firms may provide only 20%.

41. MOCIE also supports regional innovation clusters. These take the form of technology parks, technology innovation centres and business incubators. Eight technology parks and four technology innovation centres had been created as of June 2002, but the goal is to create 50 such units by 2005. MOCIE officials note that the number of venture firms in Korea with their own research units has steadily increased, from approximately 3 000 in 1999 to more than 8 000 in 2002, much of this with government support.

42. MOST also funds R&D with industrial applications, largely determined by national priorities. Its HAN programme, which began in 1992 and will come to an end in 2002, is being replaced by the New Frontiers me. Both of these programmes fund R&D in critical technology areas that were identified as the result of foresight and technology road-mapping efforts. The HAN programme encouraged private sector participation through the form of cost-shared partnerships and between 30% and 50% of funded programmes included industry participation. The New Frontiers programme, which will fund the establishment of research centres will not require industry participation, but will accept it on a cost-shared basis. Technology transfer efforts will be left to the discretion of the centre directors, who will have the authority to make decisions regarding patenting and licensing of research results.

43. Nevertheless, MOST plans to increase its emphasis on research as opposed to development. This implies greater emphasis on public sector research and the strengthening of universities and government research institutes. The interest in public sector research is two-fold: first to provide the basic scientific and technological knowledge that is increasingly important to leading-edge innovation, and second to strengthen Korea's human resources in science and technology. Only 6% of industrial R&D personnel have PhD-level training; most PhD-holders work in the academic sector. While many PhD researchers are without jobs, there are significant shortages in certain industries, including the ICT sector. The government has already instituted a 20% tax credit for SMEs that hire PhD-level researchers and is contemplating expanding the tax credit to large firms as well.

Project implementation

44. Available R&D statistics presented in this report indicate that Korean R&D spending in 2000 was similar in many ways to R&D spending before the financial crisis. Overall amounts of R&D spending continued to grow after the crisis and R&D intensity has achieved its pre-crisis level. The concentration of R&D in large firms and in high technology manufacturing sectors also continued. The question is whether the nature of that R&D has changed in more subtle ways that cannot be detected in internationally comparable statistics. Toward this end, continued work on Korean business R&D should concentrate on understanding changes in firm-level business R&D strategies, attempting to identify patterns that are common among firms in the same industry sectors or of the same size. In order to observe changing patterns of R&D strategy across a large number of firms and to gain sufficient insight to interpret those patterns, the study should proceed with a survey that is sent to a large number of firms and a more limited number of in-depth interviews. Depending upon interest and

availability of resources a more quantitative, econometric analysis could be conducted, using the information gained from the surveys, to estimate the economic returns generated by government programmes for stimulating business R&D.

Issues to address

45. In keeping with the overall trends in business R&D strategy that are seen in other OECD countries, the study should therefore examine the following topics:

- *Motivations for changing R&D strategies*. What has driven recent changes in business strategies for R&D in Korean firms and the resulting increase in business R&D expenditures (e.g., increased scientific and technological opportunity, maturing of the industry sector, increased competition)? Does the growth in Korean business R&D reflect a changing perception of the role of R&D within firms (e.g., a more important determinant of competitive advantage)? How do such trends differ across industry sectors and in firms of different sizes?

- *Effects on in-house R&D and its management*. How have Korean firms restructured their internal R&D capabilities to improve their contributions to corporate objectives? Are individual firms focusing on a narrower set of scientific and technological opportunities? Is research more closely linked to product development activities? If so, is it more applied? What changes have been made in the way internal R&D is financed or scientists and engineers are rewarded to promote such changes?

- *Internal vs. external R&D.* To what extent are large Korean firms becoming more reliant on university based research and start-ups for new science and technology? How do Korean firms determine what research to conduct in-house versus to fund externally? How do they manage the acquisition of technology from outside sources? What are the roles of mergers & acquisitions and corporate venture capital funds in helping firms acquire technology from outside sources? What are the advantages and disadvantages of these mechanisms compared to internal R&D? How might changing economic conditions (*e.g.*, slowdown in growth, correction of stock markets) influence the use of these tools by firms?

- *The role of start-ups*. How do technology-based start-up firms in Korea change patterns of business R&D and the strategies of other firms? What kinds of R&D projects do start-ups conduct in comparison to larger firms? How effective are start-ups (university-based spin-offs, in particular) in transferring technology from universities to larger firms with greater manufacturing and marketing capabilities?

- *Effect and effectiveness of government policy*. How effective are various government policies in stimulating additional R&D spending in Korean firms or in altering the R&D strategies of Korean firms? How effective and influential are: direct financing of R&D, tax incentives, financing of public sector research, and programmes aimed at SMEs?

