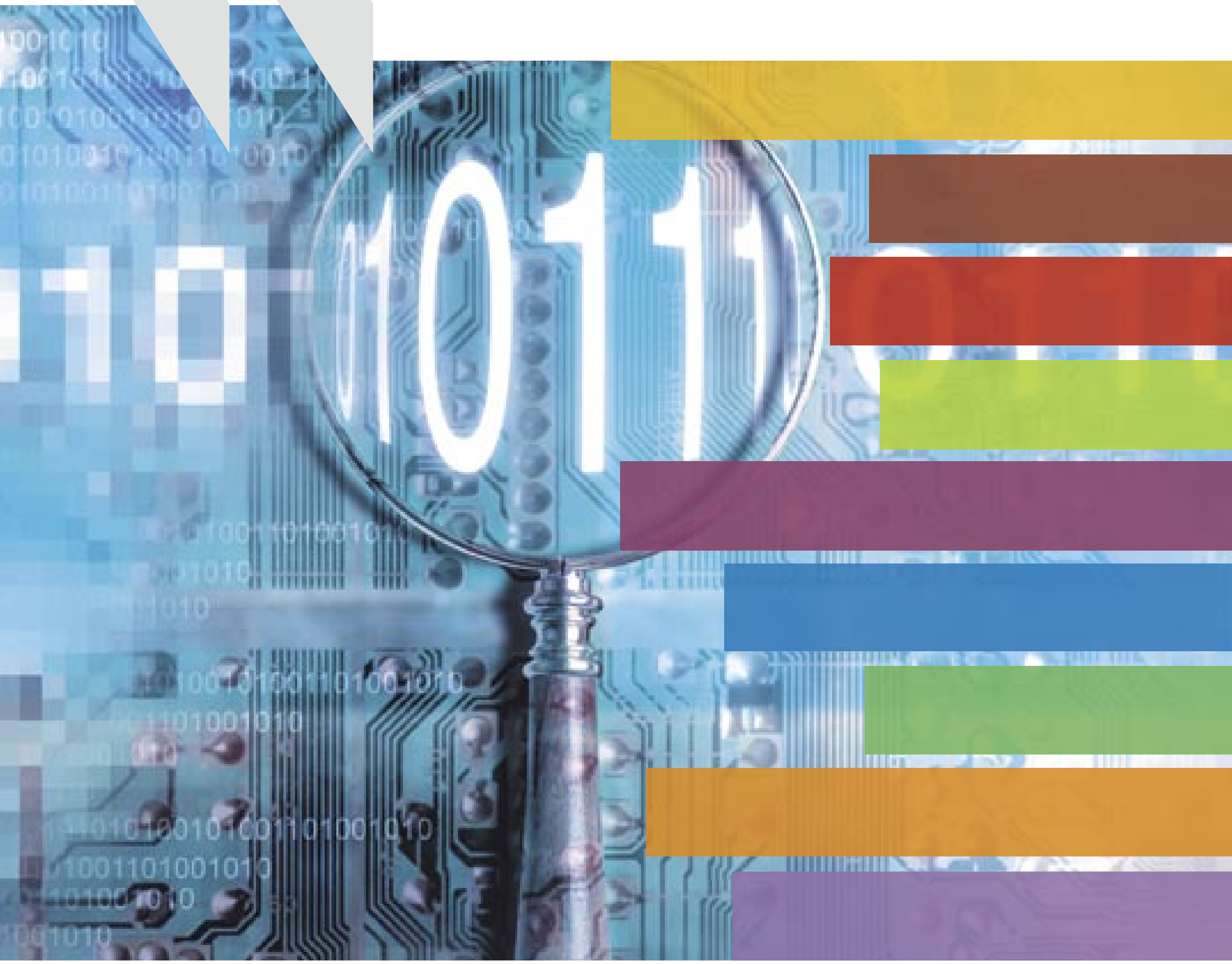
OECD Science, Technology and Industry Scoreboard 2007

INNOVATION AND PERFORMANCE IN THE GLOBAL ECONOMY



OECD

OECD Science, Technology and Industry Scoreboard

2007

INNOVATION AND PERFORMANCE IN THE GLOBAL ECONOMY

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Foreword

The *OECD Science, Technology and Industry Scoreboard 2007* brings together the latest internationally comparable data to explore the growing interaction between knowledge and globalisation at the heart of the ongoing transformation of OECD economies. It draws mainly on OECD databases, indicators and methodology developed by the Directorate for Science, Technology and Industry and focuses on key areas of policy interest:

- *R&D and investment in knowledge:* R&D investment and sources of financing, software and education investment, R&D investment by business and by industry.
- *Human resources in S&T:* flows of university graduates, employment of tertiary level graduates, international mobility of scientists, skills and earnings of the highly skilled.
- *Innovation policy:* cross-funding R&D linkages, governmental R&D budgets, tax treatment of R&D, industry and science linkages, university patenting, cooperation in innovation between private companies and public research organisations.
- *Innovation performance:* scientific and patenting activities (the latter including at the industry and regional level), and indicators on innovation performance of companies (*e.g.* innovation in SMEs and large firms, co operation in innovation, etc.).
- *ICT:* resources and infrastructure for the information economy, the diffusion of and use of internet technologies, *e.g.* ICT investment, occupation and skills, telecommunication networks, internet use by businesses and individuals, broadband and security, e-commerce.
- *Particular fields:* indicators addressing the evolution of S&T in biotechnologym, nanotechnology (*e.g.* publications and patents) and environmental technologies.
- *Internationalisation of S&T:* international collaboration in science, technology (international collaboration in research and cross-border invention, research activity by multinational companies, funding from abroad for R&D.
- *Global economic flows:* key channels of economic integration, including foreign investment and trade, the role of foreign-owned affiliates in the economy, the contents of imports on exports and patterns of international outsourcing (intermediates).
- *Trade and productivity:* comparison of OECD economies in terms of productivity, contributions of sectors to productivity (*e.g.* business sector, manufacturing and other industries), export performance, international trade in knownedge-intensive industries.

This volume was prepared by the Economic Analysis and Statistics Division (EAS) of the OECD Directorate for Science, Technology and Industry (DSTI). Pluvia Zuniga served as overall co-ordinator of the publication, Laurent Moussiegt provided statistical assistance, and Julie Branco-Marinho, Beatrice Jeffries and Paula Venditti provided secretarial support. Laudeline Auriol, Nevra Aydogan, Frédéric Bourassa, Agnes Cimper, Hélène Dernis, Koen De Backer, Isabelle Desnoyers-James, Eric Gonnard, Masatsura Igami, Elif Koksal, Vladimir

Lopez-Bassols, Teruo Okazaki, Martin Schaaper, Cristina Serra Vallejo, Sharon Standish, Brigitte van Beuzekom, Colin Webb, Norihiko Yamano and Alison Young all contributed to the publication. Alessandra Colecchia, Dominique Guellec, Thomas Hatzichronoglou, Sam Paltridge, Vincenzo Spiezia and Yoshiaki Tojo offered guidance and commented on the draft. Joseph Loux supervised the publication process.

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Executive Summary

Throughout the world, innovation and globalisation are the two major sources of economic performance. They directly affect productivity, job creation and citizens' well-being, and they help make it possible to address global challenges such as health and the environment. As their role has taken on greater prominence, their characteristics have evolved and policies have had to adapt.

This eighth edition of the ***Science, Technology and Industry Scoreboard*** explores recent developments in matters relating to science, technology, globalisation and industrial performance. In this regard, it compares characteristics of OECD member and major non-member countries and provides information on national policies that have been implemented and their outcome. Major findings include:

- Investment in new knowledge, notably in R&D, is now growing in line with GDP. This contrasts with the late 1990s when investment in knowledge outpaced growth of GDP.
- Skilled workers constitute an increasing share of the labour force, notably in the services industries.
- Public policies that seek to foster innovation are being progressively reoriented, from subsidies and procurement to alternative instruments such as R&D tax relief and reinforcement of industry-science linkages.
- The pace of diffusion of information and communication technologies has become steadier than in the heady days of the late 1990s, notably in terms of broadband Internet access among households and adoption by businesses for e-commerce.
- The economies of Brazil, Russia, India, China and South Africa are taking further steps in many areas of the knowledge economy, most notably in terms of investment in research (in China and India), patenting and trade in high-technology industries.
- Research and S&T activities have become more internationalised, in line with the increasing globalisation of value chains. In most OECD countries foreign affiliates of multinational firms now have a higher share in R&D than in manufacturing activities.

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Highlights

This eighth edition of the ***Science, Technology and Industry Scoreboard*** brings together the latest data and indicators on trends in knowledge, on globalisation and on its impact on economic performance in OECD and non-member economies. In this edition, the focus broadens to include emerging countries, with a special focus on the BRICS (Brazil, Russia, India, China and South Africa). New data document trends in public support for knowledge creation and diffusion, and new indicators point to the changing landscape of countries' scientific specialisation and innovation performance. New sources of data on the international mobility of the highly skilled provide a more complete picture of the role of scientific and technological human capital as an engine of growth. Information on emerging fields (biotechnology, nanotechnology and the environment) reveals the increasing linkages between science and technology.

First are analysed the inputs and mechanisms that aim to stimulate innovation: the current situation of investment in research and development (R&D), the continuing growth of human resources in science and technology (HRST), and recent policy changes in the field of research and innovation. Next are examined the outputs of investment in knowledge and advances in information and communication technologies (ICT) and other technology fields (biotechnology, nanotechnology and environmental technologies). There follows an overview of recent patterns in scientific and technological research and economic globalisation. Finally, consideration is given to the impact of investment in knowledge and innovation on productivity and trade.

Investment in knowledge has grown at the same pace as GDP

Since 2001, R&D expenditure in the OECD area has kept pace with the growth of GDP, at about 2.25% of overall GDP

Investment in knowledge is the basis of innovation and technological progress. As measured by R&D expenditure, software and education, it continues to rise in most OECD economies. Since 2000, in most of the countries surveyed, growth has been more rapid in education and R&D than in software. Across the OECD, however, R&D has grown more slowly than in the second half of the 1990s, owing in part to a readjustment of investment following the acceleration of the late 1990s and the slowdown of investment in R&D in the United States.

In 2005, China took third place world wide in terms of R&D expenditure

In both Japan and the EU, R&D intensity (R&D expenditure relative to GDP) picked up in 2005 to 3.3% and 1.7%, respectively, following a drop in 2004. In the United States, R&D intensity declined from a peak of 2.7% in 2001 to 2.6% in 2006, mainly owing to stronger growth in GDP than in the other main regions. In 2005, China became the third R&D spender world wide (in purchasing power parity terms) after the United States and Japan, with growth of more than 18% a year in 2000-05.

The business enterprise sector accounts for the bulk of R&D in OECD countries in terms both of performance and of funding (at 63 and 68%, respectively, of the total), and, except in the United States, its share has risen over the past few years. Compared to 1995, the share of business-funded R&D in GDP in 2005 is much higher in Japan (2.5%), the United States (1.7%) and the EU (0.9%).

Venture capital is a major source of funding for new technology-based firms and a decisive determinant of entrepreneurship and innovation. It represented about 0.12% of OECD-wide GDP in 2005, up from 0.10% in 2003. It was much higher in Nordic countries (and growing rapidly), but it still remains concentrated in the United Kingdom and the United States. In 2005, these two countries attracted half of all OECD venture capital.

Employment of HRST has expanded due notably to increases in female employment and expansion of the services sector

Human resources in science and technology are a major factor in countries' ability to generate and adopt new technology and new business practices. According to the most recent figures, employment of HRST continues to grow much faster than total employment in all countries, at an average annual rate of 2.5% in the United States and 3.3% in the EU15. This expansion has been mainly driven by increases in female employment and the expansion of service industries (with a share of HRST in employment that is on average twice that of manufacturing). Nordic countries report the highest shares of R&D personnel and highly skilled workers in total employment.

The share of foreign doctoral students in total doctoral enrolments is particularly high in Switzerland, Belgium and English-speaking countries. It rose significantly between 1998 and 2004 in all countries (less so in the United States). Among the OECD countries which report these figures, the United States has the largest number of foreign doctoral students. About 10 000 foreign citizens obtained a doctorate in S&E in the United States in 2004 and in 2005 and represented 38% of S&E doctorates awarded there. In 2005, Asians accounted for more than two-thirds of non-US doctorates (Chinese students accounted for 30% and Koreans for 10%). Doctorate recipients, particularly from China and India, often remain in the United States on a post-doctoral position or take a job.

Innovation policies: increased focus on tax incentives and industry-university linkage

In 2006, 20 OECD countries offered tax relief for R&D compared to 12 in 1995

OECD countries' policy mix for fostering innovation is changing. In 2005, direct government funds financed an average of 7% of business R&D, down from 11% in 1995, with a shift away from public procurement (direct subsidies) and towards tax relief. In 2006, 20 OECD countries offered tax relief for business R&D, up from 12 in 1995 (18 in 2004), and most have tended to make it more generous over the years. In this way, governments create an incentive to undertake R&D but leave the choice of types of projects to market forces. Government revenue forgone as a result of R&D tax credits can be substantial, *e.g.* USD 5 billion in the United States, about USD 1 billion in France and the United Kingdom, and some USD 300-400 million in the Netherlands, Mexico, Australia, Belgium and Spain (2005 figures). These sums represent 23% of direct subsidies in the United States, 43% in France, twice the total amount of direct subsidies in the Netherlands and 1.2 and 1.3 times the amount in Ireland and Australia.

In most of OECD countries, university patenting is increasing

In order to stimulate technology transfer from universities to businesses, many OECD governments have encouraged universities to patent their inventions. OECD-wide, between 1996-98 and 2002-04, the share of patents filed by universities has been stable. While decreasing slightly, to about 7%, in the countries that pioneered such policies (Australia, Canada and the United States), the share has increased markedly in Japan and the European Union, notably in France and in Germany, although levels remain modest (1.5% in Japan, 3% in the EU, but more than 5% in France). The four OECD countries with the highest rate of university patenting are Ireland, Spain, the United Kingdom and Belgium. It is not known what share of these patents is actually exploited.

Business funding of university research gives companies a way to watch out advances in science and acquire new knowledge. European companies (EU27) finance 6.4% of R&D performed by public institutions and universities compared to 2.7% in the United States and 2% in Japan.

Co-operation between industry and public research institutions (government laboratories and universities) has also been a major policy target in recent years. Information on collaboration on innovation is collected in innovation surveys. In spite of numerous obstacles (*e.g.* embryonic stage of inventions, difficulty in negotiating exploitation of intellectual property rights), co-operation with universities is a frequent innovation strategy, especially in large companies. The Nordic countries (especially Finland) and Belgium are ahead of other countries for which data are available.

S&T and innovation performance: the rise of new players

Investment in knowledge leads to S&T outputs, and in turn to new products and services and new modes of organising business. This technological and organisational innovation determines economic performance.

China ranks sixth world wide in terms of publications and has raised its share in triadic patents from close to zero in 1995 to 0.8% in 2005

The United States, Europe and Japan remain at the forefront of world science with 30, 33 and 8%, respectively, of total scientific publications; they also lead in patenting of important inventions, as measured by triadic patents (each had 30% of the total in 2005). In per capita terms, however, Switzerland takes first place, followed by the Nordic countries, and emerging countries still lag far behind the OECD average. In terms of specialisation, patent data show that emerging economies (India, China, Israel, Singapore) and the United States focus their innovative efforts on high-technology industries (computers, pharmaceuticals) while continental Europe concentrates on medium-high-technology industries (automobiles, chemicals).

In service industries new types of organisation and marketing are a major source of innovation

Innovation surveys show that large firms have a greater tendency to innovate than small ones. In terms of non-technological innovation (organisation, marketing), service industries are as strong as manufacturing industries, but they account for much less technological innovation. For service firms, non-technological innovation is a strong driver of performance.

The renewal of the population of businesses, through the birth and death of firms, is an indicator of the process of "creative destruction", a major characteristic of innovation. The creation of start-ups is a manifestation of innovation and frequently reflects the emergence of new technologies and other forms of technological change. In 2003, rates of creation varied widely, from 14 to 18% (New Zealand, Germany, Canada and the United Kingdom) to 4 to 6% (Japan, Iceland, Sweden and Portugal). Destruction rates also differed and were lower than creation rates in most countries.

The patents-to-R&D ratio is an indicator of the cost of developing technology and has been fairly constant in most countries since 1995. OECD-wide, a triadic patent family corresponds to R&D expenditures of USD 8 million on average; it is USD 11 million in the United States, USD 7 million in Europe, and USD 5 million in Japan. Since 1995, the cost has decreased in the Netherlands (to USD 3 million) and in Korea (USD 6 million), but has increased in the United States (USD 9 million in 1995).

California and Tokyo are by far the most inventive regions in ICT and biotechnology

In all OECD countries, inventive activities are more geographically concentrated than population, owing to the existence of local clusters of innovation and the dynamics of

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regional economies. For ICT and biotechnology, Europe shows less geographical concentration of innovative activity, as several regions have quite similar performance.

After the explosion of the late 1990s, steadier diffusion of ICT

Technological advances and the diffusion and use of ICT have boosted economic change over the past decade. ICT has become a strategic enabler of companies' organisational and technological innovation.

In 25 OECD countries over 89% of businesses use the Internet

ICT is diffusing at a more regular pace than in the late 1990s and early 2000s, as confirmed by Internet use in households and e-commerce, although the level of the latter remains modest. The penetration of broadband among households has progressed rapidly over the past three or four years in all countries but penetration rates vary. For households, Korea, Japan and the Nordic countries feature rates of 50 to 80%, while those for Italy and Ireland are around 10 to 15%. The take-up of broadband depends on computer penetration, but also on the level of competition and availability of service. Business use of the Internet has become fairly standard in OECD countries: in 25 countries more than 89% of businesses with ten or more employees have access to the Internet and over half have their own website.

OECD-wide, the finance and insurance industry has the highest rate of Internet connectivity, followed by wholesale trade and the real estate, renting and business services industries. Between 1995 and 2004, more ICT specialists are employed in all countries except Portugal and all countries have consistently more ICT users in total employment. Such sustained pace of diffusion is supported by the fact that ICT has maintained its technological dynamism, as reflected in higher shares of patenting in national totals in most OECD countries.

The emergence of biotechnology, nanotechnology and environmental technologies

Certain fields deserve special scrutiny, in view of their current or expected impact on society and the economy, notably in terms of industrial innovation and applications, health and the environment. Data on S&T outputs and activities in biotechnology, nanotechnology and environmental technologies clearly reveal the differences in specialisation among countries.

The United States has the most biotechnology firms (close to 2 200), followed by Japan and France (around 800 each). In most countries, biotechnology represents 2 to 6% of business R&D but the share is higher in the United States, Switzerland and Canada, and above all in some smaller countries where it exceeds 20% (Denmark, New Zealand, Iceland). In the ten reporting countries, most biotechnology firms are active in health (45%), followed by agro-food and industry-environmental applications (around 25% each). In terms of R&D expenditure as well, health is by far the most important field. The number of biotechnology-related patents has been declining since 2000 in most countries, after a sharp increase in the late 1990s, notably owing to the more restrictive criteria applied by patent offices and the end of the wave of patenting following the decoding of the human genome.

While the United States and Japan take the lead in biotechnology and nanotechnology, the EU leads the way in environment-related technology

The United States and Japan have a comparative advantage in biotechnology and nanotechnology patenting and in the relevant scientific fields, while the EU is the world leader in environment-related technologies (solid waste, renewable energy and motor vehicle abatement), with Germany playing a very active role. Japan is second to the EU in all three environmental technology fields. However, while patenting in renewable energy and motor vehicle abatement has been increasing rapidly since the mid-1990s, patenting in solid waste technologies has declined.

Innovation is an increasingly collective and international endeavour

There has recently been a sharp rise in the globalisation of scientific and technological activities, including research. Innovation has increasingly become a collaborative endeavour on a global scale, it has taken new non-technological forms, and it diffuses more rapidly because of new information technologies. The advent of global value chains, differences in R&D costs, increased flexibility in handling cross-border R&D projects (owing to ICT), and major policy changes (such as stronger intellectual property rights or the tax treatment of R&D) have all favoured this trend. Helping to drive this phenomenon are the creation of alliances (to obtain synergies and complementarities) and the search for new knowledge competencies.

Since the early 1990s cross-border ownership of inventions has expanded from 11 to 16% of total patented inventions

International co-authorship of scientific publications increased by a factor of three between 1995 and 2005. Cross-border co-operation on inventions (share of patents with co-inventors located in two or more countries) nearly doubled as a share of total inventions world wide (from less than 4% to more than 7% between 1991-93 and 2001-03). Foreign ownership of domestic inventions (patents) increased by 50% between the early 1990s and the early 2000s. It reflects the importance of multinationals' R&D labs located in a country different from that of their headquarters. EU countries interact most often with each other and are less globalised than the United States, while Japan and Korea are less internationalised overall.

In a majority of reporting countries, foreign affiliates' share of total expenditure on manufacturing R&D is now higher than their share in total manufacturing turnover

The surge in the internationalisation of research is corroborated by multinationals' recent patterns of investment. R&D performed abroad and by foreign affiliates represents

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on average well over 16% of total industrial R&D expenditure in the OECD area. Furthermore, the average R&D intensity of affiliates under foreign control is higher than the R&D intensity of domestically controlled firms in most countries. This is the case in Japan, Sweden, the United States and the United Kingdom and confirms the increasingly global dispersion of R&D activities as they move closer to markets and to sources of knowledge (poles of excellence).

International flows of technology, as reflected in the technology balance of payments, nearly doubled in the OECD area between 1995 and 2005, and their share of GDP increased from 0.32% to 0.52%. Japan has experienced the fastest growth and has almost caught up with the United States, where flows have remained nearly constant, while the EU had by far the largest, and rapidly increasing, flows.

Value chains as a centrepiece of globalisation

As reflected in available indicators the internationalisation of economic activity – trade, investment, technology trade – is trending upwards. Investment flows, notably portfolio investment, increased rapidly in 2003-05 and represented the equivalent of 12% of OECD GDP. Trade in goods represented 19% of OECD GDP in 2001-05, while trade in services represented about 5%, a significant increase over the early 1990s.

For its part, foreign direct investment has progressed steadily in most countries since the mid-1990s. Among large OECD countries, it represents a greater share of GDP in the United Kingdom and in France than in Germany, the United States and Japan. In the manufacturing sector firms under foreign control represent between 3% (Japan) and 75% (Ireland) of total turnover. In all countries they have a smaller share in employment than in turnover, as they are more capital-intensive than firms under domestic control, and their share in exports is higher as they usually serve the international more than the local market.

Intermediates represent 20 to 30% of total imports in OECD countries, reflecting the globalisation of value chains

The globalisation of value chains, which divides production processes up among different countries, is an important aspect of globalisation. It is reflected in the growing international trade of intermediates, which represented in 2000 between 20 and 30% of total imports in most OECD countries. The "import content of exports", which qualifies the export performance of countries, is also on the rise and represents some 20 to 30% of the value of exports in most OECD countries.

The weight of imported inputs in exports is greater in basic industries (which import primary goods and export transformed goods) and in ICT-related industries, in which the design and manufacturing of sophisticated components is often separated from the less technology-intensive assembly process. China is the most notable example of the growth in the level of import content of exports (20% in 2000).

The share of intra-firm trade in these transactions remains prominent in countries such as the United States and the Netherlands, where intra-firm exports continue to represent around 50% of total exports of manufacturing affiliates under foreign control.

Knowledge and innovation leading productivity and trade

GDP per capita is the most commonly used measure of welfare. It is the highest in the United States and most OECD countries are at 70-85% of US income levels. Differences in GDP per capita reflect a combination of labour productivity, measured as GDP per hour worked, and labour utilisation, measured as hours worked per capita. The latter largely reflects working time and conditions on the labour market (unemployment). In terms of productivity, several European countries have the highest levels (Belgium, Ireland, France, the Netherlands) but have much lower levels in terms of labour participation.

Productivity growth in the OECD area is increasingly dependent on ICT and on business service

From 0.3 to 0.7 percentage points of annual GDP growth in Australia, Denmark, Sweden, the United Kingdom and the United States over 1995-2005 were due to investment in ICT, which had a smaller impact in other countries. As the share of business services in the economy has increased, their contribution to productivity growth has also risen in most OECD countries since 2000, the major exceptions being Finland, Germany, Korea and Sweden.

Due notably to the globalisation of value chains, the share of high and medium high tech in manufacturing has decreased in most OECD countries

Parallel to this evolution, the share of high and medium-high-technology industries in total manufacturing has declined over the past decade in most OECD countries. This is due in part to changes in global value chains (notably offshoring) which are helping to reconfigure industrial structures and trade. High-technology industries, together with medium-high-technology industries (notably motor vehicles, chemicals and machinery and equipment), still represent just under 65% of OECD manufacturing trade. Medium-high-technology industries represent around 40% of total manufacturing trade and medium-low-technology industries represent 18%, a rise of three points since 2000. The notable spurt in the value of medium-low-technology trade is partly due to the recent significant increases in commodity prices for oil and basic metals, particularly those in great demand for the manufacture of ICT goods.

High- and medium-high-technology manufacturing accounts for significant shares of exports from Ireland, Japan and Switzerland (shares of over 75%) as well as from Germany, Hungary, Korea and the United States. Among the BRIICS (Brazil, Russia, India, Indonesia, China and South Africa), these industries' exports are most important in China and Brazil, accounting for 55 and 32%, respectively, of total exports of manufactured and primary products. Because of the globalisation of value chains, a country such as China imports more high-technology goods than it exports; much of these imports are components that are assembled in Chinese factories.

A. R&D AND INVESTMENT IN KNOWLEDGE

A.1. INVESTMENT IN KNOWLEDGE

■ Investment in knowledge is defined as the sum of R&D expenditure, expenditure for higher education (public and private) and investment in software. Such investment is crucial for innovation, economic growth, job creation and improved living standards. In 2004, it amounted to 4.9% of GDP in the OECD area.

■ The ratio of investment in knowledge to GDP is 2.8 percentage points higher in the United States than in the European Union, but the allocation of investment across the three components is similar.

■ Investment in knowledge exceeds the OECD average in the United States (6.6%), Sweden (6.4%), Finland (5.9%), Japan (5.3%) and Denmark (5.1%). In contrast, it is less than 2.5% in Ireland and less than 2% of GDP in Portugal and Greece.

■ Most OECD countries are increasing their investment in the knowledge base. For all reporting countries except Ireland, the ratio of investment in knowledge to GDP was higher in 2004 (or 2003) than in 1997. Further, the increase in the United States and Japan is sharper than in the EU countries for which data are available.

■ Investment in machinery and equipment (relative to GDP) has decreased except in Greece, Italy, Spain and Austria. In Greece and Austria, investment in machinery and equipment rose more than investment in knowledge.

■ Investment in machinery and equipment accounted for around 6.5% of OECD-wide GDP. In 2004 (or 2003), the share varied from 6% (Ireland and France) to around 9% (Japan, Italy and Greece).

■ In the United States and Belgium, higher education was the main driver of the expansion of investment in knowledge. For Japan, Sweden, France, the Netherlands and the United Kingdom, increases in software expenditure were the major source of increased investment in knowledge. R&D was the main source of increase in Denmark, Finland, Canada, Spain, Germany, Portugal, Greece, Australia and Austria.

Sources

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- OECD, Education database, June 2007.
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- OECD, Main Science and Technology Indicators database, June 2007.

For further reading

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Measuring investment in knowledge

Investment in knowledge is defined and calculated as the sum of expenditure on R&D, on total higher education from both public and private sources and on software. Simple summation of the three components would lead to overestimation of the investment in knowledge owing to overlaps (R&D and software, R&D and education, software and education). Therefore, before calculating total investment in knowledge, the data must be reworked to derive figures that meet the definition.

The R&D component of higher education, which overlaps R&D expenditure, was estimated and subtracted from total expenditure on higher education (both public and private sources).

Not all expenditure on software can be considered investment. Some should be considered as intermediate consumption. Purchases of packaged software by households and operational services in firms were estimated. The software component of R&D, which overlaps R&D expenditure, was estimated using information from national studies and subtracted from software expenditure.

Owing to a lack of information, it was not possible to separate the overlap between expenditure on education and on software; however, the available information indicates that this overlap is quite small.

A more complete picture of investment in knowledge would also include parts of expenditure on innovation (expenditure on the design of new goods), expenditure by enterprises on job-related training programmes, investment in organisation (spending on organisational change, etc.), among others. However, owing to the lack of available data, such elements could not be included.

The OECD is the source of the data on R&D and education. Because software investment data are only available for some OECD countries, this component was estimated using data from a private source. Data for a few countries are available from national sources; however, methods for compiling data vary, thereby limiting cross-country comparisons. An OECD task force has developed a harmonised method for estimating software.

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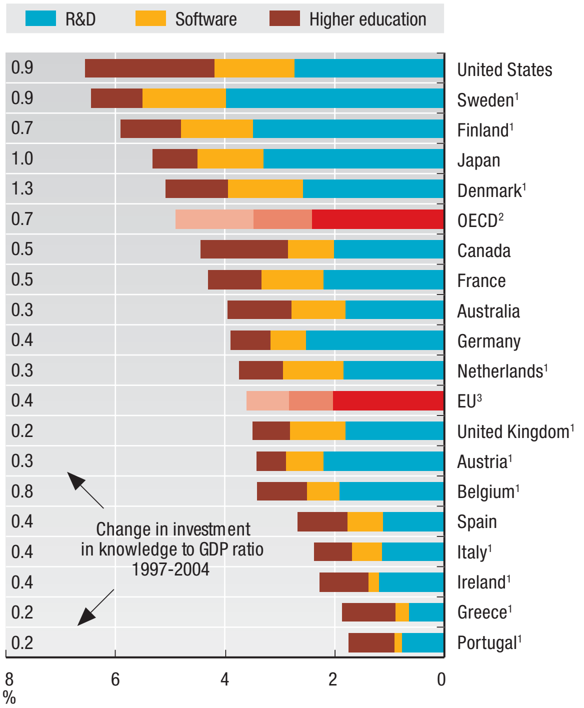
A.1. INVESTMENT IN KNOWLEDGE

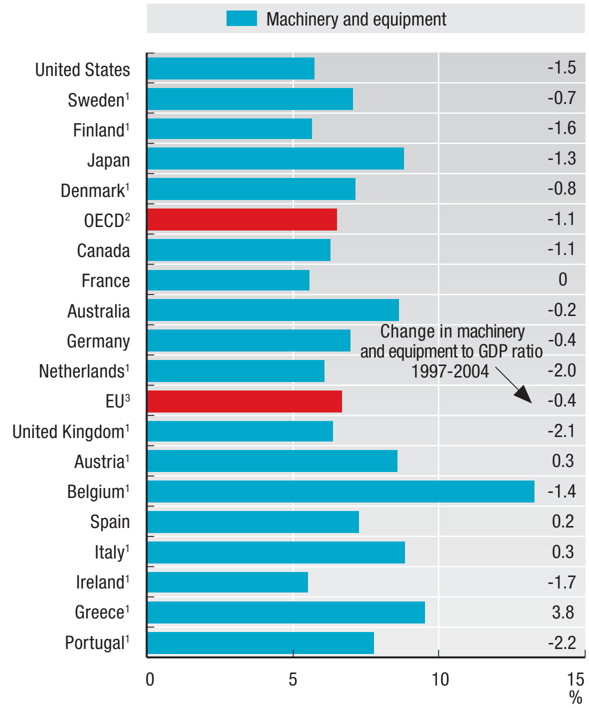
Investment in knowledge

As a percentage of GDP, 2004

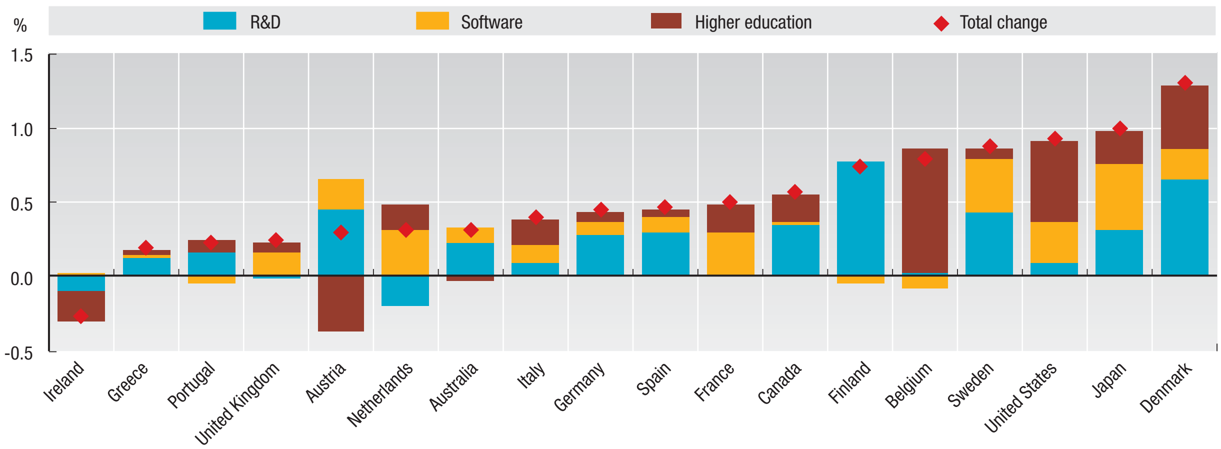


Investment in machinery and equipment

As a percentage of GDP, 2004



Sources of change in investment in knowledge, as a percentage of GDP, 1997-2004



StatLink http://dx.doi.org/10.1787/116525723455

Note: For all countries, investment on educations refers to 2003. For Belgium, Australia and Austria the period of reference is 1998-2003. Data on machinery and equipment for Belgium concerns total gross fixed capital investment.

1. 2003.
2. OECD excludes Greece, Australia and Austria from the group of reporting countries.
3. EU: excludes Greece from the group of reporting countries.

A.2. TRENDS IN DOMESTIC R&D EXPENDITURE

■ In 2005, OECD expenditure on R&D reached USD 771.5 billion (in current purchasing power parity – PPP), or about 2.25% of overall GDP.

■ OECD-area R&D expenditure has increased steadily in recent years although more slowly than during the second half of the 1990s. Total gross expenditure on R&D (GERD) grew by 4.6% annually (in real terms) between 1995 and 2001, but by less than 2.2% a year between 2001 and 2005.

■ Since the mid-1990s, R&D spending has grown at a similar pace in the United States, Japan and the EU (around 2.9% a year in real terms). The share of the three main OECD regions in total R&D expenditure remained stable in 2005 at around 42% for the United States, 30% for the EU and 17% for Japan.

■ In both Japan and the EU, R&D intensity (R&D expenditure relative to GDP) picked up in 2005, reaching 3.33% and 1.74%, respectively, following a drop in 2004. In the United States, R&D intensity declined from a peak of 2.76 in 2001 to 2.61 in 2006, mainly owing to stronger growth in GDP than in the other main regions.

■ In 2005, Sweden, Finland and Japan were the only three OECD countries in which the R&D-to-GDP ratio exceeded 3%, well above the OECD average of 2.2%. Among OECD countries, R&D expenditure has grown fastest (in real terms) since 1995 in Iceland, Turkey, Ireland and Finland with average annual growth rates of over 7.5%.

■ Some non-OECD countries are also important R&D spenders. At USD 115 billion, China's GERD in 2005 was around half of that of the EU and has been growing at over 18% annually (in real terms) since 2000. GERD growth has also been strong in South Africa (8.5% annually between 1997 and 2004), while GERD in Russia reached USD 16.7 billion in 2005.

Source

- OECD, Main Science and Technology Indicators database, May 2007.

For further reading

- OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Development*, OECD, Paris, available at: *www.oecd.org/sti/frascatimanual*.

Resources allocated to gross domestic expenditure on R&D (GERD)

Resources allocated to a country's R&D efforts are measured using two indicators, R&D expenditure and personnel. For R&D expenditure, the main aggregate used for international comparisons is gross domestic expenditure on R&D (GERD), which represents a country's domestic R&D-related expenditure for a given year. The R&D data are compiled on the basis of the methodology of the *Frascati Manual* 2002 which defines R&D as "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications".

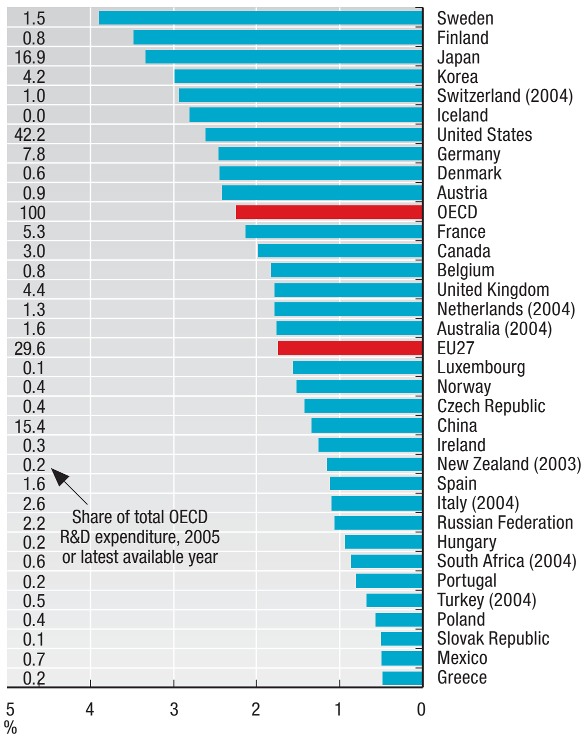
The magnitude of estimated resources allocated to R&D is affected by several national characteristics, principally:

- Coverage of national surveys on R&D in terms of industries, firm size, sampling methods.
- Frequency of national surveys.

Methodology used, *e.g.* for the United States, capital expenditure is not covered.

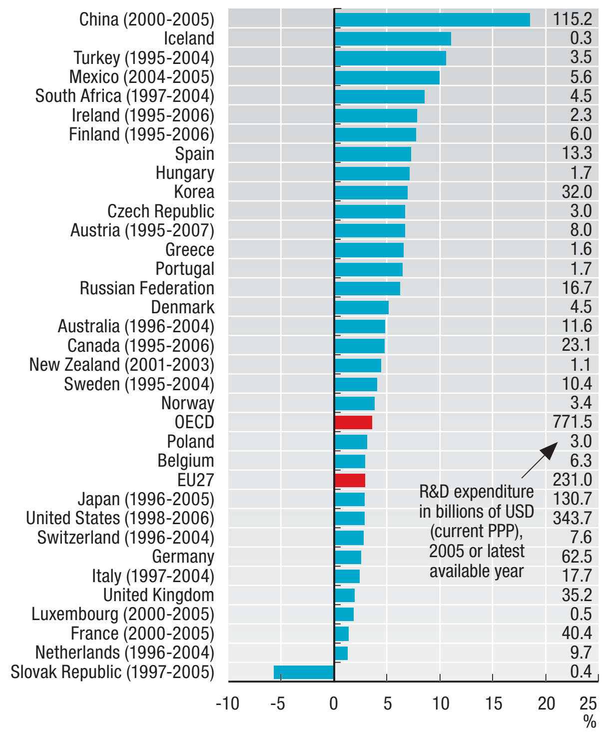
A.2. TRENDS IN DOMESTIC R&D EXPENDITURE

R&D intensity[1], 2005



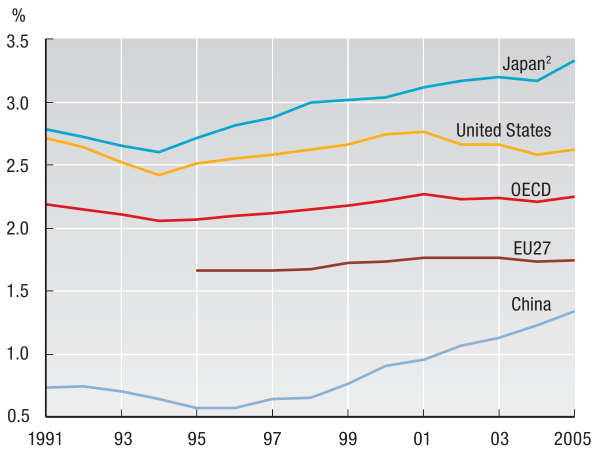
Evolution of gross domestic expenditure on R&D, 1995-2005

Average annual growth rate, constant prices



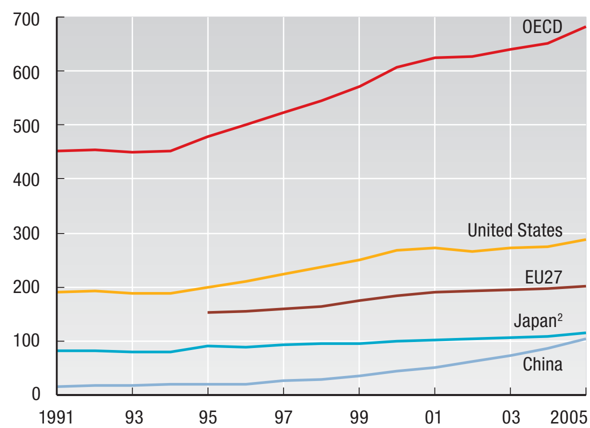
Trends in R&D intensity[1] by area, 1991-2005

As a percentage of GDP



Gross domestic expenditure on R&D by area, 1991-2005

Billions of USD PPP (2000)[3]



StatLink http://dx.doi.org/10.1787/116588372230

1. Gross domestic expenditure on R&D as a percentage of GDP.
2. Data are adjusted up to 1995.
3. USD of 2000 in purchasing power parity (PPP).

A.3. R&D FINANCING AND PERFORMANCE

The business sector continues to be the major source of financing of domestic R&D. In 2005, it accounted for almost 63% of funding in OECD countries.

The business sector's role in R&D funding differs sharply across the three main OECD regions. It funds three-quarters of R&D in Japan and 65% in the United States, but only 54% in the European Union. Since 2000, the share of business funding of R&D has decreased somewhat in the United States, increased moderately in Japan and remained stable in the EU.

During the same period, the business sector's share of R&D funding has remained stable in most countries. However, it has declined by more than 8 percentage points in the Slovak Republic, Luxembourg and Ireland.

In the Slovak Republic, Ireland, Iceland and Turkey, the share of government funding of R&D has increased moderately since 2000. Government remains the major source of R&D funding in almost one in four OECD countries.

Foreign funding of R&D continues to be an important source of financing in many OECD countries. Belgium, Denmark, Hungary, Iceland and the Netherlands receive more than 10% of their R&D funding from abroad. Austria, Greece and the United Kingdom receive more than 15%.

The business sector also performs the most R&D. Its contribution to the overall R&D effort increased in the second half of the 1990s and has remained stable at around 68% since 2002.

The higher education and government sectors perform almost 30% of all R&D in the OECD area. Their combined share is more than double the OECD average in Poland, Turkey and Greece.

Source

- OECD, Main Science and Technology Indicators database, May 2007.

For further reading

- OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Development*, OECD, Paris, available at: *www.oecd.org/sti/frascatimanual*.

R&D performance and funding

The R&D effort (expenditure and personnel) is usually broken down among four sectors of performance: business enterprise, higher education, government and private non-profit institutions serving households (PNP). This breakdown is largely based on the System of National Accounts, but higher education is viewed as a special sector, owing to the important role played by universities and similar institutions in the performance of R&D.

R&D has various sources of financing. Five are generally taken into account: the four R&D-performing sectors mentioned above and funds from "abroad". Flows of funds are measured using performance-based reporting on the funds received by one unit, organisation or sector from another unit, organisation or sector for the performance of intramural R&D. What is therefore measured are direct transfers of resources used to carry out R&D; other government provisions to encourage R&D, such as tax concessions, payment of bonuses for R&D, exemption from taxes and tariffs on R&D equipment, etc., are excluded. For purposes of international comparisons, public general university funds (GUF) are included in the sub-total for government funds. These are the funds allocated by higher education establishments to R&D from the general grant in support of their overall research and teaching activities which they receive from the Ministry of Education or the corresponding provincial or local authorities.

When assessing the contributions of the different sectors to R&D performance and the changes over time, it is important to take account of changes in methods and breaks in series, as well as national practices. For example, the transfer of public-sector organisations to the private sector would reduce the government sector's contribution and increase that of the business sector. In the United States, funds from abroad are included with financing by the business enterprise sector.

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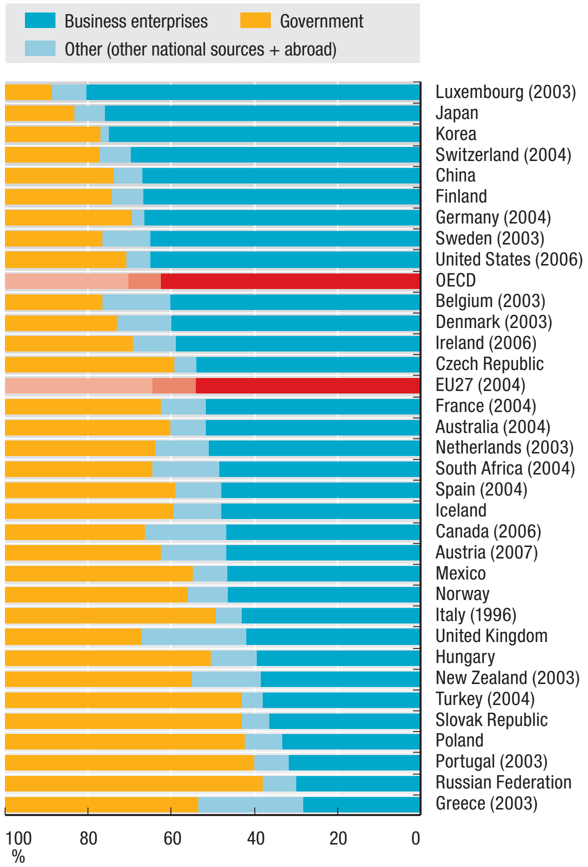
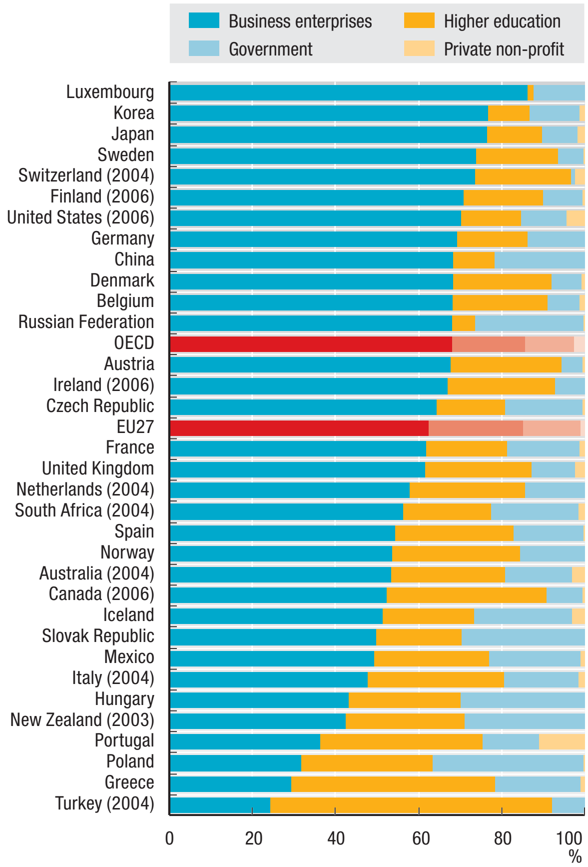
R&D expenditure by source of financing, 2005

As a percentage of the national total



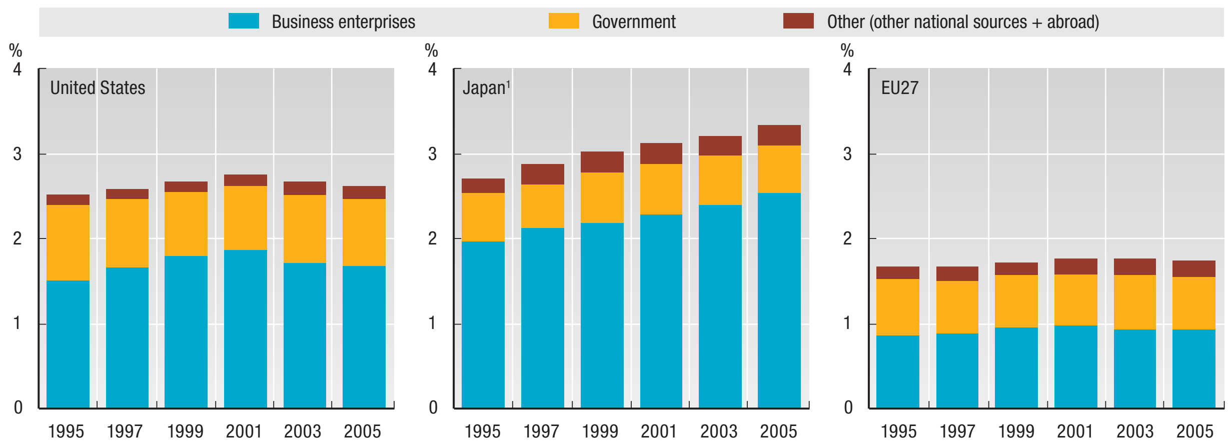
R&D expenditure by performing sector, 2005

As a percentage of the national total



R&D expenditure by source of financing, 1995-2005

As a percentage of GDP



StatLink http://dx.doi.org/10.1787/116676883373

1. Data for 1995 are adjusted.

A.4. R&D IN NON-OECD ECONOMIES

Non-OECD economies account for a growing share of the world's R&D. In 2005, those included here (see box) accounted for 21.4% of the R&D expenditure (expressed in current USD purchasing power parity – PPP) of OECD and non-OECD economies combined, up from 17% four years earlier.

China made by far the largest contribution, accounting for 55% of the non-OECD share. It ranked third world wide, behind the United States and Japan, but ahead of individual EU member states. However, the conversion from national currency into USD PPP may overestimate China's R&D effort.

In 2005, Israel had the world's highest R&D intensity, spending 4.5% of GDP on civil R&D, twice the OECD average. Chinese Taipei and Singapore were the only other non-OECD economies with an R&D intensity above the OECD average.

In most of the non-OECD economies covered, the increase in R&D was well above the OECD average. Growth of R&D expenditure in China has been particularly impressive, at an annual average rate of 18.5% for 2000-05, up from 16.4% over the preceding five years. China has set a target of raising R&D intensity to 2% by 2010 and to 2.5% or above by 2020. This is an extremely ambitious target, particularly when the rate of growth of GDP is taken into account. Implicitly, this means R&D expenditure will need to continue to increase by at least 10-15% annually. Double-digit growth rates were also reported by the new, small EU countries.

Industrial R&D is very closely linked to the creation of new products and production techniques and is therefore an important driver of economic growth. In less developed non-OECD countries, as in less developed OECD countries, however, most R&D is performed by the government and higher education sectors.

Sources

- OECD, Main Science and Technology Indicators database, July 2007.
- Eurostat, New Cronos database, July 2007.
- Data for some countries have been compiled from national sources.

For further reading

- OECD (2002), *Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development*, OECD, Paris, available at: *www.oecd.org/sti/frascatimanual*.
- OECD (2007), *Main Science and Technology Indicators 2007/1*, OECD, Paris.

Measuring R&D in non-OECD economies

R&D data for Argentina, China, Chile, Israel, Romania, the Russian Federation, Singapore, South Africa, Slovenia and Chinese Taipei are included in the OECD database and, with the exception of Chile, are published in the OECD's *Main Science and Technology Indicators* (MSTI). Data for Bulgaria, Croatia, Cyprus, Estonia, Latvia, Lithuania and Malta are from Eurostat's New Cronos database. Data for Brazil, Hong Kong (China) and India are from national S&T ministries (or equivalent) or the central statistical office.

The R&D data for non-OECD countries that are included in the MSTI database largely comply with the recommended methodology of the *Frascati Manual*, and the same can be said for the data from Eurostat's database. Data for the other countries included here may not be completely in accordance with the *Frascati Manual* guidelines.

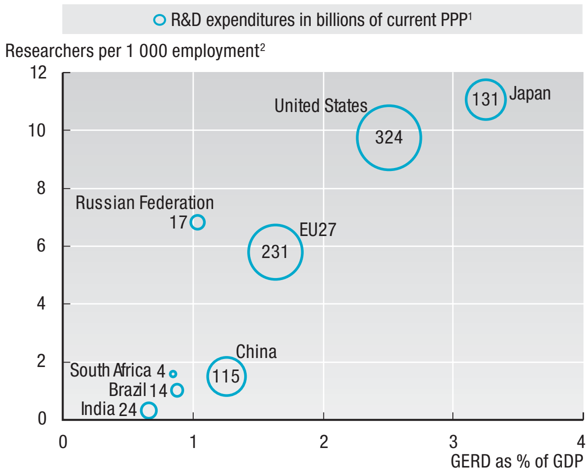
When examining the data, the following should be kept in mind.

- In Brazil, data for the business enterprise sector are collected through innovation surveys, which were held in 2000 and 2003 and cover only mining and quarrying and manufacturing. Data for 2004 are estimated. Data for the higher education sector are estimated using budgetary information and are probably underestimated.
- In Chile, data for the business enterprise sector are collected through innovation surveys. Data for the government sector are estimated using budgetary information and are probably underestimated.
- For China, the rates used to convert R&D expenditure from national currency to USD PPP are likely to be underestimated, hence R&D data expressed in USD PPP are likely to be overestimated.
- In India, the small-scale industry sector is only partially covered. Data for 2004-05 were estimated by applying sector-wise growth rates for the period 1998-99 to 2002-03.
- In Israel, defence R&D is not covered. Furthermore, humanities and law are only partially covered in the higher education sector.
- In Latvia, the business enterprise sector is not fully covered, hence the data are underestimated.
- In Romania and the Russian Federation, much R&D is traditionally performed by public enterprises, which are classified in the business enterprise sector.
- Owing to the lack of a comprehensive business register for South Africa, R&D expenditure may be underestimated by 10-15%.

A.4. R&D IN NON-OECD ECONOMIES

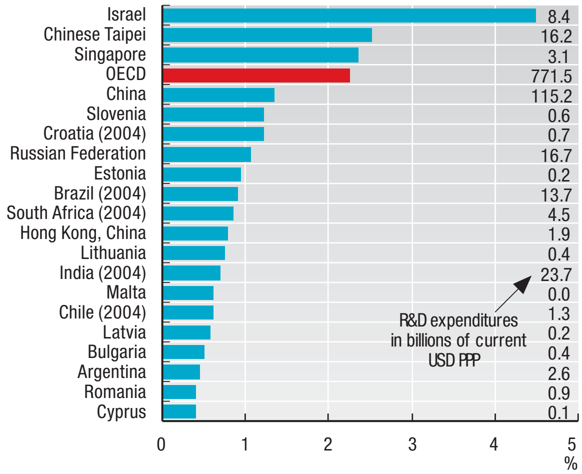
R&D in the OECD and non-OECD area, 2005

GERD as a percentage of GDP, in billions of current USD PPP, and researchers per 1 000 persons employed



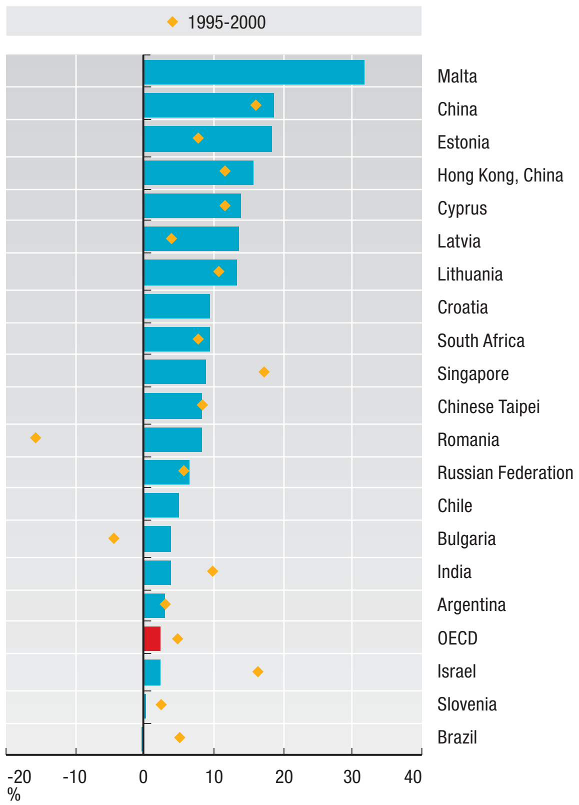
Gross expenditure on R&D (GERD), 2005

As a percentage of GDP, in billions of current USD PPP



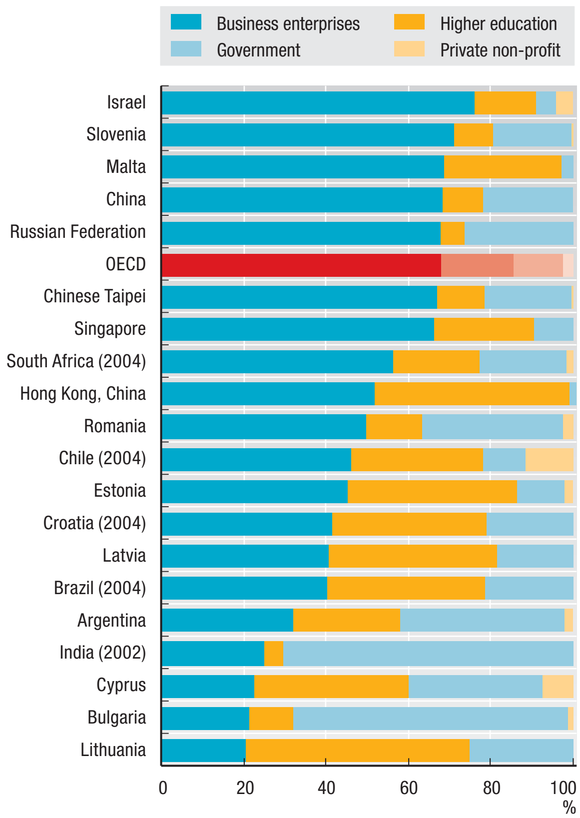
Evolution of GERD, 2000-05

Annual average growth rate[3]



R&D expenditure by performing sector, 2005

As a percentage of the national total



StatLink http://dx.doi.org/10.1787/116720355223

1. The size of the bubble represents R&D expenditure in billions of current USD in PPP; data for Brazil, India and South Africa are for 2004.
2. For researchers per 1 000 persons employed: India 2000 and EU27 2004.
3. Based on data in constant 2000 prices. Different reference years: Argentina 1996-2000; Brazil and India 2000-04; China 1995-99; Croatia and Chile 2002-04; Cyprus, Estonia and Hong Kong (China) 1998-2000; Malta 2002-05; and South Africa 1997-2001 and 2001-04.

A.5. BUSINESS R&D

■ Business enterprise R&D (BERD) accounts for the bulk of R&D activity in OECD countries in terms of both performance and funding (see A.3). In 2005, R&D performed by the business sector reached USD 524 billion (in current PPP), or close to 68% of total R&D.

■ In the OECD area, R&D performed by the business sector has increased steadily in real terms over the past two decades. The pace of growth picked up in the mid-1990s, but has slowed since 2001. Business R&D in the United States increased by 3.6% a year between 1995 and 2005, by 3.0% in the European Union and by 4.6% in Japan.

■ Between 1995 and 2005, OECD-area BERD grew by USD 143 billion (in PPP of 2000). The United States accounted for around 40% of this growth.

■ Since 1995, annual average growth rates for business enterprise R&D were highest in China, Mexico, Iceland, Portugal and New Zealand. Only the Slovak Republic experienced a significant decline. In 2005, BERD in China reached USD 78.7 billion (in current PPP), or roughly the combined value for Germany, France and Italy, although this figure is likely to be overestimated (see A.2).

■ In Japan, the United States and Europe, business R&D intensity (expenditure relative to value added in industry) increased from the mid-1990s to 2000. Growth has continued since in Japan, but business R&D intensity dropped in the United States to 2.6% in 2005, down from a peak of 2.9% five years earlier, and decreased slightly in the EU between 2001 and 2005.

■ Business R&D intensity is well above the OECD average of 2.2% in all Nordic countries except Norway, but particularly in Sweden (4.6%) and Finland (3.7%). Iceland has experienced a large increase of 1.5 percentage points in business R&D intensity since 1995.

Source

- OECD, Main Science and Technology Indicators database, May 2007.

For further reading

- OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, OECD, Paris, available at: *www.oecd.org/sti/frascatimanual*.

Business enterprise expenditure on R&D

Business enterprise expenditure on R&D (BERD) covers R&D activities carried out in the business sector by performing firms and institutes, regardless of the origin of funding. While the government and higher education sectors also carry out R&D, industrial R&D is most closely linked to the creation of new products and production techniques, as well as to a country's innovation efforts. The business enterprise sector includes:

- All firms, organisations and institutions whose primary activity is production of goods and services for sale to the general public at an economically significant price.
- The private and non-profit institutes mainly serving them.

When assessing changes in BERD over time, it is necessary to take account of changes in methods and breaks in series, notably concerning the extension of survey coverage, particularly in the services sector, and the privatisation of publicly owned firms.

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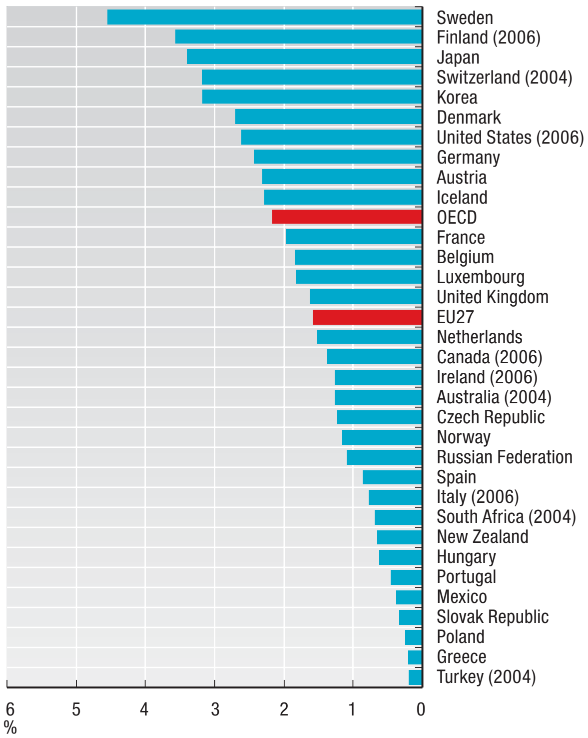
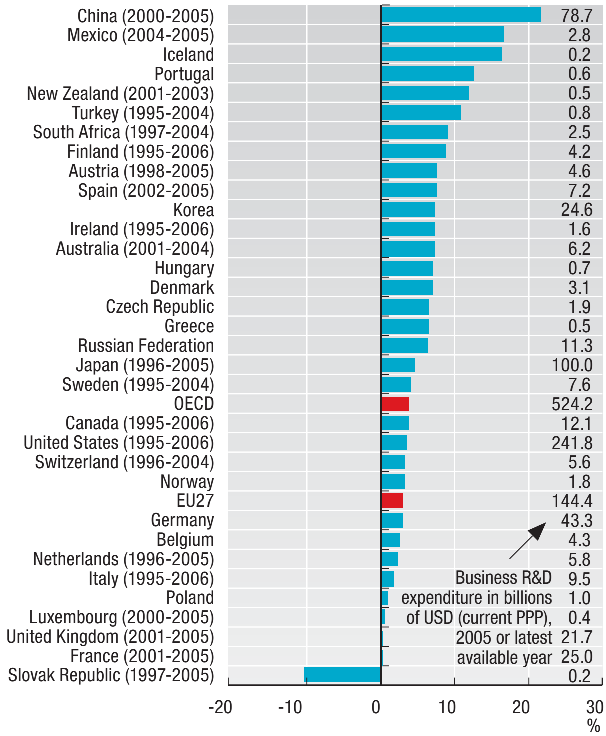
Business R&D intensity[1], 2005



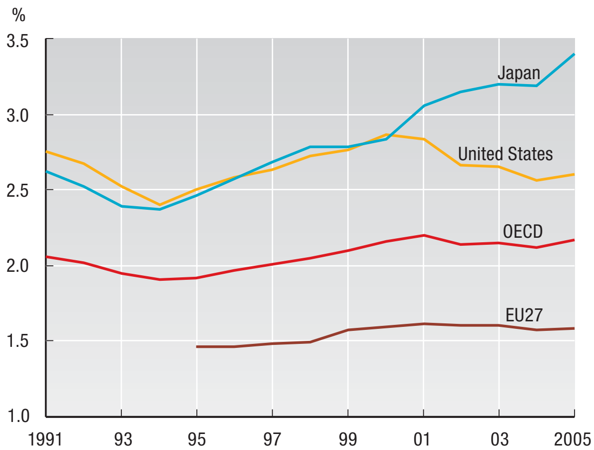
Growth of business R&D, 1995-2005

Annual average growth rate, USD PPP of 2000[2]



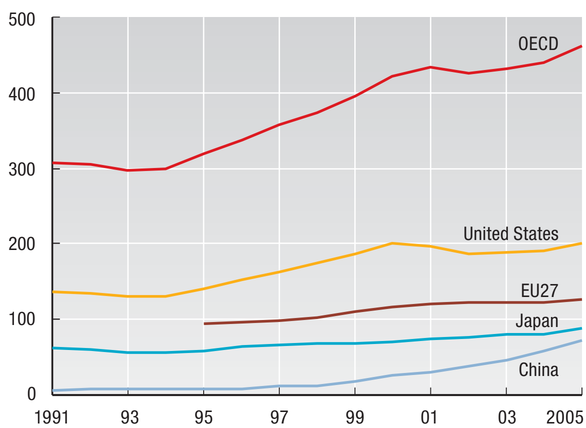
Evolution of business R&D intensity[1], 1991-2005

As a percentage of value added in industry



Evolution of business R&D, 1991-2005

Billions of USD PPP (2000)[2]



StatLink http://dx.doi.org/10.1787/116745128483

1. Business enterprise expenditure on R&D as a percentage of industry value added.
2. USD of 2000 in PPP.

A.6. BUSINESS R&D BY SIZE CLASSES OF FIRMS

Both small and large firms play an important role in countries' innovative performance, but their relative importance for business R&D varies. In OECD countries, the share of R&D performed by small and medium-sized enterprises (SMEs) (defined here as firms with fewer than 250 employees) is generally greater in smaller economies than in larger ones.

Firms with fewer than 250 employees account for a large share of business R&D in New Zealand (73%), Greece (53%), Norway (52%), the Slovak Republic (51%) and Ireland (47%). In the larger EU countries, their share is less than 20%, and in the United States it is less than 15%. Japan has one of the lowest shares among OECD countries, with only 8%.

Firms with fewer than 50 employees account for a significant share of business R&D (over 20%) in Norway, New Zealand, Ireland, and Australia.

OECD countries also differ greatly in terms of government financing of business R&D by size class. In Portugal and Hungary, SMEs receive three-quarters or more of government-financed R&D. In Portugal, Hungary, and Australia, more than half of government-financed R&D goes to firms with fewer than 50 employees. The United Kingdom, France and the United States are the countries in which the highest share of government-financed business R&D is directed to large firms.

Source

- OECD, R&D database, May 2007.

For further reading

- OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development,* OECD, Paris, available at: *www.oecd.org/sti/frascatimanual*.

R&D data by size class of firms

Small and medium-sized firms (SMEs) play an important role in innovation. They are a constant source of renewal of technology, of technological breakthroughs and of competitive pressures for large firms, which are compelled to innovate to maintain their technological edge. However, SMEs face specific problems for innovating and for adopting new technologies (access to funds, markets and skilled labour). Moreover, it is often argued that public policies are biased against SMEs and that this might justify corrective action in their favour.

On the other hand, the role of large firms should not be ignored: they play a leading role in structuring markets, carrying out large-scale innovations and even in co-ordinating smaller firms. The respective and complementary roles of small and large firms may vary across industries and across countries. The relevance of various types of policy tools may vary with the size profile of the target population of firms.

To conform to the size classification adopted by the European Commission for SMEs – and as recommended in the 2002 *Frascati Manual* (para. 183) – the data were aggregated using the size groups "fewer than 50" and "50 to 249 employees".

These data make it possible to discern whether government support is biased towards larger firms. This appears to be particularly the case in countries with large defence budgets.

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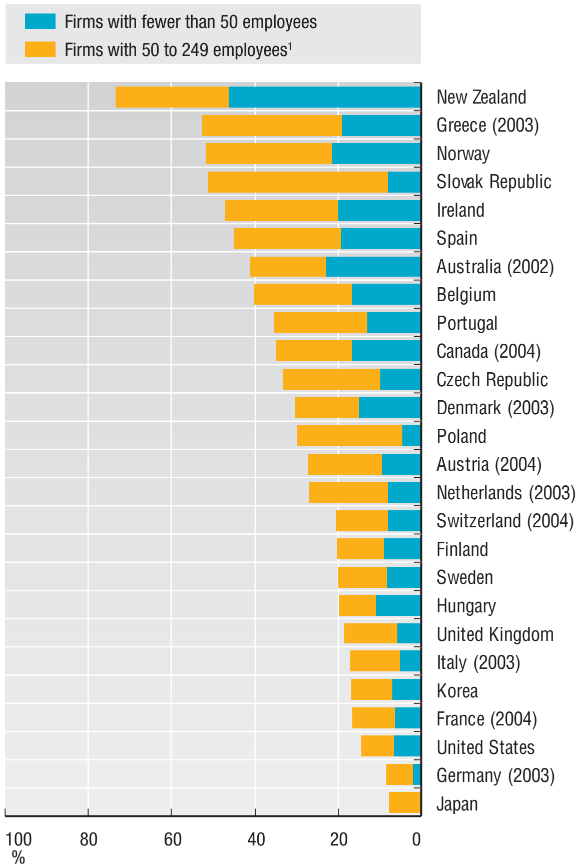
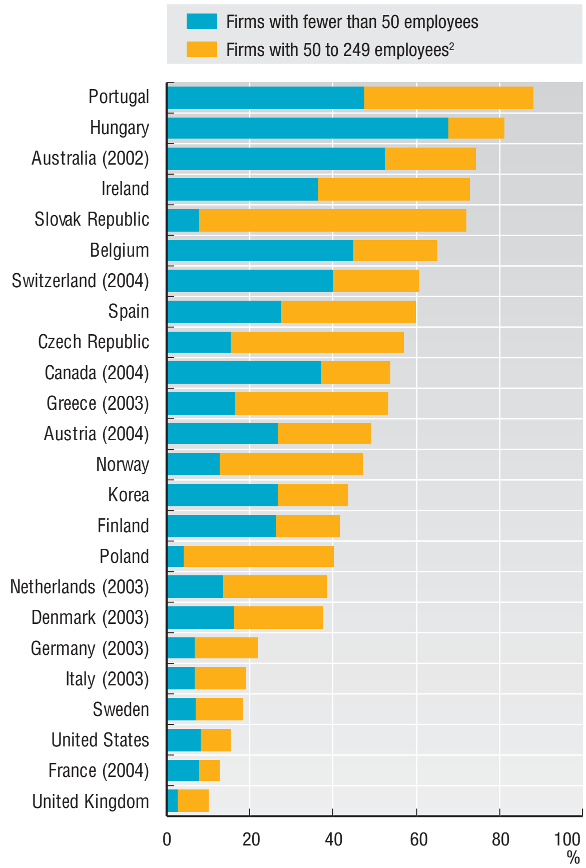
A.6. BUSINESS R&D BY SIZE CLASSES OF FIRMS

Share of business R&D by size class of firms, 2005



Share of government-financed business R&D by size class of firms, 2005



1. For Japan and Korea, fewer than 299 employees.
2. For Korea, fewer than 299 employees.

StatLink http://dx.doi.org/10.1787/116824832677

A.7. BUSINESS R&D BY INDUSTRY

While the economic structure of OECD countries has moved towards services, these still represent a much smaller share of R&D than of GDP. In 2004, they accounted for 28% of total business sector R&D in the OECD area, an increase of 11 percentage points from 1995.

Given the measurement difficulties associated with services, and the methodological differences in classifying firms' R&D expenditure by industry, this should be taken as a lower bound. The share of services in business enterprise expenditure on R&D (BERD) is often higher in countries that have undertaken special measurement efforts in this area, as well as in those that classify R&D by firms' principal activity.

More than one-third of total business R&D is carried out in the services sector in Australia (47%), Norway (42%), Canada (39%), Ireland (39%), the Czech Republic (38%), the United States (36%) and Denmark (34%). For their part, Korea, Germany and Japan have the smallest shares of services R&D (under 10%). This may partly be due to limited coverage of the services industries in their R&D surveys.

Since 1995, average annual growth rates for R&D have been higher in services than in manufacturing for all countries except the Czech Republic. Ireland had the greatest difference in R&D growth rates for the two sectors: between 1995 and 2004, Irish R&D increased by 20.5% in services (mainly driven by growth in computer services) and by 2% in manufacturing.

Manufacturing industries are grouped in four categories according to their R&D intensity: high, medium-high, medium-low and low technology (see I.7). In the OECD area, high-technology industries account for more than 53% of total manufacturing R&D. In 2004, R&D in high-technology industries accounted for over 63% of total manufacturing R&D in the United States compared to 47% and 43% in the European Union and Japan, respectively.

Manufacturing R&D expenditure is skewed towards high-technology industries in Finland, Canada, the United States and Ireland. Medium-high-technology industries account for 50% or more in the Czech Republic and Germany. Australia and Norway are the only OECD countries in which medium-low and low-technology industries account for more than 30% of manufacturing R&D.

Source

- OECD, ANBERD database, June 2007.

For further reading

- OECD (2006), *Research and Development Expenditure in Industry 1987-2004*, available at: *www.oecd.org/sti/anberd/*.
- OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, OECD, Paris, available at: *www.oecd.org/sti/frascatimanual*.

Business R&D by industry

National statistical authorities recognise the need to improve R&D data for services, and R&D surveys are being extended to this end. However, certain methodological issues that have arisen need to be resolved. One is the way in which a firm's R&D is assigned to an industry, a particular problem for firms conducting heterogeneous research activities. Some countries follow a "principal activity" approach in which all of a firm's R&D is assigned to that firm's principal industrial activity code. Others break R&D down by "product field", *i.e.* the R&D is assigned to the industries of final use. Many countries follow a combination of these approaches. The *Frascati Manual* (2002) recommends distributing R&D by product field for all industry groups and as a minimum for the R&D industry (ISIC Rev. 3 Division 73), but not all countries follow this method.

The Analytical Business Enterprise R&D (ANBERD) database was constructed to create a data set that is as consistent as possible in order to overcome problems of international comparability and temporal discontinuities associated with official data on business enterprise expenditure on R&D (BERD). The current ANBERD database covers 19 OECD member countries and 58 sectors and has greater coverage of services. The data, from 1987, are based on ISIC, Rev. 3. ANBERD data are estimated by the OECD from official data supplied by national statistical authorities. Therefore, while efforts are made to adjust the data, it is important to exercise caution when using them.

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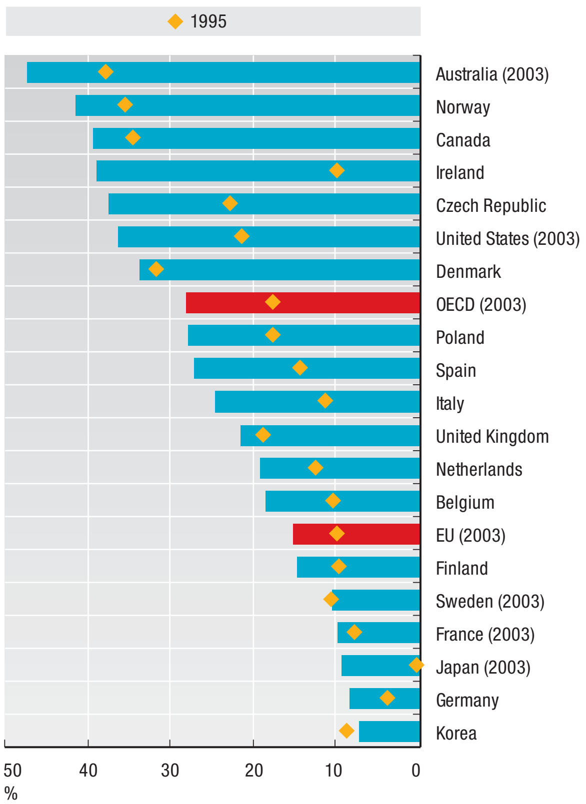
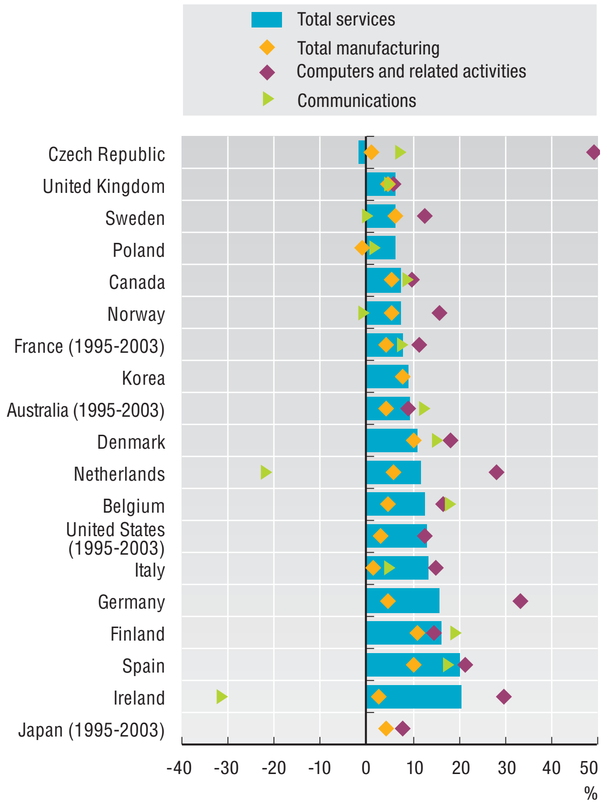
A.7. BUSINESS R&D BY INDUSTRY

Share of services in business R&D,[1] 2004

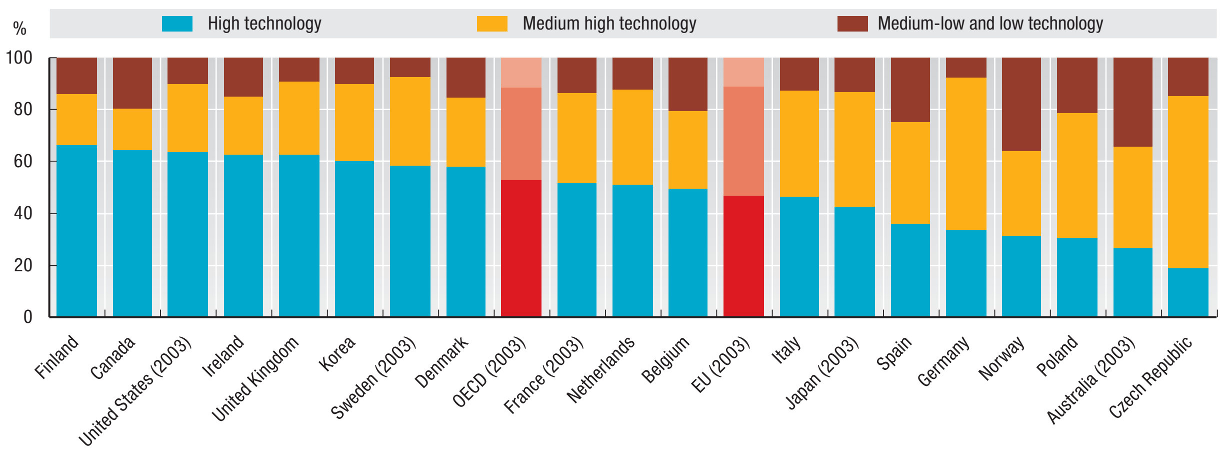


R&D in selected services industries and the manufacturing sector, 1995-2004

Average annual growth rate



Share of business R&D in the manufacturing sector by technological intensity, 2004



StatLink http://dx.doi.org/10.1787/116852022367

1. Share of services in total services and manufacturing industries.

A.8. HEALTH-RELATED R&D

R&D expenditures for health are of great interest because of the sector's size and its expected growth owing to the ageing of the population in many OECD countries. They are difficult to measure; however, because of institutional complexity and diversity (*e.g.* health-related R&D may be publicly or privately funded and be carried out in firms, universities, hospitals and private non-profit institutions).

In OECD countries in 2005, direct government support for health-related R&D based on government budget appropriations for R&D (GBAORD – see box for definition) was about 0.11% of their combined GDP.

In 2006, direct support for health-related R&D represented over 0.22% of GDP in the United States, far above the levels for the European Union (0.05% in 2005) and Japan (0.03% in 2006). Since 2000, it has decreased only in the Slovak Republic.

The data on direct support for health-related R&D suggest that the United States accounts for around three-quarters of the OECD total. However, when data from additional GBAORD categories are used to adjust for institutional differences in the funding of health R&D, a different picture emerges. The United States is no longer an outlier: health-related R&D budgets relative to GDP approach that of the United States in a number of countries, notably owing to the important contribution of funding of medical science (through general university funds and non-oriented research). Sweden, with one of the smallest direct government budgets for health-related R&D as a percentage of GDP, is a case in point.

Another indicator often used as a component of health-related R&D is R&D expenditure by the pharmaceutical industry. In 2004, it represented over 0.5% of GDP in Sweden, compared to 0.47% in 1999 and only 0.25% in 1991. It exceeded 0.2% in Denmark, Belgium and the United Kingdom.

The share of pharmaceutical R&D in business sector R&D (BERD) is above 20% in the United Kingdom, Belgium, Denmark and Sweden. While the ratio of pharmaceutical R&D to GDP is low in Italy, Poland and Spain (less than 0.1%), this sector accounts for a significant share of total business sector R&D in the three countries (at least 8%).

Sources

- OECD, R&D database, May 2007.
- OECD, ANBERD database, May 2007.
- Eurostat, GBAORD database, May 2007.

For further reading

- OECD (2006), *Research and Development Expenditure in Industry 1987-2004*, OECD, Paris, available at: *www.oecd.org/sti/anberd*.
- OECD (2002), *Frascati Manual*, Annex 4 – "Deriving data on health-related R&D from regular R&D statistics", OECD, Paris, available at: *www.oecd.org/sti/frascatimanual*.
- OECD (2001), *Measuring Expenditure on Health-related R&D*, OECD, Paris.

Measuring government support for health-related R&D

One way of measuring health related R&D expenditure is to compile data from funders of R&D. The data on central government support for R&D are derived from budgets and are referred to as government budget appropriations or outlays for R&D (GBAORD). GBAORD can be broken down by socioeconomic objectives (SEO), such as the protection and improvement of public health, which is defined as follows:

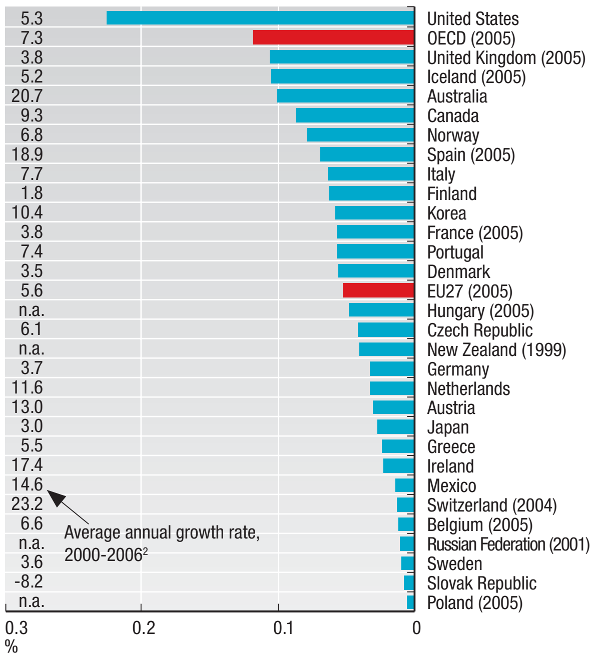
"This category covers research aimed at protecting, promoting and restoring human health broadly interpreted to include health aspects of nutrition and food hygiene. It ranges from preventative medicine, including all aspects of medical and surgical treatment both for individuals and groups and provision of hospital and home care to social medicine and paediatric and geriatric research." (*Frascati Manual*, OECD, 2002).

The GBAORD health category is used here as a proxy for total central government funding of health-related R&D. However, it should be borne in mind that it only covers programmes for which health is the primary objective. Furthermore, the classification of programme and institutional funding depends on how governments present their R&D priorities as well as on the formal mandate of the institutions concerned. For example, long-term research may be the responsibility of a medical research body classified in health objectives (*e.g.* the National Institutes of Health in the United States) or of a general research council whose funds are mainly awarded for non-oriented research (*e.g.* the National Council for Scientific Research in France). Arrangements for funding R&D in hospitals also vary between countries.

To address some of the limitations mentioned above and to provide a more complete picture of health-related R&D, funding of medical sciences via non-oriented research and general university funds are included when available as are other relevant funds, notably general support for R&D in hospitals.

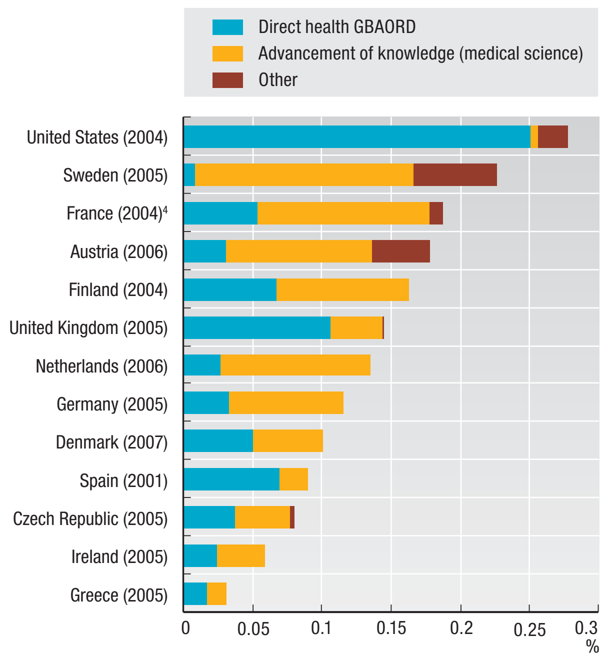
Health-related R&D in government budgets (GBAORD[1])

As a percentage of GDP, 2006

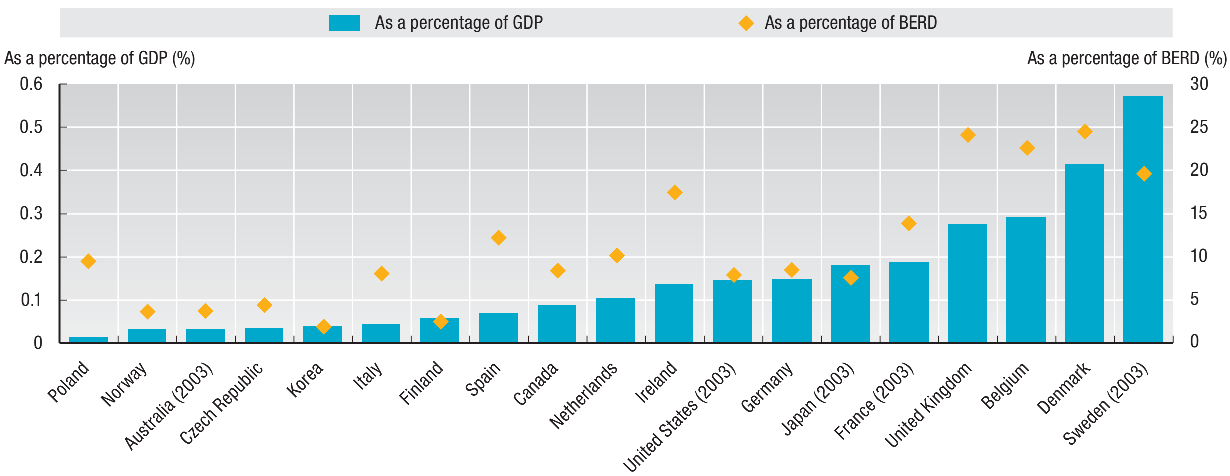


Effect of including other health-related NABS[3] categories in health GBAORD

As a percentage of GDP, 2006



R&D expenditure in the pharmaceutical industry as a percentage of GDP and BERD,[5] 2004



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1. Government budget appropriations or outlays for R&D.
2. Growth rate for 2000-05 for OECD, the United Kingdom, Iceland, Spain, France, EU27 and Belgium; 2000-04 for Norway and Switzerland; and 2002-06 for the Czech Republic and the Slovak Republic.
3. Nomenclature for the analysis of science budgets. "Advancement of knowledge" comprises non-oriented R&D and general university funds and "other" other relevant national and international categories.
4. Includes "some other life sciences research".
5. Business enterprise expenditure on R&D.

A.9. VENTURE CAPITAL

■ Venture capital is a major source of funding for new technology-based firms. It plays a crucial role in promoting the radical innovations often developed by such firms and is one of the decisive determinants of entrepreneurship.

■ Interestingly, over 2003-05, venture capital investment in the early and expansion stages rose significantly in the three countries with the highest level of venture capital investment as a percentage of GDP in 2005: Denmark, with an annual growth rate of 95%, Sweden (45%) and United Kingdom (35%). It declined in Finland, Spain and Italy.

■ In 2005, the United States (with 39%) and the United Kingdom (with 11%) attracted half of all OECD venture capital. The United Kingdom received more than 40% of total EU venture capital investments. As a percentage of GDP, venture capital investment in early-stage and expanding firms was highest in Denmark (40%), followed by Sweden and the United Kingdom (over 30%) and the United States (18%); other OECD countries had substantially smaller shares.

■ High-technology firms attracted 40% of OECD venture capital investments, but disparities among countries are large. Investment in high-technology sectors was particularly strong in Ireland (96%), the United States (88%) and Canada (81%), but accounted for 20% or less in Hungary, the Netherlands, the Czech Republic and Australia.

■ Within the three main high-technology sectors, the portfolio of investment differs considerably across countries. Communications attracted more than 60% of high-technology investments in the Slovak Republic, Italy, Spain and the United Kingdom. Information technology led in Poland, Finland, Austria and Ireland. Health and biotechnology attracted the most funds in Denmark (92%), as well as in Belgium, Sweden and New Zealand.

Sources

- OECD, Venture Capital database. Based on data from EVCA (Europe), PWC MoneyTree (United States), CVCA (Canada), AVCAL (Australia), NZVCA (New Zealand) and AVCJ(Asia).

For further reading

- OECD Entrepreneurship Indicators Project , *www.oecd.org/statistics/industry-services/entrepreneurship*.
- Baygan, G. and M. Freudenberg (2000), “The Internationalisation of Venture Capital Activity in OECD Countries: Implications for Measurement and Policy”, *STI Working Paper 2000/07*, available at: *www.oecd.org/sti/working-papers*.

Venture capital

Venture capital is provided by specialised financial firms acting as intermediaries between primary sources of finance (such as pension funds or banks) and firms (formal venture capital). It is also provided by so-called “business angels” (usually wealthy individuals experienced in business and finance who invest directly in firms).

Data on venture capital are collected by national or regional venture capital associations from their members. Statistics only capture formal venture capital (provided by specialised intermediaries). As business angels are excluded, international comparisons may be affected since business angels in the United States have tended to invest much more in new firms than venture capital funds. This is probably much less the case in other OECD countries.

The development of a venture-backed company has three basic financing stages:

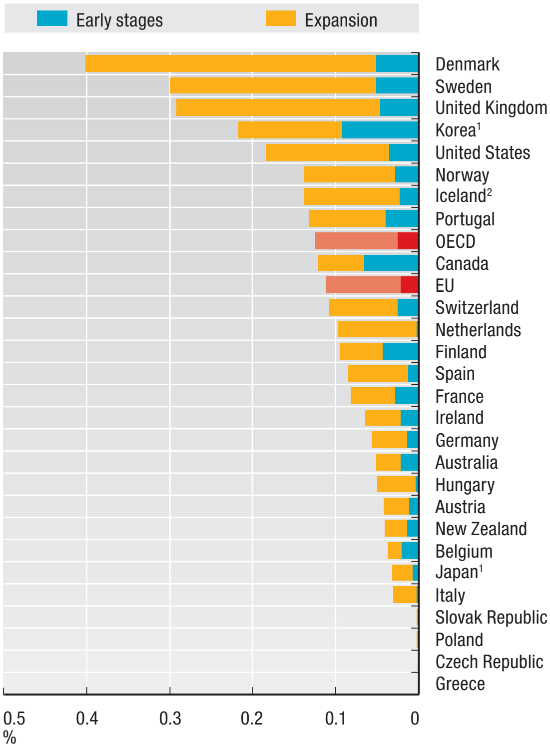
- *Seed capital* is provided to research, assess and develop an initial concept.
- *Start-up* financing is provided for product development and initial marketing. Companies may be being set up or may have been in business for a short time, but have not yet sold their product commercially.
- *Expansion* financing is provided for the growth and expansion of a company that is breaking even or trading profitably. Capital may be used to finance increased production capacity, market or product development and/or to provide additional working capital.

Not all funds managed by a venture capital firm operating in a given country are from investors in that country. In fact, there are substantial and increasingly important cross-border flows of funds, both inflows and outflows. Venture capital data can be collected using two different approaches: country of management and country of destination. The former refers to the geographic location of the venture capital firms that raise and invest these funds. The latter indicates the geographic destination of investments made by firms. This distinction between country of management and country of destination is important as investment in a country may matter more than investment by a country.

A.9. VENTURE CAPITAL

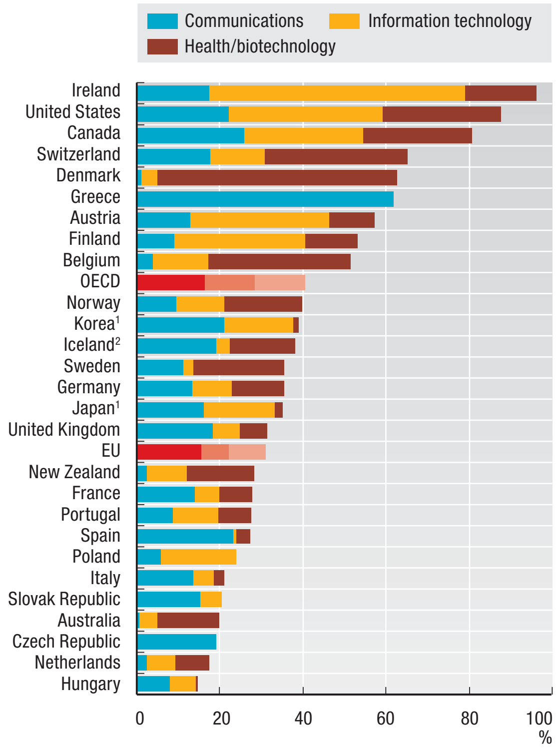
Venture capital investment, 2005 or latest available year

As a percentage of GDP



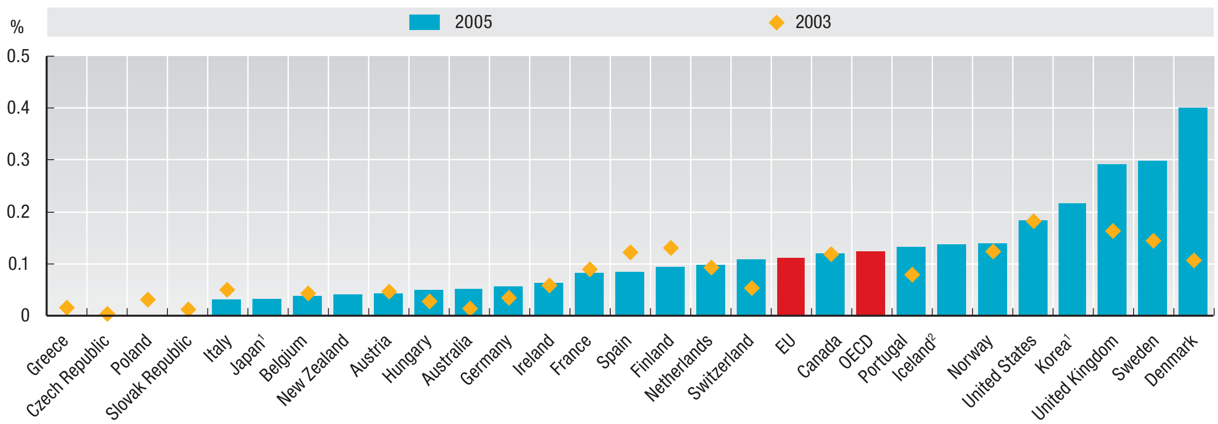
Share of high-technology sectors in total venture capital, 2005 or latest available year

As a percentage of total venture capital investment[3]



2003-05 trends in venture capital investment

As a percentage of GDP



StatLink http://dx.doi.org/10.1787/117030452887

1. 2001.
2. 2002.
3. For European countries, total venture capital investment broken down by sectors includes investments in early-stage, expansion, buy-out and others.

