HIGHLIGHTS

OECD Science, Technology and Industry Outlook

OECD

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HIGHLIGHTS

Regaining momentum in science, technology and innovation

Science, technology and innovation are central to improved economic performance.

As the recent economic slowdown gives way to prospects of stronger economic growth across the OECD region, renewed attention is being directed to ways of tapping into science, technology and innovation to achieve economic and societal objectives. The continued transition to more knowledge-based economies, coupled with growing competition from non-OECD countries, has increased the reliance of OECD countries on the creation, diffusion and exploitation of scientific and technological knowledge, as well as other intellectual assets, as a means of enhancing growth and productivity. High-technology industries account for a growing share of OECD-wide value added and international trade and can be expected to play a significant role in the economic recovery.

Recent investments in science, technology and innovation have been constrained by slow economic growth.

In recent years, weak economic conditions limited investments in science and technology. Global investments in R&D, for example, grew at a rate of less than 1% between 2001 and 2002, compared to 4.6% annually between 1994 and 2001. As a result R&D spending slipped from 2.28% to 2.26% of GDP across the OECD, driven by declines in the United States, which was hard hit by the economic downturn. R&D intensity also declined in several Eastern European countries that are continuing to restructure their economies, but it increased in the EU25 as a whole, as well as in Japan and the Asia-Pacific region.

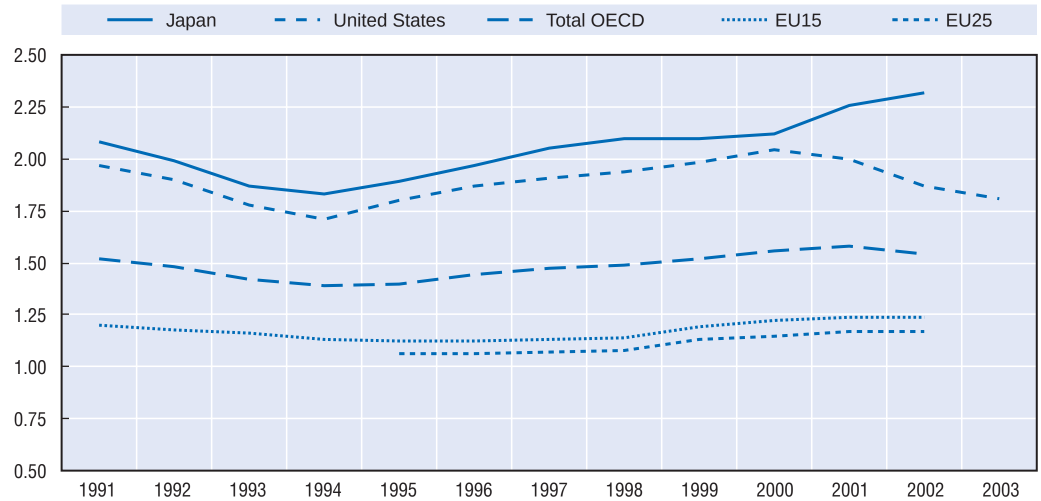
Government R&D expenditures grew modestly…

Recognising the importance of innovation to economic growth and performance, most OECD governments aimed to shield public R&D investments from spending cutbacks and, in many cases, were able to increase them modestly. Although they remain far below levels of the early 1990s, OECD-wide government expenditures for R&D rose from 0.63% to 0.68% of GDP between 2000 and 2002 as budget appropriations grew, most notably in the United States, followed by Japan and the EU. Reflecting growing concerns about national security, much of the US increase related to defence R&D, although health-related R&D expenditures also increased.

… while business R&D spending declined, due to cut-backs in the United States.

Driving recent reductions in OECD-wide R&D intensity were steep cutbacks in R&D in the US business sector. Industry-financed R&D declined from 1.88% to 1.65% of GDP in the United States between 2000 and 2003, while R&D performed by the business sector declined from 2.04% to 1.81% of GDP. Japan, in contrast, saw a steep increase in business-performed R&D – from 2.12% to 2.32% of GDP between 2000 and 2002 – and modest gains were posted in the EU. Venture capital investments also plummeted, from USD 106 billion to USD 18 billion in the United States between 2000 and 2003, and from EUR 19.6 billion to EUR 9.8 billion in the EU between 2000 and 2002. While improved economic prospects promise a turn-around in business R&D and venture capital, rates of growth may be limited by lingering uncertainties about the pace of the recovery.

