

**CHANGING BUSINESS STRATEGIES FOR R&D AND THEIR  
IMPLICATIONS FOR SCIENCE AND TECHNOLOGY POLICY:**

**OECD BACKGROUND AND ISSUES PAPER**

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## Background

1. Considerable evidence indicates that business strategies for research and development (R&D) have changed significantly in recent years. Not only did industry funding for R&D grow rapidly in the late 1990s, but the numbers of R&D alliances, mergers and acquisitions, and patent licenses also increased significantly, as did the share of R&D conducted by small and medium-sized enterprises (SMEs) and business funding for university research. These data suggest that firms have adopted new models of knowledge creation, management, and sharing that supplement more strategically oriented internal R&D activities with greater use of externally acquired technology. Internal R&D is being linked more closely to specific business interests, and relationships with competitors, suppliers, start-up companies, universities, and public laboratories are being used to provide broader scientific and technological expertise to the innovation process.

2. The changing character of business R&D has potentially far-reaching and profound implications for science and technology (S&T) policy. Business R&D is a key driver of industrial innovation and economic growth, so governments have a strong interest in both boosting business R&D expenditures and in implementing other policies that will make national innovation systems more efficient and productive (OECD 2001a). If government R&D funding is to complement business R&D funding—correcting market failures and boosting societal returns to R&D—governments need to know what types of R&D business is likely to fund itself. Similarly, if firms increasingly acquire knowledge from external sources—often foreign sources—then governments may need to take steps to ensure that the intellectual property that results from public research can be efficiently transferred to the private sector. Such issues are relevant both to countries that have already witnessed dramatic shifts in business R&D strategies and to countries that would like to encourage similar changes in their own economies to boost the efficiency of their innovation systems.

3. At present, the development of suitable S&T policies to respond to (or encourage) this environment is difficult, in part because the nature of the changes in business R&D strategies are hard to deduce from publicly available sources. Standard indicators provide evidence of changing levels, sources, and recipients of R&D funding, but they do not provide sufficient insight into the strategies firms are developing to guide their R&D investments or into the motivations behind such changes. Available case studies of individual firms provide additional guidance, but only reflect the choices of a handful of companies or industry sectors. As a result, it is not clear whether the growing reliance of large companies on external sources of R&D has resulted in a commensurate decline in internal R&D efforts or whether these external activities are in fact supplementing a more focused, yet still growing, internal portfolio. Nor do available data show whether industrial R&D has shifted in all sectors toward more narrow, near-term projects at the expense of long-term studies and whether the result has been to foster or to hinder innovation.

4. This paper provides a high-level overview of some of the key trends in business R&D and outlines a number of the outstanding issues that policy makers are seeking to address. It is intended to seed the discussion at the Workshop on "Changing Business Strategies for R&D and their Implications for S&T

Policy," which is being co-sponsored by the OECD, the European Industrial Research Management Association (EIRMA), and the French Ministry of Research. The paper is not intended to be exhaustive or to resolve these issues, but to provide initial indications of trends that should be explored in greater detail and on which additional input is needed. The paper is organised according to the Workshop agenda, providing a brief introduction to each topic area and suggesting questions for discussion in each session. A short statistical annex presents a sampling of data on business R&D funding and performance.

### Session 1—An overview of key trends in business R&D<sup>1</sup>

5. Aggregated 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 significant gains. Between 1990 and 1998, industry funding for R&D rose 35 percent in real terms, from approximately USD 230 billion to more than USD 310 billion, with most of the growth occurring after 1994 (Figure A.1). Total business enterprise expenditures on R&D (BERD)—a measure of R&D performed in the business sector—grew 25 percent in real terms between 1993 and 1998, from USD 236 billion to USD 345 billion.<sup>2</sup> Growth in industrial R&D outpaced growth in the economy as a whole, with industry-financed R&D increasing from 1.27% to 1.36% of gross domestic product (GDP) and BERD growing from 1.44% to 1.51% percent of GDP between 1993 and 1998. Government R&D expenditures stagnated during this time period and, as a result, industry financing accounted for 63 percent of gross national expenditures on R&D (GERD) in the OECD region in 1998, up from 58 percent in 1990.