B. HUMAN RESOURCES IN S&T

B.1. NEW UNIVERSITY GRADUATES

New university graduates furnish an indicator of a country's potential for assimilating, developing and diffusing advanced knowledge and supplying the labour market with highly skilled workers.

In 2004, OECD universities awarded about 6.7 million degrees, of which 179 000 doctorates. At the typical age of graduation, 35% of the population completed a university degree and 1.3% a doctoral degree. Iceland, New Zealand, Finland, Australia, Norway and Denmark had the highest graduation rates (over 45% of the population), and Sweden, Switzerland and Portugal the highest rates at doctoral level with 3.1, 2.7 and 2.5 doctorates granted per 100 inhabitants respectively. China is also massively expanding its university system and awarded 2.1 million degrees in 2004 (23 000 doctorates). In India, 13 700 doctorates were awarded in 2003, of which 38% in science and engineering (S&E).

More than one-third of university graduates obtain a degree in social sciences, business or law. Scientific studies (excluding health and welfare) remain the second most popular field although the share of OECD graduates obtaining an S&E degree has declined to one-fifth. In Korea S&E degrees account for almost 40% of all new degrees.

The US and EU outflows of university graduates are equivalent to 31 and 39%, respectively, of all OECD university degrees, but the EU delivers an even higher share of advanced research and S&E diplomas. In 2004, European universities granted 609 000 S&E university degrees, 43% of total OECD university degrees awarded in these fields, compared to only 22% for the United States. The gap widens for doctoral degrees: European universities awarded 57% of all S&E doctorates.

In about two-thirds of OECD countries, universities deliver more engineering than science degrees; in Finland, Japan, Korea and Sweden the number of engineering degrees awarded far exceeds that of science degrees. The reverse is true in Australia, Greece, New Zealand and the United Kingdom.

While graduation rates for females equal or exceed those for males in most OECD countries, women are still under-represented in advanced research programmes. They are less likely to graduate at doctoral level except in Portugal, Italy and Iceland; in Japan and Korea, they receive less than a quarter of all doctorates awarded. They are even less likely to obtain university degrees in S&E. Women account on average for more than two-thirds of OECD degrees in humanities, arts, education, health and welfare, but for less than one-third in mathematics and computer science, and less than one-quarter in engineering. Some 80% of S&E university degrees awarded in Japan, the Netherlands and Switzerland are delivered to men.

Sources

- OECD, Education database, 2007, UNESCO Institute for Statistics and *China Statistical Yearbook 2005*.

For further reading

- OECD (2006), *Education at a Glance: OECD Indicators 2006*, OECD, Paris. Available at: *www.oecd.org/edu/eag2006*.
- OECD and Eurostat (1995), Manual on the Measurement of Human Resources Devoted to S&T – Canberra Manual, OECD, Paris.
- OECD (2006), *Evolution of Student Interest in Science and Technology Studies, Policy Report*. Available at: www.oecd.org/dataoecd/16/30/36645825.pdf

Higher education outflows to stocks of human resources in science and technology

New university graduates encompass all those who receive tertiary degrees delivered at the levels 5A and 6 of the 1997 International Standard Classification of Education (ISCED-1997). Doctoral graduates are those who complete an advanced research programme at ISCED level 6. Science degrees include the following ISCED-1997 fields of study: life sciences; physical sciences; mathematics and statistics; and computing. Engineering degrees comprise the following fields of study: engineering and engineering trades; manufacturing and processing; and architecture and building.

Graduation rates for advanced research programmes give the number of persons receiving a doctorate-level degree as a percentage of the population at the typical age of graduation. Figures refer to net graduation rates, calculated by summing graduation rates by individual years of age. However, for a few countries, the net graduation rate is unavailable and the gross graduation rate is used instead. Gross rates are calculated as the percentage of graduates in the population at the typical age of graduation.

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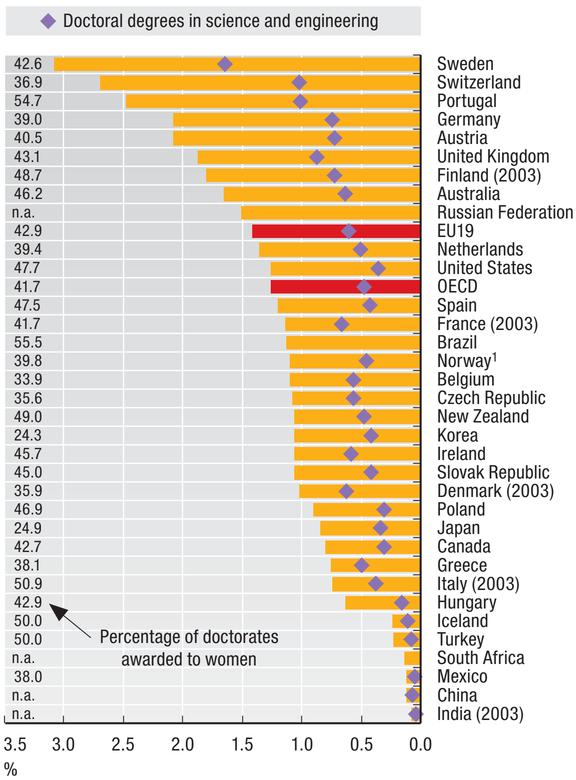
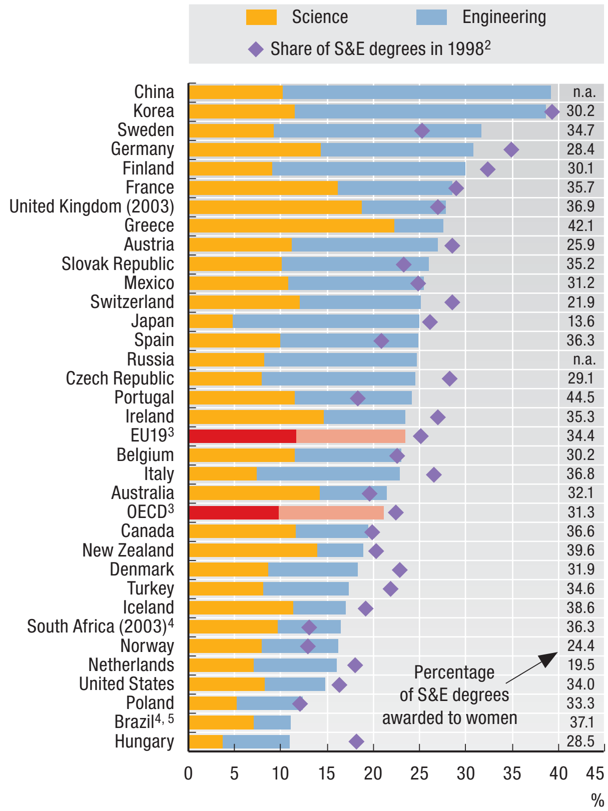
Graduation rates at doctoral level, 2004

As a percentage of the relevant age cohort



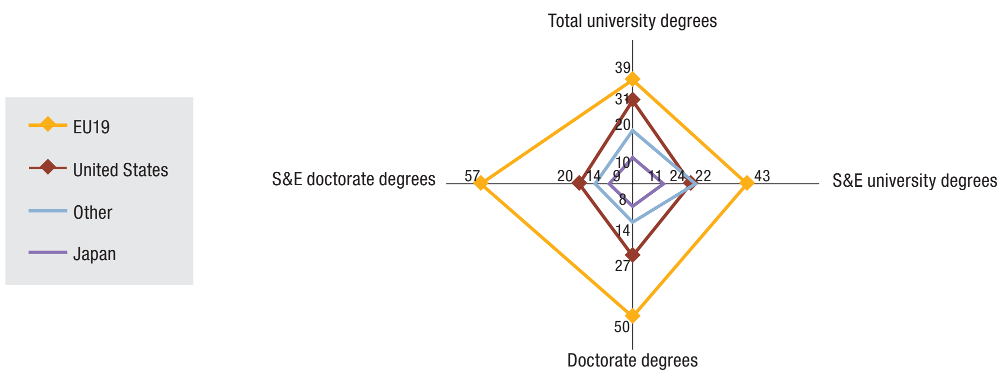
Science and engineering degrees, 2004

As a percentage of total new degrees



OECD output of university and doctoral degrees by main region of graduation and field of study, 2004

Percentage of all OECD graduates receiving their degrees by region



StatLink http://dx.doi.org/10.1787/117066108886

1. 2003 for doctoral degrees in science and engineering.
2. 1999 instead of 1998 for the Slovak Republic and Denmark; 2000 for Portugal and Belgium. These four countries as well as Greece and Luxembourg are excluded from the calculations of EU19 and OECD in 1998.
3. Excludes Luxembourg. 2003 data for the United Kingdom.
4. ISCED 5B programmes are included with ISCED 5A/6.
5. Share of S&E degrees awarded to women is for 2003.

B.2. FOREIGN AND INTERNATIONAL DOCTORAL STUDENTS

■ International mobility of doctoral students is an indicator of the internationalisation of both the higher education sector and the research system. It highlights the attractiveness of advanced research programmes and in some cases the existence of career opportunities for junior researchers in the host country. During their studies and afterwards, doctoral students contribute to the advancement of research in the host country. When they return home, they take back new competencies and connections with international research networks.

■ The share of foreign doctoral students in total enrolment differs widely across countries. Non-citizen or international students represent 40% of the doctoral population in Switzerland and the United Kingdom, but less than 5% in Italy or Korea. Canada, Belgium and the United States have between 20% and 35% of foreign and international doctoral students. Australia has 18%, Austria 17% and New Zealand 15% of international students.

■ In absolute numbers, the United States hosted the largest foreign doctoral population in 2001 with about 79 000 students from abroad. The United Kingdom followed with some 35 000 international students in 2004.

■ Language plays a role in the choice of destination, notably for English-speaking countries, or for Spain, which attracts students from Central and South America. However, a wide range of other factors matters: geographical proximity, cultural and historical links, the existence of exchange programmes (*e.g.* Erasmus) or scholarships, and immigration policies. Asian students (particularly from China, India, Korea and Chinese Taipei) represent the bulk of foreign doctoral students in the United States; European universities enrol a large share of doctoral students from other European countries.

■ International mobility of doctoral students has increased over the past five or six years, particularly strongly in New Zealand, Canada, Norway and Spain. The share of foreign students enrolled in advanced research programmes grew in most countries between 1998 and 2004. Belgium, one of the main European host countries, is an exception.

■ Men still account for the majority of foreign doctoral students. Women represent between 21% (Slovak Republic) and 47% (Spain) of international doctorates.

Source

- OECD, Education database, 2007.

For further reading

- OECD (2006), *Education at a Glance: OECD Indicators 2006*, OECD, Paris, available at: *www.oecd.org/edu/eag2006*.
- OECD (2004), *Internationalisation and Trade in Higher Education, Challenges and Opportunities*, 2004, OECD, Paris.

Foreign and international doctoral students

Internationally mobile doctoral students are of particular interest for two reasons: first, they are an important subset of HRST, as they have completed tertiary education; second, they are involved in R&D activities abroad while preparing their doctorate.

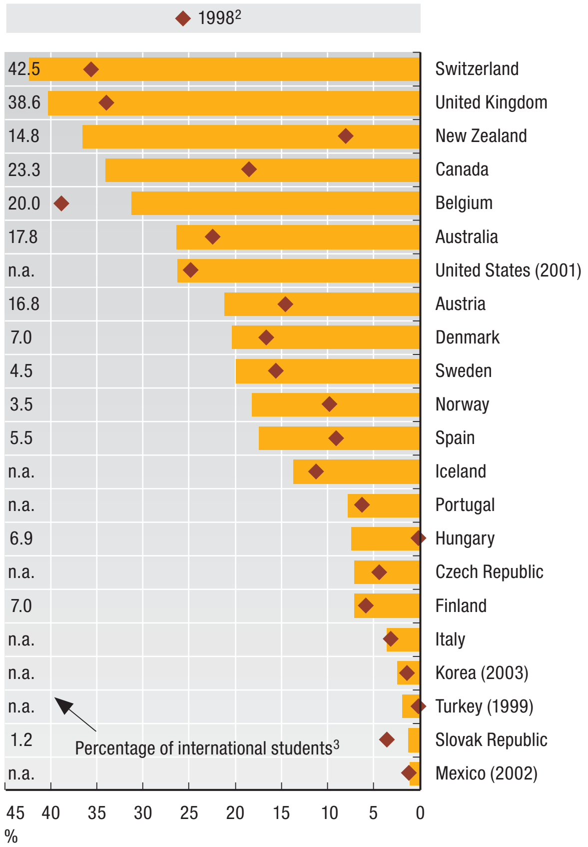
The data used are from the Indicators for Education Systems (INES) project conducted jointly by the OECD, the UNESCO Institute for Statistics (UIS) and Eurostat. The educational level of students is based on the International Standard Classification of Education developed by UNESCO (ISCED 1997). ISCED level 6 corresponds to programmes that lead to an advanced or research qualification, equivalent to a doctorate.

Previous versions of this indicator presented data on foreign doctoral students only, defined as non-citizens of the country. This concept can only be considered a proxy of student mobility since not all foreign students come to the country expressly to study. In particular, foreign students who are permanent residents in their country of study are included in the total. In an effort to improve the measurement of student mobility, the OECD, Eurostat and UIS revised in 2005 the instrument for gathering data on student mobility. In the new approach, the term "international students" refers to students who have crossed borders in order to study. Yet, the measurement of student mobility depends to a large extent on country-specific immigration legislation and data availability constraints. For this reason, the data collected by the UIS, OECD and Eurostat allow countries to define as international students those who are not residents of the country in which they study or, alternatively, as those who received their prior education in another country, depending on which operational definition is most appropriate in their national context. Overall, the country of prior education is considered a better operational criterion for EU countries so as not to omit intra-EU student mobility, while the residence criterion is usually a good proxy in countries that require a student visa to enter the country for educational purposes. Since not all countries are yet able to report data according to the new concept, data for both "foreign students" and for "international students" are presented below.

B.2. FOREIGN AND INTERNATIONAL DOCTORAL STUDENTS

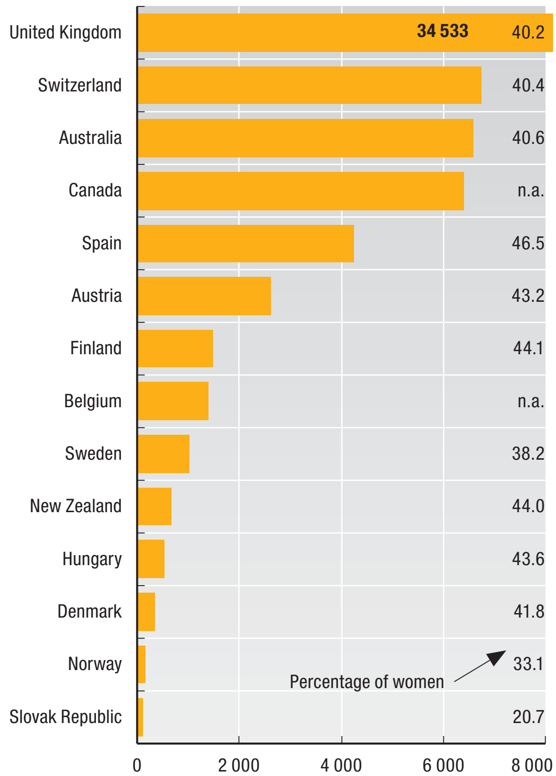
Share of foreign doctoral students,[1] 2004

As a percentage of total doctoral enrolment in host country



Number of international doctoral students[3], 2004

By host country



StatLink http://dx.doi.org/10.1787/117086583466

1. Including foreign students from non-OECD countries.
2. 1999 for Belgium, Mexico and the Slovak Republic; 2000 for Iceland and Portugal.
3. International students are defined as non-resident students of reporting country for all countries except Finland and Switzerland where they are defined as students with prior education outside the reporting country.

B.3. S&E DOCTORATES AWARDED AND POSTDOCTORATE APPOINTMENTS TO FOREIGN CITIZENS IN THE UNITED STATES

■ The United States, like France and the United Kingdom, educates large numbers of foreign students. Of the 43 400 doctorates awarded in 2005, two-thirds were in science and engineering (S&E) and 38% of new graduates in these fields were foreign citizens with temporary visas. Over the past decade, the US higher education system has granted an average of 9 700 new S&E doctorates to foreign citizens each year; the number exceeded 10 000 in 2004 and 2005.

■ Asians account for more than two-thirds of new non-US doctorates. Chinese students account for 30%, Koreans for 10% and students from Chinese Taipei for 4%.

■ For students from China, Korea and Chinese Taipei, as well as from Argentina, Greece and Turkey, US universities award about one S&E doctorate for every three or four granted in their home country. US-earned doctorates represent up to three-quarters of those granted to Chilian citizens. The proportion of doctorates granted to Europeans in the United States remains very small.

■ In 2005, the number of S&E doctorates awarded by US universities peaked at 28 000, surpassing the previous high of 1998. This is the result of a three-year increase in S&E doctorate awards (2002-2005), following a four-year decrease (1998-2002). This suggests that there has in fact been no decline in the number of S&E doctorates granted to non-US citizens. Indeed, most of the recent growth is due to non-US citizens.

■ Foreign doctoral graduates often stay in the United States after completing their studies. In 2005, US universities awarded almost 26 000 S&E postdoctoral positions to temporary visa holders, compared to 19 500 to US-born or resident graduates. The number of appointments for foreigners grew markedly over the decade but changed little for citizens and residents.

■ The propensity of new doctorate recipients to remain in the United States varies according to country of origin but has increased for all citizenships since the beginning of the 1990s. Two-thirds of Indian and Chinese recipients of S&E doctorates and over half of European recipients receive a postdoctoral appointment or job in the United States after graduation. The number of those from Japan, Korea or Chinese Taipei, who were traditionally less likely to stay, has also increased.

Sources

- National Science Foundation (2006), *Science and Engineering Indicators 2006*, Arlington, Virginia, available at: *www.nsf.gov/sbe/srs/seind06/start.htm*.
- National Science Foundation (2006), *Science and Engineering Doctorate Awards: 2005*, Arlington, Virginia, available at: *www.nsf.gov/statistics/* and *www.nsf.gov/statistics/survey.cfm*.
- National Science Foundation (2006), *S&E Doctorates Hit All-time High in 2005, InfoBrief*, available at: www.nsf.gov/statistics/infbrief/nsf07301/nsf07301.pdf.

National Science Foundation (NSF) data on US doctorates and postdoctorates

The Survey of Earned Doctorates (SED) is a census of all individuals receiving a research doctorate from a US institution in the academic year. The results are used to assess characteristics and trends in doctorate education and degrees. The data are published annually since 1958.

The definition of postdoctorates differs among academic disciplines, universities and sectors. For the US NSF, postdoctorates include "individuals with science and engineering Ph.D.'s, M.D.'s, D.D.S.'s, or D.V.M.'s (including foreign degrees equivalent to US doctorates) who devote their primary effort to their own research training through research activities or study in the department under temporary appointments carrying no academic rank". Postdoctorates may contribute to the academic programme through seminars, lectures or working with graduate students.

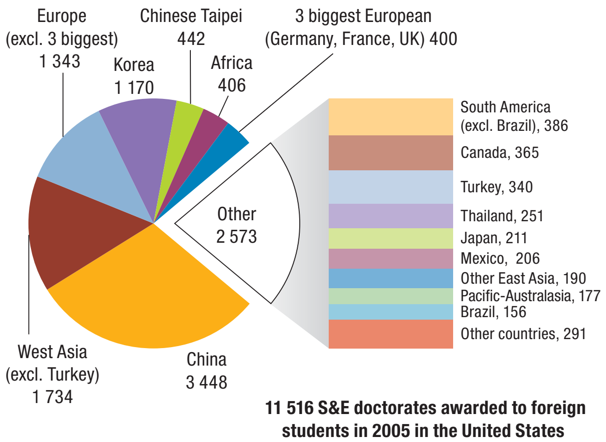
S&E fields include the natural sciences (*e.g.* physical, biological, earth, atmospheric and ocean sciences), mathematics/computer sciences, agricultural sciences, social/behavioural sciences, engineering, medical/other life sciences.

New graduates who intend to stay are measured by those who accept a postdoctoral research appointment or academic, industrial or other firm employment in the United States at receipt of doctorate. This gives an indicator of how much the United States relies on inflows of doctorate holders and of whether working in the United States is an attractive option for foreign students who obtain US doctorates.

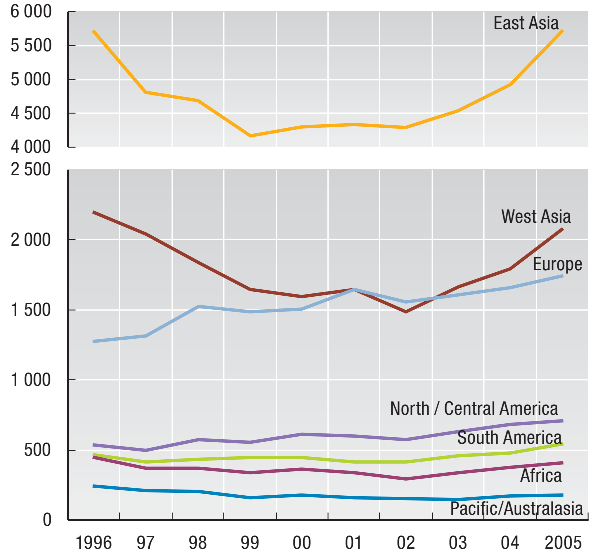
B.3. S&E DOCTORATES AWARDED AND POSTDOCTORATE APPOINTMENTS TO FOREIGN CITIZENS IN THE UNITED STATES

S&E doctorates awarded to foreign citizens in the United States, by citizenship or origin

Total number, 2005

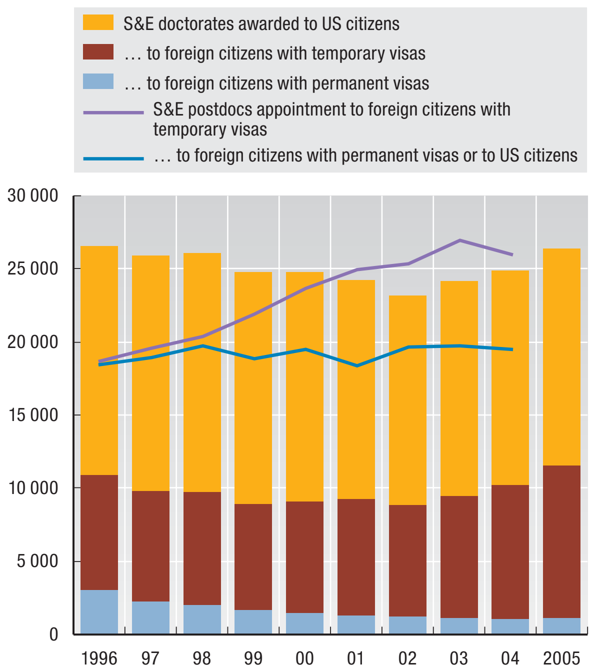


Changes by main geographical area, 1996-2005



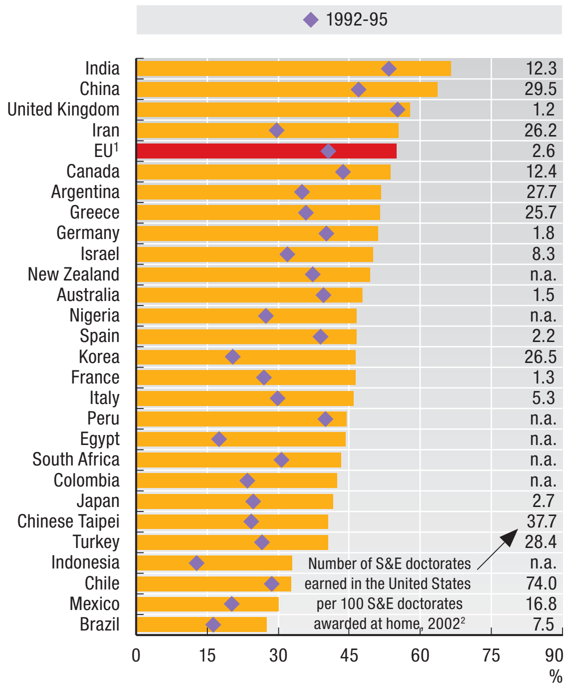
S&E doctorates and postdoctoral appointments in the United States, by citizenship and type of visa, 1996-2005

Total number



Foreign S&E doctorate recipients who intend to stay in the United States, 2000-03

As a percentage of total foreign S&E doctorate recipients



StatLink http://dx.doi.org/10.1787/117106138840

1. Includes all European countries.
2. OECD estimates based on NSF data. The ratio compares the number of new foreign citizens graduating at doctoral level in S&E fields in the United States to the number of earned S&E doctoral degrees in the country of origin. New S&E doctorates refer to 1996 for Chile, 1999 for Brazil, 2001 for Canada, China, Greece, Italy and Spain, 2003 for Germany, Japan and the United Kingdom.

B.4. EMPLOYMENT OF TERTIARY-LEVEL GRADUATES

■ Employment of tertiary-level graduates is an indicator of the labour market's innovative potential and displays a general trend towards upskilling.

■ Large investments in education have led to a rise in educational attainment which is also reflected in the composition of employment. On average, 31% of persons employed in the OECD area had a tertiary-level degree in 2004. Canada and Japan (over 40%) and the United States (39%) ranked far ahead of the European Union, where fewer than one worker in four holds a tertiary-level degree. Europe shows large disparities: in Finland, Belgium and Sweden, tertiary-level graduates account for more than one-third of employment; in Portugal, Italy and the Czech and Slovak Republics they account for 15% or less.

■ Between 1998 and 2004, employment of tertiary-level graduates grew at an annual pace of about 3.6% in the OECD area. It increased in all countries and rose on average four times faster than total employment. The fastest growth was in Spain (8.8%), Austria (8.3%) and Portugal (7.8%); the slowest in Germany (1.0%) and Finland (2.2%). In countries where levels of tertiary-level graduates were already high (the United States, Japan), growth was over 2.5% a year.

■ This growth is due in part to the increased presence of women in the labour market. Despite their greater propensity to graduate at tertiary level, there are fewer women working in certain countries. They represent on average 46% of tertiary-level employment, ranging from 60% in Portugal to 31% in Switzerland.

■ The population of tertiary-level workers is ageing. In 2004, more than one in three OECD workers with a tertiary-level degree was over 45 years of age. Over a span of seven years, the share of those aged 45-64 has increased in almost all countries. Compared to 2002, the number of countries in which this age group accounts for 40% of tertiary-level employment has increased from four to seven: the Czech Republic, Denmark, Finland, Germany, Hungary, Sweden and the United States.

■ University graduates are generally less likely than non-graduates to remain unemployed. However, the unemployment rate among university graduates is high in Turkey (12.5%). It is also high in Spain (8.1), France (7.4) and Poland (7.3). Women with a university degree are less likely to be unemployed than women without one, yet their unemployment rate is higher than that of men with the same level of education. The largest gender gaps in university graduates' unemployment rates are found in Austria and Greece, where unemployment rates are twice as high for women as for men.

Source

- OECD, Educational Attainment database, 2007.

For further reading

- OECD, (2006), *Education at a Glance: OECD Indicators 2006*, available at: *www.oecd.org/eag2006*.

Measuring employment of tertiary-level graduates

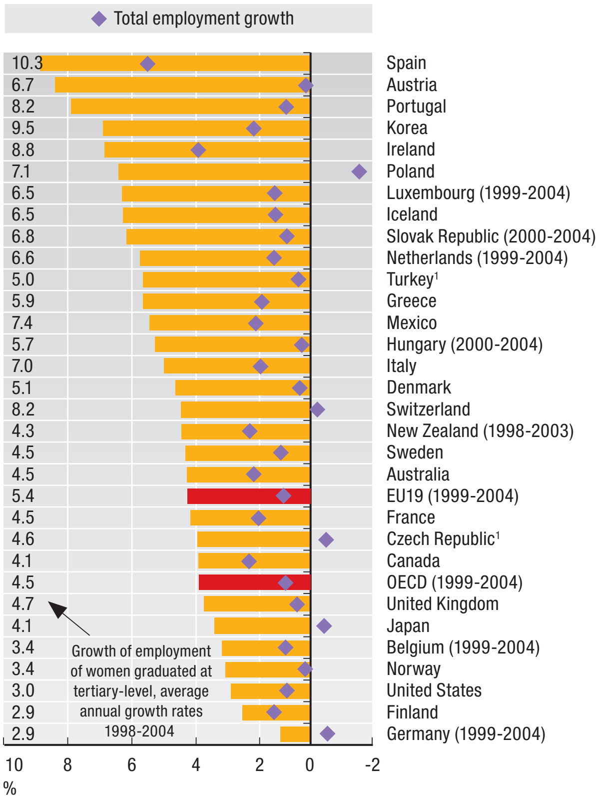
The OECD Educational Attainment database provides data on population at different levels of education distributed by sex, age and work status (employed, unemployed, inactive). It is compiled from member countries' labour force surveys and/or the European Labour Force Survey. Adjustments are made to ensure comparability across countries, notably concerning national levels of education, which are recoded according to the International Standard Classification of Education 1997 (ISCED 1997).

Tertiary-level graduates are defined as holders of degrees at ISCED levels 5B, 5A and 6. University graduates only include graduates at ISCED levels 5A and 6. ISCED level 5A programmes have a minimum cumulative duration of three years' full-time equivalent and typically are of four years or more. They are largely theoretical or preparatory to research (history, philosophy, mathematics, etc.) and intended to provide qualifications sufficient for gaining entry into advanced research programmes (ISCED level 6) or professions with high skills requirement (medicine, dentistry, architecture, etc.). The short streams (ISCED 5B) are more practically oriented.

B.4. EMPLOYMENT OF TERTIARY-LEVEL GRADUATES

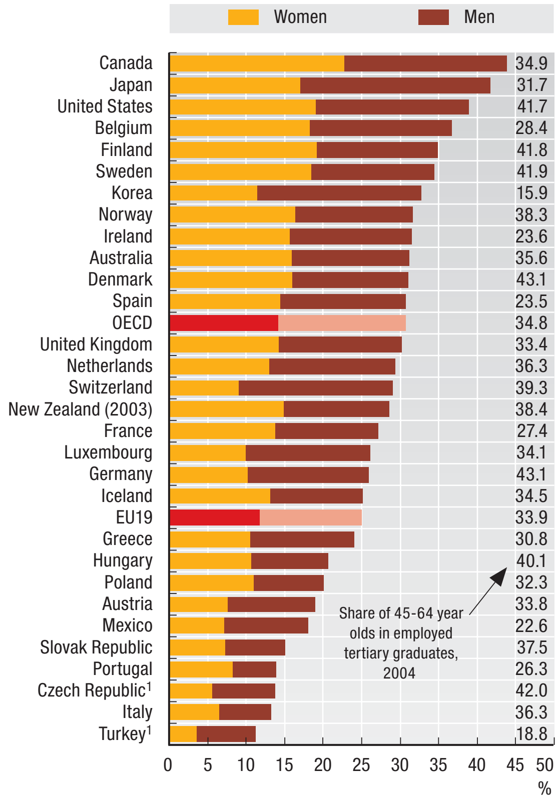
Employment growth of tertiary-level graduates, 1998-2004

Average annual growth rate

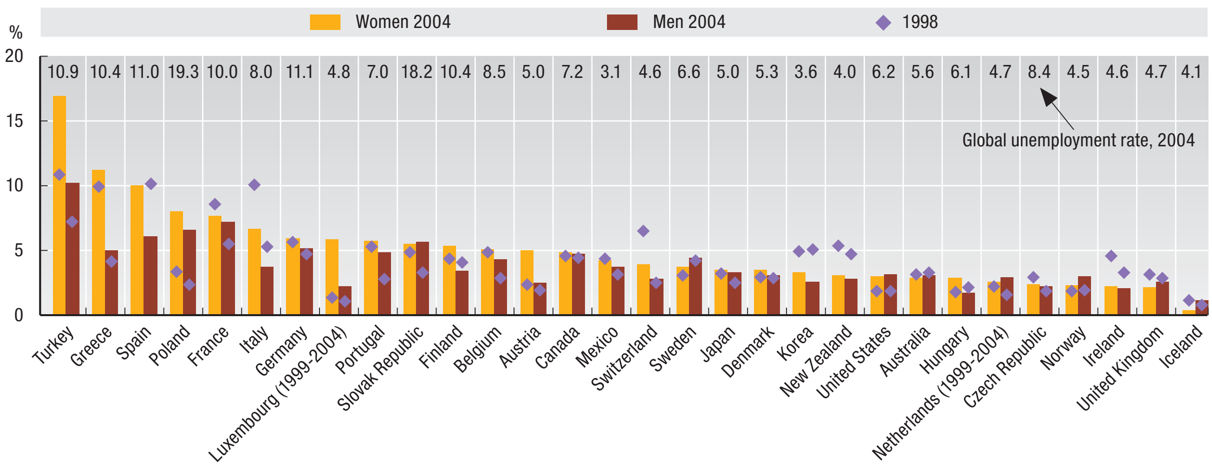


Tertiary-level graduates in total employment, 2004

As a percentage of total employment



Unemployment rates of university graduates, 2004



StatLink http://dx.doi.org/10.1787/117152887881

1. Does not include graduates at ISCED level 5B.

B.5. HUMAN RESOURCES IN SCIENCE AND TECHNOLOGY

■ Human resources in science and technology (HRST) are the main pillar of knowledge-based economies. In 2005, workers in professional and technical occupations (see box) represented more than 30% of total employment in the United States and in the EU25 (*i.e.* nearly 57 and 59 million persons, respectively). In Japan, they were about 10 million in 2004, and one in six workers was employed in an S&T occupation.

■ In Europe, almost two-thirds of HRST were concentrated in the four largest economies (22% in Germany, 12% in both France and the United Kingdom, 11% in Italy). The Czech Republic, Hungary, Poland and the Slovak Republic together employed more than 11%. Northern European countries were among the top ten with respect to the share of S&T occupations in total employment (more than 35%); in Spain, Greece, Ireland and Portugal the share was around 20%.

■ According to the latest available data, more than 50% of professionals and technicians are women in most OECD countries, with the highest shares in Poland (60.7%) and Hungary (60.3%). On the other hand, women are under represented in Japan (34.0%) and in Korea (40.1%).

■ In 2006, there was quite a good balance between the shares of professionals and technicians. However, in Norway, the Czech Republic, Italy and Austria technicians were significantly more numerous than professionals.

■ Over the past decade, employment in HRST occupations has grown much faster than total employment in all countries, at an average annual rate of 2.5% in the United States, 3.3% in the EU15, 4.1% in Korea and 4.5% in Australia. Some countries with low shares of professionals and technicians have been catching up (*e.g.* Spain, Hungary, Ireland and Greece). Luxembourg and Australia, with already high shares, have maintained strong growth in S&T employment.

■ With a few exceptions (*e.g.* Hungary, Poland, the Slovak Republic and the Czech Republic), the growth in HRST occupations has been mainly driven by increases in female employment (1996-2006).

Sources

- OECD calculations, based on data from the EU Labour Force Survey; from the US Current Population Survey; from the Canadian and Japanese labour force surveys, the Korean Economically Active Population survey, and the Australian and New Zealand censuses.

For further reading

- OECD and Eurostat (1995), *Manual on the Measurement of Human Resources Devoted to S&T: Canberra Manual*, OECD, Paris, available at: www.oecd.org/dataoecd/34/0/2096025.pdf.
- OECD (2001), *Innovative People: Mobility of Skilled Personnel in National Innovation Systems*, OECD, Paris.

HRST stocks: definition of occupations

Human resources in science and technology (HRST) are defined according to the *Canberra Manual* (OECD and Eurostat, 1995) as persons having graduated at the tertiary level of education (see B.4), or, persons employed in an S&T occupation for which a high qualification is normally required and the innovation potential is high. HRST data reported here only concern occupations. This category of workers corresponds to professionals, technicians as defined in the International Standard Classification of Occupations (ISCO-88).

- Professionals (ISCO group 2) include physical, mathematical and engineering science professionals (physicists, chemists, mathematicians, statisticians, computing professionals, architects, engineers), life science and health professionals (biologists, agronomists, doctors, dentist, veterinarians, pharmacists, nursing), teaching professionals, and other professionals (business, legal, information, social science, creative, religious, public service administrative).
- Technicians and associate professionals (ISCO group 3) includes: Physical and engineering science associate professionals, life science and health associate professionals, teaching associate professionals, other associate professionals (finance, sales, business services, trade brokers, administrative, government, police inspectors, social work, artistic entertainment and sport, religious).

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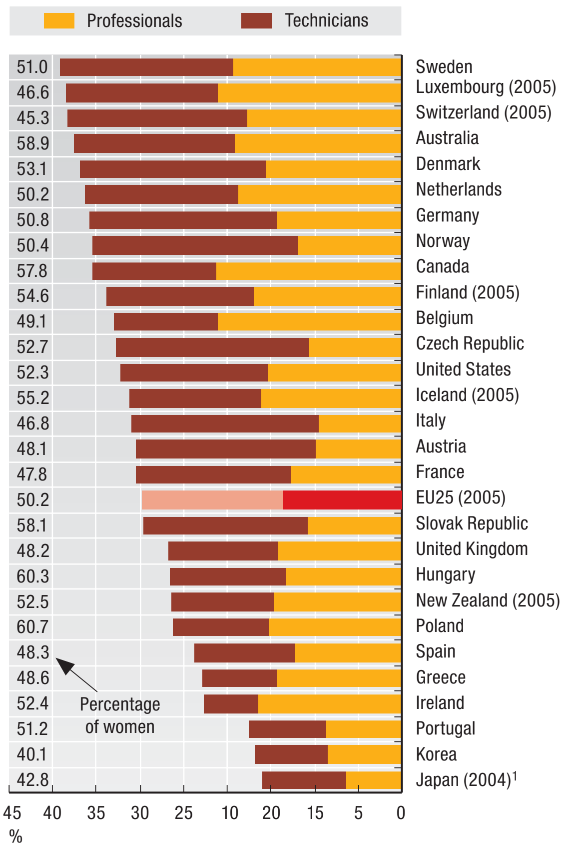
B.5. HUMAN RESOURCES IN SCIENCE AND TECHNOLOGY

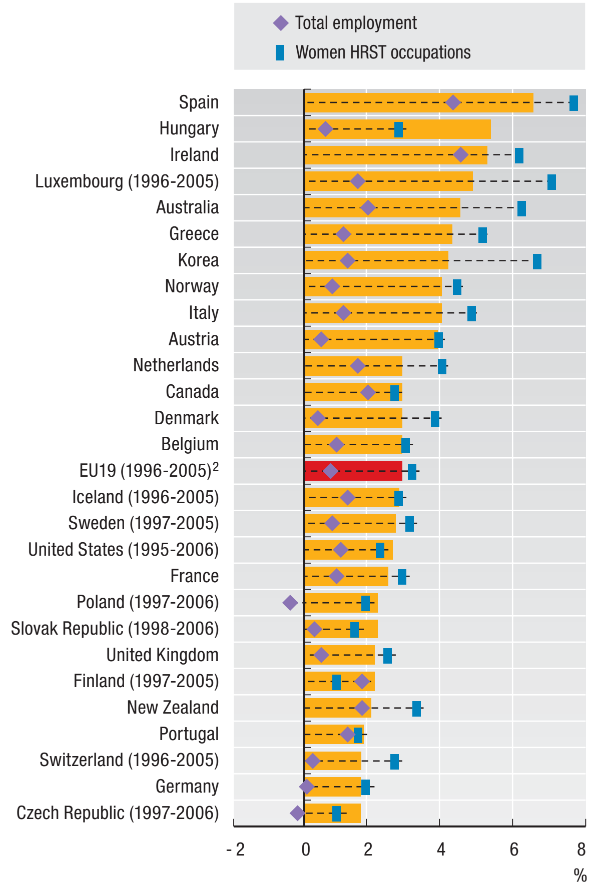
HRST occupations, 2006

As a percentage of total employment



Growth of HRST occupations, 1996-2006

Average annual growth rate (%)



StatLink http://dx.doi.org/10.1787/117173327210

1. OECD calculations based on national estimates.
2. OECD estimates.

B.6. INTERNATIONAL MOBILITY OF THE HIGHLY SKILLED

■ Modern economies rely on human expertise and compete to attract the best competencies. In 2000-01, out of the 40.5 million foreign-born individuals residing and employed in an OECD country, 9.2 million were professionals or technicians. In most OECD countries for which data are available, the percentage of employed professionals was higher for the foreign-born than for the native-born. The percentage of those with tertiary education in science and engineering was also higher among the foreign-born.

■ The United States captured 45% of this professional and technical migration (and 55% of those born in non-OECD countries), the three largest European countries (France, Germany and the United Kingdom) 20%, and Canada 10%.

■ Close to 60% of these professional and technical migrants were born outside the OECD area. Of the 8.3 million whose place of birth is known, 4.9 million were from non-OECD countries and 3.4 million represented intra-OECD migration. The United States, Canada, France, Portugal, Spain and the United Kingdom benefit from a strong colonial heritage or linguistic advantages and seem best able to attract highly skilled workers from non-OECD countries. About 30% of professional and technical migrants to OECD countries originated from Asia, of which 5.7% from India and 3.5% from China. Another 30% were European-born, with a large share involved in intra-European movements.

■ Some of the countries with high shares of employed professional and technical migrants also had high expatriation rates of professionals and technicians to other OECD countries. Luxembourg, New Zealand, Switzerland, Portugal and the United Kingdom all had positive net inflows of professional and technical workers and may be considered as benefiting from strong knowledge flows. Positive net inflows in New Zealand and the United Kingdom relied on the contribution of such workers born in non-OECD countries, while those in Portugal were probably due in part to repatriation of professionals and technicians born in the former Portuguese colonies. Ireland had a high immigration rate (15.4%) but an even higher emigration rate (26.0%). Finland, Mexico, Poland and the Slovak Republic experienced net outflows. France and the United States had in common high inflow rates (8.3% and 12.0% respectively) and low outflow rates (2.6% and 0.5% respectively), with a large contribution from persons born in non-OECD countries.

■ With a few exceptions, women represent at least 45% of employed professional and technical migrants in OECD countries. Women from southern Europe and Austria are less likely to emigrate than their female counterparts in other OECD countries.

Source

- OECD, database on Immigrants and Expatriates, May 2007.

For further reading

- Dumont, J.C. and G. Lemaître (2004), "Counting Immigrants and Expatriates: A New Perspective", OECD, Social, Employment and Migration Working Papers.

Highly skilled expatriates: definition and data issues

Data relate to professionals and technicians, as defined by ISCO groups 2 and 3 respectively (see Box B.5). Lack of data on the permanent and temporary flows of migrants according to skill levels in many OECD countries makes international comparisons difficult. Nevertheless, several data sources can be used to gauge the stocks and flows of highly skilled migrants in receiving OECD countries. Censuses are one, and the OECD has developed a database on immigrants and expatriates based on census data. Most censuses in member countries were conducted around 2000, and the results are currently available for almost all of them. Several countries, however, do not have a population census, so that data from population registers or from large sample surveys have been used. Census data were used for 23 of the 29 participating countries and other sources for six; Iceland does not participate. The database currently includes data on the foreign-born in OECD countries by place of birth, nationality and educational attainment (three levels). New data on employment by occupation are presented here.

Expatriates in the OECD area are defined as residents in any OECD country born in another OECD country or in a non-OECD country, whether naturalised or not. The information in the database therefore reflects the cumulative effect of movements within and to the OECD area over the past decades. Except for France (1999), the reference year for the data is 2000 or 2001, depending on each country's census year.

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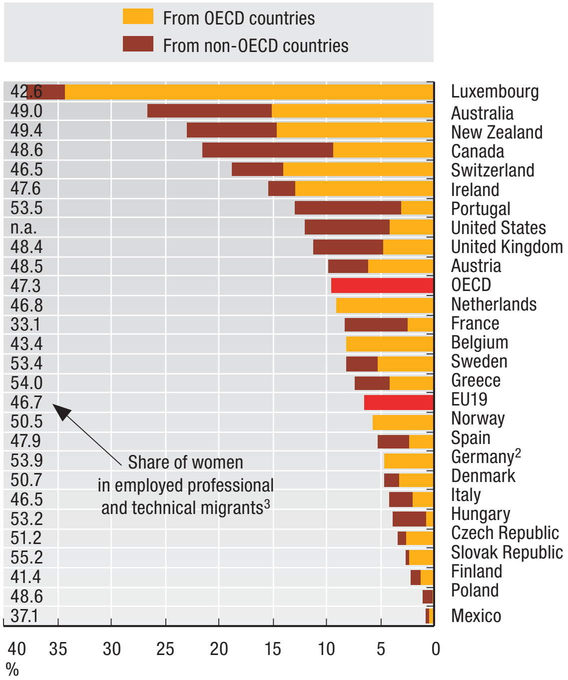
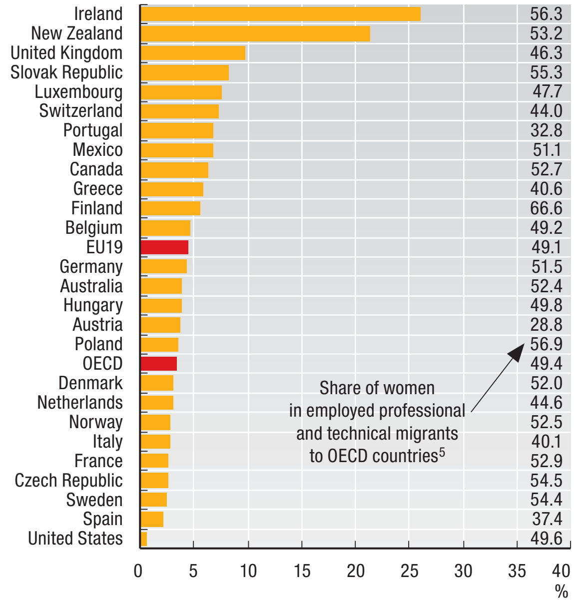
Employed professional and technical migrants from OECD and non-OECD countries, by OECD country of residence[1], 2000 or 2001

As a percentage of total employed professionals and technicians in the country of residence

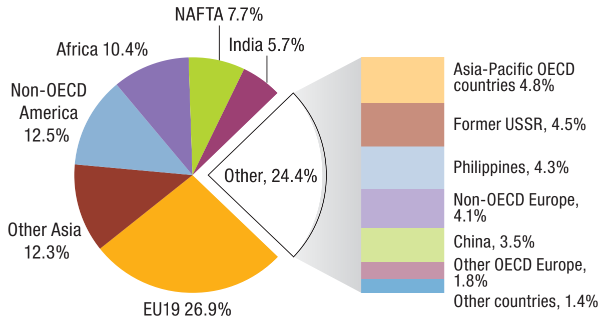


OECD-born employed professional and technical migrants to other OECD countries, by country of birth[4], 2000 or 2001

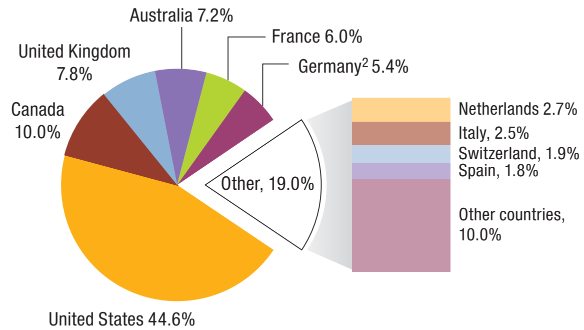
As a percentage of total employed professionals and technicians in the country of birth



Share of employed professional and technical migrants to OECD countries[6], by country of birth, 2000 or 2001



Share of employed professional and technical migrants to OECD countries[1], by country of residence, 2000 or 2001



StatLink http://dx.doi.org/10.1787/117183211161

1. Data are not available for Iceland, Japan, Korea and Turkey, which are excluded from the OECD total.
2. The country of birth is unknown for a significant number of employees who have been excluded from the calculation.
3. Data for the United States are not available. The OECD total excludes Iceland, Japan, Korea, Turkey and the United States.
4. Excluding Belgium, Germany, Iceland, Japan, Korea, the Netherlands, Norway and Turkey as country of residence.
5. OECD migrants to all available OECD countries except Iceland, Japan, Korea, Turkey and the United States.
6. Excluding migrants to Belgium, Iceland, Japan, Korea, the Netherlands, Norway and Turkey.

B.7. R&D PERSONNEL

The number of personnel engaged in R&D in OECD economies is directly linked to their R&D effort. In Finland, Sweden and Denmark, over 15 R&D personnel per 1 000 employees contribute to R&D activities, well above the EU average of 10 per 1 000. Japan, Luxembourg, France and New Zealand also employ a higher than average ratio of R&D personnel (over 14 per 1 000).

In the vast majority of OECD countries, the number of researchers rises at a faster rate than the number of total R&D personnel. This is partly due to the increased number of postgraduate students who perform R&D and are counted as researchers in the higher education sector. Greater use of new information technologies in R&D activities may also explain the need for fewer technicians and support staff per full-time equivalent researcher. Nevertheless, some laboratories lack technicians or support staff.

The number of researchers has increased the most in China (albeit from a small base), Finland and New Zealand, with average annual growth rates of close to 9%, more than double the OECD average of 3.2%. In New Zealand, Turkey, Mexico, South Africa, Greece and Italy, as well as in the Netherlands and the Russian Federation, however, the number of researchers has grown more slowly than that of total R&D personnel.

The under-representation of women in R&D activities has gained the attention of policy makers. In most countries for which data are available, women represent between 25% and 35% of total researchers. While women represent over 40% of researchers in Portugal, the Russian Federation and the Slovak Republic, they represent under 13% in Japan and Korea.

The low share of women researchers is partly a reflection of the uneven distribution of women among sectors of R&D performance. With the exception of Denmark, Korea, Luxembourg and the Russian Federation, women researchers are principally in the higher education sector; their participation is particularly low in the business sector, which attracts the largest number of researchers in most countries (see B.8).

Source

- OECD, Main Science and Technology Indicators database, May 2007.

For further reading

- OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Development*. OECD, Paris, available at: *www.oecd.org/sti/frascatimanual*.

Measuring R&D personnel

Research and development personnel includes all persons employed directly in R&D activities and therefore covers technicians and support staff in addition to researchers.

R&D personnel can be expressed both in full-time equivalents (FTE) on R&D and in headcounts.

A person working half-time on R&D is counted as 0.5 person-year in FTE. FTE includes staff engaged in R&D during the course of a particular year. FTE data are a true measure of the volume of personnel and give an indication of countries' research effort.

Headcount data are a measure of the stock of researchers and other R&D personnel employed at a certain date in the year, and are the most appropriate measure for collecting additional information about R&D personnel, such as age, gender or national origin.

Both the FTE on R&D and headcounts data presented here comply with the methodology laid down in the *Frascati Manual*. Data for R&D personnel and researchers in China may be overestimated (see Box B.10).

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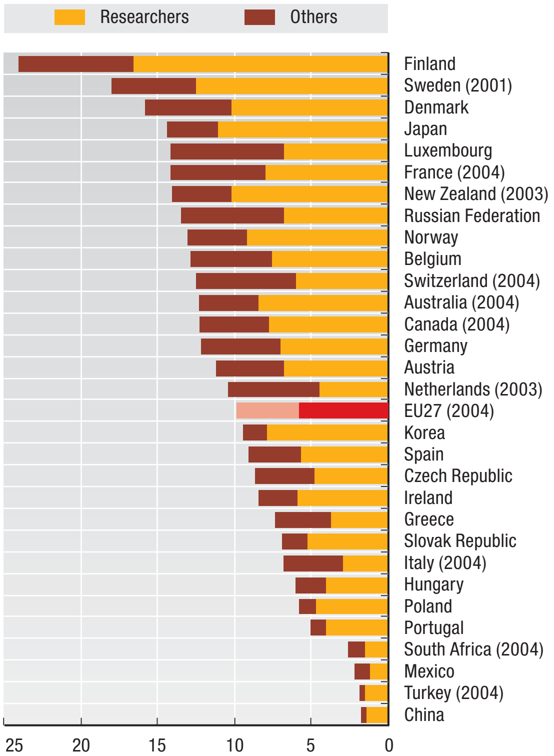
B.7. R&D PERSONNEL

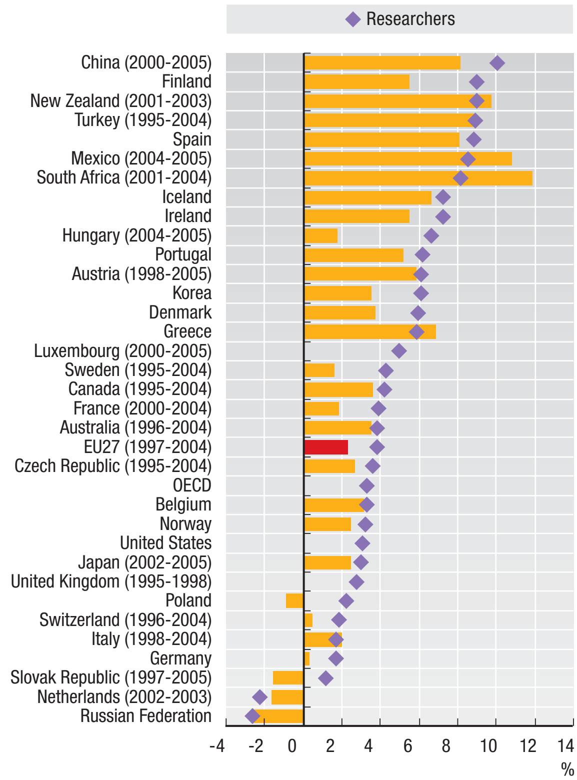
R&D personnel, 2005

Per thousand employment



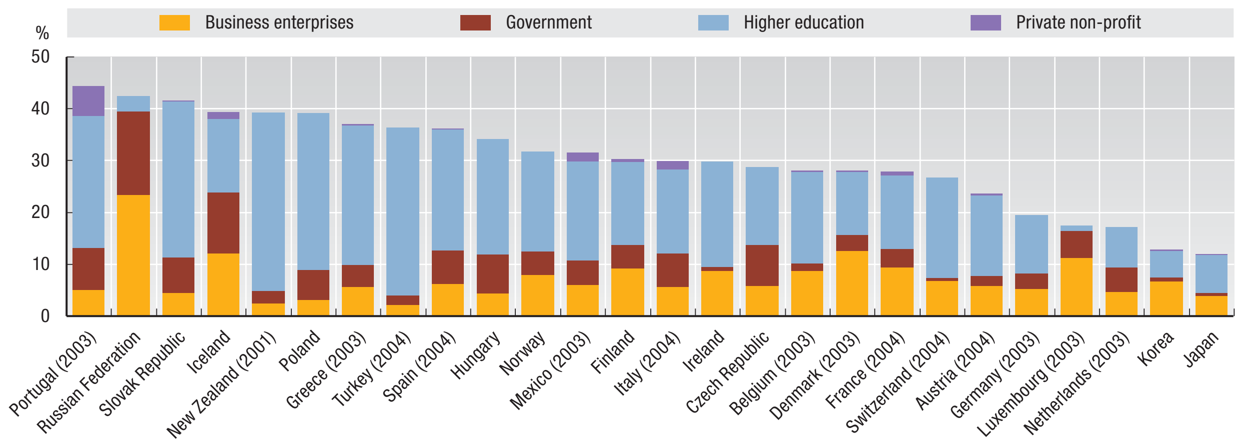
Growth of R&D personnel, 1995-2005

Average annual growth rate



Women researchers by sector of employment, 2005

As a percentage of total researchers



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B.8. RESEARCHERS

■ In 2005, approximately 3.9 million researchers were engaged in research and development (R&D) in the OECD area. This corresponds to about 7.3 researchers per 1 000 employees, a significant increase from the 1995 level of 5.9 per 1 000.

■ Among the major OECD regions, Japan has the largest number of researchers relative to total employment, followed by the United States and the European Union. However, around 37% of all OECD-area researchers reside in the United States, 33% in the EU and 18% in Japan.

■ The R&D intensity of Finland, Sweden, Japan and the United States, in terms of both researchers and R&D expenditure (see A.2), is substantially above the OECD average.

■ In 2005, approximately 2.5 million researchers (about 64% of the total) were employed by the business sector in the OECD area.

■ In the major economic zones, the share of business researchers in the national total differs widely. In the United States, four out of five researchers work in the business sector, two out of three in Japan, but only one out of two in the European Union.

■ Finland, Sweden, Japan, Denmark and the United States are the only countries where business researchers exceed 6 per 1 000 employees; in the large European economies, they are only 3 or 4 per 1 000.

■ Mexico, Turkey, Portugal, Greece, Poland and the Slovak Republic have a low intensity of business researchers (fewer than 1.5 per 1 000 employees in industry). This is mainly due to national characteristics; in these countries, the business sector plays a much smaller role in the national innovation system than the higher education and government sectors. Business enterprise expenditure on R&D in these countries accounts for only 25 to 35% of total R&D expenditure and just under 50% of the total in Mexico and the Slovak Republic (see A.3).

■ Growth in the number of business researchers is most dynamic in smaller OECD economies such as New Zealand, Portugal, Spain, Iceland and Greece, where the number of business researchers increased by more than 10% annually over the past decade. China's business enterprise researchers have also shown strong growth with an annual average growth rate of 15% over the past five years.

Source

- OECD, Main Science and Technology Indicators database, May 2007.

For further reading

- OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, OECD, Paris, available at: *www.oecd.org/sti/frascatimanual*.

Researchers

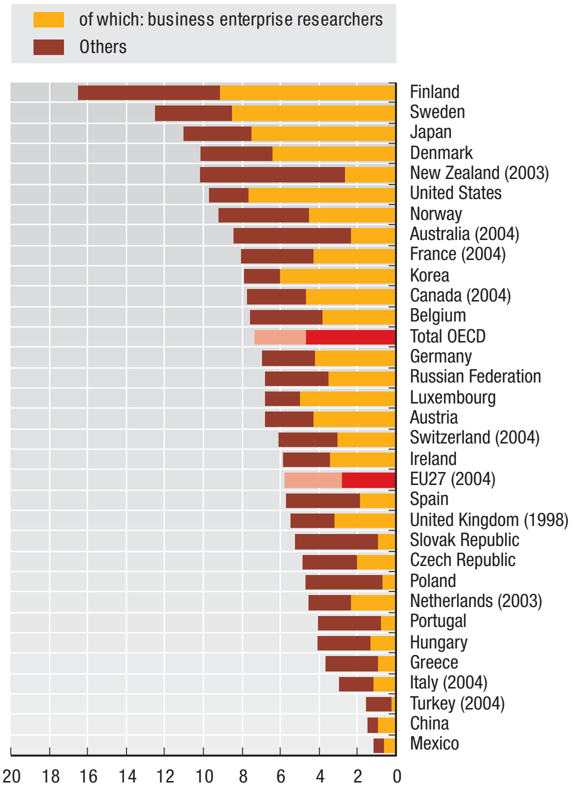
Researchers are viewed as the central element of the research and development system. They are defined as professionals engaged in the conception and creation of new knowledge, products, processes, methods and systems and are directly involved in the management of projects. For those countries that compile data by qualification only, data on university graduates employed in R&D are used as a proxy. The number of researchers is here expressed in full-time equivalent (FTE) on R&D (see Box B.7). The magnitude of estimated resources allocated to R&D is affected by national characteristics (see Box A.2).

Researchers in the United States are underestimated owing to the exclusion of military personnel in the government sector. For 2000-05, owing to the lack of official data for the higher education sector, total researchers is an OECD estimate.

The business enterprise sector covers researchers carrying out R&D in firms and business enterprise sector institutes. While the government and the higher education sectors also carry out R&D, industrial R&D is more closely linked to the creation of new products and production techniques, as well as to a country's innovation effort.

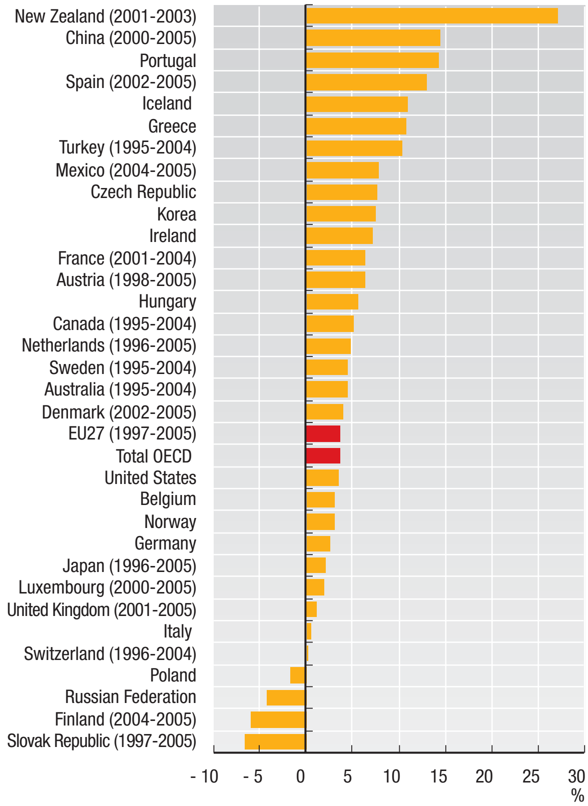
Researchers, 2005

Per 1 000 total employment



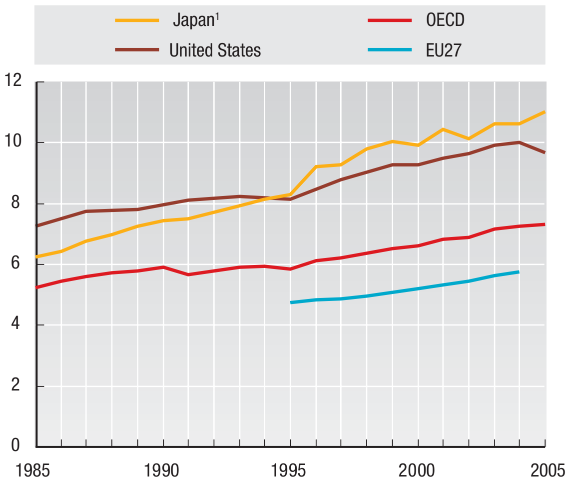
Growth of business researchers, 1995-2005

Average annual growth rate



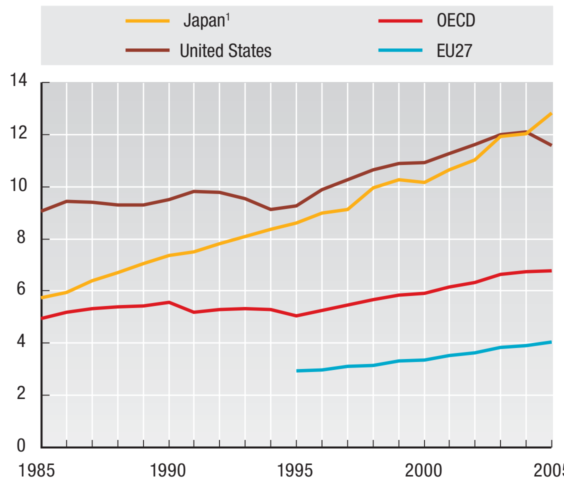
Researchers by area, 1985-2005

Per 1 000 total employment



Business researchers by area, 1985-2005

Per 1 000 employment in industry



1. Data are adjusted up to 1995.

StatLink http://dx.doi.org/10.1787/117351106853

B.9. FOREIGN SCHOLARS IN THE UNITED STATES

■ The presence of foreign scholars in US higher education institutions is an indicator of the international attractiveness of the country's universities and of opportunities for researchers.

■ In 2005/06, US higher education institutions hosted 97 000 foreign scholars engaged in research or teaching activities. Most were involved in research. Two-thirds were in life, biological, health or physical sciences and in engineering. The share in life and biological sciences has been growing rapidly.

■ Just 20 countries account for 80% of the foreign scholars in the United States. China is the leading country of origin and Asia the most important region. Around 20% of non-US scholars are Chinese, around 9% Korean or Indian, and more than 6% Japanese. From Europe, Germany, France, the United Kingdom, Italy and Spain each provided between 2% and 5% of foreign academic staff. In addition, Canada and Russia accounted for 5% and almost 2.5% of the total, respectively.

■ Mobility of scholars with respect to the size of the local academic population varies. For most OECD countries, two to four scholars per 100 working at home hold positions in US universities. Academic mobility is strongest from Korea (13), the Netherlands (8), Russia (8) and Chinese Taipei (6).

■ The population of foreign scholars working in the United States has increased over the past 12 years (from 60 000 in 1993/94). After a decline during the two post-September 11 academic years, with security-related changes in visa policy, numbers have risen again since 2004 and the 2005/06 figure represents an increase of 8.2% from the previous year.

■ Expansion of the population of foreign scholars has been driven by a massive and sustained arrival of Asian academics. Although a large number of Asian academics already worked in US universities in the mid-1990s, numbers from Korea, India and China have kept growing at average annual rates of 10%, 8% and 6%, respectively. Growth in academic mobility from Turkey (8%) and Russia (6%) has also been rapid. However, the increase has been more moderate from European countries (around 2%) except for the Slovak Republic (11%), the Czech Republic (6%), Portugal (6%) and Italy (5%).

■ Although most foreign scholars are men, women are more numerous than in the past; in 2005/06 female academics accounted for 35% of total foreign scholars in the United States.

Sources

- OECD, based on Institute of International Education (IIE), April 2007.
- OECD, Main Science and Technology Indicators, May 2007.

For further reading

- Institute of International Education (2006), *Opendoors 2006: Report on International Educational Exchange*, New York, available at: *http://opendoors.iienetwork.org/*.

Opendoors data: Report on international educational exchange

The Institute of International Education (IIE) is a non-profit international organisation for educational and cultural exchange. IIE conducts a yearly statistical survey of the internationally mobile student population in the United States. *Opendoors* is a long-standing, comprehensive information resource on international students in the United States and on US students studying abroad. It highlights key facts and trends in international flows of scholars to the United States.

International scholars are defined as non-immigrant, non-student academics (teachers and/or researchers, and administrators). Scholars may also be affiliated with US institutions for other activities such as conferences, colloquia, observation, consultation or other short-term professional development activities. The survey is limited to doctoral degree-granting institutions.

Sciences include life and biological sciences, health sciences and physical sciences.

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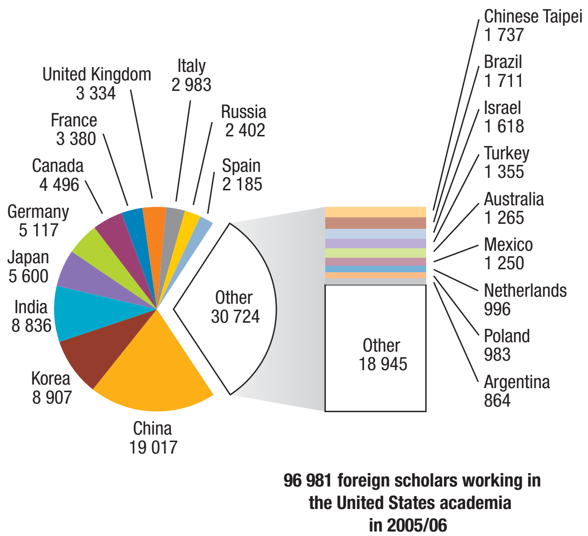
B.9. FOREIGN SCHOLARS IN THE UNITED STATES

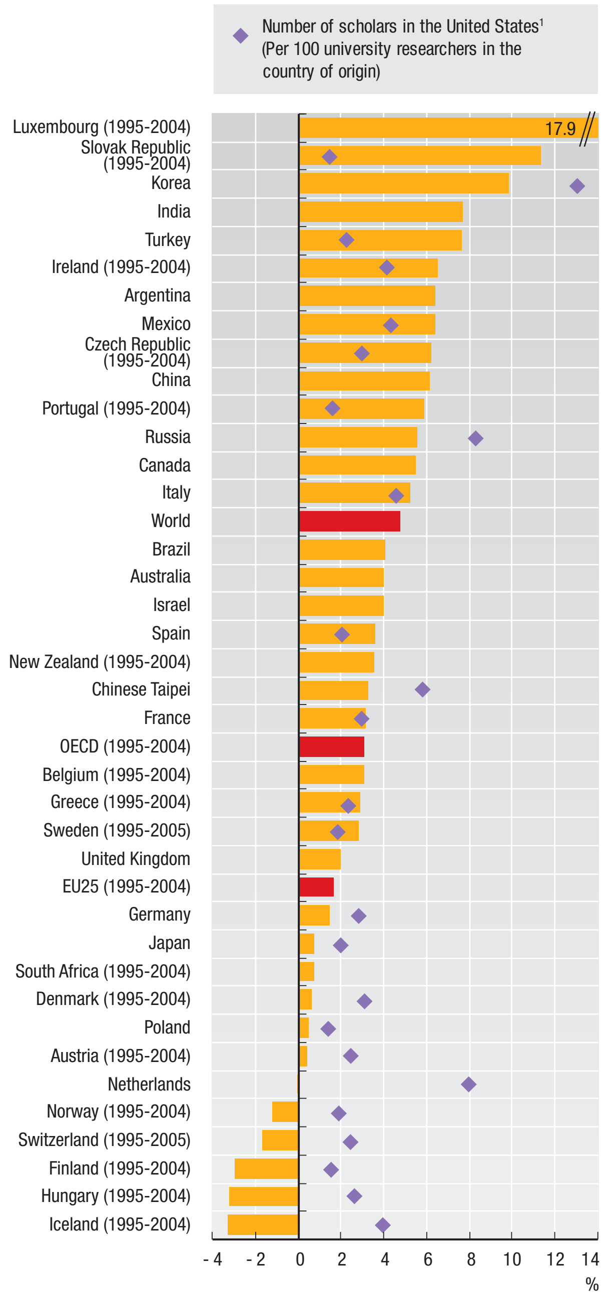
Top 20 places of origin of foreign scholars in the United States, 2005/06

Headcounts



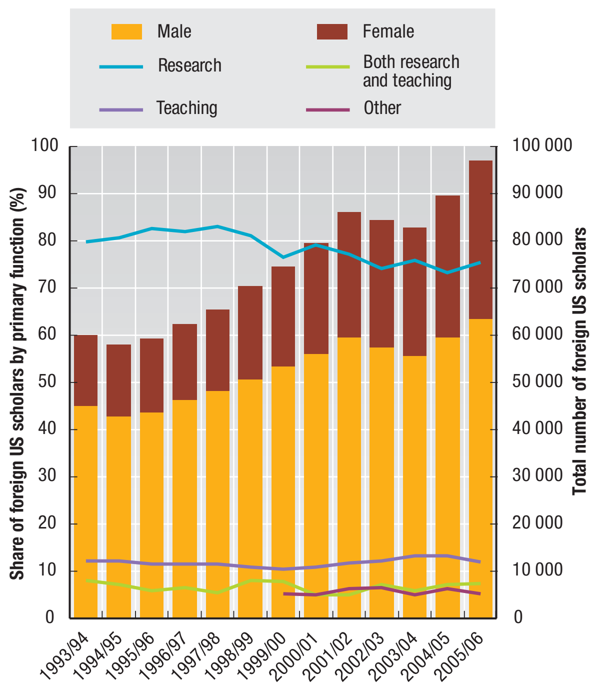
Growth in foreign scholars, by country of origin, 1995-2006

Average annual growth rate



Growth of foreign US scholars, by gender and activity, 1993/04-2005/06

Headcounts and as a percentage of total foreign US scholars



StatLink http://dx.doi.org/10.1787/117371522225

1. 2005 for Japan, Korea and Poland; 2004 for France, Germany, Italy, Spain, Switzerland and Turkey; 2003 for Mexico, the Netherlands, Norway, Russia and Sweden; 1999 for Greece, Iceland and Portugal; 2002 for other countries.

B.10. HUMAN RESOURCES IN S&T IN NON-OECD ECONOMIES

■ Human capital, often proxied by the educational attainment of a population, is a key driver of economic growth. In the four large emerging economies, Brazil, Russia, India and China, 171 million people aged 25-64 had a tertiary degree in 2004, as many as in the entire OECD area. However, as a proportion of the total population of the corresponding age group, the OECD average (25.1%) was much higher than that of Brazil (7.8%), China (9.5%) and India (11.4%).

■ In these economies, there has been a massive inflow of new students into the university system, the main channel for increasing the S&T base. In China alone, 3.9 million students entered university for the first time in 2005, about half the OECD total. Over the last decade, the number has been growing at breakneck speed. Because of the time required to obtain a degree, the number of university graduates in China (2.6 million in 2005) represented only one-third of the OECD total, but their number is rising fast.

■ The "quality" of education is important. One indicator of quality is provided by the number of graduates of advanced research programmes or of doctorates. The number is growing fast in China, but it lags the numbers for Brazil and Russia. In all, more than 90 000 people obtained a PhD degree in 2004 in these three countries, compared with almost 180 000 in the OECD area. India turned out close to 14 000 PhDs in 2003 (see B1).

■ Student mobility gives an indication of the perceived quality of the education system in other countries. The number of foreign students enrolled in tertiary education in OECD countries increased from 1.6 million in 2000 to 2.3 million in 2004. Two-thirds were from non-OECD economies, with China accounting for 22.8% of the non-OECD total, followed by India at 8.3%. Among OECD countries, the United States was still by far the most attractive destination, with 25.4% of the OECD share in 2004, down from 29.6% in 2000, followed by the United Kingdom (13.3%), Germany (11.5%) and France (10.5%).

■ Researchers in the non-OECD economies shown here accounted for over a third of the combined total of OECD and non-OECD researchers. This is much higher than their share in R&D expenditure (see A.4), as expenditure per researcher is considerably lower in less developed countries (lower wages, less and cheaper support staff, less expensive equipment, etc.).

■ The number of researchers in China has grown tremendously, from 695 000 in 2000 to 1.1 million in 2005. In absolute terms China ranks third behind the United States (estimated by the OECD at almost 1.4 million) and the EU (an estimated 1.2 million in 2004), and ahead of Japan (705 000) and Russia (465 000). Expressed as a proportion of employment however, China, at 1.5 researchers per 1 000 persons employed, is still far behind the estimated OECD average of 7.3. The same can be said of Brazil (1.0 in 2004) and India (0.3 in 2000). Moreover, the number of researchers in China may be overestimated (see box).

Sources

- OECD, Main Science and Technology Indicators database, May 2007.
- OECD, Education database, May 2007.
- Eurostat, New Cronos database, May 2007.
- Data for some of the countries have been compiled from national sources.

For further reading

- OECD (2002), *Frascati Manual 2002*, OECD, Paris, available at *www.oecd.org/sti/frascatimanual*.
- OECD (2006), *Education at a Glance; OECD indicators 2006*, OECD, Paris, *www.oecd.org/edu/eag2006*.
- OECD (2007), *Main Science and Technology Indicators 2007/1*, OECD, Paris.

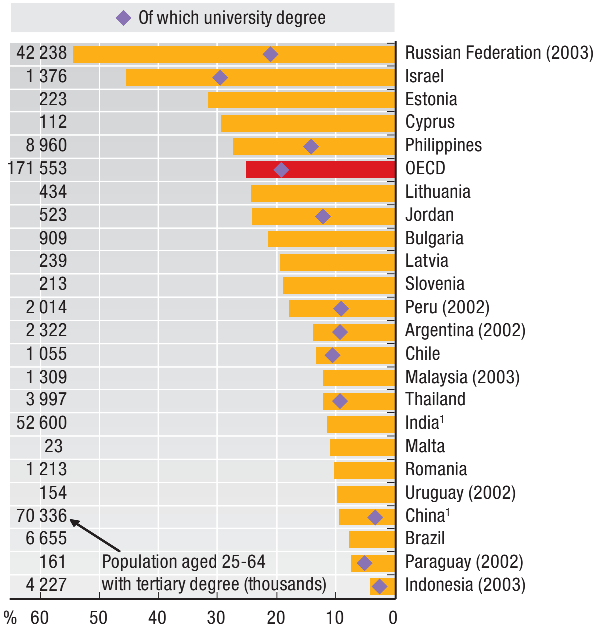
Measuring human resources in S&T in non-OECD economies

Data for researchers are drawn from the same sources as the R&D data presented in section A.4 and are generally measured according to *Frascati Manual* guidelines. Researcher data are expressed in full-time equivalents (FTE). The notes in section A.4 apply to these data as well. In addition, data for researchers in China are collected according to the UNESCO concept of "scientist and engineer", which differs somewhat from the *Frascati Manual* notion of researcher. The concept of "scientist and engineer" is a combination of academic degree and occupation, closely linked to core HRST as defined in the *Canberra Manual*. Figures on researchers in China may be overestimated.

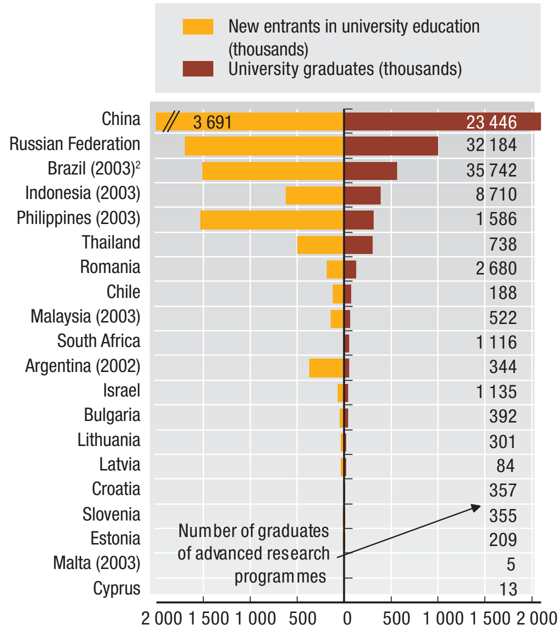
B.10. HUMAN RESOURCES IN S&T IN NON-OECD ECONOMIES

Educational attainment in non-OECD economies, 2004

Percentage of population aged 25-64 with tertiary degree

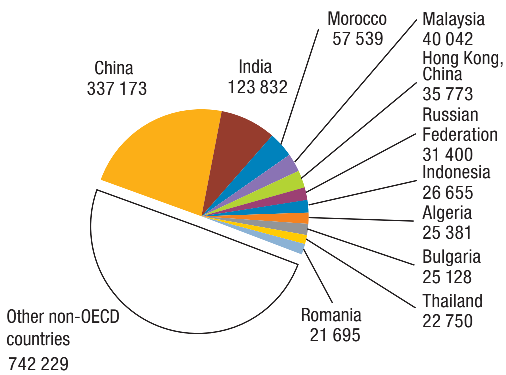


University entrants and graduates in non-OECD economies, 2004

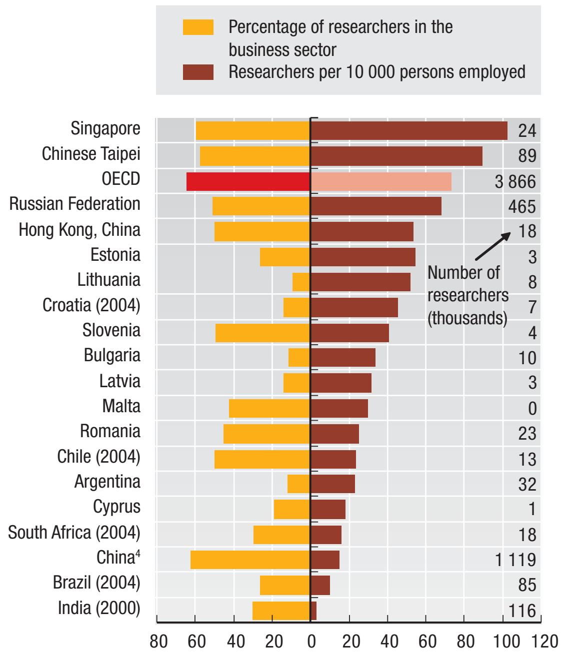


Students from non-OECD economies enrolled in tertiary education in OECD countries³, 2004

By country of citizenship



Researchers in non-OECD economies, 2005



StatLink http://dx.doi.org/10.1787/117384133584

1. Overestimated, as all people with a tertiary degree are included.
2. Includes non-university tertiary education.
3. Excludes tertiary-type B programmes for Austria, Spain and Switzerland; for Canada: reference year 2002; excludes advanced research programmes for Germany, the Netherlands and Poland.
4. Data are for scientists and engineers rather than researchers; overestimation possible, see methodological box.

B.11. EMPLOYMENT OF HRST BY INDUSTRY

■ The services sector accounts for the majority of employees in OECD countries, and in 2004, it employed more than 70% of professional and technical workers (see box). Manufacturing industry has the second largest share of human resources in science and technology (HRST). Electricity, gas and water supply and construction have an average of 3.5% of HRST, and the primary sector an average of only 1%.

■ The share of professionals and technicians in the services sector was between 20% and 45% in 2004, much higher than in the manufacturing sector (between 7% and 27%). Luxembourg and Switzerland, countries with important financial and banking activities, had the largest shares of HRST in the services sector (around 45%).

■ In 2004, the share of HRST workers in the manufacturing sector was the highest in Finland (27.2%), Sweden (26.1%), France and Austria (26.0%); it was below 10% in Japan and Portugal.

■ Over the past decade, the number of professionals and technicians increased more rapidly than total employment in both the manufacturing and service sectors. It increased the most in the services sector (7.2% a year in Spain, 7% in Australia, 6.8% in Ireland, and 6.5% in Luxembourg). The average annual growth rate was around 2% in Portugal, Finland and the United States.

■ Over the same period, in most OECD countries the number of HRST rose in the manufacturing sector although total employment decreased. The increase was greatest in Ireland (8.1%), Spain (7.8%) and Italy (7.1%). In these countries and in Austria and Finland, professionals and technicians grew faster in the manufacturing than in the services sector. The United States, Japan, Luxembourg, Sweden and the United Kingdom have seen numbers of HRST decrease in the manufacturing sector in a context of even faster decline in employment in the sector.

■ Changes in the share of HRST in the services and in manufacturing are closely correlated across countries: countries with the largest increase in HRST in services are also those with the greatest increase in manufacturing. This indicates that the dynamics of HRST in these sectors are not independent.

Source

- OECD, ANSKILL database (*forthcoming*).

For further reading

- OECD and Eurostat (1995), *Manual on the Measurement of Human Resources devoted to S&T: Canberra Manual*, OECD, Paris, available at: www.oecd.org/dataoecd/34/0/2096025.pdf.

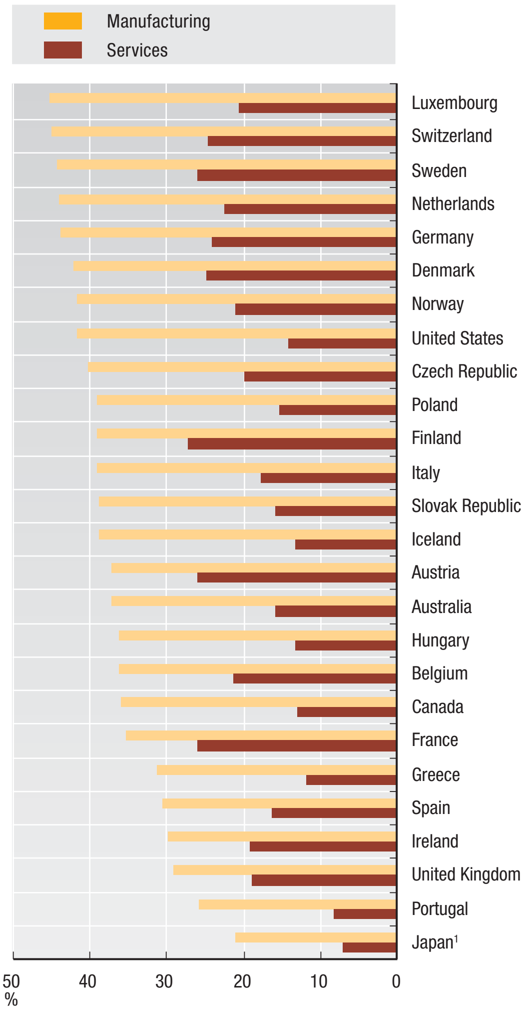
HRST workers by industry: definitions and sources

- Human resources in science and technology (HRST) are defined according to the *Canberra Manual* (OECD and Eurostat, 1995) as persons having graduated at the tertiary level of education (see B.4), or persons employed in an S&T occupation for which a high qualification is normally required and the innovation potential is high.
- HRST data reported here concern professionals and technicians as defined in the International Standard Classification of Occupations (ISCO 88) major groups 2 and 3 (see B.5).
- The original data were collected according to the following industry classifications: European Union (NACE Rev.1), Canada (NAICS 2002-Canada), Japan (JSIC 2002), United States (NAICS 2002 -US), Australia (ANZSIC 1993). They have then been converted to ISIC Rev.3 for the ANSKILL database.
- The industry groupings analysed here are the following:
  - Manufacturing (ISIC 15 to 37).
  - Services (ISIC 50 to 99).

B.11. EMPLOYMENT OF HRST BY INDUSTRY

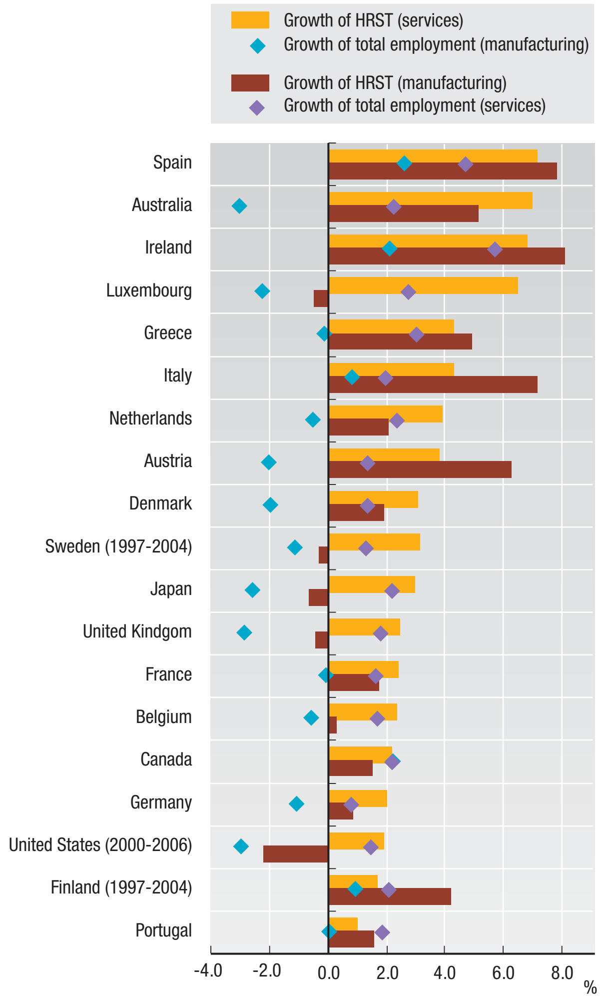
Share of HRST employees by industry, 2004

As a percentage of total employees of the industry

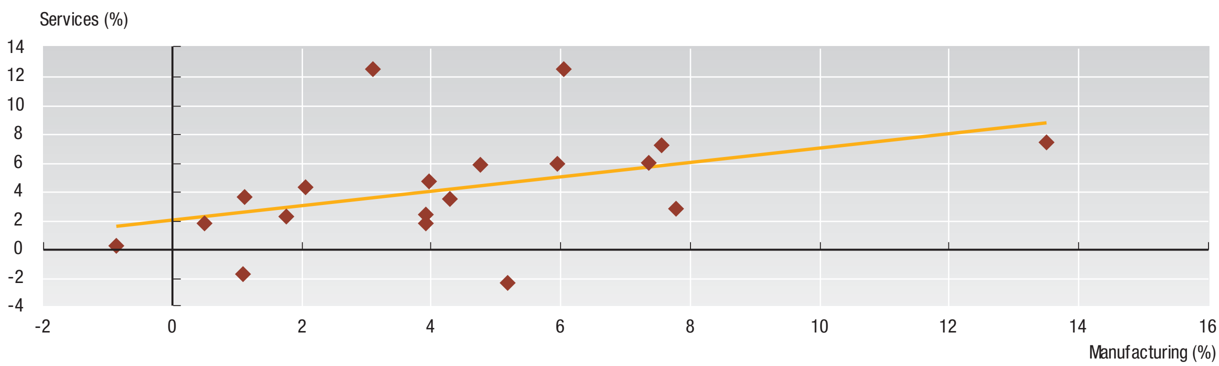


Growth of HRST employees by industry, 1995-2004

Average annual growth rate (%)



Change in the shares of HRST in the manufacturing and service sectors, 1995-2004



StatLink http://dx.doi.org/10.1787/117405408281

1. OECD calculations based on national estimations.

B.12. EARNINGS BY EDUCATIONAL LEVEL

The pool of people potentially available to work in science and technology will be a function, among other things, of the earnings premium linked to tertiary education. This indicator compares earning differentials between highly educated and other workers, with a particular focus on gender differences.

The earnings benefit of completing tertiary education (ISCED) can be analysed by comparing the average annual earnings of persons who graduate from tertiary education with the average annual earnings of upper secondary (ISCED 3) or post-secondary non-tertiary (ISCED 4) graduates. According to the latest data available, there is a strong positive correlation in all countries between the level of educational attainment and average earnings. This is especially true in Hungary (217%), the Czech Republic (182%), the United States (172%), Switzerland (164%) and Poland (163%). The earning differentials are smallest in the Scandinavian countries with a percentage of around 125%.

In most OECD countries, earning differentials between individuals with tertiary education and those with upper secondary education are generally more pronounced than those between upper secondary and lower secondary or below. Scandinavian countries are again exceptions, but Belgium, Germany and France are as well.

Over the recent period, these differentials decreased significantly in Italy, Hungary and Germany. In other words, the earnings premium of highly skilled workers decreased compared to that of medium skilled workers. However, in Spain, Norway, New Zealand and Finland, it increased at an average annual rate of 1% or more.

The gender breakdown shows that, even if an education premium exists for both males and females, differentials between males and females with the same educational attainment remain important. In the United States, Italy, Germany and Canada, women earn almost 40% less than their male HRST counterparts. On the other hand, in Luxembourg, Belgium, Spain, Hungary and France average annual earnings of women with tertiary education represent slightly more than 70% of the earnings of men with the same level of education.

These figures should be interpreted with caution since most countries' earnings data include part-time work (see box), which is an important characteristic of women's employment.

Source

- OECD, raw data of the *Education at a Glance* (2006).

For further reading

- OECD (2006), *Education at a Glance: OECD Indicators 2006*, OECD, Paris, available at: *www.oecd.org/edu/eag2006*.
- OECD and Eurostat (1995), *Manual on the Measurement of Human Resources devoted to S&T: Canberra Manual*, OECD, Paris, available at: www.oecd.org/dataoecd/34/0/2096025.pdf.

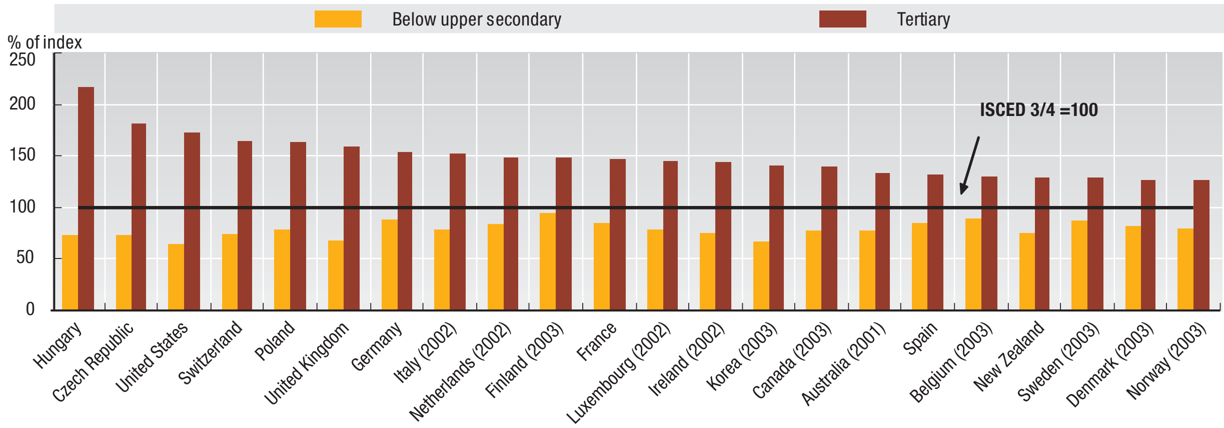
Earnings by educational level: definitions and methodological aspects

- The original sources of earnings data are as follows: Australia (Australia: Survey of Education and Training; Belgium: Labour Force Survey; Canada: Survey of Labour and Income Dynamics (SLID); Czech Republic: Microcensus; Denmark: *i)* Income register (end of 2001); *ii)* Register of educational attainment (October 2001); Finland: Register-based Employment Statistics; France: French life force survey; Germany: German socio-economic panel study (GSOEP); Hungary: Individual Salary and Earnings of Employees; Ireland: Living in Ireland Survey; Italy: Bank of Italy Survey on Household Incomes and Wealth; Korea: Survey on wage structure; Luxembourg: Structure of earnings survey (every four years); Netherlands: Structure of Earnings Survey; New Zealand: Labour Market Statistics; Norway: Income Statistics for Persons and Families; Portugal: List of Personnel; Spain: European Household Panel, Eighth wave; Sweden: National income register; Switzerland: Labour Force Survey; United Kingdom: Labour Force Survey; United States: 2003 March Current Population Survey.
- Earnings are considered before income tax except for Belgium and Korea for which data are after income tax.
- Earnings data for the Czech Republic, Hungary, Luxembourg and Poland exclude part-time work. Moreover, earnings data for Hungary, Luxembourg and Poland exclude part-year or seasonal employment.
- The length of the reference period is one week for Australia, New Zealand and United Kingdom; one month for Belgium, France, Hungary, Ireland, Germany and Portugal; the calendar year for Canada, the Czech Republic, Denmark, Finland, Italy, Luxembourg, Netherlands, Norway, Spain and Sweden; and other 12-month periods for Korea, Switzerland and United States.

