HIGHLIGHTS

The rising knowledge intensity of OECD economies…

This issue of the *Science, Technology and Industry Scoreboard* reveals that the knowledge intensity of OECD economies has continued to increase in recent years, despite the economic slowdown and talk of the death of the "new economy". Investment in research and development (R&D) rose in 2001 and into 2002, as did investment in software in several countries. Information and communication technology (ICT) continued to diffuse to households and businesses and electronic commerce continued to gain in importance, despite the slowdown in parts of the ICT sector.

… is reflected in trade patterns and in stronger productivity growth in some OECD countries.

The growing role of knowledge is reflected in economic performance. Trade in high-technology goods, such as aircraft, computers, pharmaceuticals and scientific instruments, accounted for over 25% of total trade in 2000 and 2001, up from less than 20% in the early 1990s. Some OECD economies have performed better than others. In Australia, Canada, Finland, Ireland and the United States, the overall efficiency of capital and labour – multi-factor productivity (MFP) – increased considerably over the 1990s, partly thanks to rapid technological progress and the effective use of ICT. Services sectors accounted for some of the acceleration, particularly in Australia and the United States. In some countries that have historically lagged behind, technology diffused very rapidly in recent years. For example, 86% of all enterprises in the Czech Republic with more than ten employees had Internet access in 2002, close to the levels of Australia and Canada.

It is accompanied by closer integration of OECD and non-OECD economies.

The globalisation of OECD economies continues. The trade-to-GDP ratio increased by about 2 percentage points over the 1990s in the United States and the European Union, although it remained stable in Japan. Over the 1990s, manufacturing, particularly high-technology industries, was increasingly exposed to international competition. Services have been characterised by large flows of foreign direct investment and the growing role of foreign affiliates in turnover and employment. Moreover, globalisation has been accompanied by greater international mobility, notably of highly skilled workers. A range of new indicators for non-OECD economies shows that they play a greater role in this process.

The composition of R&D expenditure is changing

Investment in knowledge is highest in the United States, Sweden and Finland.

In the United States, investment in knowledge – the sum of investment in R&D, software and higher education – amounted to almost 7% of GDP in 2000, well above the share for the European Union or Japan. The OECD average was about 4.8% of GDP, of which almost

half for R&D. In most OECD countries, investment in knowledge has grown more rapidly than investment in fixed assets; the United States, Canada and Australia are the major exceptions.

R&D expenditure has risen steadily…

In 2001, OECD countries allocated about USD 645 billion (current purchasing power parity) to R&D. The United States accounted for approximately 44% of the OECD total, the European Union for 28% and Japan for 17%. R&D expenditure in the OECD area rose annually by 4.7% over 1995-2001. R&D expenditure has risen faster in the United States (5.4% a year) than in the European Union (3.7%) and Japan (2.8%). In 2001, the R&D intensity of the European Union reached 1.9% of GDP, its highest level since 1991, still well below the Lisbon target of 3% in 2010. In 2001, Sweden, Finland, Japan and Iceland were the only OECD countries in which the R&D-to-GDP ratio exceeded 3%. In 2002, the R&D intensity of the United States remained stable at 2.8% of GDP.

… mainly owing to greater business investment in the United States and Japan.

Most of the rise in R&D expenditure is due to higher business investment. During the second half of the 1990s, the share of business funding of R&D increased significantly in the United States, moderately in Japan and only slightly in the European Union. R&D expenditure by the higher education sector increased in the first half of the 1990s and then stabilised. R&D by the government sector has declined in recent years, partly owing to the reduction in defence R&D and the transfer of some public agencies to the private sector.

The services sector and high-technology industries account for much of the increase in R&D spending.

In 2000, services accounted for about 23% of total business sector R&D in the OECD area, an increase of 8 percentage points from 1991. More than 30% of all R&D is carried out in the services sector in Norway, Denmark, Australia, Spain and the United States but less than 10% in Germany and Japan. High-technology industries accounted for more than 52% of total manufacturing R&D in 2000, ranging from over 60% in the United States to 47% and 44% in the European Union and Japan, respectively. Finland allocated more than 1% of GDP to ICT-related manufacturing R&D in 2000.