6. 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 1998, a figure virtually unchanged from 1993 and considerably below that of other OECD countries, including Japan, Sweden, and the United States (Figure A.2). In Australia, Italy, and the United Kingdom, industry funding for R&D *declined* in real terms and as a share of GDP. 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.<sup>3</sup>
- *Sectoral differences.* Growth in business R&D was driven disproportionately by high-technology industries, such as ICT and pharmaceuticals, and the service sector (Figure A.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 (Figure A.4).

7. Rapid growth of venture capital contributed to the rise in private-sector investment in R&D. While the United States has the largest venture capital sector with over USD 103 billion invested in

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1. Unless another citation is given, the data in this issues paper derive from the OECD Main Science and Technology Indicators (MSTI) database, April 2001.

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

3. 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.

venture funds in 2000,<sup>4</sup> many Member countries saw their venture capital markets grow 30% or more between 1995 and 1998 (OECD, 2000b) (Figure A.5).<sup>5</sup> 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 (Table A.3). 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).

8. 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. 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.

*In this context, the following issues might be briefly discussed:*

- *Business perspectives.* What other important trends do business executives see in R&D expenditures or the performance of business R&D? What are the primary concerns that R&D managers face in developing R&D strategies?
- *Policy implications.* What are the main policy issues to consider in this context? How important are policies related to public financing of R&D compared to those related to stimulating linkages among firms and other R&D performers? What other policy areas will need to be addressed?

## **Session 2—Toward a new model of business R&D**

9. 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.<sup>6</sup> 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

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4. US venture capital funding declined in the first half of 2001 as the economy weakened and market valuations of technology companies fell. Nevertheless, the National Venture Capital Association reports investments totalling USD 22.8 billion between January and June 2001, a figure lower than the first half of 2000, but ahead of the first half of 1999. Data from the National Venture Capital Association [www.nvca.com](http://www.nvca.com).

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.

6. 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.

numerous examples exist of technologies being brought to market by competitors who did not conduct the original R&D.<sup>7</sup>

10. 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 programs 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 replaced by problem- or product-oriented structures. Incentive plans are rewarding researchers and research managers for both quality research and contributions to business performance.
- *Leveraging intellectual property.* Firms are increasingly patenting inventions and licensing those that do not match their corporate objectives to other firms, in some cases spinning off separate companies to commercialise the technology. The revenues from licensing streams (or from the appreciation of stock in spin-offs) can provide a financial return to technology that might otherwise go unused within the firm.

11. 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 A.6).<sup>8</sup> 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.

12. 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

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7. One of the most famous examples is that of Xerox Corporation, whose Palo Alto Research Center developed many of the basic technologies of personal computing, yet failed to introduce a successful personal computer. See Smith and Alexander (1988). The difficulty firms face in fully appropriating the benefits of R&D (and preventing competitors from capturing some of the benefits) has been thoroughly explored in the economics and business literature and forms of primary justification for government support of business R&D.

8. Available statistics indicated that the share of BERD allocated to basic research fell from 6.8% to 5% in the United States and from 6.8% to 5.5% in Japan.

organisations (e.g., universities and start-ups) for more fundamental advances that stimulate radical innovation.

*In this context, the following issues might be discussed:*

- *Motivations for changing R&D strategies.* What has driven recent changes in business strategies for R&D 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 R&D reflect a changing perception of the role of R&D within firms (e.g., a more important determinant of competitive advantage)? Are R&D investments likely to continue to grow in the foreseeable future? How do such trends differ across industry sectors and countries?
- *Effects on in-house R&D and its management.* How have 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 as opposed to fundamental or basic? What changes have been made in the way internal R&D is financed or scientists and engineers are rewarded to promote such changes? How successful have such changes been in improving the returns from business R&D investments?

### **Session 3—Networks of knowledge creation and acquisition**

13. 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.

14. Firms report that they increasingly outsource basic 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 (Table A.1). 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.<sup>9</sup> 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 programs and licenses for public research results, both of which occur can without measurable transfers of R&D funds.<sup>10</sup>

15. 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

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9. This statement is based on data from the OECD's ANBERD database and NSF (2000).

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

existing technologies);<sup>11</sup> and (3) they do not have to worry about cannibalising existing product lines (Christenson, 1997).<sup>12</sup> 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.

16. 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.<sup>13</sup> 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).<sup>14</sup>
- *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.<sup>15</sup>

17. 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 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

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11. New generations of disk drive technology were consistently introduced by new firms in part because the customers of existing firms saw little advantage in their smaller size when it implied accepting lower storage capacity. Over time, the storage capacity of the new devices would exceed that of the older technology.