B.12. EARNINGS BY EDUCATIONAL LEVEL

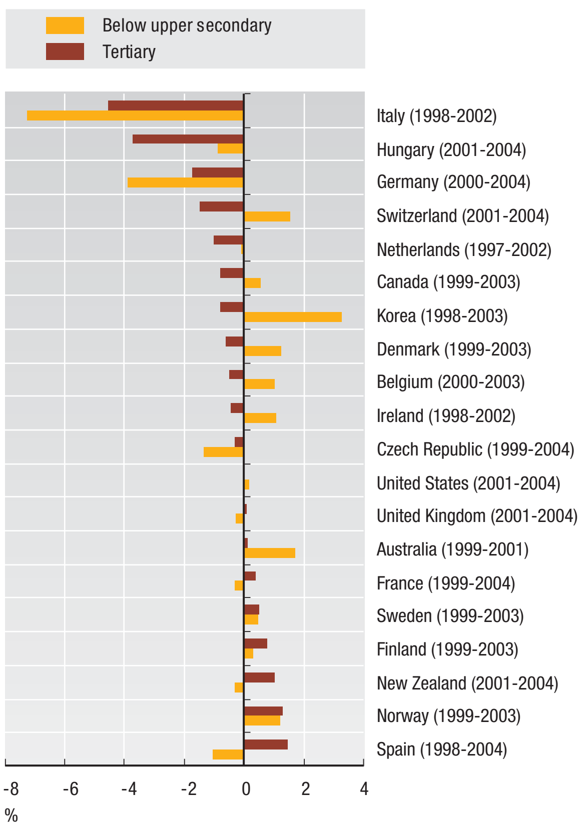
Relative earnings of the population with income from employment (2004)

By level of education for 25-to-64-year-olds (upper-secondary and post-secondary non-tertiary education = 100)



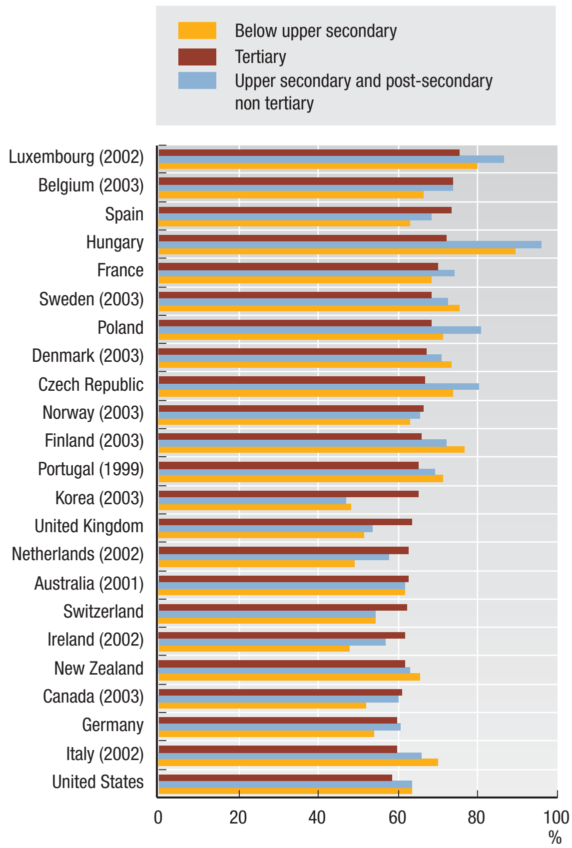
Change in earning differentials[1, 2]

By level of skills for 25-to-64-year-olds (compared to workers having upper-secondary and post-secondary non-tertiary education)



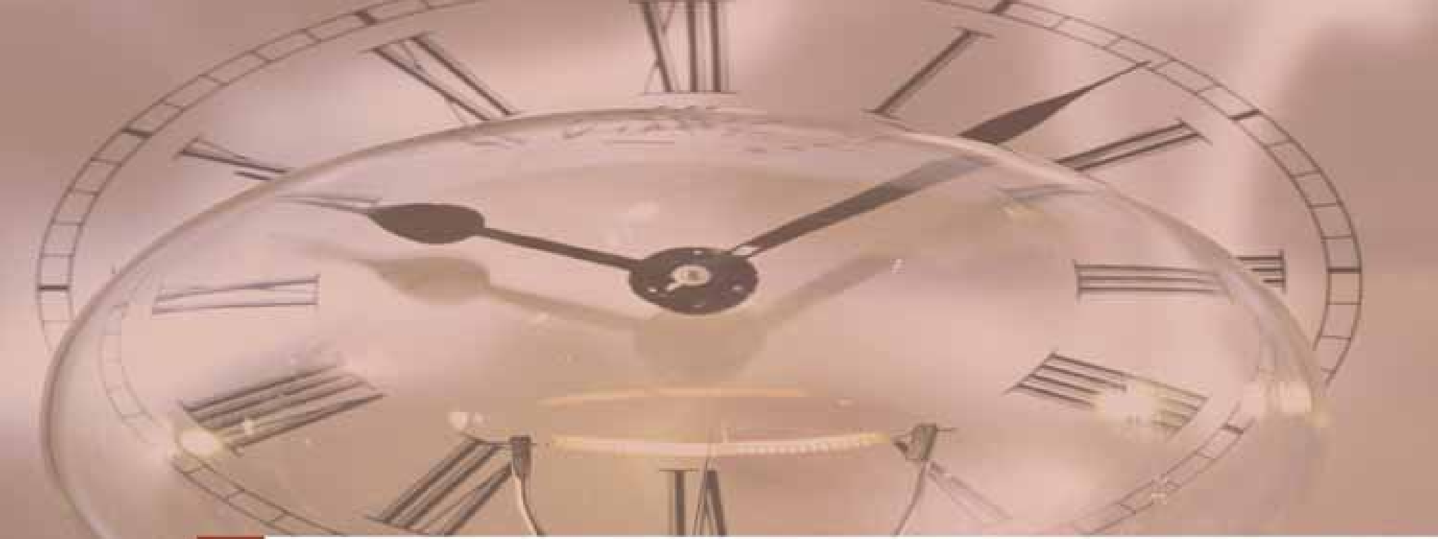
Differences in earnings between females and males (2004)

Average annual earnings of females as a percentage of males by level of education of 25-to-64-year-olds



StatLink http://dx.doi.org/10.1787/117447401408

1. This indicator is calculated as follows: [(Final index value/Initial index value) $^{1/n}$ -1] x 100; *n* being equal to the difference between final and initial year.
2. This figure should be read as follows: In Italy, over 1998-2002, the earning differentials of HRST workers with respect to those with an upper-secondary and post-secondary non-tertiary educational attainment, have decreased at an average annual rate of 4.5%.



C. INNOVATION POLICY

C.1. PUBLIC-PRIVATE CROSS-FUNDING OF R&D

■ Interaction between industry and government in science and innovation takes many forms and is often difficult to quantify. Direct financial flows for R&D between government and the business enterprise sector are one way to track such cross-sectoral linkages.

■ On average, around 7% of R&D performed in the business sector is financed by direct government funds, although the share is considerably higher in the Russian Federation (53.6%), the Slovak Republic (26%), the Czech Republic (15%) and Italy (14%). In many countries, this share has decreased compared to 1995. This pattern is coherent with the increasing adoption of other policy instruments to stimulate innovation, such as R&D tax incentives.

■ Likewise, business funds an important share of the R&D performed in the higher education and government sectors, with an OECD-area average of 4.7% in 2005. In the EU27, companies financed 6.4% of total R&D performed in public institutions and universities, compared to only 2.7% in the United States and 2.0% in Japan. Japan, Mexico and Italy have the smallest shares of business-funded R&D performed in the higher education and government sectors.

■ Between 1995 and 2005, business-funded R&D in the higher education and government sectors increased considerably in Turkey, Austria, Germany, Switzerland, Luxembourg, Iceland, Hungary and the Russian Federation. An inversed trend is reported in New Zealand, Korea, Ireland, Poland, Slovak Republic and South Africa.

■ In spite of increases in many countries, funding of R&D performed in public institutions and universities by companies still represent less than 8% in most large OECD economies. High values for both indicators in the Russian Federation (and to a lesser extent New Zealand) suggest strong linkages between the private sector and the public sector in terms of cross-funding of R&D activities. The opposite is true for Japan and Denmark, with very low values for both.

Sources

- OECD, Research and Development database, May 2007.

For further reading

- OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, OECD, Paris, available at: *www.oecd.org/sti/frascatimanual*.

Measuring the performance of R&D in the government and higher education sectors

Measures of R&D performance in the higher education sector and its evolution are often based on estimates by national authorities and evaluation methods are periodically revised (see boxes in A.2 and A.3). Moreover, certain national characteristics may strongly influence R&D performance by the government and higher education sectors:

US figures for these sectors are underestimated. The governement sector R&D covers only federal government activities, not those of individual state and local governments; and since 1985 figures for researchers exclude military personnel in the government sector. In the higher education sector, R&D in the humanities is not included, and since 1991 capital expenditures have been excluded. In Korea, the higher education sector is probably greatly underestimated owing to the exclusion of R&D in the social sciences and humanities (SSH).

Certain transfers of public agencies to private enterprise, as in the case of the privatisation of Swisscom (Switzerland) in 1998, and the partial privatisation of the Defence Evaluation and Research Agency – DERA – (United Kingdom) in 2001, have had the effect of reducing R&D performance in the government sector and increasing it in the business enterprise sector.

Conversely, for the United States, in 2005 following a survey of the federally funded research and development centres (FFRDCs), it was determined that FFRDC R&D belongs to the government sector rather than to the sector of the FFRDC administrator as had been reported in the past. This R&D expenditure was therefore reclassified from the other three performing sectors to the government sector and data revised historically.

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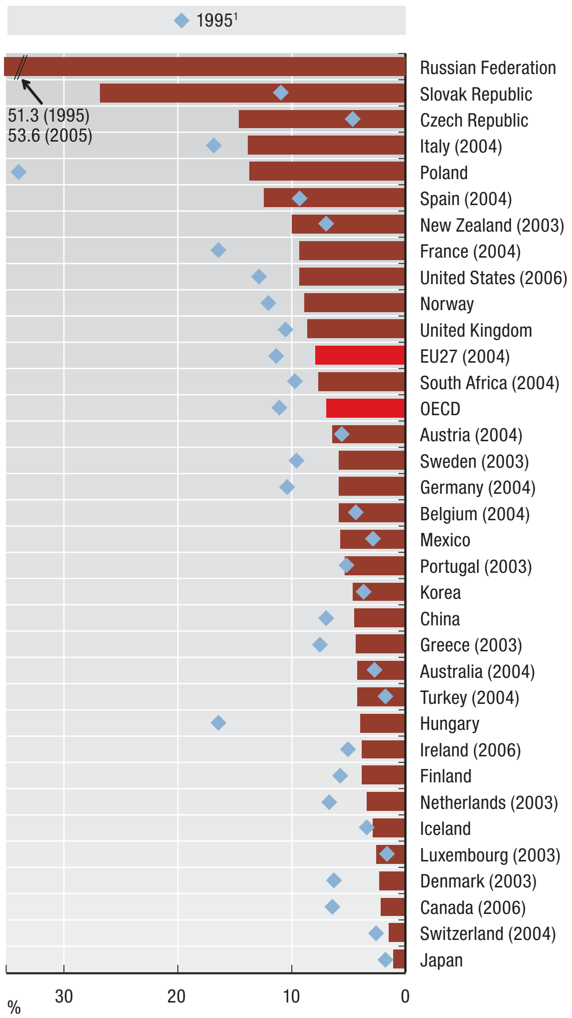
C.1. PUBLIC-PRIVATE CROSS-FUNDING OF R&D

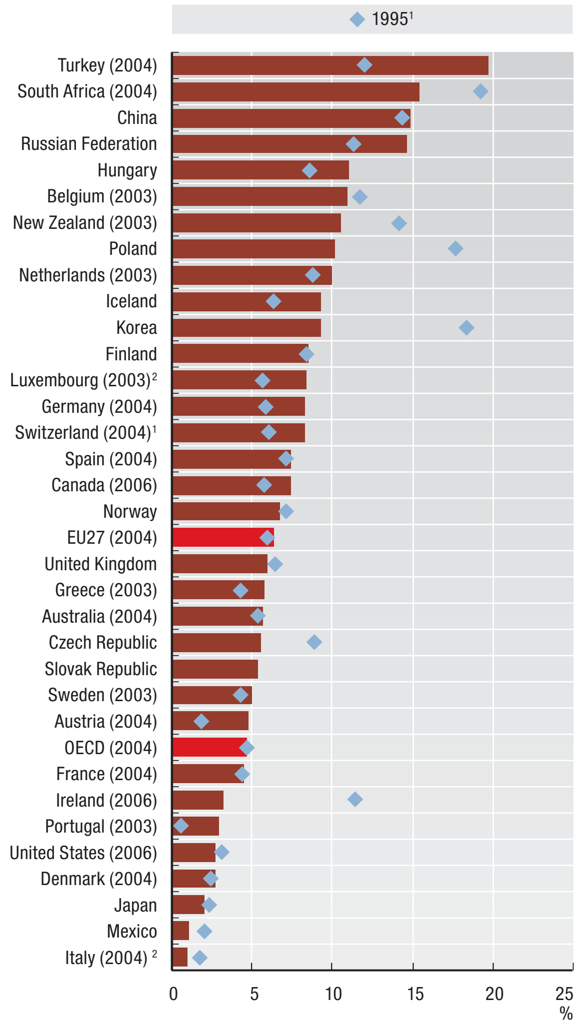
Government-financed R&D in business, 2005

As a percentage of R&D performed in the business sector



Business-funded R&D in the higher education and government sectors, 2005

As a percentage of R&D performed in these sectors (combined)



StatLink http://dx.doi.org/10.1787/117463686705

1. 1995 data for Australia and Switzerland: 1996; Luxembourg and China: 2000; Austria: 1998; and South Africa: 2001.
2. Government sector only.
3. Higher education sector only.

C.2. GOVERNMENT R&D BUDGETS

Data on GBAORD (see box for definition) provide an indication of the relative importance of various socio-economic objectives, such as defence, health and the environment, in public R&D spending.

The United States continues to have the largest defence R&D budget as a share of GDP (0.6% in 2006). This is more that 1.5 times the ratio of the Russian Federation and twice that of the United Kingdom, with the second- and third-highest shares (about 0.4 and 0.2% of GDP, respectively). In 2005, the United States accounted for more than 83% of the overall OECD-area budget for defence R&D, or six times the EU27 total.

The United States also had the largest share of GBAORD devoted to defence R&D, with 57% of the total in 2005. The United Kingdom was second with almost one-third of its GBAORD allocated to defence, followed by France (22%), Sweden (17%) and Spain (16%).

Iceland leads the OECD area for GBAORD as a percentage of GDP, at 1.44% in 2005; it is entirely devoted to civil R&D. Iceland and Finland are the only two countries in which civil GBAORD is at least 1% of GDP, or twice the OECD average.

Since 2000, government R&D budgets have grown on average by 4.3% (in real terms) in the OECD area. In Luxembourg they grew by more than 20% annually between 2000 and 2006. Spain and Ireland both had growth rates exceeding 10% a year. Poland is the only country in which the government R&D budget decreased, by around 2% a year between 2000 and 2005. Growth of GBAORD has been modest in the EU27 region, averaging 1.8% a year since 2000, compared to 2.7% in Japan and 5.8% in the United States.

Sources

- OECD, Main Science and Technology Indicators database, May 2007.
- OECD, Research and Development database, May 2007.

For further reading

- OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Development*, OECD, Paris, available at *www.oecd.org/sti/frascatimanual*.

GBAORD

GBAORD (government appropriations or outlays for R&D) measures the funds committed by the federal/central government for R&D to be carried out in one of the four sectors of performance – business enterprise, government, higher education, private non-profit – at home or abroad (including by international organisations). The data are usually based on budgetary sources and reflect the views of the funding agencies. They are generally considered less internationally comparable than the performer-reported data used in other tables and graphs but have the advantage of being more timely and reflecting current government priorities, as expressed in the breakdown by socio-economic objectives.

A first distinction can be made between defence programmes, which are concentrated in a small number of countries, and civil programmes, which can be broken down as follows:

- Economic development: agricultural production and technology; industrial production and technology; infrastructure and general planning of land use; production, distribution and rational utilisation of energy.
- Health and environment: protection and improvement of human health, social structures and relationships, control and care of the environment, exploration and exploitation of the earth.
- Exploration and exploitation of space.
- Non-oriented research.
- Research financed from general university funds (GUF): the estimated R&D content of block grants to universities.

It should be noted that the series for Japan excludes the R&D content of military procurement. In the United States, general support for universities is the responsibility of state governments and therefore GUF is not included in total GBAORD. In France, a change in the method of evaluating defence R&D resulted in a reduction in the defence objective from 1997.

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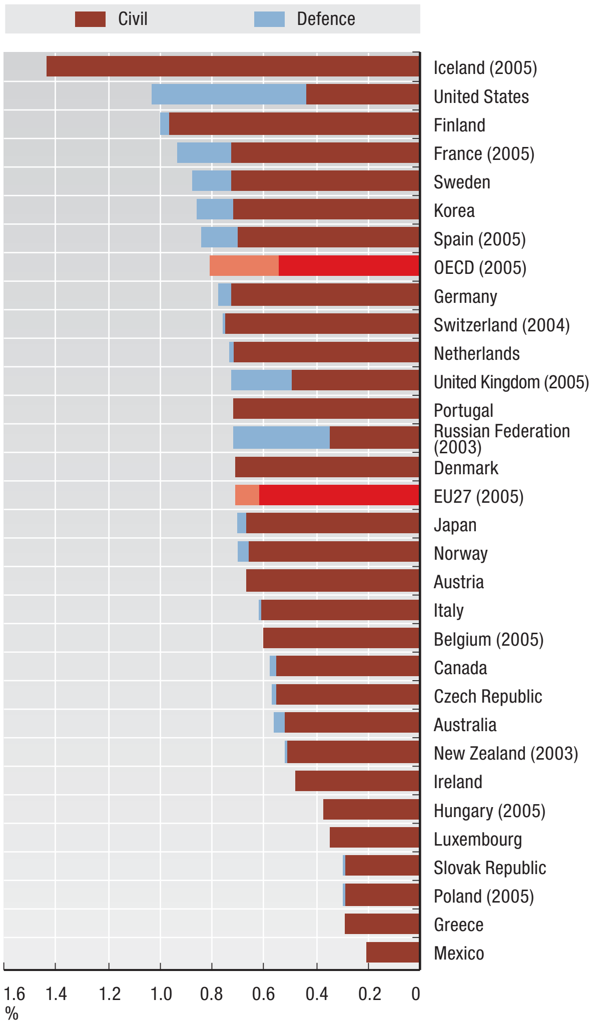
C.2. GOVERNMENT R&D BUDGETS

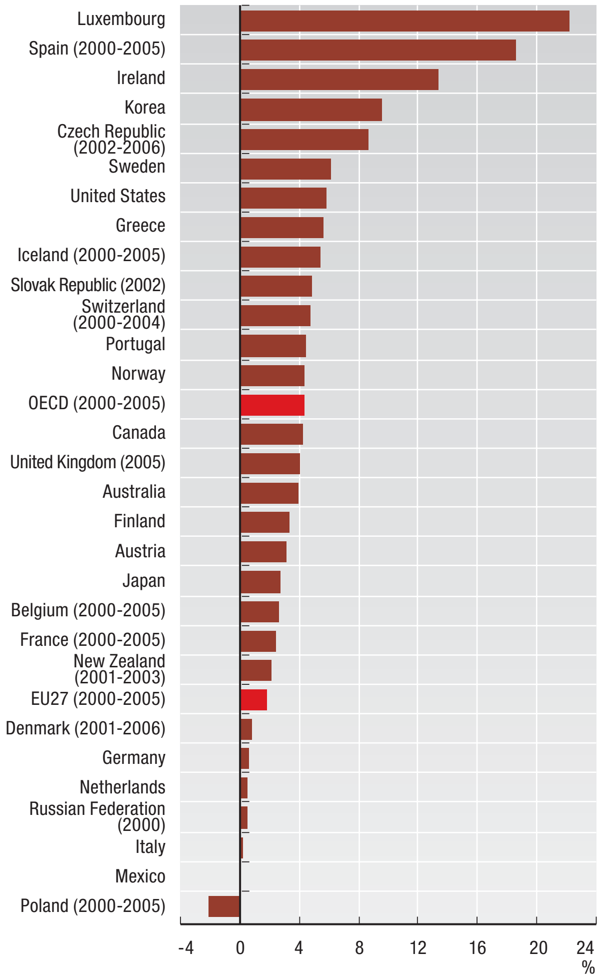
Defence and civil R&D budgets (GBAORD)

As percentage of GDP, 2006 or latest available year



Growth in government R&D budgets (GBAORD)

Average annual growth rate in %, 2000-2006 or latest available years



StatLink http://dx.doi.org/10.1787/117536746430

C.3. TAX TREATMENT OF R&D

R&D tax concessions are extensively used by OECD countries as an indirect way of encouraging business R&D expenditures. Special tax treatment for R&D expenditures includes immediate write-off of current R&D expenditures and various types of tax relief such as tax credits or allowances against taxable income. Depreciation allowances are a third type (Warda, 2001).

In 2006, 20 OECD countries had R&D tax credits, up from 18 in 2004. It is an increasingly popular measure among OECD and non-OECD governments. Since 2006, Spain, China, Mexico and Portugal provide the largest subsidies and make no distinction between large and small firms. Canada and the Netherlands continue to be significantly more generous to small firms than to large ones. Emerging economies are also implementing these policy instruments to encourage R&D investments. Brazil, India, Singapore and South Africa provide a generous and competitive tax environment for investment in R&D.

Tax subsidies for R&D for large firms increased significantly between 1999 and 2007 in Mexico and Norway, and to a lesser extent in Portugal, New Zealand, France, Belgium, Japan and the United Kingdom. Elsewhere, the rate of tax subsidies remained stable.

R&D tax incentives reduce the cost incurred by companies for undertaking R&D. In contrast with most types of subsidies, R&D tax incentives give the recipient full discretion as to the financing of its R&D strategy. For the government, these incentives represent taxes forgone.

In response to a recent OECD-NESTI questionnaire, some countries provided estimates of the gross tax expenditures/taxes forgone due to R&D tax incentives to indicate the potential government revenue gain to be realised by removing the R&D tax credit. For the Netherlands, Mexico, Australia, Belgium and Spain it amounted on average to USD 375 million while in the United States, Canada, France and the United Kingdom, it reached over USD 800 million.

For further reading

- OECD (2006), OECD *Science, Technology and Industry Outlook*, OECD, Paris, available at *www.oecd.org/sti/sti-outlook*.
- Warda, Jacek (2001), "Measuring the Value of R&D Tax Treatment in OECD Countries", in *Special Issue on New Science and Technology Indicators*, *STI Review No. 27*, OECD.

The B index

The amount of tax subsidy to R&D is calculated as 1 minus the B index (Warda, 2001). The B index is defined as the present value of before tax income necessary to cover the initial cost of R&D investment and to pay corporate income tax, so that it becomes profitable to perform research activities. Algebraically, the B index is equal to the after-tax cost of an expenditure of USD 1 on R&D divided by one minus the corporate income tax rate. The after-tax cost is the net cost of investing in R&D, taking into account all the available tax incentives.

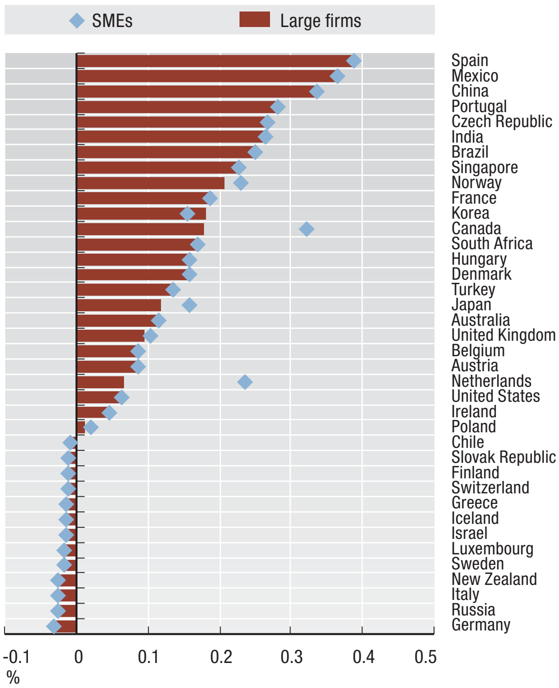
$$Bindex = \frac{(1-A)}{(1-\tau)}$$

where A = the net present discounted value of depreciation allowances, tax credits and special allowances on R&D assets; and τ = the statutory corporate income tax rate (CITR). In a country with full write-off of current R&D expenditure and no R&D tax incentive scheme, $A = \tau$, and consequently $B = 1$. The more favourable a country's tax treatment of R&D, the lower its B index.

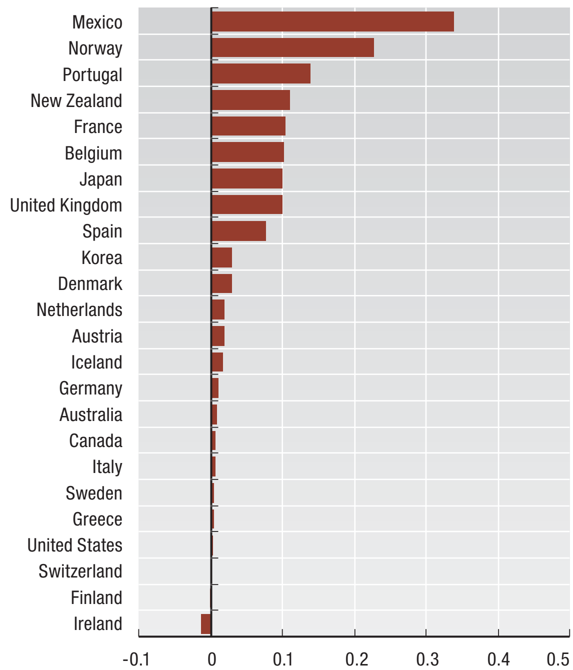
The B index is a unique tool for comparing the generosity of the tax treatment of R&D in different countries. However, its computation requires some simplifying assumptions. It should therefore be examined together with a set of other relevant policy indicators. Furthermore, its "synthetic" nature does not allow for distinguishing the relative importance of the various policy tools it takes into account (*e.g.* depreciation allowances, special R&D allowances, tax credit, CITR). B indexes have been calculated under the assumption that the "representative firm" is taxable, so that it may enjoy the full benefit of the tax allowance or credit. For incremental tax credits, calculation of the B index implicitly assumes that R&D investment is fully eligible for the credit and does not exceed the ceiling if there is one. Some detailed features of R&D tax schemes (*e.g.* refunding, carry-back and carry-forward of unused tax credit, or flow-through mechanisms) are therefore not taken into account.

The effective impact of the R&D tax allowance or credit on the after-tax cost of R&D is influenced by the level of the CITR. An increase in the CITR reduces the B index only in those countries with the most generous R&D tax treatment. If tax credits are taxable, the effect of the CITR on the B index depends only on the level of the depreciation allowance. If the latter is over 100% for the total R&D expenditure, an increase in the CITR will reduce the B index. For countries with less generous R&D tax treatment, the B index is positively related to the CITR.

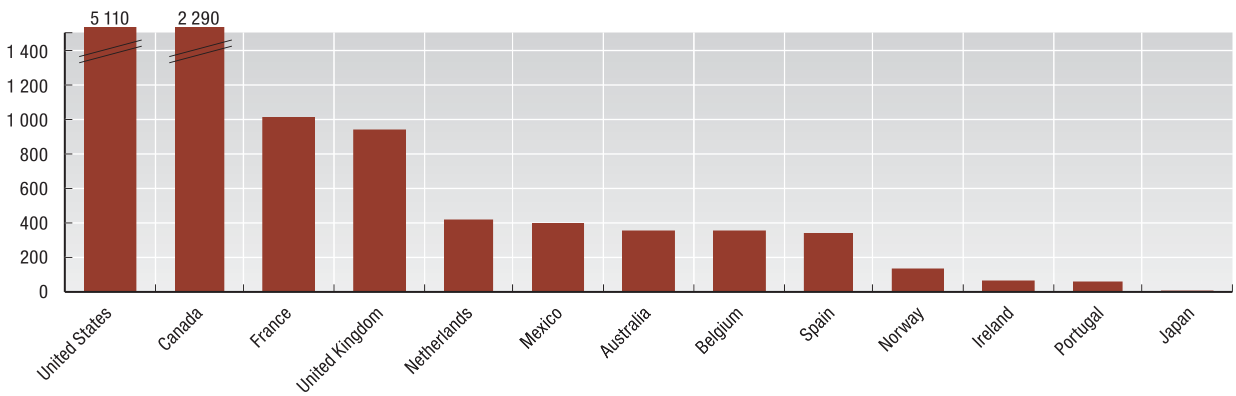
Rate of tax subsidies for USD 1 of R&D[1], large firms and SMEs, 2007



Change in the rate of tax subsidies for USD 1 of R&D, large firms, between 1999 and 2007



Estimates of revenue losses due to R&D tax incentives[2], 2005, USD millions in PPP



StatLink http://dx.doi.org/10.1787/117566660733

1. Tax subsidies are calculated as 1 minus the B index. For example, in Spain, 1 unit of R&D expenditure by large firms results in 0.39 unit of tax relief. See Warda (2001) for country reviews of policy instruments.
2. OECD, based on national estimates (NESTI R&D tax incentives questionnaire), some of which may be preliminary. The estimates cover the federal research tax credit for the United States; the SR&ED tax credit for Canada; the mixed volume and incremental incentive for France; the refundable research premium for Austria; the tax credit consisting in a reduction of taxes on R&D wages as well as the allowance on profits of R&D self-employed for the Netherlands; the volume measure for the United Kingdom, Mexico and Norway; the mixed volume and incremental measure for Spain (now being phased out); both the tax offset and incentive depreciation for Australia; the incremental tax credit for Ireland; the tax incentives for experimental research plus the special tax depreciation of equipment for developmental research for Japan.

C.4. PATENTING BY UNIVERSITIES AND GOVERNMENT

■ The share of public institutions (government laboratories and universities) in the ownership of patents reflects both the strength of their technological research and the legal framework. In Sweden and, until recently, in Germany and Japan, university professors have been entitled to own patents resulting from their research. The patents are thus registered as belonging to individuals or businesses rather than to public institutions.

■ Public institutions own 7% of all international patents filed under the Patent Co-operation Treaty (PCT) between 2002 and 2004. More than 10% of patent applications by US residents are owned by public institutions compared to around 4% of patents owned by European residents. In Singapore, almost 40% of all PCT filings are owned either by the government or the higher education sector.

■ Among OECD countries, Ireland has the highest proportion of patenting by universities (9.7% over 2002-04), a noticeable increase over the mid-1990s when universities owned 3.5%. In Australia, Belgium, China, Spain, the United Kingdom and the United States, the higher education sector accounts for 6 to 8% of all international patent applications. The University of California and the Massachusetts Institute of Technology (MIT) were the leading patentees in the US higher education sector between 2002 and 2004.

■ Between 1996-98 and 2002-04, the share of patents filed by universities decreased slightly in Australia, Canada and the United States but increased markedly in Japan and the European Union, notably in France and Germany. This increase results directly from policy changes in these countries in the early 2000s.

■ Among emerging economies, Brazil, Israel and Singapore also have a larger share of patenting by universities relative to other countries. The proportion was highest in China in the mid-1990s, but has since decreased by half.

■ In terms of patents owned by government agencies, India and Singapore takes first place, with 23.1% and 24.2%, respectively. France leads among OECD countries, with 5.5%, the largest contributor being the Commissariat à l'Énergie Atomique (CEA). In Japan, this proportion has risen significantly since the mid-1990s, whereas it has decreased by more than 2 percentage points in Australia, Canada, Korea and the United Kingdom to levels below 5%.

Source

- OECD, Patent database, April 2007, available at: *www.oecd.org/sti/ipr-statistics*.

For further reading

- Magerman, T., B. Van Looy and X. Song (2006), "Data Production Methods for Harmonized Patent Indicators: Patentee Name Harmonization", Eurostat Working Paper and Studies, Luxembourg.

Allocation of patents by institutional sectors

Patent indicators are frequently used to assess the innovative performance and technological progress of countries, regions or certain specific domains and technology fields. More and more studies tend to expand such analysis to include the originating companies, universities, government and individuals in order to highlight the dynamics of countries' innovative performance.

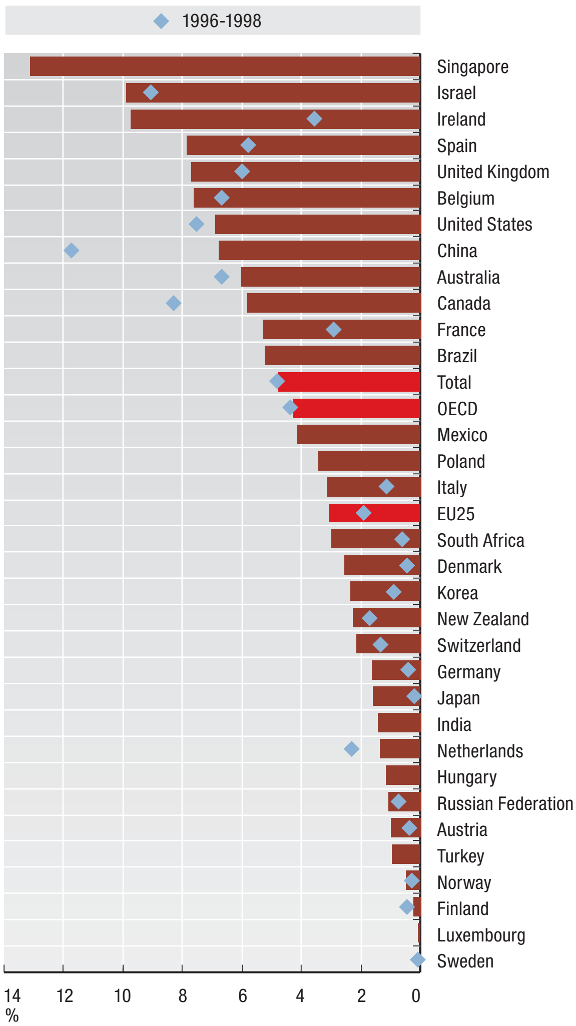
Methods for allocating an institutional sector to patents were developed in a recent project led by Eurostat, in line with the *Frascati Manual* (2002). These methods consist mainly in analysing a set of key words ("clues" to identify the sector) in the name of the patent applicant. However, "whilst the definition of categories is generally clear and precise, the matching of name characteristics to different categories is not clear-cut for certain types of organisation" (Magerman *et al.*, 2006). A separate category for hospitals was included, as the governance under which they operate is not always straightforward. The algorithm for sector attribution was applied to records on patent applications filed under the PCT in the OECD Patent database, allocating patent documents to individuals, private enterprises, government, universities, hospitals or private non-profit organisations.

Harmonisation of applicants' names is another important issue to tackle in order to undertake an analysis at the applicant level. There is a high degree of heterogeneity in applicants' names in patent databases: unique names in patent databases would make possible a more in-depth analysis of patents, and possibly the capacity to match patent data with other economic data at company level as well as to identify the institutional sector to which the patents belong. Efforts to resolve this issue are under way.

C.4. PATENTING BY UNIVERSITIES AND GOVERNMENT

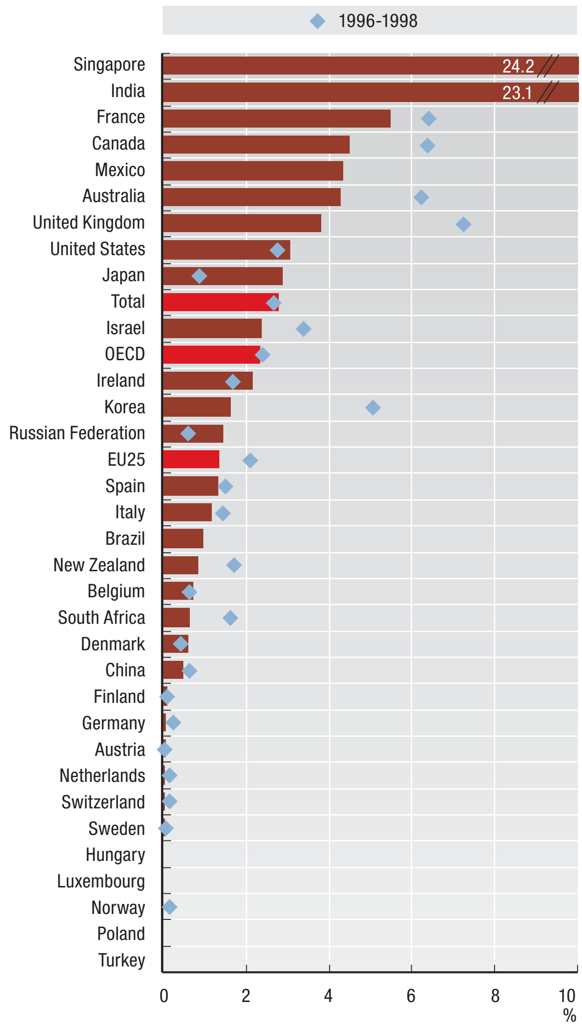
Share of patents filed under PCT[1] owned by universities[2]

2002-04



Share of patents filed under PCT[1] owned by government[2]

2002-04



StatLink http://dx.doi.org/10.1787/117608527465

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

1. Patent applications filed under the Patent Co-operation Treaty (PCT), at international phase, designating the European Patent Office. Only countries with more than 300 PCT filings per period are included.
2. PCT filings are attributed to institutional sectors using an algorithm developed by Eurostat.

C.5. COLLABORATION WITH PUBLIC RESEARCH ORGANISATIONS BY INNOVATING FIRMS

Collaboration is an important part of the innovation activities of many firms. It involves "active participation in joint innovation projects with other organisations" (*Oslo Manual*, 2005), but excludes pure contracting out of work. Collaboration can involve the joint development of new products, processes or other innovations with customers and suppliers, as well as horizontal work with other enterprises or public research bodies.

Around one in ten of all firms (or one in four innovating firms) in Europe collaborated with a partner for their innovation activities during 2002-04. Large firms were four times more likely to collaborate than small and medium-sized enterprises (SMEs). Among SMEs, the rate of collaboration is fairly similar across countries (between 10 and 20% of all firms in more than half of the countries surveyed), but it varies widely for large firms.

Collaboration with public research organisations (higher education or government research institutes) can be an important source of knowledge transfer for the innovation activities of firms. Here again, large firms are much more active than SMEs, and show much more cross-country variation. However, this indicates only the existence of some sort of collaboration, not its type or intensity.

In almost all countries, there is more collaboration with higher education institutions than with government research centres. For large firms, co-operation with the former was most prevalent in Finland, Sweden, Estonia and Belgium (over 30%), and with the latter in Finland, Norway, Iceland and Sweden (over 20%).

Sources

- Eurostat, CIS-4 (New Cronos), May 2007.
- National data sources.

For further reading

- Australian Bureau of Statistics (ABS) (2006), *Innovation in Australian Business, 2005*, 8158.0, December.
- Eurostat (2007), "Community Innovation Statistics – Is Europe growing more innovative", Statistics in Focus, 61/2007.
- OECD/Eurostat (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 3rd edition, Paris.
- Statistics New Zealand (2007), *Innovation in New Zealand – 2005*, January.

Measuring innovation in firms

Innovation surveys are increasingly used in OECD and in many non-member countries to better understand the role of innovation in economic growth as well as its determinants and the characteristics of innovative firms. Since 1992, the *Oslo Manual* had provided a harmonised framework – including coherent concepts and tools – for undertaking comparable large-scale surveys of this type. While previous editions of the Manual placed emphasis on technological product and process (TPP) innovation, the latest (3rd) edition (OECD/Eurostat, 2005) extends the scope of such surveys to marketing and organisational innovations and places new emphasis on the role of linkages (including collaboration) in innovation. Although cross-country comparability of innovation surveys based on the *Oslo Manual* is generally good and improving, certain differences may affect comparisons between CIS (Community Innovation Survey) and non-CIS countries, such as sectoral coverage, size thresholds, sampling methods and the unit of analysis. Another example is the filtering of innovators/non-innovators, *i.e.* whether firms identified as non-innovators early in the questionnaire are asked to answer subsequent questions (*e.g.* in Canada only innovators are asked to answer questions on collaboration, but for the CIS, firms which had some innovation activity but did not introduce a product/process innovation may reply). For the purposes of this report, it was decided to use the "core" CIS-4 coverage in terms of sectors and similar firm size thresholds as a benchmark in order to allow for comparability (countries using industrial classifications other than NACE performed concordances to map as closely as possible to the CIS-4 list of industries). Unless otherwise noted, the following definitions were used:

Sectors covered: *a)* Manufacturing: NACE D; *b)* Services: Core G to K services which include NACE sections G (Transport, storage and communication), and J (Financial intermediation) and NACE divisions 51 (Wholesale trade and commission trade, except of motor and motorcycles), 72 (Computer and related activities), and 74.2-74.3 (Other business services). For Korea, 73 (R&D services) and 74.1 (legal, accounting services) are also included. For Canada, the data refers to the manufacturing sector only; *c)* Total economy: Manufacturing + Services + NACE sections C (Mining and quarrying) and E (Electricity, gas and water supply).

Size classes: SMEs: firms with 10-249 employees (10-99 for New Zealand; 10-299 for Korea, 20-249 for Canada, persons employed for Japan); large firms: 250+ employees (100+ for New Zealand; 300+ for Korea).

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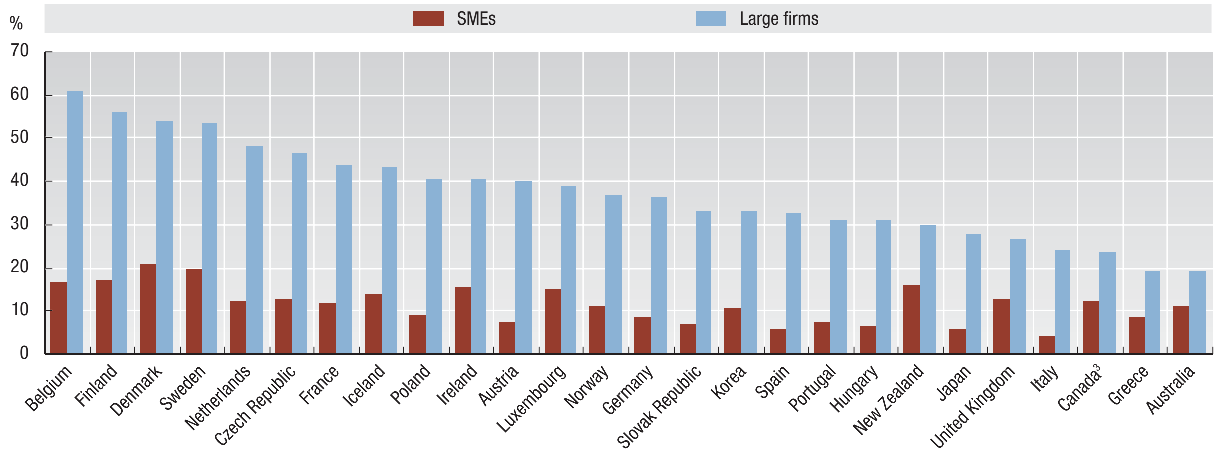
C.5. COLLABORATION WITH PUBLIC RESEARCH ORGANISATIONS BY INNOVATING FIRMS

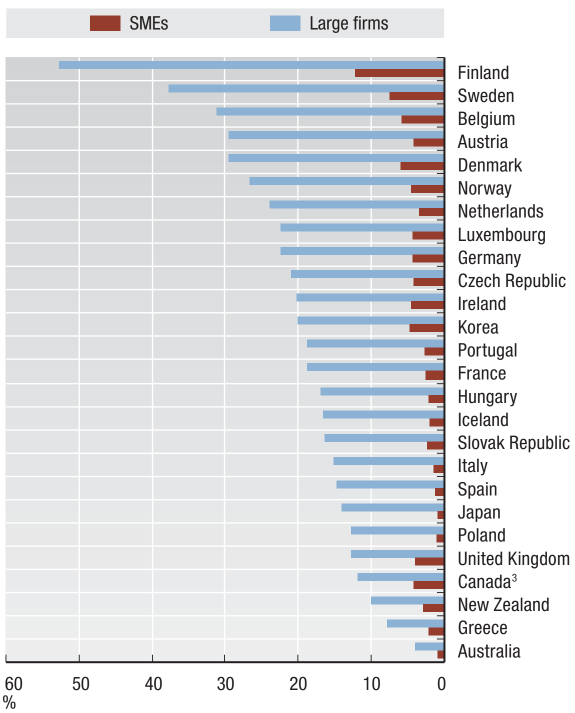
Firms collaborating in innovation activities, by size[1], 2002-04[2]

As a percentage of all firms



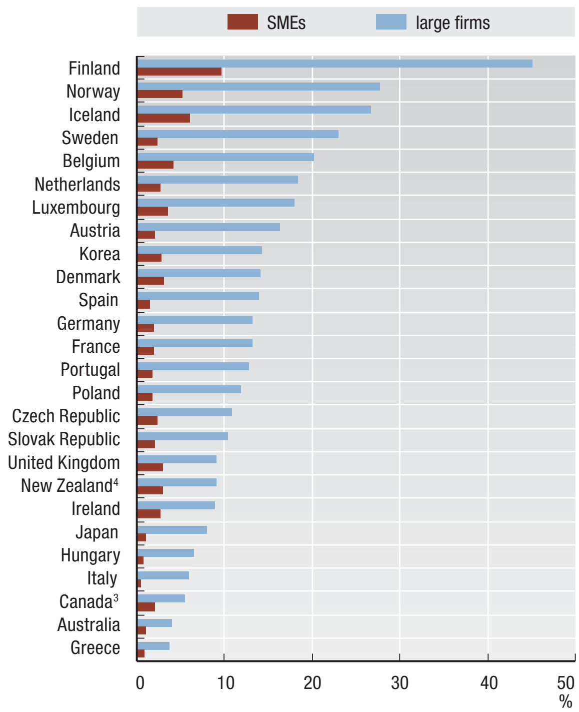
Firms collaborating in innovation with higher education institutions, by size[1], 2002-04[2]

As a percentage of all firms



Firms collaborating in innovation with government institutions by size[1], 2002-04[2]

As a percentage of all firms



StatLink http://dx.doi.org/10.1787/117662727550

1. SMEs: 10-249 employees for European countries, Australia and Japan (persons employed); 10-99 for New Zealand, 10-299 for Korea, 20-249 for Canada.
2. Or nearest available years.
3. Manufacturing sector only.
4. Refers to firms that cooperate with Crown Research Institutes, other research institutes or research institutions.

C.6. SCIENCE LINKAGES IN TECHNOLOGY

■ Most published patent applications include a list of references, or citations, to earlier patents and "non-patent literature" (NPL), such as scientific papers, that capture "prior art" and determine the boundaries of a patent's claims for novelty, inventive activity and industrial applicability. In general, the references are determined by the patent examiner and are included in the "search report". Some may have been provided by the applicant.

■ Analyses of shares of NPL in citations across patent classes can provide insights into the technologies that are closer to scientific R&D and thus more dependent on the progress of scientific knowledge. An analysis of over 540 000 international patent applications (filed under the Patent Co-operation Treaty – PCT) published by the European Patent Office (EPO) shows that in the last 15 years the International Patent Classification (IPC) sub-classes with a higher than average share of citations to NPL (over 15%) are mainly in the fields of biotechnology, pharmaceuticals, other fine organic chemistry and ICT. This is consistent with other observed patterns of science-industry linkages in these fields such as university spin-offs, industry-university co-operation in R&D and the tendency for biotechnology companies to cluster around universities.

■ Similar calculations by country of inventor reveal that higher shares of NPL in citations occur in countries whose international patenting activity is more concentrated in these high-activity or emerging technology fields. For example, Indian inventors have a recent history of international patenting activity and a relatively high proportion of their applications are in biotechnology and pharmaceuticals which have closer links to science.

■ The importance of science in developing technology differs among fields. For 1990-2004 about 55% of citations in biotechnology-related international patents are to NPL. There is little cross-country variation suggesting some general homogeneity in the rate of technological advances while hiding some structural differences across countries.

■ For ICT, the average share is about 18% and varies across countries in a range of 10 to 25%. Low shares suggest that recent ICT innovations are based more on existing technology while higher shares suggest that certain countries still benefit from scientific R&D in ICT. This is partly due to structural differences across countries and technological specialisation within this broadly defined field.

Sources

- OECD/EPO Patent Citations database, 2006.
- EPO world wide Patent Statistics (PATSTAT), DOCDB and REFI databases.
- WIPO Patent database.

For further reading

- European Commission (2002), "Linking Science to Technology Bibliographic References in Patents", DG Research project report, 2002.
- Jaffe, A. and M. Trajtenberg (2002), *Patents, Citations and Innovations: A Window on the Knowledge Economy*, MIT Press, Cambridge, MA.
- Webb, C., H. Dernis, D. Harhoff and K. Hoisl (2005), "Analysing European and International Patent Citations – A Set of EPO Patent Database Building Blocks", STI Working Paper 2005/9, OECD, Paris.

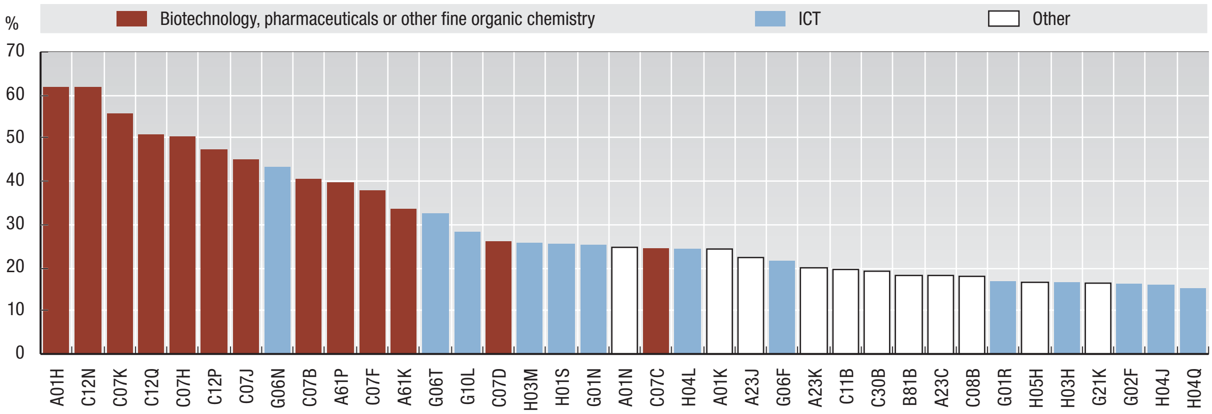
Issues to consider when analysing European and international citations

- An increasing number of applicants file patents under PCT before entering the EPO process in the "regional phase". When this occurs, most citations will appear in the international (WO) document rather than the EPO document. In order to count citations in a European patent application correctly, information from both the international and the European searches need to be combined.
- PCT and EPO publications include information for five different types of citations: *i)* added by examiners during the search (whether or not provided by the applicant); *ii)* provided by the applicant but not used in the search report; *iii)* added during examination; *iv)* provided during opposition proceedings; and v) other. Most citations in PCT and EPO publications (about 95%) are added by examiners in the search report; these are the citations analysed here.
- Non-patent literature (NPL) consists not only of peer-reviewed scientific papers but also includes conference proceedings, databases (DNA structures, gene sequences, chemical compounds, etc.) and other relevant literature. However, previous studies have found that total NPL is a good proxy for scientific papers in similar types of analyses. References to certain types of NPL such as "patent abstracts" and commercial online patent database services have been removed for the purposes of this analysis.

For a detailed description of IPC sub-classes see *www.wipo.int/classifications/fulltext/new_ipc/ipcen.html*.

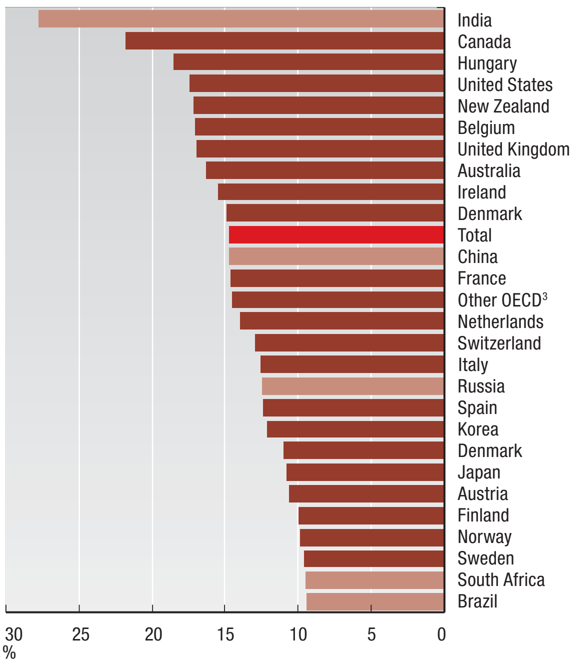
Share of NPL in citations in search reports of PCT patent applications

1990-2004, by IPC sub-class[1]



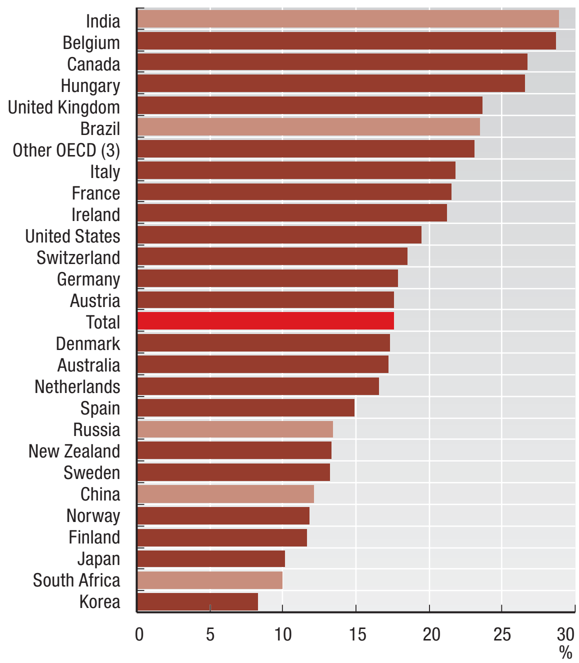
Share of NPL in citations – all patents

1990-2004, by country of inventor[2]



Share of NPL in citations – ICT related patents

1990-2004, by country of inventor[2]



StatLink http://dx.doi.org/10.1787/117700504546

1. Only those IPC sub-classes (out of over 600) with a share of NPL citations greater than the average (14.7%) and with more than 150 patent applications published in the period 1990-2004.
2. Fractional counting used when there is more than one inventor on the patent application.
3. Other OECD includes the Czech Republic, Greece, Iceland, Luxembourg, Mexico, Poland, Portugal, the Slovak Republic and Turkey.

C.7. ENTREPRENEURSHIP

■ Because it enhances economic growth, job creation and income alleviation via increased productivity and innovation, the creation of new businesses has become an increasingly important objective for OECD area policy makers in recent years.

■ The creation of new businesses and the closure of failing ones are often regarded as a source of economic dynamism. This churning (*i.e.* entry plus exit rates) is commonly viewed as a measure of an economy's ability to expand the boundaries of economic activity, to shift resources towards growing areas and away from declining ones, and to adjust the structure of production to meet consumers' changing needs.

■ Cross-country comparability of business demography data is limited owing to differences in concepts and methodologies (see box below). While the available figures should be interpreted with caution, they suggest that New Zealand, Canada, the United Kingdom and Germany are the leaders in the creation of start-ups, with more than 10% of new businesses annually (in 2003). In these countries, the rate of closures was lower than that of creations. The opposite occurred in Japan and the Slovak Republic.

Source

- OECD (2006), *Structural and Demographic Business Statistics.*

For further reading

- Ahmad, N. (2006), "A Proposed Framework for Business Demography Indicators", OECD Statistics Directorate Working Paper, OECD, Paris.
- OECD (2005), *OECD SME and Entrepreneurship Outlook, 2005 Edition*, OECD, Paris.
- OECD (2006), *Structural and Demographic Business Statistics: 1996-2003, 2006 Edition*, OECD, Paris.
- Vale, S. (2006), "The International Comparability of Business Start-Up Rates", OECD Statistics Directorate Working Paper, OECD, Paris.

Business demography and entrepreneurship statistics

The growing interest in business demography and entrepreneurship more generally has influenced statistical developments in this area. Many national statistical offices now provide official statistics on the entry, exit and turnover of businesses. However, comparability across non-EU countries is still limited, as demonstrated in a recent report investigating the comparability of start-up rates across countries (Vale, 2006). This largely reflects the fact that national definitions and concepts of business demography statistics usually reflect domestic data availability and the fact that internationally recognised definitions and concepts, with the notable exception of Eurostat, are largely non-existent.

The OECD definitions for entry and exit are:

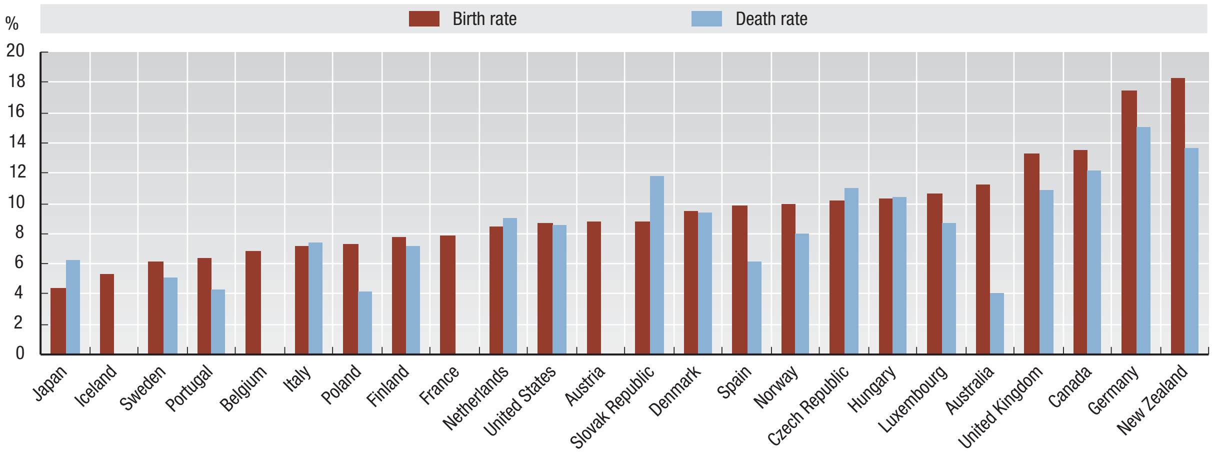
- An *enterprise is born* when it records for the first time employees and turnover greater than zero.
- The corollary is that an *enterprise dies* when a business that previously had one or more employees and turnover ceases to trade or have employees.

Several factors affect the comparability of business start-up data, some of which may have been overlooked in previous international comparisons, with the result that methodological differences may mask the variability of the data. The following nine factors have been identified as relevant (Ahmad, 2006; OECD, 2006):

- *Purity:* To what extent are "pure births" (*i.e.* new combinations of production factors) distinguished from reactivations and other creations?
- *Timing:* At what point in the creation process is a start-up measured?
- *Periodicity*: Over what period are start-ups measured, and how does this affect the measurement of very short-lived businesses?
- *Type of population:* Businesses or people?
- *Temporal basis:* Is the population measured at a specific point in time, or does it consist of all units that were present at any time during a given period?
- *Source:* Are the data taken from a register, a census or a survey? How reliable is the source?
- *Units:* What is the entity about which the data are produced?
- *Coverage:* To what extent are certain types of business included or excluded based on specific attributes (*e.g.* economic activity or legal form)?
- *Thresholds:* What explicit or implicit size thresholds apply to the source?

Birth and death rates

As a percentage of total number of enterprises, 2003 or latest available year



StatLink http://dx.doi.org/10.1787/117730525000

D. INNOVATION PERFORMANCE

D.1. TRIADIC PATENT FAMILIES

■ About 53 000 triadic patent families were filed world wide in 2005, a sharp increase from less than 35 000 in 1995. Growth during the second half of the 1990s was at a steady 7% a year on average until 2000. The beginning of the 21st century was marked by a slowdown, with patent families increasing by 2% a year on average.

■ The United States, the European Union and Japan show a similar trend, with a stronger deceleration in Japan after 2000. The number of triadic patent families remained stable in Australia, Germany, France, Sweden and Switzerland, while those originating from Denmark, Finland and the United Kingdom decreased on average by 2%, 6% and 1%, respectively, between 2000 and 2005.

■ The United States accounts for 31% of patent families, a loss of around 3 percentage points from its level in 1995 (34.4%); the relative proportion of patent families originating from Europe has also tended to decrease, losing more than 4 percentage point between 1995 and 2005 (to 28.4% in 2005). On the contrary, Japan's share in triadic patent families gained almost 2 percentage points to reach nearly 29% in 2005.

■ Changes in country shares show a surge in innovative activities in Asia. China entered the top 15 countries in 2005, having gained 16 positions since 1995. Chinese Taipei, India and Korea also rose significantly in terms of ranking (from 5 to 11 relative positions). Patent families from these economies increased notably in the late 1990s and after 2000, with an upsurge ranging from 20 to 37% a year in China, India, Korea and Chinese Taipei.

■ When triadic patent families are normalised using total population, Japan, Switzerland, Germany, the Netherlands and Sweden appear as the five most innovative countries in 2005. Ratios for Finland, Israel, Korea, Luxembourg and the United States are above the OECD average (44). Japan has the highest number of patent families per million population (119), followed by Switzerland (107).

■ Most countries have seen their propensity to patent increase, with the exception of Belgium, Finland and Sweden. One of the largest increases between 1995 and 2005, from 7 to 65 patent families per million inhabitants, occurred in Korea. By size, China has less than 0.4 patent families per million population.

Source

- OECD, Patent database, April 2007 based on EPO world wide Statistical Patent Database (PATSTAT), April 2007, available at: *www.oecd.org/sti/ipr-statistics*.

For further reading

- Dernis H. and M. Khan (2004), "Triadic Patent Families Methodology", STI Working Paper 2004/2, OECD, Paris.

Triadic patent families

Patent families are commonly constructed on the basis of information from a single patent office. While patents filed at a given patent office represent a rich source of data, these data show certain weaknesses. The "home" advantage bias is one of them, since, proportionate to their inventive activity, domestic applicants tend to file more patents in their home country than non-resident applicants. Furthermore, indicators based on a single patent office are influenced by factors other than technology, such as patenting procedures, trade flows, proximity, etc. In addition, the value distribution of patents within a single patent office is skewed: many patents are of low value and few are of extremely high value. Simple patent counts would therefore give equal weight to all patent applications.

The OECD has developed *triadic patent families* in order to reduce the major weaknesses of the traditional patent indicators described above. Triadic patent families are defined at the OECD as a set of patents taken at the European Patent Office (EPO), the Japan Patent Office (JPO) and US Patent and Trademark Office (USPTO) that protect a same invention. In terms of statistical analysis, they improve the international comparability of patent-based indicators, as only patents applied for in the same set of countries are included in the family: home advantage and influence of geographical location are therefore eliminated. Second, patents included in the family are typically of higher value: patentees only take on the additional costs and delays of extending protection to other countries if they deem it worthwhile.

The criteria for counting triadic patent families are the earliest priority date (first application of the patent world wide), the inventor's country of residence, and fractional counts. Owing to time lag between the priority date and the availability of information, 1998 is the latest year for which triadic patent families data is almost completely available. Data from 1998 onwards are OECD estimates based on more recent patent series ("nowcasting").

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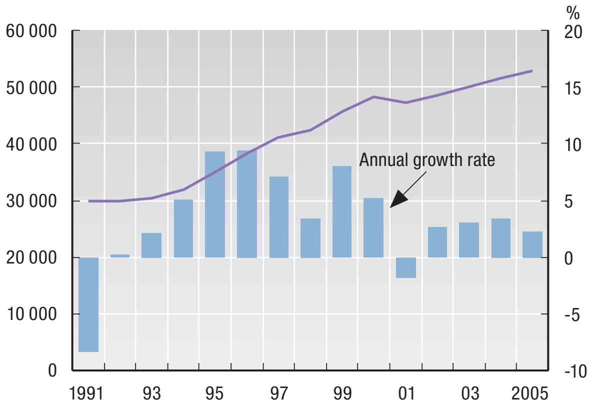
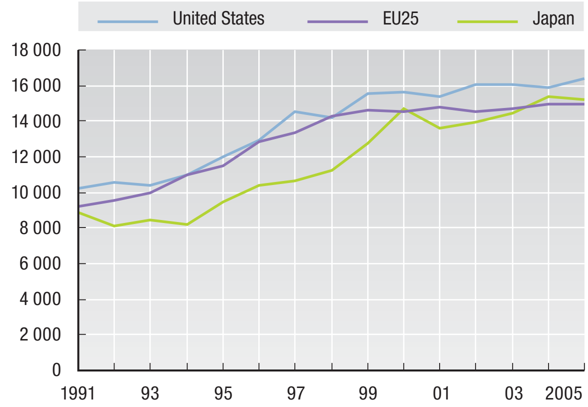
D.1. TRIADIC PATENT FAMILIES

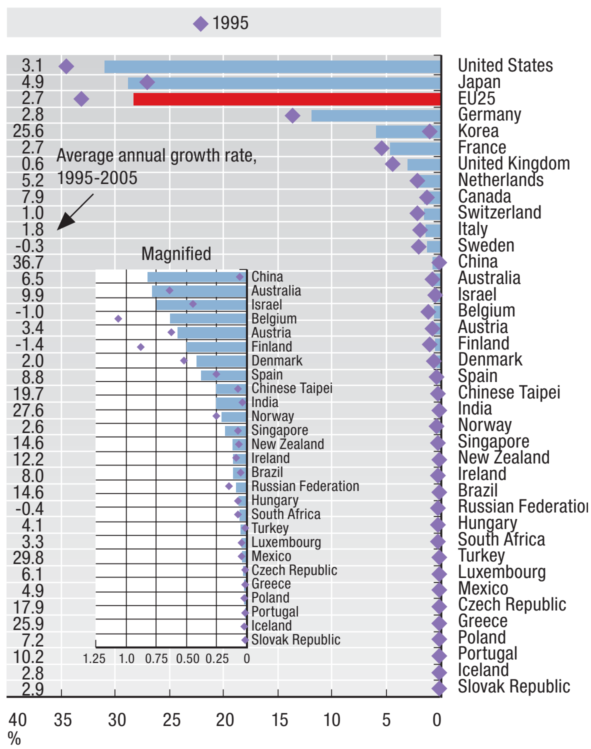
Trends in triadic patent families[1]
Total number and annual growth rate



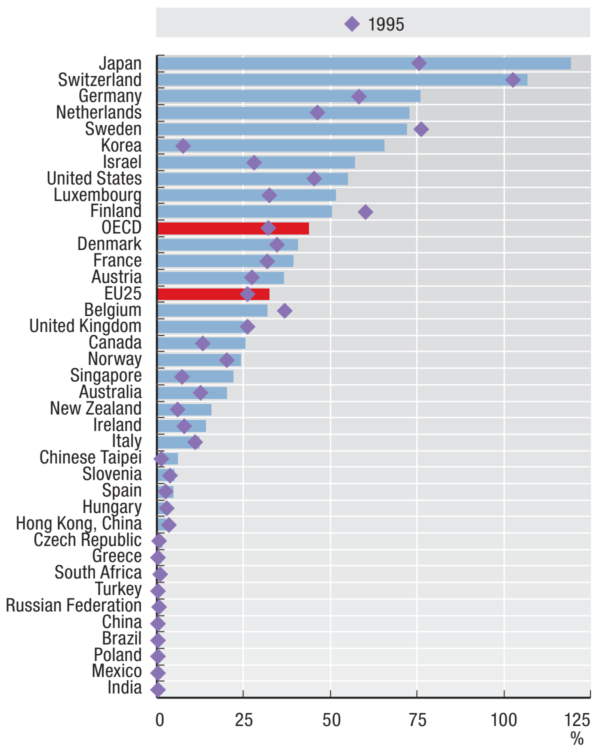
Trends in triadic patent families[1]
Main OECD regions



Share of countries in triadic patent families,[1] 2005



Triadic patent families[1] per million population,[2] 2005



StatLink http://dx.doi.org/10.1787/117751186716

Note: Patent counts are based on the earliest priority date, the inventor's country of residence and fractional counts. The data mainly derive from the EPO world wide Statistical Patent database (April 2007).

1. Patents filed at the European Patent Office (EPO), the US Patent and Trademark Office (USPTO) and the Japan Patent Office (JPO) which protect the same invention. Data from 1998 onwards are OECD estimates.
2. Only countries/economies with more than 10 families in 2005 are included.

D.2. PATENT INTENSITY

■ There is a strong positive correlation between the number of triadic patent families and industry-financed research and development (R&D) expenditures ($R^2 = 0.98$). The more a country spends on R&D (such as the United States, Japan, Germany and France), the higher the propensity to patent.

■ Most countries in the bottom-right corner of the graph (low number of patents relative to R&D) are emerging countries and OECD countries with low R&D intensity (Brazil, China, Turkey, etc.).

■ The patent intensity (triadic patent families divided by industry-financed R&D) of the main OECD regions follows a more stable pattern than the number of families in the three major regions. Japan has had the highest patent intensity of the three regions since the end of the 1990s; previously its patent intensity was similar to that of the European Union. In contrast, the United States has a propensity to patent that is below the OECD average and has decreased slightly since 2000.

■ The United States' lower patent intensity (compared to the European Union and Japan) is due to a greater increase in industry-financed R&D than in triadic patents, especially in the late 1990s. In Japan, instead, the number of triadic patent families increased more rapidly than R&D expenditures by the industry sector. In the European Union, both increased at a similar rate.

■ Germany, Japan, Korea, the Netherlands and Switzerland have the highest level of patent intensity in the OECD area in recent years, ranging from 160 patent families per billion USD of R&D expenditure (in Korea) to nearly 300 (in the Netherlands). However, this indicator shows a steady decrease for Germany and Switzerland, owing to a smaller increase in patenting since the turn of the century. In contrast, patent intensity rose significantly in Korea and in the Netherlands since the mid-1990s, owing to the more rapid growth in patenting than in R&D expenditures.

Source

- OECD, Patent and R&D databases, April 2007, also based on EPO world wide Statistical Patent database (PATSTAT), April 2007, available at: *www.oecd.org/sti/ipr-statistics*.

Guidelines for constructing patent indicators

To count patent data, certain methodological choices have to be made, and these can have a significant influence on the derived indicators and may result in conflicting messages. It is therefore important to rely on methods that minimise statistical bias while conveying a maximum amount of information. In order to interpret patent indicators accurately, the following concepts are important.

Geographical distribution – To attribute a patent to a country, three main criteria can be used:

- Counts *by priority office* (country in which the first application is filed, before protection is extended to other countries). This indicates the attractiveness of a country's patenting process, the quality of intellectual property regulations (rules and cost of patenting), the reputation of the patent office and general economic features (*e.g.* market size).
- Counts by the *inventor*'s country of residence. These inform on the inventiveness of the local labour force.
- Counts by the *applicant*'s country of residence (the owner of the patent at the time of application). These indicate control of the invention.

Patents with multiple inventors from different countries – Such patents can either be partly attributed to each country mentioned (fractional counts) or fully attributed to every relevant country (simple counts). The latter generates multiple counting at aggregate level. In general, fractional counting procedures are used to compute counts by countries, but the alternative is sometimes preferable, for example for indicators on international co-operation.

Reference date – The choice of one date among the set of dates included in patent documents is also important.

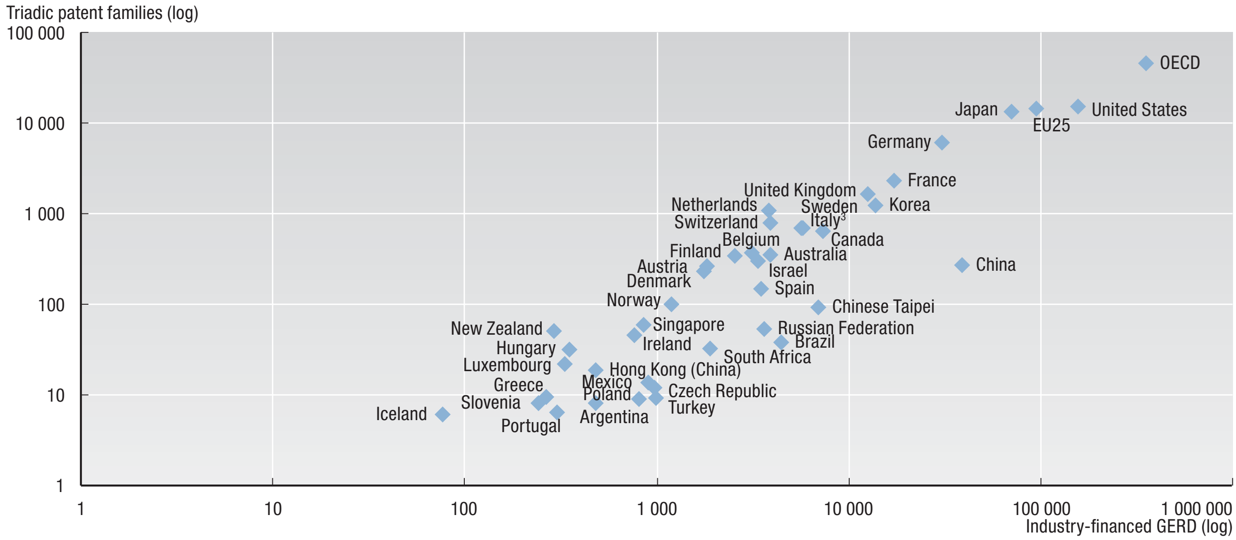
- The *priority date* (first date of filing of a patent application, anywhere in the world, to protect an invention) is the earliest and therefore closest to the invention date.
- Counts by *application date* introduce a bias owing to a one-year lag between residents and foreigners. The latter usually first file a patent application at their domestic office (the priority office) and later in other countries. The lag increases for Patent Co-operation Treaty (PCT) applications.
- Counts according to the *grant date* is not only a function of the flow of patent applications, but also depends on the administrative process of the patent office (its budget, number of examiners, etc.).

Most patent-based indicators in this publication are presented according to the priority date and the country of residence of the inventors. Applicant's residence is preferred for some statistical analysis, such as cross-border ownership of patents, etc.

D.2. PATENT INTENSITY

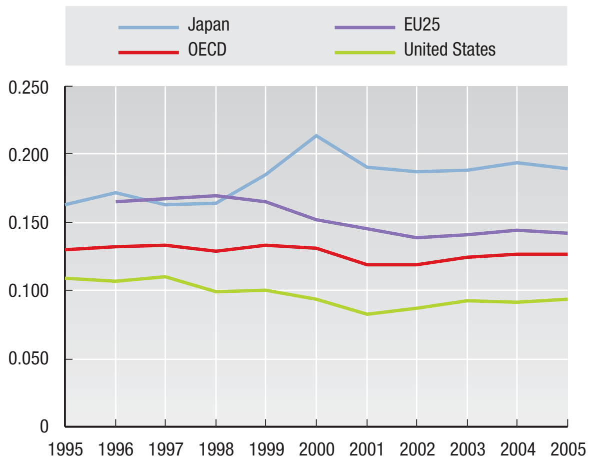
Triadic patent families[1] and industry-financed R&D[2]

1995-2005 average



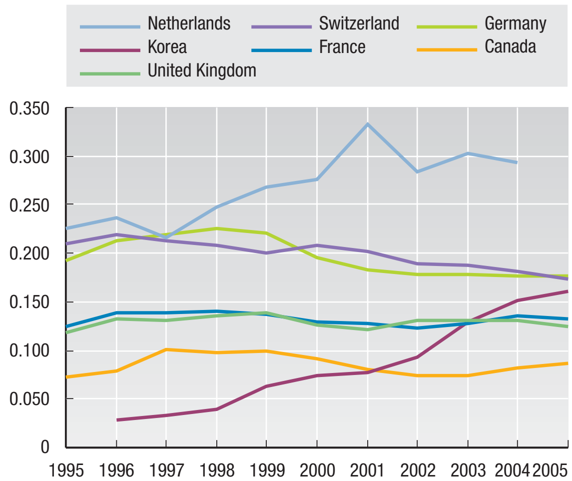
Ratio of triadic patent families[1] to industry-financed R&D[2]

Main OECD regions, 1995-2005



Ratio of triadic patent families[1] to industry-financed R&D[2]

Selected countries, 1995-2005



StatLink http://dx.doi.org/10.1787/117763305436

Note: Patent counts are based on the earliest priority date, the inventor's country of residence and fractional counts. The data mainly derive from the EPO world wide Statistical Patent database (April 2007).

1. Patents filed at the European Patent Office (EPO), the US Patent and Trademark Office (USPTO) and the Japan Patent Office (JPO) which protect the same invention. Data from 1998 onwards are OECD estimates.
2. Gross domestic expenditure on R&D (GERD) financed by industry, millions of USD (2000) using purchasing power parities, lagged by one year.
3. Business R&D (BERD) financed by industry instead of GERD financed by industry.

D.3. REGIONAL PATENTING

■ Analysis of regional patenting is a way of assessing the concentration of innovative activities within countries. In particular, the number of Patent Co-operation Treaty (PCT) applications by region can indicate innovative regions that act as important sources of world knowledge.

■ Inventive activities are likely to be concentrated in a small number of regions. The degree of concentration is much higher than that of the population. The average adjusted index of geographic concentration (see box) in OECD countries is 0.56. It is higher than the OECD average in Hungary (0.75), Spain (0.70), Japan (0.69), Sweden (0.69), the Netherlands (0.61), the United Kingdom (0.57), Finland (0.57), Korea (0.57) and Norway (0.56).

■ These concentrations are lowest in Switzerland (0.36) and Austria (0.38) although the concentration of PCT applications is much higher than that of population.

■ California (United States) and Tokyo (Japan) are leading regions in terms of the number of PCT applications both in information and communication technology (ICT) and biotechnology. In Europe, Noord-Braband (Netherlands) produces the largest number of PCT patent applications in ICT. Düsseldorf (Germany) is the largest source of biotechnology patents.

■ Among the leading regions for ICT, there is an extremely large number of PCT applications per million labour force in Noord-Braband, followed by Tokyo (Japan), East Anglia (United Kingdom) and Lansi-Suomi (Finland), indicating a high concentration of skilled personnel in these regions.

■ Massachusetts (United States) produces the largest number of PCT applications per million labour force in biotechnology. PCT applications per million labour force in Düsseldorf (Germany), Maryland (United States), Ibaraki (Japan); Kyoto (Japan), Delaware (United States), and East Anglia (United Kingdom) are also large.

■ It should be mentioned that because of the skewed distribution of PCT patent applications by region, the ranking may change dramatically depending on the reference year used, except for regions with very high patenting activity, *e.g.* California and Tokyo.

Sources

- OECD, Patent database, April 2007.
- OECD, Territorial database, April 2007.
- Eurostat Regional Statistics, April 2007.

For further reading

- OECD (2007), *Regions at a Glance*, OECD, Paris.

Definition of regions and the adjusted geographic concentration index

The Nomenclature of Territorial Units for Statistics (NUTS) is a geo-code standard for referencing the administrative division of countries in the EU for statistical purposes. Three levels of NUTS are defined. Regions in the EU countries are defined by NUTS2 except for Ireland. Ireland is treated as one region.

OECD has classified regions within each member country. The classification is based on two territorial levels (TL). The higher level (Territorial Level 2) consists of about 300 macro-regions and the lower level (Territorial Level 3) is composed of more than 2 300 micro-regions. Regions in Australia, Canada, Korea, Norway, Switzerland and the United States are defined by TL2. Regions in Japan are defined by TL3. Iceland is treated as one region. No regional patent data are available for Mexico, New Zealand and Turkey. About 300 regions in 26 OECD countries are defined.

In order to compare the concentration of population and triadic patent families of regions with different degrees of aggregation, the adjusted geographic concentration index (AGC) was calculated, which is defined as:

$$GC = \sum_{i=1}^{N} \left| y_i - a_i \right| \quad \text{and } AGC = GC / GC^{MAX}$$

where y_i is the share of region i in the population or triadic patent families, a_i is the area of region i as a percentage of the country area, and N stands for the number of regions. The geographic concentration index (GC) is adjusted by the maximum value of the GC index. Thus, the AGC index lies between 0 (no concentration) and 1 (maximum concentration) in all countries. The AGC is suitable for international comparisons of geographic concentration for regions of different degrees of aggregation.

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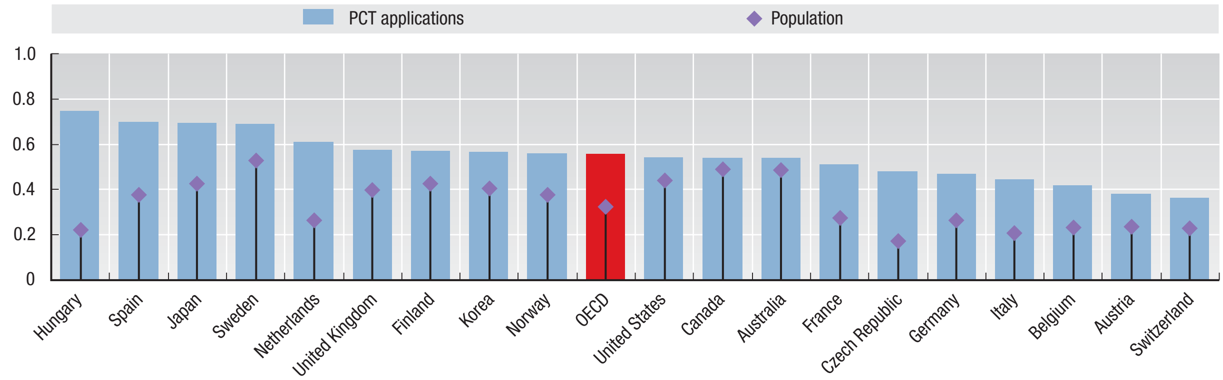
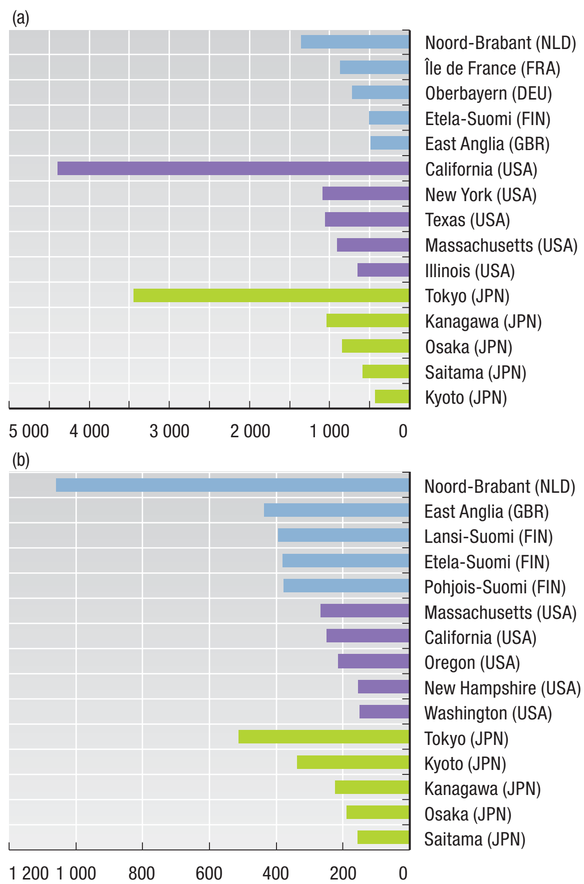
Geographic concentration of PCT applications[1, 2, 3]

2004



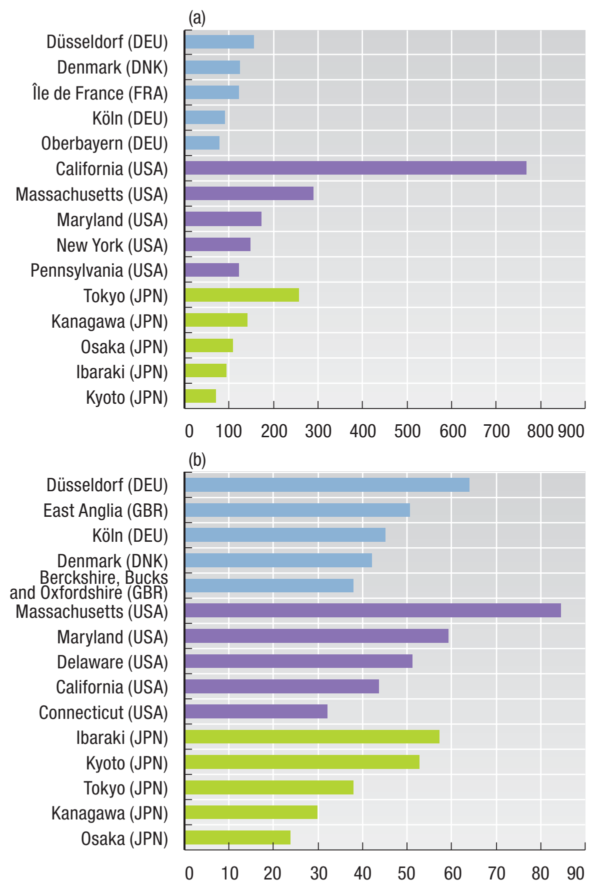
ICT patents by region in Europe, the United States and Japan[1, 3, 4]

The number of PCT applications (a) and PCT applications per million labour force (b) in 2004



Biotechnology patents by region in Europe, the United States and Japan[1, 3, 5]

The number of PCT applications (a) and PCT applications per million labour force (b) in 2004



StatLink http://dx.doi.org/10.1787/117774630675

1. Patent counts are based on the priority date, the inventor's region of residence and fractional counting.
2. Only countries with more than 100 PCT applications in 2004 are included.
3. Countries in which 60% or more inventors' addresses are assigned to regions are included.
4. Only regions with more than 100 PCT applications in 2004 are included. ICT patents are identified by the International Patent Classification (IPC).
5. Only regions with more than 20 PCT applications in 2004 are included in the graph. Biotechnology patents are identified by IPC.

D.4. PATENTING BY INDUSTRY

■ As a measure of output of S&T activities, patenting by industry provides valuable information on industries' technological strengths. In particular, the association of patents to industries makes it possible to see the link between technology and the economic performance of industries.

■ On average, most OECD economies have comparable portfolios of technology industries (see I.7) in total patenting during 2000-04. However, technologies for medium-high R&D-intensive industries are more important in total patenting for European countries (25) than for the United States or Japan, where patenting in high R&D-intensive industries is stronger.

■ On the other hand, the breakdown of countries' patent portfolio by industry shows the emergence of new producers of high technology. Singapore, India, China, Korea and Israel report the highest share of patenting activity in technologies associated with high-technology industries, notably office, accounting and computing machinery, radio, television and communication equipment, and pharmaceuticals.

■ In OECD and EU25 economies overall, patenting in high and medium-high technology industries grew faster than in other industries during 1997-2003 (annual growth of over 3,5%). China and India are leaders in the expansion of patenting. In China, this pattern is consistent with the increase in high-technology exports (see I.7).

■ There is a positive association between R&D investment and patenting. High R&D-intensive industries, such as pharmaceuticals or medical, precision and optical instruments, are among those that patent the most. Inversely, weaker technological activity, in terms both of R&D and patenting, is frequently found in textiles, leather and wood and paper-related industries.

■ The importance of patents for protecting knowledge does not depend solely on the level of R&D investments. Differences among industries in terms of the risk of imitation and the extent to which patents enhance competitive advantages in markets (*e.g.* through technology exchanges and alliances) also affect the use of patents by companies.

Source

- OECD Patent database.

For further reading

- Hatzichronoglou, T. (1997), "Revision of the High-technology Sector and Product Classification", *STI Working Paper*, 1997/2, OECD, Paris.
- Schmoch, U., F. Laville, P. Patel and R. Frietsch (2003), "*Linking Technology Areas to Industrial Sectors*", Final report to the European Commission, DG Research.

Linking technology to industries in patents

Because patents are classified according to the International Patent Classification (IPC) and based on technological categories, they cannot be directly translated into industrial sectors. In order to establish a link between technology patenting and industries (NACE, ISIC, etc.), different concordance tables have been developed. The goal has been to link technology to internationally comparable economic indicators reported at industry level, such as turnover, investment, employment, productivity, value added, R&D expenditure and exports (*e.g.* OECD STAN indicators database, EU-KLEMS database). As explained by Schmoch *et al.* (2003), a reliable concordance must meet the following conditions: *i)* international comparability; *ii)* adequate level of desegregation; *iii)* strong empirical basis; and *iv)* easy applicability to specific problems. In addition, as technologies change and industries find new uses for them, the concordance tables need to be updated on a regular basis.

The concordance table used here is the one developed by Schmoch *et al.* (2003) from the Fraunhofer Institute for Systems and Innovation Research, the Observatoire des Sciences et des Techniques (OST) and the University of Sussex, Science and Policy Research Unit (SPRU). The methodology used to develop this concordance involved four steps. First, a set of industrial sectors, defined by NACE and ISIC codes (2-digit level) was selected as a basis. Second, technical experts associated IPC subclasses to industrial categories according to the manufacturing characteristics of products. Third, the technical and industrial approaches were compared by investigating patent activities by technology-based fields of more than 3 000 firms classified by industrial sector. This computation led to the elaboration of a transfer matrix or concordance between technology and industry classifications. Fourth, the adequacy and empirical power of the concordance was verified by comparing the country structures based on the concordance.

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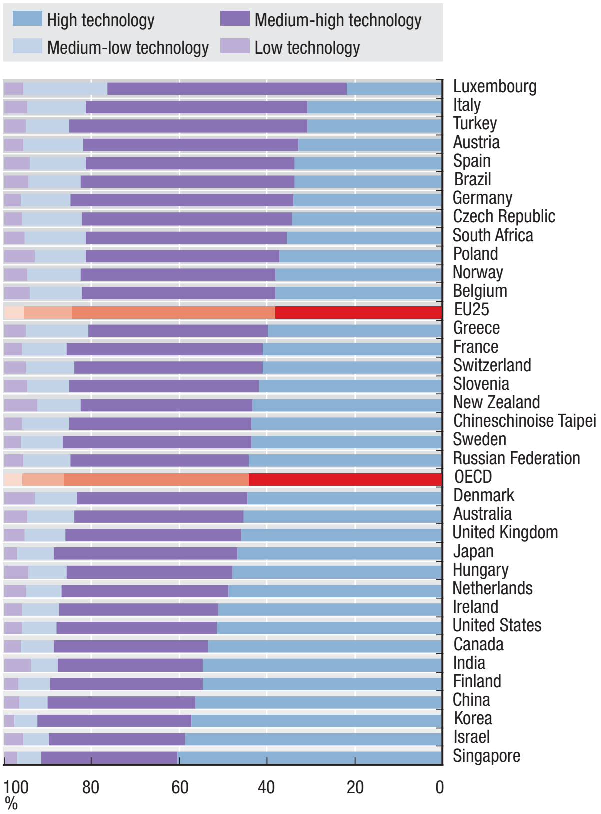
D.4. PATENTING BY INDUSTRY

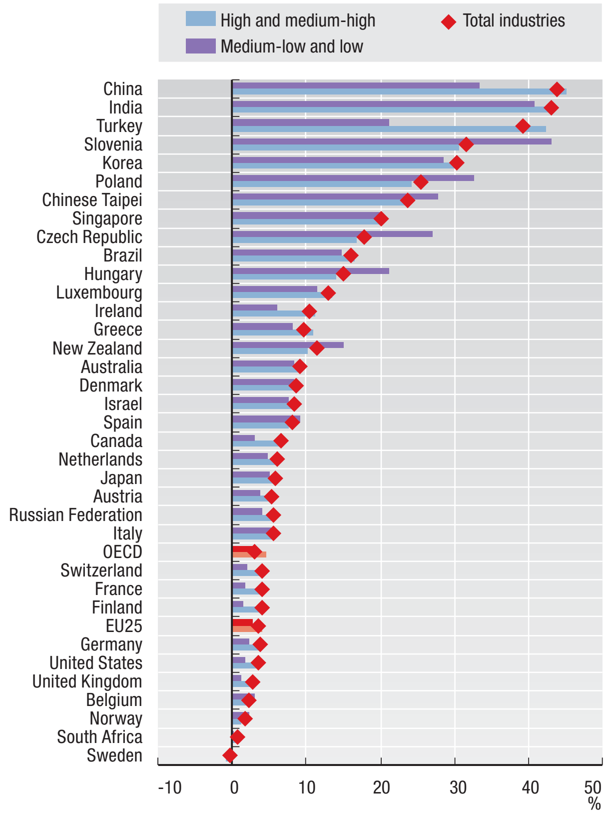
Share of industries in patenting[1, 2]

PCT filings 2002-04



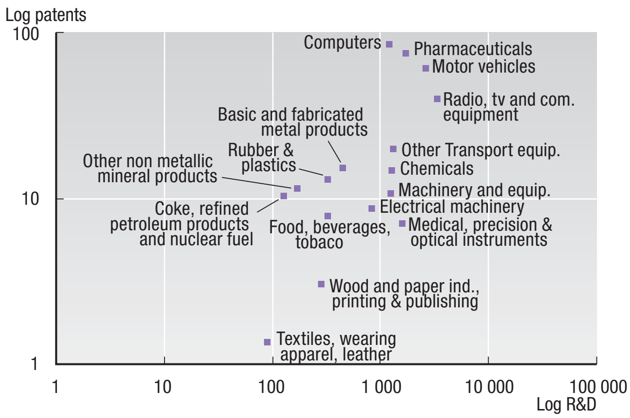
Annual growth rate of patenting[1, 2]

PCT filings 1997-2004



Patenting by industry and business R&D[3]

PCT filings 2002-04



StatLink http://dx.doi.org/10.1787/117775166205

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

1. Patent applications filed under the Patent Co-operation Treaty, at international phase, designating the European Patent Office.
2. Only countries with more than 200 PCT filings during 2002-04 are included.
3. Average business R&D expenditure in 1999-2000, millions of USD (2000) using purchasing power parities and patenting by industry in 2002-04 in OECD countries.

D.5. SCIENTIFIC ARTICLES

■ Research publications are one of the many quantitative indicators available for evaluating and assessing science and technology. Publication counts have traditionally been used as an indicator of the scientific "productivity" of universities, public research centres, companies, individuals or nations.

■ In 2003, some 699 000 new articles in science and engineering (S&E) were reported world wide, most of which resulted from research carried out by the academic sector. They remain highly concentrated in a few countries. In 2003, almost 84% of world scientific articles were from the OECD area, nearly two-thirds of them in G7 countries. The United States leads with over 210 000.

■ The geographical distribution of publications is very similar to that of R&D expenditure, with more S&E articles produced in countries with higher R&D intensity (see A.2). For instance, in Switzerland and Sweden, output exceeded 1 100 articles per million population in 2003. The level of scientific publications is low in Korea, Japan and China, compared to their R&D efforts, but a statistical bias towards English-speaking countries may be part of the reason.

■ Citations provide another measure of scientific productivity by indicating how influential previous research has been. The main producers of scientific articles by million population, Switzerland and the United States, are also the most cited. Both have a strong reputation world wide in biomedical research and physics.

■ Over the past ten years, the intensity of publication increased consistently world wide and continues to expand remarkably in some emerging economies. Scientific articles from Latin America more than tripled, closely followed by South-East Asian economies (Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam).

■ The life sciences continue to dominate the portfolio of scientific articles and account for a particularly large share of those published in the Nordic countries. The physical sciences are the main field of publication in the Czech Republic, Portugal, the Slovak Republic, Korea and Poland.

Source

- National Science Foundation (2006), *Science and Engineering Indicators 2006*, Arlington, Virginia, available at: *www.nsf.gov/statistics/seind06*.

Article counts: methodological issues and data

Output from research includes trained personnel (see section B), advances in knowledge (new products, methods), patents and scientific articles. The volume of articles published world wide is a key indicator since publication is the main means of disseminating and validating research results. In most scientific fields, articles are also crucial for researchers' career advancement (the "publish or perish" rule).