Business R&D as a share of GDP in major OECD countries and regions



Source: OECD, MSTI database, June 2004.

Science and innovation are receiving greater policy attention...

Prospects of stronger economic growth across the OECD region provide new opportunities to enhance support for science, technology and innovation. Many OECD countries have introduced new or revised national plans for science, technology and innovation policy, and a growing number of countries have established targets for increased R&D spending. Virtually all countries are seeking ways to enhance the quality and efficiency of public research, stimulate business investments in R&D and strengthen linkages between the public and private sectors. Public/private partnerships (P/PPs) have emerged as a key element of innovation policy and are attracting a growing share of financing. Human resources for science and technology have also re-emerged as a primary concern among policy makers, especially as relates to the availability of sufficient supplies of skilled workers (including scientists and engineers) to sustain innovation-led economic growth and restructuring.

... but policy must adapt to the growing role of the service sector and increased globalisation of science and technology.

More so than before, science, technology and innovation policies need to adapt to the needs of the service sector and increased globalisation. Services account for a growing share of R&D in OECD countries – 23% of total business R&D in 2000 compared to 15% in 1991 – and the ability of service sector firms to innovate will greatly influence overall growth, productivity and employment patterns. Nevertheless, they remain less innovative than manufacturing firms overall. At the same time, science, technology and innovation are becoming increasingly global. The combined R&D expenditures of China, Israel and Russia were equivalent to 15% of those of OECD countries in 2001, up from 6.4% in 1995. Within many OECD countries, the share of R&D performed by foreign affiliates of multinational enterprises (MNEs) has also increased. Policy makers need to ensure that OECD economies remain strong in the face of growing competition and benefit from the expansion of MNE networks.

Governments are strengthening science, technology and innovation systems

Government R&D budgets are poised to grow, especially for ICT, biotechnology and nanotechnology.

Despite financial constraints, many OECD governments are committed to increasing R&D spending. Several countries, as well as the European Union, have established explicit targets for boosting R&D expenditures, by both the public and private sectors. Public money is increasingly aimed at scientific and technological fields believed to have great economic and societal value, in particular, ICT, biotechnology and nanotechnology. Several countries, including Denmark, Germany, the Netherlands and Norway have created special funds to finance research in priority fields.

Reforms to public research organisations aim to improve their contributions to the economy and society...

Governments have introduced a range of reforms to strengthen public research systems and to enable them to contribute more effectively and efficiently to innovation. The governments of Denmark, Japan and the Slovak Republic, for example, have increased the autonomy of universities or transformed them into private or quasi-private institutions and removed obstacles to their co-operation with industry. Funding structures have also been changed in many countries to make universities and government laboratories less dependent on institutional (*i.e.* block grant) funding and more reliant on competitively awarded project funds for research. Many countries have stepped up efforts to evaluate public research organisations, with a view toward improving the quality of teaching and research.

... and to facilitate technology transfer to industry.