- *How can policy be improved?* How should governments balance their investments in basic versus applied research (and versus development) to best complement business investments? How should governments distribute R&D funding among industry, universities, and government labs in order to drive industrial innovation? To what extent should government funding target specific fields of science and technology, and how can

such allocation decisions best be made? What is the role of public/private partnerships in channelling government funding into areas of interest to industry? What additional steps might governments consider to strengthen business R&D and innovation by improving the linkages among R&D performing and funding organisations? Do existing laws and regulations regarding patenting and licensing need to be revised? Is the mobility of researchers between the public and private sectors unduly restricted? Do competition laws impede necessary co-operation among firms in the conduct of R&D?

Survey of businesses R&D patterns and practices

46. A central element of this study is a survey conducted of R&D patterns in Korean firms, administered by STEPI. The survey should be sent to large firms (the largest R&D performers), SMEs and venture firms (new technology-based spin-offs). To the extent possible, the survey should be co-ordinated with survey efforts underway in other OECD countries (see below). In addition to collecting basic information about the companies (industry sector, sales, employees, R&D spending), the survey should include questions on the topics highlighted in the discussion above:

- *Trends in R&D funding since 1997*—overall funding levels; sources of funding (internal versus external); balance between research and development; area of science or technology.

- *Management of internal R&D*—corporate versus product division funding; process for developing research agendas; factors driving changes in management (e.g., time to market, technological opportunity, government policy, globalisation)

- *Outsourcing of R&D*—share of R&D investment made outside the firm; joint research projects with other firms or public sector organisations; use of corporate venture capital and mergers & acquisitions to access technology in SMEs and venture firms; licensing in and licensing out of technology. In all these areas changes over time should be noted.

- *Government policy*—satisfaction with government policy; types of programmes in which the firm participates; sources of dissatisfaction (if applicable); value/benefit of government support (overcome financial limitations, encourage research in leading-edge areas, narrow or expand research agenda, encourage collaboration, etc.)

47. A survey addressing many of these topics was sent out in the summer of 2002 to more than 800 firms with significant R&D activity. STEPI is analysing the data and shared preliminary results with the OECD in October 2002.

Site visits and interviews

48. A set of site visits should also be conducted to allow interviews with business executives engaged in the development and implementation of R&D strategy. The sample of firms should include large and small firms (traditional SMEs and NTBFs or venture firms), although many of the issues to discuss will be more applicable in a large firm setting. The interviews should be conducted in a structured manner, but with sufficient flexibility to ensure that a full understanding of specific company situation is appreciated, whilst still allowing for comparability in the final outcome of the study. At attempt should be made to develop an interview protocol that is consistent with other studies of business R&D being conducted in other countries as part of the TIP project on Emerging Patterns of

Public and Private Financing of R&D (see below). For this reason, it is suggested that discussions at the visits be structured under the following headings:

- *The organisation of R&D.* The aim of these questions will be to ascertain an understanding of company specific terminology, the role and the management of R&D, its contribution within the organisation, both centrally and within the business units, the financial and organisational controls, and how longer term research fits and is managed within the broader strategic vision of the corporation. As far as possible, basic facts on these matters will be established through prior desk research.

- *Where do research programme and project ideas originate?* This topic will investigate the processes both formal and informal that lead to strategic research projects. Whether the ideas come from internal or external sources. If internal, the scope of involvement of other functions, and if external the actions of competitors. The isolation or otherwise of the corporate research function from product development will also be investigated.

- *How project ideas are treated?* The methods used for selection, evaluation and portfolio development and their merits will be discussed. In addition the re-assessment and re-targeting of projects and the consequence on staff morale and career potential will be investigated. How are successful projects moved into the business, and how is participation in more 'risky' longer term projects 'sold' to ambitious staff, and their later career development managed?

- *Examples of research projects which have had interesting consequences.* Information on the perceived value of specific projects to the corporation will be requested, both those which were seen as successful and those that were thought to be failures. Whether there are indications from the way they originated and/or were managed that may have contributed to their outcome. Whether the outcome could have been achieved by an alternative approach, for example by purchasing the technology?

49. Interviews following a similar protocol were conducted by STEPI in the summer and fall of 2002.

Co-ordination with research in other countries

50. To enhance the value of the Korea study and expand opportunities for learning through cross-country analysis, the study of Changing Strategies for Business R&D and Their Implications for S&T Policy in Korea should attempt to co-ordinate its work as much as possible with similar activities under way in other OECD countries. The OECD's Working Party on Innovation and Technology Policy is attempting to facilitate co-ordination of a number of ongoing studies:

- *Austria*—Austrian researchers are conducting a study of business R&D patterns that will consist of three main elements: *1)* a survey of Austrian businesses to collect information about R&D spending patterns, outsourcing of R&D, and the effectiveness of government policies; *2)* firm-level interviews with a limited number of firms to provide greater insight into R&D decision-making; and *3)* an econometric analysis to estimated the returns from government investments (direct and indirect) in business R&D. The econometric analysis will attempt to highlight factors that were emphasised in the survey and interview work. As of November 2002, the Austrian research team had completed its interviews and was proceeding to develop a survey instrument.