Article counts here are based on science and engineering (S&E) articles, notes and reviews published in a set of the world's most influential scientific and technical journals, as tracked by the Institute for Scientific Information (ISI at *www.isinet.com*). This set of over 5 000 journals is continuously expanding. It excludes all documents for which the central purpose is not the presentation or discussion of scientific data, theory, methods, apparatus or experiments. Fields are determined by the classification of each journal. Articles are attributed to countries by the author's institutional affiliation at the time of publication. A paper is considered co-authored only if its authors have different institutional affiliations or are from separate departments of the same institution. The same logic applies to cross-sectoral or international collaboration.

Although the ISI indexes provide good international coverage, including of electronic journals, they do not take into account journals of regional or local importance. They are also English-language-biased. Moreover the propensity to publish differs across countries and across scientific fields, distorting the relationship between real output and publication-based indicators. Lastly, the incentive to publish raises a question of quality. The volume of articles can thus be weighted by the frequency of citations. Citations also attest to the productivity and influence of scientific literature. International citations highlight the visibility of scientific research beyond national boundaries. The relative prominence of cited S&E literature is the ratio of a country's share of literature cited by the rest of the world to its world share of S&E articles (NSF, 2006).

Life sciences include clinical medicine, biomedical research and biology. Physical sciences include chemistry, physics and Earth and space sciences. Social and behavioural sciences include social sciences, psychology, health sciences and professional fields. Computer sciences are included in engineering and technology.

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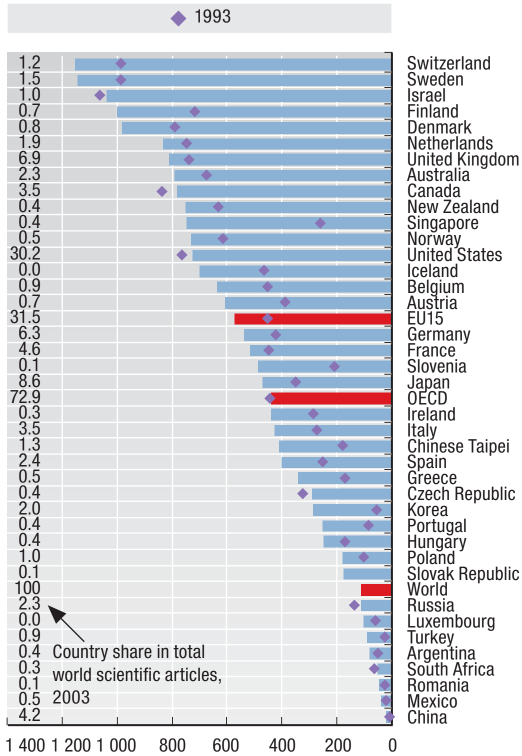
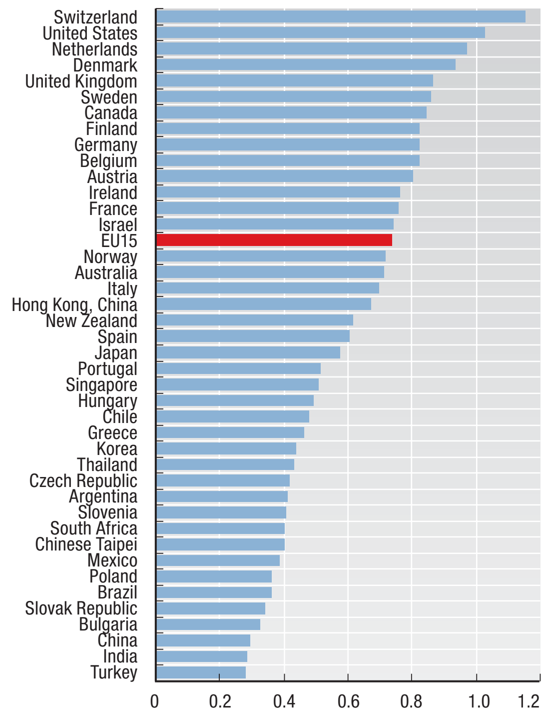
D.5. SCIENTIFIC ARTICLES

Scientific articles per million population, 2003

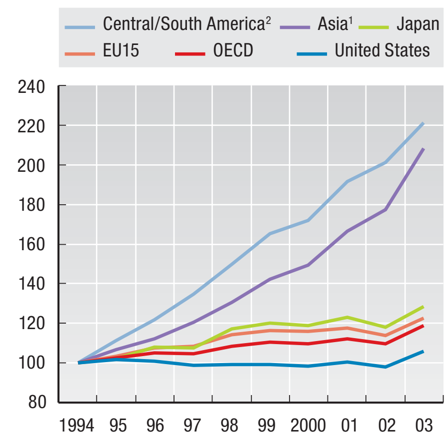


Relative prominence of cited scientific literature, 2003



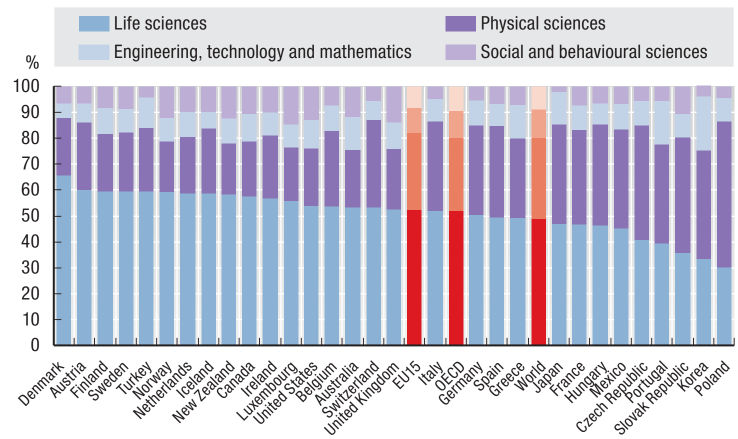
Growth of scientific articles by area, 1994-2003

Index 1994=100



Distribution of scientific articles by field, 2003

As a percentage of total scientific articles



StatLink http://dx.doi.org/10.1787/117780431687

1. All indicators on articles are from the National Science Foundation's Science and Engineering Indicators 2006.
2. Excluding Japan and Korea.
3. Excluding Mexico.

D.6. INNOVATION WITHIN COMPANIES

■ To understand how diffusion of new technologies takes place, and to produce a more complete picture of how innovative a firm is, innovation surveys collect data on whether the innovation was developed within or outside the firm, and to what extent the firm interacted with other parties during the process.

■ Data on innovations mainly developed within a firm itself (so-called "in-house innovators") confirm that small and medium-sized enterprises (SMEs) tend to be "adapters" more frequently than large firms.

■ In almost half of the countries surveyed, 40% or more of all large firms had developed an in-house product innovation. Among SMEs, the share developing in-house product innovations exceeded 20% in only around one-third of the countries.

■ The pattern is similar for in-house process innovations. The highest rates were for large firms (over 45%), in Canada, Ireland, Greece, Belgium, Luxembourg and Australia. The same countries plus New Zealand had rates above 21% for SMEs.

■ In terms of sectors, manufacturing firms tend to undertake more in-house innovation than services firms, for both products and processes. However, in Luxembourg in-house innovators (product and process) were more prevalent among service firms, while in Portugal and New Zealand, services also led for in-house process innovators.

■ In most countries, there is less sectoral difference in terms of firms' propensity to be in-house innovators for processes than for products. This confirms that product innovation is still more prevalent among manufacturing firms than process innovation.

■ The figures provide useful information on how firms in a given country may specialise in terms of their in-house innovation. For example, Korean manufacturing firms are among the most likely to be in-house product innovators (more than 30% of all firms), but among the least likely to be in-house process innovators (less than 7%).

Sources

- Eurostat, CIS-4 (New Cronos), May 2007.
- National data sources.

For further reading

- Australian Bureau of Statistics (ABS) (2006), *Innovation in Australian Business, 2005*, 8158.0, December.
- Eurostat (2007), "Community Innovation Statistics – Is Europe growing more innovative", *Statistics in Focus*, 61/2007.
- OECD/Eurostat (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 3rd edition, Paris.
- Statistics New Zealand (2007), *Innovation in New Zealand – 2005*, January.

Defining innovation

The latest (3rd) edition of the *Oslo Manual* defines innovation as the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. This implicitly identifies the following four types:

Product innovation: the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.

Process innovation: the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.

Marketing innovation: the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

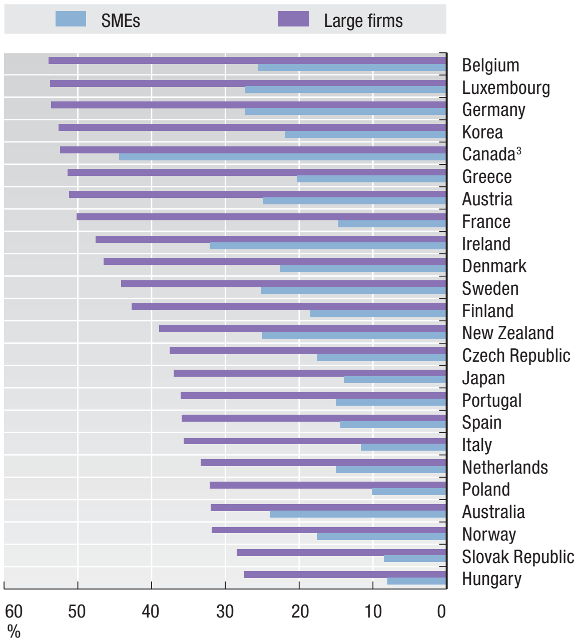
Organisational innovation: the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations.

The first two types are traditionally more closely related to technological innovation (also referred to as TPP innovation). Firms are considered innovative if they have implemented an innovation during the period under review (the observation period is usually two to three years).

D.6. INNOVATION WITHIN COMPANIES

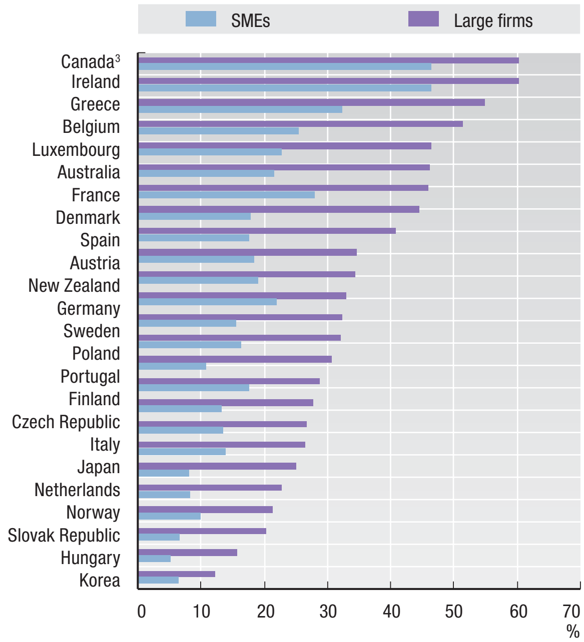
In-house product innovators by size,[1] 2002-04[2]

As a percentage of all firms



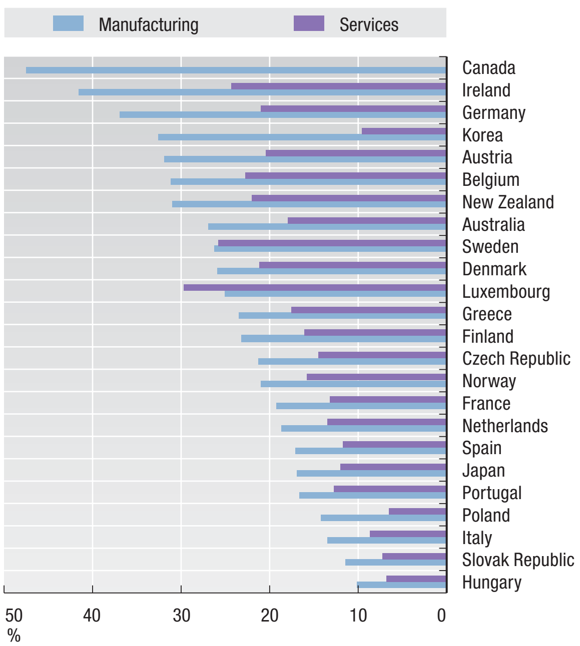
In-house process innovators by size,[1] 2002-04[2]

As a percentage of all firms



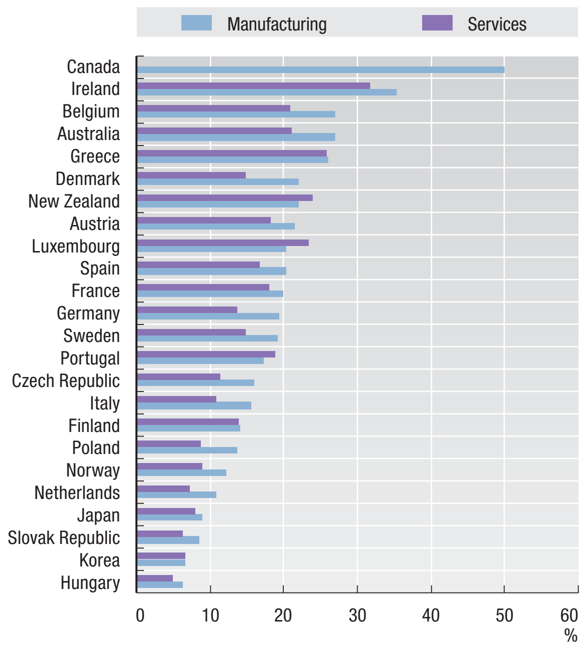
In-house product innovators by sector,[4] 2002-04[2]

As a percentage of all firms



In-house process innovators by sector,[4] 2002-04[2]

As a percentage of all firms



StatLink http://dx.doi.org/10.1787/117802327327

1. SMEs: 10-249 employees for European countries, Australia and Japan (persons employed); 10-99 for New Zealand, 10-299 for Korea, 20-249 for Canada.
2. Or nearest available years.
3. Manufacturing only.
4. See Indicator C.5 for a detailed list of industries included.

D.7. INNOVATION AND ECONOMIC PERFORMANCE

Innovations have different degrees of novelty (see box). A firm's introduction of an innovation developed elsewhere can have a significant impact on the firm's performance, but being an adopter is different from developing an innovation in house, especially if it is new to the market or to the world.

Large firms tend to introduce more "novel" innovations than small and medium-sized enterprises (SMEs). For product innovation, this ranges from more than 50% of all large firms having introduced a new-to-market innovation in Iceland, Austria and Luxembourg, to less than 20% in Australia, Germany and some of the recent EU member countries.

Overall, SMEs are less likely to introduce novel innovations. Again, there are differences across countries. Within Europe, SMEs in Iceland, Luxembourg, Sweden, and Austria had a significantly higher propensity to introduce new-to-market product innovations than those in Spain and Hungary.

The share of turnover from new-to-market product innovations can be used as indicator of the impact of innovation at the firm level. However, the data should be interpreted with caution as some firms may find it difficult to estimate this. In most countries differences between SMEs and large firms in this respect are not very significant. However, Germany and Poland, the share of turnover from such innovations was on average three times higher for large firms than for SMEs.

Sources

- Eurostat, CIS-4 (New Cronos), May 2007.
- National data sources.

For further reading

- Australian Bureau of Statistics (ABS) (2006), *Innovation in Australian Business, 2005*, 8158.0, December.
- Eurostat (2007), "Community Innovation Statistics – Is Europe growing more innovative", Statistics in Focus, 61/2007.
- OECD/Eurostat (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 3rd edition, Paris.
- Statistics New Zealand (2007), *Innovation in New Zealand – 2005*, January.

Measuring novelty and the diffusion of innovations

By definition, all innovation must contain a degree of novelty. The *Oslo Manual* distinguishes three relevant concepts: new to the firm, new to the market and new to the world. The first concept covers the diffusion of an existing innovation to a firm (the innovation may have already been implemented by other firms, but is new to the firm). Firms that first develop innovations (new to market or new to world) can be considered as drivers of the process of innovation. Many new ideas and knowledge originate from these firms, but the economic impact of the innovations will depend on their adoption by other firms. Information on the degree of novelty can be used to identify the developers and adopters of innovations, to examine patterns of diffusion and to identify market leaders and followers. In addition, innovation surveys often collect information on the developer of an innovation. This is different from questions on the degree of novelty as enterprises may develop innovations that have already been implemented by others. It therefore indicates how innovative enterprises are, but not necessarily how novel their innovations are.

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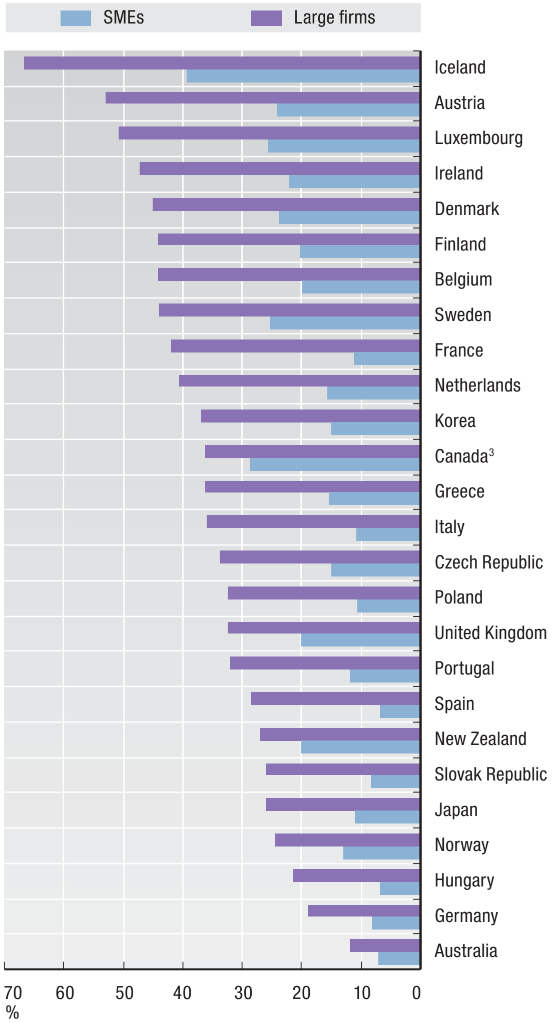
D.7. INNOVATION AND ECONOMIC PERFORMANCE

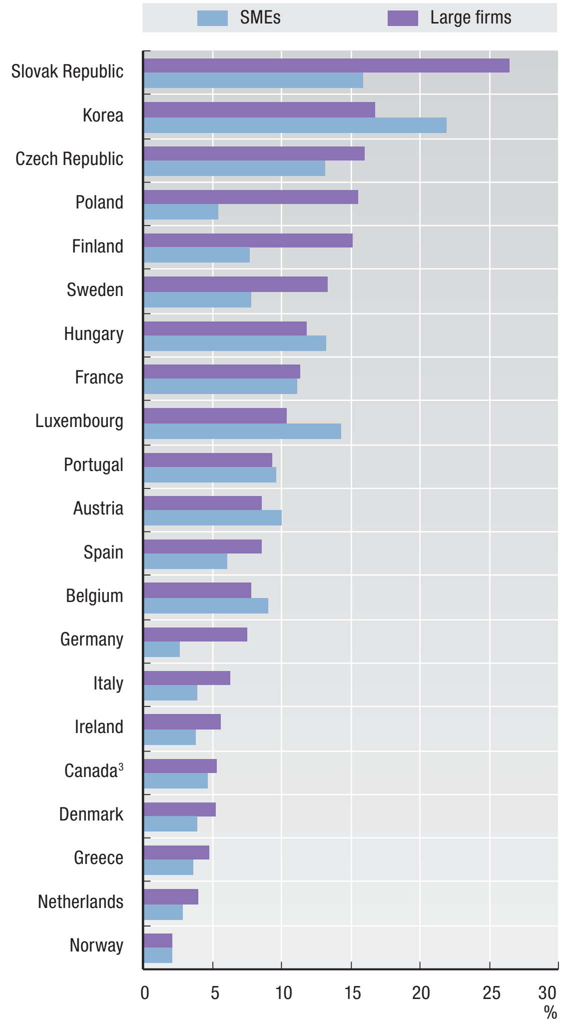
Firms with new-to-market product innovations by size,[1] 2002-04[2]

As a percentage of all firms



Share of turnover due to new-to-market product innovations by size,[1] 2002-04[2]

As a percentage of turnover (for all firms)



StatLink http://dx.doi.org/10.1787/117824480262

1. SMEs: 10-249 employees for European countries, Australia and Japan (persons employed); 10-99 for New Zealand, 10-299 for Korea, 20-249 for Canada.
2. Or nearest available years.
3. Manufacturing only.

D.8. NON-TECHNOLOGICAL INNOVATION

■ Innovation has both technological and non-technological aspects (see the box in D.6 and the box below). Non-technological innovation is an important dimension of many firms' innovation activities and is particularly relevant for many services firms.

■ Non-technological innovation is significantly more prevalent among large firms than among small and medium-sized enterprises (SMEs), although the gap is less pronounced in countries such as New Zealand, Australia and Japan.

■ Sectoral differences with regard to the introduction of non-technological innovations do not appear very pronounced in most countries. However, the rates of non-technological innovation are significantly higher in manufacturing in Ireland and Korea, and somewhat higher in services in Luxembourg, Portugal and Greece.

Sources

- Eurostat, CIS-4 (New Cronos), May 2007.
- National data sources.

For further reading

- Australian Bureau of Statistics (ABS) (2006), *Innovation in Australian Business, 2005*, 8158.0, December.
- Eurostat (2007), "Community Innovation Statistics – Is Europe growing more innovative", *Statistics in Focus*, 61/2007.
- OECD/Eurostat (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 3rd edition, Paris.
- Statistics New Zealand (2007), *Innovation in New Zealand – 2005*, January.

Non-technological innovation

Since the 2005 edition of the *Oslo Manual*, two new types of innovation that can be considered "non-technological" have been identified. They contrast with product and process innovations, which are considered more closely dependent on technology. They are defined as follows:

- A *marketing* innovation is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
- An *organisational* innovation is the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations.

Countries have begun to include these categories in their innovation surveys although the information collected is usually less detailed than for product and process innovation.

Examples include:

Marketing innovations

- The implementation of a significant change in the design of a furniture line to give it a new look and widen its appeal.
- First introduction of direct selling or exclusive retailing.
- First introduction of a method for varying the price of a good or service according to the demand for it.

Organisational innovations

- First introduction of management systems for general production or supply operations such as supply chain management, business re-engineering, lean production, quality management system.
- First establishment of formal or informal work teams to improve access to and sharing of knowledge from different departments, such as marketing, research and production.
- First use of outsourcing of research or production.

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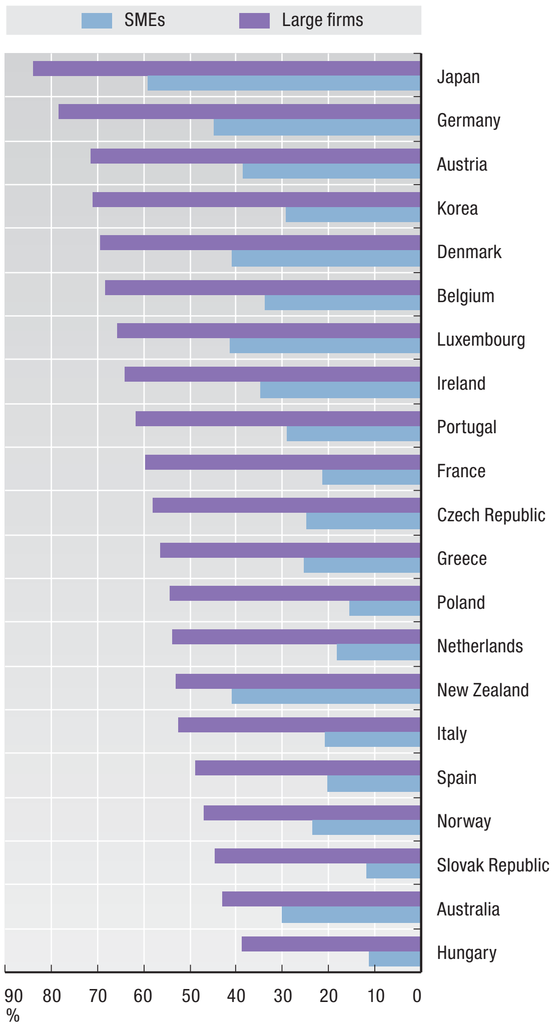
D.8. NON-TECHNOLOGICAL INNOVATION

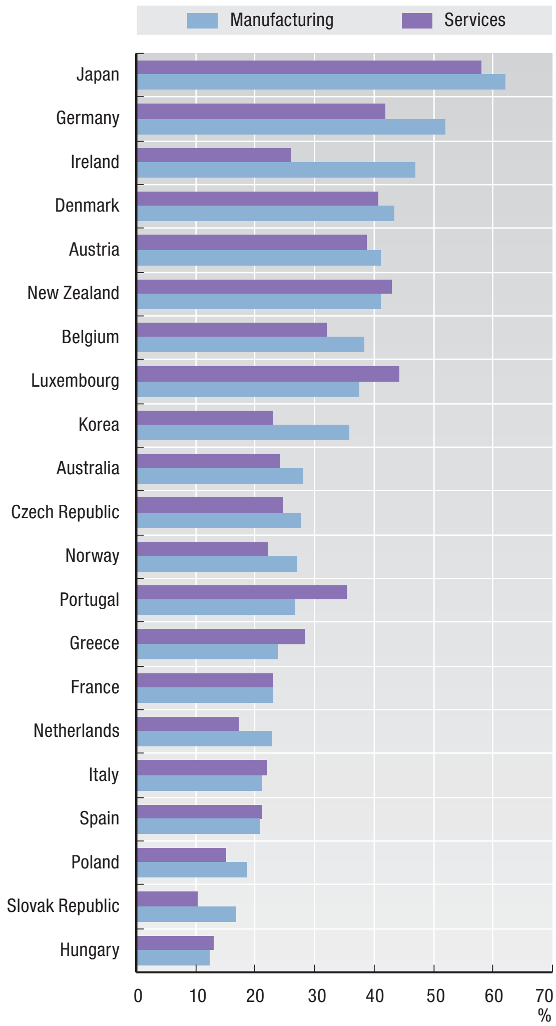
Non-technological innovators[1] by size,[2] 2002-04[3]

As a percentage of all firms



Non-technological innovators[1] by sector, 2002-04[3]

As a percentage of all firms



StatLink http://dx.doi.org/10.1787/117840413722

1. Includes firms that introduced an organisational or a marketing innovation (or both).
2. SMEs: 10-249 employees for European countries, Australia and Japan (persons employed); 10-99 for New Zealand, 10-299 for Korea.
3. Or nearest available years.

E. ICT

E.1. INVESTMENT IN ICT EQUIPMENT AND SOFTWARE

Investment in physical capital is important for growth. It is a way to expand and renew the capital stock and enable new technologies to enter the production process. Information and communication technology (ICT) has been the most dynamic component of investment in recent years.

In several OECD countries, ICT's share in total non-residential investment doubled between 1985 and 2000 but then started to decrease, following the bursting of the dotcom bubble. The available data indicate that ICT's share in total investment declined from 2000 to 2001 and deteriorated further from 2002 and 2004. In Korea, it declined from 20.8% of investment in 2000, to 15.5% in 2004. ICT investment picked up a little in France, from 2001 to 2002, and in the United States, from 2002 to 2003. ICT's share was particularly high in the United States, Sweden, Finland, the United Kingdom and Australia.

ICT investment also accounts for a considerable share of GDP. In 2003, its share in GDP was at least 3.5% in Australia, the United States, Sweden and Finland but under 2% in Ireland, Greece, Italy, Portugal and Germany.

Software has been the fastest-growing component of ICT investment. In many countries, its share in non-residential investment was multiplied several times between 1985 and 2003. Software's share in total investment was highest in the United States and Sweden (15%), in Finland (13%), and in France, Denmark and the United Kingdom (11%).

By 2005, software accounted for 50% or more of total ICT investment in France (64%), the Netherlands (58%), Sweden (57%), Denmark (55%) and the United States (52%). Communications equipment was the major component of ICT investment in Portugal, New Zealand and Greece. IT equipment was the major component in Belgium and Ireland.

Sources

- OECD database on Capital Services, April 2007.
- OECD Productivity database, available at: *www.oecd.org/statistics/productivity*.

For further reading

- F. Lequiller, N. Ahmad., S. Varjonen, W. Cave and K.H. Ahn (2003), "Report of the OECD Task Force on Software Measurement in the National Accounts", *OECD Statistics Working Paper* 2003/1, OECD, Paris.
- N. Ahmad (2003), "Measuring Investment in Software", *STI Working Paper*, 2003/6, OECD, Paris, available at: *www.oecd.org/sti/working-papers*.
- P. Schreyer, P.E. Bignon and J. Dupont (2003), "OECD Capital Services Estimates: Methodology and a First Set of Results", *OECD Statistics Working Paper*, 2003/6, OECD, Paris.

Measuring investment in ICT

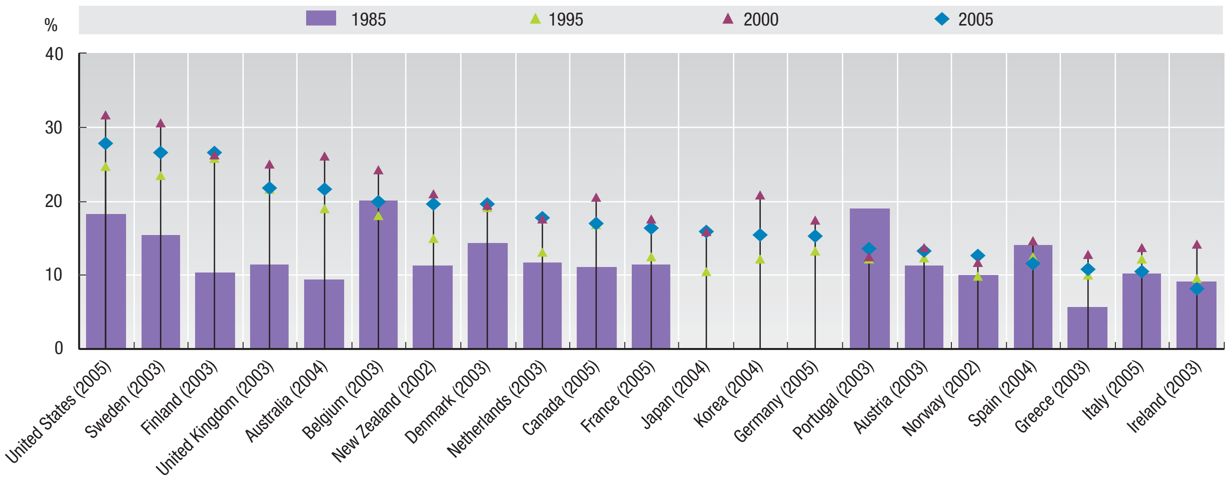
Correct measurement of investment in ICT in both nominal and volume terms is crucial for estimating the contribution of ICT to economic growth and performance. Data availability and measurement of ICT investment based on national accounts (SNA 93) vary considerably across OECD countries, especially as regards measurement of investment in software, deflators applied, breakdown by institutional sector and temporal coverage. In the national accounts, expenditure on ICT products is considered investment only if the products can be physically isolated (*i.e.* ICT embodied in equipment is considered not as investment but as intermediate consumption). This means that ICT investment may be underestimated and the order of magnitude of the underestimation may differ depending on how intermediate consumption and investment are treated in each country's accounts.

In particular, it is only very recently that expenditure on software has been treated as capital expenditure in the national accounts, and methodologies still vary considerably across countries. The difficulties for measuring software investment are also linked to the ways in which software can be acquired, *e.g.* via rental and licences or embedded in hardware. Moreover, software is often developed on own account. To tackle the specific problems relating to software in the context of the SNA 93 revision of the national accounts, a joint OECD-EU Task Force on the Measurement of Software in the National Accounts has developed recommendations concerning the capitalisation of software. These are now being implemented by OECD member countries.

E.1. INVESTMENT IN ICT EQUIPMENT AND SOFTWARE

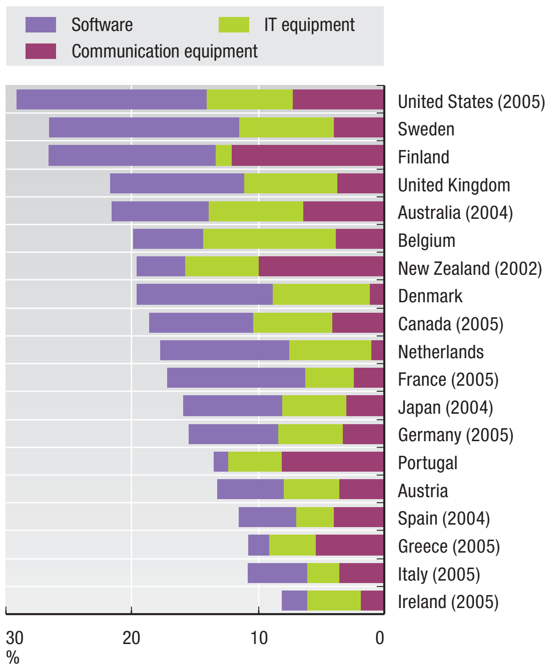
Investment in ICT,[1] 1985-2005

Percentage of gross fixed capital formation



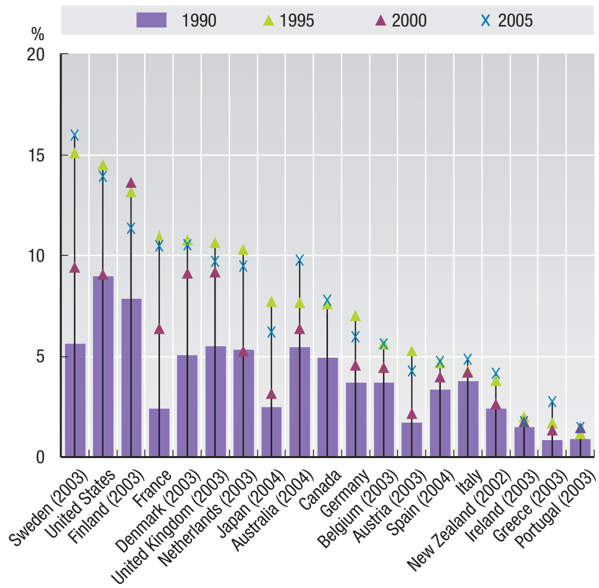
ICT investment by asset[1] in OECD countries, 2003

Percentage of non-residential gross fixed capital formation, total economy



Software investment[1] in OECD countries, 1990-2005

Percentage of non-residential gross fixed capital formation, total economy



StatLink http://dx.doi.org/10.1787/117856355513

1. ICT equipment is defined as computer and office equipment and communication equipment; software includes both purchased and own account software. Software investment in Japan is likely to be underestimated, owing to methodological differences.

Sources: OECD database on Capital Services, OECD Productivity database, May 2005.

E.2. TELECOMMUNICATIONS NETWORKS

■ For the first time, the number of fixed telephone lines has begun to shrink in the OECD area. The offset provided by ISDN to the decline in standard analogue lines has begun to slow as this platform is itself being replaced by a combination of DSL, cable modem and mobile service, which is resulting in the decrease in the number of fixed line connections and ISDN channels.

■ In terms of fixed network penetration, as measured by channels, more than two-thirds of OECD countries experienced a decline in 2003. However, if mobile cellular subscribers are included, access continues to expand across the OECD area. In 2005, there were 131 basic telecommunication access paths (*i.e.* fixed plus wireless) per 100 inhabitants. All but two OECD countries had more than one basic telecommunication access path per inhabitant.

■ The number of mobile subscribers continues to expand for the OECD area as a whole and reached 933 million at the end of 2005. In 2005, over 97 million new subscribers were added to cellular networks. This was more than the annual increase over 2002-04 but much less than the record growth achieved between 1998 and 2001, an indication of the maturing of mobile penetration rates.

■ About 80% of people in OECD countries had a mobile phone by the close of 2005, up from around one-third in 1999. In 14 OECD countries, there are more mobile subscribers than inhabitants. This may be explained by the fact that in some countries users have more than one pre-paid or SIM card on different networks to take advantage of lower prices for on-net calls. Luxembourg is the leader in terms of more mobile phones than inhabitants, probably because users who reside in surrounding countries have a second mobile for use in Luxembourg.

■ Broadband subscribers in the OECD area reached 157 million by the end of 2005, of which 38.4 million were added during the year. The OECD broadband penetration rate reached almost 17 subscribers per 100 inhabitants in 2005, up from 7.3 per 100 inhabitants in December 2003. The Netherlands and Denmark are the clear leaders in terms of broadband penetration, followed by Iceland, Korea and Switzerland. DSL is the leading broadband platform in 28 OECD countries. Canada and the United States have more cable modem than DSL subscribers. Fibre optic is becoming a significant platform in Japan and Korea with 31% and 24%, respectively, of all broadband connections.

Sources

- OECD, *Communications Outlook 2007*, OECD, Paris.
- OECD, Telecommunications database 2007.
- OECD Broadband Statistics, available at: *www.oecd.org/sti/ict/broadband*.
- OECD, ICT Key Indicators, available at: *www.oecd.org/sti/ICTindicators*.

Measuring telecommunication network access

In the past, the penetration of standard access lines provided a reasonable indication of the extent to which basic telecommunication connections were available to users. Today, use of standard access lines as a stand-alone measure would give a distorted view of network development, since in more than half of OECD countries, the number of standard access lines began to decrease as the take-up of ISDN (integrated services digital network) increased. A different methodology from the one traditionally used for the penetration of standard access lines measures the penetration of telecommunication channels, including those made possible by ISDN. To appreciate overall telecommunication penetration rates across the OECD area, it is also increasingly necessary to take into account the development of mobile communication networks and of "broadband" Internet access. The two leading technologies currently used to provide high-speed Internet access are cable modem and digital subscriber lines (DSL). Other broadband connections include satellite broadband Internet access, fibre-to-home Internet access, Ethernet LANs (local areas networks), and fixed wireless access. The data for broadband subscribers includes business and residential connections.

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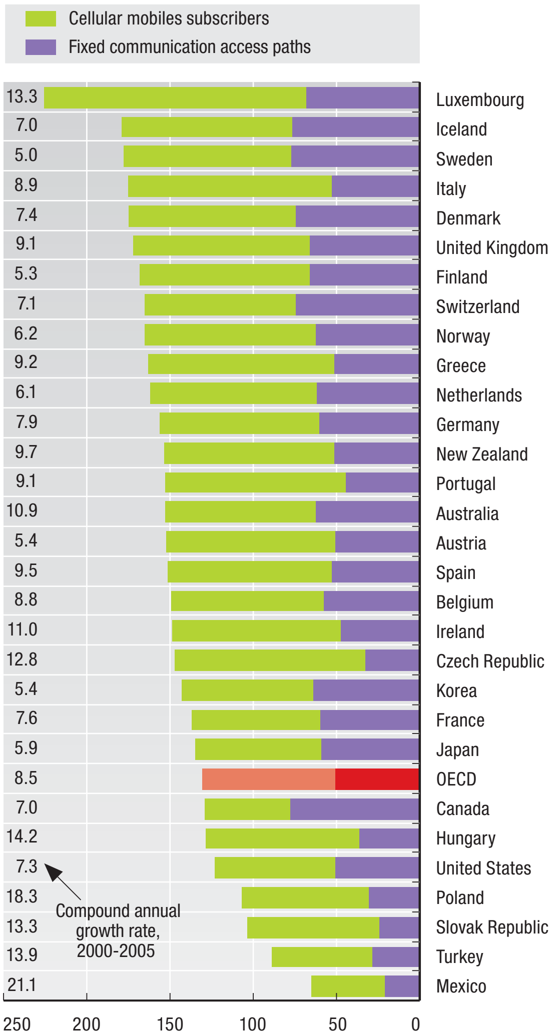
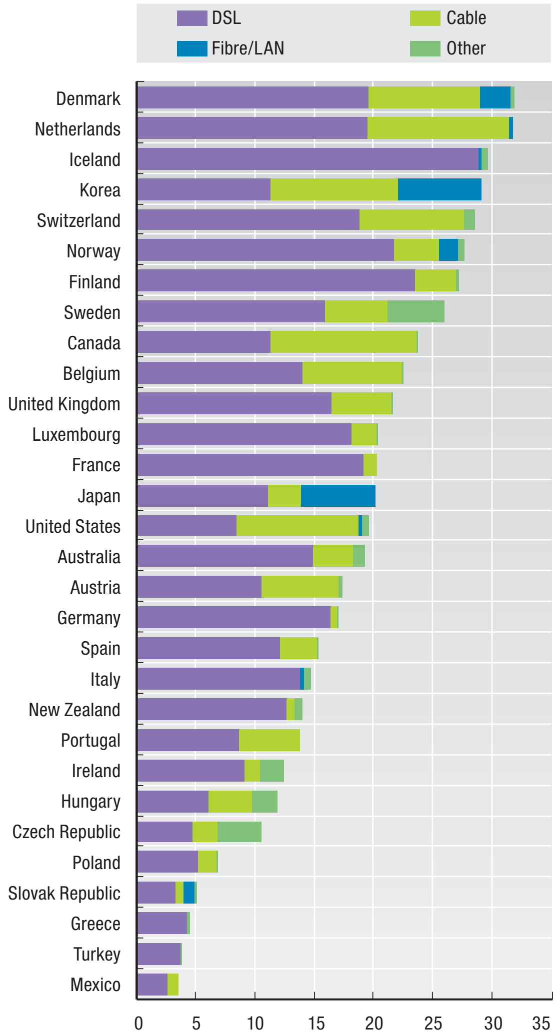
Communication access[1] per 100 inhabitants, 2005



Broadband subscribers per 100 inhabitants

By technology, December 2006



StatLink http://dx.doi.org/10.1787/118045360265

1. Fixed communication access paths = analogue lines + ISDN lines + DSL + cable modem.

E.3. INTERNET SUBSCRIBERS AND HOSTS

■ At the end of 2005, there were around 263 million active Internet subscribers with fixed Internet connections in OECD countries, up from around 189 million in 2001 or by almost 10% a year.

■ Growth in fixed Internet penetration is reflected in the overall increase in subscribers across OECD countries, from 16.6 per 100 inhabitants in 2001 to 22.5 per 100 inhabitants in 2005. In 2001, nine OECD countries had fixed Internet penetration of less than ten per 100 inhabitants. By 2005, only six countries were below that mark.

■ On a per capita basis, the highest penetration of fixed Internet accounts, at the end of 2005, was in Switzerland (36), followed by Sweden (35), Australia, the Netherlands and Denmark (34).

■ In January 2006, there were 364 million hosts connected to the Internet world wide, up from less than 30 million in January 1998. About 243 million were under generic top level domains (gTLDs), of which more than 171 million under .net and 69 million under .com.

■ In January 2006, 109 million hosts were connected under OECD-related country code top level domains (ccTLDs). The largest OECD country code domain (ccTLD) was .jp (Japan) with almost 25 million hosts. There were just under 2.4 million hosts under the .us domain, but almost 15 million more under various United States domains (.us, .edu, .mil, .gov). Other large ccTLDs included: .it (Italy) with 11 million hosts; .de (Germany) 10 million; .nl (the Netherlands) and .fr (France) 7 million; and .au (Australia) and.uk (United Kingdom) 6 million.

Sources

- OECD, *Communications Outlook 2007*, OECD, Paris.
- OECD, Telecommunications database 2007.
- OECD (2004), "Comparing Domain Name Administration in OECD Countries", 2004, see: *www.oecd.org/sti/telecom*.
- ISC Internet Domain Survey, see: *www.isc.org/index.pl?/ops/ds/*.
- OECD, ICT Key Indicators, available at: *www.oecd.org/sti/ICTindicators*.

Measuring Internet access and Internet hosts

One approach is to compile information on Internet subscribers from reports by the largest telecommunication carriers. These provide information on the number of subscribers to their Internet services and their estimates of market share. As these carriers manage connectivity via public switched telecommunication networks, they are often well placed to know subscriber numbers and associated market shares on an industry-wide basis. One drawback to these data concerns countries, such as Portugal, where users pay for Internet access via their dial-up telephone connection rather than a subscription. As a result many families have multiple Internet accounts instead of a shared subscription, in the same way as many users have multiple e-mail accounts. The use of subscription-free accounts has declined in recent years with the increasing use of broadband access.

The number of Internet hosts has been one of the more commonly used indicators of Internet development. A host is a domain name associated with an IP address. This includes any computer or device connected to the Internet via full or part-time, direct or dial-up connection. Sometimes host devices are not accessible to automated surveying techniques because of security firewalls. Consequently, host counts tend to on the low side and should be seen as an indicator of the minimum size of the Internet. It should also be remembered that there is no necessary correlation between a host's domain name and its physical location. The ISC and Network Wizards undertake the longest running and most comprehensive survey of Internet hosts.

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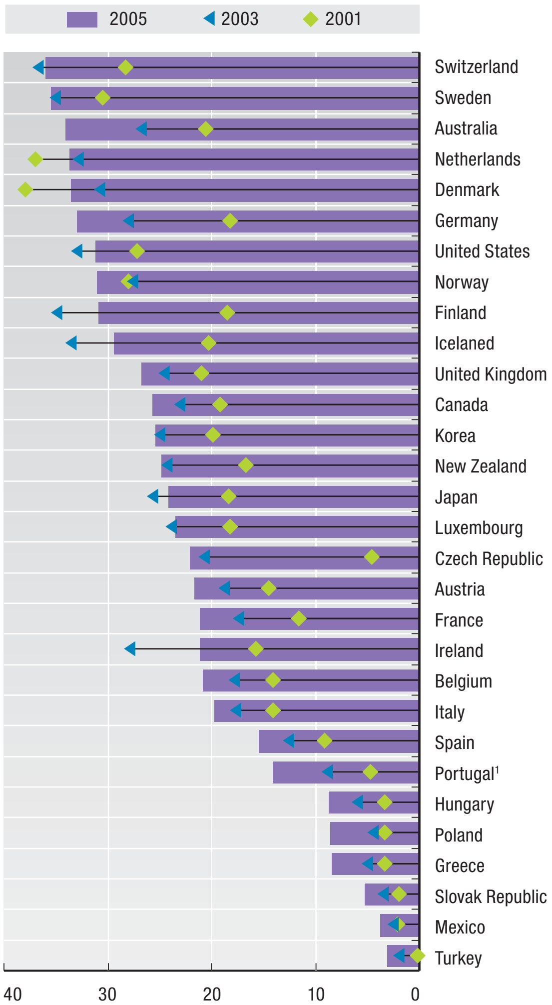
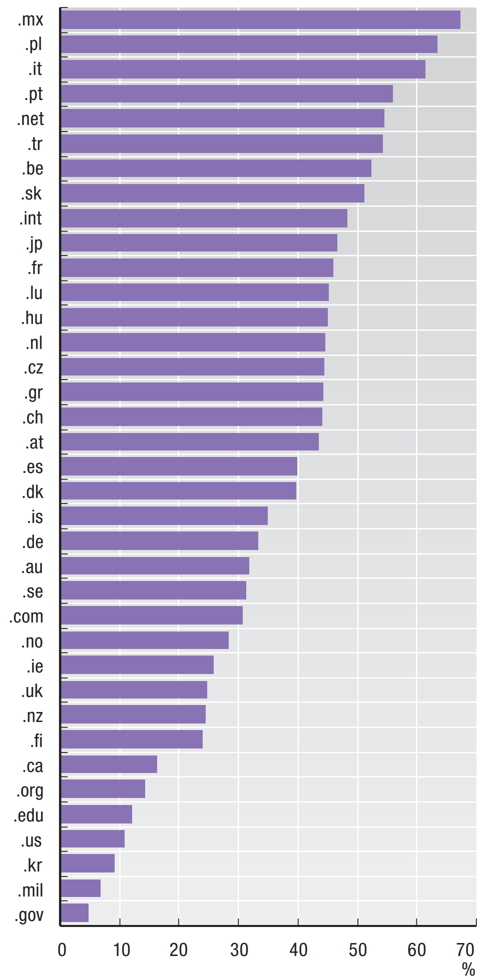
E.3. INTERNET SUBSCRIBERS AND HOSTS

Internet subscribers per 100 inhabitants, 2005



1. Data for Portugal includes subscription-free ISP accounts.

Average annual growth in Internet hosts by domain, 1998-2006



StatLink http://dx.doi.org/10.1787/118077087144

E.4. BROADBAND AND SECURITY

■ Household and business use of broadband Internet access is growing rapidly in most parts of the OECD area. In 2006, Korea remained the country with the largest share of households with a broadband connection via a computer or mobile phone (94%). However, Ireland had become the country with the highest penetration rate among business with ten or more employees (see E.7 for more information on business broadband use).

■ Canada and the Nordic countries also have high rates of broadband connectivity in the home. Iceland's household penetration rate registered the largest increase, from 45% in 2004 to 72% in 2006.

■ The growth of broadband has created a greater need for users to actively protect their security and privacy in the online environment. The always-on connectivity enabled by broadband access increases the importance of using tools such as firewalls and anti-virus software and keeping them up to date. Both individual users and businesses report that computer viruses are the "malware" with which they most come into contact.

■ While this is a challenging area to measure, differences among countries can highlight progress in working towards a culture of security. The largest proportions of Internet users encountering viruses were reported in Korea, Spain and Luxembourg. For businesses, the three countries reporting the most encounters with viruses were Japan, Finland and Italy.

■ Few businesses reported incidents of "unauthorised access" or "blackmail or threats", but respondents may be unwilling to answer questions on the subject. So-called "denial of service" attacks against businesses are likely to be a common type of incident in this category.

■ A threat which has emerged with the rise of the number of broadband connections is networks of compromised computers acting together without their owners' knowledge or control. Symantec, a private security firm, tracks "bot-infected computers" by country (see box). The most likely explanation for the level of infection is how actively users employ security precautions and install "patches".

■ The Symantec data can be correlated with the number of broadband connections to see the relative scale of infections across countries. In December 2006, the smallest numbers of bot-infected computers were in Japan, Finland and the Netherlands. The highest rates of infection were in Poland, Spain and Portugal.

Sources

- OECD, ICT database and Eurostat, Community Survey on ICT usage in households and by individuals, April 2007.
- Symantec, "Internet Threat Security Report", March 2007.

For further reading

- OECD, *Information Technology Outlook* 2006, OECD, Paris.
- OECD, *Communications Outlook* 2007, OECD, Paris.

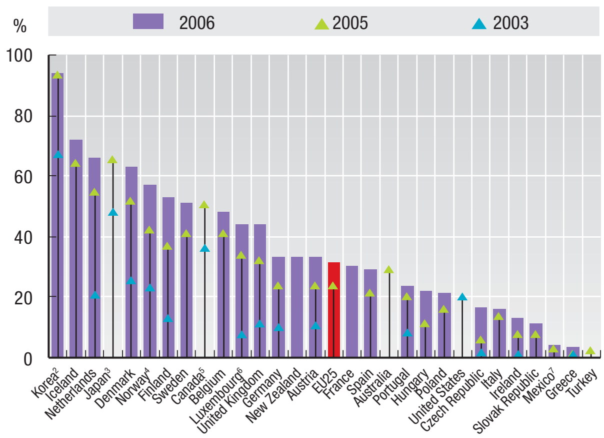
Broadband and the rise of botnets

"Botnet" is the term given to machines connected to the Internet which have been compromised in such a way that they can be directed to act in concert by an external party without the owners' knowledge or authority. Botnets may be used by the party that has commandeered the machines to mount denial of service attacks against particular sites on the Internet or to retransmit spam, phishing and so forth. Symantec's "Internet Security Report Threat Report" for the second half of 2004 contained a new indicator on botnets which gave the percentage of "bot-infected" computers by country.

Symantec gather data on bot-infected computers by monitoring 20 000 sensors located in networks in over 180 countries. Attacks from infected computers are recorded and matched against other databases such as those for malicious code and those enabling the assessment of originating addresses. Significantly, the data are not specific to Symantec customers, unlike some of the company's other indicators, so there should not be a geographical bias. As the capture of computers is believed to be opportunistic rather than targeted towards a particular country, this indicator may be useful as an international benchmark of security awareness and action by Internet users.

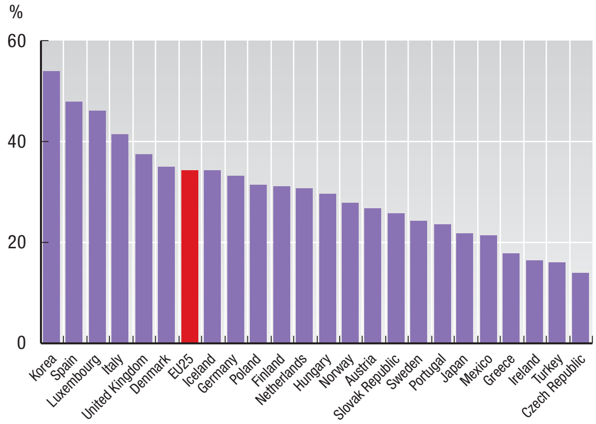
Households with broadband access, 2003-06[1]

As a percentage of all households



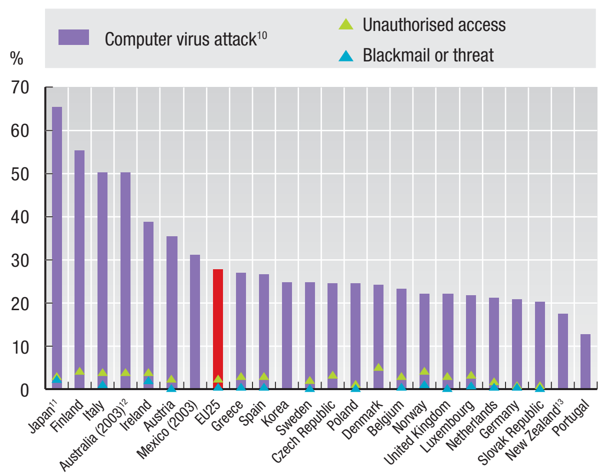
Individuals who encountered a computer virus by using the Internet, 2005[1, 8]

As a percentage of individuals using the Internet



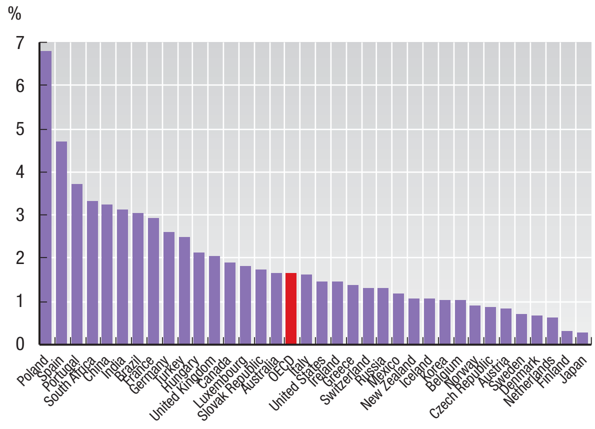
Businesses that have encountered IT security problems, 2005[9]

As a percentage of businesses with ten or more employees using the Internet



Bot-infected computers, December 2006

Per 100 broadband subscribers



StatLink http://dx.doi.org/10.1787/118080287002

1. Generally, data from the EU Community Survey on household use of ICT, which covers EU countries plus Iceland, Norway and Turkey, relate to the first quarter of the reference year. For the Czech Republic, data relate to the fourth quarter of the reference year.
2. For 2000 to 2003, data include broadband access modes such as xDSL, cable and other fixed and wireless broadband via computers. As of 2004, data also include mobile phone access.
3. Only broadband access via a computer.
4. For 2003, data include LAN (wireless or cable).
5. Statistics for 2001 and every other year thereafter include the territories (Northwest Territories, Yukon Territory and Nunavut). For the even years, statistics include the ten provinces only.
6. For 2004, data include wireless access.
7. For 2001 and 2002, households with Internet access via cable. From 2004, households with Internet access via cable, ADSL or fixed wireless.
8. Resulting in loss of information or time.
9. For European countries, enterprises in the following industries are included: Manufacturing, Construction, Wholesale and retail, Hotels and restaurants, Transport, storage and communication, Real estate, renting and business activities and Other community, social and personal service activities. For Australia, the following industries are excluded: Agriculture, forestry and fishing, Education and religious organisations. For Japan, data refer to enterprises with 100 or more employees and exclude: Agriculture, forestry, fisheries and Mining. For Mexico, data refer to enterprises with 50 or more employees and include: Manufacturing, Services and Construction.
10. Resulting in loss of information or time. It is likely that some countries also include other threats such as trojans and worms in this category.
11. Defamation, libel, etc., on the web instead of blackmail or threat, data for 2004 instead of 2005.
12. Computer virus attack consists just of viruses.
13. IT security problems in general.

E.5. ICT ACCESS BY HOUSEHOLDS

■ Household access to computers has increased significantly in recent years. Iceland, Denmark and Japan led in 2005, with over 80% of households with access to a computer. In Sweden, Korea and the Netherlands this share was just under 80%.

■ Most OECD countries have seen significant growth in home computer access in recent years. Between 2000 and 2005, the share of households with access to a computer at home increased by about 30 percentage points in the United Kingdom, Japan and Austria. Spain, Germany and Ireland saw their share increase by more than 20 percentage points.

■ Demand for Internet access has been a primary driver for the increase in home computers. It is worth noting that the Internet, a technology barely a decade old in terms of commercial availability to the public, is now used in at least 60% of households in half of the OECD countries.

■ In 2006, penetration of household Internet access was highest in Korea (94%), followed by Iceland, the Netherlands and Denmark. Between 2000 and 2006, home Internet access grew fastest in Germany, Korea, the United Kingdom and Switzerland.

■ Korea's leadership in broadband penetration follows its early high level of penetration of home computers. Both Denmark and Switzerland also had high penetration of home computers in 2000 but had a slower take-up of broadband, as measured by number of subscribers (see E.2).

■ Canada and Australia followed closely parallel paths in terms of penetration of household computers and Internet access, but Canada now has much higher broadband penetration (see E.2). Computer penetration thus appears to be only one factor in the take-up of broadband. Other factors include the level of competition and availability of service (coverage of the population).

■ In all responding OECD countries, households with children are more likely to have Internet access at home. Finland has the largest difference in this respect; the rate of Internet access for households with dependent children is 34 percentage points higher than that of households without. The differences are also significant in Norway, the Czech Republic, Canada and Norway.

Sources

- OECD, ICT database and Eurostat, Community Survey on ICT usage in households and by individuals, April 2007.

For further reading

- OECD, *Information Technology Outlook 2006*, OECD, Paris.
- OECD, *Communications Outlook* 2007, OECD, Paris.
- OECD (2005), *Guide to Measuring the Information Society*, OECD, Paris.

ICT use in households and by individuals – OECD model survey

In 2005, the OECD revised its model survey on ICT usage in households and by individuals. The questionnaire in the model is composed of self-contained modules which can be used either in their totality or as separate modules in specific national surveys. The model survey is intended to provide guidance for measuring ICT usage (including Internet use and Internet commerce) and barriers to ICT use by households and individuals. Participating countries are encouraged to use it as a core part of survey development in order to improve the international comparability of information collected and compiled on this topic.

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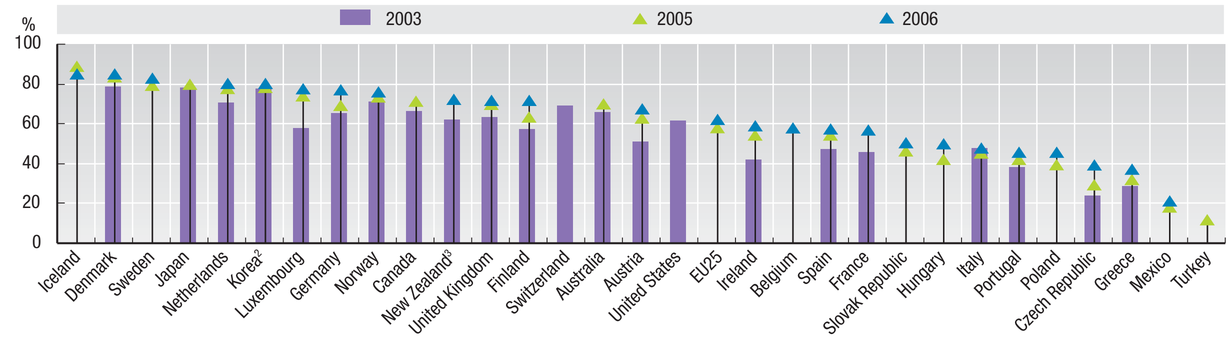
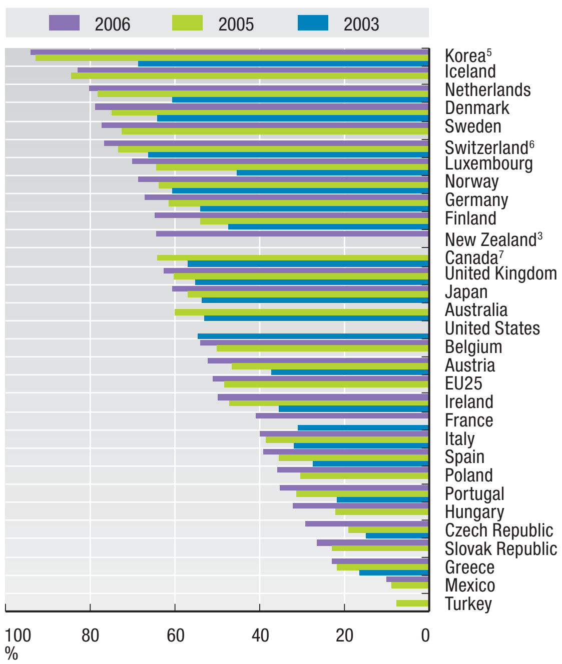
Households with access to a home computer,[1] 2003-06

As a percentage of all households



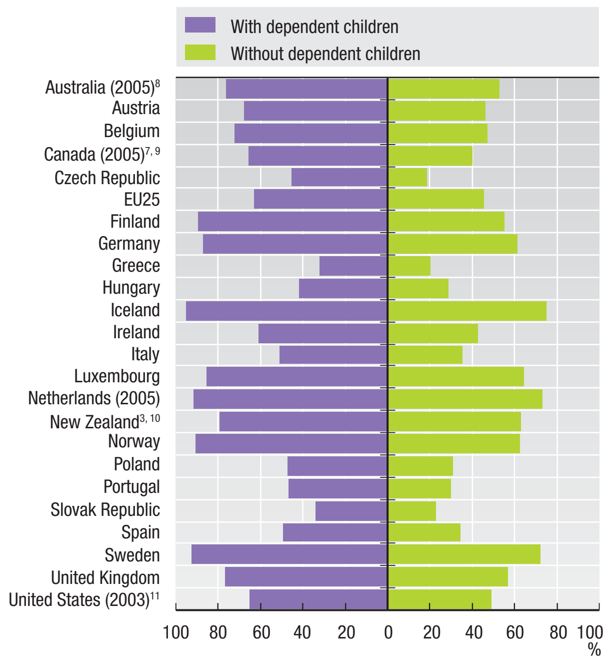
Households with access to the Internet,[1, 4] 2003-06

As a percentage of all households



Household Internet access by household type,[1] 2006

As a percentage of all households



StatLink http://dx.doi.org/10.1787/118122302858

1. Generally, data from the EU Community Survey on household use of ICT, which covers EU countries plus Iceland, Norway and Turkey, relate to the first quarter of the reference year. For the Czech Republic, data relate to the fourth quarter of the reference year.
2. Previously, data for Korea were based on the Computer and Internet Use Survey conducted by the Korean National Statistical Office. Certain items of that survey are no longer collected and data are now sourced from the Survey on Computer and Internet Usage conducted by the National Internet Development Agency (NIDA) of Korea. The NIDA series shows larger shares than the previous survey. Up until 2005, data included only desktop and notebook PCs. For 2006, data also included portable and handheld PCs.
3. The information is based on households in private occupied dwellings. Visitor-only dwellings, such as hotels, are excluded.
4. Internet access is via any device (desktop computer, portable computer, TV, mobile phone, etc.).
5. For 2000 to 2003, data include Internet access only via computer. As of 2004, Internet access through mobile phone, TV and game consoles are also included.
6. Figures refer to a sample based on individuals and are private data from *Arbeitsgruppe für Werbemedienforschung* (WEMF AG).
7. Statistics for 2001 and every year thereafter include the territories (Northwest Territories, Yukon Territory and Nunavut). For the even years, statistics include the ten provinces only.
8. Data provided relate to households with or without children under 15 years.
9. Dependent children refers in the survey to single, never married children of the household reference person, of any age.
10. Household child dependency status does not include households where there is a child with an unknown dependency status.
11. Households with dependent children are defined as households with children under the age of 18.

E.6. INTERNET USE BY INDIVIDUALS

In 2000, more than 50% of adults in only a handful of OECD countries used the Internet at home, work or another location. By 2005, participation rates were over 60% in over half of all OECD countries.

In 2006, Internet use by adults was highest in Iceland (90%), Sweden (88%), Denmark (87%), the Netherlands and Norway (83%). Outside Europe, Japan and Korea had the highest rates of adult Internet use.

Between 2000 and 2006, the share of adults using the Internet increased by more than 20 percentage points in Austria and Ireland. In Luxembourg, Korea and Germany, penetration rates increased by more than 15 percentage points.

Men are more likely than women to access the Internet in most OECD countries. The gap is largest in Luxembourg and Switzerland. In 16 of the 29 OECD countries for which data are available, penetrations rates among men are at least 5 percentage points higher than among women. Only Ireland and Mexico have less than a 1 percentage point difference.

In three countries, however, women are more likely than men to access the Internet: the United States (a difference of 2.8 percentage points), Canada (2.0) and New Zealand (1.9). Previous US surveys have produced similar results, although the difference was much smaller in 2000.

In the United States, penetration rates are higher among women than among men in every age group up to age 65. The largest differences are in the age groups 16-24 and 25-44. In both, female rates exceed male rates by 4 to 5 percentage points. However, male rates are significantly higher than female rates for the age groups 65-74 and for 75 years and over.

Sources

- OECD, ICT database and Eurostat, Community Survey on ICT usage in households and by individuals, April 2007.

For further reading

- OECD, *Information Technology Outlook 2006,* OECD, Paris.
- OECD, *Communications Outlook* 2007, OECD, Paris.
- NTIA, *A Nation Online: Entering the Broadband Age*, 2004, see: *www.ntia.doc.gov/reports/anol/index.html*.
- OECD (2005), *Guide to Measuring the Information Society,* OECD, Paris.

Comparability of country data on ICT use in households and by individuals: age cut-off and recall period

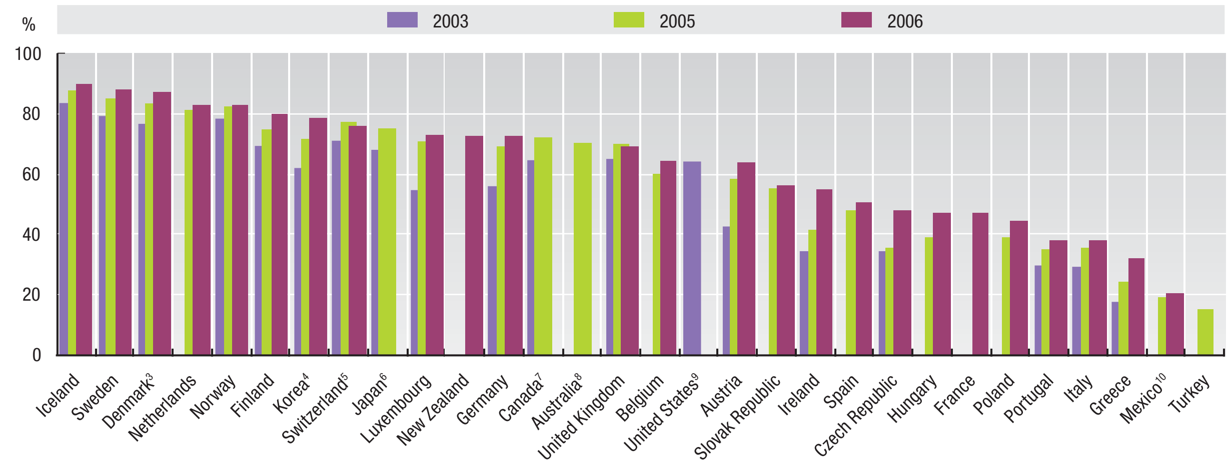
Most OECD countries collect information on the use of information and communication technology (ICT) and most use both households and individuals as statistical collection units. In general, the household unit is used to elicit information about the facilities in place in the household (for example, whether there is a TV, computer or Internet connection). The individual as a statistical unit is used to provide information on use of these facilities by individuals (both in and away from the home) and, most importantly, on intensity of use (for instance, frequency and range of activities undertaken). In terms of comparability across countries, the greatest differences are probably in the age scope used for individuals. The OECD currently recommends including all individuals aged 16 and over in the survey. Eurostat provides data to the OECD on the age grouping 16-74 (some European countries collect data for people over 74). Other OECD countries have a variety of age cut-offs which are usually constrained by the survey vehicle used to collect the data (for instance, countries using labour force surveys are likely to collect information for the relevant age group). The differences can be important as use of information technology is very age-dependent. In particular, younger people are generally more likely to use ICT than older people. In order to improve comparability, the OECD collects data for the age group 16-74 wherever possible. Information on country variations regarding age is given in the notes to the relevant figures.

Another issue for cross-country comparability concerns the recall period used for questions on ICT use by individuals. The OECD recommends use of a 12-month recall period for such questions although not all countries follow the recommendation (many European countries use 12 months for some items and three months for others). Increasingly, for OECD countries, the differences are minor for data on ICT use as most people who use ICT have done so in the last three months. More information on the recall periods used by different countries for different items can be found in the notes to the relevant figures.

E.6. INTERNET USE BY INDIVIDUALS

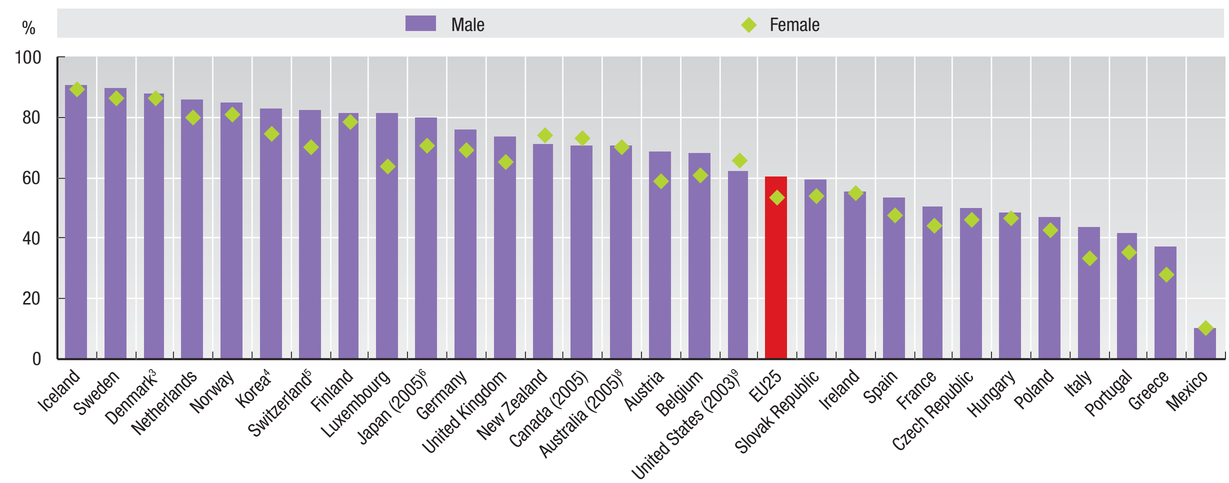
Individuals[1, 2] using the Internet from any location, 2003-06

As a percentage of all adults



Individuals[1, 2] using the Internet from any location by gender, 2006

As a percentage of all adults



StatLink http://dx.doi.org/10.1787/118128365086

1. Generally, data from the EU Community Survey on household use of ICT, which covers EU countries plus Iceland, Norway and Turkey, relate to the first quarter of the reference year. For the Czech Republic, data relate to the fourth quarter of the reference year.
2. Individuals aged 16-74 years, except for the Czech Republic (15+), Japan (6+), Korea (7+ until 2001, 6+ afterwards), Mexico (6+) and Switzerland (14-74). Data generally refer to Internet use in the last 12 months.
3. Data refer to Internet use in the last month.
4. Individuals who use the Internet at least once a month. For 2000 to 2003, data include Internet accessed only via computer. In the 2004 survey, Internet access through mobile phone is also included. From 2005, data are for the proportion of individuals using the Internet via any means, including mobile phone, in the last 12 months.
5. Private data from *Arbeitsgruppe für Werbemedienforschung* (WEMF AG). Data refer to Internet users aged 14-74 who used the Internet at least once within the last six months.
6. Aged 6 years or over. The percentages may be relatively high compared to other countries as younger people tend to be greater users of the Internet than older age groups.
7. Data for 2000 to 2003 refer to the percentage of all households with at least one member regularly using the Internet from any location. Individual data are available for 2005; data include individuals aged 18-74.
8. Aged 18 years or over. For 2001, data for individuals over 64 years of age are estimated. Data for 2004 to 2005 refer to individuals aged 18-64.
9. Respondents are asked whether they use the Internet; no time period is specified.
10. For 2001 to 2005, data refer to Internet use in the last 6 months.

E.6. INTERNET USE BY INDIVIDUALS *(continued)*

■ E-mail is the most popular of the Internet's communication services, and is used by more than half the adult population in over half of OECD countries. In 2006, it was used by more than 70% of adults in Iceland, the Netherlands, Denmark, Sweden and Norway. Finland, New Zealand, Luxembourg, Switzerland and Germany were also among the largest users of e-mail, with rates of between 56% and 60% of adults.

■ Use of Internet telephony is still relatively low but growing, along with the uptake in broadband. Iceland and Luxembourg use Internet telephony services the most, with penetration rates above 16%. Finland, Norway, Denmark, Germany and the Netherlands are also among the largest users, with no less than 10% of adults using Internet telephony services. Growing take-up of services such as Skype is likely to be fuelling the rapid increase observed in household penetration.

■ One of the most popular uses of the Internet, particularly in the Nordic countries, is to access banking services. In Iceland, Norway and Finland some 60% of adults use the Internet for banking services.

■ Purchasing and ordering of goods and services is very popular as well, although less so than banking. Norway has the largest share of adults (47%) using the Internet for online shopping, followed by Korea and Japan (40%), Sweden (39%), and the United Kingdom and Germany (38%).

■ Seeking information on health is also becoming one of the most frequent uses of Internet. In 2006, no less than 40% of adults in the Netherlands, Finland and Iceland sought health information on the web as did over 30% in Canada, Norway and Germany.

■ Playing or downloading games and music is most popular in the Netherlands (42% of adults) and Korea (40%). These activities are also very popular in all the Nordic countries, where more than a quarter of all adult Internet users play/download games or music.

■ Over half of adults in Iceland, Norway, the Netherlands and Luxembourg use the Internet for interaction with public authorities. Internet users were also very likely to interact with public authorities in Finland, Luxembourg and Denmark.

■ Using the Internet for job searches is most popular in Finland (27% of adult Internet users) followed by Sweden (24%), Norway (22%), New Zealand and Switzerland (21%).

Sources

- OECD, ICT database and Eurostat, Community Survey on ICT usage in households and by individuals, April 2007.

For further reading

- OECD, *Information Technology Outlook 2006,* OECD, Paris.
- OECD, *Communications Outlook 2007,* OECD, Paris.
- OECD, "Digital Broadband Content: The online computer and video game industry", DSTI/ICCP/IE(2004)13/Final.

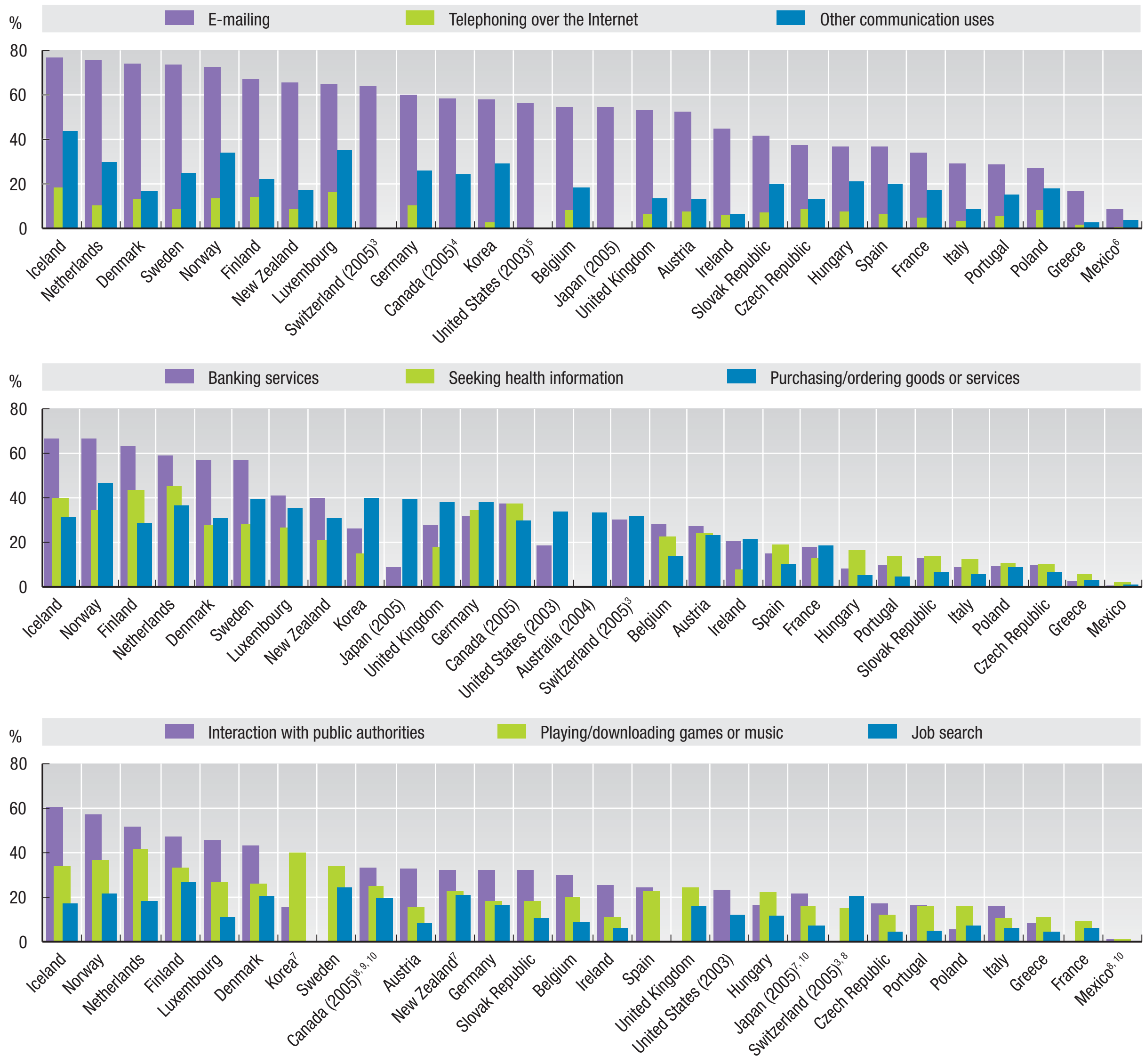
The online games we play

While audio and video delivery have been touted as the big future broadband applications, online gaming - a very high-bandwidth application - has developed faster than any online broadband content service, and has so far avoided the problems of online piracy. While Asia (including China) is a strong market for online games, the North American and European markets are also expected to grow. New online-enabled revenue models include retail purchase, subscription fees, pay-per-play, advertising, and new services including selling and/or renting digital objects and players. In the OECD area 16 to 24-year-olds are the largest group of Internet users playing and/or downloading games, but online computer and video games are spreading to other age groups, including 29-40 and older. The online game category with the greatest demand on bandwidth remains the high-end, massively multiplayer online games (MMOGs), which still mainly appeal to a fairly small user base. As online games continue to appeal to new audiences with consoles and online mobile games driving growth, games such as World of Warcraft report over 9 million paying subscribers in mid-2007. Finally, the use of online computer game and video software and applications in areas such education, health and other non-recreational environments remains promising.

E.6. INTERNET USE BY INDIVIDUALS *(continued)*

Internet use by type of activity,[1, 2] 2006

As a percentage of adults



StatLink http://dx.doi.org/10.1787/118140670521

1. Generally, data from the EU Community Survey on household use of ICT, which covers EU countries plus Iceland, Norway and Turkey, relate to the first quarter of the reference year. For the Czech Republic, data relate to the fourth quarter of the reference year.
2. Individuals aged 16-74 years, except for Australia (18+), Canada (18-74), the Czech Republic (15+), Japan (6+), Korea (7+ until 2001, 6+ afterwards), Mexico (6+), Switzerland (14-74). Data generally refer to Internet use in the last 12 months for non-Eurostat countries and last 3 months for Eurostat countries.
3. Private data from *Arbeitsgruppe für Werbemedienforschung* (WEMF AG). Data refer to Internet users aged 14-74 who used the Internet at least once within the last six months.
4. Data for 2000 to 2003 refer to the percentage of all households with at least one member regularly using the Internet from home. Individual data are available for 2005, data include individuals aged 18-74.
5. E-mailing includes instant messaging.
6. Telephoning over the Internet includes videoconferencing; data are for 2004.
7. Playing/downloading music only.
8. Playing/downloading games only.
9. Job search data is for 2003.
10. Obtaining information from public authorities' websites.

E.7. INTERNET ACCESS AND USE BY BUSINESSES

■ Business use of the Internet (firms with 10 or more employees) has become a fairly standard practice in most OECD countries. In 25 OECD countries out of 28, over 90% of businesses have Internet access, and Iceland, Finland, Switzerland, Denmark, Japan and Austria report access rates above 98%.

■ Increasingly, businesses use broadband platforms to connect to the Internet. In Iceland, Korea and Canada over 92% of businesses have a broadband connection, followed by Finland and Sweden (89%), and Spain and France (87%).

■ In a large majority of OECD countries, over half of businesses have their own website. At more than 85%, Sweden and Japan have the highest proportion, while Denmark, Finland and Switzerland record levels of 80% or more.

■ In most OECD countries for which data are available, over 90% of large businesses (those with 250 or more employees) have access to the Internet. In over two-thirds of OECD countries, access rates for large businesses exceed 95%. Medium-sized firms (with 50 to 249 employees) also have very high rates. Poland has the most significant difference in Internet penetration rates between large and small firms (10 to 49 employees) (53 percentage points). In Greece, Portugal, Ireland, Hungary and Austria, differences between large and small firms in Internet penetration rates exceed 30 percentage points.

Sources

- OECD, ICT database and Eurostat, Community Survey on ICT usage in households and by individuals, April 2007.

For further reading

- OECD, *Information Technology Outlook 2006,* OECD, Paris.
- OECD, *Communications Outlook 2007,* OECD, Paris.
- OECD (2005), *Guide to Measuring the Information Society*, OECD, Paris.

Country comparability in measurement of ICT use by businesses

To improve data comparability, OECD countries agreed in 2001 on a model survey on ICT use by businesses. In order to maintain comparability and relevance of information, the model survey was revised in 2005 (see E7bis).

The questionnaire in the model is composed of self-contained modules which can be used either in their totality or as separate modules in specific national surveys. The model survey is intended to provide guidance for measuring ICT use (including e-commerce), and participating countries are encouraged to use it as a core part of their survey development work.

While the model survey has contributed to the use of common methodologies, concepts and data items across OECD countries, there is still some variation. The OECD has attempted to standardise data where possible, the main area of standardisation being the use of a common size cut-off. Most countries provide data based on a size cut-off of 10 or more employees. Because larger businesses are generally more likely to use ICT, penetration rates for countries that include businesses with fewer than 10 employees and those that do not would not otherwise be comparable. Several countries are unable to apply the common cut-off (Japan, Mexico, New Zealand and Switzerland). Their ICT use rates are therefore less comparable than those of other countries.

Standardisation by industry scope is more difficult to achieve. However, variations in industry scope are less likely to have a major impact on the data than variations in size. Cross-country data for individual industries are given in E7bis.

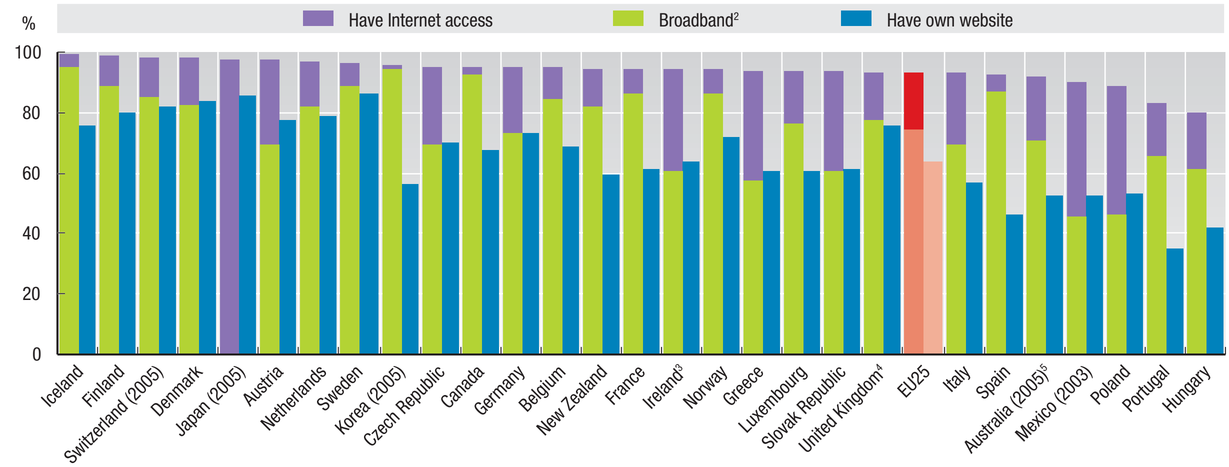
While most countries provided data for 2006, some only had data available for earlier years. Given the continuing growth in ICT use, this also affects data comparability.

Information on variations regarding size, industry and year can be found in the notes to the figures.

E.7. INTERNET ACCESS AND USE BY BUSINESSES

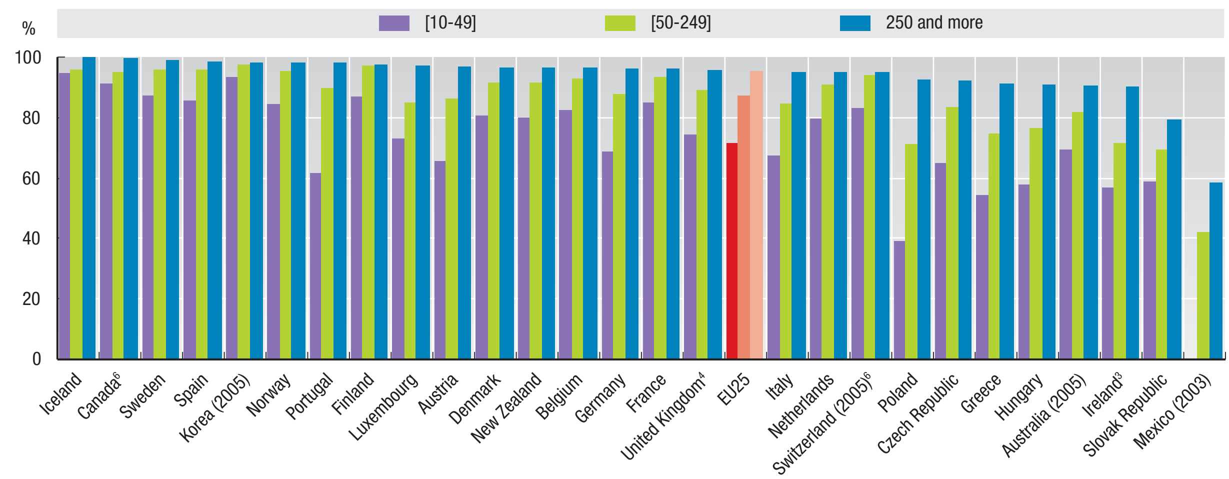
Business use of the Internet and websites, 2006

As a percentage of businesses with 10 or more employees[1]



Broadband penetration by size class, 2006

As a percentage of businesses with 10 or more employees[1]



StatLink http://dx.doi.org/10.1787/118144527771

1. For most European countries, the following industries are included: Manufacturing, Construction, Wholesale and retail, Hotels and restaurants, Transport, storage and communication, Real estate, renting and business activities and Other community, social and personal service activities. For Australia, Agriculture, forestry and fishing, Education and Religious organisations are excluded. For Canada, Agriculture, fishing, hunting and trapping, and Construction – specialist contractors are excluded. For Japan, data refer to enterprises with 100 or more employees and exclude: Agriculture, forestry, fisheries and Mining. Korea includes: Agriculture and Fisheries, Light Industry, Heavy Industry, Petrochemicals, Construction, Distribution, Finance and Insurance, and Other services. For Mexico, data refer to enterprises with 50 or more employees and include: Manufacturing, Services and Construction. For New Zealand, data exclude Government administration and defence, and Personal and other services; the NZ survey also excludes businesses with fewer than 6 employees (calculated by Rolling Mean Employment) and those with turnover of less than NZD 30 000. For Switzerland, data refer to enterprises with 5 or more employees, and include Manufacturing, Construction, Electricity, gas, water, and Services industries.
2. Most countries define broadband in terms of technology (*e.g.* ADSL, cable, etc.) rather than speed.
3. Includes all of NACE 92.
4. Includes all of NACE 55.
5. Website includes a presence on another entity's website.
6. For Canada, 50-299 employees instead of 50-249 and 300 and more instead of 250 and more. For Switzerland, 5-49 instead of 10-49 employees.

E.7. INTERNET ACCESS AND USE BY BUSINESSES *(continued)*

■ The level of Internet penetration is relatively high in most sectors of the economy, at least among businesses with 10 or more employees. The finance and insurance industry has the highest rates of Internet connectivity across the OECD area (95% or more in four out of seven countries reporting on this industry).

■ Wholesale trade and the real estate, renting and business services industries had the next highest rate of Internet connectivity for most countries. Of the 27 OECD countries reporting on these industries, 18 have Internet penetration rates of 80% or more in wholesale trade as do 20 in real estate, renting and business services. Countries reporting very high connectivity rates for wholesale trade include Iceland (100%), Korea (96%), Norway (95%) and Sweden (94%). Countries reporting very high connectivity rates for real estate, renting and business services include Korea (99%), Iceland (98%), and New Zealand, Spain and Switzerland (94%).

■ As in previous years, the retail industry has slightly lower penetration than other industries in most countries. In Iceland, Korea and Canada, more than 90% of businesses in this category report an Internet connection.

Sources

- OECD, ICT database and Eurostat, Community Survey on ICT usage in enterprises, April 2007.

For further reading

- OECD, *Information Technology Outlook 2006*, OECD, Paris.
- OECD, *Communications Outlook 2007*, OECD, Paris.
- OECD (2005), *Guide to Measuring the Information Society*, OECD, Paris.

Measuring ICT access and use by businesses: the revised OECD model survey

The OECD model survey on business use of ICT was revised in 2005 to reflect current policy needs and priorities and is better aligned with countries' survey practices. The revisions include questions on electronic business processes, selling of digitised products, use of electronic government services and IT security. These will lead to major changes in the content and structure of the model questionnaire. In particular, the inclusion of electronic business questions requires changes in a number of questions dealing with electronic business (*e.g.* e-commerce questions, activities undertaken using the Internet and website features). The broad structure of the proposed revised model questionnaire is as follows:

a) General information about business use of ICT including: use of computers, the Internet and technologies such as LAN, WAN, intranets and extranets; means of accessing the Internet; web presence; and website "trust" features such as security and privacy statements and third party certification.

b) IT security, with questions on IT security measures in place (*e.g.* anti-virus software, firewall) and IT security problems experienced.

c) How business uses ICT in its operations including: incidence and value of e-commerce (purchasing and selling); the nature of products sold via the Internet and technologies used to sell those products; links between e-commerce and back-end systems, customer and supplier systems; benefits and barriers associated with e-commerce; use of computer networks for dealing with government and undertaking customer relationship functions; and use of computer networks in other areas of the business such as logistics, finance and human resources.

d) Other information about business, such as number of employees and annual turnover.

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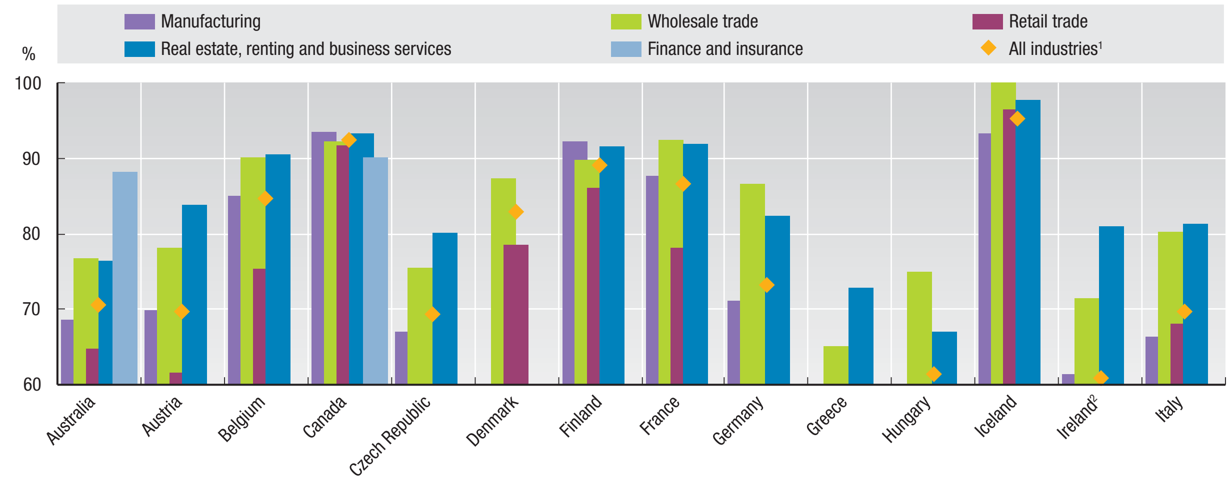
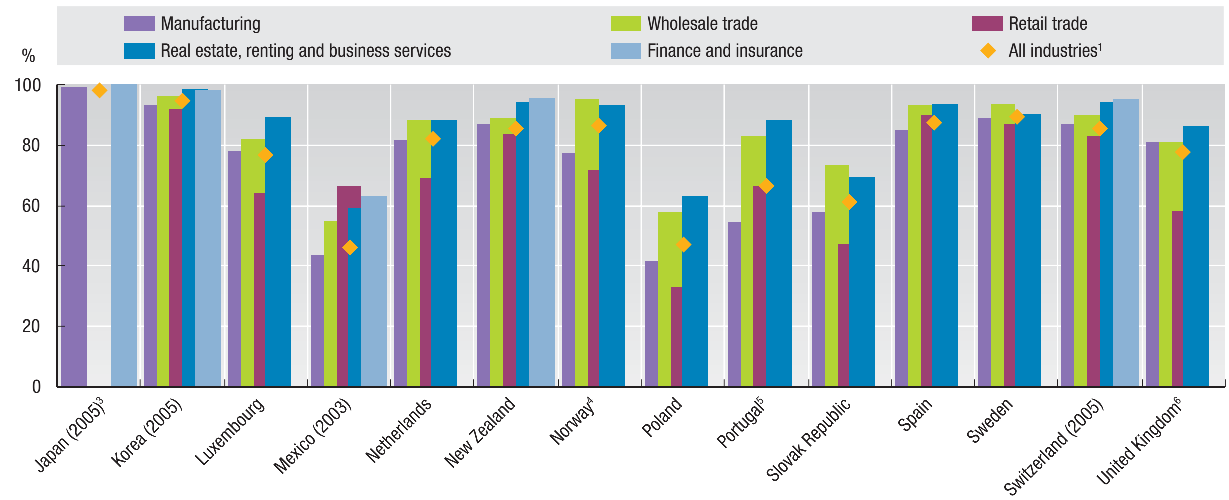
E.7. INTERNET ACCESS AND USE BY BUSINESSES *(continued)*

Broadband penetration by industry, 2006

As a percentage of businesses with 10 or more employees in each industry group





StatLink http://dx.doi.org/10.1787/118144818566

1. For most European countries, the following industries are included: Manufacturing, Construction, Wholesale and retail, Hotels and restaurants, Transport, storage and communication, Real estate, renting and business activities and Other community, social and personal service activities. For Australia, Agriculture, forestry and fishing, Education and Religious organisations are excluded. For Canada, Agriculture, fishing, hunting and trapping, and Construction – specialist contractors are excluded. For Japan, data refer to enterprises with 100 or more employees and exclude: Agriculture, forestry, fisheries and Mining. For Mexico, data refer to enterprises with 50 or more employees and include: Manufacturing, Services and Construction. For New Zealand, data excludes Government administration and defence, and Personal and other services; the NZ survey also excludes businesses with fewer than 6 employees (calculated by Rolling Mean Employment) and those with turnover of less than NZD 30 000. For Switzerland, data refer to enterprises with 5 or more employees, and include the Manufacturing, Construction, Electricity/gas/water and Services industries.
2. "All industries" includes all of NACE 92.
3. Internet penetration instead of broadband penetration.
4. Data for Manufacturing are for 2005.
5. Data for Manufacturing and Wholesale trade are for 2005.
6. "All industries" includes all of NACE 55.