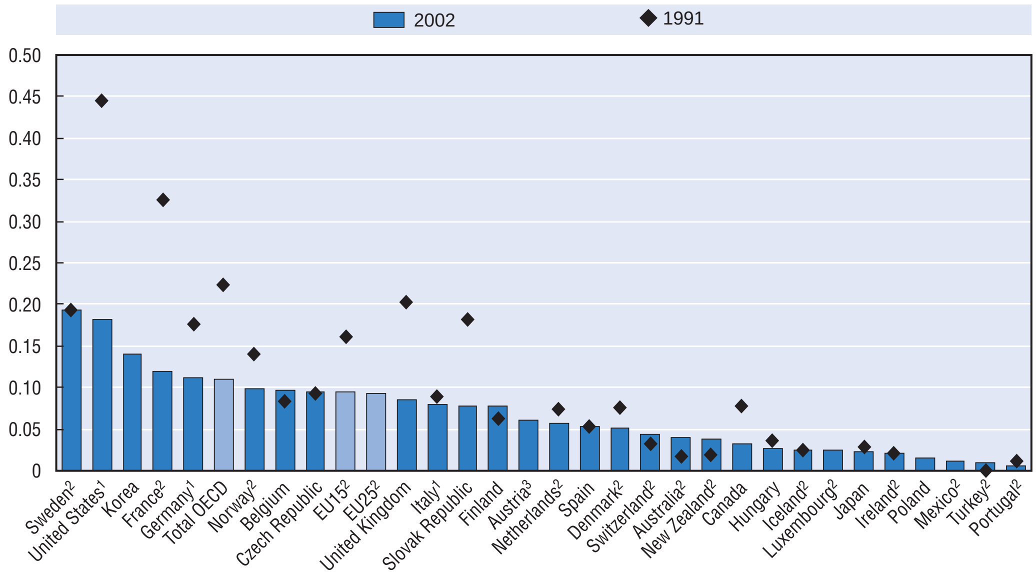
Countries are also taking steps to improve technology transfer from public research organisations to industry. New legislation in Denmark and Norway makes technology transfer to industry an explicit mission of universities, and the new University of Luxembourg has been encouraged to stimulate industry interaction through contract research and mobility of students and researchers. Countries continue to reform rules governing the ownership of intellectual property (IP) generated by public research institutions, in most cases granting ownership of IP to the institution in order to facilitate its commercialisation. Norway and Switzerland introduced such changes in recent years, and Iceland and Finland are preparing legislation on the subject. Several countries that have not changed legislation, such as Australia and Ireland, have nevertheless developed new guidelines to encourage commercialisation of research results and provide greater consistency in IP management among research organisations.

Support to business R&D is becoming more indirect.

Support to business R&D remains a central feature of innovation policies across the OECD, especially as governments aim to boost business R&D spending. With the exception of several Eastern European countries, direct government support to business R&D has declined, both in absolute terms and as a share of business R&D, and greater emphasis is being placed on indirect measures, such as tax incentives for R&D. Between 2002 and 2004, Belgium, Ireland, and Norway established new tax incentive schemes, bringing to 18 the number of OECD countries employing tax incentives for R&D. The United Kingdom also developed a tax incentive for large firms, complementing their scheme for small ones. Countries are also making efforts to stimulate entrepreneurship and boost R&D activities in small and medium-sized enterprises (SMEs), such as by supporting venture capital and providing preferential support to SMEs.

Government funding of business R&D, 1991 and 2002

As a % of GDP



1. 2003.
2. 2001.
3. 2000.

Source: OECD MSTI Database, June 2004.

Innovation policy is more consistently subject to evaluation.

To measure the effectiveness of innovation policy and inform future policy development, nearly all OECD countries are placing greater emphasis on evaluation. Such evaluations take place at all levels: individual instruments (*e.g.* tax incentives, P/PPs), institutions (*e.g.* universities and government laboratories) and national innovation systems (*e.g.* Australia, Finland, United Kingdom). Canada plans to undertake a comprehensive assessment of federal support for R&D, and the Czech Republic regularly evaluates programmes as part of its policy development. Australia recently completed an assessment of its innovation system, as did Sweden. In some cases, such as in the Netherlands, New Zealand and Switzerland, all policies and programmes are required by law to be evaluated on a regular basis.

Getting the most out of public/private partnerships

Public/private partnerships are essential to improving returns from public investments in research.

Public/private partnerships are an essential instrument for fostering innovation in OECD countries. By entailing financial contributions from the public and private sectors, P/PPs provide a means of better leveraging limited public R&D funding and ensuring strong industry commitment. By linking public and private sector needs through shared objectives and active involvement of all partners in management and decision-making, P/PPs can also improve the quality of private sector contributions to public needs, enhance prospects for commercialising results of public research and improve basic knowledge infrastructures.