12. Consistent with this statement, relational database technology and reduced instruction set computing (RISC), for example, were both invented in large corporate laboratories but brought to market by start-up firms, in part because of concerns about cannibalising existing product lines in the large firms (CSTB, 1999). Biotechnology was also pursued more vigorously by small start-up firms than by entrenched competitors in pharmaceuticals and agrifood businesses (see Christenson, 1997, and Robbins-Roth, 2000).

13. 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-

14. 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.

15. Cisco Systems exemplifies the strategy of actively looking for ways to satisfy technological needs through acquisitions. Despite growing R&D expenditures, Cisco acquired at least 65 companies between 1995 and 2000 to help it expand its product offerings and gain greater capabilities in areas such as optical networking.

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.

*In this context, the following issues might be discussed:*

- *Internal vs. external R&D.* To what extent are large firms becoming more reliant on university based research and start-ups for new science and technology? How do firms determine what research to conduct in-house versus to fund externally, for example, in universities? How do they manage the acquisition of technology from outside sources?
- *The role of start-ups.* How do technology-based start-up firms 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?
- *Acquiring technology in the open market.* 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?
- *Effect on innovative efficiency.* What are the effects of technology sourcing on the innovation system as a whole? Does it allow greater specialisation and thereby increase efficiency and effectiveness? Should governments encourage such practices through available policy mechanisms?

#### **Session 4—Globalisation of business R&D**

18. 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.<sup>16</sup> 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.<sup>17</sup> 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.

19. 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

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16. 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. 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.

17. 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).

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.

20. 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.

*In this context, the following issues might be discussed:*

- *Drivers of globalisation.* What are the primary motivations behind the globalisation of R&D and how are they changing over time? To what extent is globalisation based on the desire to tap local scientific and technical talent versus being near the market? Do foreign affiliates exhibit different forms of collaboration and outsourcing than their parent companies? Are M&As becoming more a more prevalent form of globalising R&D than the establishment of new facilities?
- *Enablers and impediments.* How have advances in ICT facilitated the globalisation of R&D by enabling greater co-ordination among R&D centres? What are the main legal and regulatory impediments to globalisation? What kinds of incentives do countries offer in order to attract R&D investments by foreign-owned firms?
- *Effects on innovation processes.* How has globalisation changed the innovation process itself (*e.g.*, by enabling 24-hour innovation by groups located around the world)? How do differences in regulatory environments influence a firm's ability to globalise its R&D or to enter into global supplier networks of large multinationals?

## **Session 5—Strengthening science and technology policy**

21. Governments face a number of challenges in developing science and technology policies that support business innovation in the emerging environment. These include the increasing diversity of R&D funders and performers in the business sector, the quickening pace of scientific and technological advance, and the declining share of government in financing business R&D across the OECD (Figure A.7).<sup>18</sup> Without significant increases in government R&D spending, policy makers will need to find ways of using existing R&D resources more effectively, such as by refining processes used to select projects to support or by altering the balance of funding among different R&D performers and types of projects. For example, if new scientific and technical knowledge is increasingly important to industrial innovation, and business is

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18. By 1999, the share of business R&D funding coming from government in Europe and the United States had dropped to less than half of their 1981 levels. In Japan, government funding has historically been small, at less than 2% of total business R&D funding (see Table A.2).

funding less fundamental research, then governments may find it more effective to allocate more of their own 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 find greater value in public/private partnerships that allow governments to share R&D costs with industry and that can help improve public and private returns to R&D.

22. Governments will also need to consider other indirectly mechanisms to stimulate business R&D, such as tax incentives and funding of public research institutions (PRIs).

- *Tax incentives*, such as tax credits, appear to stimulate additional business R&D investments that are approximately equal to the loss in tax revenue, and they can be used by a wide range of R&D conducting firms. Nevertheless, they tend not to induce non-R&D conducting firms to start R&D efforts, nor can they channel R&D resources into areas with potentially large social returns; investments continue to be evaluated against private returns to the business (OECD, 2001b).
- *Strengthening public research institutions*. Government funding for public research institutions (*i.e.*, universities and government laboratories) can also stimulate business R&D by creating new knowledge that firms leverage in their own innovative efforts.<sup>19</sup> This approach often requires policy initiatives to strengthen research programmes in areas of interest to industry and ensuring necessary linkages between the public and private sectors to ensure transfer of technology.<sup>20</sup>

23. The increasing collaboration among firms and between researchers in industry, universities, and government labs also demands 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 programs, 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 may 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.