E.8. INTERNET ACCESS AND USE IN NON-OECD ECONOMIES

Official data on access and use of information and communication technologies (ICTs) by households, individuals and businesses rely on surveys, which can be expensive to undertake and generally do not have very high priority in developing countries. While such data are relatively scarce, some do exist among developed and developing economies outside the OECD area. Supported by the work of the Partnership on Measuring ICT for Development (see box), the list of economies undertaking such surveys is set to grow in the coming years.

Household data on ICT use are certainly the most widely available and comprehensive in terms of what they cover in terms of ICT use, as they are often collected in general household surveys. The available data indicate a high correlation between an economy's level of development and the proportion of households accessing the Internet, with the highly developed non-OECD economies of Chinese Taipei, Singapore and Hong Kong (China) having shares just below those of the highest ranking OECD countries. These were also the economies with the highest number of broadband connections.

However, access at home is not the only determinant of Internet use by individuals, as shown by the relatively high proportion of Internet users in the Baltic countries, Brazil and Uruguay compared to home access in these countries.

In Latin American countries and China, Internet cafés are an important location for accessing the Internet. For the Baltic countries, Internet access is most frequent at place of work or education.

In China, 113 million people aged 18 and over used the Internet in 2006, although they represented less than 12% of the adult population. China is expected to become the country with the largest population of Internet users in the near future.

For business use of ICT, most non-OECD economies for which data are available report penetration rates nearly as high as those in OECD countries. This also seems to be true for some developing countries, although the figure presented here is certainly not representative of all developing countries.

Sources

- Eurostat, New Cronos database, June 2007.
- ITU, World Telecommunication Indicators 2006 database.
- OSILAC (Observatory for the Information Society in Latin America and the Caribbean).
- UNCTAD, e-business database.
- OECD, based on national sources.

For further reading

- Partnership on Measuring ICT for Development (2005), *Core ICT Indicators*, New York/Geneva.

Measuring ICT access and use in non-OECD economies

Policy makers are very interested in ICTs as a tool for reducing poverty in developing countries. Unfortunately, statistical measures of the impact of ICTs on development are difficult to define and collect. In OECD countries, measurement in this area, beyond the supply of telecommunication infrastructure and services, is relatively new. For developing countries, limited data availability generally prevents any attempt to analyse their impact. The international community has launched an effort to increase the availability of indicators on ICT access and use in developing countries. The process was initiated at the World Summit on the Information Society (WSIS), in December 2003 in Geneva and led to the creation of the Partnership on Measuring ICT for Development in 2004. The Partnership is composed of a number of international and regional organisations that are involved in measuring ICT and aims to assist developing countries to set up a sustainable system of indicators. It has three main objectives:

i) To develop a set of core ICT indicators that can be collected by all countries and harmonised at the international level.

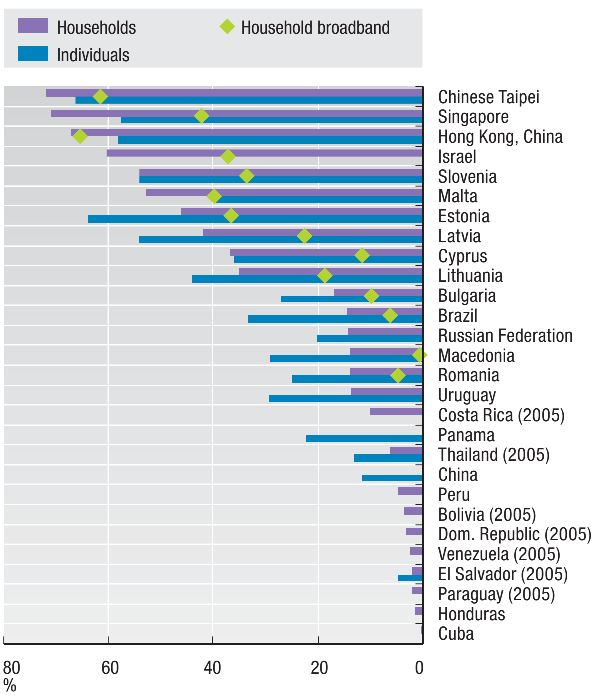
ii) To assist developing countries in building capacity to produce ICT statistics and monitor ICT developments at the national level.

iii) To develop a database of core indicators and make it available on the Internet, including links to relevant supporting information.

A list of core indicators was agreed upon and presented at the second meeting of the WSIS in Tunis in November 2005, supplemented by a methodological annex. Over time, the list – which for the moment consists of infrastructure indicators, indicators on access and use of ICT by households, individuals and businesses and indicators on the ICT sector – will be complemented by other core indicators, for example concerning ICTs in relation to government, education and health. Technical assistance will be the main focus of the Partnership for the years 2007-08.

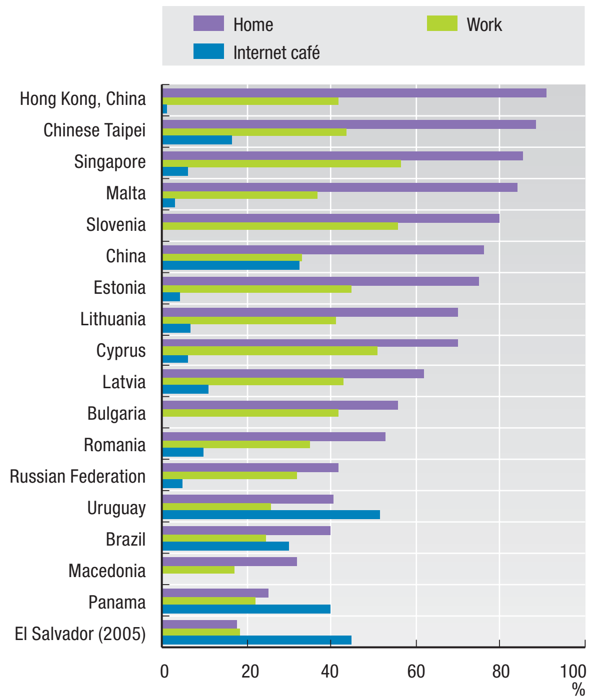
E.8. INTERNET ACCESS AND USE IN NON-OECD ECONOMIES

Proportion of households and individuals[1] accessing the Internet, 2006 (%)

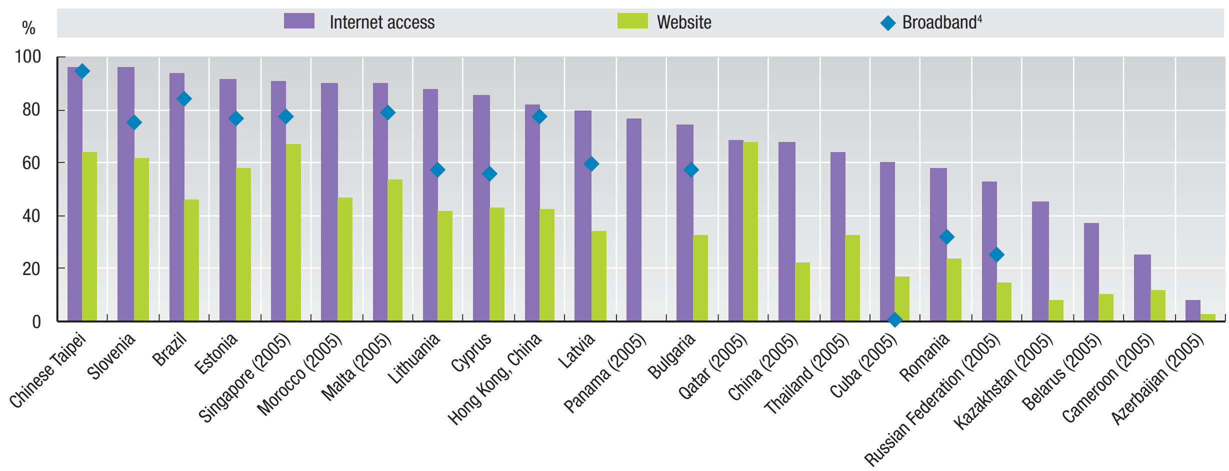


Location of Internet access of individuals,[2] 2006

As a proportion of all Internet users



Businesses[3] accessing the Internet and with a website, 2006 (%)



StatLink http://dx.doi.org/10.1787/118205636276

1. Individuals who accessed the Internet in the last twelve months, except for Brazil (at least once during lifetime) and China (people who accessed the Internet an average of at least one hour a week). Individuals aged 16-74 years, except for Uruguay (6+); Brazil and El Salvador (10+); Hong Kong (China), Panama, Singapore, Chinese Taipei and Thailand (15+); and China (18+). The numbers for individuals are the proportion of all individuals of the corresponding age group.
2. Individuals aged 16-74 years, except for China and Uruguay (6+); Brazil, Hong Kong (China) and El Salvador (10+); and Panama, Singapore and Chinese Taipei (15+). Multiple answers allowed.
3. Size cut-off: 10+ employees, except Panama (0+), Costa Rica (10-249), Chinese Taipei (20+) and China (size unknown).
4. Broadband: download speeds equal to or faster than 256 kbit/s.

E.9. VOLUME OF ELECTRONIC COMMERCE

In most European countries, the volume of Internet and other e-commerce sales transactions (including proprietary electronic data interchange – EDI) is increasing as a percentage of total turnover. In 2006, Denmark, the United Kingdom, Ireland and France reported the highest shares.

The increase in the share of e-commerce sales between 2003 and 2006 has not been dramatic in Europe, except in Denmark (10 percentage points), Norway (8), Portugal (7) and Spain (5).

Outside Europe, data on e-commerce are less comparable. However, information on growth over time is available for countries that have collected data for a number of years. Australia and Canada have Internet commerce sales data (including business-to-business [B2B] and business-to-consumer [B2C] transactions) from 1999-2000 and 2001, respectively.

The Australian Bureau of Statistics measures Australian business income on the basis of orders for goods or services received via the Internet or the web. Survey results indicate that the value of Internet income increased significantly between 2001-02 and 2004-05 (from 0.8% of total income to 2.2%). Statistics Canada's data for 2001-05 show an increase in Internet sales as a proportion of total business operating revenue from 0.3% to 1.3%.

Japan and the United States have long time series of B2C e-commerce sales data. Japanese data show increasing growth, and US retail trade data reveal steady growth in retail e-commerce sales, with a twofold increase between the last quarter of 2002 and the last quarter of 2006.

In spite of significant recent increases in Internet sales in many countries, total B2C plus B2B Internet commerce still only represents 2.2% of turnover in Australia, 1.3% in Canada and ranges from 0.01 to 17% for European countries.

Among the impediments to Internet selling, the most commonly reported barrier is that products are not suited to Internet sales. Security concerns are also important in Germany, Japan, Spain and Switzerland. Legal concerns are important in Germany and Switzerland.

Sources

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- Australian Bureau of Statistics, Business Use of Information Technology, 1999-2000 to 2004-05, cat. No. 8129.0.
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- Survey on Actual Condition and Market Size of Electronic Commerce, Ministry of Economy, Trade and Industry, Electronic Commerce Promotion Council of Japan (ECOM), NTT Data Institute of Management Consulting, Inc., 2005.
- United States Department of Commerce, Census Bureau, monthly Retail Trade Survey, www.census.gov/mrts/www/data/pdf/06Q4.pdf.

For further reading

- OECD, *Information Technology Outlook 2006*, OECD, Paris.
- OECD, *Measuring the Information Economy*, 2002, available at: *www.oecd.org/sti/measuring-infoeconomy*.
- OECD (2005), *Guide to Measuring the Information Society*, OECD, Paris.

Measuring electronic commerce: statistical challenges

In 2000, OECD member countries endorsed two definitions of electronic transactions (electronic sales and purchase orders) based on narrower and broader definitions of the communications infrastructure. According to the OECD definitions, it is the method by which the order is placed or received, not the payment or delivery channel, which determines whether or not the transaction is electronic commerce.

While efforts have been made to harmonise definitions and concepts in this area, differences among countries remain. They include whether or not information on non-Internet e-commerce is collected; whether Internet commerce includes or excludes orders placed by conventional e-mail; and the conceptual basis of e-commerce value (for instance, the treatment of sales made by agents).

In addition, a number of conceptual and measurability issues remain unresolved. They include the challenge of converging technologies, which makes it increasingly difficult to split Internet and non-Internet e-commerce; the treatment of transactions in the finance sector; and statistical issues relating to the measurement of small values and rare events (these include high standard errors and the consequent reliability of disaggregated data). These and other issues are detailed in the *Guide to Measuring the Information Society*, 2005.

Because of measurement differences, the approach taken here is, first, to make cross-country comparisons only on data sets that are reasonably comparable (*e.g.* Eurostat data on European countries) and, second, to look at longer time series from particular countries (Australia, Canada, Japan and the United States) and try to draw broad conclusions on e-commerce trends.

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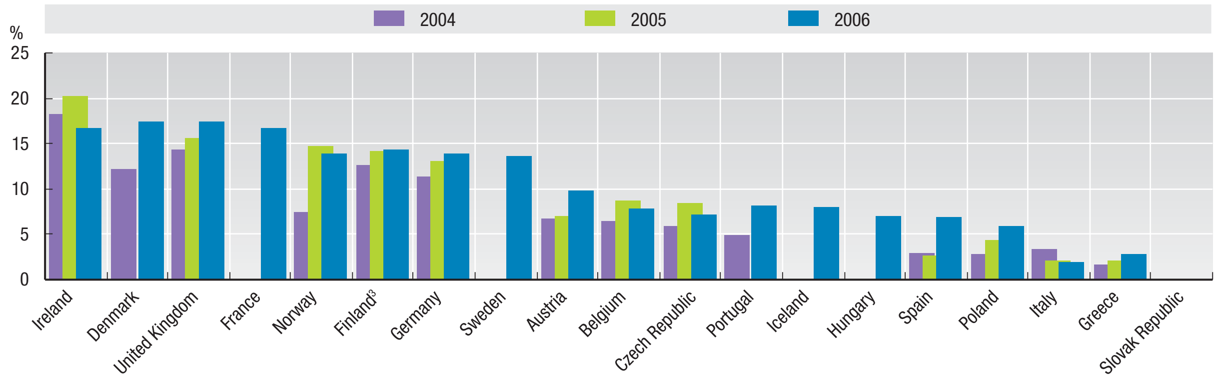
E.9. VOLUME OF ELECTRONIC COMMERCE

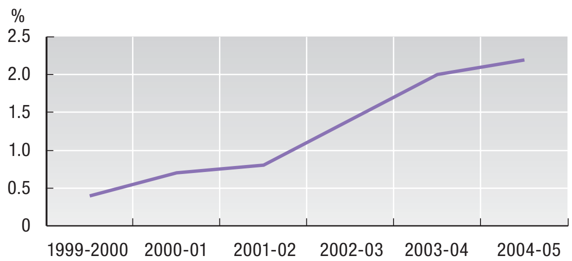
Percentage of enterprises' total turnover from e-commerce, 2004-06[1, 2]

As a percentage of total enterprise turnover



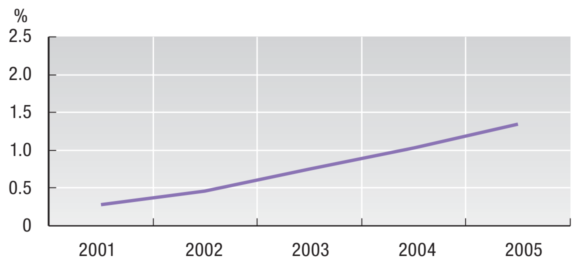
Australian business[4] income from orders received via the Internet,[5] 1999-2000 to 2004-05

Percentage of total business income



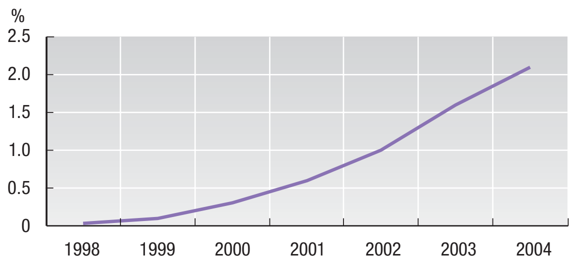
Canadian business[6] sales conducted over the Internet,[7] 2001-05

Percentage of total business operating revenue



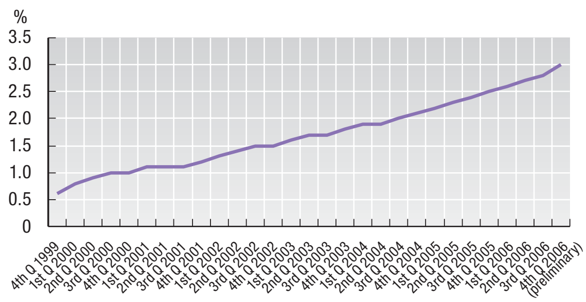
Business-to-consumer electronic commerce in Japan,[8] 1998-2004

Percentage of total B2C sales



Quarterly US e-commerce retail sales,[9, 10] 4th quarter 1999 to 4th quarter 2006

Percentage of total retail sales



StatLink http://dx.doi.org/10.1787/118238065426

1. Enterprises in the following industries are included: Manufacturing, Construction, Wholesale and retail, Hotels and restaurants, Transport, storage and communication, Real estate, renting and business activities, and Other community, social and personal service activities.
2. Total sales via the Internet or other networks during reference year, excluding VAT.
3. For 2006, networks other than Internet: only EDI.
4. Includes all employing businesses, except those in the following industries: Agriculture, forestry and fishing; Education; and Religious organisations.
5. Internet income is income resulting from orders received via the Internet or the web for goods or services, whether or not payment and/or delivery are made over the Internet. E-mail orders over the Internet are explicitly included in the estimates. From 2003-04, an Internet order was defined as a commitment to purchase goods or services over the Internet.
6. Includes all but the smallest employing businesses (whose omission is considered to have a negligible impact on the value of electronic commerce), except those in the following industries: Agriculture, fishing, hunting and trapping, and Construction – specialist contractors.
7. Sales conducted over the Internet with or without online payment. Includes orders received by e-mail, on the business's website, by EDI over the Internet and any other methods of receiving orders via the Internet. Excludes Internet sales made on the business's behalf by other organisations and Internet sales made by the business on behalf of other organisations.
8. Includes mobile e-commerce.
9. E-commerce sales are sales of goods and services for which an order is placed by the buyer or price and terms of sale are negotiated over an Internet, extranet, EDI network, electronic mail, or other online system. Payment may or may not be made on line.
10. Estimates are adjusted for seasonal variation and holiday and trading-day differences, but not for price changes.

E.10. INTERNET COMMERCE ACTIVITY

■ Use of the Internet to sell goods or services varies across industries and countries. In OECD countries, on average, over 30% of all businesses (with 10 or more employees) use the Internet for purchasing and about 17% for selling goods or services.

■ Canada, Ireland, the United Kingdom and Switzerland have the largest share of businesses purchasing via the Internet, with about half of all businesses doing so. New Zealand, the United Kingdom and Denmark have the largest share selling goods or services via the Internet (over one-third of all businesses).

■ In most OECD countries for which data are available, the real estate, renting and business activities and the wholesale and retail industries make the most use of the Internet for purchasing. The wholesale and retail, manufacturing, and transport, storage and communications industries generally make the greatest use of the Internet for selling their products.

■ Few countries report data separately for the retail industry. Australia, Canada and New Zealand report that fewer retailers than wholesalers sell and purchase over the Internet.

■ As might be expected, the construction industry uses the Internet least for Internet selling and is also a low user of Internet purchasing. However, its share is relatively high in Denmark (for selling), in Canada and Switzerland (for purchasing), and in Australia, Norway and New Zealand (for both).

■ Canada and Germany have the largest differences between the proportions of businesses selling and purchasing over the Internet. Large differences coincide with an exceptionally high use of Internet purchasing and, generally, an average level of Internet selling.

Source

- OECD, ICT database and Eurostat, Community Survey on ICT usage in enterprises, April 2007.

For further reading

- OECD, *Information Technology Outlook 2006*, OECD, Paris.
- OECD (2002), *Measuring the Information Economy*, available at: *www.oecd.org/sti/measuring-infoeconomy*.
- OECD (2005), *Guide to Measuring the Information Society*, OECD, Paris.

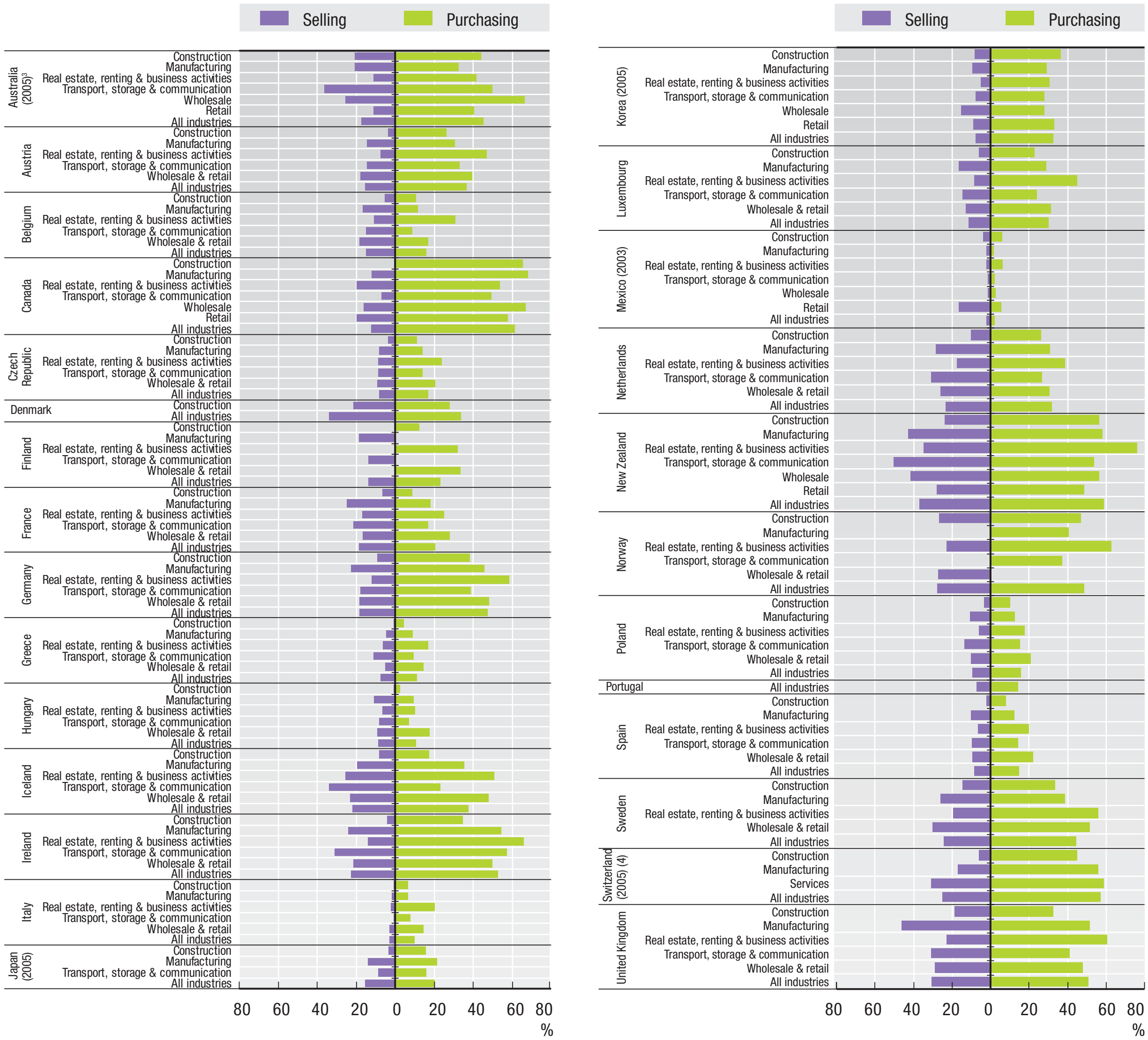
Measuring electronic commerce: OECD definitions of Internet and other electronic commerce transactions

OECD defines an Internet commerce transaction as "the sale or purchase of goods or services, whether between businesses, households, individuals, governments, and other public or private organisations, conducted over the Internet". The goods or services are ordered over the Internet, but the payment or ultimate delivery of the good or service may be conducted on or off line. The OECD suggests including: orders received or placed on any Internet application used in automated transactions such as web pages, extranets and other applications that run over the Internet (such as electronic data interchange [EDI] over the Internet), or over any other web-enabled application regardless of how the web is accessed (*e.g.* mobile phone, TV set, etc.). It suggests excluding orders received or placed by telephone, facsimile or conventional e-mail. A broader electronic commerce transaction may be conducted over any computer-mediated network (including the Internet). The OECD suggests including: orders received or placed on any online application used in automated transactions such as Internet applications, EDI over proprietary networks, Minitel or interactive telephone systems.It should be noted that differences exist in the statistical treatment of e-commerce by countries. For more information, see the notes to the figures.

E.10. INTERNET COMMERCE ACTIVITY

Internet selling and purchasing[1] by industry,[2] 2006

Percentage of businesses with 10 or more employees in each industry group



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1. The definition of Internet selling and purchasing varies between countries, with some explicitly including orders placed by conventional e-mail (*e.g.* Australia and Canada) and others explicitly excluding such orders (*e.g.* Ireland, the United Kingdom and some other European countries). Most countries explicitly use the OECD concept of Internet commerce, that is, goods or services are ordered over the Internet but payment and/or delivery may be off line.
2. All industries includes: for most European countries: Manufacturing, Construction, Wholesale and retail, Hotels and restaurants, Transport, storage and communication, Real estate, renting and business activities and Other community, social and personal service activities. For Australia, Agriculture, forestry and fishing, Education and Religious organisations are excluded. For Canada, Agriculture, fishing, hunting and trapping, and Construction – specialist contractors are excluded. For Japan, data refer to enterprises with 100 or more employees and exclude: Agriculture, forestry, fisheries and Mining. Korea includes the following industries: Agriculture and Fisheries, Light Industry, Heavy Industry, Petrochemicals, Construction, Distribution, Finance and Insurance, and Other services. For Mexico, data refer to enterprises with 50 or more employees and include: Manufacturing, Services and Construction. For New Zealand, data excludes Government administration and defence, and Personal and other services; the NZ survey also excludes businesses with fewer than 6 employees (calculated by Rolling Mean Employment) and those with turnover of less than NZD 30 000. For Switzerland, data refer to enterprises with 5 or more employees, and include the Manufacturing, Construction, Electricity/gas/water and Services industries.
3. Internet income results from orders received via the Internet or the web for goods or services, where an order is a commitment to purchase.
4. Data for Construction, Manufacturing and Services refer to the percentage of businesses using the Internet.

E.11. TELECOMMUNICATIONS PRICING

The OECD undertakes three comparisons of mobile prices for users with low, medium and high volumes. The comparison is based on the least expensive offer available in each country for a same "basket" of telecommunication services over a one-year period. In May 2007, the least expensive mobile basket for low-usage offers, measured in USD purchasing power parity (PPP), were in Denmark Sweden, Norway and Finland. Luxembourg, the Netherlands and Germany also have relatively low prices. Japan has the most expensive low-usage basket but the high prices are partially due to a lack of prepaid calling plans, which tend to be the least expensive offers in this category.

In ten OECD countries, access to low-usage baskets is offered free of charge; in these countries, however, usage charges are significantly higher. Sweden is the only country combining no fixed charges and comparatively low usage charges. The Netherlands is the only country with no usage charges for low-usage baskets.

Over the last few years, the capacity (speed) of top-range broadband offers has increased dramatically in many OECD countries while subscription costs have fallen. In some cases, Internet service providers have kept prices constant but increased broadband speeds. The lowest prices for a monthly subscription with an entry-level 256 kbit/s connection were in Sweden, Denmark and Switzerland, while Turkey and Spain registered the highest prices.

Evaluating monthly subscription ranges alone neglects the differences in prices for bandwidth. Countries can also be compared by the price per Mbit/s that users pay for connectivity.

The least expensive per Mbit/s charges are typically over fibre. Japan, Sweden, Korea and Finland have the lowest prices per Mbit/s in the OECD area. Operators in each of these countries offer broadband speeds up to 100 Mbit/s over fibre and the prices per Mbit/s are between USD 0.22 and 0.59 (PPP). France has the least expensive bandwidth over ADSL for which subscribers pay USD 0.82 (PPP) per Mbit/s.

The most expensive entry-level charges per Mbit/s are in the Turkey, Greece, Mexico, Hungary and the Czech Republic. Turkey is by far the most expensive at USD 81 (PPP) per Mbit/s.

The three residential fixed-line baskets examine the price of low, medium, high calls over a one-year period. The most expensive medium-usage baskets are in Poland, the Czech Republic and Hungary while the least expensive are in Canada and the United States. Ireland, Korea and Denmark also have relatively low prices.

The variation in prices among countries is significant as well. For instance, the price of the same basket of medium-usage calls in Poland is more than three times higher than in Canada.

Sources

- OECD, *Communications Outlook 2007*, OECD, Paris.
- OECD, Telecommunications database, May 2007.
- OECD, Reports on telecommunications policy, 2005, available at: *www.oecd.org/sti/telecom*.

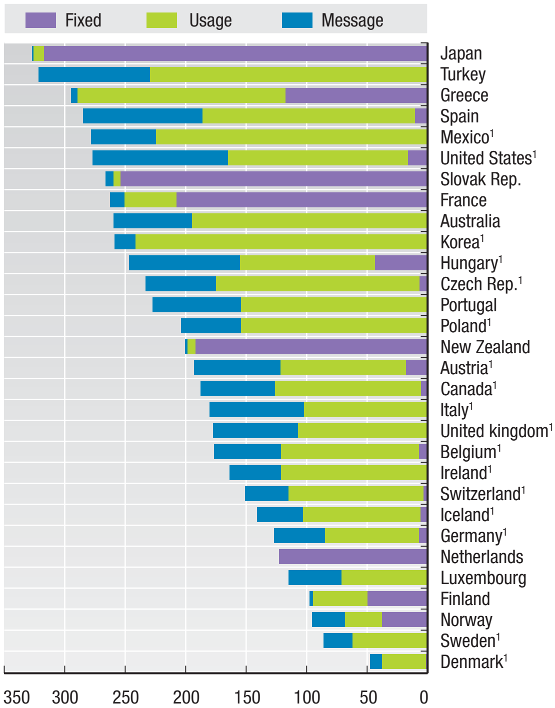
The OECD telecommunication price baskets

The OECD has eight baskets for the comparison of telecommunications prices across OECD countries, according to network and usage type. These baskets are developed with input from member countries and telecommunications operators in an effort to produce the most "representative" consumption basket for the entire OECD area.

Five of the baskets are dedicated to fixed-line telephony (business and residential use), and the other three are for mobile. The three residential fixed-line baskets examine the price of 600 (low), 1 200 (medium), or 2 400 (high) calls over a one-year period. The two business baskets are broken down into usage patterns common for small offices/ home offices (one user) and a larger consumption pattern found in small and medium-sized enterprises (assumed to have 30 employees). Finally, the three mobile baskets measure prices for users with low (360 voice calls, 396 SMS messages and 8 MMS), medium (780 calls, 600 SMS messages and 8 MMS messages) and high (1 680 voice calls, 660 SMS messages and 12 MMS) volumes.

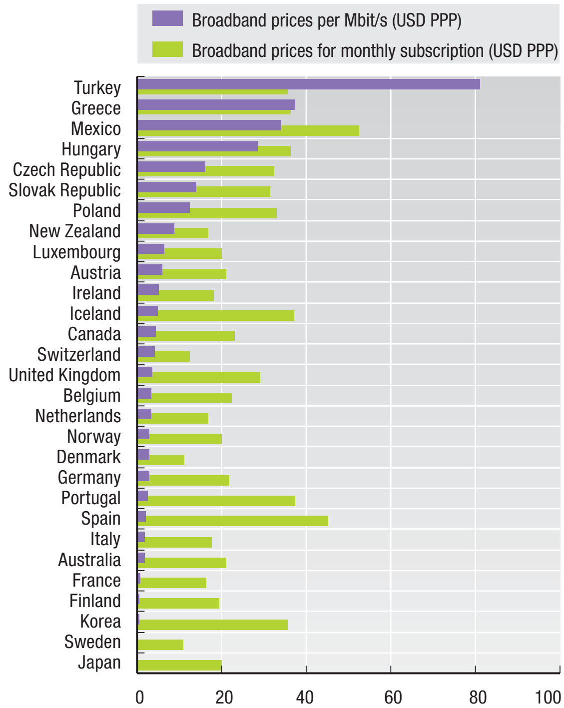
OECD basket of low user mobile telephone charges, May 2007

Annual charge, USD PPP, including tax



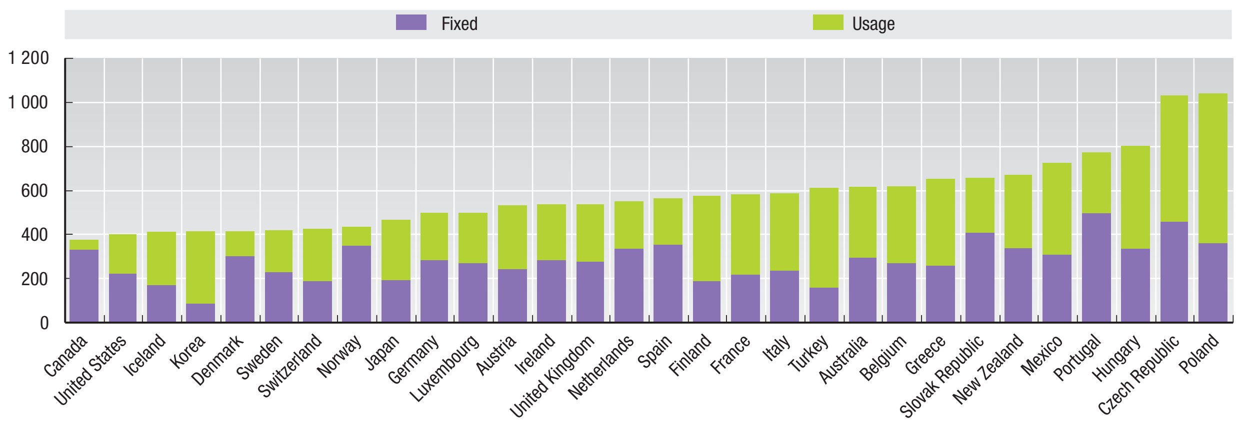
Broadband prices per Mbit/s and prices for monthly subscription[2], October 2006

Monthly charge, USD PPP, including tax



OECD Residential basket, Medium Usage, May 2007

USD PPP, VAT Included



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Notes: The OECD basket of mobile telephone charges (low usage) includes subscription and usage (360 voice calls, 396 SMS messages and 8 MMS, distributed between peak and offpeak hours and based on an average call duration) over a one-year period. Calling patterns were all determined through extensive discussions with carriers across the OECD. USD purchasing power parities (PPP) are used to aid international comparisons.

The OECD medium usage basket of residential telephone charges includes fixed access and 1 200 calls, broken down according to distance, destination (fixed, mobile and international), and time of day, over a one-year period. USD purchasing power parities (PPP) are used to aid in international comparisons. Discounts, if available, are subtracted from the usage charges.

1. Package using pre-paid card.
2. Prices selected are the lowest observed price per Mbit/s and the lowest observed price for a monthly subscription which has an entry-level 256 kbit/s connection.

E.12. OCCUPATIONS AND SKILLS IN THE INFORMATION ECONOMY

■ Two indicators have been developed to assess the use of ICTs in the economy: one for ICT specialists (producers) and one for ICT users, both basic and advanced, who rely on ICTs in carrying out their work.

■ In 2004, ICT specialists accounted for less than 5% of total employment in all countries but Switzerland. In Norway, Sweden, the Netherlands, Finland and Canada, ICT specialists accounted for over 4% of total employment. All OECD countries, except Portugal, experienced an increase in the share of ICT specialists between 1995 and 2004. The largest increase occurred in countries with a relatively large share of ICT specialists: Finland and Austria (1.3 percentage points), Canada and Denmark (1).

■ Switzerland Norway, Sweden, the Netherlands Finland and Denmark, countries with a high share of ICT specialists in employment, also have a relatively high share of ICT users. However, Luxembourg and the United Kingdom, which have the highest share of ICT users in employment, have average shares of ICT specialists. In 2004, ICT specialists and ICT users together accounted for between 17% (Greece) and 33% (Luxembourg) of total employment in OECD countries. Over 1995-2004, most countries experienced an increase in the share of broadly defined ICT-skilled employment, except Australia, Italy and the United States.

Sources

- Eurostat, EU Labour Force Survey, 2004.
- US Bureau of Labor Statistics, Current population survey, 2003, available at: *www.bls.census.gov/cps*.
- Statistics Canada.
- Australian Bureau of Statistics.
- Korean Work Information Center, Human Resource Development Service.
- Japanese Ministry of Public Management, Home Affairs, Post and Telecommunications, Statistics Bureau.

For further reading

- OECD, *Information Technology Outlook 2006*, OECD, Paris.
- Van Welsum, D., and G. Vickery (2005), "New perspectives on ICT skills and employment", *Information Economy Working Paper*, www.oecd.org/dataoecd/26/35/34769393.pdf.

ICT-related skills

There is currently no commonly adopted definition of ICT skills and there is no internationally agreed list of ICT-related occupations. Skills are difficult to measure, and proxies are often used to capture observable characteristics such as educational attainment, on the supply side, and occupations, on the demand side. In an effort to capture not only ICT specialists, but also intensive users of ICTs, at various levels of skill complexity, the indicators in this section are based on the following three definitions:

1. *ICT specialists,* who have the capabilities to develop, operate and maintain ICT systems. ICTs constitute the main part of their job.
2. *Advanced users*: competent users of advanced, and often sector-specific software tools. ICTs are not their main job but a tool.
3. Basic *users*: competent users of generic tools (*e.g.* Word, Excel, Outlook, PowerPoint) needed for the information society, e-government and working life. Here too, ICTs are a tool, not the main job.

Thus, the first category covers those who supply the ICT tools, and the second and third categories include those who use them intensively in order to do their job. In this section, the first category corresponds to the narrow measure of ICT-skilled employment, and the sum of all three categories to the broad measure of ICT-skilled employment.

Data for EU countries are based on ISCO 88 (the International Standard Classification of Occupations), but data for the non-EU countries are based on national classification systems. The classification and the selection of occupations were not harmonised internationally as there are no official cross-classifications. Moreover, national classifications have more detail. The same logic and rationale were applied to each of the national classification systems to identify the occupations to be included in the narrow and broad definition of ICT-skilled employment. This means, however, that the level of the indicators is not directly comparable across countries. Furthermore, there may be differences in ICT usage in occupations, both within and between countries, even when they are based on the same classification. For Europe, data from the European Labour Force Survey are based on three-digit ISCO 88. US data on employment by occupation are from the US Current Population Survey (CPS). However, as the 1990 Census Occupational Classification was replaced by one derived from the US Standard Occupational Classification (SOC) in January 2003, the 2003 data were estimated. Statistics Canada provided the Labour Force data for Canada based on SOC 91-Canada. The data for Australia are based on four-digit ASCO (Australian Standard Classification of Occupations) provided by the Australian Bureau of Statistics. Data for Korea are provided by the Human Resource Development Services of the Korean Work Information Center, and are based on a new classification system, which is being revised. Finally, the Labour Force Survey data for Japan were provided by the Statistics Bureau of the Japanese Ministry of Public Management, Home Affairs, Post and Telecommunications. These data only distinguish a small number of occupations relative to the detail available in the occupational classifications of other countries.

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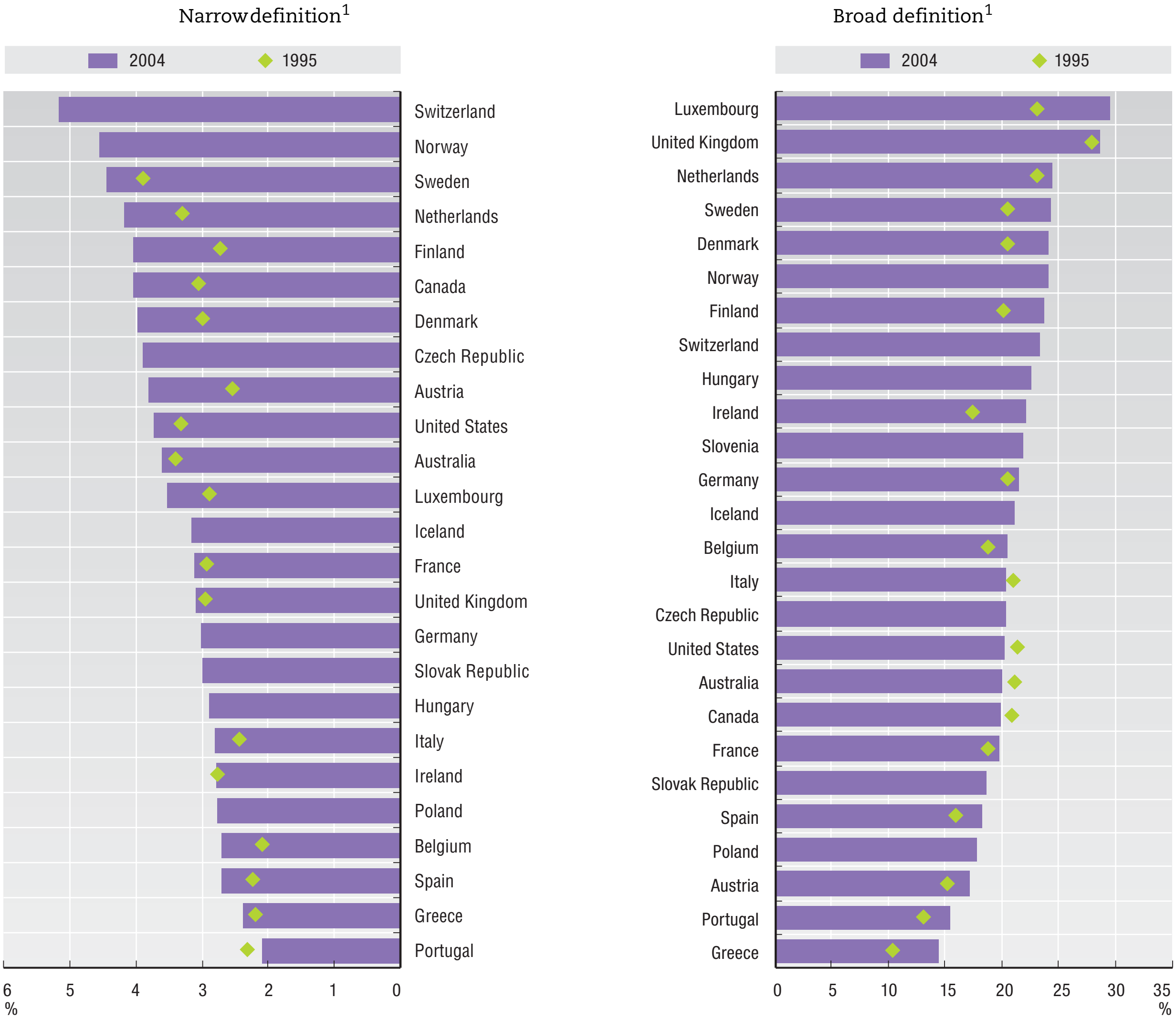
E.12. OCCUPATIONS AND SKILLS IN THE INFORMATION ECONOMY

Share of ICT-related occupations in the total economy, 1995 and 2004[2]

Narrow and broad definitions,[1] percentages



StatLink http://dx.doi.org/10.1787/118267362457

1. Narrow and broad definitions based on methodology developed in chapter 6 of the *Information Technology Outlook 2004*. See also D. van Welsum and G. Vickery (2005), "New perspectives on ICT skills and employment", Information Economy Working Paper DSTI/ICCP/IE(2004)10/FINAL, OECD. Calculations based on EULFS, US Current Population Survey, Statistics Canada, Australian Bureau of Statistics, the Korean Work Information Center, Human Resource Development Service, Japanese Ministry of Public Management, Home Affairs, Post and Telecommunications, Statistics Bureau.
2. Except: Australia, Finland and Sweden 1997 instead of 1995; Portugal 1998 instead of 1995; Ireland 1999 instead of 1995; Austria, Canada 2003 instead of 2004.

E.13a. INTERNATIONAL TRADE IN ICT GOODS

■ During the 1990s, ICT trade grew much more rapidly than total goods trade. In 2000, ICT trade grew by more than 20% compared with less than 10% for total goods. After 2000, trade in ICT was markedly affected by the downturn following the "dotcom" financial bubble, falling by 13% in 2001 and 3.6% in 2002.

■ Trade in the ICT sector picked up in 2003 (9.1%), growth accelerated in 2004 (19.3%), but then slowed in 2005 (7.3%).

■ In 2005, the share of ICT trade in total goods trade for the OECD area was just over 13%, a value very close to the level in 1996. Between 2003 and 2005, the share of ICT trade decreased in 18 OECD countries, particularly Korea (–3.3 percentage points), Japan (–1.8), Hungary (–1.6) and Ireland (–1.4).

■ ICT manufacturing plays a particularly important role in Korea (25% of manufacturing trade in 2005), Ireland and Hungary (23%), the Netherlands (21%), Mexico (20%), Finland (19) and Japan (18%).

■ Only nine countries showed a positive ICT trade balance in 2005. The surplus was highest in Korea, Finland, Hungary and Japan. The main source of surplus in Finland and Sweden is trade in telecommunications equipment; in Ireland, it is trade in computers. In 2005, Australia, New Zealand and Norway recorded the largest deficits in ICT trade.

Sources

- OECD, International Trade by Commodity Statistics (ITCS) and Structural Analysis (STAN) databases, May 2007.

For further reading

- OECD, *Communications Outlook 2007*, OECD, Paris.
- OECD, *Information Technology Outlook 2006*, OECD, Paris.

Measuring ICT sector trade

In the absence of tables of international trade in goods and services by detailed industrial activity that are compatible with the national accounts, ICT sector exports and imports at current prices have been estimated using the OECD's International Trade by Commodity Statistics (ITCS) database. The OECD definition of the ICT manufacturing sector, based on ISIC Rev. 3, has been used as the basis for the ICT trade indicators. Exports and imports for this sector in current prices have been derived from the product-based data in the ITCS database by applying the Harmonised System Rev. 1 (HS1) to the ISIC Rev. 3 conversion key. Thus, the trade indicators constructed here reflect trade in goods for which the ICT manufacturing sector can be considered the origin (exports) or the destination (imports) according to the UN standard conversion table. This type of aggregation, as well as the use of a single conversion key for all OECD countries, means that the figures reported here are not strictly comparable with those published in the national accounts.

Data on selected ICT services (telecommunications and computer and related services) are instead estimated within a Balance of Payments (BPM 5) framework and, as a general rule, cannot be compared to data on trade in ICT goods based on customs returns and related surveys. It is therefore not possible to calculate indicators of overall trade in ICT goods and services.

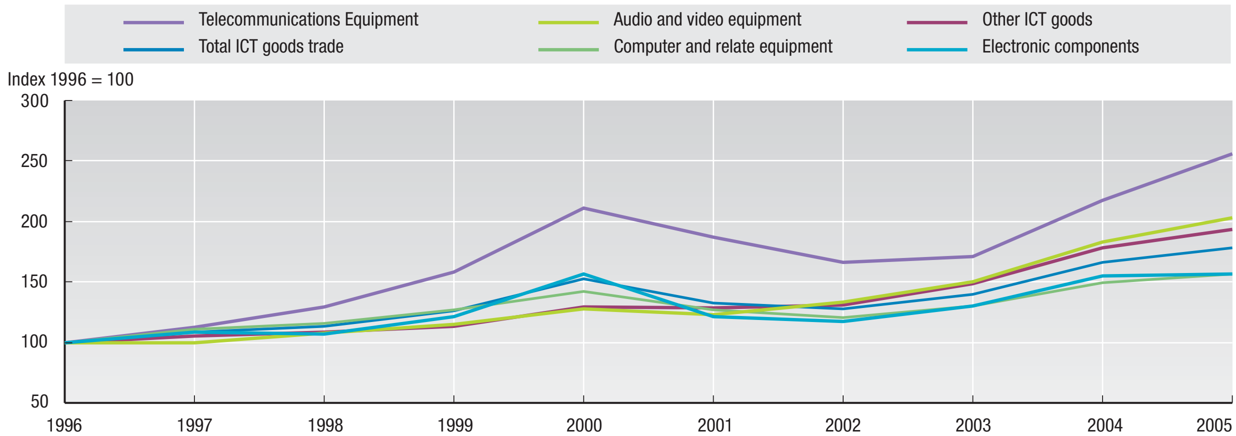
Finally, individual countries' data for both imports and exports include imported goods that are subsequently re-exported. Imports and subsequent re-exports may be in the same or in different reference periods. In the latter case, both the indicators of countries' relative trade performance and the indicators of their trade balances may be affected.

The ICT sector trade balance is calculated as ICT exports minus ICT imports divided by total manufacturing trade (the average of exports and imports).

E.13a. INTERNATIONAL TRADE IN ICT GOODS

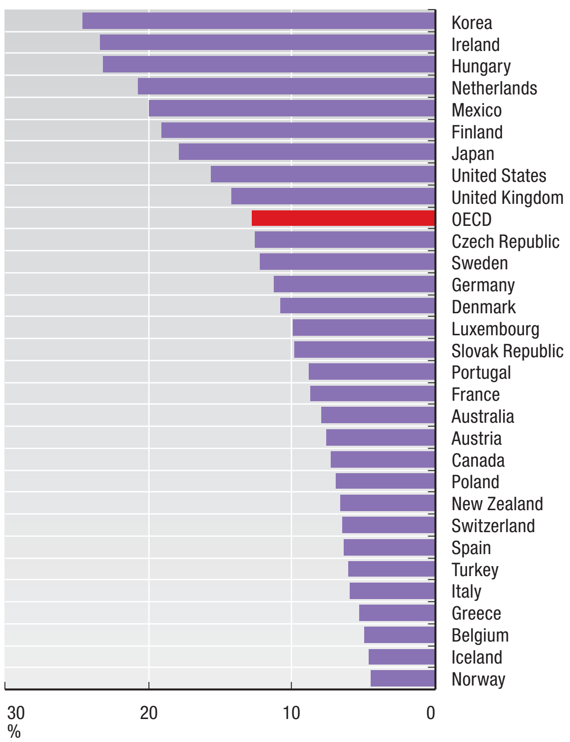
ICT goods trade in the OECD area, 1996-2005

By categories, index: 1996=100



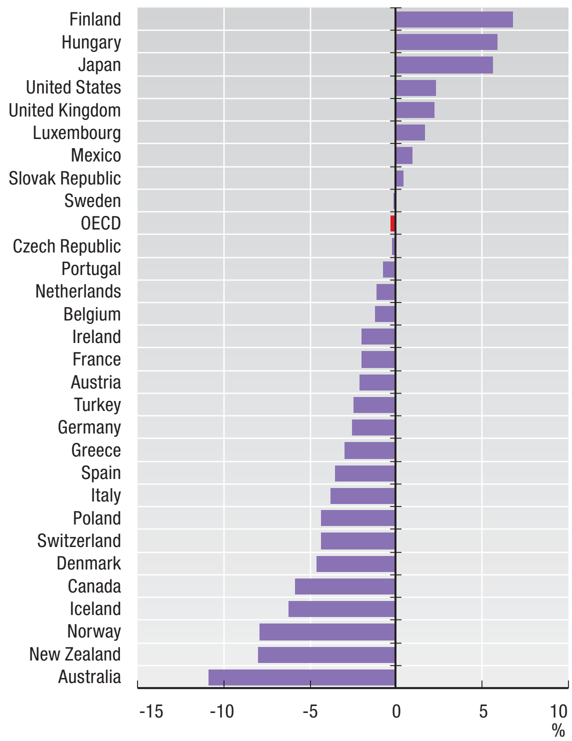
ICT goods trade, 2005

Share of total goods trade



ICT goods trade balance, 2005

Share of total goods trade



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E.13b. INTERNATIONAL TRADE IN ICT GOODS IN NON-OECD ECONOMIES

■ After increasing from 14.5% in 1996 to a peak of 17.9% in 2000, international trade in ICT goods as a share of total trade slowly declined to 15.2% in 2005.

■ During this period, a substantial share of the production of ICT goods in OECD countries moved to non-OECD economies, and the share of non-OECD economies in ICT goods trade rose from 31% in 1996 to 42% in 2005.

■ Asian economies, many of them non-OECD, are the main exporters of ICT goods, together with the United States and Germany. Some, such as China and Chinese Taipei, produce these goods, while others mainly act as gateways for trade to other countries. For Hong Kong (China), for example, re-exports accounted for more than 97% of exports in 2006.

■ China has become the leading exporter of ICT goods, accounting for 15.5% of the world total in 2005, up from only 2.5% in 1996. Although many (OECD and non-OECD) economies have also been affected, its rise has mainly come at the expense of Japan and the United States, which saw their shares decline to a combined 18.2% in 2005, down from 30.5% in 1996.

■ When trade figures are broken down by type of good, China appears predominantly as an assembler of ICT equipment that imports the electronic components for the audio, video, computer and telecommunication equipment it produces. The figures show that imports of electronic components in China increased in equal measure to exports of ICT equipment, with both rising from 4% of the world total in 1996 to more than 20% in 2005.

■ In terms of its trading partners (treating China and Hong Kong, China, as one country, see box), China appears to have become the regional hub for the production of ICT goods: 82% of imports of ICT goods in 2006 came from Chinese Taipei, Japan, Korea, Malaysia, Singapore, the Philippines and Thailand. In many cases, this is the result of foreign multinationals setting up shop in China. This holds particularly for Chinese Taipei, which accounted for 20% of Chinese imports of ICT goods in 2006.

■ Most exports of ICT goods go to the developed OECD economies. Slightly more than half of all exports of ICT goods in 2006 went to the United States, Japan, Germany and the Netherlands, with the United States alone accounting for 30% of all exports.

Sources

- OECD, International Trade by Commodities Statistics database, June 2007.
- UN COMTRADE database, June 2007.

For further reading

- OECD (2005), *Guide to Measuring the Information Society*, OECD, Paris, available at: www.oecd.org/dataoecd/41/12/36177203.pdf.

Measuring international trade in ICT goods in non-OECD economies

ICT goods have been expressed in terms of the Harmonized System (HS) classification 1996. However, data are not available for all economies according to the HS 1996 classification, in particular for the years 1996-99. Therefore, for these years, trade in ICT goods and total trade are estimated using the HS 1992 classification. Since there is a 98% overlap between the ICT goods classification for HS 1992 and for HS 1996, the margin of error is expected to be minimal.

ICT goods can be classified into five broad categories: telecommunications equipment, computer and related equipment, electronic components, audio and video equipment and other ICT goods. The category "Other ICT goods" is somewhat problematic, and makes the ICT goods classification a rather broad one. Most of the goods in this category are likely to be removed from a revised ICT goods classification (to be based on the Central Product Classification [CPC] Version 2). In the figure showing Chinese trade in ICT goods by category, the category "Other ICT goods" is ignored, while the categories of telecommunications equipment, computer and related equipment and audio and video equipment have been aggregated into one category, entitled "equipment".

A substantial amount of trade takes place between China and Hong Kong (China), owing to the latter's role as a transhipment port. In order to give a more realistic picture of the "real" origin of imports and destination of exports, the figure showing China's trading partners treats China and Hong Kong (China) as one country, with trade flows between the two economies netted out.

More details on the classification of ICT goods can be found in E.13.

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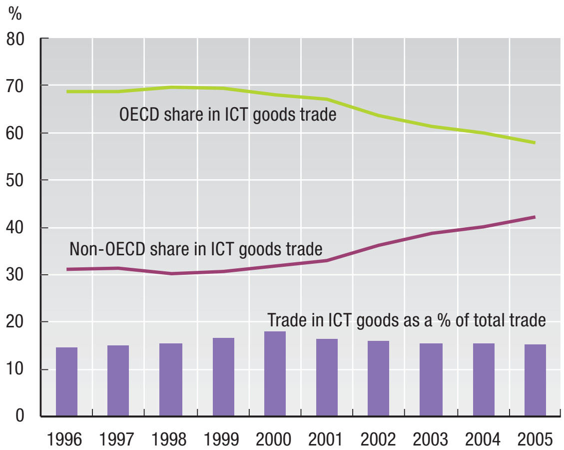
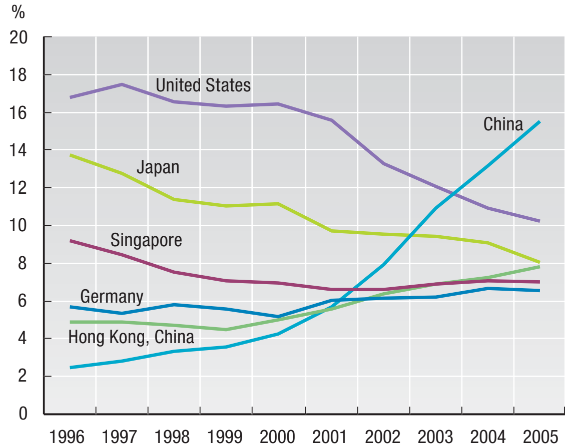
E.13b. INTERNATIONAL TRADE IN ICT GOODS IN NON-OECD ECONOMIES

Trade in ICT goods[1]



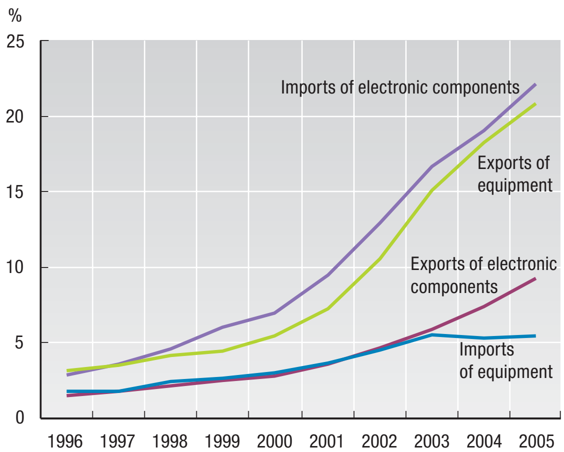
Top exporting economies of ICT goods

As a % of world total



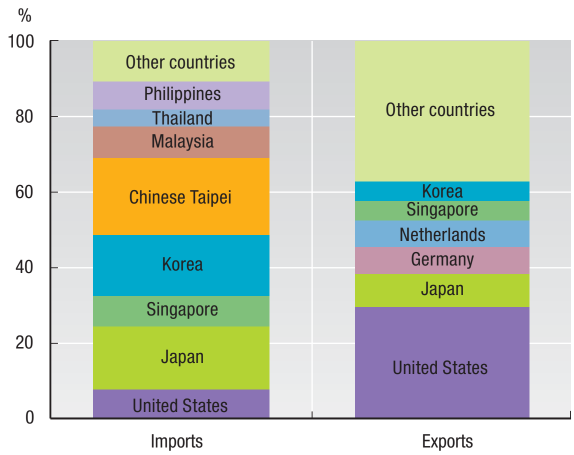
Chinese trade in ICT goods by category[2]

As a % of total trade in ICT goods



Chinese trade in ICT goods by partner economy,[3] 2006

As a % of total Chinese trade in ICT goods



StatLink http://dx.doi.org/10.1787/118323318240

1. Average of imports and exports.
2. Equipment = audio, video, computer and telecommunication equipment; other ICT goods are not reported in the figure (see box).
3. China and Hong Kong (China) treated as one country, with intra-China-Hong Kong (China) trade netted out (see box).

E.14. R&D IN SELECTED ICT INDUSTRIES

■ The highly innovative ICT sector invests heavily in R&D. In 2004, ICT manufacturing industries accounted for more than a quarter of total manufacturing business R&D expenditure in most OECD countries. It accounted for more than half in Finland, and Korea (63 and 57%, respectively), and more than 30% in the United States (39%), Canada (38%) and Ireland (34%).

■ In countries with data for both manufacturing and services industries, expenditure on R&D generally expanded in ICT-related service industries but contracted in ICT-related manufacturing industries. However, investment in R&D still accounted for a small share of GDP in both sectors (less than 1.3% in the former and less than 0.2% in the latter). Only Norway and Sweden reported a decrease in R&D investment as a share of GDP in ICT-related service industries in 2004.

■ The ratio of R&D expenditure to GDP or to total business enterprise R&D can be a sign of R&D specialisation. Finland is clearly more specialised than large countries in both ICT manufacturing and services. In 2004, it allocated 1.3% of GDP to ICT-related manufacturing R&D, compared to 0.79% in 1997.

Source

- OECD, ANBERD database, June 2007.

For further reading:

- OECD (2006), *Research and Development Expenditure in Industry 1987-2004*, OECD, Paris, available at: *www.oecd.org/sti/anberd*.

Measuring ICT R&D expenditure

The OECD definition of the ICT sector is largely based on the four-digit level of ISIC Rev. 3.1; however, data on R&D expenditure at this level are often not available. Therefore, the ICT R&D indicators reported here are calculated at the two-digit level for selected ICT industries and include the following ISIC Rev. 3 divisions:

- *Manufacturing industries:* 30 (Office, accounting and computing machinery); 32 (Manufacture of radio, television and communication equipment apparatus); and 33 (Manufacture of medical, precision and optical instruments, watches and clocks).
- *Services industries:* 64 (Post and communications); and 72 (Computer and related activities). Data on R&D in services suffer from two major weaknesses. In certain countries, R&D surveys cover services industries only partially. Also, the definition of R&D is better suited to manufacturing industries than to services industries.

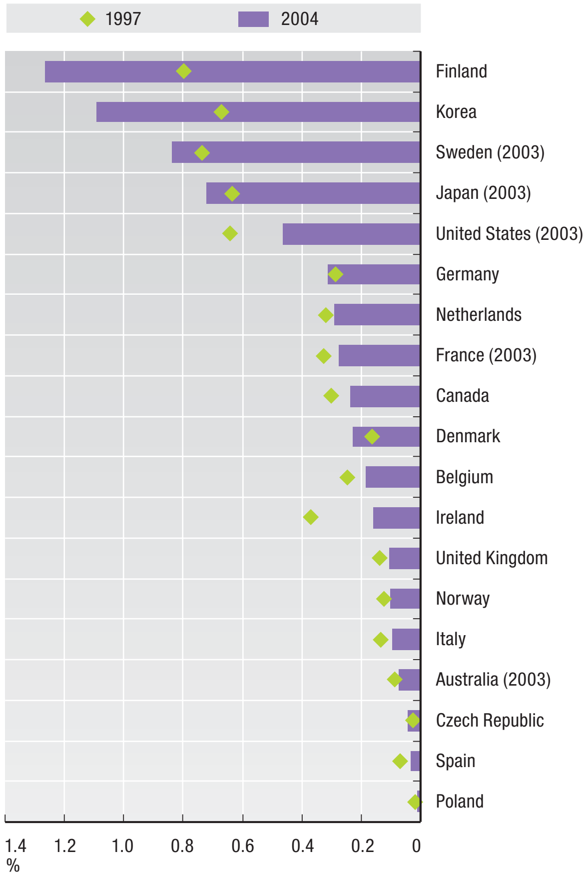
Data for R&D expenditure for selected ICT industries are from OECD's Analytical Business Enterprise R&D Expenditure (ANBERD) database, the basis of which is more closely related to product field than to enterprise level. ANBERD data are estimated by the OECD on the basis of official business enterprise R&D data (OFFBERD) and may differ significantly from official data (see A.7).

These data refer to R&D performed by the ICT sector and might underestimate significantly total ICT R&D given that much of this R&D may be performed in other industries (for example, software R&D). Figures should also be compared with caution owing to differences in how countries classify R&D by industry (see A.7): countries which follow a "product group" approach (instead of principal economic activity) will therefore have more accurate estimates of "true" ICT R&D.

E.14. R&D IN SELECTED ICT INDUSTRIES

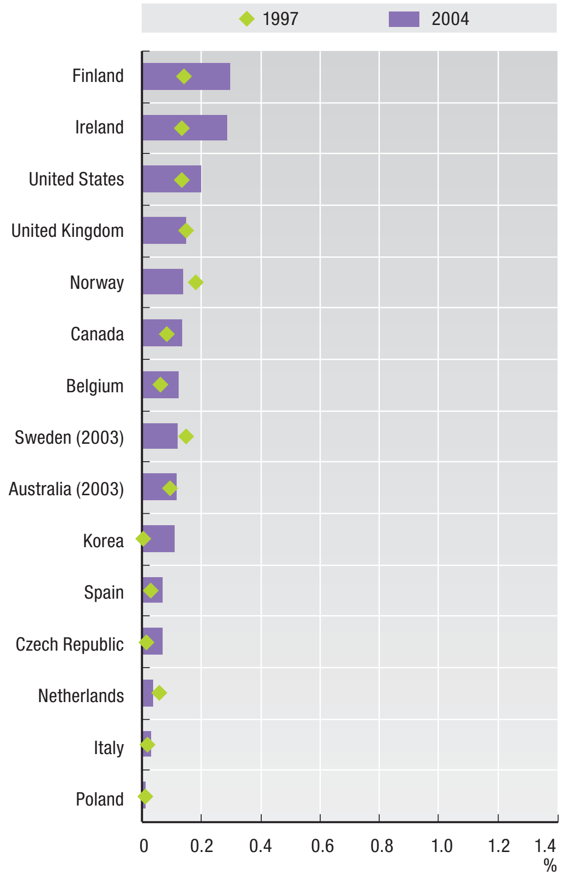
Business R&D expenditure by selected ICT manufacturing industries, 1997 and 2004

As a percentage of GDP



Business R&D expenditure by selected ICT services industries, 1997 and 2004[1]

As a percentage of GDP



1. Owing to unavailability of R&D for class 642 (Telecommunications), division 64 (Post and telecommunications) is used as a proxy. Available information shows that in the United States, class 642 accounts for 97-98 % of the R&D in division 64.

StatLink http://dx.doi.org/10.1787/118336706313

E.15. ICT-RELATED PATENTS

The number of ICT-related patents grew steadily from the mid-1990s to 2004 when some 43 000 international patents applications were filed under the Patent Co-operation Treaty (PCT) for an average increase of 3% a year over 2000-04, compared to 4.6% for all PCT filings. The number of ICT-related patents grew strongly in China and in Korea, with more than 1 078 and 1 758 international patents, respectively, in 2004.

The United States (33.3%), Japan (17.1%) and Germany (12.2%) lead in ICT-related patenting under the PCT. China, Finland, Japan, Korea, the Netherlands and the United States have a large concentration of ICT-related patents in their patent portfolio, and their country shares in ICT-related patents are higher than in total patents.

The number of ICT-related patents increased more rapidly than the total number of patents filed under the PCT procedure: the share of ICT patents in total patents rose in almost all countries from the late 1990s to the beginning of the 2000s. Over 2002-04, more than 50% of patents were related to ICT in Singapore, Finland and the Netherlands. ICT-related patents represent on average 34.6% of total PCT filings. The proportion of ICT patents more than doubled in China, up from 17.3% in 1996-98 to 43.4% in 2002-04.

Source

- OECD, Patent database, April 2007, available at: *www.oecd.org/sti/ipr-statistics.*

Definition of ICT patents

Within a patent document, several sections can be analysed in order to connect the patent to the relevant technology: the International Patent Classification system (IPC) and the national patent classification system; the title of the invention; the abstract describing the invention and the list of claims. One or several classification codes are attributed during the patent examination process. However, for emerging technologies, a specific category or class might not yet be incorporated in the patent classification systems, which makes it difficult to identify patents related to these technologies afterwards. Therefore, to select patents related to specific technological domains, one can either look at the IPC classes and subclasses, and/or search for appropriate keywords within the text fields of the patent document. Such a method might exclude, or include, patents that are, or are not, relevant for a specific domain, but it makes it possible nonetheless to provide a relatively good picture of innovative activity in the technology field.

The 8th edition of IPC is used to identify patents in the ICT or biotechnology sectors. This definition remains provisional, as such fields evolve rapidly.

Patents in the ICT sector can be split into four fields, based on selected IPC classes:

- **Telecommunications**
  [G01S,G08C,G09C,H01P,H01Q,H01S3/(025,043,063,067,085,0933,0941,103,133,18,19,25), H1S5,H03B,H03C,H03D, H03H,H03M,H04B,H04J,H04K,H04L,H04M,H04Q]
- **Consumer electronics**
  [G11B,H03F,H03G,H03J,H04H,H04N,H04R,H04S]
- **Computers, office machinery**
  [B07C,B41J,B41K,G02F,G03G,G05F,G06,G07,G09G,G10L,G11C,H03K,H03L]
- **Other ICT**
  [G01B,G01C,G01D,G01F,G01G,G01H,G01J,G01K,G01L,G01M,G01N,G01P,G01R,G01V,G01W,G02B6, G05B,G08G,G09B,H01B11,H01J(11/,13/,15/,17/,19/,21/,23/,25/,27/,29/,31/,33/,40/,41/,43/,45/),H01L]

For further details on the IPC classes (IPC, 8th edition, 2006): *www.wipo.int/classifications/ipc/ipc8.*

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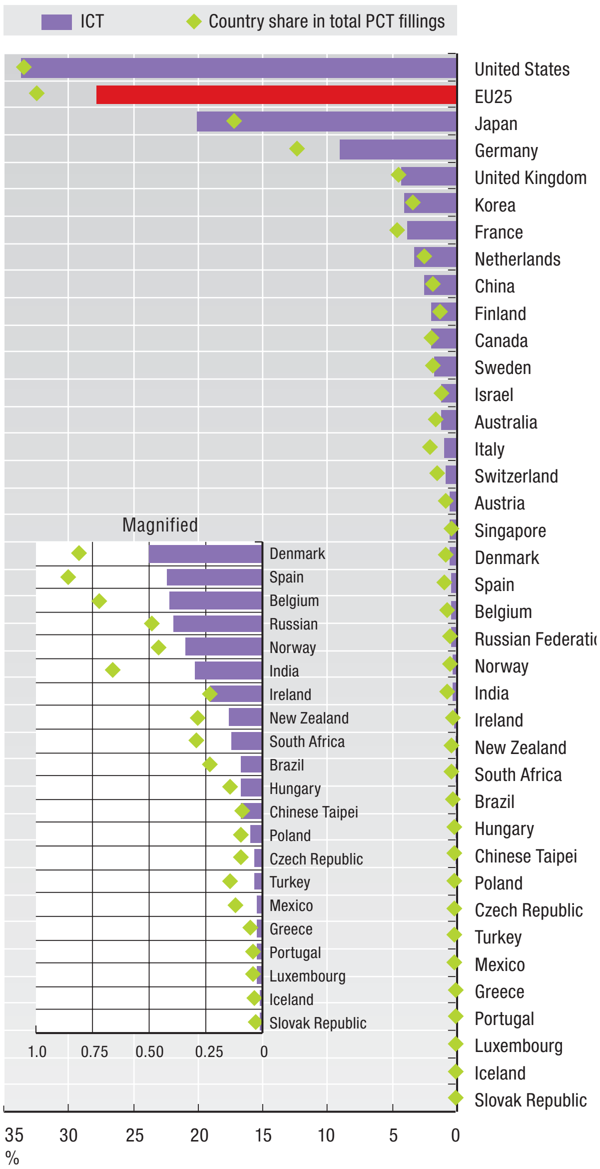
E.15. ICT-RELATED PATENTS

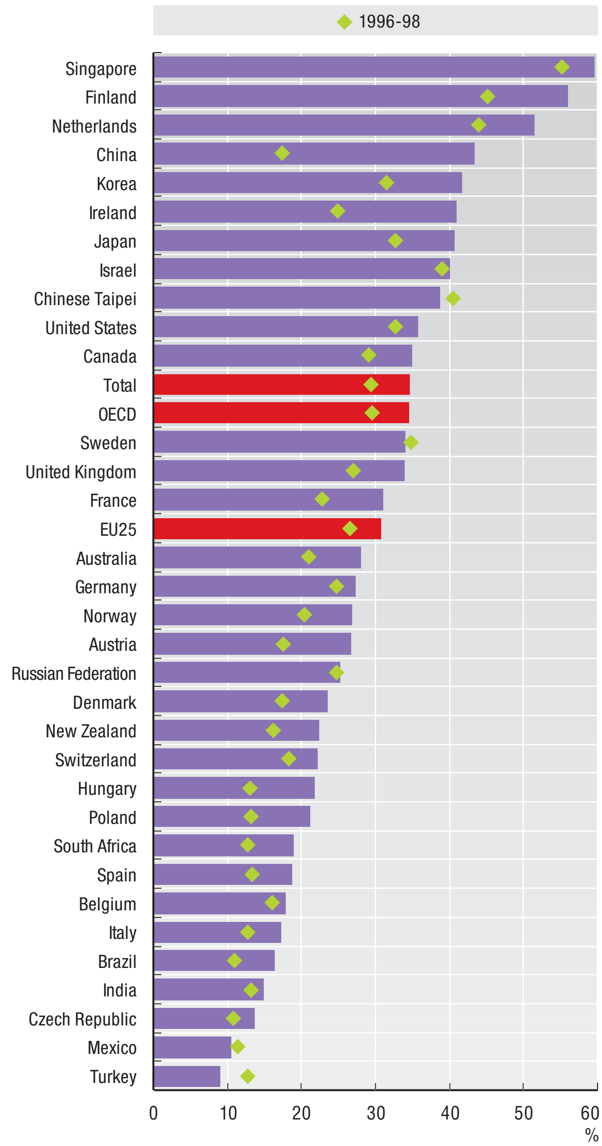
Share of countries in ICT-related patents filed under the PCT[1]

2004



ICT-related patents as a percentage of national total[2] (PCT filings),[1]

2002-04



StatLink http://dx.doi.org/10.1787/118343055453

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

1. Patent applications filed under the Patent Co-operation Treaty, at international phase, designating the European Patent Office.
2. Only countries with more than 250 PCT filings during 2002-04 are included in the graph.

F. PARTICULAR TECHNOLOGIES

F.1. BIOTECHNOLOGY FIRMS

■ The number of biotechnology firms is the most widely available indicator, although it is not the best measure of a country's biotechnology effort, owing to large differences in the size of individual firms.

■ Results can be broken down between "dedicated" biotechnology firms and "biotechnology-active" firms. The former are defined as firms whose predominant activity involves the application of biotechnology techniques to produce goods or services and/or the performance of biotechnology R&D. The latter are defined as firms engaged in key biotechnology activities such as the application of at least one biotechnology technique to produce goods or services and/or the performance of biotechnology R&D.

■ Countries that collect biotechnology statistics through their R&D surveys (see Annex 1) may underestimate the number of biotechnology firms, as firms that use biotechnology but do not perform biotechnology R&D are excluded.

■ The share of dedicated biotechnology firms in all biotechnology-active firms is available for ten countries. It ranges from a low of 37% (Spain) to a high of 89% (Germany), with an average of 70%. These results indicate that the number of biotechnology firms will be underestimated in countries, such as Poland, with data only for dedicated biotechnology firms.

■ The United States has the largest number of biotechnology firms (2 196), followed by Japan (804) and France (755). The European Union, estimated by using non-official data where necessary, has an estimated total of 3 154 biotechnology firms.

■ Comparable data on the number of biotechnology firms with fewer than 50 employees are available for ten countries, in all of which the majority of biotechnology firms have fewer than 50 employees. The percentage is over 85% in South Africa, Israel and Germany.

■ Five countries provide data on the number of biotechnology-active large firms with over 500 employees. The share of large firms in all biotechnology-active firms is 1% in Germany, 6% in the United States, 7% in Belgium and France, and 11% in Korea.

Source

- OECD (2006), *OECD Biotechnology Statistics 2006*, OECD. Paris, available at: www.oecd.org/dataoecd/51/59/36760212.pdf.

For further reading

- OECD (2005), *A Framework for Biotechnology Statistics*, OECD, Paris. Available at: www.oecd.org/dataoecd/5/48/34935605.pdf.

Defining biotechnology for statistical purposes

The OECD has developed both a single definition and a list-based definition (see below) of biotechnology. The single definition of biotechnology is deliberately broad. It covers all modern biotechnology but also many traditional or borderline activities. For this reason, the single definition should **always** be accompanied by the list-based definition. The single definition is:

The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services.

The OECD list-based definition of biotechnology includes seven categories, and respondents are usually given a write-in option for new biotechnologies that do not fit any of the categories. A firm that reports activity in one or more of the categories is defined as a biotechnology firm. The seven categories include:

DNA/RNA: Genomics, pharmacogenomics, gene probes, genetic engineering, DNA/RNA sequencing/synthesis/amplification, gene expression profiling, and use of antisense technology.

Proteins and other molecules: Sequencing/synthesis/engineering of proteins and peptides (including large molecule hormones); improved delivery methods for large molecule drugs; proteomics, protein isolation and purification, signaling, identification of cell receptors.

Cell and tissue culture and engineering: Cell/tissue culture, tissue engineering (including tissue scaffolds and biomedical engineering), cellular fusion, vaccine/immune stimulants, embryo manipulation.

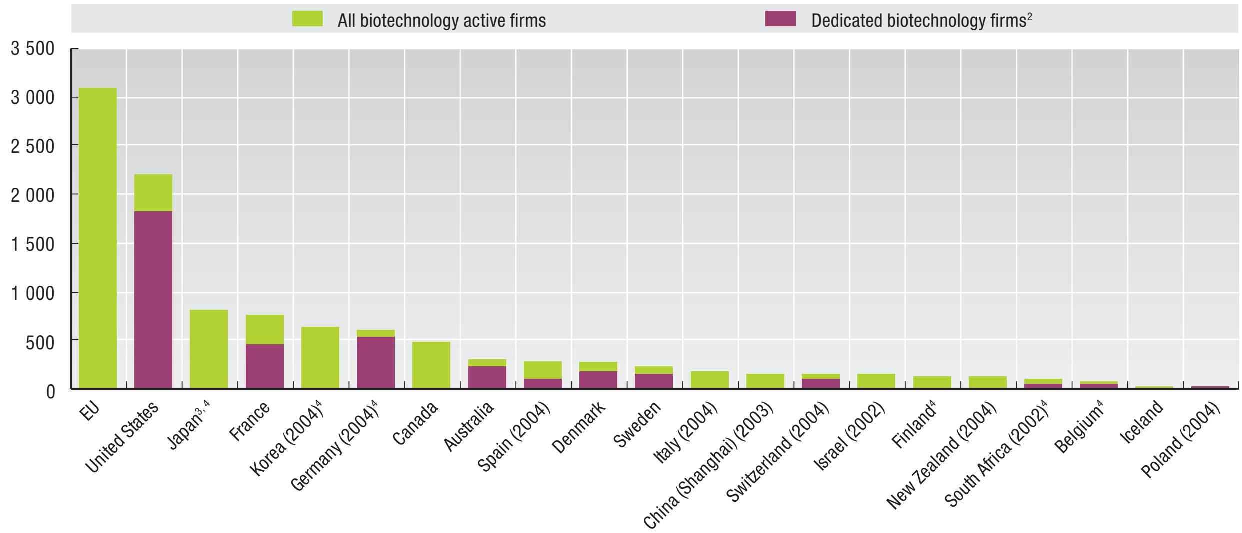
Process biotechnology techniques: Fermentation using bioreactors, bioprocessing, bioleaching, biopulping, biobleaching, biodesulphurisation, bioremediation, biofiltration and phytoremediation.

Gene and RNA vectors: Gene therapy, viral vectors.

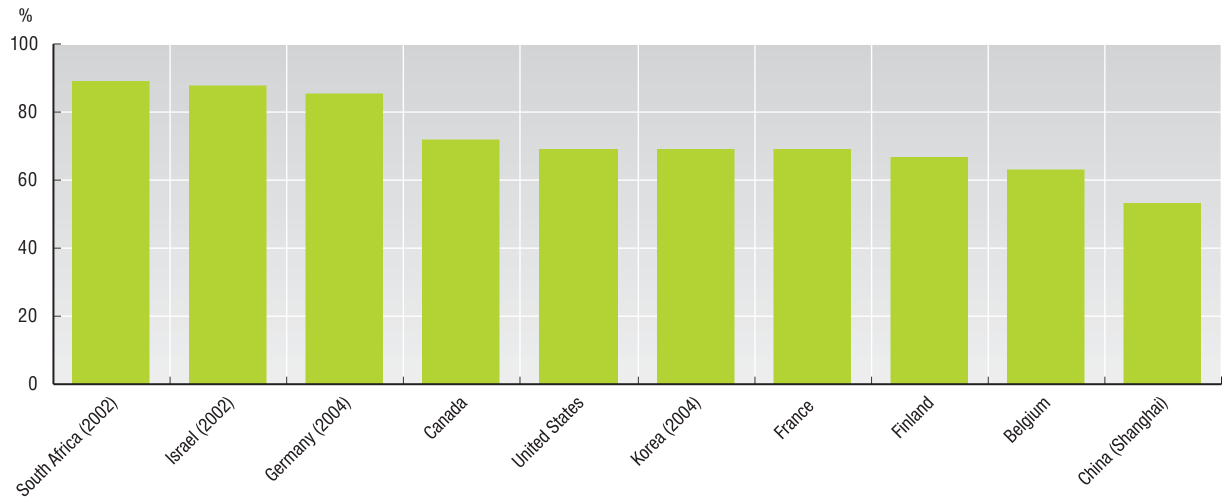
Bioinformatics: Construction of databases on genomes, protein sequences; modelling complex biological processes, including systems biology.

Nanobiotechnology: Applies the tools and processes of nano/microfabrication to build devices for studying biosystems and applications in drug delivery, diagnostics, etc.

Number of firms active in biotechnology,[1] 2003



Share of biotechnology firms with fewer than 50 employees, 2003



StatLink http://dx.doi.org/10.1787/118371276250

1. Excludes firms that only supply biotechnology equipment. In most countries biotechnology firms are defined as innovative, having either performed R&D or introduced a new biotechnology product or process onto the market in the previous two or three years.
2. The definition of a "dedicated/core" biotechnology firm varies across countries, but is usually defined as a firm with fewer than 500 employees and with biotechnology as its main activity. When no data are available for dedicated biotechnology firms, the results are limited to all firms with some reported activities in biotechnology.
3. May include some firms that are only active in traditional biotechnology, but as far as possible firms that are only active in traditional biotechnology are excluded.
4. May include a few firms that are active in biotechnology but do not develop biotechnology innovations.

F.2. BIOTECHNOLOGY R&D

Business sector expenditures on biotechnology R&D are available for 17 countries plus Shanghai, China (see Annex 1).

Firms active in biotechnology can perform R&D in biotechnology and in other areas. Data on the share of biotechnology R&D in R&D performed by biotechnology firms are available for three countries. These firms' share of biotechnology R&D in total R&D expenditures was 65% in Canada, 38% in Finland and 36% in Spain.

These results show that a large share of total R&D expenditures of biotechnology firms may be for non-biotechnology R&D. For this reason, the results given below exclude countries for which only total R&D spending by biotechnology firms is available, as an unknown percentage of this R&D will be on non-biotechnology-related research.

Business-sector expenditures on biotechnology R&D are highest in the United States (USD 14 232 million current PPP), which represents 66.3% of all business-sector biotechnology R&D in the 17 countries and Shanghai.

The share of biotechnology in all business-sector R&D is an indicator of the level of the focus on biotechnology research. In Iceland, biotechnology R&D accounts for 51.4% of all business sector R&D. The share exceeds 10% in Canada (12.0%), New Zealand (20.9%) and Denmark (23.8%). In the United States, the share is 7.0%.

The share of business-sector biotechnology R&D performed in the services sector (mostly in NACE 73: Research and Development) is available for five countries. It ranges from 24.7% in Switzerland to 70.3% in Australia.

Complete data on business-sector biotechnology R&D by size of biotechnology firms are available for only two countries. In the United States and France, large firms with over 500 employees account for only 6.2% and 7.0%, respectively, of all biotechnology firms, but these firms perform 61.4% and 48.5% of all business-sector R&D in biotechnology. Small firms with fewer than 50 employees account for only 9.3% and 18.0% of business-sector biotechnology R&D in the United States and France, respectively. In Canada, Germany and Switzerland, small firms with fewer than 50 employees account for 33.3%, 50.1% and 13.9%, respectively, of business-sector biotechnology R&D.

Source

- OECD (2006), *OECD Biotechnology Statistics 2006*, OECD, Paris, available at: www.oecd.org/dataoecd/51/59/36760212.pdf.

For further reading

- OECD (2005), *A Framework for Biotechnology Statistics*, OECD, Paris, available at: www.oecd.org/dataoecd/5/48/34935605.pdf.
- OECD (2002), *Frascati Manual, Proposed Standard Practice for Surveys on Research and Experimental Development*, OECD, Paris.

Biotechnology R&D, products and processes

Biotechnology research and experimental development (R&D) is defined as R&D into biotechnology techniques, biotechnology products or biotechnology processes, in accordance with both the definitions of biotechnology (F.1) and the *Frascati Manual* for the measurement of R&D.

A biotechnology product is defined as a good or service, the development of which requires the use of one or more biotechnology techniques given in the list-based definition or included by the respondent in a write-in "other" category for modern biotechnology. It includes knowledge products (technical know-how) generated from biotechnology R&D.

A biotechnology process is defined as a production or other (*e.g.* environmental) process using one or more biotechnology techniques or products.

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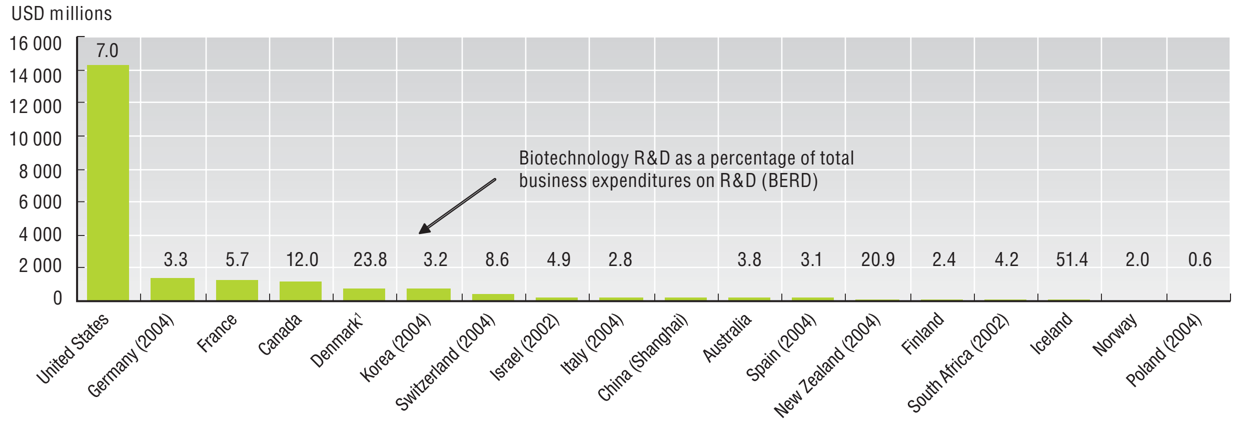
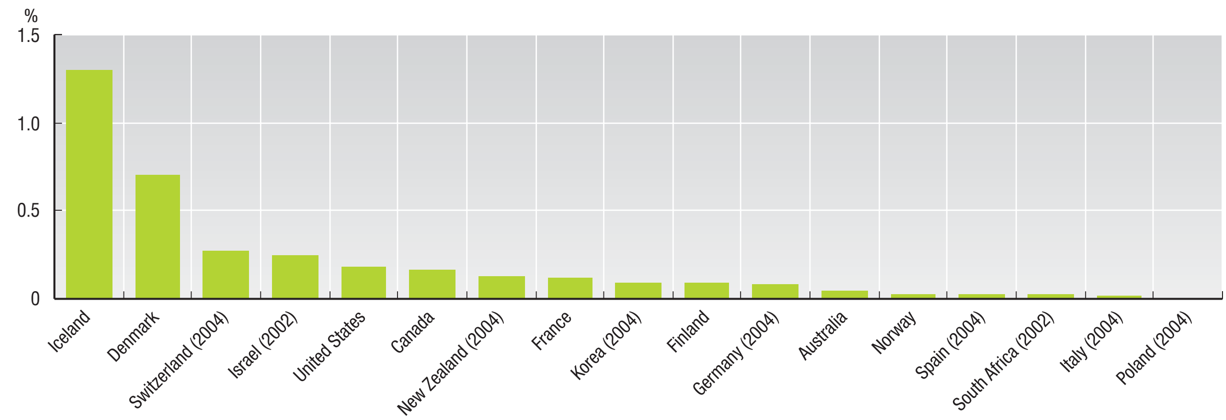
Total expenditures on biotechnology R&D by biotechnology-active firms, millions of USD PPP (current), 2003

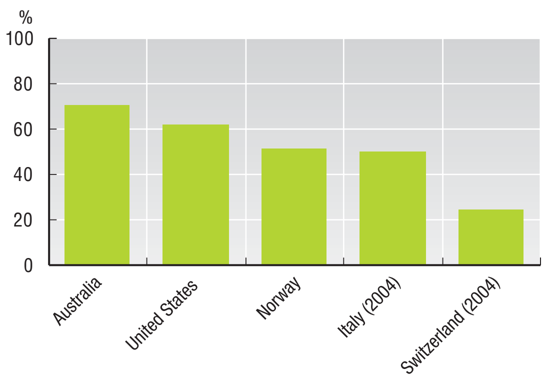


Biotech R&D intensity in the business sector, 2003

Biotechnology R&D expenditures in the business sector as a percentage of value added in the business sector

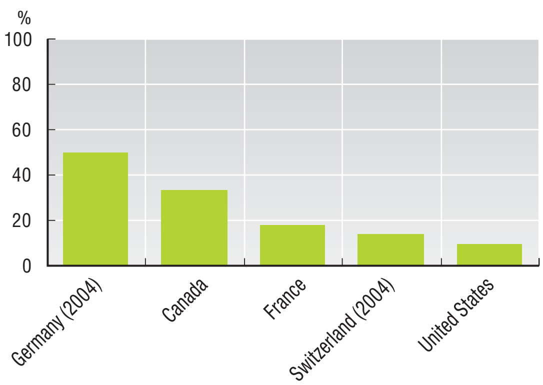


Percentage of business-sector biotechnology R&D performed in the total services sector, 2003



Percentage of business-sector biotechnology R&D performed by small firms, 2003

Firms with fewer than 50 employees



StatLink http://dx.doi.org/10.1787/118430750002

1. Results for Denmark may overestimate biotechnology R&D because a few health biotechnology firms did not give the percentage of total R&D allocated to biotechnology. For these firms, all R&D was assigned to biotechnology.

F.3. PUBLIC-SECTOR BIOTECHNOLOGY R&D

Data on public-sector expenditures on biotechnology R&D are available for ten countries (see Annex 1). In most the results refer to all expenditures by government research institutes and higher education institutions. The results for Canada are for R&D expenditures in the public sector that are financed by the federal government. Data for the United Kingdom are limited to government expenditures in public research institutions, and for Sweden the results are limited to government expenditures in higher education institutions.

Among the ten countries, Korea has the highest level of government expenditures on biotechnology R&D, at USD 727.4 million (current PPP), followed by Canada and Spain. Total government biotechnology R&D expenditures in Korea increased by 63.1% in two years to reach USD 1 186.6 million (current PPP) in 2005.

The share of all public-sector R&D expenditures on biotechnology is a measure of the government's focus on biotechnology research. New Zealand has the highest share, at 24.2%, followed by Korea (15.3%) and Canada (12.4%). The share is less than 2% for the United Kingdom and Sweden, but in both of these countries the data only capture a part of total government R&D spending.

Although the Norwegian public sector spends comparatively little on biotechnology R&D, public expenditures account for 75.5% of all biotechnology R&D (public and private sectors combined). The majority of biotechnology R&D is performed within the public sector in Spain (69.5%), New Zealand (61.0%), Korea (58.0%) and Finland (54.2%). Conversely, only 7.1% of total biotechnology R&D in Iceland is performed in the public sector, and 15.3% in Denmark.

Source

- OECD (2006), *OECD Biotechnology Statistics 2006*, OECD. Paris, available at: www.oecd.org/dataoecd/51/59/36760212.pdf.

For further reading

- OECD (2005), *A Framework for Biotechnology Statistics*, OECD, Paris, available at: www.oecd.org/dataoecd/5/48/34935605.pdf.
- Arundel, A. (2003), "Biotechnology Indicators and Public Policy", *STI Working Papers*, 2003/5, OECD, Paris, June.
- Senker, J. and P. van Zwanenberg (2000), "European Biotechnology Innovation System: EC Policy Overview", DG Research, European Commission, TSER Contract No. SOEI-CT98-1117, September.

Measuring public R&D funding of biotechnology

The two main types of government programmes to support biotechnology research are either direct funding of research by the public research sector or direct (research grants) and indirect (tax deductions for research expenditures) funding of research by the private sector. Government funding of both public and private biotechnology research can be substantial. A study by Senker and Zwanenberg (2000) estimated that almost half of all biotechnology R&D in the late 1990s in the United States was funded by government. Relevant indicators for public funding of biotechnology research consist of both basic data on public R&D spending on biotechnology and intermediate output measures of public biotechnology research, such as patenting by public research institutes and citations to public research papers.

Recommendations for collecting statistics on public R&D funding were beyond the scope of the 2005 version of the *Framework for Biotechnology Statistics*. However, they are seen as highly relevant to policy decisions and represent a future extension of the development of statistical standards.