P/PPs account for a growing share of R&D funding in the OECD. In France, P/PPs accounted for 78% of all competitive research funding in 2002, up from 37% in 1998, and the Dutch government has reserved EUR 805 million for P/PPs in strategic areas between 2003 and 2010. Existing P/PP programmes in Australia, Austria and Sweden have also been reinforced with additional funding, and new P/PPs have been established in the Czech Republic, Ireland, Hungary and Switzerland. While many of these P/PPs take the form of join research centres, countries such as Belgium, Denmark, France, Netherlands, New Zealand, Switzerland and the United Kingdom are making efforts to establish networks between researchers in various research centres to improve co-ordination and quality of work.

P/PPs account for a growing share of public R&D investment.

Experience to date indicates that P/PPs must be carefully designed and managed so as to engage partners with different cultures, management practices and objectives. Success depends on how well P/PPs ensure industry commitment while balancing public and private objectives, fit into national innovation systems, optimise financing arrangements, create appropriate international linkages, engage SMEs, and are evaluated. For example, using a competitive, bottom-up approach to selection appears effective in ensuring that P/PPs attract capable firms and draw upon established competencies, but top-down criteria may also be needed so that P/PP programmes address areas of strategic importance for the country. The balance of financial contributions from the public and private sectors and the duration of public funding should also be adjusted to reflect the degree to which the research aims to fulfil government needs versus improving support to business R&D.

Selection criteria and financing ratios should reflect the balance of public and private interest in the partnership.

Although SMEs are essential to the success of many P/PPs, they have not been fully represented in many national programmes. France has seen some success, with SMEs accounting for almost 30% of the financing of 13 public/private research networks, compared to just over 20% of funding for all business R&D in the country. To encourage greater participation of SMEs, governments can take steps to lower entry barriers, such as by allowing participation of industry associations. They can also encourage formation of partnerships in fields where SMEs play a significant role. Policy can also have an influence on the participation of foreign firms, which can be important sources of talent and know-how but face numerous restrictions in many countries.

Greater participation by SMEs and foreign partners is further required for the success of P/PPs.

Stimulating innovation in the service sector

Boosting innovation in the service sector is key to improving future economic performance. Services accounted for 70% of total value added in the OECD in 2000, with market services accounting for 50% of the total, up from 35% to 40% in 1980. Two-thirds of the increase in value added in OECD economies between 1990 and 2001 came from services, as did most employment growth. Services also accounted for the bulk of labour productivity growth in many OECD countries, including the United States, United Kingdom and Germany. The importance of services is likely to grow across the OECD as economies continue to become more knowledge-intensive and firms locate manufacturing in lower-cost regions of the world.

The service sector is a growing contributor to economic growth and employment.

Despite the long-held view of services as slow-changing, recent survey results illustrate great potential for innovation in service sector firms. The

Service sector firms are innovative...

share of innovative firms in the service sector remains lower than that in manufacturing, but innovation rates in financial intermediation and business service firms (more than 50% and 60%, respectively) exceed the manufacturing average. Growth rates for R&D in services outpace those in manufacturing by a sizeable margin. While large service sector firms tend to be more innovative than smaller ones overall, small firms in the business services and financial intermediation sectors are more innovative than those in other service industries.

... but innovation processes differ from those in manufacturing.