*In this context, the following issues might be discussed:*

- *Government funding for R&D*. How much should governments invest in R&D in an environment characterised by growing business R&D expenditures? 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?
- *Indirect incentives for business R&D*. To what extent can governments rely more heavily on indirect incentives, such as tax credits, to stimulate business R&D? Can government funding of public research

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19. Government funding of university research has been extremely important in stimulating innovation in ICT and biotechnology. See, for example, CSTB (1999).

20. For further discussion of policy options for strengthening public research institutions, see OECD (2001).

organisations be used to more effectively contribute to business innovation? What other kinds of incentives might be effective in encouraging business R&D investments, in SMEs and service sector firms as well as large manufacturing firms? How can indirect approaches best complement direct government funding of business R&D?

- *Small business R&D and new technology-based firms.* What kinds of specialised support should governments provide for R&D in small and medium-sized enterprises, including high-technology ased start-ups?<sup>21</sup> How can governments design such programs to avoid crowding out—and potentially competing with—private sector funding, including venture capital?
- *Strengthening linkages.* 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?

### Concluding remarks

24. The Workshop discussions are expected to lead to a richer understanding of the evolving structure of business R&D and its implications for policy makers. The results will be used in several ways, within the OECD and beyond. The OECD will produce a summary report that will be disseminated to Workshop participants, business leaders, policy makers, and the general public. This summary will be used as the basis of a chapter of the 2002 edition of the *Science, Technology, and Industry Outlook*, a biennial publication of the Directorate for Science, Technology, and Industry. The deliberations will also provide substantive input for a number of ongoing and future activities related to public financing of R&D, intellectual property protection, and industry-science relations. It is hoped that the Workshop will produce information to help policy makers craft science, technology, and innovation policies that better reflect the realities of industrial innovation and will help business R&D managers to be better informed of the role of public policy in shaping the innovative environment.

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21. Many OECD countries have programmes designed to support SMEs. While some provide general business support, a number focus specifically on R&D. Belgium, Canada, Italy, Japan, Korea, the Netherlands and the United Kingdom, for instance, offer R&D tax incentives that are targeted exclusively at small firms. The U.S. government sponsors a Small Business Innovative Research (SBIR) programme that requires federal agencies with R&D budgets of more than USD 100 million per year to set aside 2.5% of their R&D budgets specifically for competitively selected awards to small firms.

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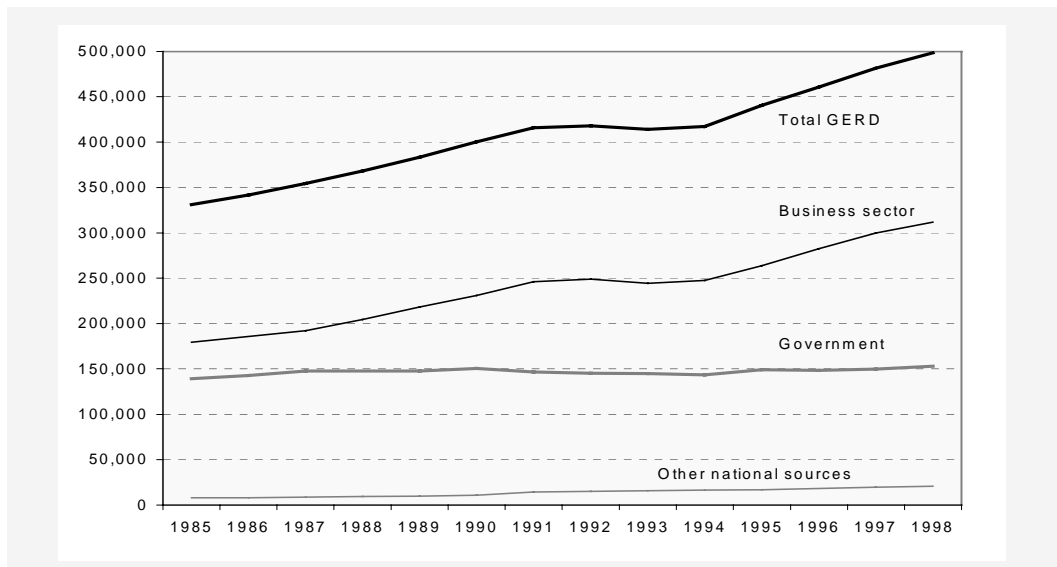
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## STATISTICAL ANNEX