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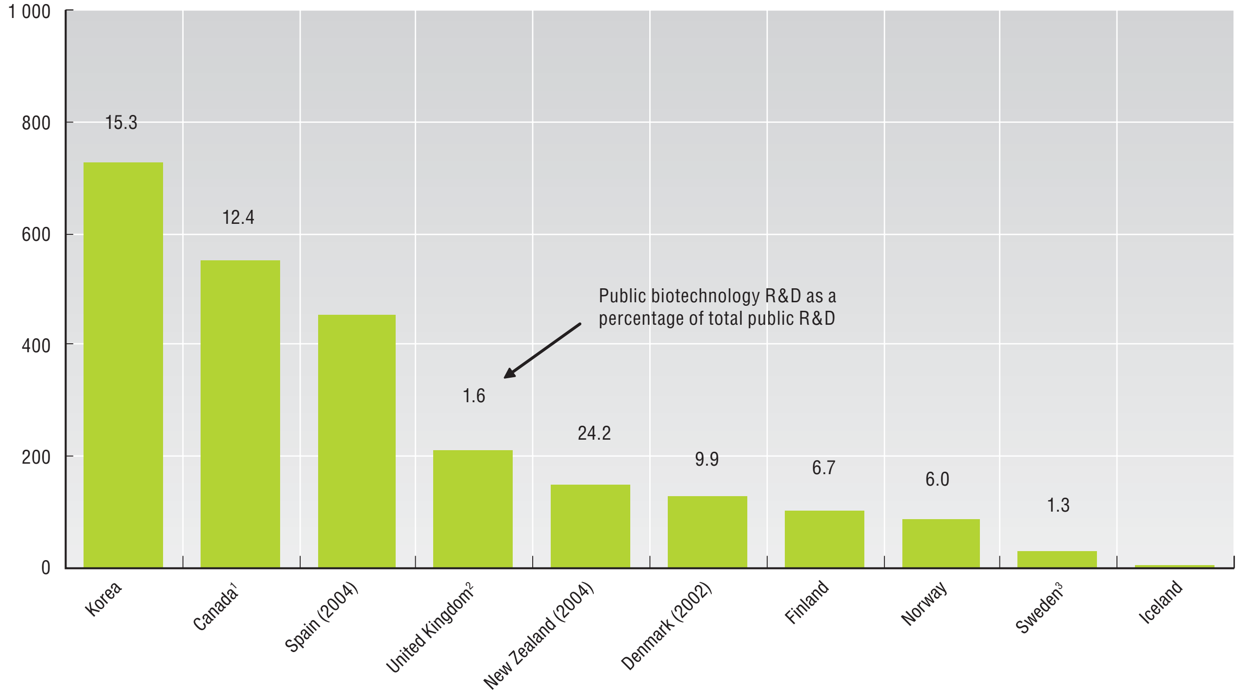
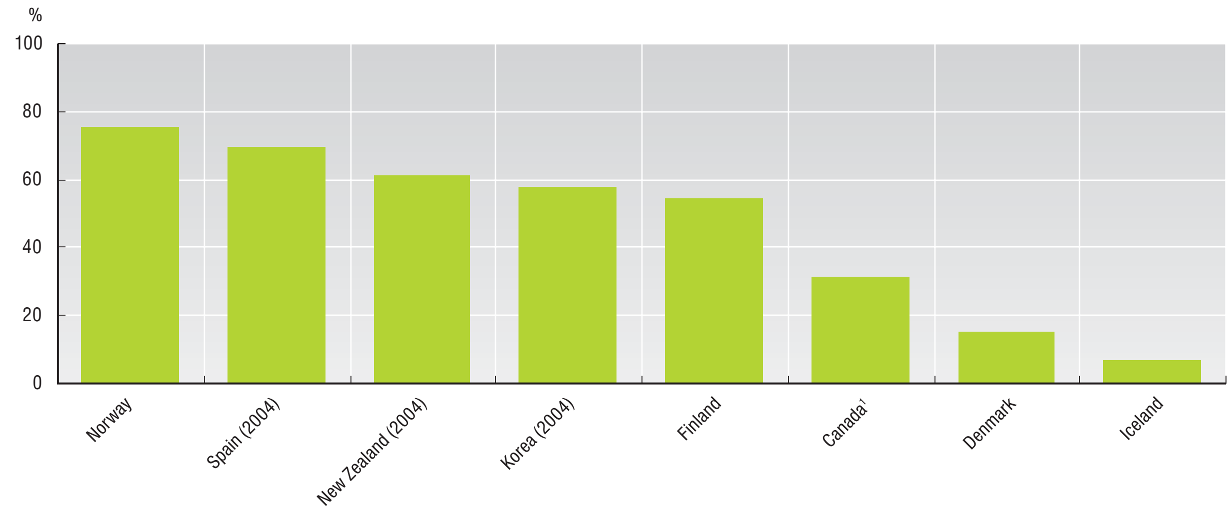
Biotechnology R&D expenditures by the public sector, millions of USD PPP (current), 2003

Government and higher education biotechnology R&D



Public-sector biotechnology R&D as a percentage of total expenditures on biotechnology R&D, 2003

Private and public sector combined



StatLink http://dx.doi.org/10.1787/118431261285

1. Biotechnology R&D financed by the federal government only (excludes provincial funding) and excluding business funding of public sector research.
2. Central government budget provision for R&D expenditure data.
3. Higher education sector only.

F.4. BIOTECHNOLOGY APPLICATIONS

■ Data on the number of firms active in individual fields of application are available for 14 countries plus Shanghai, China (see Annex 1).

■ Firms may be active in more than one field. For five countries and Shanghai, each firm was assigned to a primary application; for seven countries firms could report activity in more than one field; and for two countries the field was based on the firm's sector. For the seven countries in which firms report activity in more than one field, the results are the percentage of the total number of "reports" in each field of application.

■ The majority of firms are active in health (45%), followed by agro-food (22%), industry-environmental applications (19%), and "other" (18%).

■ Germany and the United States lead in health applications (65%), followed by Shanghai, China (63%) and Canada (54%). Only 19% of New Zealand firms are active in heath applications.

■ However, New Zealand leads all other countries in agro-food applications, at 53%, while less than 10% of Swedish firms are active in this area.

■ Industry-environmental activity is highest in Korea (41%) and lowest in Canada (under 10%).

■ Data on biotechnology R&D expenditures by application field are available for six countries plus Shanghai, China. Sweden and Belgium provide data on R&D employees. Given the close relationship between R&D employees and R&D expenditures, the two methods of measuring shares of R&D investment are presented in the same graph.

■ In all countries, the majority of investments and employment in biotechnology R&D is for health applications. The share is 89% for the United States and 92% for Iceland. On average, 88% of all estimated biotechnology R&D expenditures are for health applications, 5% for agro-food applications, 2% for industrial-environmental applications, and 5% for "other" applications.

■ Israel and Shanghai, China have the highest share of biotechnology R&D investment in agro-food applications (14% and 13%, respectively), followed by Australia (12%).

■ Australia has the highest share of biotechnology R&D investment for industrial-environmental applications (15%), followed by Switzerland (10%) and Israel (7%). The share is below 4% for Shanghai, China (3%), Canada (2%), United States (2%) and Iceland (0.1%).

Source

- OECD (2006), *OECD Biotechnology Statistics 2006*, OECD. Paris, available at: www.oecd.org/dataoecd/51/59/36760212.pdf.

For further reading

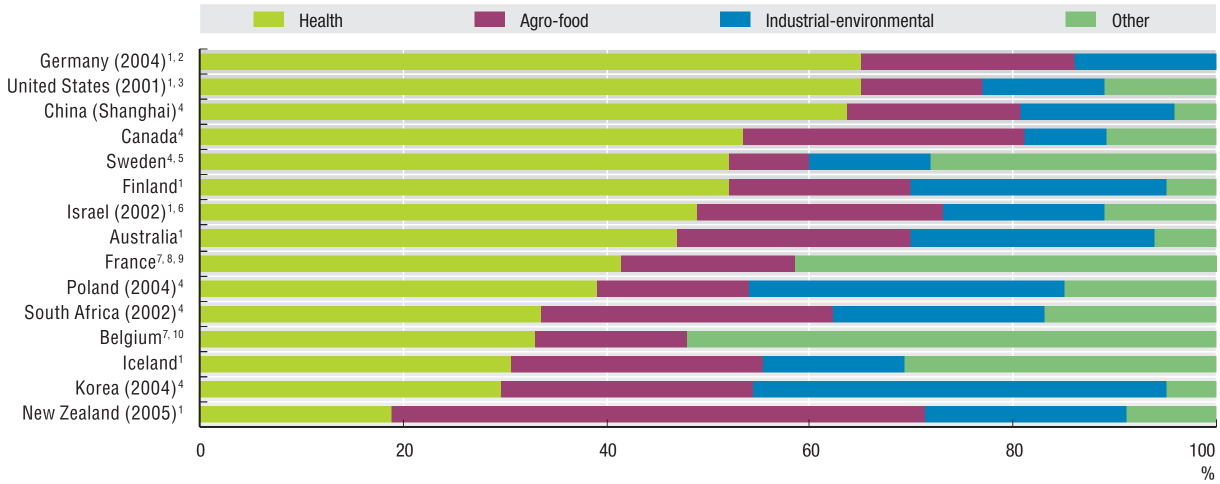
- OECD (2005), *A Framework for Biotechnology Statistics*, OECD, Paris, available at: www.oecd.org/dataoecd/5/48/34935605.pdf.

Biotechnology applications

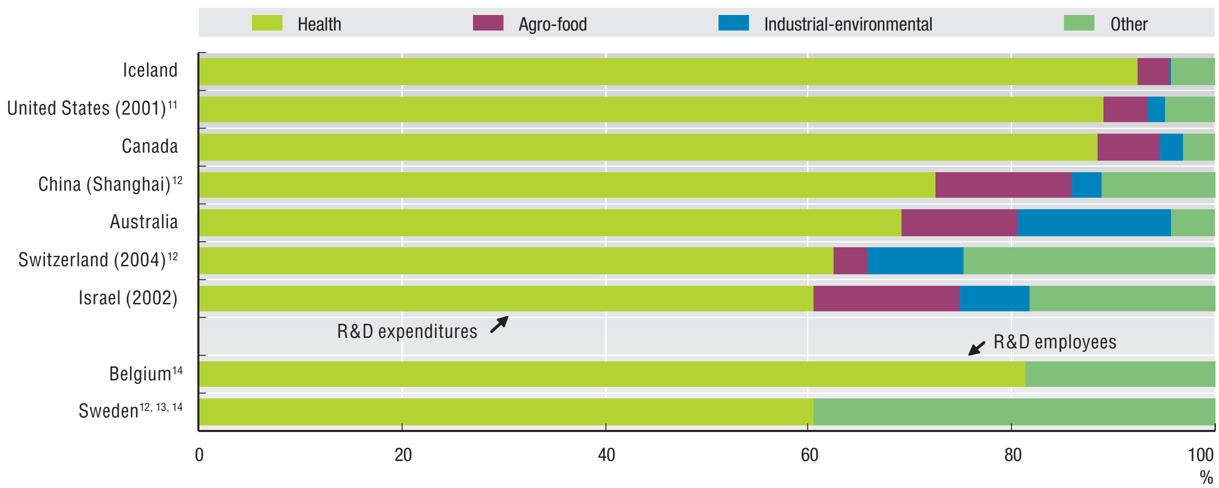
Biotechnology has applications in many fields, including human and animal health, agriculture, fishing and forestry, food processing, industrial processing, and natural resource extraction, including energy.

Although the definition of the fields of application differs across countries, it is possible to create three main fields of application that are generally comparable across countries: health, agro-food, and industry-environmental applications. Health includes both human and animal health, agro-food includes all agricultural applications plus fishing, silviculture and food processing; and industry-environmental includes industrial processing, natural resources, and environmental applications. In addition, an "other" category covers services and platform technologies such as bioinformatics plus other application fields that are not included in the three main categories in some countries.

Percentage of biotechnology firms active by field of application, 2003



Percentage of biotechnology R&D investments by field of application, 2003



StatLink http://dx.doi.org/10.1787/118465016450

Definitions

Health: includes human and animal health applications.

Industrial-environmental: includes industrial processing, environmental, energy and natural resource extraction applications.

Agro-food: includes agricultural and food processing, marine, and silviculture applications.

Other: includes bioinformatics, support services and platform technologies not included above, and other applications not included above.

1. Each firm can be active in more than one application field. The results are the percentage of the total number of firm-application combinations in each application.
2. None of the firms in Germany is assigned to "other". Health: probably includes platform technology firms.
3. Agriculture-derived processing assigned to industrial-environmental applications.
4. Main application field of the firm.
5. Limited to firms with more than 50 employees. Other: includes manufacturers of biotechnology tools and supplies.
6. Other: includes cosmetics; silviculture is assigned to industrial-environmental applications.
7. Application field based on NACE sector of activity. This will underestimate the number of firms active in health as many of these firms are in R&D services and assigned to "other".
8. Other: includes firms in industry sectors where it is not possible to determine their applications.
9. Estimate of industrial-environmental applications is inaccurate for France, as most manufacturing firms outside of pharmaceuticals are assigned to "other".
10. Health services included under "other".
11. Agriculture-derived processing assigned to 'industrial-environmental' applications.
12. Application field-based on sector of activity.
13. Limited to firms with more than 50 employees.
14. Other: includes agro-food and industry-environment applications.

F.5. BIOSCIENCE

Bioscience is one of the most dynamic fields of modern science. Four research categories have been identified by co-citation analysis of highly cited articles, *i.e.* the top 1% of cited articles, published from 1999 to 2004. They are: "Brain research", "Genomics", "Regenerative medicine" and "Plant science research".

Two groups of scientific articles exist in the co-citation analysis. Highly cited articles aggregated by co-citation are referred to as "core articles". The articles that cite the core articles are referred to as "citing articles". The United States has a prominent position both in core (70%) and citing articles (50%), followed by the EU15 and the United Kingdom.

After the United States, the United Kingdom has the second largest share in "Brain research" and "Genomics", Germany in "Plant science research" and Japan in "Regenerative medicine". The US lead is less strong in "Plant science research" than in other categories. Germany, the United Kingdom and Japan compete with each other in this category. Korea also has a relatively large share in "Plant science research".

The shares of Brazil, Russia, India and China are still small in both core and citing articles, but the shares of the latter are much larger. This suggests that these countries are followers more than leaders.

Ratios of international collaboration are generally smaller (less than 40%) in larger countries such as the United States and Japan, but also in emerging countries such as China and India. Knowledge flows in the Asian countries seem to be largely domestic. International collaboration between countries within and outside the EU15 is as low as in the United States and Asian countries, an indication that intra-regional collaboration predominates.

"Genomics" is a multidisciplinary research category within bioscience. In particular, non-life sciences have a crucial role as a source of knowledge, physics being such an example.

Source

- Igami, M. and A. Saka (2007), "Capturing the evolving nature of science, the development of new scientific indicators and the mapping of science", *STI Working Paper,* 2007/1, OECD, Paris.

For further reading

- Small, H., and E. Sweeney, (1985), "Clustering the Science Citation Index using Co-citations". A Comparison of Methods, *Scientometrics* 7, 3-6, pp. 391-409.
- Gauffriau, M. and P. J., Larsen, (2005), "Counting Methods are Decisive for Rankings Based on Publication and Citation Studies", *Scientometrics* 64, 1, pp. 85-93.

Identification of research areas based on co-citation analysis and counting methods

Knowledge creation and flows in cutting-edge research are transmitted through information exchange among researchers. The exchange can take various forms. Citation of scientific articles is one of the major ways for knowledge to flow. Analysis of citations and identification of core articles, which play a central role in research areas, makes it possible to examine the characteristics of the research areas and the relations among them.

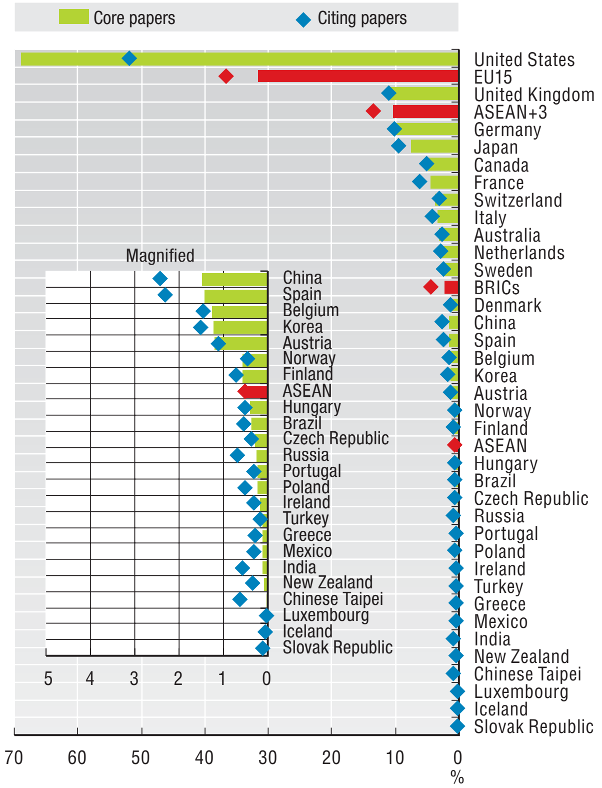
Clusters of articles with similar research subjects were identified via co-citation analysis. Co-citation is a form of citation in which a set of articles is simultaneously cited by other articles. A total of 47 218 highly cited articles, *i.e.* the top 1% of cited articles in the database from 1999 to 2004, were clustered through co-citation analysis, so as to obtain a total of 133 research areas, *i.e.* clusters of highly cited articles related to similar research. The Essential Science Indicators (ESI) database, a commercial database provided by Thomson Scientific, was used as the information source.

Two groups of scientific articles exist in the co-citation analysis. Highly cited articles aggregated by co-citation are referred to as "core articles". Articles that cite the core articles are referred to as "citing articles". The share of core articles is used as a proxy for the quality of research, while the share of citing articles is considered a sign of catch-up, especially in non-OECD countries. It is known that researchers in "catching-up" countries tend to cite more articles than researchers in advanced countries.

Two counting methods are often applied to analyse countries' shares in scientific publications, whole count and fractional count. In the former, the contribution of a paper from an analytical unit, *e.g.* country, institution, author, etc., is counted as a unit, if at least one address in that analytical unit is included in the address list. Thus the sum of shares exceeds 100%. In the fractional count, the contribution of an analytical unit is weighted by its share in all contributions. Therefore, the sum of countries' shares always equals 100%. The choice of counting method strongly affects the share of analytical units. The literature offers few examples of the differences between the whole and fractional counts. Recent literature shows that the differential of the two models is especially noteworthy in research with a high degree of international co-authorship, especially in analytical units with a small number of publications. The differences are likely to increase over time because of greater international co-operation in research. Because of data availability, countries' shares were evaluated by the whole count method here.

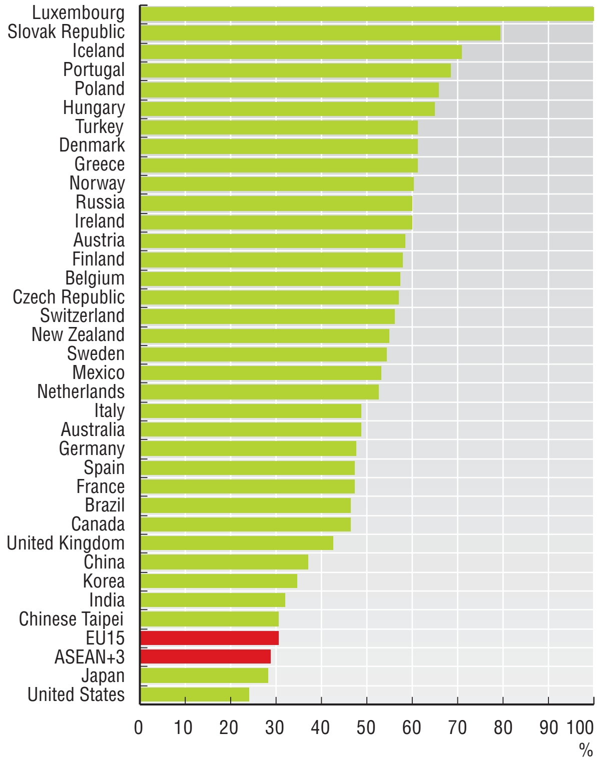
Countries' shares in core and citing articles[1, 2]

1999-2004

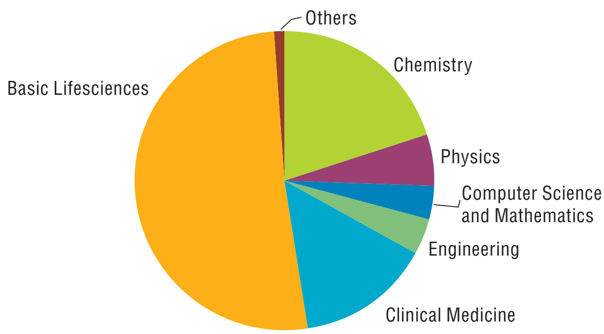


International co-authorship ratio in citing articles[3]

1999-2004



Distribution of fields in core articles in "Genomics"[4]



StatLink http://dx.doi.org/10.1787/118473087121

1. Article counts are based on whole counts.
2. EU15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. ASEAN countries: Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. ASEAN+ 3 countries: ASEAN countries + China, Japan and Korea.
3. Ratios of international co-authorship in EU15 and ASEAN+3 show collaboration with outside EU15 and ASEAN+3, respectively.
4. The scientific field of the articles is identified on the basis of the field of the journals in which they are published.

F.6. BIOTECHNOLOGY PATENTS

■ International applications for biotechnology patents, filed under the Patent Co-operation Treaty (PCT), grew by 7% a year between 1995 and 2004. However, applications started to decrease from 2000 to almost 6 700 in 2004 (–8.6% on average over 2000-04, compared to +21.4% on average between 1995 and 2000). However, from 2000 total PCT patent applications continued to increase by an average of 4.6%.

■ The surge in the late 1990s was partly due to the flow of patent applications concerning the human genome, while the reduction in the 2000s is often explained by patent offices' more stringent criteria for granting patents on genetic material.

■ In 2004, the United States had the highest share of biotechnology patents filed under the PCT procedure (38.9%). Japan and Germany had 17.7% and 10.0%, respectively. The United States, Japan, Australia, Belgium, Canada, Denmark, Israel, India and Spain had more patents in biotechnology than in other technical fields.

■ OECD-wide, from 2002 to 2004 6.6% of total PCT filings related to biotechnology, compared to 8.5% in the late 1990s. Biotechnology represented more than 10% of all patents filed under PCT in Denmark. Belgium and Canada followed with more than 9% of patents relating to biotechnology. The relative weight of biotechnology in all international patent filings decreased between the mid-1990s and the early 2000s in many countries, notably in Belgium, Canada, China, Ireland, Korea, Mexico, the United Kingdom and the United States.

Source

- OECD, Patent database, April 2007, available at: *www.oecd.org/sti/ipr-statistics*.

Definition of biotechnology patents

To identify patents related to specific technological domains, one can either look at the International Patent Classification system (IPC) classes, and/or search for appropriate key words within the text fields of the patent document. Such a method might exclude, or include, patents that are, or are not, relevant for a specific domain, but it makes it possible nonetheless to provide a relatively good picture of innovative activity in the technology field.

The 8th edition of the IPC is used to identify patents in the biotechnology sector. IPC classes selected include areas such as transgenic vertebrates, invertebrates and plants; methods, processes and testing; bioinformatics; biological materials, etc. These are: A01H1/00, A01H4/00, A61K38/00, A61K39/00, A61K48/00, C02F3/34, C07G (11/00, 13/00, 15/00), C07K (4/00, 14/00, 16/00, 17/00, 19/00), C12M, C12N, C12P, C12Q, C12S, G01N27/327, G01N33/ (53*, 54*, 55*, 57*, 68, 74, 76, 78, 88, 92).

This definition remains provisional; its coverage is being discussed in the framework of the OECD Working Party on Biotechnology. For further details on the IPC classes (IPC, 8th edition, 2006): *www.wipo.int/classifications/ipc/ipc8*.

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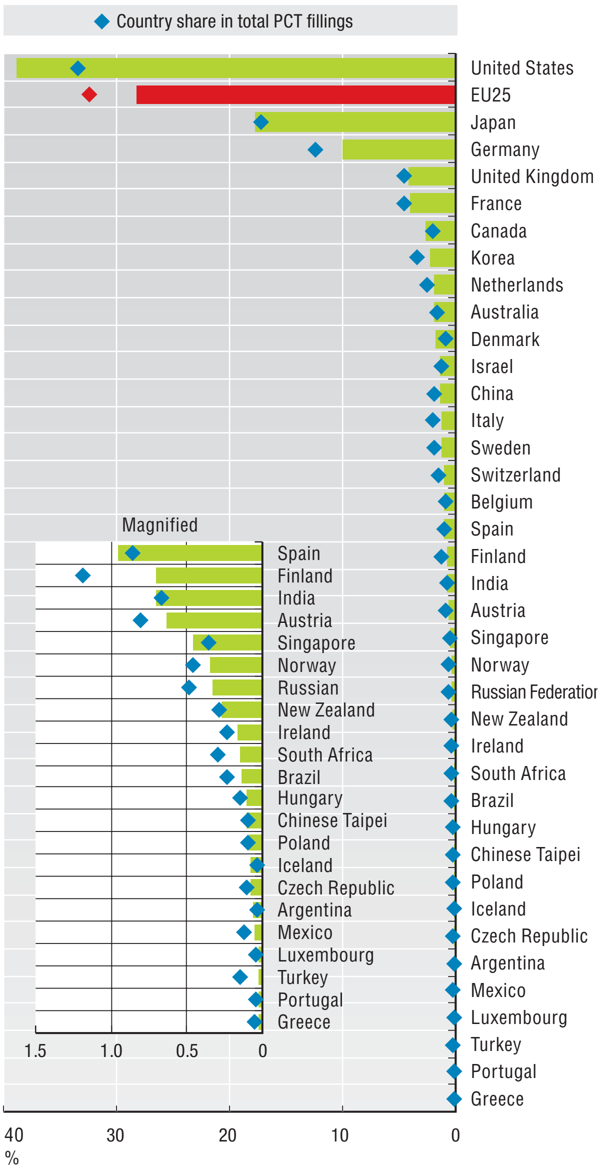
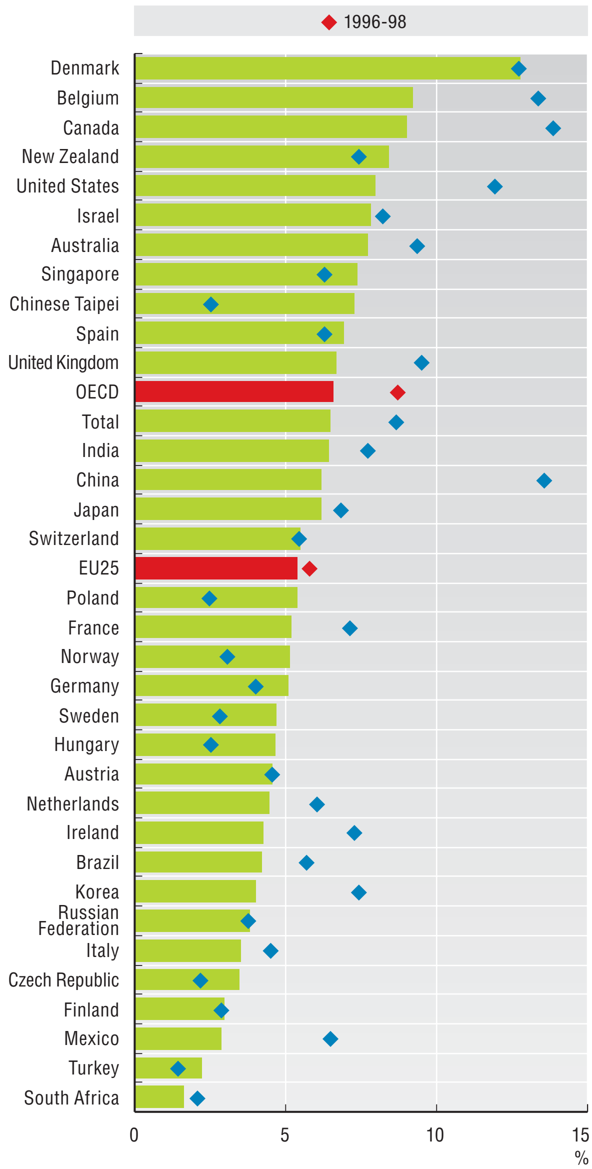
Share of countries in biotechnology patents filed under PCT[1]

2004



Biotechnology patents as a percentage of national total[2] (PCT filings)[1]

2002-04



StatLink http://dx.doi.org/10.1787/118482443630

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

1. Patent applications filed under the Patent Co-operation Treaty, at international phase, designating the European Patent Office.
2. Only countries with more than 250 PCT filings during 2002-04 are included.

F.7. NANOSCIENCE

In nanoscience, co-citation analysis is used to identify three research categories: "Chemical synthesis", "Superconductivity and quantum computing", and "Nano materials and devices". Research areas examined here cover only a part of nanoscience in which there has been active research in recent years.

The co-citation analysis identifies two groups of scientific articles. Highly cited articles aggregated by co-citation are referred to as "core articles". Articles that cite the core articles are referred to as "citing articles". The United States seems to have some advantage in terms of quality of articles. It has the largest share of core articles, an indication of its leading role in nanoscience. The EU15 follows in core articles and has the largest share of citing articles, followed by ASEAN+3 countries, Germany and Japan.

Brazil, Russia, India and China are catching up. They have the sixth largest share of core articles and the fourth largest share of citing articles. They have about twice as many citing articles as core articles. Their contribution mainly comes from China.

EU countries take advantage of the diversity of their researcher base through intra-regional co-operation, and knowledge flows appear to be largely regional. International co-authorship between the EU15 and countries outside the EU15 is as low as that of the United States, but higher than that of Asian countries.

The low level of international research collaboration in the United States can be explained by the presence of lead researchers in the field and a diversified researcher base within the country. For their part, Asian countries tend to compete actively with each other and knowledge flows tend to remain within national borders. Asian countries tend to have less international co-authorship than European countries.

The mapping of research illustrates the multidisciplinary character of "Nano materials and devices": its intermediate location between "Chemical synthesis" and "Superconductivity and quantum computing" on the map implies that it benefits from interaction between physics and chemistry.

Source

- Igami, M. and A. Saka (2007), "Capturing the evolving nature of science, the development of new scientific indicators and the mapping of science", *STI Working Paper,* 2007/1, OECD, Paris.

For further reading

- Börner, K., C. Chen and K.W. Boyack (2003), "Visualizing Knowledge Domains" and references therein, *Annual Review of Information Science and Technology* 37, pp. 179-255.

Mapping of science

The recent unprecedented progress in access, use and analysis of information on scientific publications and patents offers innovative ways to study the structure and evolution of science. In particular, mapping of knowledge has received wide recognition as a new, evolving area of research. Observation of the changing nature of science with the use of mapping can help to understand how science is evolving.

The map of nanoscience was created by a gravity model in which each research area is treated like an atom in a molecule. A research area feels attractive and repulsive forces which are caused by interactions with other research areas. An attractive force between a pair of research areas is evaluated by the intensity of co-citations between them. A constant repulsive force is introduced between all pairs of research areas. This is necessary in order to obtain a stable configuration of research areas. The mapping relies on the attractive and repulsive forces among research areas, and only the relative location of research areas is important. Research areas with similar topics tend to be located on the basis of the definition of the attractive force.

Each circle in the map represents a research area and the size of the circle is proportional to the number of citing articles. Among the circles, the shaded ones represent research areas with high activity. Research areas in the same category are indicated by a shaded circle in the map. The strongest link stemming from individual research areas is depicted by a solid line, if its normalised co-citation frequency exceeds a certain threshold.

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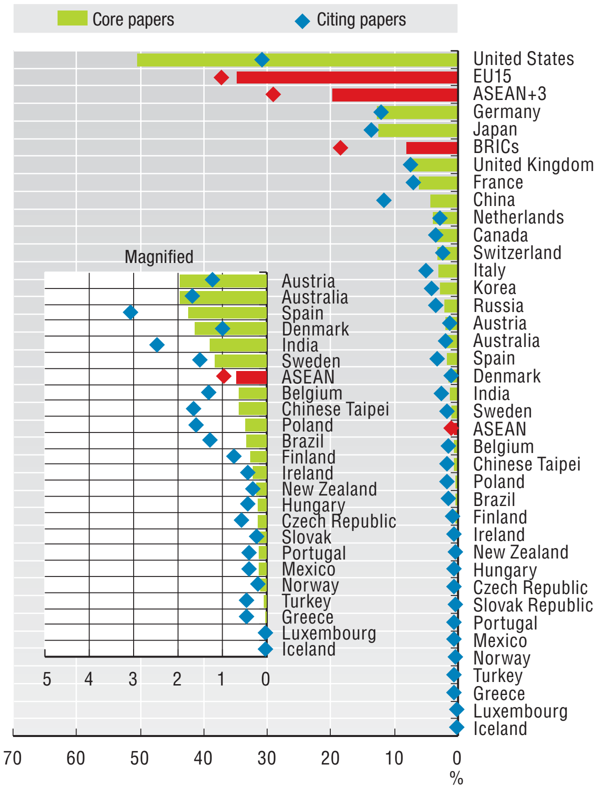
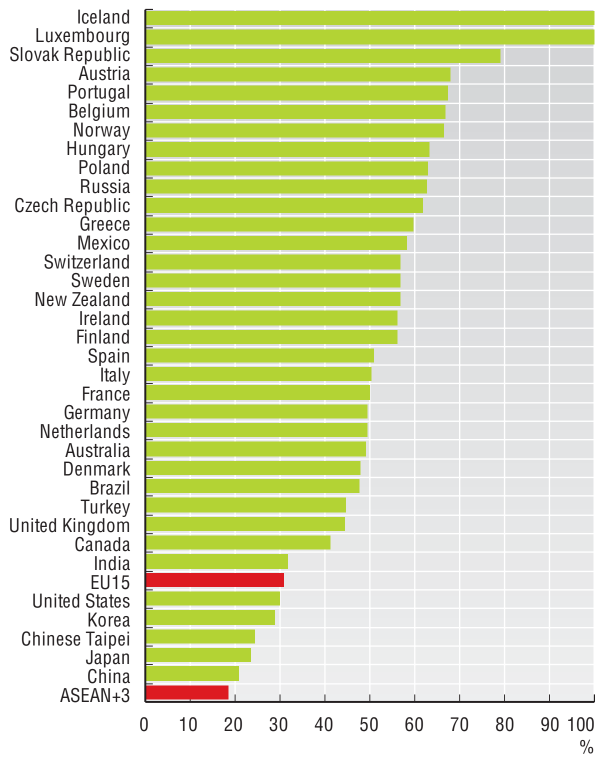
Countries' share in core and citing articles[1, 2]

1999-2004

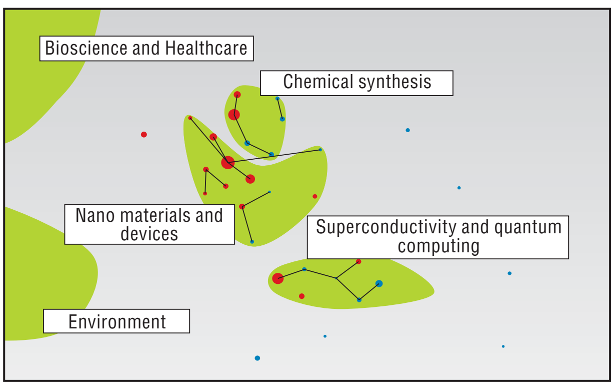


International co-authorship ratio in citing articles[3]

1999-2004



Map of nanoscience



StatLink http://dx.doi.org/10.1787/118504387323

1. Article counts are based on whole counts.
2. EU15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. ASEAN countries: Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. ASEAN+ 3 countries: ASEAN countries + China, Japan and Korea.
3. Ratios of international co-authorship in EU15 and ASEAN+3 show collaboration with outside EU15 and ASEAN+3, respectively.

F.8. NANOTECHNOLOGY PATENTS

■ Inventive activities in nanotechnology have been gathering momentum since the end of the 1990s. International applications for nanotechnology patents, filed under the Patent Co-operation Treaty (PCT), increased steadily from the mid-1980s to the mid-1990s and have risen strongly over the past decade; at 24.2%, the annual growth rate in nanotechnology surpasses that of the overall PCT applications (12.0%) for the period 1995-2004 (priority year).

■ In 2004, the United States had the highest share of nanotechnology patents filed under the PCT (40.3%), followed by the EU25 (26.4%), Japan (19.0%) and Germany (10.0%). OECD-wide, from 2002 to 2004, 0.9% of total PCT filings related to nanotechnology. Shares in total nanotechnology patents are larger than shares in total PCT filings in the United States, Japan, Ireland, Poland, and Singapore.

■ Most countries report a significant increase in the shares of nanotechnology in total national patenting in the mid-2000s as compared to the late 1990s, although activity remains relatively limited (0.8% on average).

■ Nanotechnology is multifaceted. At present, it consists of a set of technologies on the nanometre scale rather than a single technological field. It covers "Electronics", "Optoelectronics", "Medicine and biotechnology", "Measurements and manufacturing", "Environment and energy", and "Nano materials".

■ Most nanotechnologies, especially nanotechnologies related to "Electronics" and "Optoelectronics", seem to be developed through a top-down process in which nano-structures are created by the miniaturisation of existing technologies.

■ Another group of nanotechnologies is developed by a bottom-up process. The development of such technologies, *e.g.* "Nano materials", has been particularly intense in the past decade and is fuelled by scientific discoveries such as carbon nanotubes and fullerenes. At this stage, bottom-up nanotechnology is likely to have a relatively small impact on fields of application. It will take a while for bottom-up nanotechnologies to have social and economic impacts.

Source

- OECD, Patent database, April 2007, available at: *www.oecd.org/sti/ipr-statistics.*

For further reading

- Scheu, M., V. Veefkind, Y. Verbandt, E. Molina Galan, R. Absalom and W. Förster (2006), "Mapping nanotechnology patents: The EPO approach", *World Patent Information* 28, pp. 204-211.
- Igami, M. and T. Okazaki (2007), "Capturing nanotechnology's current state of development via analysis of patents", *STI Working Paper*, 2007/4, OECD, Paris.

Definition of nanotechnology patents

Reflecting the increasing interest and importance of nanotechnology in patents, the United States Patent and Trademark Office (USPTO), the European Patent Office (EPO), and the Japan Patent Office (JPO), have made intense efforts to improve their respective classification systems and collect all nanotechnology-related patents in a single patent class. Nanotechnology patent applications identified via the EPO are analysed in this section. The EPO definition of nanotechnology is the following:

"The term nanotechnology covers entities with a controlled geometrical size of at least one functional component below 100nm in one or more dimensions susceptible to make physical, chemical or biological effects available which are intrinsic to that size. It covers equipment and methods for controlled analysis, manipulation, processing, fabrication or measurement with a precision below 100nm."

Identification of nanotechnology patents requires hard work. In the EPO, a nanotechnology working group (NTWG) was created in 2003. At first, it worked on the definition of nanotechnology in order to watch trends in nanotechnology patents. Then the NTWG identified nanotechnology patents through keyword searches, consultations with nanotechnology experts in the EPO, and peer reviews by external experts. Patent applications from 15 countries or organisations were analysed. As a consequence of these endeavours, about 90 000 out of 20 million patent or non-patent literature documents were tagged to class Y01N.

Nanotechnology patent applications were further categorised into six fields of application by the OECD, *e.g.*"Electronics", "Optoelectronics", "Medicine and biotechnology", "Measurements and manufacturing", "Environment and energy", and "Nano materials", based on the International Patent Classification.

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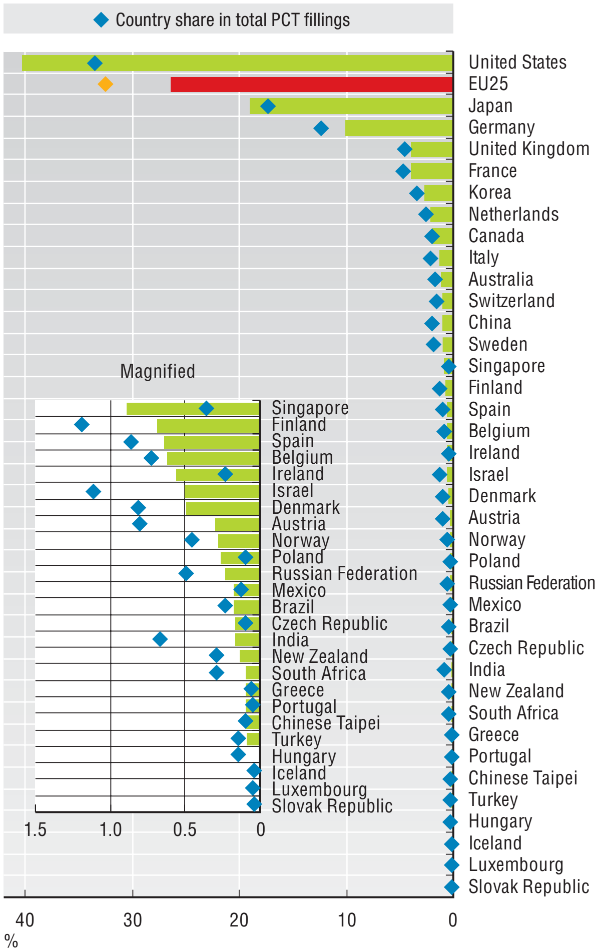
F.8. NANOTECHNOLOGY PATENTS

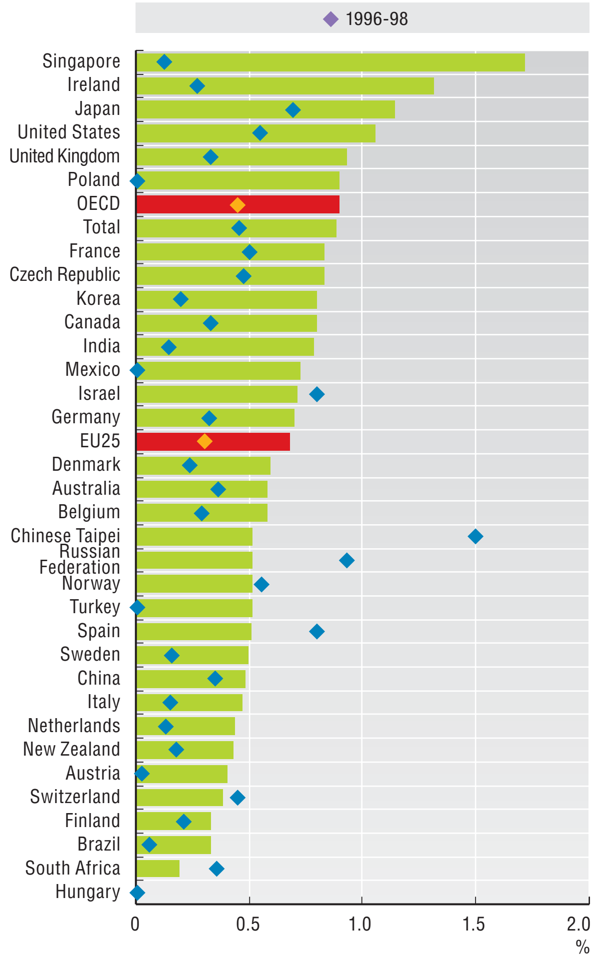
Share of countries in nanotechnology patents filed under PCT[1]

2004

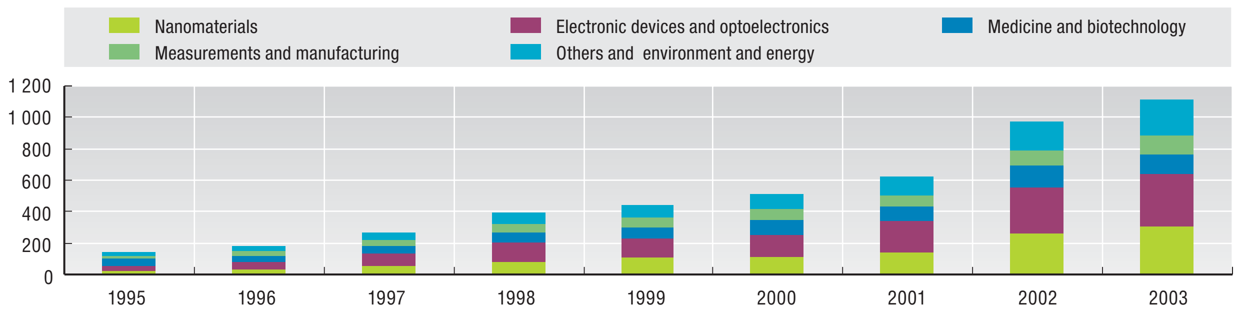


Nanotechnology patents as a percentage of national total[2] (PCT filings)[1]

2002-04



Trends in nanotechnology patents by field of application



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

1. Patent applications filed under the Patent Co-operation Treaty, at international phase, designating the European Patent Office.
2. Only countries with more than 250 PCT filings during 2002-04 are included.

StatLink http://dx.doi.org/10.1787/118541047655

F.9. ENVIRONMENTAL SCIENCE

■ A co-citation analysis identified three kinds of research in environmental science: "Climate change", "Air and chemical pollutants" and "Biodiversity". Research areas analysed here do not include all environmental science, but only a part of environmental science in which there has been active research in recent years.

■ There are two groups of scientific articles in the co-citation analysis. Highly cited articles aggregated by co-citation are referred to as "core articles". The articles that cite the core articles are referred to as "citing articles". As in bioscience, the United States has the largest share of core articles, followed by the EU15. Nordic countries, Brazil, Canada and New Zealand have a large share in both core and citing articles compared to the country average. Except for Brazil, the shares of Brazil, Russia, India, China are not large at present.

■ Most countries are actively engaged in collaboration with foreign researchers (over 40% of articles). The United States, Spain and Turkey are exceptions. Among Asian countries, Korea and China conduct more international co-operative research in environmental science than in other scientific fields. Approximately 60% of articles from Korea and China have co-authors from abroad.

■ Environmental science is multidisciplinary. Geosciences have the largest share of core articles, followed by engineering and environment/ecology. The distribution of core and citing articles by field differs. There is a sharp increase in the shares of chemistry and basic life sciences, especially plant and animal sciences, among citing articles.

Source

- Igami, M. and A. Saka (2007), "Capturing the evolving nature of science, the development of new scientific indicators and the mapping of science", *STI Working Paper*, 2007/1, OECD, Paris.

Environmental science captured by a co-citation analysis

A co-citation analysis found three kinds of environmental science in which there has been active research in recent years: "Climate change", "Air and chemical pollutants" and "Biodiversity". Research on climate change consists, for example, of research on the global carbon cycle, the North Atlantic Oscillation, and the paleoclimate. The impact of increasing greenhouse gases on global climate is extensively studied. Owing to increasing awareness of global warming, research on climate change is likely to be a big issue for environmental science.

Research on air and chemical pollutants appears to be another important domain. It models generation and diffusion processes of aerosols and air pollutants and studies their impact on climate. It also covers aquatic pollution by toxic chemical compounds and environmental pollution caused by persistent organic pollutants.

Biodiversity was defined in the 1992 United Nations Earth Summit in Rio de Janeiro as "the variability among living organisms from all sources, including, *inter alia,* terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems". Scientific research on biodiversity reflects increasing awareness of its importance.

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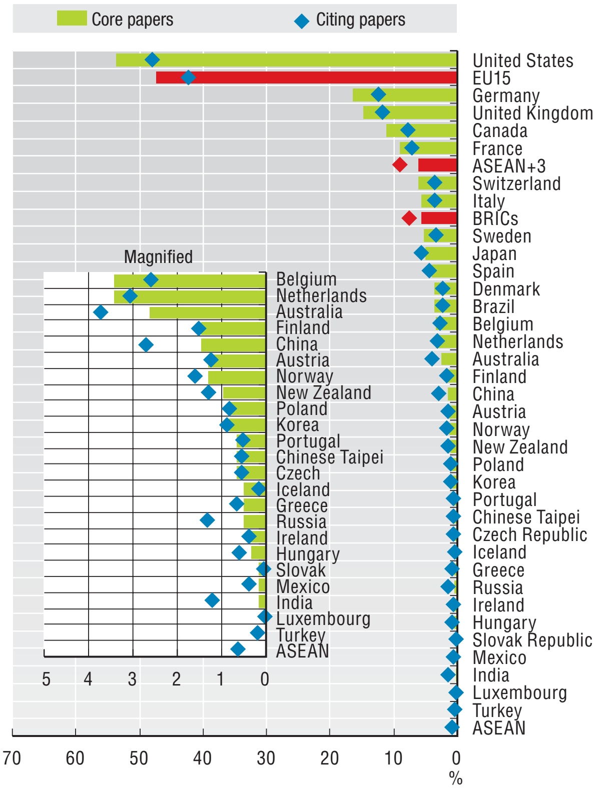
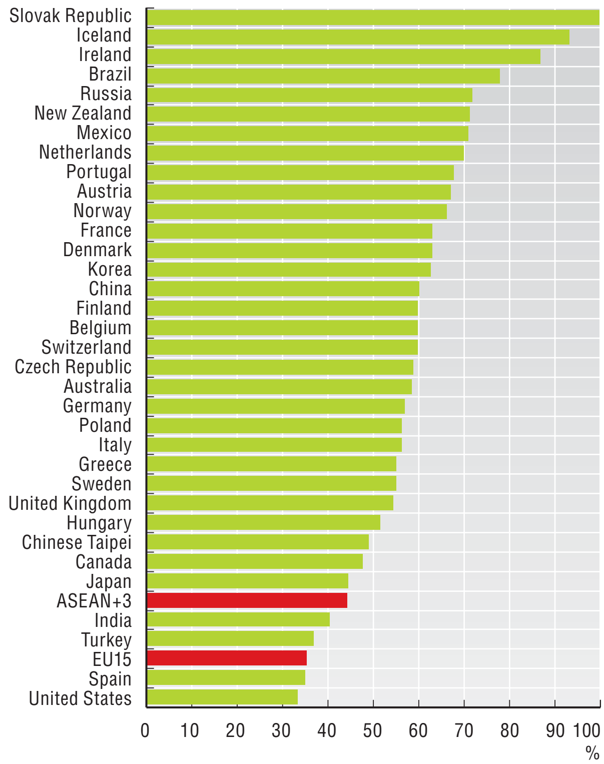
Countries' share in core and citing articles[1, 2]

1999-2004

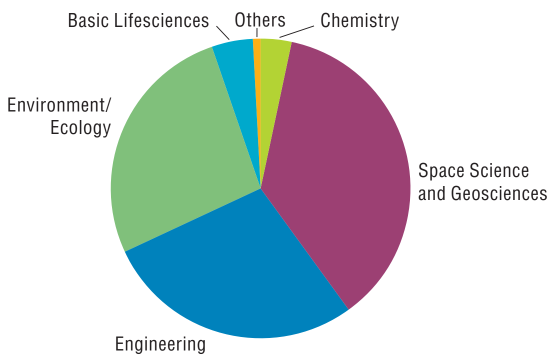


International co-authorship ratio in citing articles[3]

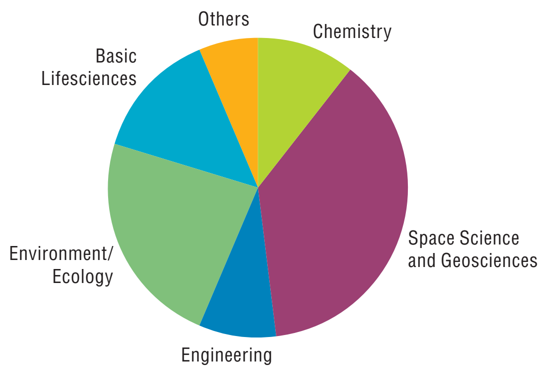
1999-2004



Distribution of fields in core articles[4]



Distribution of fields in citing articles[4]



StatLink http://dx.doi.org/10.1787/118548020778

1. Article counts are based on whole counts.
2. EU15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. ASEAN countries: Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. ASEAN+ 3 countries: ASEAN countries + China, Japan and Korea.
3. Ratios of international co-authorship in EU15 and ASEAN+3 show collaboration with outside EU15 and ASEAN+3, respectively.
4. The scientific field of the articles is identified on the basis of the field of the journals in which they are published.

F.10. PATENTS IN ENVIRONMENT-RELATED TECHNOLOGIES

■ Technological change plays a crucial role in reducing pollution and in coping with environmental constraints. Compared to pollution control and waste treatment technologies, which are generally imposed by law, energy-efficient innovation is the result of both stronger regulation and the need for alternative sources of energy in the face of rising fuel prices.

■ Overall, there has been a modest increase in patenting in renewable energy and in motor vehicle abatement technologies. Technologies related to renewable energy appear as the most dynamic group. They include wind, solar, geothermal technologies, wave and tide, biomass and waste technologies. Within this group, solar, wind power and waste-to-energy have exhibited rapid growth, particularly since the mid-1990s.

■ Patenting activity in motor vehicle abatement technologies is strong, although the average annual growth rate lags that of renewable energy. The rise in innovation activity in this area is positively related to changes in the regulatory framework (*i.e.* automotive emissions control) in the main producer countries. Furthermore, foreign regulatory pressures appear to influence domestic innovation. For instance, Japanese inventors played a lead role in the development of catalytic converters, even though the regulatory "shock" initially came from the United States. Japan, the United States and Germany dominate innovation activity in this field.

■ Overall, EU (25) has the largest share for the three technology fields. Japan leads in solid waste technologies and Germany in motor vehicle abatement technologies. For renewable energy, Japan, the United States and Germany report a similar performance. Other countries reporting a share above 5% are the United Kingdom (solid waste and renewable energy), Denmark (renewable energy), and France (motor vehicle abatement).

Source

- OECD, Patent database, April 2007, available at: *www.oecd.org/sti/ipr-statistics*.

For further reading

- Johnston, N. and I. Hascic (2007a) "Environmental Regulation and International Innovation in automotive Emissions Control Technologies", OECD, Paris.
- Johnston, N. and I. Hascic (2007b). "Renewable Energy Policies and Technological Innovation: Empirical Evidence based on Patent Counts", OECD, Paris.

Identifying patents related to environmental technology

World Intellectual Property Organization (WIPO) descriptions of the IPC classification (8th edition) were used to identify IPC classes that matched environmental technologies more closely. Keyword searches were also conducted to find patents embedding technology specific to a particular field (see Johnston and Hascic, 2007a, 2007b).

Renewal technologies: Based on an extensive literature on technology developments in the area of renewable energy, a set of keywords was identified. These were used to determine IPC codes which relate directly to renewable energy in the areas of wind, solar, geothermal, wave-tide, biomass and waste (see Johnston and Hascic, 2007b).

Motor vehicle abatement: Identifying IPC classes and relying on keyword searches, a set of technologies relating to emission control was identified. Automobile pollution control technologies comprise all technologies used to reduce pollutants produced and released into the atmosphere by automobiles. These automotive-generated emissions fall broadly into two categories based on the point of emission: *i)* tailpipe or exhaust emissions; and *ii)* evaporative emissions (Johnston and Hascic, 2007a). Abating pollution from vehicles must target both tailpipe and petrol tank venting. Searches conducted for these technologies are primarily based on specific regulations imposed on the automobile sector such as the US Tier standards and the European Union's Euro standards. The IPC classes identified are broadly categorised into the three major technology groups identified above: *i)* those that relate to improvements in engine (re)design and therefore generate fewer emissions; *ii)* those that treat pollutants produced before they are released into the atmosphere; and *iii)* those that reduce evaporative emissions. Unfortunately, the last category is somewhat opaque, because there is no IPC sub-classification that clearly defines improvements to nozzles and/or canisters.

For further details on the IPC classes (IPC, 8th edition, 2006): *www.wipo.int/classifications/ipc/ipc8*.

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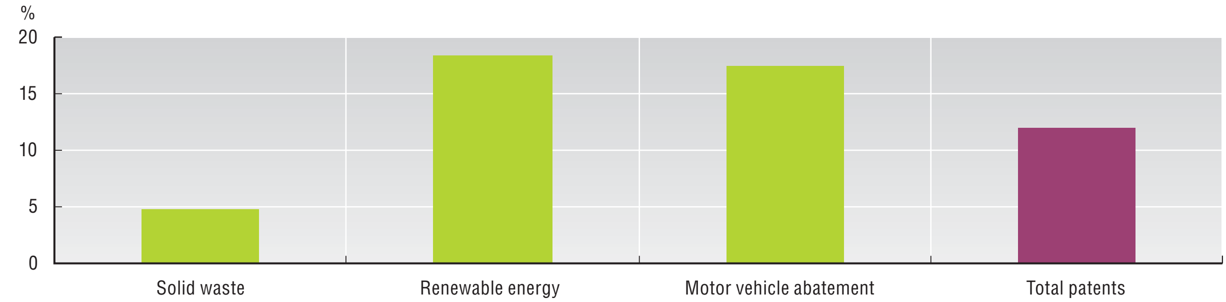
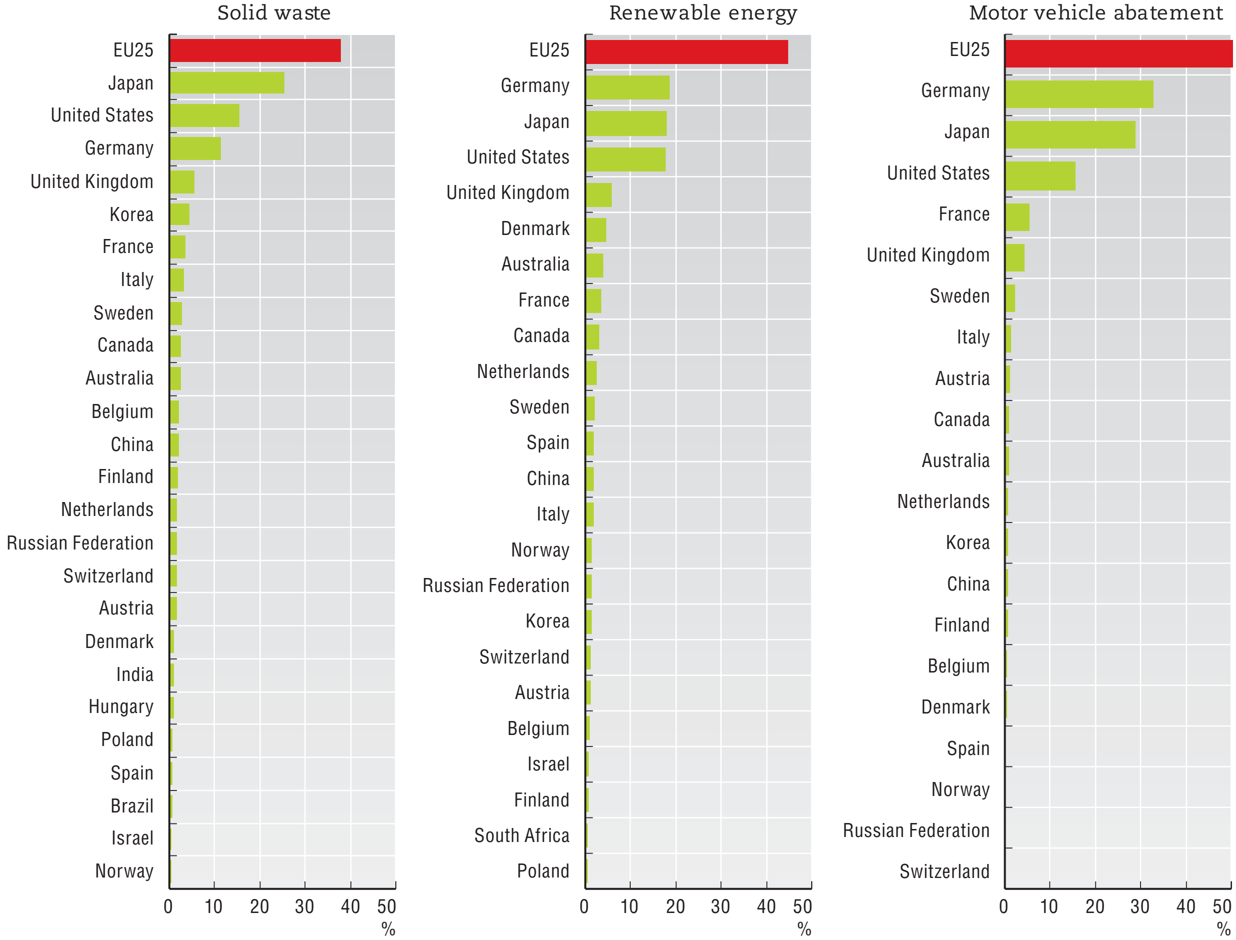
Trends in patents filed under PCT in selected environmental technologies[1]

Average annual growth rate 1995-2004



Countries' shares in environmental technology patents filed under PCT[1]

2000-04



StatLink http://dx.doi.org/10.1787/118555582818

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

1. Patent applications filed under the Patent Co-operation Treaty, at international phase, designating the European Patent Office.

G. INTERNATIONALISATION OF S&T

G.1. FOREIGN OWNERSHIP OF DOMESTIC INVENTIONS

■ The technological activities of multinational firms are increasingly internationalised. In the search for new technological competences, better adaptation to markets and lower research and development costs, companies are moving research activities overseas more intensively.

■ On average, 16.7% of all inventions filed at the European Patent Office (EPO) were owned or co-owned by a foreign resident in 2001-03, a notable increase from 11.6% in 1991-93.

■ The extent of internationalisation, as reflected in foreign ownership, varies substantially across countries. In the Russian Federation, Luxembourg, Mexico, Hungary and the Czech Republic, over 50% of domestic inventions belong to foreign residents, a higher share than in 1991-93. However, in China, Singapore, Poland, Brazil and India, foreign ownership has decreased markedly, owing in part to an increase in domestic patenting activity.

■ The United States and Germany have increased their shares of foreign ownership (from 8 and 10, to 14 and 15%, respectively). Korea and Japan report the lowest shares in 2001-03 (4.5 and 4%, respectively). The United Kingdom is an exception among large countries, with around 40% of domestic inventions owned by foreign residents, compared to 30% in the early 1990s.

■ The breakdown of foreign ownership by main owner (country) shows the importance of geographical and cultural proximity in cross-border activities. The origin of foreign ownership in EU25 countries is largely intra-regional (companies from EU countries owning inventions in other EU countries). US ownership appears strong in Mexico, Canada, Ireland, India and Israel but also in Korea and Japan.

■ While the United States dominates foreign ownership of domestic inventions in India, European countries are the main owner of inventions subject to cross-border ownership in Brazil, Russia, China and South Africa).

Source

- OECD, Patent database, April 2007, available at: *www.oecd.org/sti/ipr-statistics*.

Patents as indicators of the globalisation of science and technology (S&T) activities

Globalisation of technological activities can be quantified with patents. Patents have a distinctive feature that makes them very attractive as an indicator of global S&T activities: patent documents report the inventor(s) and the applicant(s) – the owner of the patent at the time of application – along with their addresses and countries of residence. When the owners' and inventors' country of residence differs there is cross-border ownership of inventions. In most cases, cross-border ownership of inventions is mainly the result of activities of multinationals: the applicant is an international conglomerate and the inventors are employees of a foreign subsidiary. The information contained in patents makes it possible to trace the internationalisation of technological activities and the circulation of knowledge among countries.

Foreign ownership of domestic inventions is one of the measures of globalisation of technological activities. It refers to the number of patents invented domestically and owned by non-residents in the total number of domestic inventions. It expresses the extent to which foreign firms control domestic inventions. Obviously, what is considered foreign ownership in one inventor country implies a domestically owned invention abroad by firms in another country. Foreign ownership includes inventions in which the inventor country shares ownership (co-owned inventions), but this share is frequently a small part of the total of cross-border inventions.

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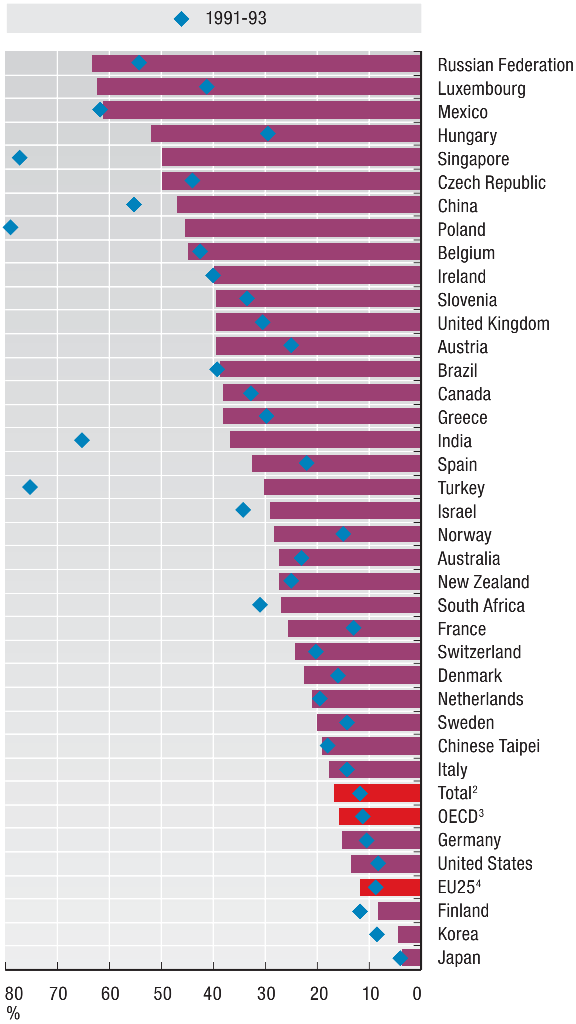
G.1. FOREIGN OWNERSHIP OF DOMESTIC INVENTIONS

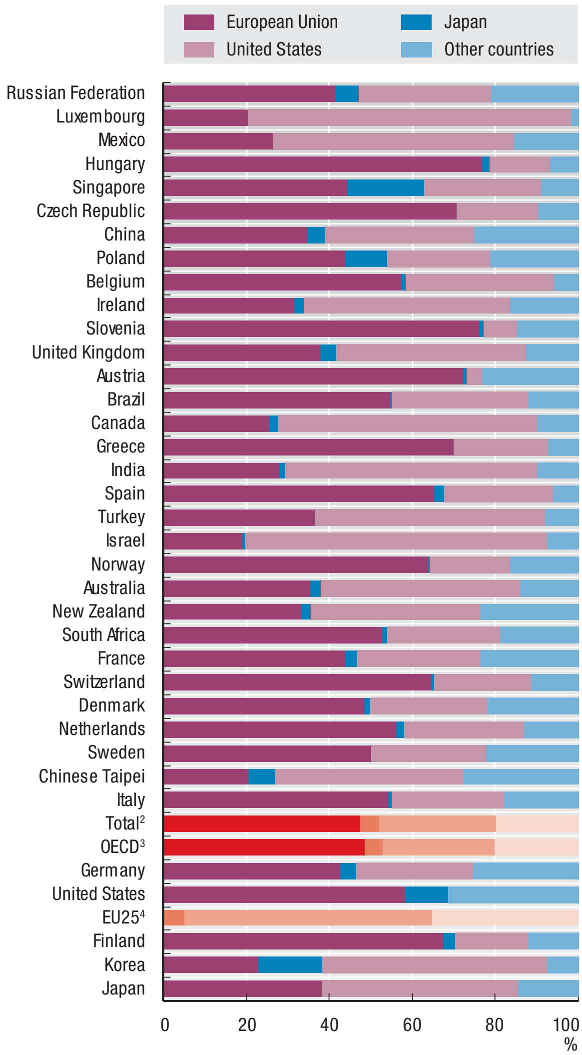
Foreign ownership of domestic inventions[1]

2001-03



Foreign ownership of domestic inventions[1]

Partner in the three major regions, 2001-03



StatLink http://dx.doi.org/10.1787/118568451275

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

1. Share of patent applications to the European Patent Office (EPO) owned by foreign residents in total patents invented domestically. This graph only covers countries/economies with more than 200 EPO applications over 2001-03.
2. All EPO patents that involve international co-operation.
3. Patents of OECD residents that involve international co-operation.
4. The EU is treated as one country; intra-EU co-operation is excluded.

G.2. DOMESTIC OWNERSHIP OF INVENTIONS MADE ABROAD

■ Research and development (R&D) activities have become more international. Changes in the global value chain, in the cost of R&D, in flexibility in handling cross-border R&D projects (*e.g.* ICT technologies), and major policy changes (*e.g.* strengthening of intellectual property rights) have all favoured this trend.

■ In the early 2000s, most economies have become more strongly involved in cross-border inventive activity. In particular, the share of foreign inventions in patents owned by domestic companies more than doubled in Sweden, Finland, Brazil and India. This climb seems to coincide with a stronger global economic presence. A significant rise is also reported for France, where the share increased from 11 to 21% in 2001-03.

■ Patents filed at the EPO show that domestic ownership of inventions made abroad is particularly high in small open economies. In Luxembourg more than 80% of inventions owned were made with inventors abroad and more than 30% in Ireland, Switzerland, Singapore, the Netherlands, Belgium and Sweden. Japan, Korea, Spain and Italy report the weakest share of inventions made abroad (less than 10%).

■ As regards the main locations, more than 50% of inventions with cross-border ownership in 2001-03 were made with inventors located in EU countries, twice the number of inventions made with US inventors.

■ The breakdown by country shows that geographical and cultural proximity matters in the choice of location. EU countries own inventions in other EU countries more frequently than in other locations; when intra-EU location excluded, the United States is the leading location.

■ Non-EU countries (Canada, Singapore, Israel, India, Korea and Japan) own more patents with US inventors than with EU inventors. The exceptions are Brazil and South Africa which report more patents with inventors located in EU countries. China shows a more even distribution of domestic ownership across regions while Russia prefers other countries as main location.

Source

- OECD, Patent database, April 2007, available at: *www.oecd.org/sti/ipr-statistics*.

Further reading

- Guellec, D. and B. Van Pottelsberghe de la Potterie (2001), "The internationalisation of technology analysed with patent data", *Research Policy*, 2001, Vol. 30, Issue 8, 1253-1266.

Patents as indicators of globalisation of science and technology (S&T) activities

Domestic ownership of inventions made abroad indicator evaluates the extent to which domestic firms control inventions made by residents of other countries. It refers to patents that are the property of a country, but have at least one inventor located in a foreign country by the total number of domestic applications.

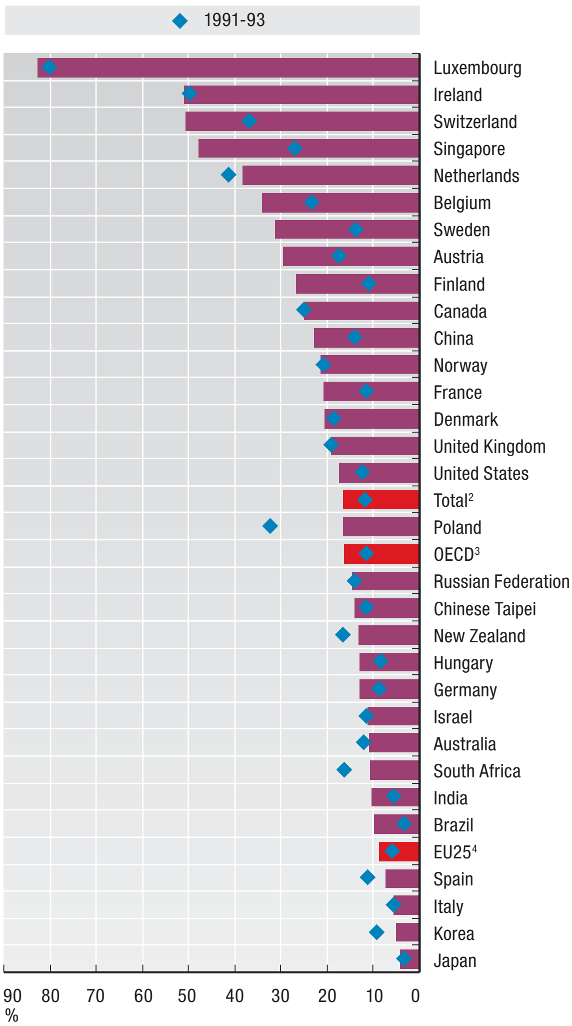
As indicated in patents applications at the European Patent Office (EPO) and the United States Patent and Trademark Office (USPTO), an increasing share of patent applications is owned or co-owned by applicants whose country of residence is different from the country of residence of the inventor(s). The growing cross-border ownership of inventions basically reflects two motivations of globalisation of S&T activities by companies (Guellec and van Pottelsberghe de la Potterie, 2001): the need to adapt products and processes to host markets ("asset-exploiting" strategies) and to acquire new knowledge ("asset-seeking" strategies). The latter is influenced not only by the access to specific foreign knowledge but also by cost differentials in the production of technology.

The use of patent indicators to measure globalisation of technology is not without shortcomings. Most of the caveats have to do with limitations on the proper identification of companies' country of origin. One concerns the financial content of the cross-border ownership. A patent invented abroad may mean an acquisition or merger rather than the setting up of a R&D laboratory. Patent databases do not register such changes in the ownership of patents. A second problem concerns the origin of subsidiaries. In some cases, the owner country reported may be not the country in which the company's headquarters are located but that of the subsidiary in charge of management of international intellectual property. In other cases, the company owing the invention may be the subsidiary and the address reported that of the host country (and not that of the headquarters). Domestic ownership of foreign inventions will be lower than it should be and for inventor countries, foreign ownership will also be underestimated.

G.2. DOMESTIC OWNERSHIP OF INVENTIONS MADE ABROAD

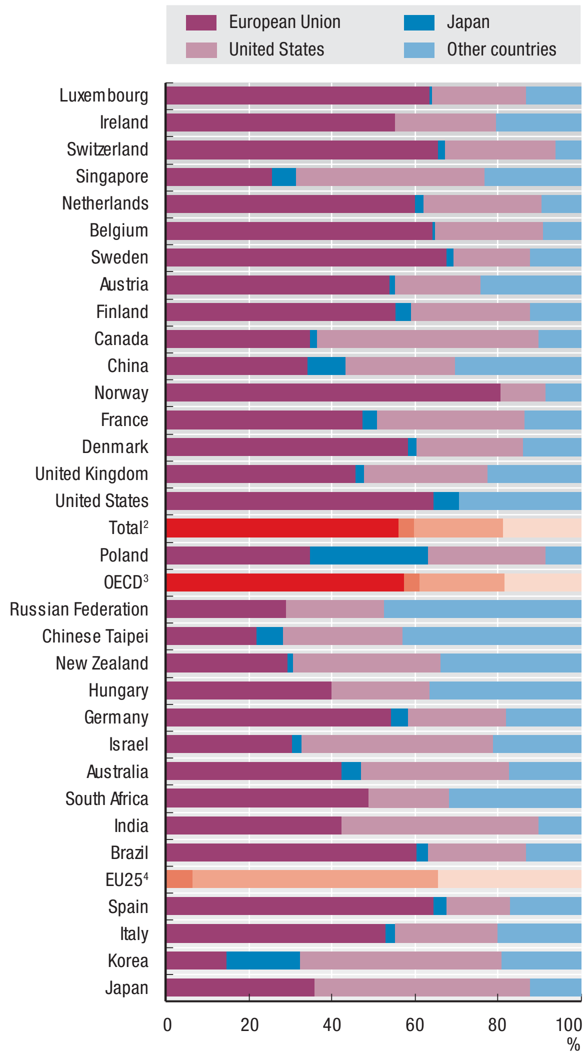
Domestic ownership of inventions made abroad[1]

2001-03



Domestic ownership of inventions made abroad[1]

Partner in the three major regions, 2001-03



StatLink http://dx.doi.org/10.1787/118572281248

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

1. Share of patent applications to the European Patent Office (EPO) invented abroad in total patents owned by country residents. This graph only covers countries/economies with more than 200 EPO applications over 2001-03.
2. All EPO patents that involve international co-operation.
3. Patents of OECD residents that involve international co-operation.
4. The EU is treated as one country; intra-EU co-operation is excluded.

G.3. INTERNATIONAL CO-OPERATION IN RESEARCH

■ International co-operation is a particular aspect of the globalisation of research activities. The world share of patents involving international co-invention increased from 4% in 1991-93 to 7% in 2001-03.

■ The extent of international co-operation differs significantly between small and large countries. Small and less developed economies engage more actively in international collaboration. Co-invention is particularly high in Luxembourg (52%), Mexico (48%), Russia (46%), Singapore (41%), the Czech Republic (40%) and Poland (39%). This reflects these countries' need to overcome limitations due to the size of internal markets and/or the lack of the infrastructure needed to develop technology.

■ For their part, large countries, such as the United States, the United Kingdom, Germany and France, report international co-operation of between 12 and 23% in 2001-03. These countries report also the greatest expansion in the extent of international collaboration. In France, for instance, it increased from 8% in 1991-03 to 16% in 2001-03.

■ Korea and Japan have the smallest shares of international co-invention. Korea, China, India and Turkey all report a contraction of more than 20% in international co-invention. However, while the intensity of international collaboration has decreased dramatically in Korea (35%), it has increased to an important extent in Japan (28%).

■ The breakdown of collaboration by main partner country reveals patterns similar to those reported for cross-border ownership: EU countries collaborate essentially with other EU countries, whereas Canada, Mexico, India, China, Israel, Korea and Japan collaborate most frequently with the United States. For instance, more than 20% of inventions made in India, Canada and Mexico are collaborations with a US inventor. Brazil and South Africa collaborate more with EU inventors.

Source

- OECD, Patent database, April 2007, available at: *www.oecd.org/sti/ipr-statistics.*

International co-invention as measured by patents

Co-Invention of patents is an additional measure of the internationalisation of research. It constitutes an indicator of formal R&D co-operation and knowledge exchange between inventors located in different countries. International co-invention is the number of patents invented by a country with at least one foreign inventor as a share of the total of patents invented domestically.

As there are differences in researchers' specialisation and knowledge in different countries, they often need to seek competences or resources beyond their national borders. International collaboration can take place either within a multinational corporation (with research facilities in several countries) or through a joint venture among several firms or institutions (*e.g.* universities or public research organisations). For multinational corporations, international collaboration frequently reflects companies' strategies to integrate geographically dispersed knowledge (*e.g.* within the multinational network) and/or to develop complementarities with foreign inventors (firms or institutions) in the production of technology.

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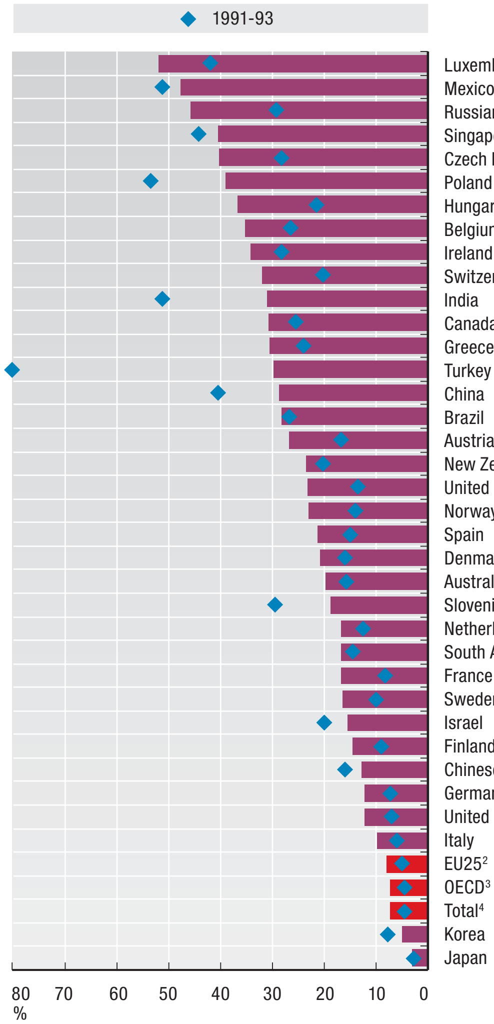
G.3. INTERNATIONAL CO-OPERATION IN RESEARCH

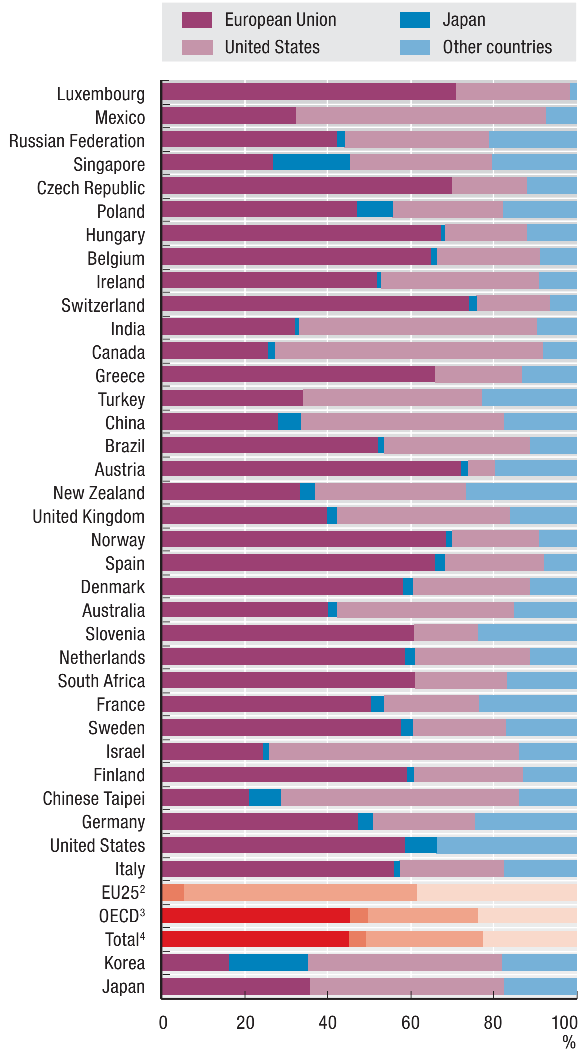
Patents with foreign co-inventors[1]

2001-03



Patents with foreign co-inventors[1]

Partner in the three major regions, 2001-03



StatLink http://dx.doi.org/10.1787/118647740467

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

1. Share of patent applications to the European Patent Office (EPO) with at least one foreign co-inventor in total patents invented domestically. This graph only covers countries/economies with more than 200 EPO applications over 2001-03.
2. The EU is treated as one country; intra-EU co-operation is excluded.
3. Patents of OECD residents that involve international co-operation.
4. All EPO patents that involve international co-operation.

G.4. SOURCES OF R&D FUNDING FROM ABROAD

The sources of funding of business enterprise R&D may be national or foreign and originate from private business, public institutions (governmental and higher education) or international organisations. As defined in the *Frascati Manual*, R&D funding from abroad includes, for instance, R&D performed by foreign affiliates when funded by the (foreign) parent company but excludes it when funded internally.

On average, R&D funding from abroad plays quite an important role in the funding of business R&D. In EU27, it represented around 10% of total business enterprise. The weight of foreign multinationals in the economy and domestic production of technology seem to matter in this respect. For the United Kingdom, Austria, Greece, Hungary and South Africa, funds from abroad represented 15% of total business enterprise R&D funding in 2005. In China, Korea, Japan and Turkey, they represented less than 3%.

In most countries, the financing of business enterprise R&D from abroad comes mainly from other business enterprises. In a group of 12 countries for which data are available, only Portugal, Greece and Turkey reported more than 50% of sources from abroad from international organisations (namely the European Union). The Czech Republic was the only country reporting more than 20% of finance from abroad originating from other governments and foreign higher education institutions.

As regards business sources, for countries for which data are available, more than half of funding from abroad is intra-company funding. It represented more than 80% in the Netherlands and Denmark, and 50% in Sweden and Norway, with 20% originating from non-affiliated foreign companies.

Source

- OECD, R&D database, May 2007.

For further reading

- OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, OECD, Paris, available at: *www.oecd.org/sti/frascatimanual*.

Sources of funds: measurement methods

R&D is an activity involving significant transfers of resources between units, organisations and sectors. In order to better measure and evaluate innovation policies and globalisation, it is important to trace the flow of R&D funds. According to the *Frascati Manual* (2002), these transfers may be measured in two ways.

One is *performer-based reporting* of the sums which one unit, organisation or sector has received or will receive from another unit, organisation or sector for the performance of intramural R&D during a specific period. Funds received for R&D performed during earlier periods or for R&D not yet started should be excluded from the sources of funds reported for the specific period.

The second is *source-based reporting* of extramural expenditures which are the sums a unit, organisation or sector reports having paid or committed itself to pay to another unit, organisation or sector for the performance of R&D during a specific period. The first of these approaches is strongly recommended.

For such a flow of funds to be correctly identified, two criteria must be fulfilled:

- There must be a direct transfer of resources.
- The transfer must be both intended and used for the performance of R&D.

For further details on the identification of these criteria, see the *Frascati Manual* (2002), OECD.

As far as possible, the following sources of funds from abroad should be identified in R&D surveys:

- Business enterprise sector (enterprises within the same group and other enterprises).
- Other national governments.
- Private non-profit.
- Higher education.
- EU, and international organisations.

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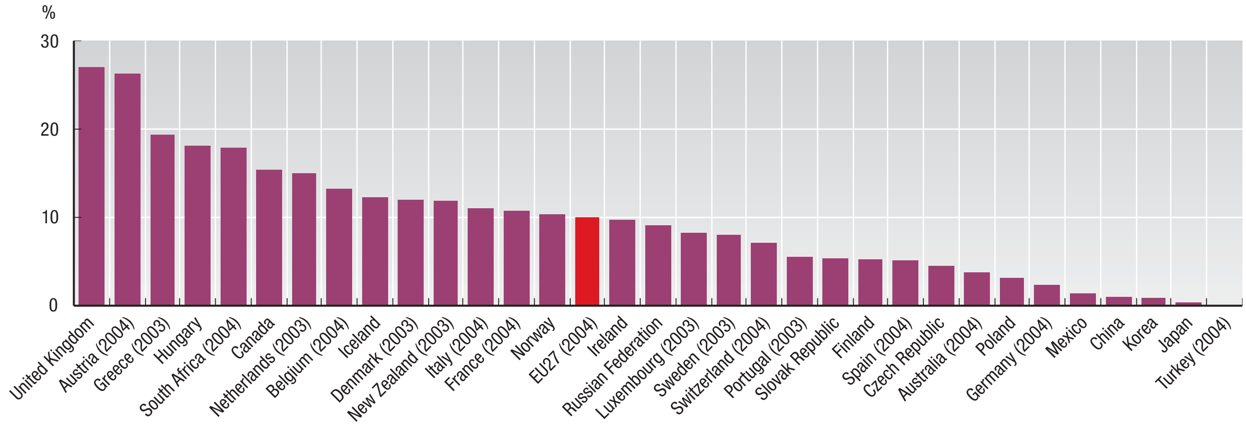
G.4. SOURCES OF R&D FUNDING FROM ABROAD

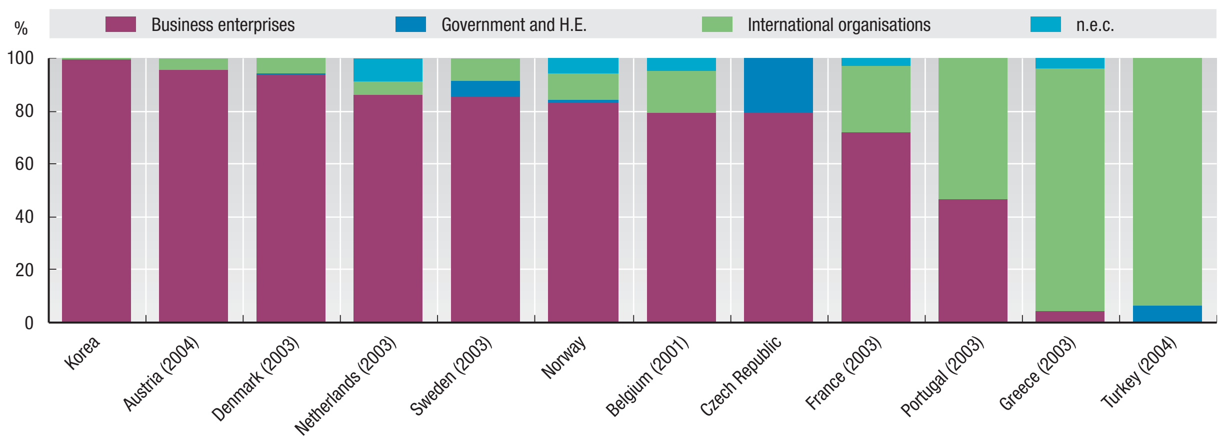
Funds from abroad

As a percentage of business enterprise R&D, 2005



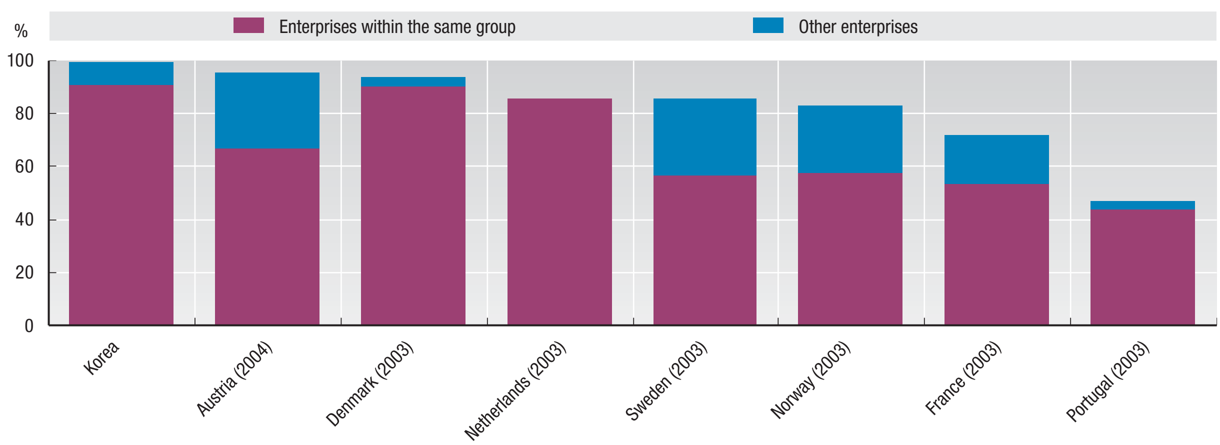
Business enterprise R&D funded from abroad

By source, 2005



Funding from foreign enterprises

As a percentage of funds from abroad, 2005



StatLink http://dx.doi.org/10.1787/118655512744

G.5. INTERNATIONAL COLLABORATION IN SCIENCE

■ Authorship indicators are a measure of collaboration in science. Here, four types of authorship of scientific articles are analysed: single, single-institutional, domestic and international. These indicators show how knowledge is shared or diffused among researchers and how the forms of collaboration in science are changing.

■ Collaboration among researchers in a single institution was a major form of collaborative research until the end of the 1990s. The number of single-institutional co-authorships has been quite constant over the last two decades.

■ Co-authorship, both domestic and international, has grown in importance over the past decade. Domestic co-authorship, *i.e.* collaboration among researchers of different institutions in the same country, has been increasing rapidly. It surpassed the share of single-institutional co-authorships in 1998 and has since been the most common form of collaboration in science.

■ International co-authorship has been growing as fast as domestic co-authorship. In 2005, 20.6% of scientific articles involved international co-authorship, a figure three times higher than in 1985. Increases in domestic and international co-authorship point to the crucial role of interaction among researchers in order to diversify their sources of knowledge.

■ Groups are a vital unit of knowledge creation in modern science. The number of authors of a scientific article is an indicator that shows the changes in scientific collaboration. In 1981, some three-quarters of all scientific articles had three or fewer authors. In 2005, 40% of scientific articles had five or more authors.

■ The degree of international collaboration varies across countries. Large European countries (France, Germany and the United Kingdom) conduct more collaborative work than the United States and Asian countries. Further, the ratio of international co-authorship has increased over the past decade, except in China where it has been almost constant.

■ Diversification of sources of knowledge through collaboration seems important in cutting-edge and multidisciplinary research fields such as nanoscience and bioscience. The indicator of international co-authorship in bioscience is shown in F.5 and in nanoscience in F.7.

Source

- National Institute of Science and Technology Policy in Japan, Science and Technology Indicators – Data updated in 2006 for 5th edition, June 2006.

Co-authorship as an indicator of collaboration in science

Four types of authorship of scientific articles are analysed in this section: single authorship, single-institutional co-authorship, domestic co-authorship and international co-authorship. The analysis was based on the Science Citation Index on CD-ROM (1985-2005) provided by Thomson Scientific and analysed by the National Institute of Science and Technology Policy in Japan.

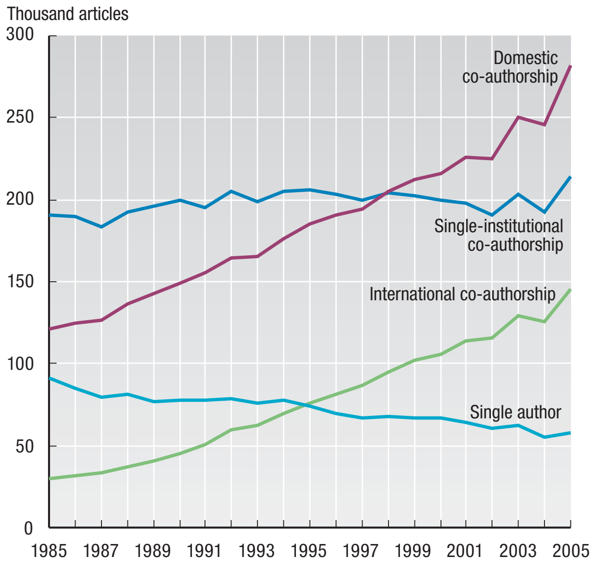
Single authorship measures scientific papers authored by a single author. Single-institutional co-authorship measures scientific papers authored by two or more authors of the same institution. Domestic co-authorship measures scientific articles authored by two or more authors of different institutions in the same country. International co-authorship measures scientific articles authored by two more authors of different countries.

Indicators of co-authorship highlight language barriers and geographical factors. However, these obstacles have diminished as English has become the language most commonly used internationally among researchers. Furthermore it seems to be reasonable to think that physical distance between researchers has some correlation with the ratio of co-authorship, although the effect of information and communication technology on knowledge flows has undoubtedly facilitated distance collaboration.

G.5. INTERNATIONAL COLLABORATION IN SCIENCE

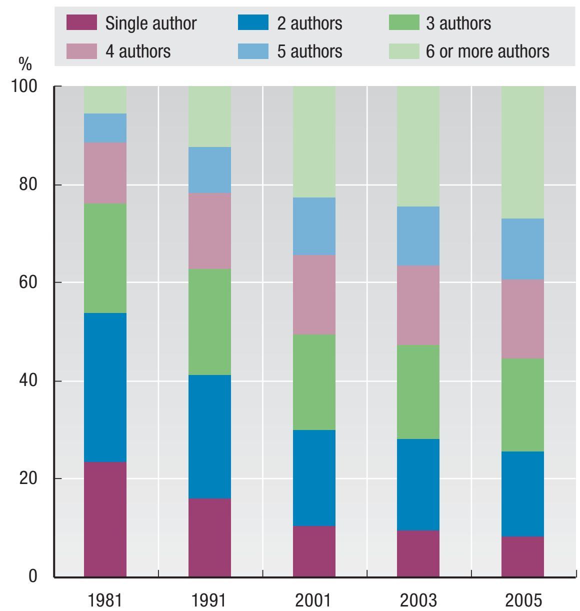
Change in authorship of scientific articles[1, 2]

1985-2005



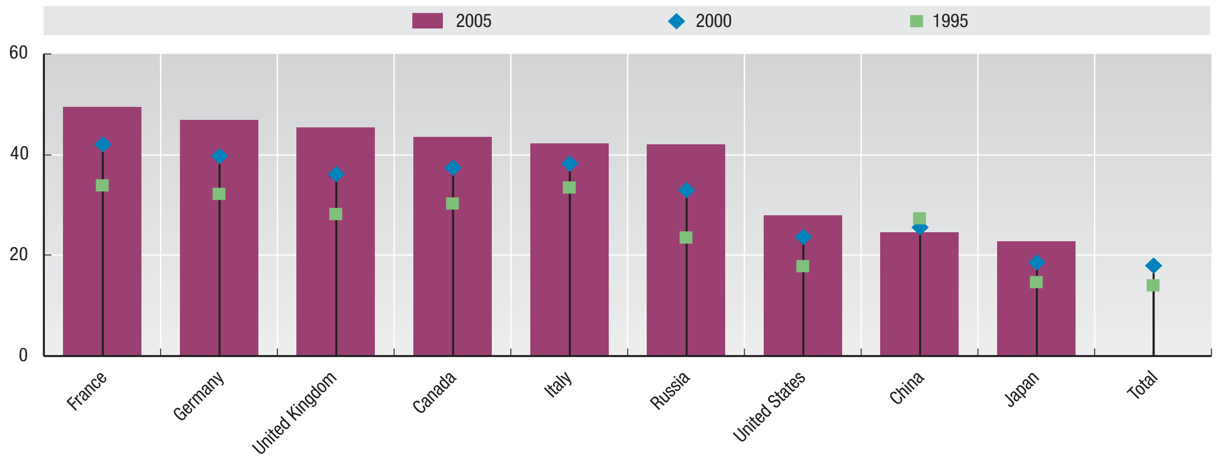
Trends in the authorship pattern in scientific articles[1, 2]

1981, 1991, 2001, 2003, and 2005



Trends in the ratio of internationally co-authored scientific articles by country[1, 2, 3]

Share in total articles, 1995, 2000, and 2005



StatLink http://dx.doi.org/10.1787/118733537462

1. Only scientific articles of natural science were analysed.
2. Analysis was conducted based on Science Citation Index on CD-ROM [1985-2005]; provided by Thomson Scientific; analysed by National Institution of Science and Technology Policy in Japan.
3. Data are only available for selected countries.