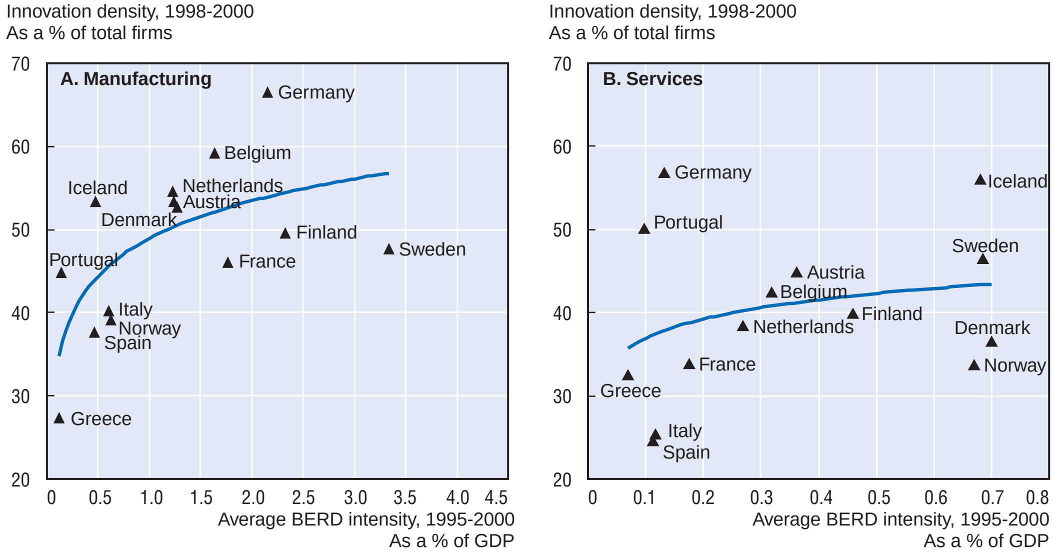
Innovation in services does not follow the same patterns as in manufacturing. Formal R&D plays a smaller role, and education and training are relatively more important. The share of service-sector employees with higher education is considerably higher than in manufacturing – twice as high in many OECD countries – with the largest concentration in the financial services sector. Reflecting their lower levels of R&D, services firms are more dependent on the acquisition of knowledge from external sources (*e.g.* via licensing of intellectual property and purchases of machinery and equipment), meaning that networking and supply chain considerations are paramount. Entrepreneurship also contributes to innovation, but the tendency of new service firms to be innovative is conditioned by the level of innovation in the economy as a whole.

Government policy needs to be tailored to specific needs of service sector innovation.

Boosting the innovation performance of service sector firms entails policies that better target and accommodate their needs. To date, service sector firms have only limited participation in government innovation programmes and are less likely than manufacturing firms to receive public funding. Despite the growing importance of service sector firms in OECD economies, few governments have developed innovation programmes

Business R&D intensity and innovative density by country and sector

BERD as a % of value added in industry and innovative density as a % of all firms



Source: OECD, based on data from Eurostat, CIS3 survey and ANBERD database, 2004.

specifically tailored to their needs. Greater efforts could be made, for example, to strengthen links between services firms and public research institutions, improve worker training, direct research to needs of particular service industries or help service firms make better use of ICT. Several countries, including Denmark, Finland, Ireland and Norway, are steps in these directions that could point the way to for other countries to follow.

Ensuring sufficient supplies of human resources for S&T

Demand is growing for skilled scientists and engineers...

Efforts to increase innovative capacity and make economies more knowledge-based are fundamentally enabled by the availability of human resources for science and technology (HRST). Employment in HRST occupations grew approximately twice as fast as overall employment between 1995 and 2000, and the number of researchers across the OECD grew, from 2.3 million in 1990 to 3.4 million in 2000 – or from 5.6 to 6.5 researchers per 10 000 employees. Approximately two-thirds work in the business sector. Efforts to boost national and regional R&D spending will create additional demand for researchers. For example, the number of additional researchers needed to attain the EU's objective of boosting R&D to 3% of GDP by 2010 could exceed a half million, by some estimates, raising questions about future supplies of S&T workers.

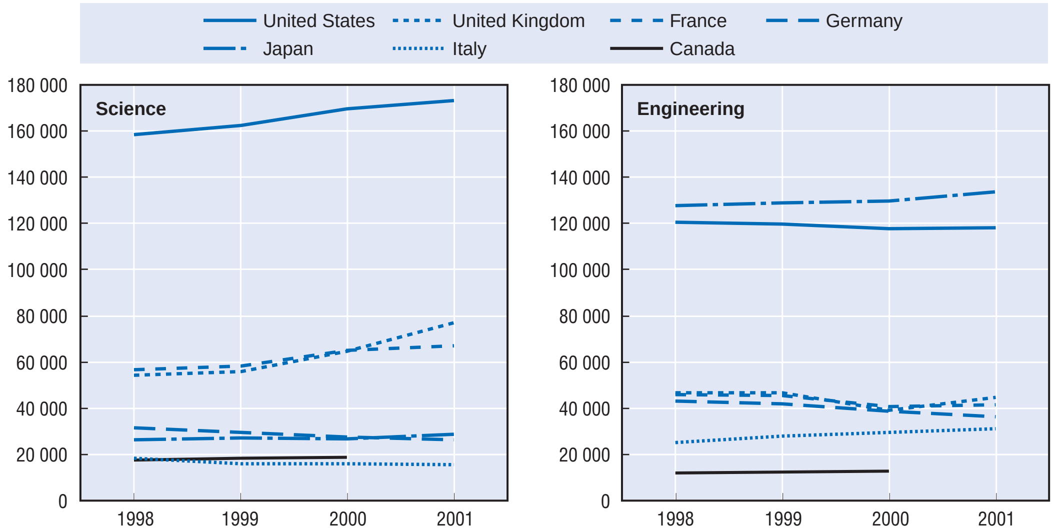
... but domestic supplies are uncertain in several countries.