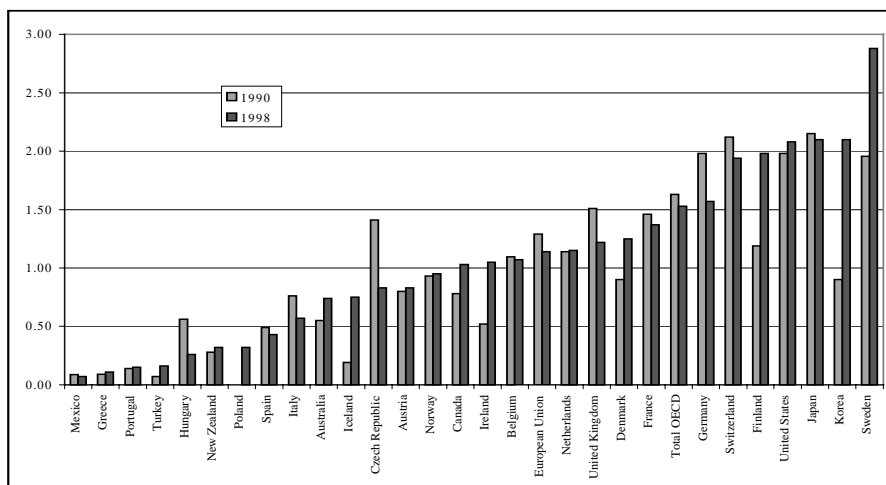
**Figure A.1. Trends in Gross Expenditures on R&D in the OECD Region, 1985-1998**

In millions 1995 US\$ PPP



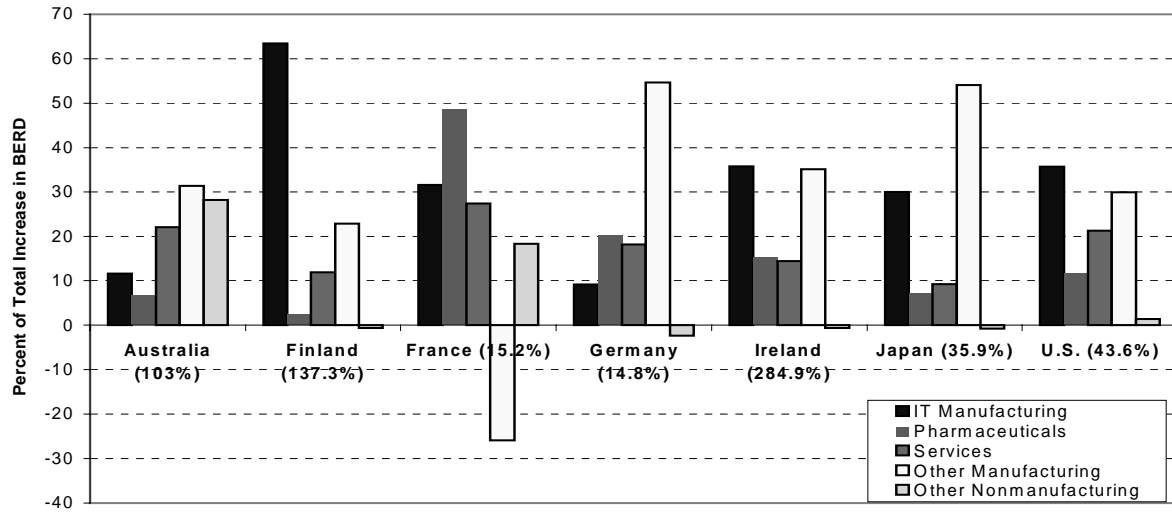
Source: OECD, S&T database (STI/EAS Division), December 2000.