G.6. INTERNATIONALISATION OF R&D

■ As more multinationals set up offshore R&D laboratories, R&D activities in many OECD countries are becoming more internationalised and more closely linked to production abroad. Still, there remain differences in the shares of foreign affiliates in total R&D manufacturing expenditure as compared to their shares in total manufacturing turnover. In most countries, the share of foreign affiliates in total R&D is higher than their part in total manufacturing turnover, which suggests that research is now more internationalised than production.

■ R&D performed abroad and by foreign affiliates represents on average well over 16% of total expenditure on industrial R&D in the OECD area. In most OECD countries, the share of foreign affiliates in industrial R&D is increasing. In Spain, the United Kingdom, Sweden, the Czech Republic, Hungary, Portugal and Ireland, this share currently exceeds 35%.

■ However, not all activities related to R&D are recorded in company transactions. There are other intra-company transfers (e.g. intra-company mobility of researchers) with no monetary counterparts that result in R&D efforts that do not appear in the statistics as R&D spending by foreign affiliates.

■ The share of foreign affiliates in industrial R&D varies widely across countries, ranging from less than 5% in Japan to over 60% in Hungary and Ireland. At over 40%, the share of R&D conducted by foreign affiliates is also high in the Czech Republic, Portugal and Sweden.

■ The share of foreign affiliates in R&D also reflects the size of their R&D effort relative to that of domestic firms. In 2004, foreign affiliates in many countries carried out relatively more R&D than national firms. The intensity of R&D (as a share of turnover) by foreign affiliates was notably higher than that recorded by domestic companies in Japan, Sweden, the United States and the United Kingdom. In France, where domestic companies' average R&D intensity was less than 0.5% of turnover, for affiliates under foreign control it was superior to 1.6%. In Finland, Ireland and Poland the opposite is true. This largely reflects the industrial mix of foreign affiliates relative to domestic firms.

Source

- OECD, AFA database, April 2007.

For further reading

- OECD (1998), *Internationalisation of Industrial R&D: Patterns and Trends*, OECD, Paris.
- OECD (2005), *Handbook on Economic Globalisation Indicators*, Chapter 4, OECD, Paris, available at: *www.oecd.org/sti/measuring-globalisation*.
- OECD (2005), *Economic Globalisation Indicators*, OECD, Paris.

The internationalisation of industrial R&D

The marked growth in R&D expenditures in OECD countries from the first half of the 1980s was accompanied by two major trends:

- First, the growing internationalisation of R&D activities of multinational firms linked to an increase in the number of R&D laboratories located abroad.
- Second, the emergence and development of international networks of co-operation agreements or alliances either between firms or between firms and government or university R&D bodies.

While the first of these trends is restricted to multinationals, the second characterises all innovation-intensive firms. The decentralisation of R&D activities by multinational firms, *i.e.* the establishment of laboratories outside the home country of the parent company, is by no means a new phenomenon. Decentralised R&D facilities have been used for some time to serve and support overseas production units. Until recently, owing to the absence of data on the R&D activities of multinationals, it was thought that internationalisation of R&D was fairly marginal to the general process of economic globalisation.

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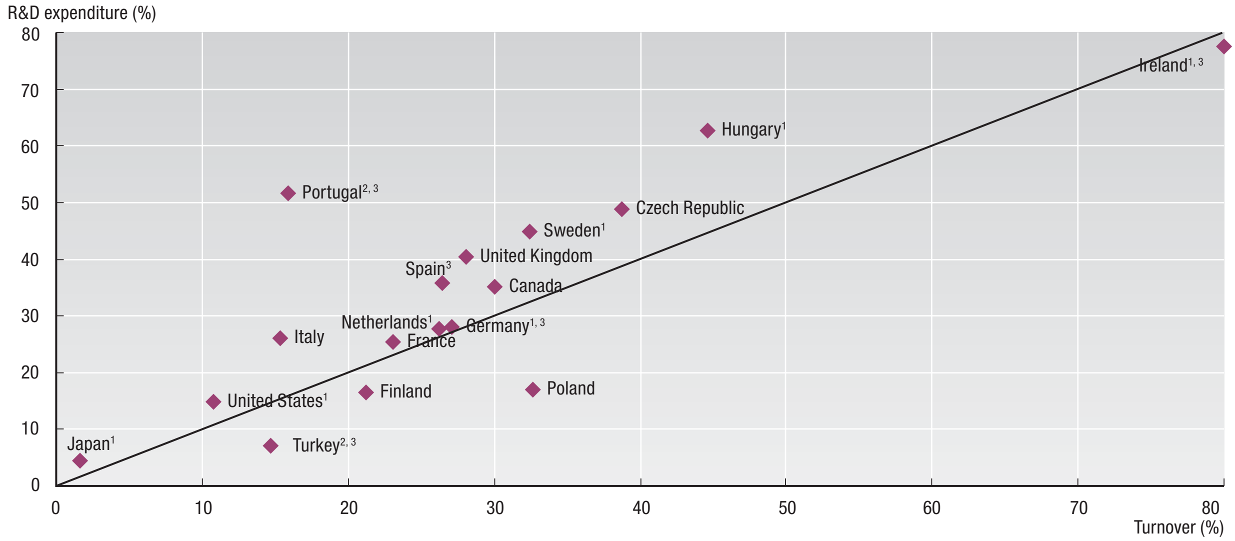
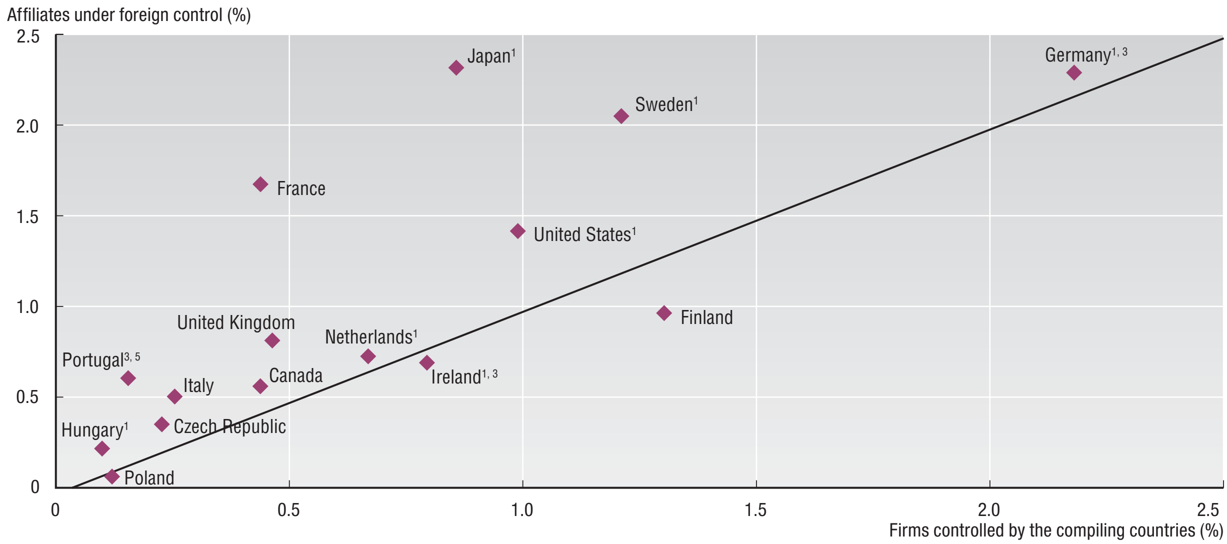
Share of R&D expenditure and turnover of affiliates under foreign control in total R&D and turnover, 2004



R&D intensities[4] of affiliates under foreign control and firms controlled by the compiling countries, 2004



StatLink http://dx.doi.org/10.1787/118755763637

1. 2003.
2. 2001.
3. Manufacturing sector only.
4. R&D intensity=R&D expenditures/turnover. Portugal: 2002; Germany, Hungary, Ireland, Japan, the Netherlands, Sweden, and the United States: 2003. Germany, Ireland, Portugal: manufacturing sector.
5. 2002.

G.7. FOREIGN COLLABORATION ON INNOVATION

■ Collaboration with foreign partners can play an important role in the innovation process by allowing firms to gain access to a broader pool of resources and knowledge at a lower cost as well as sharing the risks with their partners.

■ In the case of European firms, the share of those collaborating with partners in a different country *within* Europe ranges from less than 2% in Italy and Spain, to more than 12% in Denmark, Luxembourg, Finland and Belgium.

■ Collaboration with partners *outside* Europe is much less frequent, concerning only between 1 and 5% of all firms in most European countries.

■ For firms in other regions, the propensity to collaborate on innovation with partners abroad varies widely between countries, ranging from less than 2% of all firms in Korea, Japan and Australia, to more than 8% in Canada and New Zealand.

■ The percentage of all firms that rely on foreign collaboration when innovating can be broken down into: the overall innovation rate and the propensity of innovating firms to collaborate with foreign partners (see box). Results for intra-European collaboration on innovation show that differences across countries are mainly explained by differences in how frequently innovators had foreign partners, rather than differences in overall innovation rates.

■ In Germany, despite a high overall innovation rate (65% of all firms), foreign collaboration on innovation was very low (less than 5% of innovative firms), resulting in a foreign collaboration of only 3%, below the European average of 4.1%.

■ Innovating firms from the Nordic countries as well as some smaller open European economies (*e.g.* Luxembourg, Belgium, the Czech Republic) tend to collaborate more frequently with partners abroad.

Sources

- Eurostat, CIS-4 (New Cronos), May 2007.
- National data sources.

For further reading

- Australian Bureau of Statistics (ABS) (2006), *Innovation in Australian Business, 2005*, 8158.0, December
- Eurostat (2007), "Community Innovation Statistics – Is Europe growing more innovative", Statistics in Focus, 61/2007.
- OECD/Eurostat (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 3rd edition, Paris.
- Statistics New Zealand (2007), *Innovation in New Zealand – 2005*, January.

Foreign collaboration in innovation

Collaboration on innovation with foreign partners is an important source of knowledge inflows. It can take a variety of forms with different levels of interaction ranging from simple one-way information flows to highly interactive and formal arrangements. These types of linkages allow firms to access a broader pool of inputs (*e.g.* information, technologies, human or financial resources) than what they can find within their local environment. Collaboration with foreign customers or suppliers can also help firms in the development of new products, processes or other innovations.

In a given country X, the propensity of firms to collaborate with partners abroad ($Collab_X$) in their innovation activities can be broken down into two effects:

- The overall innovation rate for the country: IR_X = number of innovating firms / all firms.
- The intensity of foreign co-operation on innovation: IFC_X = number of firms with foreign co-operation / number of innovating firms.

$Collab_X = IR_X \times IFC_X$ = number of firms with foreign co-operation / all firms

This allows for identifying two effects, each of which provides useful information. Countries X and Y may have a similar overall propensity to collaborate on innovation with foreign partners ($Collab_X \approx Collab_Y$), but while country X has a low overall innovation rate (IR_X) and a high intensity of foreign co-operation among innovators (IFC_X), country Y displays the opposite trend. The policy implications for these two countries may be quite different: country X may focus on measures targeted at non-innovative firms, while country Y may focus on facilitating foreign linkages for its innovative firms.

When comparing an individual country (country X) to the EU average (see Figure G.7.2), the following calculation is performed:

- Innovation rate effect (X) = $(IFC_X - IFC_{EU}) \times IR_X$; and
- Intensity of foreign cooperation effect (X) = $(IR_X - IR_{EU}) \times IFC_{EU}$.

The sum of these 2 effects = $Collab_X - Collab_{EU}$.

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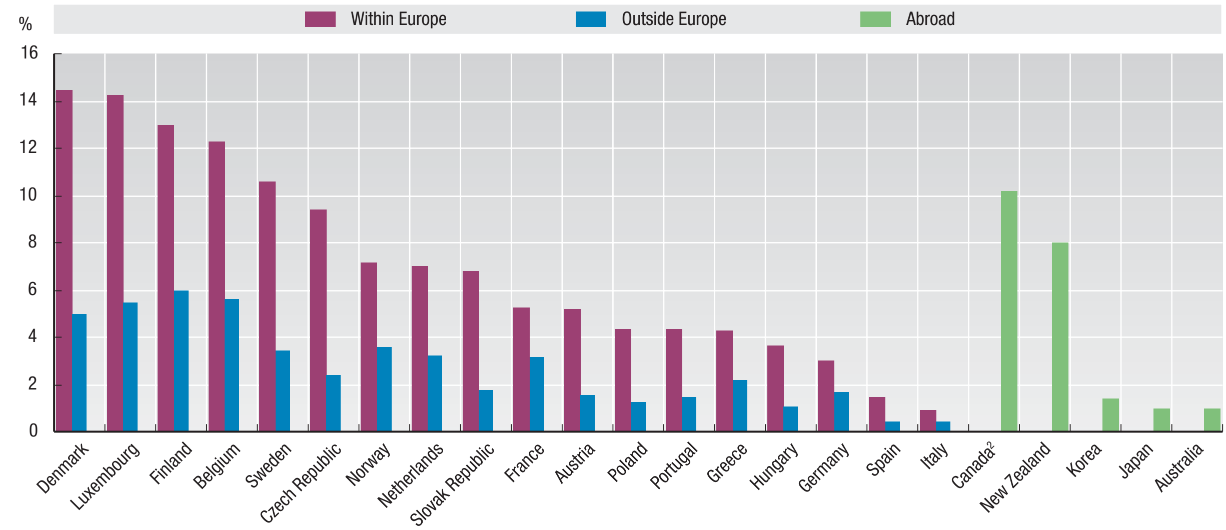
G.7. FOREIGN COLLABORATION ON INNOVATION

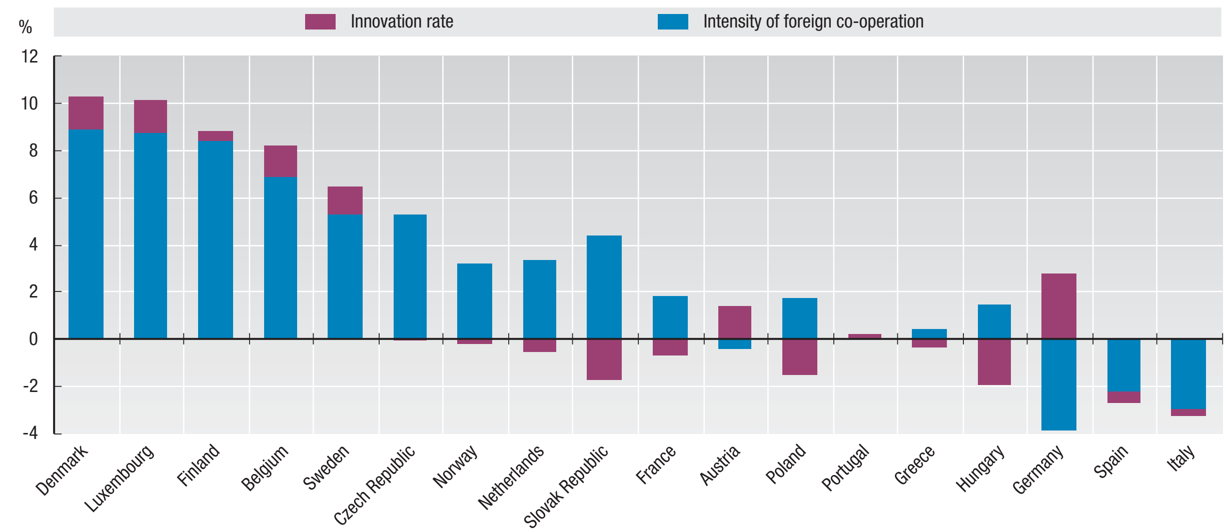
Firms with foreign co-operation on innovation, 2002-04[1]

As a percentage of all firms



Foreign co-operation on innovation within Europe, 2002-04[1]

Deviation from European average[3] in percentage points



StatLink http://dx.doi.org/10.1787/118810438408

1. Or nearest available years.
2. Manufacturing sector only.
3. As explained in the box, this figure breaks down the percentage of foreign collaborators in total firms into two effects: the overall innovation rate (innovators as a percentage of all firms) and the intensity of foreign collaboration (foreign collaborators as a percentage of innovators), and compares them for each country to the EU average (where the foreign collaboration rate of 4.1% can be broken down into 39% and 10.6% respectively). For example, for Denmark, where the difference from the European average is 10.3% (*i.e.* 10.3% + 4.1% = 14.4% of all firms co-operated with foreign partners within Europe), the figure shows that most of this is due to the high intensity of foreign collaboration among innovators.

H. GLOBAL ECONOMIC FLOWS

H.1. TRENDS IN INTERNATIONAL TRADE AND INVESTMENT FLOWS

■ In the dynamic, multidimensional process of globalisation, national economies integrate their activities and internationalise through various channels: trade in goods and services, capital and labour flows, transfer of production facilities and/or technology.

■ Such economic linkages are not new, but the intensity and multiplicity of transactions have accelerated over the past decade, making the economic implications of globalisation harder to quantify.

■ More advanced information and communication technology, lower transport costs, firms' strategies regarding location and the need to exploit technological and organisational advantages world wide, liberalisation of trade and financial flows, etc., have all contributed to speed up the globalisation process.

■ Financial transactions (portfolio investment, direct investment, other investment) have been the fastest-growing segment of international transactions. The surge in direct investment and portfolio investment was especially significant in the second half of the 1990s and has continued to rise since then.

■ Such investment flows have also proved highly volatile. Portfolio investment, for instance, declined in the early 1990s, tripled between 1995 and 1999, declined again between 1999 and 2002 and from 2002 showed a significant increase. For its part, foreign direct investment rose sharply from 1997, declined between 2000 and 2003 but increased after 2003.

■ The lowering of transport costs and of tariff and non-tariff barriers has contributed to the steady rise in international trade. The share of trade in international transactions has remained high, averaging 18% of OECD GDP during 2001-05.

■ In terms of the composition of international trade, the share of trade in goods is more than three times that of trade in services.

Sources

- OECD, Annual National Accounts database, June 2007.
- IMF, Balance of Payments Statistics, June 2007.

For further reading

- OECD (2005), *Measuring Globalisation – OECD Handbook on Economic Globalisation Indicators*, OECD, Paris, available at: *www.oecd.org/sti/measuring-globalisation*.
- OECD (2005), *Measuring Globalisation – Economic Globalisation Indicators*, OECD, Paris.

Main components of international trade and investment

Trade in goods and services. Data relating to trade in goods and services correspond to each country's exports to, and imports from, the rest of the world. These data are collected to determine the balance of payments. Data relating to international trade in goods are also collected in customs surveys, but are generally not systematically comparable to balance of payment data. Since trade data need to be compared with data on international investment, the balance of payments has been chosen as source data to ensure comparability of trade and investment data.

Foreign direct investment. Foreign investment is defined as being "direct" if the foreign investor holds at least 10% of the ordinary shares or voting rights in the firm in which the investment is made. This 10% threshold means that the direct investor is able to influence and participate in the management of a firm but does not necessarily have complete control.

Portfolio investments. In cases where the foreign investor holds less than 10% of the capital (ordinary shares or voting rights) of a firm, the investment is considered to be a "portfolio investment". This type of investment usually corresponds to "short-term" investments for which the investor does not intend to influence the management of the firm.

Investment income. This covers receipts and payments on external financial assets and liabilities, including receipts and payments on portfolio investment, direct investment and other investments, and receipts on reserve assets.

Other investment. This is a residual category that covers all financial transactions not covered by direct investment, portfolio investment or reserve assets. It includes trade credits, loans, currency and deposits, and other assets and liabilities.

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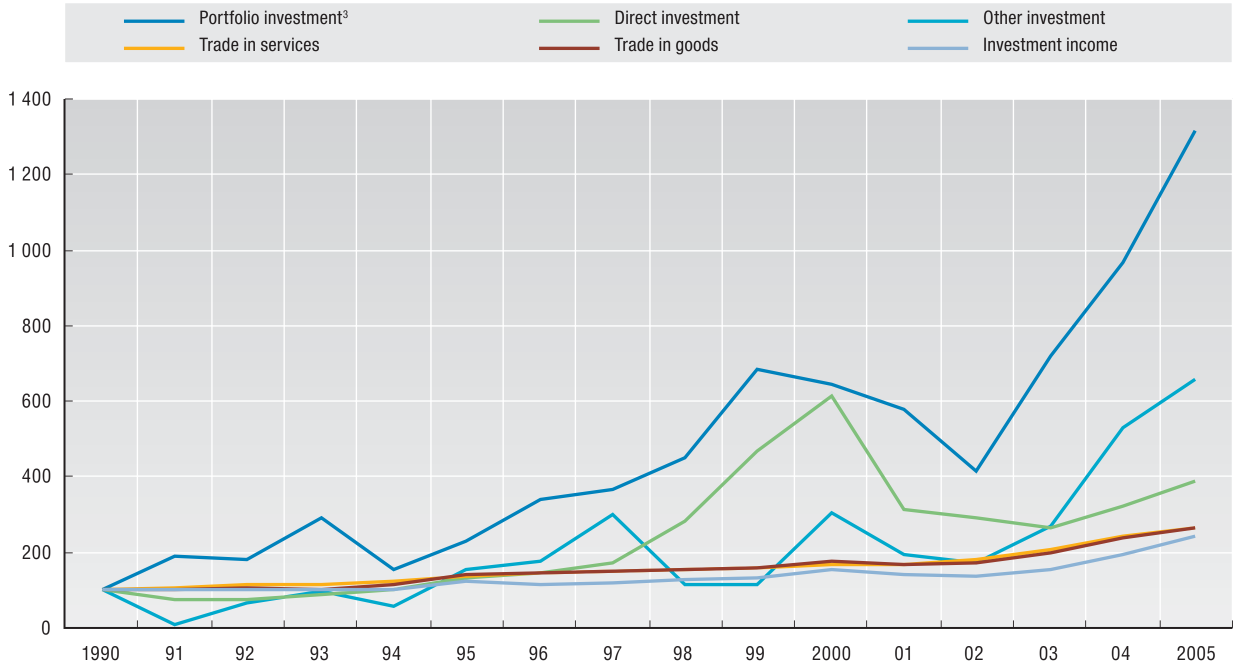
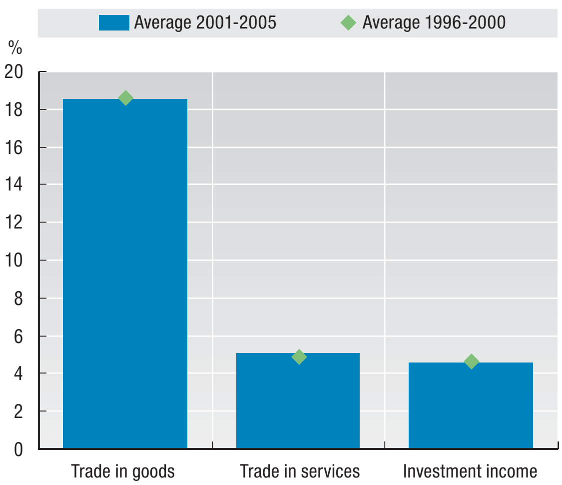
Trends in international trade and investment components,[1] OECD[2]

1990 = 100, current prices



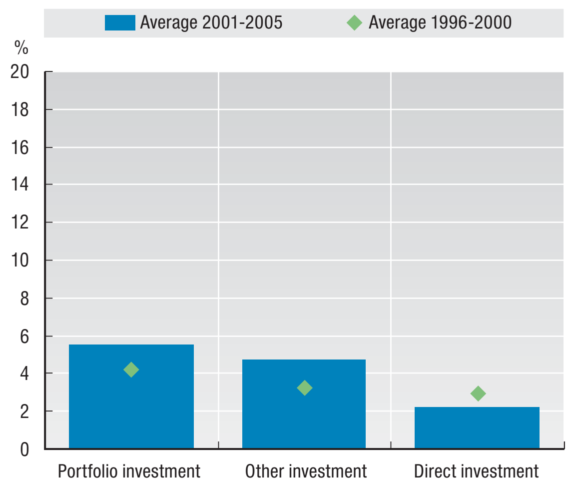
Main components of the current account, OECD,[4] average 2001-05

As a percentage of GDP,[5] gross basis



Main components of the financial account, OECD,[4] average 2001-05

As a percentage of GDP,[6] net basis



StatLink http://dx.doi.org/10.1787/118812734807

1. Average imports + exports or average assets + liabilities.
2. OECD excludes the Czech Republic 1990-92, Greece 1998, the Slovak Republic 1990-92, 2001, 2004 and 2005.
3. Excluding financial derivatives.
4. Excluding the Slovak Republic in 2001, 2004 and 2005.
5. Imports + exports divided by 2 and by GDP.
6. Assets + liabilities (in absolute terms) divided by 2 and by GDP.

H.2. INTERNATIONAL TRADE

A country's international trade in goods and services reflects its integration into the world economy. In relation to GDP, small countries are generally more integrated. They tend to specialise in a limited number of sectors and they need to import and export more goods and services than larger countries in order to satisfy domestic demand. Size alone, however, does not determine the level of trade integration.

The average ratio of exports and imports to GDP, in constant prices of 2005, increased between 1995 and 2005 in all OECD countries. In 2005, it was over 150% in Luxembourg and very high in the Slovak Republic, Hungary, Ireland, Belgium, the Netherlands and the Czech Republic. In contrast, it was less than 13% in the United States and 11% in Japan, owing in part to their larger size.

Traditionally, international trade in goods has been the principal channel for economic integration. Over the past 20 years, however, other forms of transactions have become increasing prevalent (*e.g.* foreign direct investment, portfolio investment) as firms increasingly implement global strategies and capital movements are liberalised.

In 2005, the average trade-to-GDP ratio of goods in the OECD area was 19.4%, up from 13.3% in 1995, an increase very similar to that in total trade.

As a share of GDP in 2003, average trade in services in the OECD area only accounted for around 4.7% of GDP. Luxembourg and Ireland had the highest values. In Luxembourg, financial services played a dominant role in exports, and in Ireland, technology payments were a very important component of total imports.

Source

- OECD, National Accounts database, June 2007.

For further reading

- OECD (2005), *Measuring Globalisation – OECD Handbook on Economic Globalisation Indicators*, OECD, Paris, available at: *www.oecd.org/sti/measuring-globalisation*.
- OECD (2005), *Measuring Globalisation – Economic Globalisation Indicators*, OECD, Paris.

The trade-to-GDP ratio

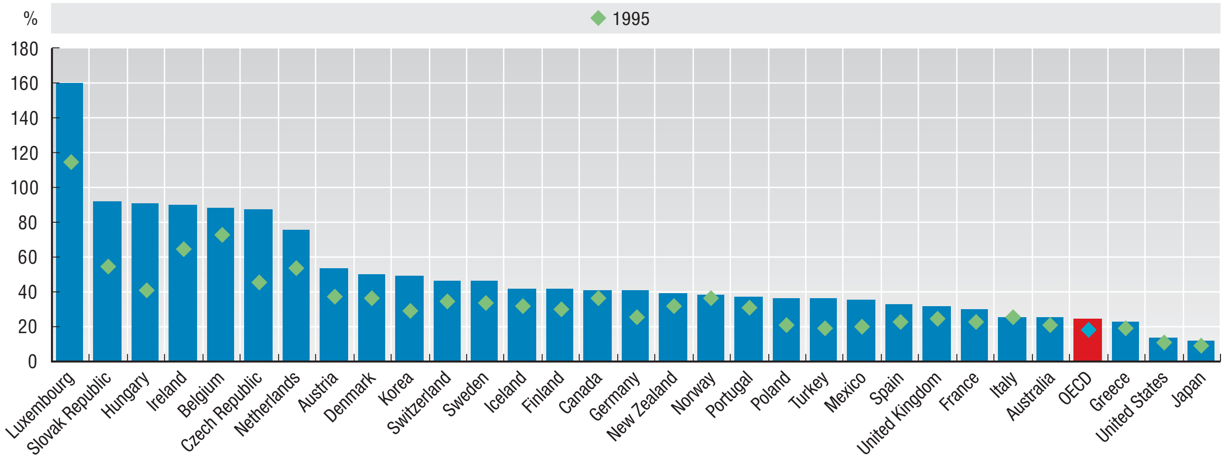
The most frequently used indicator of the importance of international transactions relative to domestic transactions is the trade-to-GDP ratio, which is the average share of exports and imports of goods and services in GDP.

International trade tends to be more important for countries that are small (in terms of size or population) and surrounded by neighbouring countries with open trade regimes than for large, relatively self-sufficient countries or those that are geographically isolated and thus penalised by high transport costs. Other factors also help explain differences in trade-to-GDP ratios across countries, such as history, culture, (trade) policy, the structure of the economy (especially the weight of non-tradable services in GDP), re-exports and the presence of multinational firms (intra-firm trade).

The trade-to-GDP ratio is often called the trade openness ratio. However, the term "openness" to international competition may be somewhat misleading. In fact, a low ratio does not necessarily imply high (tariff or non-tariff) obstacles to foreign trade, but may be due to the factors mentioned above, especially size and geographic remoteness from potential trading partners.

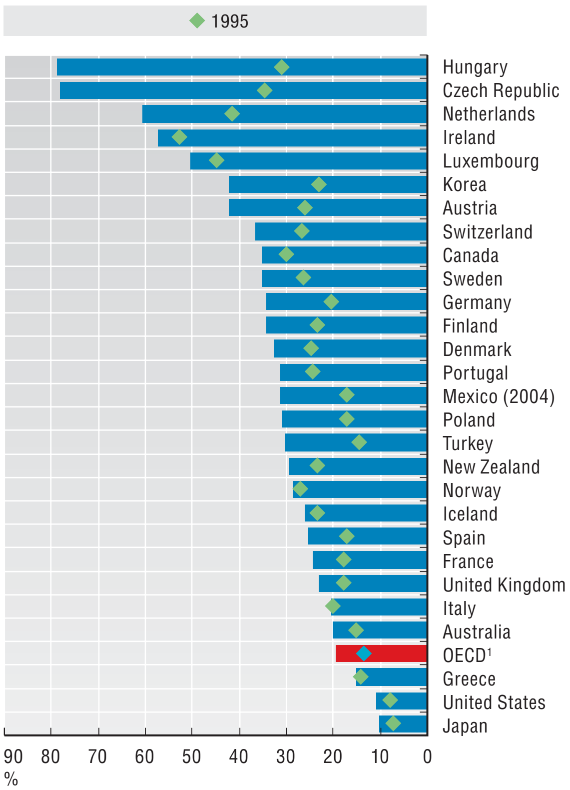
Total exports and imports, 2005

Average, as a percentage of GDP



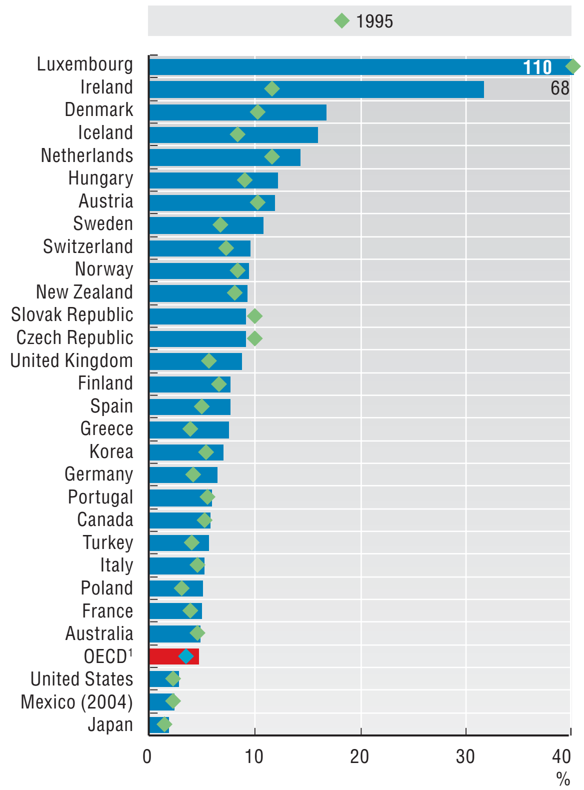
Exports and imports of goods, 2005

Average, as a percentage of GDP



Exports and imports of services, 2005

Average, as a percentage of GDP



StatLink http://dx.doi.org/10.1787/118835722530

1. As data for Belgium are not available it is excluded from the OECD total. Data for Mexico refer to 2004, which affects the OECD average.

H.3. INTRA-FIRM TRADE

■ The share of intra-firm exports in the total exports of manufacturing affiliates under foreign control ranges between 20 and 60% in the OECD countries for which such data are available.

■ While this proportion held steady in the United States and the Netherlands at around 50% throughout the 1990s and the beginning of 2000s, it rose sharply in Sweden (from 45 to 60%) and declined in Japan (from 45 to 20%). As a result, in 2003, only 40% of the exports of affiliates under foreign control in Sweden went to non-affiliated firms; the corresponding proportion in Japan was 80%.

■ In 2004, the countries for which the ratio of intra-firm trade of US parent companies was highest were Sweden, Switzerland and Singapore, with respect to exports, and Singapore, Ireland and Hong Kong (China), with respect to imports.

■ However, it must be borne in mind that ratios of intra-firm trade with partner countries, even if they attain substantial values, may account for only a small percentage of overall intra-firm trade. For example, in 2004, intra-firm imports from Canada accounted for less than 30% of aggregate US imports from Canada, as opposed to almost 56% of those from Singapore. However, in absolute value, intra-firm imports from Canada accounted for 37% of aggregate US intra-firm imports (*i.e.* 1.5 times the share of the European Union), while intra-firm imports from Singapore accounted for only 4.3%.

Sources

- OECD, AFA database, April 2007.
- OECD, ITS database, April 2007.

For further reading

- OECD (2005), *Measuring Globalisation - OECD Handbook on Economic Globalisation Indicators*, OECD, Paris, available at: *www.oecd.org/sti/measuring-globalisation*.
- OECD (2005), *Measuring Globalisation – Economic Globalisation Indicators*, OECD, Paris.

Measuring intra-firm trade

Intra-firm trade refers to trade between enterprises belonging to the same group and located in different countries. The ratio of intra-firm trade to total trade in countries that publish the relevant data is quite high. Once foreign investments have been made, these transactions reflect centralised decisions made as part of a group's global strategy.

A significant portion of intra-firm trade may reflect the fact that affiliates have a better understanding of local market demand. Parent corporations and other firms in the group often prefer to export to their own affiliates, which then sell the goods unchanged to local consumers. In fact, parent corporations could sell these products directly to local distributors, without involving their affiliates. It is difficult to determine whether such transactions would be less numerous if they did not pass through affiliates.

Four basic indicators are proposed: two for inward investment and two for outward investment.

Inward investment

Exports (X_F^{intra}) and imports (M_F^{intra}) by the foreign-controlled affiliates in compiling countries with parent companies and other affiliates located abroad to total exports (*X*) and imports (*M*) of the compiling countries

X_F^{intra} / X , M_F^{intra} / M

Outward investment

Exports (X_{out}^{intra}) and imports (M_{out}^{intra}) by parent companies in the compiling country with their affiliates abroad to total exports and imports:

X_{out}^{intra} / X , M_{out}^{intra} / M

These indicators might also be calculated in terms of total exports and imports of these firms, and by industrial sector and by country of origin and destination.

In the case of imports by affiliates under foreign control in host countries and by parent companies in compiling countries, it would also be very useful to distinguish between imports destined for use in their own production, those resold as same-state goods on the domestic market and those re-exported, either in the same state or after further processing.

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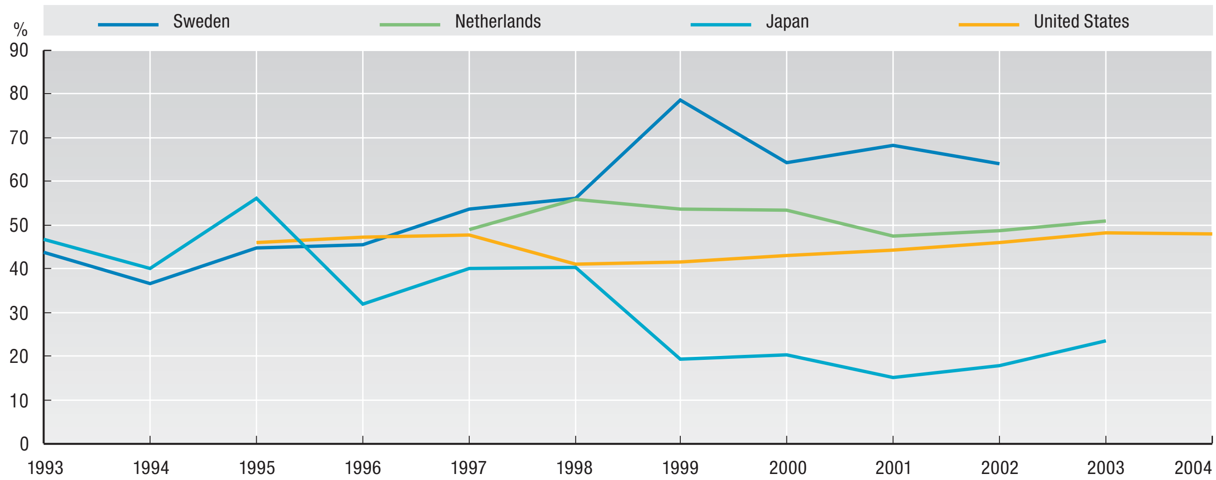
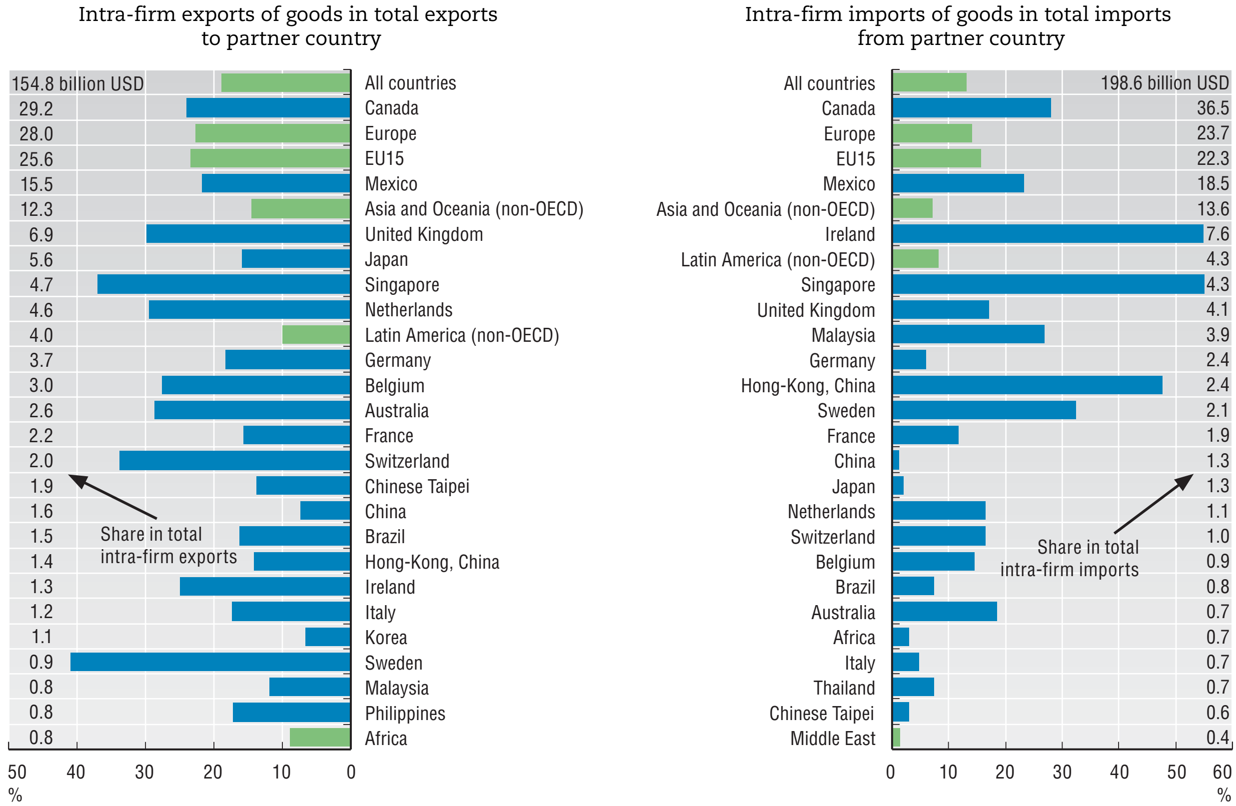
Share of intra-firm exports in total exports of affiliates under foreign control (inward investment),[1] 1993-2004



US intra-firm trade in goods from outward investment, 2004



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1. The US data also include minority-controlled affiliates. For the United States, Japan and the Netherlands, trade in goods only.

H.4. FOREIGN DIRECT INVESTMENT FLOWS

Flows of direct investment as a percentage of GDP help measure the relative importance of globalisation by relating an economy's direct investment to its level of economic activity.

In absolute terms, the United States is both the largest foreign investor and the largest recipient of foreign direct investment (FDI) in the OECD area. However, when measuring FDI as a share of GDP, its relative importance appears in a different light. In 2005, the United States occupied, on average, the third position among G7 countries, after the United Kingdom and France.

Some OECD countries have relatively high ratios for both inward and outward flows of FDI. In the Benelux countries, for example, some of these flows are largely due to the activities of special purpose entities and holding companies established by multinationals to finance and manage their cross-border investment. Owing to the methodology currently used for FDI statistics, a significant share of the transactions of such entities is included in FDI statistics.

Ireland, Sweden, Belgium, Switzerland, the Netherlands and Iceland invest on average 6% or more of their GDP in non-resident enterprises. At the same time, the Slovak Republic, the Netherlands, Iceland, the Czech Republic and Belgium receive FDI corresponding on average to more than 6% of their GDP.

Source

- OECD, International Investment database, May 2005.

For further reading

- OECD (2005), *Measuring Globalisation – OECD Handbook on Economic Globalisation Indicators*, OECD, Paris, available at: *www.oecd.org/sti/measuring-globalisation*.
- OECD (2005), *Measuring Globalisation – Economic Globalisation Indicators*, OECD, Paris.

Foreign direct investment capital transactions

Direct investment flows are transactions between a direct investor in one economy and a direct investment enterprise in another economy, and among affiliated direct investment enterprises that are in a direct investment relationship, other than those that are resident in the same economy. Direct investment flows are recorded on a directional basis: *i)* as resident direct investment abroad (outflows); or *ii)* non-resident direct investment in the reporting economy (inflows). Direct investment financial flows are composed of equity capital, reinvested earnings (and undistributed branch profits) and other capital.

Equity capital comprises: *i)* equity in branches; *ii)* all shares in subsidiaries and associates (except non-participating preference [preferred] shares, which are treated as debt securities and included under direct investment, other capital); and *iii)* other capital contributions, including non-cash acquisitions of equity (such as through the provision of capital equipment).

Reinvested earnings and undistributed branch profits comprise, in proportion to equity held, direct investors' shares of earnings that foreign subsidiaries and associated enterprises do not distribute as dividends (reinvested earnings), and earnings that branches and other unincorporated enterprises do not remit to direct investors (undistributed branch profits).

Other capital: covers the borrowing or lending of funds between *i)* direct investors resident in one economy and their subsidiaries, branches, and associates resident in other economies, and *ii)* enterprises within a group of related direct investment enterprises that are resident in different economies. The instruments covered include loans, debt securities, suppliers' (trade) credits, financial leases, and non-participating preference [preferred] shares which are treated as debt securities.

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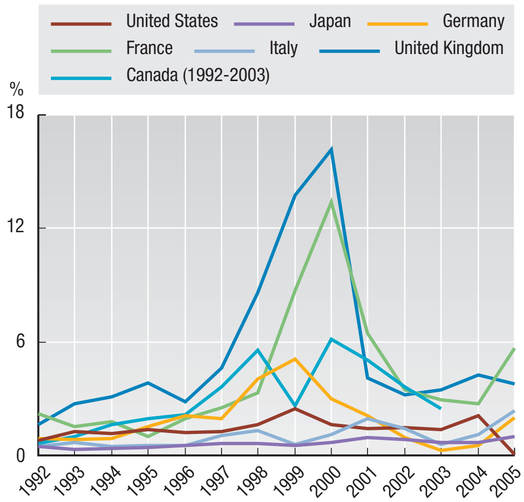
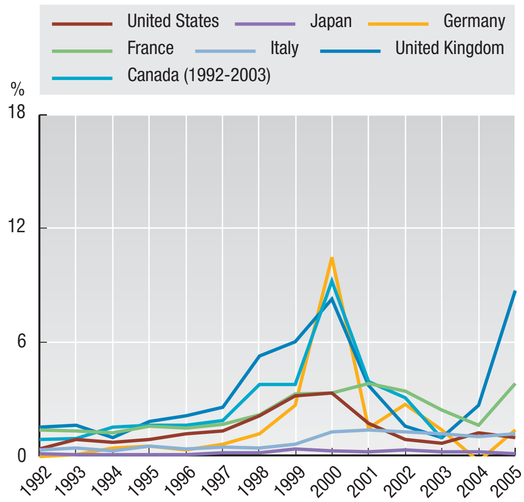
FDI outflows from G7 countries, 1992-2005

As a percentage of GDP



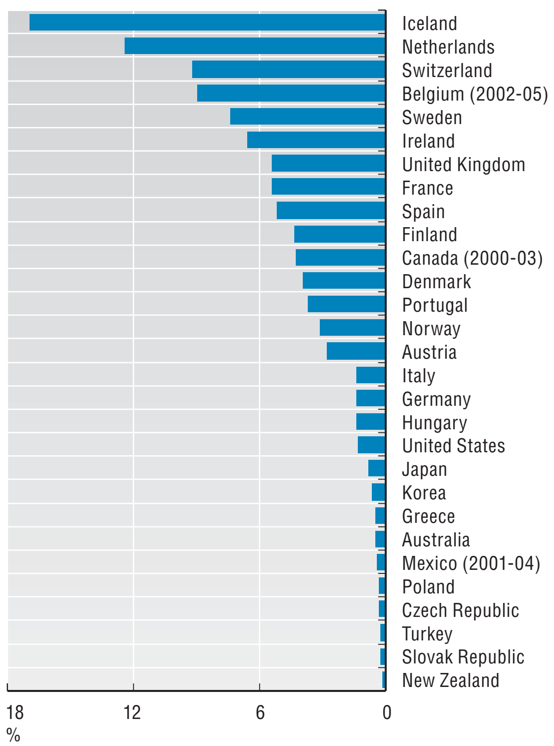
FDI inflows to G7 countries, 1992-2005

As a percentage of GDP



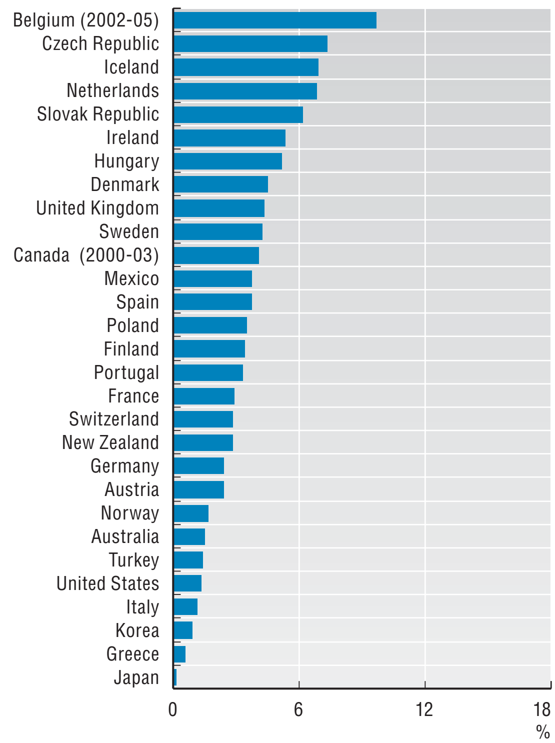
FDI outflows from OECD countries, average 2000-05

As a percentage of GDP



FDI inflows to OECD countries, average 2000-05

As a percentage of GDP



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H.5. ACTIVITY OF AFFILIATES UNDER FOREIGN CONTROL IN MANUFACTURING

■ The share of firms under foreign control in the total turnover of the manufacturing sector in 2004 varied from about 80% in Ireland to less than 3% in Japan. It exceeded 40% in Hungary, Canada, Belgium, the Czech Republic, Sweden, France, Poland, the Netherlands and the United Kingdom. In Japan, the penetration remained the lowest in the OECD area in spite of the rise in the level of production of firms under foreign control in recent years.

■ Employment under foreign control in OECD countries generally follows the same pattern as turnover except in terms of the share in total employment, which is lower because foreign direct investments are more capital- than labour-intensive. There are however differences among countries; for example, the share of turnover under foreign control is greater in the United Kingdom than in France while employment under foreign control is about the same in both countries.

■ It might be supposed that the main task of affiliates under foreign control is to meet local demand, with exports only a secondary objective. However, the vast majority export more than the average domestic firm. This is particularly true for manufacturing. In Ireland, for example, over 90% of the manufacturing output of foreign affiliates is exported, and in Sweden and Poland over half is exported.

■ Except in the United States, the import propensity of affiliates under foreign control is lower than their export propensity. In the United States, the trade balance of affiliates under foreign control is in deficit, as is the trade balance of manufacturing firms overall.

■ Since 1999, manufacturing employment in firms controlled from the compiling countries declined except in Spain and Hungary. On the other hand, employment in foreign affiliates rose in all countries except the United States, Portugal, France, Finland and Ireland. The generally rapid growth in employment and production of foreign affiliates in some countries, as compared with national firms, does not generally indicate the creation of new foreign affiliates. In most cases, it reflects changes of ownership owing to acquisitions.

Sources

- OECD, AFA and FATS databases, April 2007.

For further reading

- OECD (2005), *Measuring Globalisation – OECD Handbook on Economic Globalisation Indicators*, OECD, Paris, available at: *www.oecd.org/sti/measuring-globalisation*.
- OECD (2005), *Measuring Globalisation – Economic Globalisation Indicators*, OECD, Paris.

Foreign affiliates – the concepts of influence and control

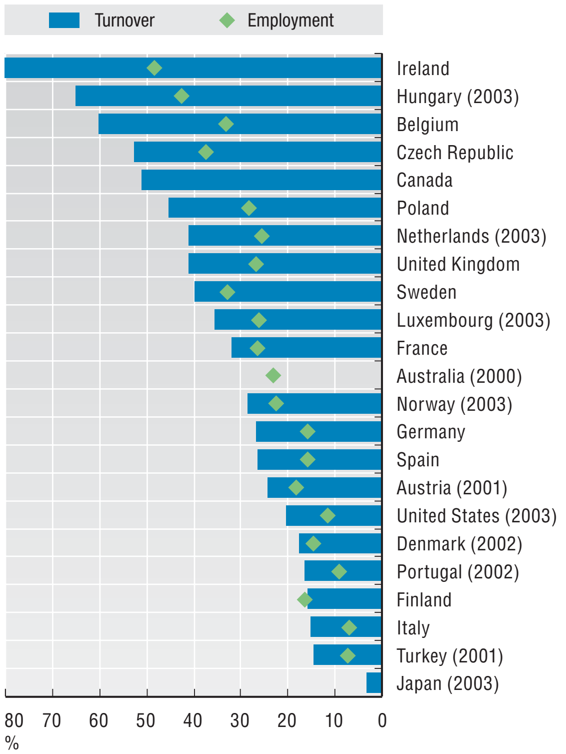
The basic criterion used to determine whether an investment is a direct investment is its capacity to exert "influence" on company management. The notion of influence is reflected, in statistical terms, in the holding of more than 10% of the ordinary shares or voting rights, while any investment below 10% is considered to be portfolio investment. The notion of influence is not sufficient to allow data on the activities of multinational enterprises to be collected in a coherent and operational manner, whence the need to resort to the notion of "control".

The notion of control implies the ability to appoint a majority of administrators empowered to direct an enterprise, to guide its activities and determine its strategy. In most cases, this ability can be exercised by a single investor holding more than 50% of the shares with voting rights. The notion of control allows all of a company's activities to be attributed to the controlling investor. This means that variables such as a company's turnover, staff or exports are all attributed to the controlling investor and the investor's country of origin.

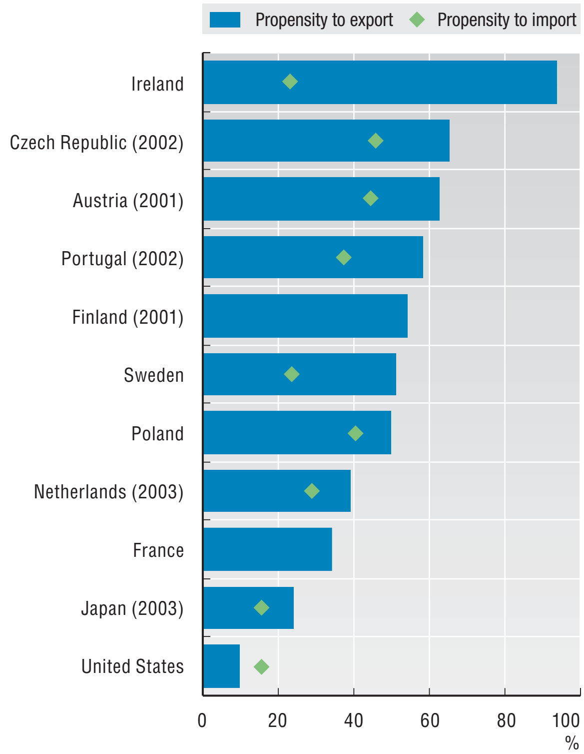
The term "foreign affiliate" is restricted to affiliates under foreign control that are majority-owned. Accordingly, the geographical origin of a foreign affiliate is the country of residence of the ultimate controller. An investor (company or individual) is considered to be the investor of ultimate control if it is at the head of a chain of companies and controls directly or indirectly all the enterprises in the chain without itself being controlled by any other company or individual.

H.5. ACTIVITY OF AFFILIATES UNDER FOREIGN CONTROL IN MANUFACTURING

Foreign-controlled affiliates' share of manufacturing turnover[1] and employment, 2004



Export and import propensity[2] of affiliates under foreign control in the manufacturing sector, 2004

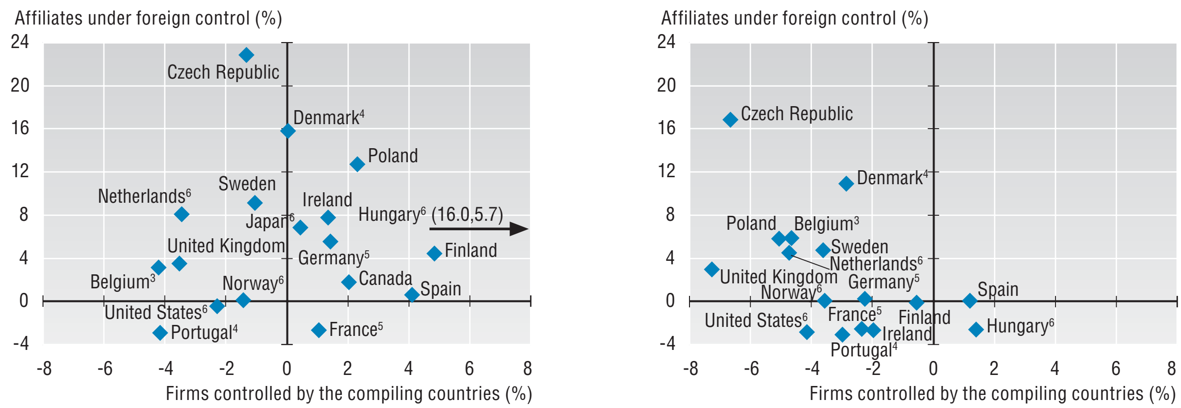


Turnover[1] and employment of manufacturing foreign affiliates and firms controlled from the compiling countries, 1999-2004

Average annual growth rate (%)

Turnover

Employment



StatLink http://dx.doi.org/10.1787/120008323248

1. Production rather than turnover for Canada and Ireland.
2. Exports and imports as a percentage of turnover (or production for Ireland).
3. 1997-2004.
4. 1999-2002.
5. 2002-2004.
6. 1999-2003.

H.6. ACTIVITY OF AFFILIATES UNDER FOREIGN CONTROL IN SERVICES

■ Collection of data on the activity of foreign affiliates in services did not start until the second half of the 1990s, and data are not yet available for all OECD countries. However, the growing availability of data confirms the increasing importance of foreign affiliates in the services sector.

■ The share of turnover under foreign control in the services sector is over 30% for Luxembourg, the Czech Republic, Ireland and Hungary. In terms of employment, the share of foreign affiliates ranges from more than 22% in the Czech Republic and Sweden, to less than 5% in Japan, Portugal and the United States.

■ In all countries except Finland and Luxembourg the share of turnover of foreign affiliates is greater for manufacturing than for services (see E.5). In terms of employment, penetration of foreign affiliates seems more evenly distributed between services and manufacturing in Finland, Italy, Portugal and Spain. The largest differences are in Belgium, Hungary, Ireland, the Netherlands and the Czech Republic.

■ In Japan and Finland, penetration of foreign affiliates is similar in services and manufacturing with respect to turnover, but the shares are quite low compared with those of other OECD countries.

Source

- OECD, Foreign Affiliates Trade in Services (FATS) database, June 2007.

For further reading

- OECD (2005), *Measuring Globalisation – OECD Handbook on Economic Globalisation Indicators*, OECD, Paris, available at: *www.oecd.org/sti/measuring-globalisation*.
- OECD (2005), *Measuring Globalisation – Economic Globalisation Indicators*, OECD, Paris.

Foreign affiliates – more on the concepts of influence and control

Data on the activity of multinationals use the notion of "control" to a greater degree than the notion of "influence". Influence implies attributing production, value added, the number of employees and other variables according to shareholders' percentage stakes in the enterprise, and it is the "financial" aspect that predominates. In the case of control, it is the "power to take decisions" and "decide corporate strategy" that does.

When control of all of an enterprise's economic variables is attributed to a single majority shareholder, this does not mean that the latter appropriates all of the enterprise's output or profits, but that it makes all of the strategic choices. Where a firm's activity is concerned, however, there are other reasons for taking a control-based approach. When there are numerous minority shareholders and when the chain of indirectly owned companies is also included, attributing the variables according to the principles of ownership becomes much more complicated. The difficulty is compounded when the investors' countries of residence have to be attached to these variables. (*Handbook on Economic Globalisation Indicators*, Chapter 3, § 297-301).

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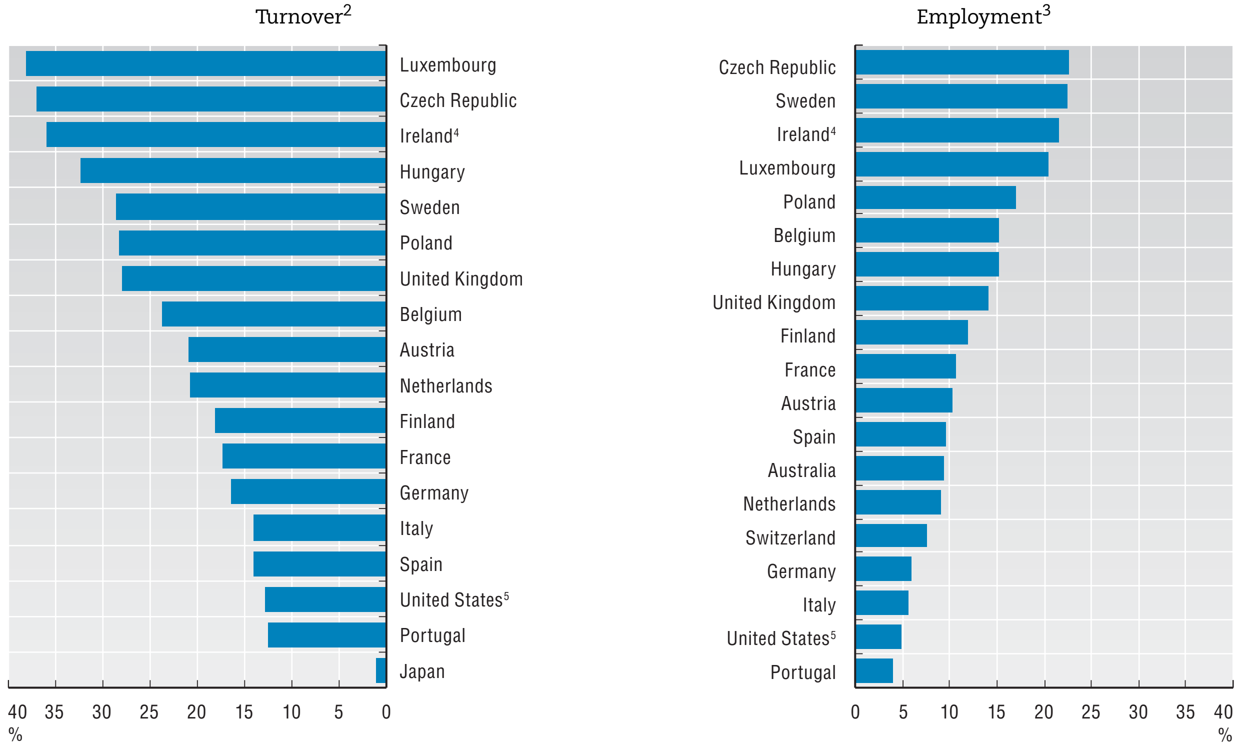
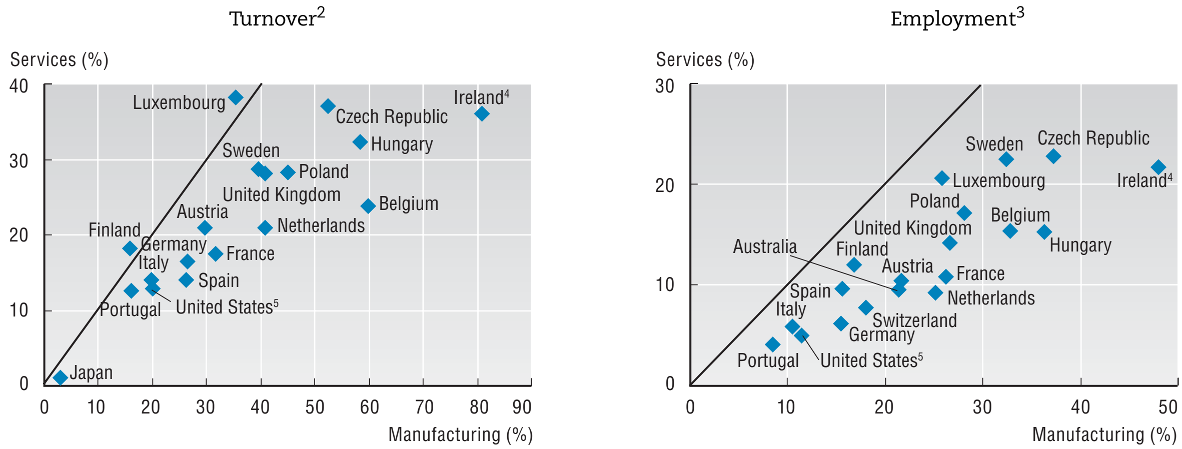
H.6. ACTIVITY OF AFFILIATES UNDER FOREIGN CONTROL IN SERVICES

Share of foreign affiliates in services, 2004[1]



Share of foreign affiliates in services and manufacturing sectors, 2004[1]



StatLink http://dx.doi.org/10.1787/120010681627

1. 2003 for Austria, Hungary, Italy, Japan, Luxembourg, the Netherlands and the United States; 2002 for Portugal; 2001 for Australia and Finland.
2. Turnover: Financial intermediation (ISIC 65 to 67) excluded completely or in part for all countries except Austria, the Czech Republic and France; Community, social and personal services (ISIC 80 to 93) excluded completely or in part for Austria, the Czech Republic, Germany, Portugal, Spain and the United Kingdom.
3. Employment: Financial intermediation (ISIC 65 to 67) excluded completely or in part for all countries except Australia, Austria, the Czech Republic, Finland, France, Luxembourg and Switzerland; Community, social and personal services (ISIC 80 to 93) excluded completely or in part for Austria, the Czech Republic, Germany, Portugal, Spain and the United Kingdom.
4. Enterprises with 20 employees or more.
5. The data used here for foreign affiliates are broken down by industry of sales to be compatible with total national data.

H.7. TRENDS IN EMPLOYMENT IN FOREIGN AFFILIATES

■ Between 1995 and 2003, employment in affiliates under foreign control in manufacturing in OECD countries increased by 17%. In the United States in 2003, employment in foreign affiliates in manufacturing accounted for more than 27% of total employment in such foreign affiliates in the OECD area, a decrease from its share in 1995.

■ During the same period in France, employment in affiliates under foreign control in manufacturing grew by 325 000, close to half the expansion reported in other OECD countries. Between 1995 and 2003, the United States is the only OECD country in which employment in this category fell substantially (by 164 000).

■ Between 1995 and 2004, in all selected OECD countries except Belgium, employment in foreign affiliates in services increased. The most important increase, of approximately 180 000, was observed in the Czech Republic. This may partly reflect the importance of interim enterprises in the services sector.

■ It is worth noting that these developments do not necessarily imply job creation but are often due to a change of ownership resulting from the acquisition of existing firms by foreign investors.

Sources

- OECD, AFA database and OECD estimates, April 2007.
- OECD, FATS database, June 2007.

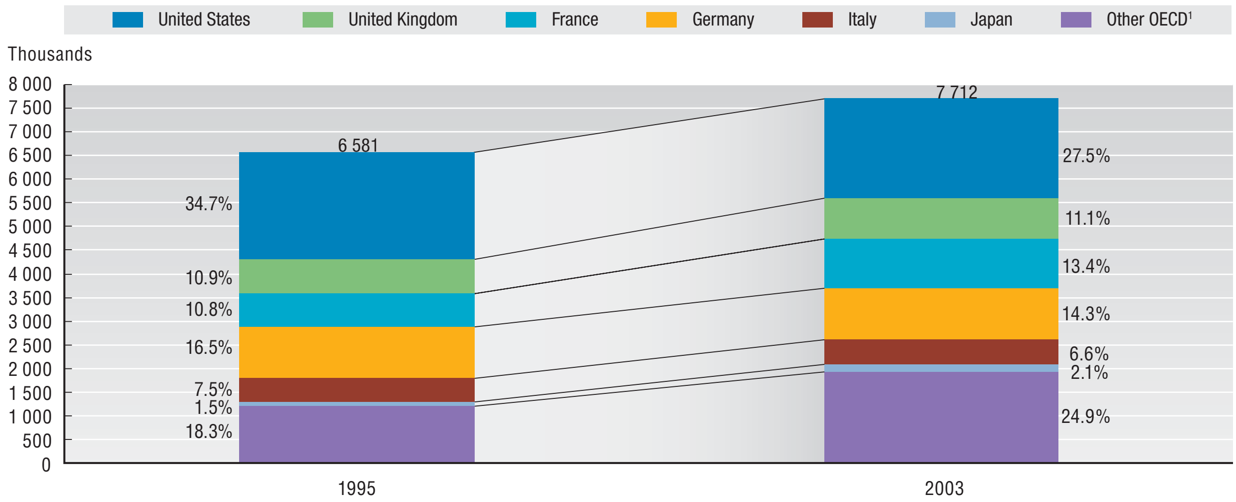
For further reading

- OECD (2005), *Measuring Globalisation - OECD Handbook on Economic Globalisation Indicators*, OECD, Paris, available at: *www.oecd.org/sti/measuring-globalisation*.
- OECD (2005), *Measuring Globalisation – Economic Globalisation Indicators*, OECD, Paris.

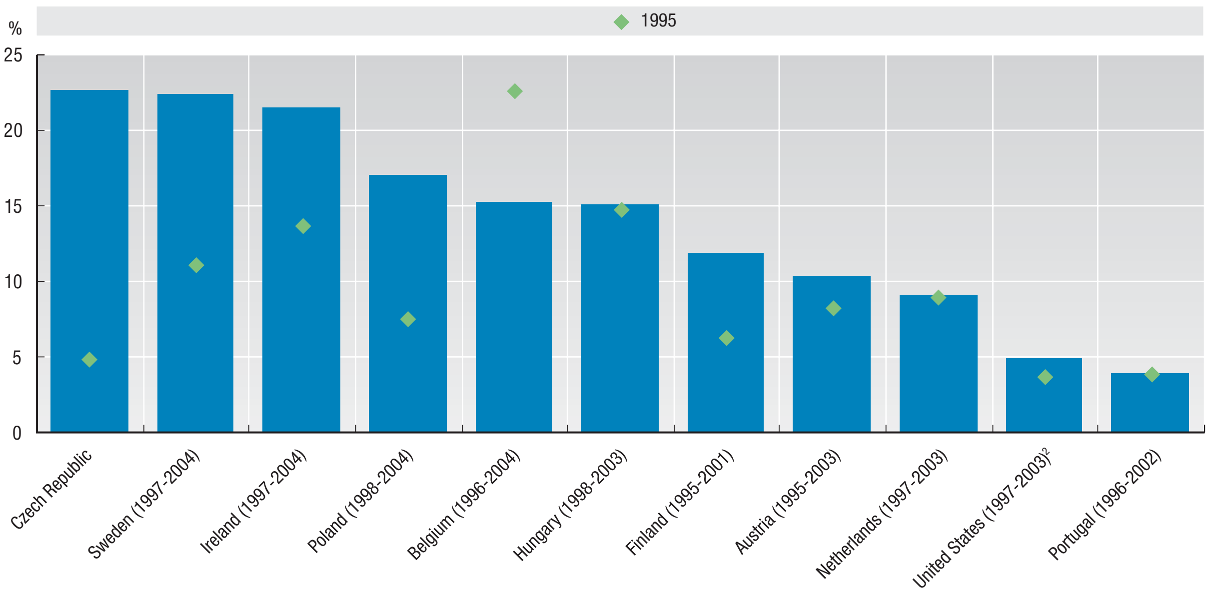
The share of foreign affiliates in employment

Employment should normally be measured as the number of persons on the payroll of affiliates under foreign control. Employment data are sometimes converted to a full-time equivalent (FTE) basis, with part-time workers counted according to time worked. Employment data can be used to determine the share of affiliates under foreign control in host country employment or to help determine the extent to which employment by affiliates under foreign control complements or substitutes for domestic (home country) employment by parent companies or other domestic firms. The share of affiliates under foreign control in host country employment may reflect the importance of foreign direct investment in maintaining or creating employment in a compiling country. However, this information is not sufficient for evaluating the net job creation due to foreign investment in the compiling countries.

Trends in manufacturing employment of foreign affiliates in selected OECD countries between 1995 and 2003



Share of foreign affiliates in services employment in selected OECD countries, 1995 and 2004



StatLink http://dx.doi.org/10.1787/120016500888

1. Consists of the Czech Republic, Hungary, Finland, Ireland, Luxembourg, the Netherlands, Norway, Poland, Portugal and Sweden.
2. The data used here for foreign affiliates are broken down by industry of sales to be compatible with national total data.

H.8. SHARE OF TURNOVER UNDER FOREIGN CONTROL IN SELECTED MANUFACTURING AND SERVICES SECTORS

■ The contribution of foreign affiliates to turnover differs considerably across countries and activities. In 2004, for example, foreign affiliates controlled more than 70% of the motor vehicle industry in Hungary, the Czech Republic, Poland, Canada and the United Kingdom. In France, Germany and Finland, foreign affiliates were responsible for less than 20% of total turnover in this industry. In the United States, more than 30% of turnover in motor vehicles was due to foreign affiliates in 2004.

■ In the computer manufacturing industry in 2004, more than 70% of total turnover was due to foreign affiliates in Ireland, the Czech Republic, Ireland and Hungary, while its share was less than 20% in the United States. Different patterns emerge in other manufacturing industries.

■ Similar data can be derived for the services sector, and they typically point to a more modest role for foreign affiliates in total turnover. In computer services, the share of foreign affiliates in total turnover was highest in the Czech Republic (45%), followed by Belgium (44%). Other countries where foreign affiliates had a relatively important role (with shares above 30%) include Spain, the United Kingdom, and Poland. In the United States Austria, Hungary and the Netherlands, foreign affiliates play a relatively minor role in overall turnover.

Sources

- OECD, AFA database, April 2007.
- OECD, FATS database, April 2007.

For further reading

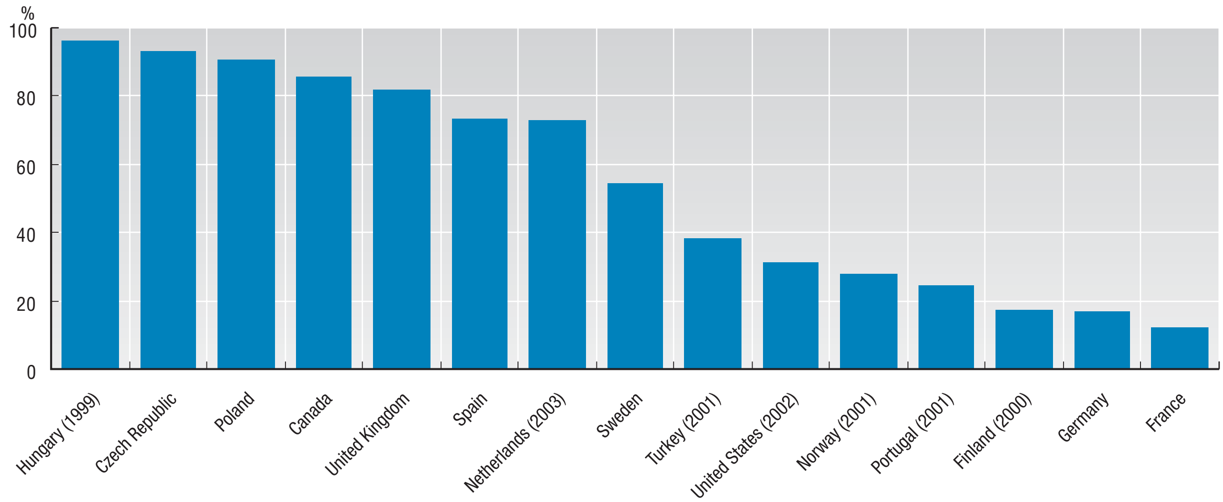
- OECD (2005), *Measuring Globalisation – OECD Handbook on Economic Globalisation Indicators*, OECD, Paris, available at: *www.oecd.org/sti/measuring-globalisation*.
- OECD (2005), *Measuring Globalisation – Economic Globalisation Indicators*, OECD, Paris.

The share of foreign affiliates in turnover

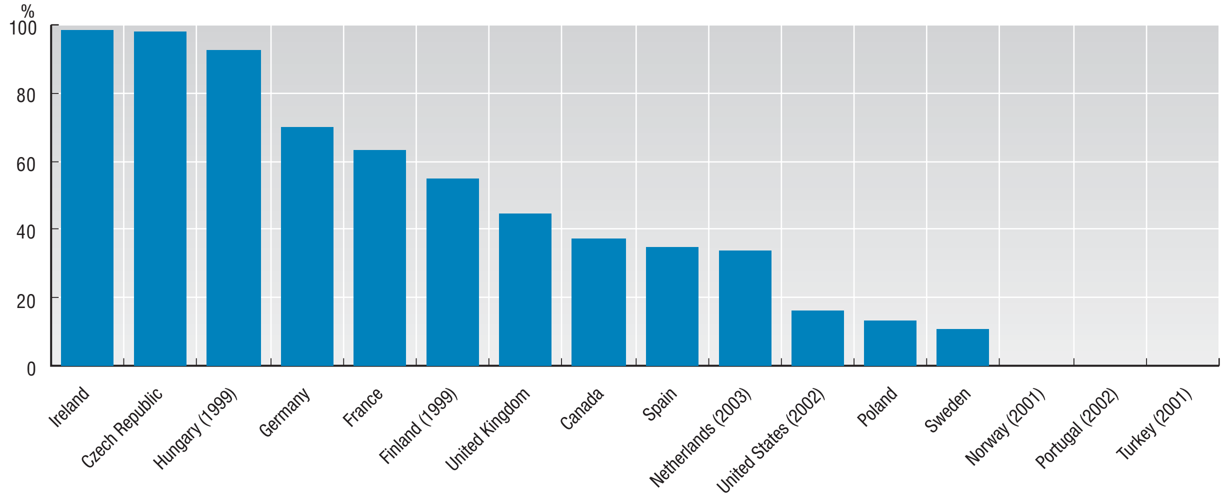
Output differs from turnover because it includes changes in stocks of finished goods and work in progress and because of differences in the measurement of activities involving trade or financial intermediation. Turnover covers gross operating revenues less rebates, discounts and returns. It should be measured exclusive of consumption and turnover (sales) taxes on consumers and value-added taxes. The turnover variable generally presents fewer collection difficulties and thus is likely to be more widely available than value added. Also, unlike value added, turnover indicates the extent to which affiliates under foreign control are used to deliver outputs originating in the affiliates themselves or in other firms.

H.8. SHARE OF TURNOVER UNDER FOREIGN CONTROL IN SELECTED MANUFACTURING AND SERVICES SECTORS

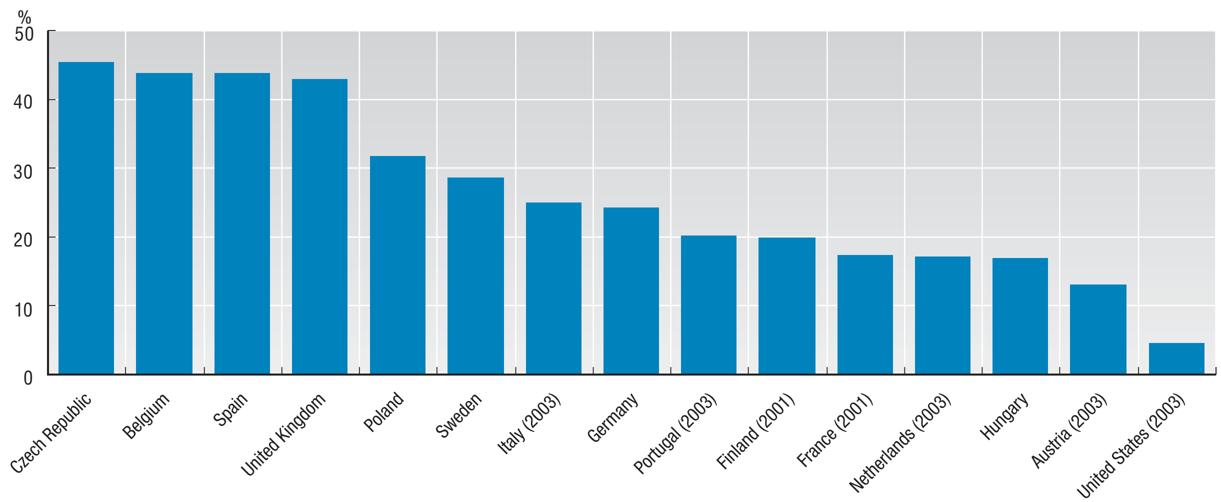
Motor vehicles (ISIC 34), 2004



Computer manufacturing (ISIC 30), 2004



Computer and related services (ISIC 72), 2004



StatLink http://dx.doi.org/10.1787/120032720428

H.9. IMPORT CONTENT OF EXPORTS

With the emergence of global value chains, imports and exports increasingly move together in companies' production processes, and companies' exports are thus based to a larger or smaller extent on intermediate inputs imported from abroad,

The import content of exports is greatest in basic industries that are heavy users of primary goods, such as mining and basic metals but also chemicals and rubber and plastics. A second group of industries with quite high import content of exports are more technology-intensive industries that produce modular products. Parts and components are often produced in one country and then exported to another where final assembly takes place. This international division of labour is found in industries such as electrical machinery, radio/television and communication equipment, and office, accounting and computing machinery.

Between the mid-1990s and the early 2000s, the import content of exports has increased in almost all countries. Smaller countries have a greater degree of import content in their exports. Larger countries such as the United States, Japan and the United Kingdom rely relatively less on imports of intermediates sourced abroad.

The increase in vertical specialisation is clearest in countries such as Ireland, Hungary, the Czech Republic and Belgium with a significant presence of multinationals, as international sourcing of intermediates has become more prominent in companies' networks. Foreign affiliates in various countries produce intermediates that are exported to final consumers but also to other affiliates and to the multinational's headquarters.

Among emerging countries, China and Indonesia show high dependence on imported intermediates. The results for China illustrate the increasingly international sharing of production within ICT industries. For example, a triangular trade pattern has emerged in the ASEAN region, in which parts and components are produced in Japan, Chinese Taipei and Korea and then exported to China where they are assembled into finished products. This restructuring process has accelerated in recent years, suggesting that more recent data would show a higher import content of exports for China.

Source

- OECD, Input-Output database, available at: *www.oecd.org/std/io-tables/data/*

For further reading

- Wixted, B., N. Yamano and C. Webb (2006), "Input-Output Analysis in an Increasingly Globalised World: Applications of OECD's Harmonised International Tables", *STI Working Paper*, 2006/7, OECD Paris.
- OECD (2007), *Staying Competitive in the Global Economy: Moving Up the Value Chain*, OECD, Paris.
- Hummels, D. J. Ishii and K-M Yi (2001), "The Nature and Growth of Vertical Specialization in World Trade", *Journal of International Economics*, Vol. 54(1), pp. 75-96.

Import content of exports

Input-Output tables measure the interrelationships between the producers of goods and services (including imports) in an economy and the users of the same goods and services (including exports). As such, they can be used to estimate the contribution of imports to the production of any good and service for export. For example, if a computer manufacturer imports certain components (*e.g.* computer chips) the direct import contribution will be the ratio of the value of these computer chips to the total value of the computer. If the computer manufacturer purchases other components from domestic manufacturers, which in turn use imports in their production process, those imports should be also included in the value of the computer. These indirect imports should be included in statistics that attempt to measure the contribution of imports to the production of computers for export. These total direct and indirect imports are known as embodied imports.

Based on earlier work by Hummels *et al.* (2001), the import content of exports can be calculated as:

uAm (I-Ad)-1X/ Σ X

where *Am* and *Ad* are the input-output coefficient matrices (n x n) of import and domestic products respectively, u and *X* are the (1xn) vector of 1 and industry's exports. An import content of exports of 20% for example means that 20% of the exports are directly and indirectly based on imported intermediates.

While of interest, the indicator is not an indicator of a country's competitiveness, as increased import content in exports does not necessarily signal shrinking competitiveness. It merely describes the (changing) structure and dynamics of countries and can be used with other appropriate indicators to discuss a country's competitiveness.

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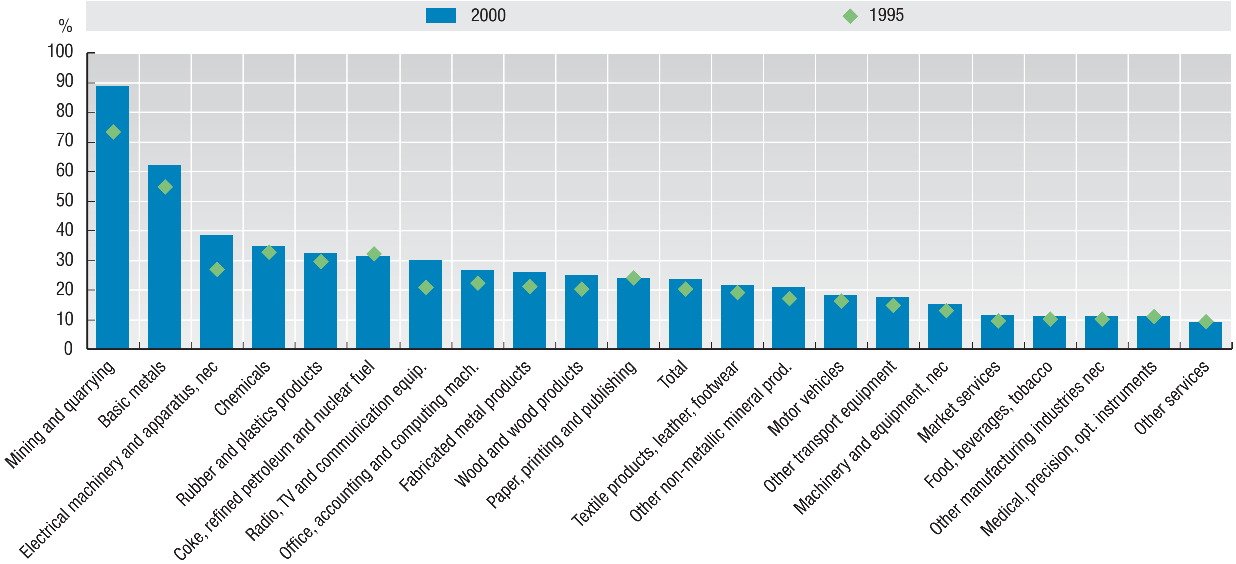
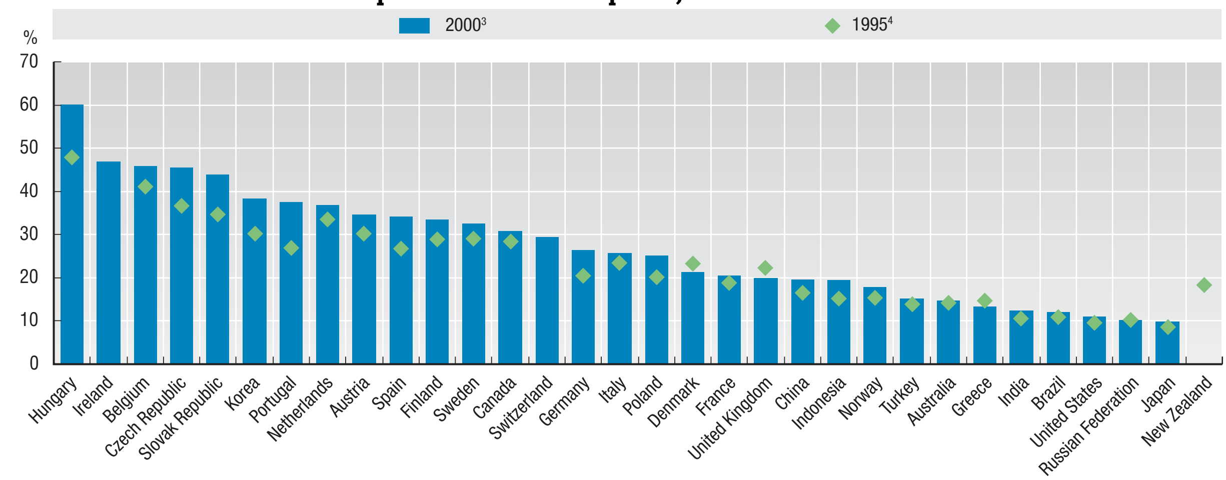
Import content of exports, individual industries, OECD,[1] 1995[2] and 2000[3]



Import content of exports, 1995[4] and 2000[3]



StatLink http://dx.doi.org/10.1787/120058735685

Note: Data from OECD Input-Output 2002 and 2006 editions.

1. OECD excludes Iceland, Ireland, Luxembourg, Mexico and Switzerland for 1995 and Iceland, Luxembourg and Mexico for 2000.
2. 1995 data for Australia are 1994, for Canada 1997, for Hungary 1998, for New Zealand 1996, for Norway 1997, for Turkey 1996, for India 1993; no data for Iceland, Ireland, Luxembourg, Mexico, Switzerland.
3. 2000 data for Australia are 1998, for Greece 1999, for Ireland 1998, for Norway 2001, for Portugal 1999, for Switzerland 2001, for Turkey 1998, for India 1998; no data available for Iceland, Luxembourg, Mexico and New Zealand.
4. 1995 data for Australia are 1994, for Canada 1997, for Denmark 1997, for Hungary 1998, for New Zealand 1996, for Norway 1997, for Turkey 1996, for India 1993, for China 1997; no data for Iceland, Ireland, Luxembourg, Mexico, Switzerland.

H.10. OFFSHORING OF INTERMEDIATES

Owing to the emergence of global value chains, trade has increased not only in finished goods and services but also, and especially, in intermediates: primary goods, parts and components, and semi-finished goods. The growing international sourcing of intermediates is reflected in the increasing level of intermediates in trade between 1995 and 2000 in almost all OECD countries.

Because of their limited size and typically greater openness, smaller countries have higher levels of intermediates offshoring. The sourcing of intermediates within multinational networks has become especially important in recent years. Japan and the United States offshore relatively little compared with other countries.

In emerging countries such as Brazil, Russia, India and China the offshoring of intermediates has also increased in importance over the years, although the level remains below the OECD average.

While offshoring of intermediates, like trade of final products, has traditionally involved manufacturing industries, the emergence of global value chains increasingly extends to services sectors. Improvements in technology, standardisation, infrastructure growth and decreasing data transmission costs have all facilitated the sourcing of services from abroad.

In particular, knowledge work, such as data entry or research and consultancy services, can easily be carried out via the Internet and e-mail, and through tele- and video-conferencing. However, the level of offshoring is still much lower in market services than in manufacturing industry as a whole.

Within manufacturing, there is more offshoring of intermediates in higher-technology industries than in lower-technology industries.

Source

- OECD, Input-Output database, available at: *www.oecd.org/std/io-tables/data/*.

For further reading

- Wixted, B., N. Yamano and C. Webb (2006), "Input-Output Analysis in an Increasingly Globalised World: Applications of OECD's Harmonised International Tables", *STI Working Paper*, 2006/7, OECD Paris.
- OECD (2007), *Staying Competitive in the Global Economy: Moving Up the Value Chain*, OECD, Paris.
- Feenstra R.C. and G.H. Hanson (1999), "The Impact of Outsourcing and High-Technology Capitalon Wages: Estimates for the United States, 1979-1990", *Quarterly Journal of Economics*, Vol.114 (3).

Intermediate imports and globalisation

The geographical fragmentation of production processes within global value chains has resulted in increased trade in intermediates. Data on trade do not generally distinguish between intermediate and final goods, apart from some (unofficial) classification schemes using descriptive characteristics of the goods and services. Input-Output tables may offer complementary insights as they explicitly provide information on the value of intermediate goods and services imported from another country. The key advantage of Input-Output tables is that they classify goods according to their use (as an input into another sector's production or as final demand) instead of dividing them into intermediate and other categories based on their descriptive characteristics. Another key advantage of these tables is that they also include information on (domestic and international) inputs of/in services sectors, which makes it possible to monitor the rapidly growing sourcing of services activities.

The OECD's Input-Output database was developed over a decade ago and is currently being updated for the second time. The database contains information for 29 OECD countries, and for the latest years nine non-OECD countries have also been included. The database thus covers 66% of the world's population and over 90% of world GDP (in nominal USD). Over the years, the database has been used in a number of analytical applications both within and outside the OECD.

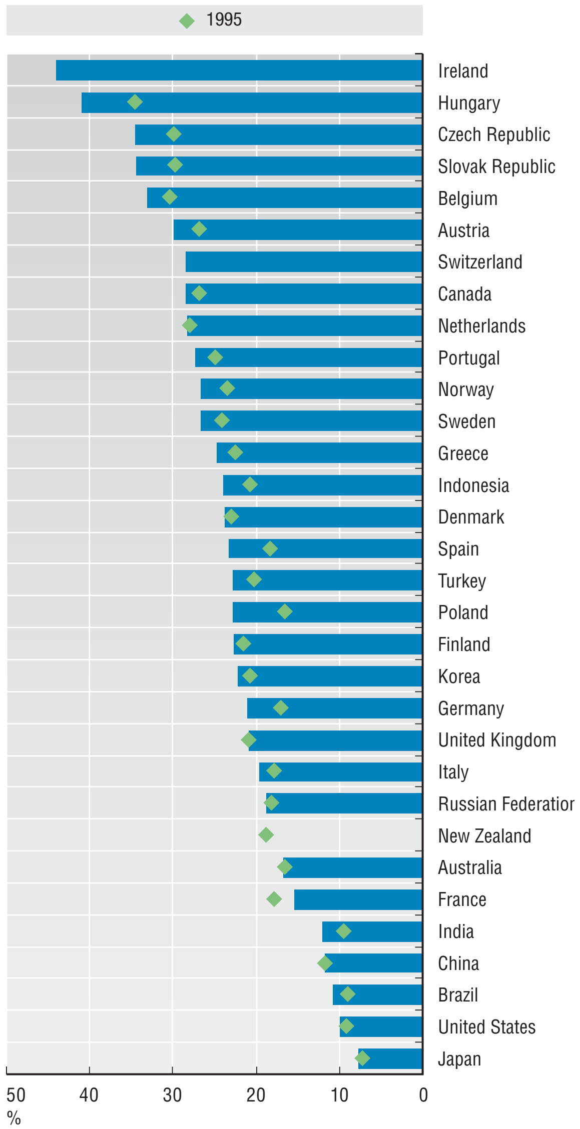
Based on earlier work by Feenstra and Hanson (1999), input-output tables can be used to compute the level of offshoring of intermediates as the share of non-energy imported intermediate inputs in total non-energy intermediate inputs.

$$\text{OFFSH} = \sum_j x_d^{ij} \Big/ \left(\sum_j x_d^{ij} + \sum_j x_m^{ij} \right)$$

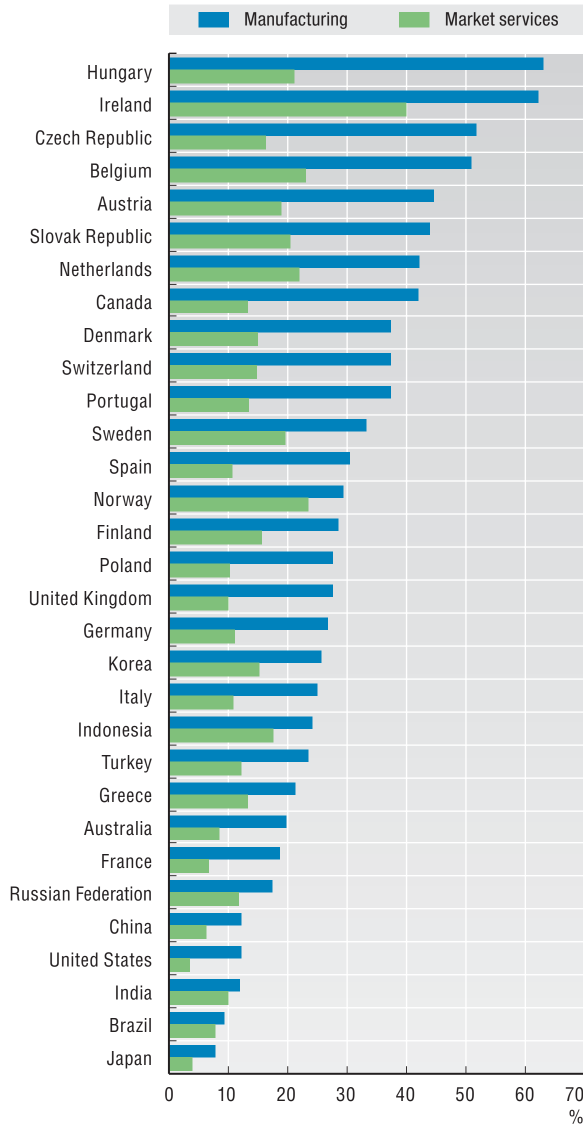
where x_d^{ij} and x_m^{ij} are respectively the domestic and imported transactions of intermediate demand in the input-output tables.