New technologies attract a considerable share of both public- and private-sector R&D funding.

Certain new technologies and socio-economic objectives account for a growing part of R&D spending. Nanotechnology, for example, is among the most rapidly growing targets of R&D funding, but it still accounts for only a small share of total R&D. Between 1997 and 2000, government R&D funding for nanotechnology trebled to 293 million in the United States, doubled to USD 210 million in the European Union and doubled to USD 190 million in Japan.

Government R&D priorities differ.

Direct government support for health R&D accounts for over 0.2% of GDP in the United States, substantially above the levels for the European Union and Japan. Canada, Denmark and New Zealand devote a large share of government funding to biotechnology R&D. In the United States, Spain and France, defence accounts for a large share of overall government R&D spending (over 54% in the United States in 2003), although defence R&D declined in most OECD countries over 1995-2003. US defence R&D accounts for more than 75% of total OECD spending on defence R&D. Government-funded R&D on space is particularly important in the United States, France and Belgium.

Patenting is on the rise

Patenting, which is a measure of innovation, is increasing…

OECD data on patent families (a set of patents filed in various countries to protect a single invention) show the existence of more than 40 000 patent families in 1998 in the OECD area, a 32% increase from 1991. The United States accounted for around 36%, followed by the European Union (33%) and Japan (25%). Biotechnology and ICT have been among the main growth areas. On average, biotechnology patents filed at the European Patent Office (EPO) increased about 9.9% a year compared to 6.7% for total patents. ICT-related patent applications grew by 8.9% a year over the same period.

… but more quickly in certain countries.

Over the 1990s the European Union's share of patent families converged towards that of the United States, while that of Japan declined by 4 percentage points. Korea had the highest annual growth in patent families at more than 20%. When population is taken into account, Switzerland and Sweden had the highest propensity to patent among OECD countries.

The human resource base is expanding and becoming more mobile

More and more young people enter university…

In the OECD area, a quarter of the population aged 25-64 has completed tertiary-level education. The share is much higher in the United States (37%) and Japan (34%) than in the European Union (21%). The share of women exceeds that of men in half of all OECD countries. The educational level of the population continues to rise, as 45% of young people now enter university. However, entry rates vary from over to 60% in Finland, Sweden, Hungary and Poland to around or below 25% in Mexico, the Czech Republic and Turkey.

… but study in different disciplines in different regions.

While the United States and the European Union award approximately the same shares of total OECD university degrees, the European Union awards 36% of science and engineering (S&E) degrees while the United States only awards 24%. The gap is even larger for PhD degrees. Ireland, France and the United Kingdom have the largest share of science degrees; Finland, Japan, Korea and Sweden award the largest shares of engineering degrees. Women only account for 30% of university degrees in S&E and 27% of PhDs. In Japan, these shares are only around 10%.

Higher levels of education are reflected in the employment of tertiary-level graduates…

Large investments in education over the past decades have led to a general rise in the educational attainment of the employed population. On average, 28.2% of employed persons in OECD countries have a tertiary-level degree. The United States (36.8%) and Japan (36.5%) rank far ahead of the European Union (24.0%), which also has large cross-country disparities. Employment growth of tertiary-level graduates ranged between 2% and 6% a year over 1997-2001, substantially faster than aggregate employment growth. Unemployment rates are generally much lower for university graduates than for the overall population, although they are higher for women than for men.

… and the large share of professional and technical occupations.

Professional and technical workers represent between 20% and 35% of total employment in most OECD countries, and over 35% in Sweden, Switzerland, Australia and Denmark. The share of women in

these professions stands at more than 60% in Hungary and Poland. Professional and technical occupations have grown at a much faster rate than overall employment over 1995-2002. Growth has been particularly rapid among highly skilled ICT workers, with annual average growth of 5% in the United States and over 10% in the European Union.