**Figure A2. Trends in the intensity of business-funded R&D relative to GDP**



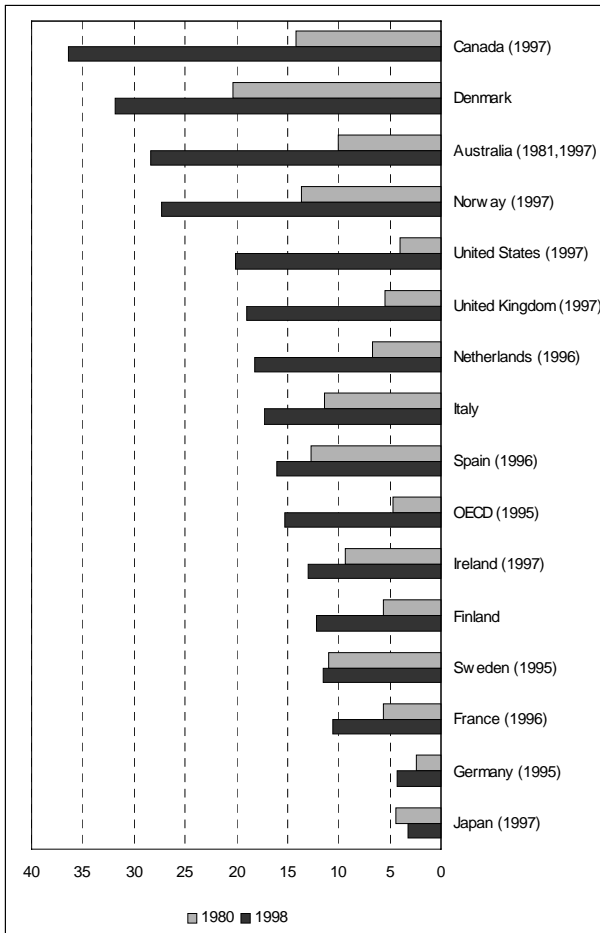
Source: OECD.

**Figure A.3. Distribution of the Growth in Business R&D by Industry, 1990-1998**

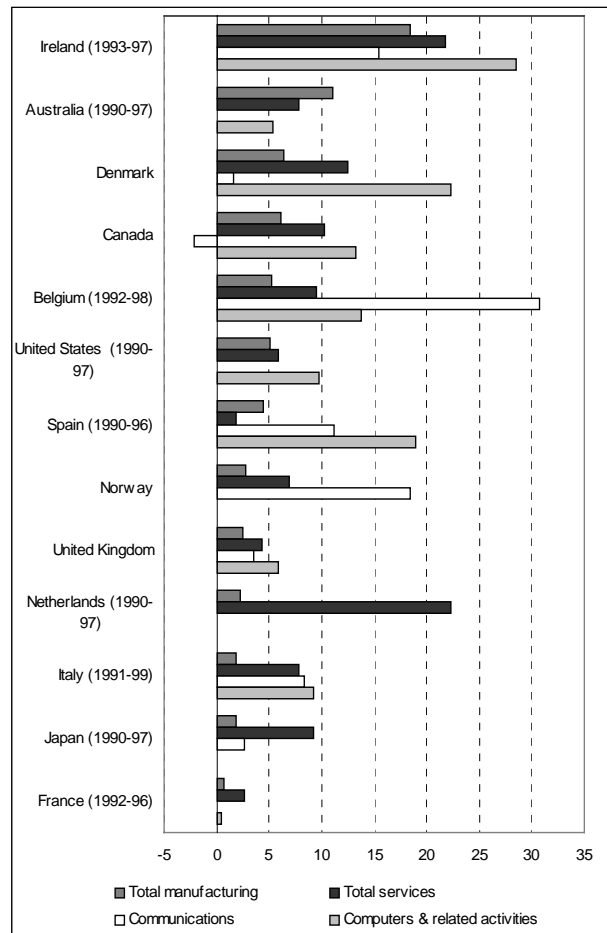


*Notes:* Information technology manufacturing includes office, computing, and accounting machines, communications equipment, and electronic components. The decline in R&D in other manufacturing industries in France derives from steep reductions in defense expenditures (OST, 2000).  
*Source:* OECD ANBERD Database, November 2000.