- *Belgium*—Researchers in Belgium are conducting a wide-ranging review of policy mechanisms to support business R&D. As part of this effort, researchers conducted interviews with a number of R&D-performing firms to better understand how government R&D programmes influence business R&D strategies and patterns. Several econometric studies are also being conducted to estimate the returns from different government financing programmes.

- *Finland*—The Finnish government has initiated several research projects to estimate the effectiveness of public R&D subsidies to firms. Current efforts focus on analysing the selection mechanism underlying the allocation of R&D subsidies and modelling the way in which a firm's knowledge of the public agencies' behaviour (e.g., evaluation criteria) factor into the firm's decision processes in applying for government funding. Better understanding of firm behaviour lies at the basis of this effort.

- *Switzerland*—Swiss researchers conducted a study of business R&D in late 2001 that relied on both surveys and interviews. They are currently planning a follow-on study to examine specific issues in greater detail. Although the Swiss government provides limited support to business R&D, policy makers are interested in understanding better factors that influence firms' R&D behaviour, including their globalisation strategies.

- *United Kingdom*—With financial support from UK business and government, researchers (led by Luke Georghiou) are conducting an international study of R&D management in leading firms. Preliminary phases of the work examined R&D management strategies in the United States and Europe using an interview-based methodology. The second phase of the work is examining second-tier large firms in the UK and large firms in Asia (including Korea and Japan). Firms included in phase 1 of the study will be contacted again to see whether and how R&D management strategies have been affected by the economic downturn.

51. In order to discuss opportunities for co-operation among these projects and to share preliminary research results, two workshops were organised to convened the researchers involved in the above projects. The first was held in Vienna, Austria in February 2002; the second in Paris in November 2002. Participants expressed interest in continuing to share results and methodological approaches and opportunities are being explored for both a joint publication and for future work that would centre on better understanding R&D decision making processes within firms. Presentations from both of these workshops are available on the World Wide Web (see www.oecd.org/sti/innovation).

Next steps

52. Given that the survey of Korean businesses and interviews with large firms have already been conducted by STEPI and preliminary results have been analysed, next steps will need to be agreed upon by the participating researchers at OECD and STEPI. As a preliminary guide to such discussions, the following suggestions are offered for furthering the project:

- *Refine analysis of existing data*—The preliminary data analysis presented to the OECD in October and at the Workshop on Empirical Research on Business R&D Strategies and the Effectiveness of Government Policies in November 2002 revealed a number of interesting patterns related to the outsourcing of R&D, joint R&D, and the factors influencing technology strategies. A first step in extending that analysis would be to

break out those results by industry sector and by size of firm. This would both provide insight into differences among different populations of firms and may allow results from the surveys to be more readily compared with results from the firm-level interviews.

- *Follow-up survey or interviews on the effectiveness of government programmes and policy changes*—The interviews conducted to date revealed a general lack of interest among large firms in government R&D programmes. This finding conflicts to some extent with the survey results that showed higher levels of satisfaction with both direct government funding programmes and indirect programmes (i.e., tax incentive). Follow-up interviews with the firms would provide an opportunity to resolve this conflict, understand the reasons for the dissatisfaction expressed during the interviews and to explore means of improving government programmes to better meet business needs.

- *Interviews with SMEs and venture firms*—The interviews conducted to date focused on large firms, which will enhance the comparability of results with those from other country studies. Given the interest in boosting R&D in SMEs and new technology-based venture firms in Korea, addition interviews with R&D executives in SMEs or venture firms would be useful in revealing the changing strategies of these firms, their relationships with large firms, and the perceived effectiveness of different government programmes. The single interview with a small firm that was conducted during Phase 1 of the study provided much useful information, indicating the value of further work with such companies.

- *Develop a set of policy-relevant conclusions and recommendations*—The ultimate goal of the Phase 2 study is to inform policy making related to support for business R&D. STEPI and OECD should work with other countries conducting similar studies and with the OECD Working Party on Innovation and Technology Policy to develop a set of conclusions and policy recommendations for guiding future policy making in Korea. This process would be facilitated by the interview discussed above or a more detailed survey of firms that focuses specifically on the effectiveness of government policy in changing firms' R&D behaviour.

- *Final report and dissemination*—A final, synthesis report containing contributions from the OECD and STEPI, and possibly from other countries conducting similar studies, should be completed by the middle of 2003. To disseminate the results of this work, a conference could be considered for the autumn of 2003, in either Seoul or Paris.

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