The human resource base is increasingly likely to cross national borders…

In the United States, the largest number of foreign-born scientists and engineers with S&E doctorates born in the OECD area come from the United Kingdom and Canada. However, the United States has three times as many foreign-born scientists from China and twice as many from India as from the United Kingdom. In the European Union countries, the relative share of non-national human resources in science and technology (HRST) is between 3% and 3.5%, with Belgium, Luxembourg, Austria and the United Kingdom having high shares. Women seem somewhat less internationally mobile than men; the share of women employed as non-national HRST is lower than the share of all women in HRST occupations in all OECD countries except the Netherlands.

… partly owing to the mobility of PhD students.

Foreign students represent more than a third of PhD enrolments in Switzerland, Belgium and the United Kingdom, 27% in the United States, 21% in Australia, 18% in Denmark and 17% in Canada. In absolute numbers, the United States has far more foreign PhD students than other OECD countries, with around 79 000. The United Kingdom follows with some 25 000. Language plays a role in the choice of destination, notably for English-speaking countries, but also for Spain, which receives many students from Central and South America.

Non-OECD economies make a growing contribution to the global knowledge base

Non-OECD economies account for a growing share of the world's R&D…

The major non-OECD economies currently account for 17% of global R&D expenditure. In 2001, Israel allocated 4.8% of GDP to R&D (excluding R&D for defence), a higher ratio than Sweden. R&D expenditure in China grew rapidly over the past decade and in 2001 reached almost USD 60 billion. This is behind the United States (USD 282 billion) and Japan (USD 104 billion), but ahead of Germany (USD 54 billion). India spent about USD 19 billion on R&D in 2000-2001, which puts it among the top ten countries worldwide. R&D spending by Brazil, the Russian Federation and Chinese Taipei is comparable to that of the G7 countries and Korea.

… but only a small share of innovation.

Non-OECD economies still make only a minor contribution to global patenting. OECD countries accounted for 97.6% of patent applications to the EPO in 1999 and over 95% of patents granted by the US Patent and Trademark Office (USPTO) in 1998. In 1999, Israel – at 122 patent applications per million population – was the only non-member economy whose patent applications at the EPO exceeded the OECD average of 88. In 1998, Chinese Taipei had 223 patents granted per million population at the USPTO. Of a world total of around 41 000 patent families in 1998, non-OECD economies accounted for only 1.5%, up from 1% in 1991.

Several non-OECD economies have highly educated human resources.

In 2001, China had the second highest number of researchers in the world (743 000), behind the United States (1.3 million), but ahead of Japan (648 000) and Russia (505 000). China delivered 739 000 university degrees in 2000, equivalent to 13% of the OECD total in that year (5.6 million). India (687 000) and Russia (611 000) also contributed substantially to the world total. Non-OECD economies also contribute significantly to advanced research. In 2000, Russia granted 26 000 new degrees in advanced research programmes (equivalent to PhDs), and Brazil and Thailand had around 20 000 each. In comparison, the OECD awarded 147 000 new advanced research degrees in 2000.

ICT continues to diffuse and is used more effectively

Investment in ICT grew rapidly over the 1990s, but slowed in recent years.

The share of ICT in total non-residential investment doubled and in some cases quadrupled between 1980 and 2000. In 2001, it was particularly high in the United States, the United Kingdom and Sweden. In many countries, the share of software in non-residential investment multiplied several times between 1980 and 2000. Available data for 2001 indicate that ICT's share in total investment declined from 2000 to 2001.

Despite the slowdown, ICT technologies have diffused widely…

In OECD countries, access to telecommunications networks has increased in recent years by more than 10% a year, especially in countries with lower penetration rates, such as Poland, Mexico and Hungary. Wireless access has grown particularly fast. The Internet also continues to diffuse rapidly. Germany had 84.7 Web sites per 1 000 population in 2002, followed by Denmark (71.7) and Norway (66.4). Mexico, Turkey, Greece and Japan all had less than three Web sites per 1 000 population.

… and increasingly adopt broadband technologies.