**Figure A.4. Business Expenditure on R&D in services**

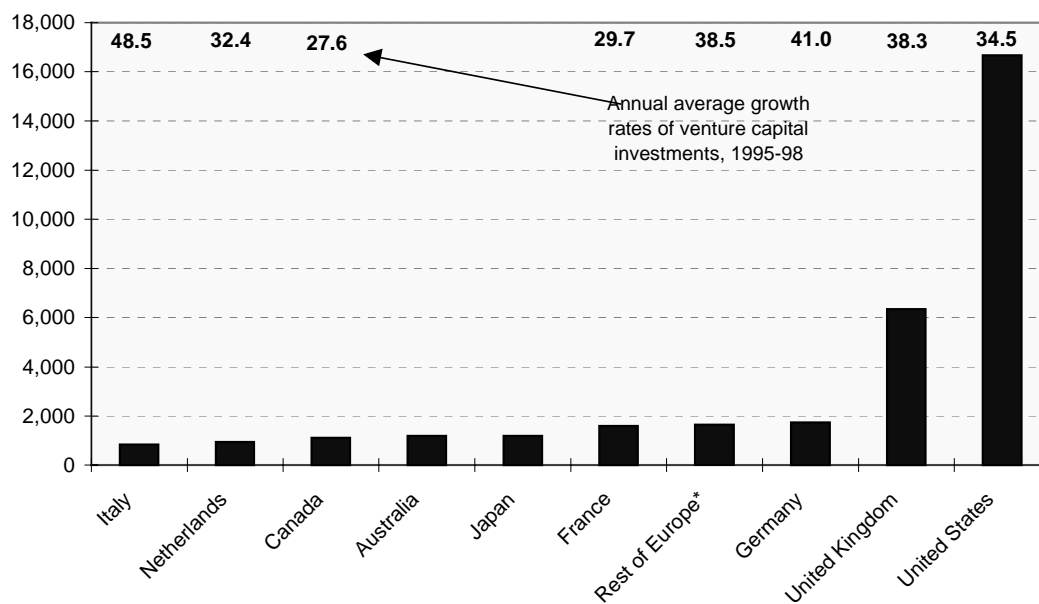


**3.a. Share of services in business R&D, 1980 and 1998**



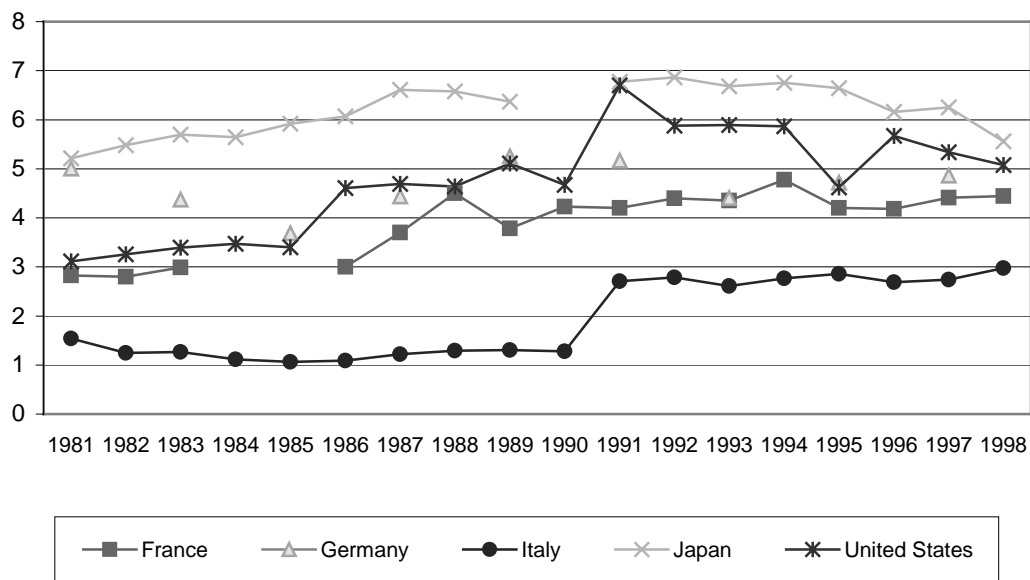
**3.b. R&D growth in selected service industries  
Average annual growth rate, 1990-1998**