H.10. OFFSHORING OF INTERMEDIATES

Offshoring of intermediates, 1995[1] and 2000[2]



Offshoring of intermediates, manufacturing and market services, 2000[2]



StatLink http://dx.doi.org/10.1787/120100635618

1. 1995 data for Australia are 1994, for Canada 1997, for Hungary 1998, for New Zealand 1996, for Norway 1997, for Turkey 1996, for India 1993; no data for Iceland, Ireland, Luxembourg, Mexico, Switzerland.
2. 2000 data for Australia are 1998, for Greece 1999, for Ireland 1998, for Norway 2001, for Portugal 1999, for Switzerland 2001, for Turkey 1998, for India 1998; no data available for Iceland, Luxembourg, Mexico and New Zealand.

H.11. TECHNOLOGY BALANCE OF PAYMENTS

The technology balance of payments measures international technology transfers: licence fees, patents, purchases and royalties paid, know-how, research and technical assistance. Unlike R&D expenditure, these are payments for production-ready technologies.

In most OECD countries, technological receipts and payments increased sharply during the 1990s and up to mid-2000. Overall, the OECD area maintained its position as net technology exporter *vis-à-vis* the rest of the world.

Between 1995 and 2005, the European Union transformed its technology balance of payments deficit into a surplus, although this includes intra-EU flows, while the US surplus was reduced. The most spectacular change occurred in Japan. In particular, transactions concerning new contracts for technology have showed a very large surplus (receipts-payments) since 1980.

In 2005, the main technology exporters as a percentage of GDP were Luxembourg, Sweden, the United Kingdom, Denmark, Belgium, the United States, Japan, Finland, Canada, the Netherlands, Germany, France and Norway. The main importers were Ireland, Hungary, New Zealand, the Czech Republic, Poland and Korea.

The magnitude of Ireland's deficit in technology payments is mainly due to the strong presence of foreign affiliates (particularly US and UK firms). The figures may also be affected by intra-firm transactions and transfer pricing.

Technological development can be achieved either through a national R&D effort or the acquisition of foreign technology. Particularly in Ireland, Poland, Portugal, Hungary, Belgium and Luxembourg, expenditure on foreign technology (technological payments) is greater than expenditure for domestic business enterprise R&D.

Sources

- OECD, Technology Balance of Payments (TBP) database and OECD estimates, May 2007.

For further reading

- OECD (2005), *Measuring Globalisation – OECD Handbook on Economic Globalisation Indicators*, OECD, Paris, available at: *www.oecd.org/sti/measuring-globalisation*.
- OECD (2005), *Measuring Globalisation – Economic Globalisation Indicators*, OECD, Paris.

Technology balance of payments

Technology receipts and payments constitute the main form of disembodied technology diffusion. Trade in technology comprises four main categories:

- Transfer of techniques (through patents and licences, disclosure of know-how).
- Transfer (sale, licensing, franchising) of designs, trademarks and patterns.
- Services with a technical content, including technical and engineering studies, as well as technical assistance.
- Industrial R&D.

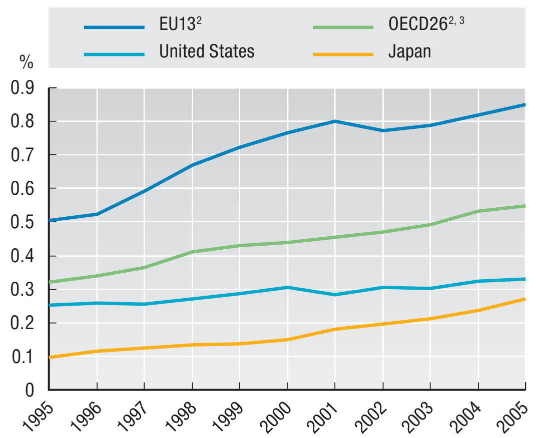
Although the balance reflects a country's ability to sell its technology abroad and its use of foreign technologies, a deficit does not necessarily indicate low competitiveness. In some cases, it results from increased imports of foreign technology; in others, it is due to declining receipts.

Likewise, if the balance is in surplus, this may be due to a high degree of technological autonomy, a low level of technology imports or a lack of capacity to assimilate foreign technologies. Most transactions also correspond to operations between parent companies and affiliates. Thus, it is important to have additional qualitative and quantitative information in order to analyse correctly a country's deficit or surplus position in a given year.

There is also the difficulty of dissociating the technological from the non-technological content of trade in services, which falls under the heading of pure industrial property. Thus, trade in services may be underestimated when a significant portion does not give rise to financial payments or when payments are not in the form of technology payments.

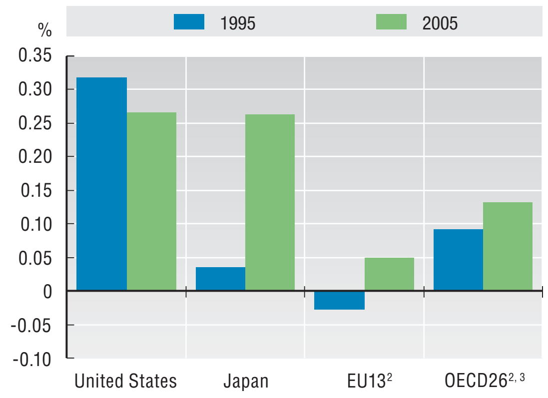
Trends in technology flows[1] by main areas, 1995-2005

As a percentage of GDP



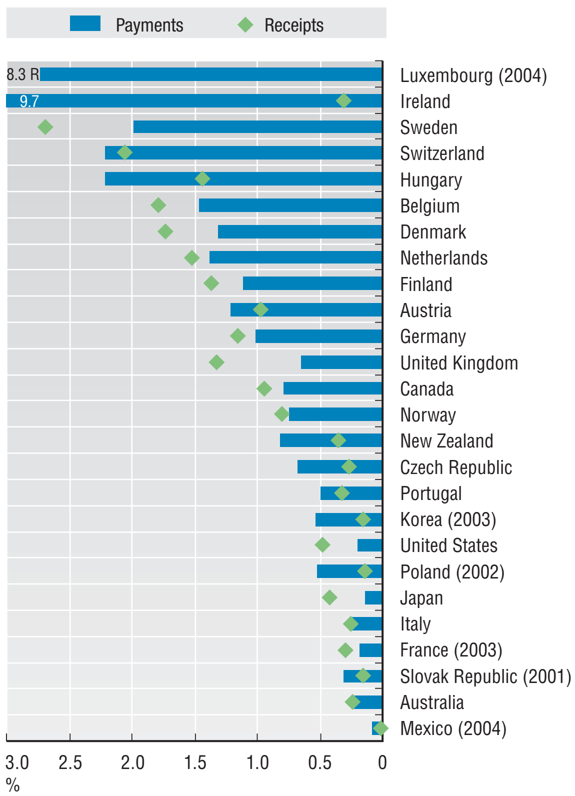
Change in the technology balance of payments by main areas, 1995 and 2005

As a percentage of GDP



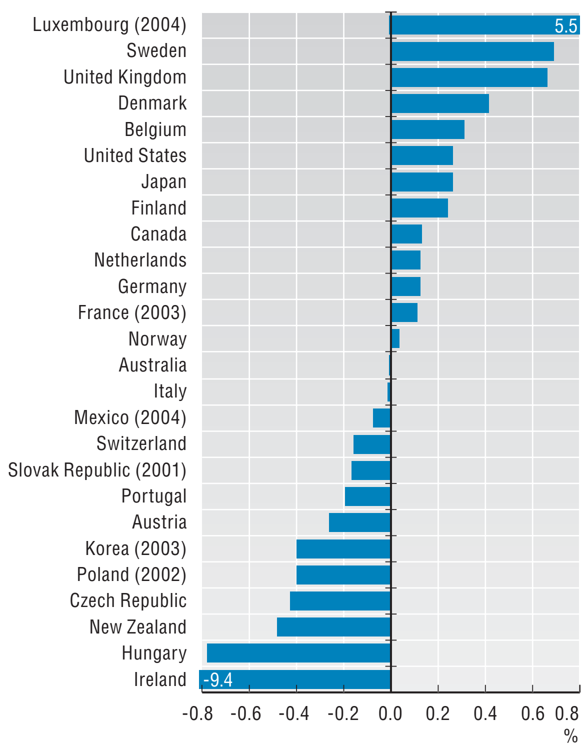
Technology flows,[1] 2005

As a percentage of GDP



Technology balance of payments, 2005

As a percentage of GDP



StatLink http://dx.doi.org/10.1787/120108101160

1. Average of technological payments and receipts.
2. Includes intra-area flows. Excludes Denmark and Greece. Data partially estimated.
3. Excludes Iceland and Turkey.

I. PRODUCTIVITY AND TRADE

I.1. INCOME AND PRODUCTIVITY LEVELS

In 2005, GDP per capita in the OECD area ranged from over USD 36 000 in Iceland, Ireland, Luxembourg, Norway and the United States to less than USD 15 000 in Mexico, Poland and Turkey. Income levels were 70-85% of the US income level for most OECD countries, except for Norway with 115% of the US income level.

The differences in income reflect a combination of labour productivity, measured as GDP per hour worked, and labour utilisation, measured as hours worked per capita. A country's labour productivity level is typically the most significant factor in determining differences in income, particularly in countries with low levels of GDP per capita.

Relative to the United States, most OECD countries have higher levels of GDP per hour worked than GDP per capita because their levels of labour utilisation are lower. The difference between income and productivity levels is largest in European countries; in 2005, GDP per hour worked surpasses the US productivity level in several countries, notably in Belgium, Ireland, France, the Netherlands and Norway, whereas income levels in most of these countries are substantially lower than in the United States.

In most OECD countries, labour use for 2005 is substantially lower than in the United States, owing to disparities in working hours but also, in several countries, to high unemployment and low participation of the working-age population in the labour market. However, in Australia, Canada, the Czech Republic, Japan, New Zealand and Switzerland, labour input per capita is higher than in the United States, while in Iceland and Korea labour use considerably surpasses that of the United States, mainly owing to relatively long working hours and high rates of labour force participation.

Sources

- OECD, Productivity Database, April 2007, available at: *www.oecd.org/statistics/productivity*.
- OECD, Annual National Accounts and Labour Force Statistics databases, March 2007.

For further reading

- OECD (2006), *Compendium of Productivity Indicators*, OECD, Paris.
- OECD (2001), *Measuring Productivity – OECD Manual*, OECD, Paris.
- Pilat, D. and P. Schreyer (2004), "The OECD Productivity Database – An Overview", *International Productivity Monitor*, No. 8, Spring, OECD, Paris, pp. 59-65.
- OECD (2004), "Clocking In (and Out): Several Facets of Working Time", *OECD Employment Outlook 2004*, Chapter 1, OECD, Paris.

Comparisons of income and productivity levels

Comparisons of income and productivity levels face several measurement problems (for further details *see* Annex 2 of *OECD Compendium of Productivity Indicators* 2006). First, they require comparable data on output. In the 1993 System of National Accounts (SNA), the measurement and definition of GDP are treated systematically across countries. Most countries have implemented this system and, in the OECD area, Turkey is the only exception; its output is therefore likely to be understated relative to other OECD countries. Other differences, such as the measurement of software investment, also affect the comparability of GDP across countries, although the differences are typically quite small.

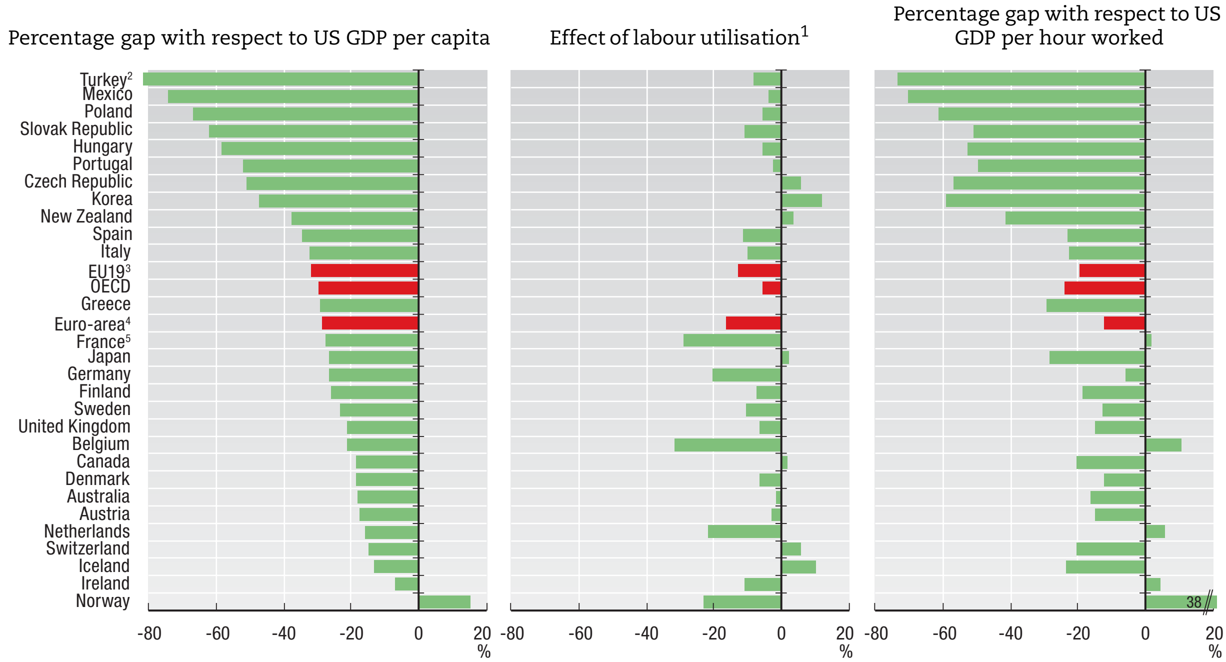
The second problem is the measurement of labour input. Some countries integrate the measurement of labour input in the national accounts. This may ensure that estimates of labour input are consistent with those of output. In most countries, however, employment data are derived from labour force surveys which are not entirely consistent with the national accounts. Labour input also requires measures of hours worked, which are typically derived either from labour force surveys or from business surveys. Several OECD countries estimate hours worked from a combination of these sources or integrate these sources in a system of labour accounts, which are comparable to the national accounts. The OECD Productivity database includes estimates of total hours worked which aim at consistency between estimates of employment and hours worked. The cross-country comparability of hours worked remains somewhat limited, however, with a margin of uncertainty in estimates of productivity levels.

Third, international comparisons require price ratios to convert output expressed in a national currency into a common unit. Exchange rates are of limited use for this purpose because they are volatile and reflect many influences, including capital movements and trade flows. The alternative is to use purchasing power parities (PPP), which measure the relative prices of the same basket of consumption goods in different countries. The estimates shown here are based on official OECD Purchasing Power Parities for 2005.

Note: in September 2006, the Greek authorities revised the national accounts with a consequent upward change of about 25.8% in GDP levels in 2000 and subsequent years, while GDP growth rates were little affected. In parallel, employment in 2000 was also revised up by 10.4% and hours worked by 14.2%. Further information can be found in the publication: OECD (2007), *OECD Economic Surveys: Greece*, No. 5, OECD, Paris.

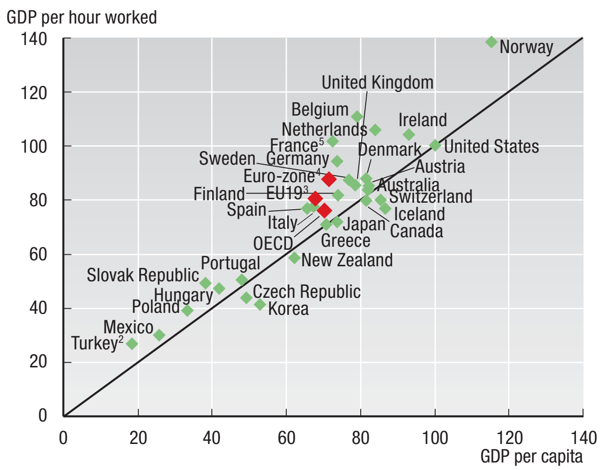
Income and productivity levels, 2005

Percentage point differences with respect to the United States



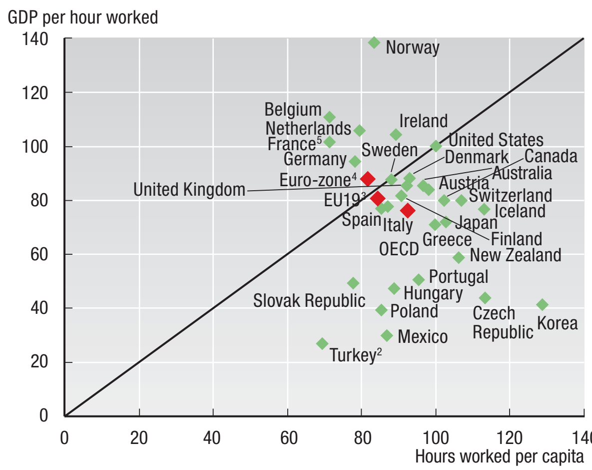
GDP per capita and GDP per hour worked, 2005

United States = 100



Hours per capita and GDP per hour worked, 2005

United States = 100



StatLink http://dx.doi.org/10.1787/120125551550

1. Based on total hours worked per capita.
2. GDP for Turkey is based on the 1968 System of National Accounts.
3. EU member countries that are also member countries of the OECD.
4. Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain.
5. Includes overseas departments.

I.2. LABOUR PRODUCTIVITY GROWTH

■ Productivity growth is measured by relating changes in output to changes in one or more inputs to production. The most common productivity measure is labour productivity, which links changes in output to changes in labour input. It is a key economic indicator and is closely associated with standards of living.

■ Since 2000, most OECD countries have experienced a marked slowdown in labour productivity growth, with the exception of some small countries, such as the Czech Republic, Hungary and Iceland which had among the highest labour productivity growth over the last decade, together with Greece, Ireland and the Slovak Republic.

■ In the first half of the 2000s, labour productivity growth in the Czech Republic, Hungary, Iceland, Korea and the Slovak Republic ranged from 4.3 to 4.8% and was stronger than in Italy, Mexico and Portugal, where growth of GDP per hour worked was below 0.3%.

■ Over the past ten years, labour productivity growth has varied considerably. In the Czech Republic, Hungary and Iceland, growth of GDP per hour worked grew much faster in 2000-05 than in 1995-2000 while over the same period, it slowed in Austria, Canada, Ireland, Luxembourg, Mexico and Portugal.

■ The rates shown here are not adjusted for differences in the business cycle; cyclically adjusted estimates might show a somewhat different pattern.

Sources

- OECD Productivity database, April 2007, available at: *www.oecd.org/statistics/productivity*.
- OECD, Annual National Accounts Database, March 2007.

For further reading

- OECD (2006), *Compendium of Productivity Indicators*, OECD, Paris.
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- Ahmad, N., F. Lequiller, P. Marianna, D. Pilat, P. Schreyer and A. Wölfl (2003), "Comparing Labour Productivity Growth in the OECD Area: The Role of Measurement", *STI Working Papers 2003/14*, OECD, Paris.
- Pilat, D. and P. Schreyer (2004), "The OECD Productivity Database – An Overview", *International Productivity Monitor*, No. 8, Spring, OECD, Paris, pp. 59-65.
- OECD (2004), "Clocking In (and Out): Several Facets of Working Time", *OECD Employment Outlook 2004*, Chapter 1, OECD, Paris.

OECD measures of labour productivity growth

The OECD Productivity Manual. There are many different approaches to the measurement of productivity. The calculation and interpretation of the different measures are not straightforward, particularly for international comparisons. To give guidance to statisticians, researchers and analysts who work with productivity measures, the OECD released the *OECD Productivity Manual* in 2001. It is the first comprehensive guide to various productivity measures and focuses on the industry level. It presents the theoretical foundations of productivity measurement, discusses implementation and measurement issues and is accompanied by examples from OECD member countries to enhance its usefulness and readability. It also offers a brief discussion of the interpretation and use of indicators of productivity. See: *www.oecd.org/sti/measuring-ind-performance*.

The OECD Productivity database. Productivity measures rely heavily on the integration of measures of output and input. Some of the most important differences among studies of labour productivity growth are linked to choice of data, notably the combination of employment, hours worked and GDP. To address this problem, OECD has developed a reference database on productivity at the aggregate level, with a view to resolving the problem of data consistency. In deriving estimates of labour productivity growth for the economy as a whole, the database combines information on GDP, employment and hours worked. For employment and hours worked, a special effort is made to use the best available information for each country, based on a consistent matching of data on employment and annual hours worked per person employed (see Annex 1).

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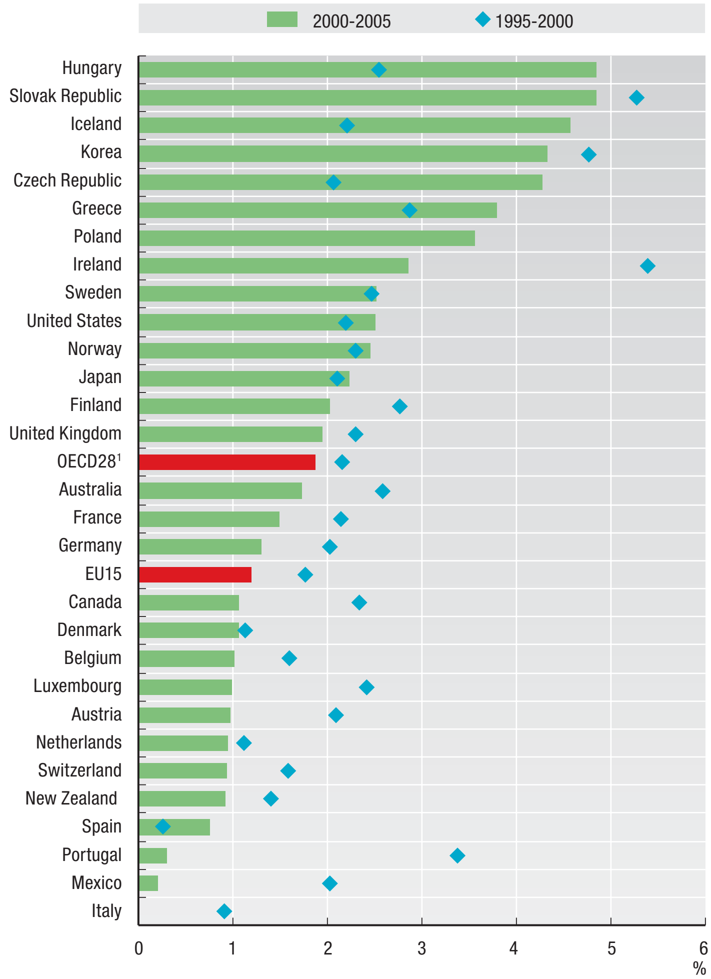
2000-2005 compared with 1995-2000

Total economy, percentage change at annual rate



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1. OECD countries excluding Poland and the Slovak Republic.

I.3. GROWTH ACCOUNTS FOR OECD COUNTRIES

■ In the first half of the 2000s, G7 countries, with the exception of Japan, experienced a slowdown in growth. This was largely due to a smaller contribution of labour input, to capital reduction, in particular a slight decrease in investment in information and communications technology (ICT), and/or to slower multi-factor productivity (MFP) growth.

■ Between 1995-2000 and 2000-05 in G7 countries the contribution of labour input to growth fell most notably in Germany and in the United States, where the contribution of labour input became negative in the later period. During 2000-05, the contribution of labour input to growth declined most sharply in France and the United Kingdom.

■ In 2000-05, the contribution of MFP to growth fell in most G7 countries, particularly in Canada and Italy but rose in Japan and the United States.

■ From 1995 to 2005, investment in ICT represented between 0.3 and 0.7 percentage points of growth in GDP. ICT accounts for the bulk of capital's contribution to GDP growth in Australia, Denmark, Sweden, the United Kingdom and the United States; its contribution was more modest in Japan and Canada and even smaller in Austria, Italy and Germany.

■ Over the same period, an increase in labour input made a large contribution to growth of GDP in Canada, Finland, Ireland, the Netherlands, New Zealand and Spain.

■ MFP growth was also an important source of growth of GDP in Ireland, Finland, Greece, Sweden and the United States, but its contribution was very small or negative in Denmark, Italy and Spain.

Source

- OECD Productivity database, April 2007, available at: *www.oecd.org/statistics/productivity*.

For further reading

- OECD (2006), *Compendium of Productivity Indicators*, OECD, Paris.
- OECD (2001), *Measuring Productivity – OECD Manual*, OECD, Paris.
- Schreyer, P., P. E. Bignon and J. Dupont (2003), "OECD Capital Services Estimates: Methodology and a First Set of Results", *OECD Statistics Working Paper 2003/6*, OECD, Paris.
- Schreyer, P. (2004), "Capital Stocks, Capital Services and Multi-factor Productivity Measures", *OECD Economic Studies No. 37*, 2003/2, OECD, Paris, pp. 163-184.

Growth accounting

Economic growth can be increased by increasing the amount and types of labour and capital used in production, and by attaining greater overall efficiency in how these factors of production are used together, *i.e.* higher multi-factor productivity. Growth accounting involves breaking down growth of GDP into the contribution of labour input, capital input and MFP. The growth accounting model is based on the microeconomic theory of production and rests on a number of assumptions, among which the following are important: *i)* production technology can be represented by a production function relating total GDP to the primary inputs labour L and capital services K; *ii)* this production function exhibits constant returns to scale; and *iii)* product and factor markets are characterised by perfect competition.

For any desired level of output, the firm minimises costs of inputs, subject to the production technology discussed above. Factor input markets are competitive, so that the firm takes factor prices as given and adjusts quantities of factor inputs to minimise costs. The rate of growth of output is a weighted average of the rates of growth of the various inputs and of the multi-factor productivity term. The weights attached to each input are the output elasticities for each factor of production. Output elasticities cannot be directly observed, however, and the factor shares of labour and capital are often used as weights.

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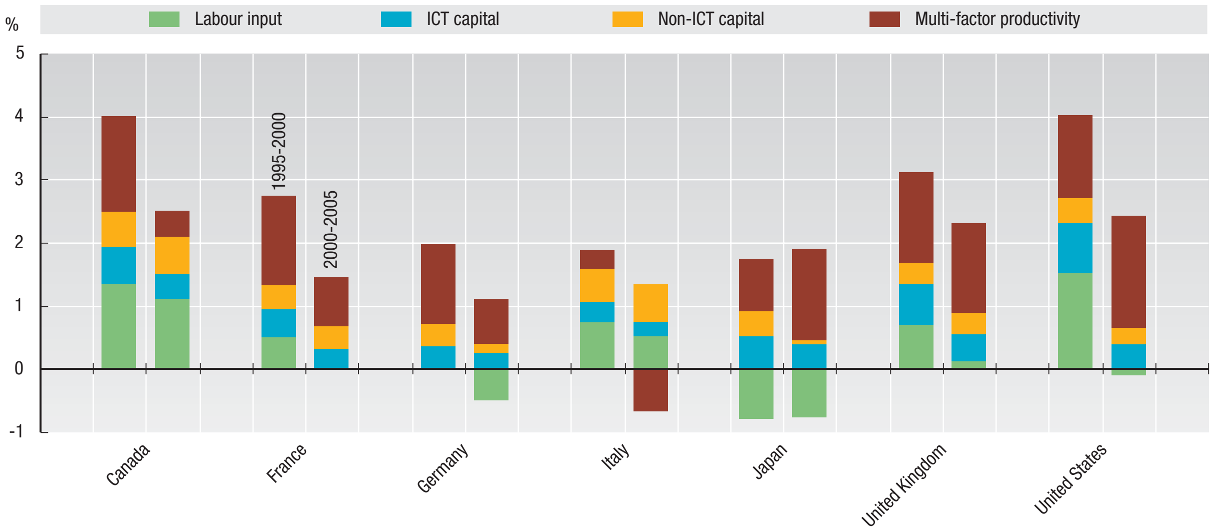
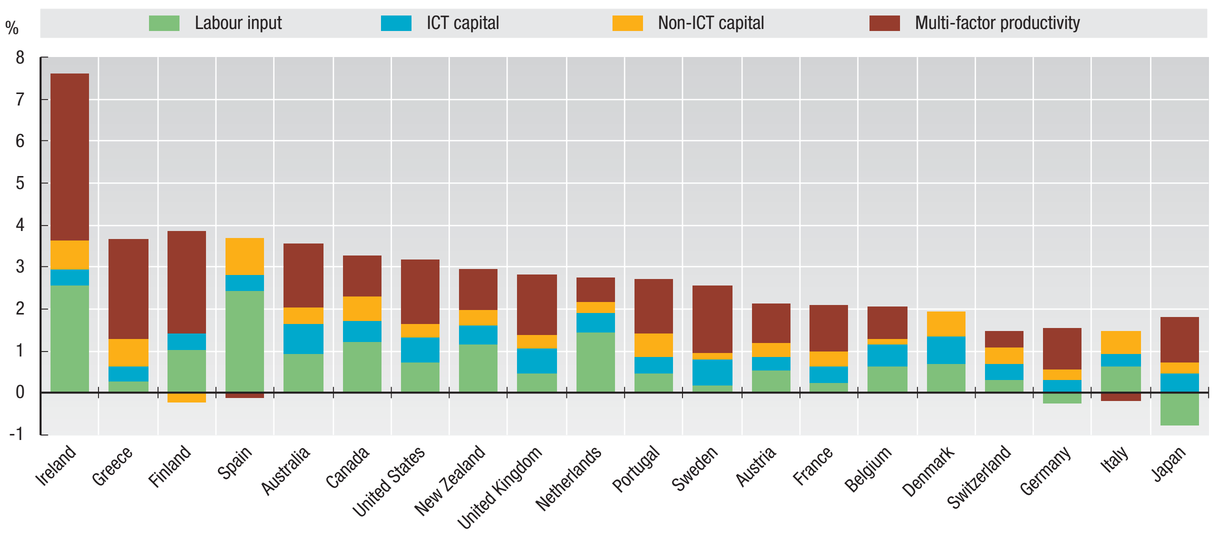
Contributions to GDP growth, G7 countries, 1995-2000 and 2000-05[1]

Percentage points



Contributions to GDP growth, OECD countries, 1995-2005[2]

Percentage points



StatLink http://dx.doi.org/10.1787/120152356066

1. Data refer to 1995-2000 and 2000-03 for the United Kingdom; 1995-2000 and 2000-04 for Japan.
2. Data refer to 1995-2002 for New Zealand; 1995-2003 for Austria, Belgium, Denmark, Finland, Greece, Ireland, the Netherlands, Portugal, Sweden and the United Kingdom; 1995-2004 for Australia, Japan, Spain and Switzerland.

I.4. LABOUR PRODUCTIVITY GROWTH IN THE BUSINESS SECTOR

■ A breakdown of productivity growth by activity can highlight industries that are particularly important for overall productivity performance. Over the period 2000-05, business sector services accounted for the bulk of labour productivity growth in most OECD countries, notably in Canada, Greece, New Zealand, the United Kingdom and the United States, where the business sector accounted for over 55% of aggregate labour productivity growth. Over the same period, manufacturing remained important in Finland, Germany, Korea, the Slovak Republic and Sweden.

■ Between 1995-2000 and 2000-05, the contribution of business sector services to labour productivity growth increased in Belgium, the Czech Republic, France and New Zealand. The growing contribution of business sector services is sometimes linked to their growing share in total value added, but in the Czech Republic, Japan and New Zealand, for example, it also reflects faster labour productivity growth in the business sector. However, in Canada, Mexico, Portugal, the Slovak Republic and Switzerland, labour productivity growth in business sector services slowed over the past five years, a trend that can also be observed at the aggregate level (see I.2).

Sources

- OECD, Annual National Accounts database, March 2007, available at: *www.oecd.org/statistics/national-accounts*.
- OECD, STAN database.

For further reading

- OECD (2006), *Compendium of Productivity Indicators*, OECD, Paris.
- OECD (2001), *Measuring Productivity – OECD Manual*, OECD, Paris.
- Wölfl, A. (2003), "Productivity Growth in Service Industries: An Assessment of Recent Patterns and the Role of Measurement", *STI Working Paper 2003/7*, OECD, Paris.
- Wölfl, A. (2005), "The Service Economy in OECD Countries", *STI Working Paper 2005/3*, OECD, Paris.

Measuring labour productivity growth by industry

Labour productivity growth can be calculated as the difference between the rate of growth of output or value added and the rate of growth of labour input. Calculating a sector's contribution to aggregate productivity growth requires a number of simple steps, as explained in the *OECD Productivity Manual* (OECD, 2001). First, the aggregate rate of change in value added is a share-weighted average of the industry-specific rate of change in value added, with weights reflecting the current price share of each industry in value added. On the input side, aggregation of industry-level labour input is achieved by weighting the growth rates of total employment (National Accounts detailed series on hours worked by industry are not available across OECD countries) with each industry's share in total labour compensation.

Aggregate labour productivity growth can then be calculated as the difference between aggregate growth in value added and aggregate growth in labour input. An industry's contribution to aggregate labour productivity growth is therefore the difference between its contribution to total value added and total labour input. If value added and labour shares are the same, total labour productivity growth is a simple weighted average of industry-specific labour productivity growth. Similar approaches can be followed when production, instead of value added, is used as the output measure. Difficulties in measuring output and productivity in services sectors should also be taken into consideration when interpreting the results (see Wölfl, 2003).

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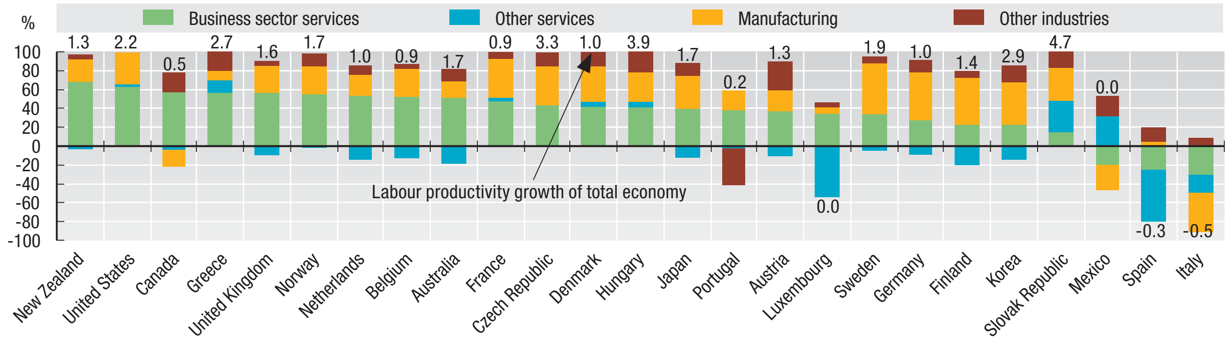
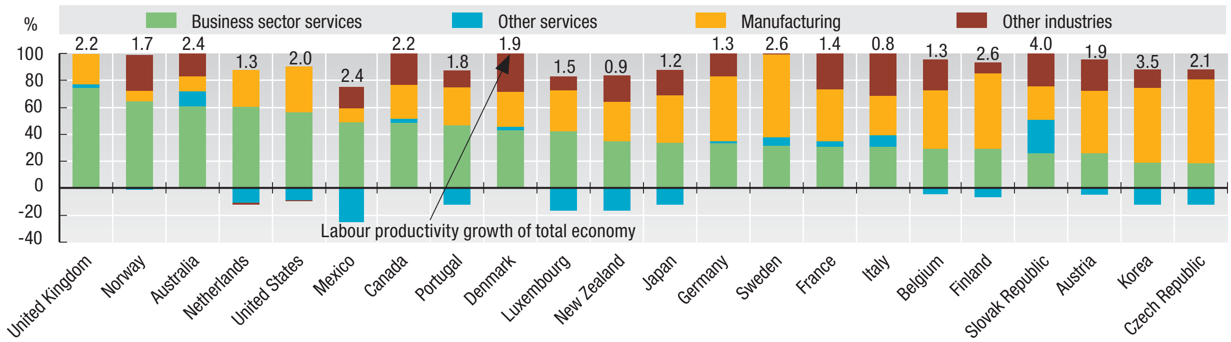
I.4. LABOUR PRODUCTIVITY GROWTH IN THE BUSINESS SECTOR

Contribution of key activities to growth of value added per person employed

Percentage points 2000-2005

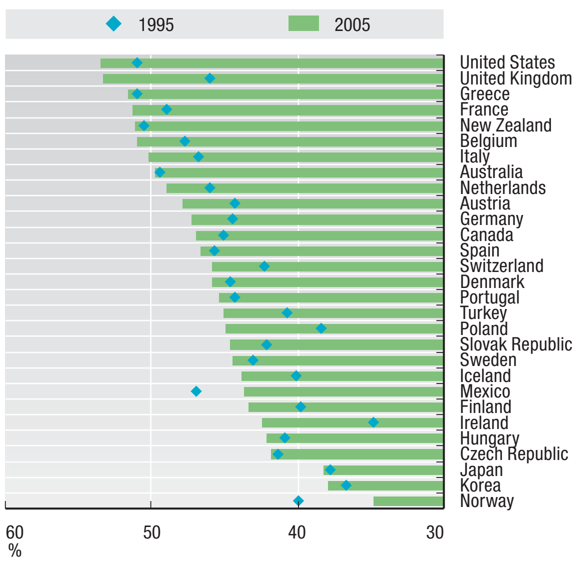


1995-2000



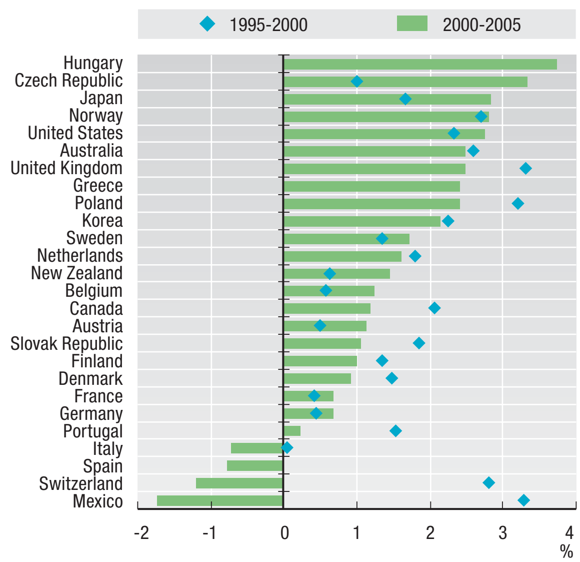
Share of business sector services in total value added

1995 and 2005



Growth in business sector services labour productivity

Annual average growth rates in percentage points



StatLink http://dx.doi.org/10.1787/120220272803

Note: Data refer to 1995-2002 for Canada and New Zealand; 1995-2003 for Portugal; 1995-2004 for Mexico, Sweden and Switzerland; 1997-2004 for Iceland; 1998-2005 for the United States; 2000-05 for Greece, Hungary and Spain. Business sector services cover "Wholesale, retail trade, hotels and restaurants" (ISIC 50-55), "Transport, storage and communication" (ISIC 60-64), "Finance, insurance, real estate and business services" (ISIC 65-74).

I.5. TECHNOLOGY- AND KNOWLEDGE-INTENSIVE INDUSTRIES

All industries generate and/or exploit new technology and knowledge to some extent, but some are more technology- and/or knowledge-intensive than others. To gauge the importance of technology and knowledge, it is useful to focus on the leading *producers* of high-technology goods and on the activities (including services) that are intensive *users* of high technology and/or have the relatively highly skilled workforce necessary to benefit fully from technological innovations.

The share of high- and medium-high-technology manufacturing in OECD value added has been declining steadily in recent years and by 2004 stood at about 7%. This reflects the continuing global shift of such activities towards non-OECD countries, including off-shoring by multinational firms, and the increasing importance of service activities in many OECD countries. The share of knowledge-intensive "market" services (see box) continues to rise and now accounts for about 21% of OECD value added.

In Ireland, high- and medium-high-technology manufacturing continues to be an important driver of economic growth although its share has peaked and has recently fallen to about 15%. Of the larger OECD economies only Germany, Japan and Korea have maintained a strong and persistent presence in high- and medium-high-technology manufacturing over the last decade. In the meantime, the Czech Republic, Finland and Hungary have seen their shares rise.

Switzerland and Luxembourg's high shares of knowledge-intensive services (over 25% of total value added) are due to their strong financial sectors. In most other countries, business services account for the largest proportion of knowledge-intensive services.

Between 1995 and 2004 most OECD countries continued to experience a steady increase in the importance of knowledge-intensive services. Among the largest OECD countries, the United Kingdom has seen particularly strong growth and has raised its share in recent years close to the high level of the United States. The economies of Italy and Japan are less oriented towards knowledge-based services although more so than many smaller European countries.

Sources

- OECD, National Accounts for OECD countries, 2007.
- OECD, STAN database, November 2005.
- OECD, Structural and Demographic Business Statistics, 2006.
- European Commission, EUKLEMS database, March 2007.
- Various national statistical publications.

For further reading

- Pilat, D. , A. Cimper, K. Olsen and C. Webb (2006), "The Changing Nature of Manufacturing in OECD Countries", *STI Working Paper 2006/9,* OECD, Paris.
- Hatzichronologou, T. (1997), "Revision of the High-Technology Sector and Product Classification", *STI Working Paper 1997/2,* OECD, Paris.

Measuring technology- and knowledge-intensive industries

While methods have been established for classifying manufacturing industries according to technological intensity (see Annex 1), capturing the "knowledge-intensive" services sectors has proved more challenging. This area will require more work as more data for services at a detailed level of economic activity become available in OECD countries. In the meantime, the classification introduced in the 2003 *STI Scoreboard* is used here. The figures presented opposite reflect the following features:

- A technology classification of manufacturing industries based on ISIC Rev. 3 R&D intensities in the 1990s (see Annex 1).
- A relatively narrow definition of knowledge-based services, which reflects data availability. "Real estate activities" (over 10% of total OECD area value added) are excluded, as a significant proportion consists of "Imputed rent of owner-occupied dwellings".
- Value-added shares are presented in relation to total gross value added.

The following ISIC Rev. 3 "market" service activities are considered knowledge-intensive:

- Division 64: Post and telecommunications (these activities cannot be separated for most countries).
- Divisions 65-67: Finance and insurance.
- Divisions 71-74: Business activities (not including real estate).

In addition, although not shown in the figures, the value-added shares of the education and health sectors (about 12% of the total for the OECD area) are presented for most countries in Annex Table I.5.

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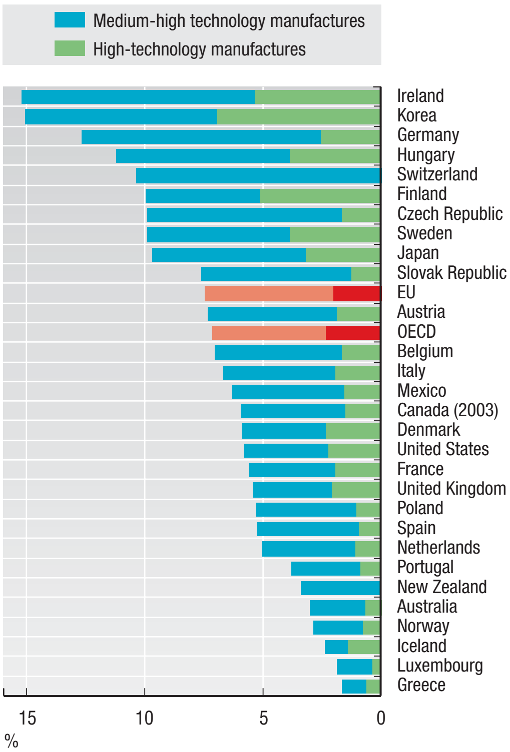
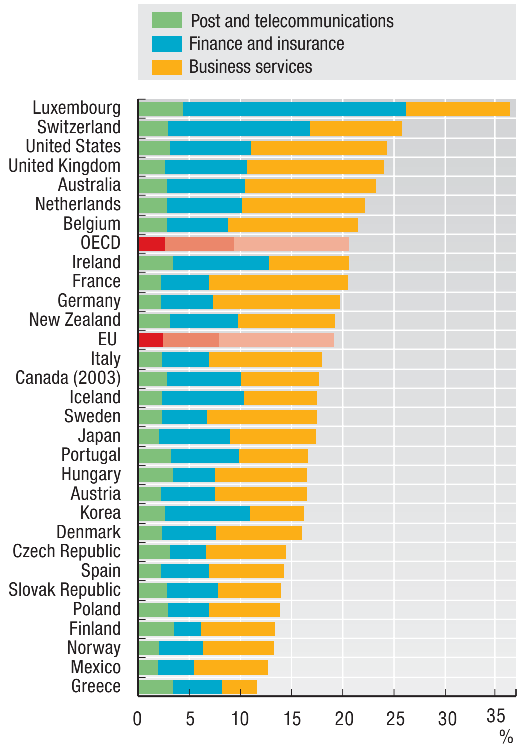
I.5. TECHNOLOGY- AND KNOWLEDGE-INTENSIVE INDUSTRIES

Share of total gross value added, 2004

High- and medium-high-technology manufactures

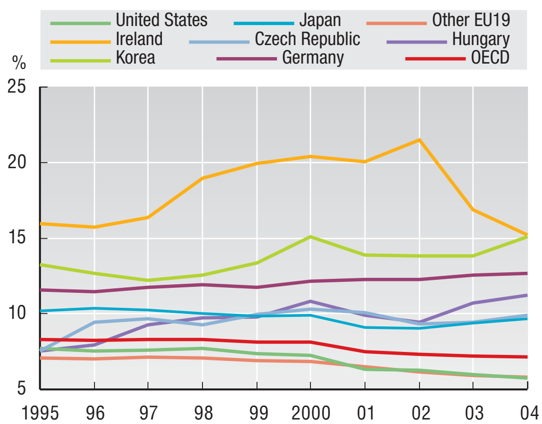


Knowledge-intensive "market" services

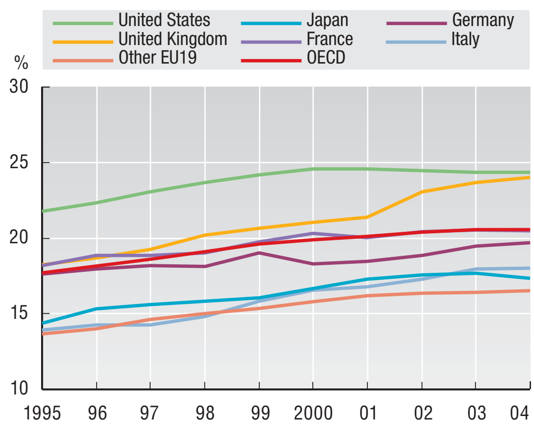


Shares of gross value added 1995-2004

High- and medium-high-technology manufactures



Knowledge-intensive "market" services



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I.6. INTERNATIONAL TRADE BY TECHNOLOGY INTENSITY

Following a strong downturn in ICT trade from 2000 to 2001, trade in high-technology industries has since recovered. International demand for products of these industries has risen, as they can have positive effects on productivity and competitiveness when used throughout the economy.

High-technology industries are more oriented towards international trade than other industries. They currently represent about one-quarter of total OECD trade in manufactured goods, a share that has declined marginally in recent years. Together with medium-high-technology industries (notably motor vehicles, chemicals and machinery and equipment), high-technology industries currently account for the bulk of OECD manufacturing trade (just under 65%). The notable spurt in the value of trade in medium-low technology is partly due to recent significant increases in commodity prices for oil and basic metals, notably the metals in great demand for the manufacture of ICT goods.

In the OECD area, the value of international trade in pharmaceuticals grew faster between 1996 and 2005 than in other technology intensive industries. Output of other high-technology industries, such as scientific instruments and radio, TV and communication equipment, also had above-average growth, while the value of trade in office machinery and computers grew relatively slowly.

Sources

- OECD, STAN Indicators database (*forthcoming*).
- OECD, International Trade by Commodity Statistics, May 2007.

For further reading

- OECD (2007), *Staying Competitive in the Global Economy – Moving Up the Value Chain*, OECD, Paris.
- OECD (2005), *Economic Globalisation Indicators*, OECD, Paris.
- Pilat, D., A. Cimper, K. Olsen and C. Webb (2006), "The Changing Nature of Manufacturing in OECD Countries", *STI Working Paper 2006/9,* OECD, Paris.
- Hatzichronoglou, T. (1997). "Revision of the High-Technology Sector and Product Classification", *STI Working Paper1997/2*, OECD, Paris.

Measuring trade in high-technology industries

The very concept of a "high-technology" industry is debated. Is it one that largely *produces* technology or one that largely *uses* technology? A certain number of potential indicators range from input-related measures (*e.g.* expenditures on research and development, number of scientists and engineers) to output-related measures (*e.g.* number of patents). For such indicators, the choice of cut-off points that separate different technology classes is somewhat arbitrary.

On the basis of methodological work at the OECD, manufacturing industries are classified in four categories of technological intensity: high technology, medium-high technology, medium-low technology and low technology. For reasons of availability of comparable statistics, this classification is based on indicators of (direct as well as indirect) technological intensity which reflect to some degree "technology-producer" or "technology-user" aspects. These indicators are R&D expenditures divided by value added, R&D expenditures divided by production and R&D expenditures plus technology embodied in intermediate and capital goods divided by production. The level of detail in the industrial breakdown is limited only by the availability of comparable input-output tables and R&D surveys. The indicators were calculated in the aggregate for 1990 for ten OECD countries for which the embodied technology variable is available using purchasing power parities in 1990 USD. Embodied technology intensities appear to be highly correlated with direct R&D intensities; this reinforces the view that the latter largely reflect an industry's technological sophistication.

This classification is particularly useful for analysing industry information on employment or value added by technological intensity, for example. To do likewise for international trade flows – which are defined at product level – requires attributing each product to a specific industry. However, not all products in a "high-technology industry" necessarily have a high technology content. Likewise, some products in industries with lesser technology intensities may well incorporate a high degree of technological sophistication. Because no detailed data are available for services at present, industry and product classifications only concern manufacturing industries.

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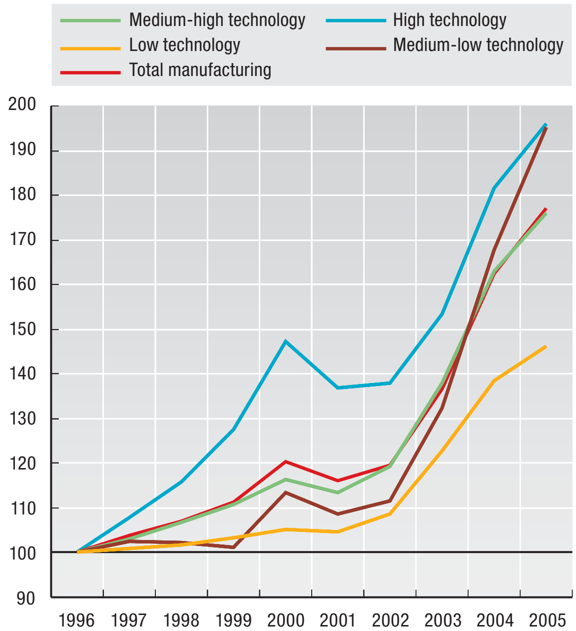
I.6. INTERNATIONAL TRADE BY TECHNOLOGY INTENSITY

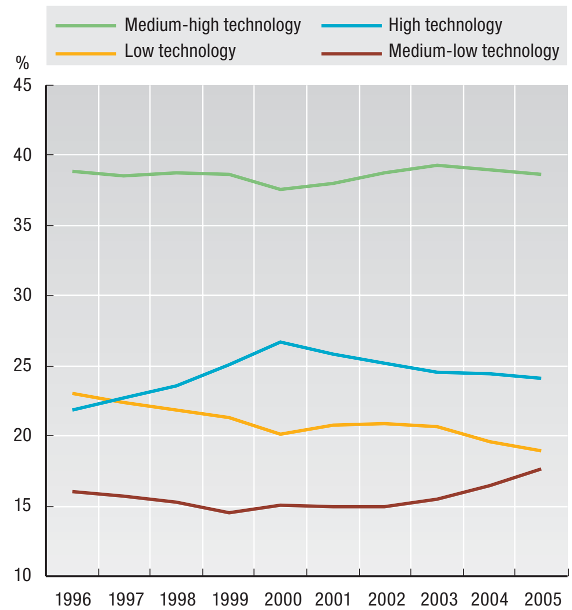
OECD[1] manufacturing trade[2] by technology intensity

Index 1996 = 100



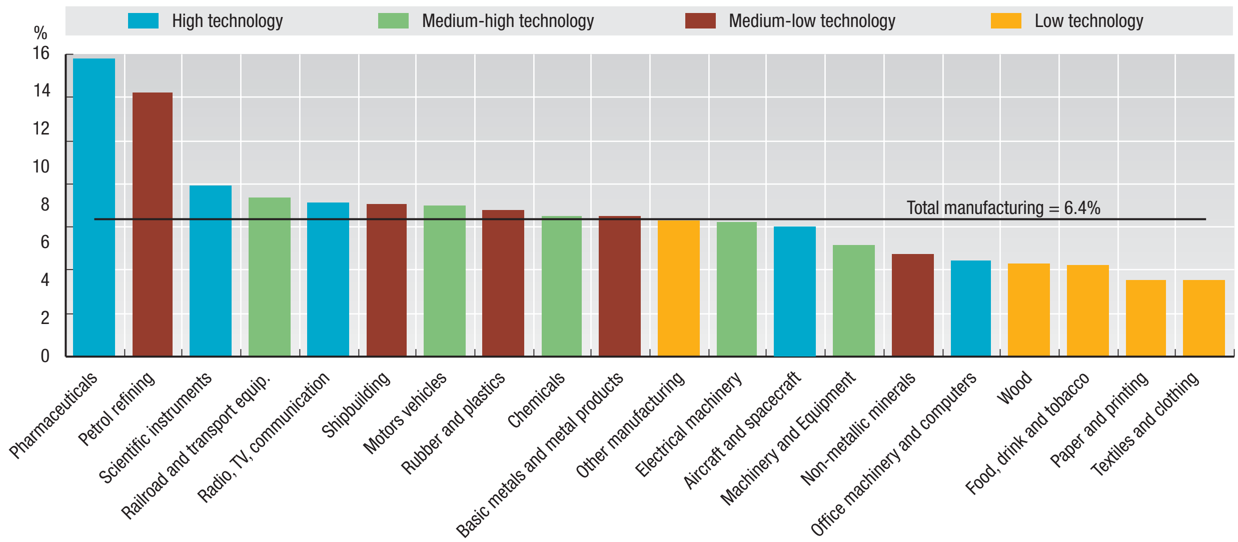
Structure of OECD[1] manufacturing trade[2] by technology intensity

Share in total manufacturing trade



Growth of OECD[1] manufacturing trade[2] by industry and technological intensity

Average annual growth rate, 1996-2005



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1. Excluding Luxembourg and the Slovak Republic.
2. Average value of total OECD exports and imports of goods.

I.7. EXPORTS FROM HIGH- AND MEDIUM-HIGH-TECHNOLOGY INDUSTRIES

■ In 2005, exports from high- and medium-high-technology manufacturing industries (see Annex A) accounted for just under 65% of total OECD exports of manufactured goods and primary products from agriculture and mining. OECD countries whose exports are particularly oriented towards high- and medium-high-technology manufactures include Ireland, Japan and Switzerland (with shares of over 75%) as well as Germany, Hungary, Korea and the United States.

■ Owing to the globalisation of value chains, the most sophisticated parts of the production process (*e.g.* R&D) may be located in different countries than the less sophisticated and more labour-intensive parts. Hence, a high share of high-technology goods in exports does not necessarily reflect sophisticated high-technology industrial activities.

■ Among the BRIICS (Brazil, Russia, India, Indonesia China, South Africa), exports of high and medium-high-technology manufacturing industries are most important in China and Brazil, accounting for 55% and 32% of total exports of manufactured and primary products, respectively. China's share of exports of high-technology manufactures (35%) is significantly higher than the OECD average (23%).

■ Differences across countries are substantial. Shares of high- and medium-high-technology industries in exports range from under 20% for countries specialising in exports of primary products or low-technology manufactures (such as Australia, Iceland, New Zealand, Norway and Russia) to over 80% for Ireland and Japan.

■ Technology-intensive goods have accounted for much of the growth in total exports of goods in recent years. During 1996-2005, growth in exports of high-technology goods outstripped that of total manufacturing in all OECD countries except Japan and Sweden. High-technology exports increased very rapidly in China, Iceland, Greece, Turkey and the eastern European OECD countries.

■ Between 1996 and 2005, the shares of Germany and Korea in total OECD technology exports increased at the expense of Japan, the United States and other large European technology suppliers. With around 16% of total OECD technology exports, Germany had the largest share of the market in 2005, closely followed by the United States. With a share representing over 10% of total OECD technology exports, China was just behind Japan as the fourth largest exporter of high- and medium-high technology goods in 2005.

Sources

- OECD, STAN indicators (*forthcoming*).
- OECD, International Trade by Commodity Statistics, May 2007.

For further reading

- OECD (2007), *Staying Competitive in the Global Economy – Moving Up the Value Chain*, OECD, Paris.
- Pilat, D. , A. Cimper, K. Olsen and C. Webb (2006), "The Changing Nature of Manufacturing in OECD Countries", *STI Working Paper 2006/9*, OECD, Paris.
- OECD (2005), *Measuring Globalisation: OECD Economic Globalisation Indicators*, OECD, Paris.
- Hatzichronoglou, T. (1997), "Revision of the High-Technology Sector and Product Classification", *STI Working Paper* 1997/2, OECD, Paris.

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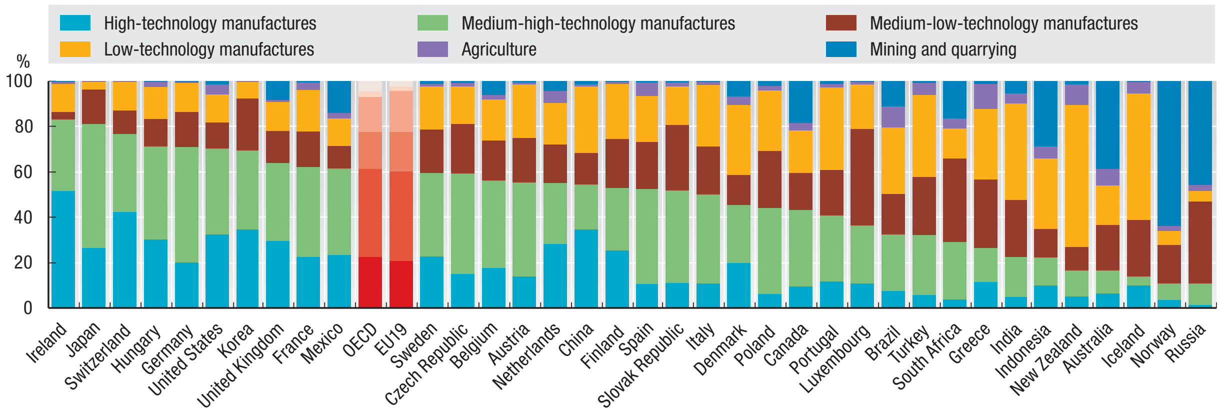
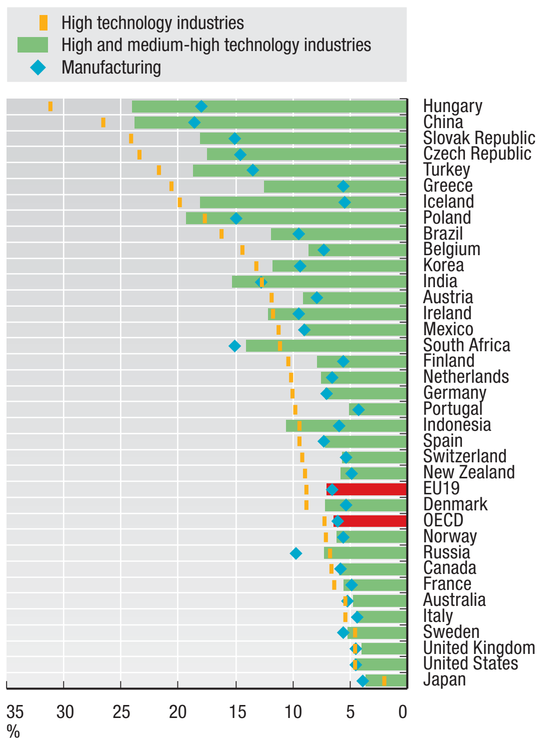
I.7. EXPORTS FROM HIGH- AND MEDIUM-HIGH-TECHNOLOGY INDUSTRIES

Share of technology industries in total exports of manufactured goods and primary products,[1] 2005



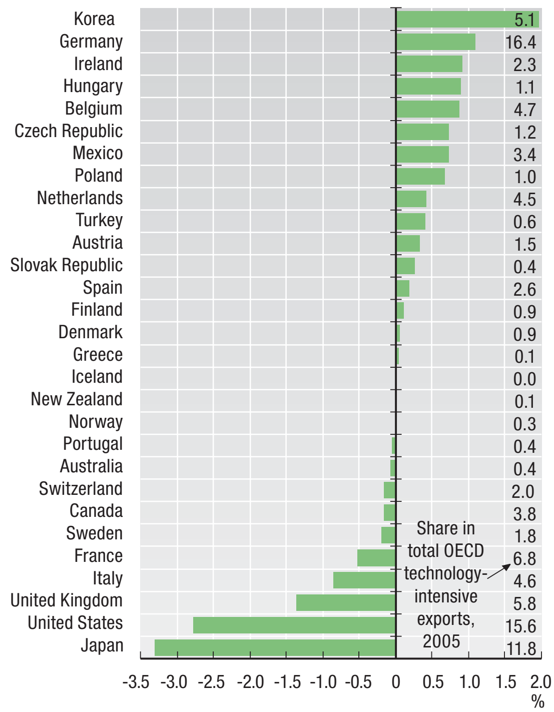
Growth of high- and medium-high technology exports, 1996-2005

Annual average growth rate



Share in total OECD high- and medium-high technology exports

Percentage change in shares of exports over 1996-2005



StatLink http://dx.doi.org/10.1787/120463637500

Note: OECD and EU aggregates exclude Luxembourg. Underlying data for China include exports to Hong Kong (China).

1. A total consisting of manufactured goods and primary products from agriculture and mining is preferred here since published total exports of products can include exports of scrap metal and waste (where identifiable) as well as confidential data that cannot be allocated to product or industry codes.

I.8. CONTRIBUTIONS TO THE MANUFACTURING TRADE BALANCE

An assessment of countries' strengths and weaknesses in terms of technological intensity should not focus solely on exports (see I.7) but should also gauge the role of imports, as production of exported goods may depend heavily on imports of intermediate goods (components) from the same industry. Indicators of revealed comparative advantage allow for a better understanding of countries' specialisation profiles.

In 2005, few OECD countries had a comparative advantage in trade in high-technology manufactures. Switzerland enjoyed a surplus of over 7% while Ireland and United States had surpluses of around 6% and 4%, respectively. The relative strengths of Germany and Japan lie in medium-high-technology manufactures; in 2005 these made a positive contribution to their manufacturing trade balances of over 7% and 15%, respectively.

Many OECD countries still have a strong comparative advantage in medium-low and/or low-technology manufacturing industries. This is also the case in all the BRIICS (Brazil, Russia, India, Indonesia, China and South Africa), although Indonesia also benefits from a positive contribution, of about 4%, from high-technology manufactures. In spite of the significant volume of China's high-technology exports, its trade balance, in 2005, still relied on the positive contribution of low-technology industries.

For most countries, these comparative advantages changed little over the period 1996-2005. However there are exceptions, the most noteworthy being Japan, which saw its comparative advantage in high-technology industries disappear. Ireland, Indonesia and Switzerland saw their comparative advantage in high-technology manufactures increase noticeably while Finland and Hungary developed a comparative advantage in this area.

Sources

- OECD, STAN indicators (*forthcoming*).
- OECD, International Trade by Commodity Statistics, May 2007.

For further reading

- OECD (2007), *Staying Competitive in the Global Economy – Moving Up the Value Chain*, OECD, Paris.
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- OECD (2005), *Measuring Globalisation: OECD Economic Globalisation Indicators*, OECD, Paris.
- Hatzichronoglou, T. (1997), "Revision of the High-Technology Sector and Product Classification", *STI Working Paper* 1997/2, OECD, Paris.

Measuring contributions to the trade balance

The "contribution to the trade balance" makes it possible to identify an economy's structural strengths and weaknesses via the composition of international trade flows. It takes into account not only exports, but also imports, and tries to eliminate business cycle variations by comparing an industry's trade balance with the overall trade balance. It can be interpreted as an indicator of "revealed comparative advantage", as it indicates whether an industry performs relatively better or worse than the manufacturing total, whether the manufacturing total itself is in deficit or surplus.

If there were no comparative advantage or disadvantage for any industry *i*, a country's total trade balance (surplus or deficit) should be distributed across industries according to their share in total trade. The "contribution to the trade balance" is the difference between the actual and this theoretical balance:

$$(X_i - M_i) - (X - M)\frac{(X_i + M_i)}{(X + M)}$$

where $(X_i - M_i)$ = observed industry trade balance,

and $(X - M)\frac{(X_i + M_i)}{(X + M)}$ = theoretical trade balance

A positive value for an industry indicates a structural surplus and a negative one a structural deficit. The indicator is additive and individual industries can be grouped together by summing their respective values: by construction, the sum over all industries is zero. To allow comparisons across industries, the indicator is generally expressed as a percentage of total trade or of GDP.

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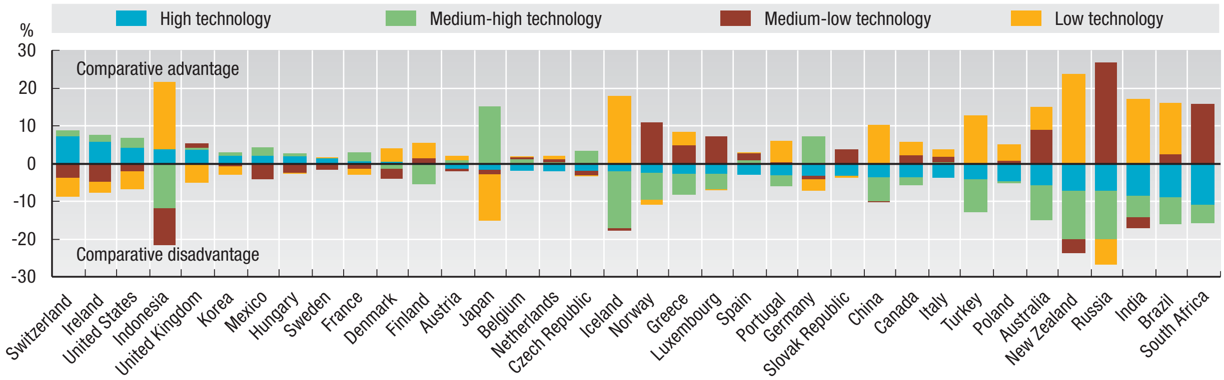
I.8. CONTRIBUTIONS TO THE MANUFACTURING TRADE BALANCE

Contribution to the manufacturing trade balance, 2005

As a percentage of manufacturing trade

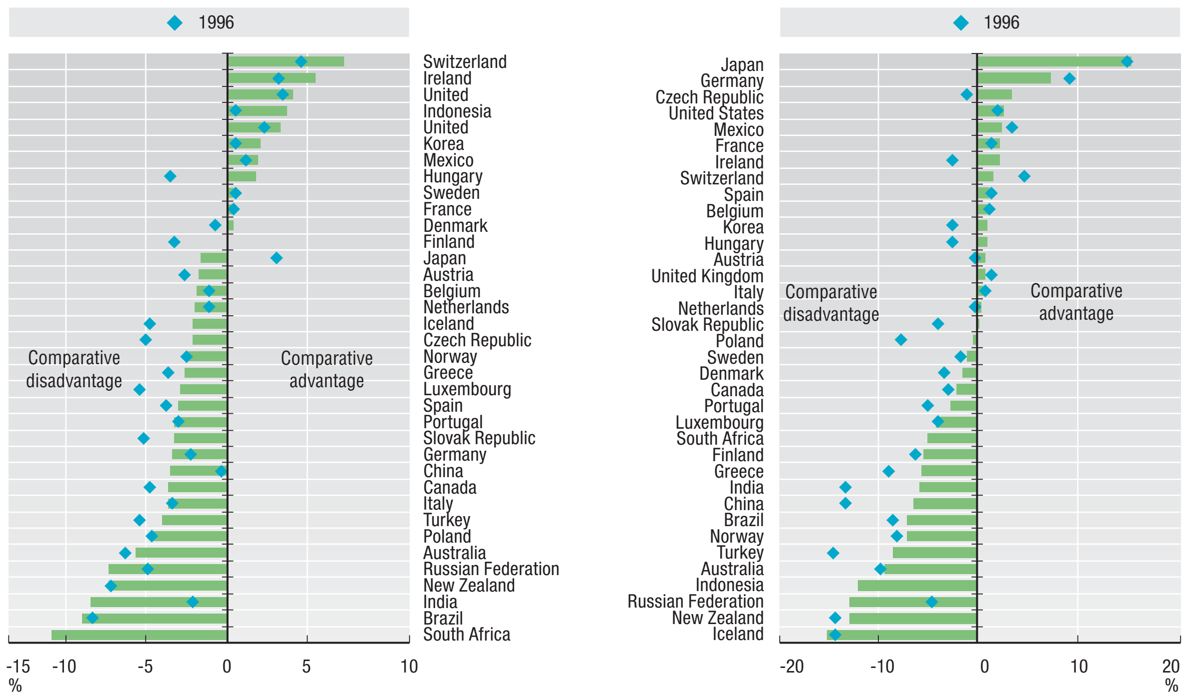


Change in contribution to the manufacturing trade balance, 2005

As a percentage of total manufacturing trade

High-technology industries

Medium-high-technology industries



StatLink http://dx.doi.org/10.1787/120467034628

Note: Underlying data for China include trade with Hong Kong (China). Data for Luxembourg refer to 1999 and 2005, 1997 and 2005 for the Slovak Republic

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ANNEX 1
CLASSIFICATION OF MANUFACTURING INDUSTRIES BASED ON TECHNOLOGY

Annex Table 1.1 presents manufacturing industries classified according to technology intensity using the ISIC Rev. 3 breakdown of activity.

Technological effort is a critical determinant of productivity growth and international competitiveness. However, since it is not spread evenly across the economy, analyses of industry performance and structural change attach much importance to technological criteria. Methodological work carried out at the OECD is used to determine these criteria.

In the past, a technology classification based on ISIC Rev. 2 industry classifications was widely used. The methodology uses three indicators of technology intensity reflecting, to different degrees, "technology-producer" and "technology-user" aspects: *i)* R&D expenditures divided by value added; *ii)* R&D expenditures divided by production; and *iii)* R&D expenditures plus technology embodied in intermediate and investment goods divided by production. These indicators were evaluated for 1990 and for the aggregate of the ten OECD countries for which a measure of embodied technology was available, using 1990 USD purchasing power parities (see T. Hatzichronoglou, "Revision of the High-Technology Sector and Product Classification", STI Working Paper 1997/2).

The current classification is based on analysis of R&D expenditure and output of 12 OECD countries according to ISIC Rev. 3 (NACE Rev. 1 in Europe) and covering the period 1991-99. In the absence of updated ISIC Rev. 3 input-output tables (required for estimating embodied technology), only the first two indicators could be calculated.

The division of manufacturing industries into high-technology, medium-high-technology, medium-low-technology and low-technology groups was made after ranking the industries according to their average over 1991-99 against aggregate OECD R&D intensities. Industries classified to higher categories have a higher average intensity for both indicators than industries in lower categories. Also considered were: *i)* temporal stability: for adjacent years, industries classified to higher categories have a higher average intensity than those in lower categories (see Annex Table 1.2); and *ii)* country median stability: industries classified to the higher categories have a higher median intensity than those in lower categories.

Points to note:

- The cut-off points are clear except possibly the distinction between the medium-low- and low-technology groups.
- The low-technology group consists of relatively aggregate sectors, owing to limited detailed R&D expenditure data across countries. The few cases in which R&D intensities are available for more detailed (2-digit) breakdowns confirm the allocation of these industries to low technology.
- The classification concerns the OECD area as a whole. For individual countries, allocation to the technology groups may differ. Also, at national level, finer technology classifications may be generated from more detailed underlying data.

Annex 1.1. **Classification of manufacturing industries based on technology**[1]

		1999				1991			
		R&D divided by production		R&D divided by value added		R&D divided by production		R&D divided by value added	
	ISIC Rev. 3	Aggregate intensity[2]	Median intensity	Aggregate intensity[2]	Median intensity	Aggregate intensity[2]	Median intensity	Aggregate intensity[2]	Median intensity
High-technology industries									
Aircraft and spacecraft	353	10.3	10.4	29.1	27.5	13.9	12.9	34.7	32.1
Pharmaceuticals	2423	10.5	10.1	22.3	25.8	9.4	8.7	20.6	19.7
Office, accounting and computing machinery	30	7.2	4.6	25.8	15.1	10.9	6.4	29.4	15.2
Radio, TV and communciations equipment	32	7.4	7.6	17.9	22.4	7.9	8.2	17.0	21.5
Medical, precision and optical instruments	33	9.7	5.6	24.6	11.9	6.6	6.1	15.6	12.5
Medium-high-technology industries									
Electrical machinery and apparatus, n.e.c.	31	3.6	2.3	9.1	6.7	4.2	2.6	9.3	5.9
Motor vehicles, trailers and semi-trailers	34	3.5	2.8	13.3	11.7	3.7	3.0	14.3	11.9
Chemicals excluding pharmaceuticals	24 excl. 2423	2.9	2.2	8.3	7.1	3.4	2.8	9.8	8.0
Railroad equipment and transport equipment, n.e.c.	352 + 359	3.1	2.8	8.7	7.9	2.9	2.1	7.6	5.4
Machinery and equipment, n.e.c.	29	2.2	2.1	5.8	5.3	1.9	2.0	4.6	4.7
Medium-low-technology industries									
Building and repairing of ships and boats	351	1.0	1.0	3.1	2.9	0.9	0.9	2.8	2.6
Rubber and plastics products	25	1.0	1.1	2.7	3.0	1.0	0.6	2.6	1.5
Coke, refined petroleum products and nuclear fuel	23	0.4	0.3	1.9	2.7	1.2	0.7	5.4	3.8
Other non-metallic mineral products	26	0.8	0.6	1.9	1.3	1.0	0.6	2.4	1.5
Basic metals and fabricated metal products	27-28	0.6	0.5	1.6	1.4	0.7	0.6	2.0	1.6
Low-technology industries									
Manufacturing, n.e.c.; Recycling	36-37	0.5	0.5	1.3	1.2	0.5	0.4	1.2	0.9
Wood, pulp, paper, paper products, printing and publishing	20-22	0.4	0.1	1.0	0.3	0.3	0.1	0.8	0.3
Food products, beverages and tobacco	15-16	0.3	0.3	1.1	1.0	0.3	0.3	1.1	1.1
Textiles, textile products, leather and footwear	17-19	0.3	0.4	0.8	1.0	0.2	0.3	0.7	0.7
Total manufacturing	15-37	2.6	2.2	7.2	6.5	2.5	2.0	7.0	5.7

1. Based on data for 12 OECD countries: United States, Canada, Japan, Denmark, Finland, France, Germany, Ireland, Italy, Spain, Sweden, United Kingdom

2. Aggregate R&D intensities calculated after converting countries' R&D expenditures, value added and production using GDP PPPs

Source: OECD: ANBERD and STAN databases, May 2003

Annex 1.2. **R&D intensity[1] for aggregate of 12 OECD countries, 1991-1999**

	ISIC Rev.3	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	mean intensity 1991-1999
Aircraft and spacecraft	353	13.9	13.9	13.5	13.9	16.2	14.8	12.8	10.7	10.3	13.3
Pharmaceuticals	2423	9.4	10.1	10.8	10.9	10.6	10.3	11.0	11.1	10.5	10.5
Office, accounting and computing machinery	30	10.9	10.4	9.3	8.8	7.5	9.1	10.4	8.9	7.2	9.2
Radio, TV and communciations equipment	32	7.9	8.3	7.9	7.8	7.7	8.2	8.0	8.6	7.4	8.0
Medical, precision and optical instruments	33	6.6	6.8	7.1	7.7	7.7	7.4	8.0	8.0	9.7	7.7
Electrical machinery and apparatus, n.e.c.	31	4.2	4.0	4.0	3.8	4.0	3.9	3.9	4.0	3.6	3.9
Motor vehicles, trailers and semi-trailers	34	3.7	3.4	3.5	3.4	3.5	3.7	3.5	3.3	3.5	3.5
Chemicals excluding pharmaceuticals	24 excl. 24	3.4	3.3	3.4	3.1	2.8	3.1	2.7	3.1	2.9	3.1
Railroad equipment and transport equipment, n.e.c.	352 + 359	2.9	2.4	2.4	2.7	2.6	3.2	3.5	3.0	3.1	2.9
Machinery and equipment, n.e.c.	29	1.9	2.0	2.0	2.1	2.0	2.1	2.1	2.1	2.2	2.1
Building and repairing of ships and boats	351	0.9	1.0	1.0	0.9	0.9	1.0	0.8	1.0	1.0	1.0
Rubber and plastics products	25	1.0	1.0	0.9	1.0	0.8	0.9	0.9	0.9	1.0	0.9
Coke, refined petroleum products and nuclear fuel	23	1.2	1.2	1.1	1.0	0.9	0.8	0.7	0.9	0.4	0.9
Other non-metallic mineral products	26	1.0	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.8	0.9
Basic metals and fabricated metal products	27-28	0.7	0.7	0.7	0.6	0.6	0.7	0.7	0.6	0.6	0.6
Manufacturing, n.e.c.; Recycling	36-37	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.6	0.5	0.5
Wood, pulp, paper, paper products, printing and publishing	20-22	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.4	0.4	0.3
Food products, beverages and tobacco	15-16	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.3
Textiles, textile products, leather and footwear	17-19	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Total manufacturing	**15-37**	**2.5**	**2.5**	**2.5**	**2.4**	**2.4**	**2.6**	**2.6**	**2.6**	**2.6**	**2.5**
High-technology industries		**9.4**	**9.5**	**9.3**	**9.3**	**9.2**	**9.3**	**9.5**	**9.3**	**8.7**	**9.3**
Medium-high-technology industries		**3.1**	**3.0**	**3.1**	**3.0**	**2.9**	**3.1**	**2.9**	**3.0**	**3.0**	**3.0**
Medium-low-technology industries		**0.9**	**0.9**	**0.9**	**0.8**	**0.8**	**0.8**	**0.8**	**0.8**	**0.7**	**0.8**
Low-technology industries		**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.4**	**0.4**	**0.4**	**0.4**	**0.3**

1. R&D intensity defined as direct R&D expenditures as a percentage of production (gross output), calculated after converting countries' R&D expenditures and production using GDP PPPs

Source: OECD: ANBERD and STAN databases, May 2003

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ANNEX 2
MAIN OECD DATABASES USED

STAN – Industry: The STAN database for **Industrial Analysis** includes annual measures of output, labour input, investment and international trade by economic activity, which allow users to construct a wide range of indicators focused on areas such as productivity growth, competitiveness and general structural change. The industry list based on the International Standard Industrial Classification (ISIC) Rev. 3, provides sufficient details to enable users to highlight high-technology sectors and is compatible with those lists used in related OECD databases in the 'STAN' family (see below). STAN-Industry is primarily based on member countries' annual National Accounts by activity tables and uses data from other sources, such as national industrial surveys/censuses, to estimate any missing detail. Since many of the data points in STAN are estimated, they do not represent the official member country submissions. See: www.oecd.org/sti/stan.

> *Publication*: STAN - Industry is available on line via SourceOECD (www.sourceoecd.org) where it is regularly updated (new tables are posted as soon as they are ready). A "snapshot" of STAN - Industry is also available on CD-ROM together with the latest versions of STAN – R&D (ANBERD), STAN – Bilateral Trade and a set of derived STAN Indicators. See: www.oecd.org/sti/stan/indicators.

STAN – R&D (ANBERD): The **Analytical Business Enterprise Research and Development** database is an estimated database constructed with a view to creating a consistent data set that overcomes the problems of international comparability and time discontinuity associated with the official business enterprise R&D data provided to the OECD by its member countries. ANBERD contains R&D expenditures for the period 1987-2004, by industry (ISIC Rev. 3), for 19 OECD countries. See: www.oecd.org/sti/anberd.

> *Publication*: OECD (2006), *Research and Development Expenditure in Industry 1987-2004*. Annual. ANBERD is also available on line via SourceOECD (under the STAN heading) as well as on the STAN family CD-ROM.

STAN – Bilateral Trade (BTD): The forthcoming edition (2007) of this database will present detailed **trade flows** by manufacturing industry between OECD and, for the first time, a selection of non-OECD *declaring* countries and a range of OECD and non-OECD *partner* countries and geographical regions. The data are derived from OECD's *International Trade by Commodities Statistics* (ITCS) database via standard conversions from product classification schemes to an activity classification scheme based on ISIC Rev. 3. BTD's industry list is compatible with those used in related OECD data sets such as the STAN-Industry and STAN R&D (ANBERD) databases and STAN I-O, a collection of harmonized Input-Output tables. Data will be presented in thousands of USD at current prices, and will cover the period 1988-2006. See: www.oecd.org/sti/btd

> *Publication:* OECD (2007), *Bilateral Trade Database, 2007*. BTD will be available on line via SourceOECD (under the STAN heading) as well as on the STAN family CD-ROM.

STAN – Bilateral Trade (BTD): The forthcoming edition (2007) of this database will present detailed **trade flows** by manufacturing industry between OECD and several non-OECD *declaring* countries and a selection of *partner* countries and geographical regions. The data are derived from the OECD database *International Trade by Commodities Statistics* (ITCS - formerly *Foreign Trade Statistics* or FTS) and are converted from product classification schemes to an activity classification scheme based on ISIC Rev.3. BTD's industry list is compatible with those used in the OECD's STAN - Industry, Input-Output tables and ANBERD databases. Data will be presented in thousands of USD at current prices, and will cover the period 1988-2006. See: www.oecd.org/sti/btd

> *Publication:* OECD (2007), *Bilateral Trade Database, 2007*. BTD will be available on line via SourceOECD (under the STAN heading) as well as on the STAN family CD-ROM.

STAN – I-O: The latest set of OECD **Input-Output** tables consists of matrices of inter-industrial transaction flows of goods and services (domestically produced and imported) in current prices for 27 OECD countries (for the time being, all OECD member countries except Iceland and Mexico) and 9 non-member countries (Argentina, Brazil, China, Chinese Taipei, India, Indonesia, Israel, Russia and South Africa) covering the years around the mid-1990s and early 2000s. The tables are based on ISIC Rev. 3 and are available for free in zipped Excel format. See: www.oecd.org/std/io-tables/data.

R&D: The **R&D** database contains the full results of the OECD surveys on **R&D expenditure and personnel**. This database serves, *inter alia*, as raw material for both the ANBERD and MSTI databases.

Publication: OECD (2006), *Research and Development Statistics: 2005 Edition.* (formerly *Basic Science and Technology Statistics)* Updated annually on CD-ROM as *OECD Science and Technology Statistics.*

MSTI: The **Main Science and Technology Indicators** database provides a selection of the most frequently used annual data on the scientific and technological performance of OECD member countries and nine non-member economies (Argentina, China, Israel, Romania, Russian Federation, Singapore, Slovenia, South Africa, Chinese Taipei). The indicators, expressed in the form of ratios, percentages, growth rates, cover resources devoted to R&D, patent families, technology balance of payments and international trade in highly R&D-intensive industries.

Publication: OECD (2007), *Main Science and Technology Indicators 2007/1*. Biannual. Also available on CD-ROM as *OECD Science and Technology Statistics*.

TBP: The **TBP** database presents information on the **technology balance of payments**. The database serves, *inter alia*, as raw material for the MSTI database and publications.

Patent database: This database contains patents filed at the largest national patent offices - European Patent Office (EPO); US Patent and Trademark Office (USPTO); Japanese Patent Office (JPO) – and other national or regional offices. Each patent is referenced by: patent numbers and dates (publication, application and priority); names and countries of residence of the applicants and of the inventors; and technological categories, using the national patent classification as well as the International Patent Classification (IPC). The compiled indicators mainly refer to single patent counts in a selected patent office, as well as counts of triadic patent families (patents filed at the EPO, the USPTO and the JPO to protect a single invention). See: www.oecd.org/sti/ipr-statistics.

The series are published on a regular basis in OECD, *Main Science and Technology Indicators.*

AFA: The **Activities of Foreign Affiliates** database presents detailed data on the performance of foreign affiliates in the **manufacturing** industry of OECD countries (inward and outward investment). The data indicate the increasing importance of foreign affiliates in the economies of host countries, particularly in production, employment, value added, research and development, exports, wages and salaries. AFA contains 18 variables broken down by country of origin (inward investment) or location (outward investment) and by industrial sector (based on ISIC Rev. 3) for 23 OECD countries.

Publication: OECD, *Measuring Globalisation: Activities of Multinationals*, 2007 Edition. *Vol. I: Manufacturing.* Biennial. Also available annually on line on SourceOECD (www.sourceoecd.org).

FATS: This database gives detailed data on the **activities of foreign affiliates** in the **services** sector of OECD countries (inward and outward investment). The data indicate the increasing importance of foreign affiliates in the economies of host countries and of affiliates of national firms implanted abroad. FATS contains five variables (production, employment, value added, imports and exports) broken down by country of origin (inward investments) or implantation (outward investments) and by industrial sector (based on ISIC Rev. 3) for 21 OECD countries.

> *Publication (forthcoming):* OECD, *Measuring Globalisation: The Role of Multinationals in OECD Economies*, 2007 Edition. *Vol. II: Services*. Biennial.

Telecommunications: This database is produced in association with the biennial *Communications Outlook*. It provides time-series data covering all OECD countries, where available, for the period 1980-2006. It contains telecommunication, Internet and economic indicators.

> *Publication*: OECD (2007), *Telecommunications Database 2007*. Only available on OECD.Stat.

ICT: Work is under way to develop a database on ICT supply and ICT usage statistics.

Current country coverage of main DSTI databases used in this publication

	Industry	Science & technology					Globalisation			ICT
	STAN	R&D	TBP	MSTI	ANBERD	Patents	AFA	FATS	BTD	Telecom.
Australia	X	X	X	X	X	X	X	X	X	X
Austria	X	X	X	X		X	X	X	X	X
Belgium	X	X	X	X	X	X		X	X	X
Canada	X	X	X	X	X	X	X	X	X	X
Czech Republic	X	X	X	X	X	X	X	X	X	X
Denmark	X	X	X	X	X	X	X		X	X
Finland	X	X	X	X	X	X	X	X	X	X
France	X	X	X	X	X	X	X	X	X	X
Germany	X	X	X	X	X	X	X	X	X	X
Greece	X	X		X		X		X	X	X
Hungary	X	X	X	X		X	X	X	X	X
Iceland	X	X		X		X			X	X
Ireland	X	X	X	X	X	X	X	X	X	X
Italy	X	X	X	X	X	X	X	X	X	X
Japan	X	X	X	X	X	X	X	X	X	X
Korea	X	X	X	X	X	X			X	X
Luxembourg	X	X	X	X		X	X	X	X	X
Mexico	X	X	X	X		X			X	X
Netherlands	X	X	X	X	X	X	X	X	X	X
New Zealand	X	X	X	X		X			X	X
Norway	X	X	X	X	X	X	X	X	X	X
Poland	X	X	X	X	X	X	X	X	X	X
Portugal	X	X	X	X		X	X	X	X	X
Slovak Republic	X	X	X	X		X			X	X
Spain	X	X	X	X	X	X	X	X	X	X
Sweden	X	X	X	X	X	X	X	X	X	X
Switzerland	X	X	X	X		X	X		X	X
Turkey		X		X		X	X		X	X
United Kingdom	X	X	X	X	X	X	X	X	X	X
United States	X	X	X	X	X	X	X	X	X	X
China		X		X						
Russian Federation		X		X						
South Africa		X		X						

Other OECD databases

ANA: SNA93 - Annual National Accounts (Statistics Directorate).

Database on Immigrants and Expatriates (Directorate for Employment, Labour and Social Affairs).

Education (Directorate for Education).

Educational Attainment (Directorate for Education).

ITCS: International Trade by Commodity Statistics (Statistics Directorate).

International Direct Investment (Directorate for Financial and Enterprise Affairs).

LFS: Labour Force Statistics (Statistics Directorate).

Productivity (Statistics Directorate, Directorate for Employment, Labour and Social Affairs, Directorate for Science, Technology and Industry).

Further details on OECD statistics are available at: www.oecd.org/statistics/.

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ANNEX 3
BIOTECHNOLOGY STATISTICS: METHODOLOGY

Biotechnology consists of a group of related technologies with applications in many different economic sectors – agriculture, forestry, aquaculture, mining, petroleum refining, environmental remediation, human and animal health, food processing, chemicals, security systems – and in many industrial processes. It is the range of current and potential applications, together with their economic, environmental and social impacts, that creates policy interest in obtaining high-quality economic and innovation indicators for biotechnology.

However, unlike information and communication technology or other technologies, biotechnology lacks a core "sector" that can be quickly identified and surveyed. This has created major challenges for developing comparable biotechnology indicators. These include national differences in the definition of biotechnology and the fields of application of biotechnology, and of a biotechnology firm. To address these issues, over the past seven years the OECD co-ordinated work by national experts to improve definitions and survey methodologies. This resulted in the "OECD" definition of biotechnology and the *Framework for Biotechnology Statistics*, which provides guidance for collecting data on biotechnology.

OECD Biotechnology Statistics 2006 presents some results of this international effort to improve the comparability of biotechnology indicators. Most countries now use the OECD list-based definition of biotechnology or similar definitions that focus on modern biotechnologies. However, full comparability has not yet been reached, owing to different methods of constructing sample frames and dealing with survey non-responses. Methodological similarities and differences in national biotechnology surveys are summarised in the table.

Although every effort has been made to maximise comparability across countries, caution must be used when comparing biotechnology activities across countries when the data are obtained from studies with different methodologies. This applies particularly to differences between studies limited to firms whose main economic activity is biotechnology (dedicated biotechnology firms) and studies of all firms with some biotechnology activity (biotechnology-active firms). Other factors, such as differences in the definition of biotechnology, whether or not firms must innovate, and low response rates in some countries, will also reduce comparability.

As a final caution, some of the results for specific countries vary, depending on the data source. For example, the 2001 Department of Commerce survey estimates total biotechnology R&D at USD 16 834 million current PPP, while the 2003 National Science Foundation (NSF) R&D survey for the United States estimates total biotechnology R&D at USD 14 232 million in current purchasing power parity (PPP). The estimated decline in biotechnology R&D between 2001 and 2003 could be an artefact due to different survey methodologies. The 2003 results are likely to be more accurate, owing to the use of the R&D sample frame and a higher response rate. However, the 2003 survey did not provide results by field of application. Consequently, the 2001 results were used to estimate the distribution of biotechnology R&D expenditures by application.

The biotechnology data presented in section F are official data collected by national statistical offices. This is only a small selection of the data presented in *OECD Biotechnology Statistics 2006*.

Source

- OECD (2006), *OECD Biotechnology Statistics 2006*, OECD. Paris, available at: www.oecd.org/dataoecd/51/59/36760212.pdf.

For further reading

- OECD (2005), *A Framework for Biotechnology Statistics*, OECD, Paris, available at: www.oecd.org/dataoecd/5/48/34935605.pdf.
- Arundel, A. (2003), *Biotechnology Indicators and Public Policy*, STI Working Paper 2003/5, OECD, Paris.

Methodological information for national biotechnology surveys

	Year	Biotech definition[1]	Biotech firm type[2]	All firms innovate?	Sample frame[3]	Source[4]	Response rate	Extrapolation[5]
Australia	2003-04	OECD	R&D	Yes	R&D	GOV	86%	Partial
Belgium	2003	OECD	All	..	Secondary	NP-GOV	31%	No
Canada	2003	OECD	All	Yes	Secondary	GOV	80%	Yes
China (Shanghai)	2003	Modern	All	..	Secondary	GOV	39%	No
Denmark	2003	None	R&D	Yes	R&D	NP-GOV	63%	Yes
Finland	2003	OECD	R&D	Yes	R&D	GOV	83%	Yes
Finland	2003	Modern	Dedicated	..	Secondary	NP-GOV	71%	Partial
France	2003	OECD	R&D	Yes	R&D	GOV	72%	Yes
Germany	2004	OECD	All	No	Secondary	GOV	65%	Yes
Iceland	2003	OECD	R&D	Yes	R&D	NP-GOV	100%	Not relevant
Israel	2002	OECD	All	No	Secondary	GOV	96%	Yes
Italy	2004	OECD	R&D	Yes	R&D	GOV	50%	No
Japan	2003	Mixed[6]	All	No	Secondary	JBA-GOV	76%	No
Korea	2004	Modern[6]	All	..	Secondary	GOV	100%	Not relevant
Korea	2004	..	R&D	Yes	R&D	GOV	76%	..
New Zealand	2004	OECD	All	No	Secondary	GOV	94%	No
New Zealand	2004	OECD	R&D	Yes	R&D	GOV	84%	Yes
New Zealand	2005	OECD	All	No	Secondary	GOV	93%	No
Norway	2003	OECD	R&D	Yes	R&D	GOV	95%	Yes
Poland	2004	OECD	..	Yes	..	GOV	34%	No
South Africa[7]	2002-03	Mixed	All	No	Secondary	EgoliBio-GOV	72%	No
Spain	2004	OECD	R&D	Yes	R&D	GOV	86%	Yes
Sweden	2003	None	R&D	Yes	R&D	GOV	94%	Yes
Sweden	2003	..	Dedicated	..	Secondary	NP-GOV	..	..
Switzerland	2004	OECD	R&D	Yes	R&D	GOV	81%	Yes
United States[8]	2001	OECD	All	No	Secondary	GOV	61%	No
United States	2003	OECD	R&D	Yes	R&D	GOV	81%	Partial

1. What definition of biotechnology was used in the survey? Categories are: OECD (list-based definition), Modern (similar to the OECD list-based definition), Mixed (includes both modern and traditional biotechnologies, but it is possible to separate modern from traditional biotechnologies), All (modern and traditional combined), and None (no definition given in the survey).
2. OECD defined three types of firms for this data collection: All (all firms with some activities in biotechnology or "biotechnology-active"' firms), Dedicated biotechnology firms (the firm's main economic activity is biotechnology), and R&D (all firms that perform some biotechnology R&D). Typically, the information on biotechnology-active firms and dedicated biotechnology firms is collected by surveys of firms believed to be active in biotechnology, whereas the information on biotechnology R&D firms is obtained from R&D surveys of the business enterprise sector.
3. What sample frame was used in the survey? Two main methods of constructing the frame are in common use: R&D survey (all respondents to the business R&D survey are asked if they have expenditures for biotechnology R&D); and secondary sources (a list of biotech firms is constructed from a diverse set of sources, such as biotechnology industry associations, searching patent data to identify firms that have applied for a biotechnology patent, results of previous R&D surveys, applicants to government support programmes for biotechnology R&D, etc.).
4. Who conducted the survey? GOV (survey or study conducted by a government agency), and NP-GOV (conducted by a non-profit organisation at the request of a government agency).
5. Are survey non-respondents accounted for by the use of extrapolation techniques such as weighting, imputation or other methods to estimate the full population of biotechnology firms? Categories are Yes, No, and Partial. "Partial" was used in cases where extrapolation was limited to selected firms or limited to some of the survey questions or indicators.
6. Wherever possible, the results are limited to "modern'" biotechnology, but this could still include some second-generation or traditional biotechnology activity.
7. Large firms in traditional biotechnology (fermented food products) were excluded, but some traditional and second-generation biotechnology firms are in the sample.
8. The definition of biotechnology used in the R&D survey was similar but not identical to the OECD definition.

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