Domestic supplies of scientists and engineers are highly unpredictable. While the overall number of tertiary-level science and engineering graduates grew in the EU, Japan and the United States, rates of growth have been modest and considerable variation exists across country, degree type and field of science or engineering. Between 1998 and 2001, the number of science graduates declined in Germany and Italy, while the number of engineering graduates declined in France, Germany, the United Kingdom and the United States. Tertiary-level enrolments in science and engineering appear to be growing faster than in all other fields combined, suggesting that longer-term supplies of HRST could increase if students complete their studies, but again patterns are mixed. Enrolments in US graduate science and engineering programmes grew from 405 000 to 455 000 students between 1998 and 2002, but Germany saw declines in physics and chemistry enrolments between 1993 and 2002. France reports declines in enrolments in first and second-level physics and biology programmes, but gains in PhD enrolments between 2001 and 2003. Well-functioning labour markets will be needed to ensure gainful employment of future graduates and avoiding skill shortages or mismatches.

Foreign workers can supplement supplies, but patterns of international migration are changing.

Nations can supplement domestic supplies of HRST by tapping into international sources of scholars and highly skilled workers. International mobility has increased over the past decade as industry and education have become more global and as OECD countries have reformed immigration rules. Some 1.5 million foreign students were enrolled in higher education institutions in the OECD in 2000, about half of which originated in the OECD area, but migration patterns are changing. While the United States receives more foreign PhD-level students than other OECD countries, the number of foreign first-time PhD students and scholars declined slightly in recent years due to stricter immigration rules and growing competition from other OECD countries; numbers rose in the United Kingdom and Australia as they and other countries have implemented a number of new measures to attract

Number of science and engineering graduates in G7 countries, 1998-2001



Note: Data concern science and engineering graduates at all levels of post-secondary education.
Source: OECD Education database, July 2004.

foreign and expatriate workers. At the same time, growing numbers of students in non-OECD countries are receiving degrees in their home countries, and non-member governments are actively seeking to repatriate scholars and workers who have gained experience abroad.

Governments need to take a broad-based approach.

Ensuring adequate supplies of HRST will require efforts in a number of areas, many of which are being exploited by OECD countries. First, efforts are needed to attract more people into science and engineering careers by, for example, raising interest in and awareness of science especially among youth, improving teacher training and educational curricula, and recruiting more women and under-represented populations. Second, funding can be increased, especially for PhD students and post-doctoral researchers, who can often find more lucrative employment outside the research profession. Third, demand-side policies can be used to improve the match between supply and demand, such as by fostering mobility of young researchers, improving career prospects for public researchers, and providing better information to students about employment opportunities in the business sector. Efforts to increase business R&D will also create additional jobs in the business sector.

Benefiting from globalisation

Foreign affiliates play a larger role in host economies.

Globalisation has been fuelled largely by the activities of foreign affiliates of large multinational enterprises (MNEs). Between 1995 and 2001, the share of manufacturing output and employment under foreign control rose in all OECD countries for which data is available, except Germany and the Netherlands. In 2001, the share of manufacturing R&D under the control of foreign affiliates in OECD countries ranged from 4% in Japan to more than 70%

in Hungary and Ireland, with most countries falling between 15% and 45%. The share of employment in foreign affiliates ranged between 15% and 30% in most OECD countries. Growth in output from foreign affiliates grew more quickly than for domestic firms.