**Figure A.5. Size and Growth of Venture Capital Markets in OECD Countries, 1995-1998**



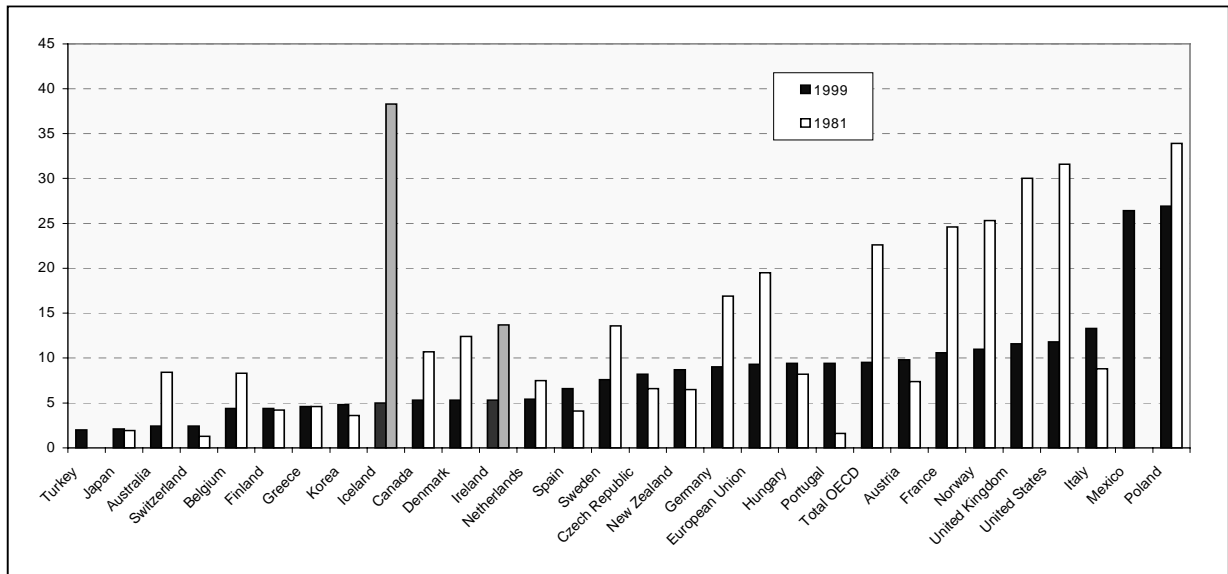
Source: OECD (2000b).

**Figure A.6. Percentage of BERD Allocated to Basic Research in Select OECD Countries**



Source: OECD, MSTI database.

**Figure A.7. Share of BERD Financed by Government (%)**



Source: OECD, Main Science and Technology Indicators, May 2000.

**Table A.1. Industry Funding of R&D by Recipient of Funds**

(percent of total business R&amp;D funding)

Country/Region	To Industry			To Higher Education			To Government			To Public, Non Profit		
	1981	1990	1999	1981	1990	1999	1981	1990	1999	1981	1990	1999
European Union	97.4	96.5	95.6	0.7	2.0	2.5	1.5	1.3	1.9	0.5	0.2	N/A
Japan	95.4	95.5	95.6	0.4	0.6	0.5	0.2	0.6	0.2	4.0	3.4	3.7
United States	98.6	97.8	97.9	0.8	1.4	1.3	0	0	0	0.6	0.8	0.7
OECD	97.4	96.7	96.4	0.8	1.4	1.7	0.6	0.6	N/A	1.2	1.2	1.2

Source: OECD MSTI Database, November 2000.

**Table A.2. Funding for BERD by Source of Funds**

(Percentage of total BERD funding)

Country/Region	From Industry			From Government			From Abroad		
	1981	1990	1999	1981	1990	1999	1981	1990	1999
European Union	76.5	78.5	82.3	19.1	14.2	8.9	4.3	7.1	8.8
Japan	97.9	98.5	97.5	1.9	1.3	1.8	0.1	0.1	0.5
United States	68.4	74.4	86.4	31.6	25.6	13.6	N/A	N/A	N/A
OECD	76.2	81.0	87.2	22.1	16.4	9.5	N/A	N/A	N/A

Source: OECD MSTI Database, November 2000.

**Table A.3. R&D Expenditures by Small US Companies  
(millions of constant 1992 dollars)**

Size of firm	1997	1998	1999	Percent change
Fewer than 25	2,536	3,804	5,579	120%
25 to 49	2,455	2,525	3,824	56%
50 to 99	3,415	5,155	5,779	69%
100 to 249	5,907	6,622	5,707	-3%
250 to 499	5,229	5,522	6,463	24%
Total	19,542	23,627	27,352	40%

Source: NSF (2001).