Non-member countries are more capable contributors to S&T.

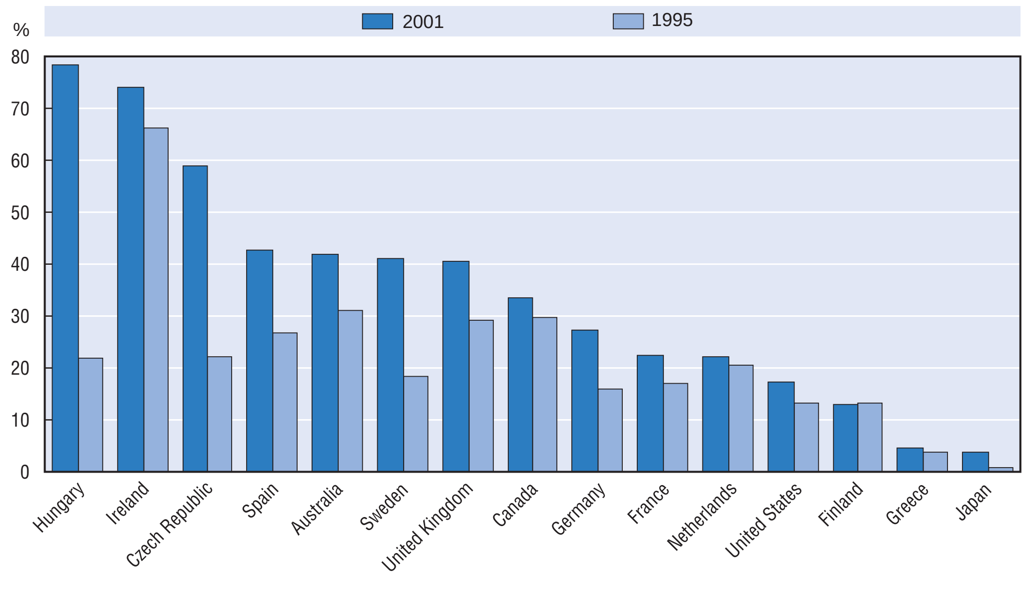
The global reach of MNEs is expanding as non-OECD countries improve their scientific and technical capabilities. China, Israel, and Russia, among other countries, have made sizeable increases in their R&D intensity in the last few years.* China's R&D intensity doubled between 1996 and 2002 (from 0.6 to 1.2% of GDP) and its total R&D investments lag those of only the United States and Japan in absolute terms. Foreign R&D investments in China have grown rapidly as the nation's technological capabilities have increased and its markets have become more open. US investments alone in China grew from USD 7 million to USD 500 million between 1994 and 2000.

MNEs contribute disproportionately to productivity and technology development.

Recent analysis based on firm-level data indicates that MNEs make sizeable contributions to productivity growth in their home and host countries and are important conduits for technology transfer. MNEs accounted for more of the growth in labour productivity in Belgium, the United Kingdom and the United States than uni-national or unaffiliated domestic firms; they also contributed to technological spill-overs that improve innovative performance in both home and host countries. Nearly all of the pickup in US non-financial corporate labour productivity in the late 1990s came from MNEs, and MNEs located in the United Kingdom also tended to out-perform domestic firms that were not part of a global network.

R&D spending in foreign affiliates

As % of business R&D expenditures



Note: Or nearest available years.
Source: OECD, AFA database, May 2004.

* China, Israel, the Russian Federation and South Africa are Observers to the OECD Committee for Scientific and Technological Policy.

Policy should aim to capture the benefits of MNE activities, rather than limiting them.

While much attention focuses on the potential down-sides to globalisation – *i.e.* movement of domestic jobs to other countries, loss of control to foreign-owned MNEs – policy makers need to recognise the benefits to home and host countries and design policies to capture them. Policies designed to limit globalisation and repatriate foreign affiliates, for example, may not be effective means of strengthening domestic economies, as they will limit links to important sources of knowledge and productivity growth. Policy should focus on improving the attractiveness of the domestic economy to foreign affiliates and to ensuring spill-overs from their activities, such as by encouraging linkages with local firms and suppliers.

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