Broadband has diffused most widely in Korea, Canada, Sweden, Denmark, Belgium and the United States. In Denmark and Sweden, one out of five enterprises accesses the Internet through a connection faster than 2Mbps. In Italy and Greece, relatively few firms have such a rapid Internet connection. In Canada, Ireland, Spain and Sweden, however, more than 40% of enterprises still connect to the Internet via dial-up.

Computers are more present in homes…

In Denmark, Germany, Sweden and Switzerland, some two-thirds of households had access to a home computer in 2002. In many other OECD countries, the share is less than 50%. Data on Internet access by household size show that Internet access is more frequent in households with children than in households without.

… and the Internet is increasingly used…

At the end of 2001, there were 77.5 million Internet subscribers to fixed networks in the United States, approximately 24 million in Japan, more than 23 million in Korea, almost 15 million in Germany and 13.6 million in the United Kingdom. A ranking in terms of Internet subscribers per capita places Iceland, Korea, Denmark, Sweden and Switzerland at the top of the list. The number of secure servers per capita increased significantly between July 1998 and July 2002, a sign of the growing importance of security for Internet applications. Iceland has the highest number of secure servers per capita, followed by the United States, Australia, Canada and New Zealand.

... by individuals for various purposes.

Men use the Internet more than women in all countries for which data are available. More than eight out of ten people in Switzerland, Austria, the United States, Denmark and Sweden use the Internet for e-mail. It is also commonly used to find information about goods and services, particularly in Sweden, Denmark and Finland. In the United States, almost 40% of Internet users buy on line, as do many users in Denmark, Sweden and Finland. In Portugal and Sweden, about half of all Internet users play games on line and/or download games and music. In Sweden and Denmark, more than half of all Internet users utilise e-banking.

In many OECD countries, enterprise access to the Internet is almost universal for enterprises with more than ten employees.

In many countries almost all enterprises with ten or more employees use the Internet. In Finland, Denmark, Canada, Sweden and Ireland, two-thirds or more of such enterprises have Web sites. The Internet is less used by smaller than by larger enterprises, and differences among countries are more striking when small enterprises are compared. Internet penetration in enterprises with ten or more employees also varies considerably across sectors. In the financial sector, almost all firms use the Internet. The retail sector seems to lag behind, particularly in countries with low overall Internet use by enterprises.

Electronic commerce is growing, but remains small in most countries.

Internet sales range between 0.3% and 3.8% of total sales. Electronic sales, *i.e.* sales over any kind of computer-mediated network, reach 10% or more of sales in Austria, Sweden, Finland and Ireland. In the US retail sector, the share of electronic sales in total sales grew by 70% between the fourth quarter of 2000 and the fourth quarter of 2002. Large firms use the Internet more frequently than small ones to sell goods and services. It is also more common to purchase than to sell over the Internet. As many as two-thirds or more of enterprises with 250 or more employees in Australia, Canada, Denmark and Finland buy goods or services via the Internet.

The ICT sector makes an important contribution to value added and employment.

The ICT sector grew strongly in OECD economies over the 1990s, particularly in Finland, Sweden and Norway. In Finland, the ICT sector's share of value added doubled over 1995-2001 and now represents over 16.4% of total business sector value added. In most OECD countries, ICT services have increased their relative share of the ICT sector, owing to the increasing importance of telecommunication services and software. In 2000, the ICT sector accounted for about 6.6% of total business employment in the 21 OECD countries for which estimates are available. Over 1995-2000, OECD-area employment in the ICT sector grew by more than 3 million, *i.e.* an average annual growth rate of over 4.3% a year, more than three times that of overall business sector employment. ICT services were the main driver of employment growth.

OECD economies continue to integrate

The rise in international trade and investment implies the growing integration of OECD economies.

Financial transactions (direct investment, investment income, portfolio investment) constitute the fastest-growing and the most volatile segment of international transactions. The share of trade in international transactions has grown slowly and averaged just under 18% of OECD GDP for 1999-2001. The share of international trade in

services remains substantially lower, at around 4% of GDP. Trade in services has increased slightly over time as services such as software, financial services and accounting have become more internationally tradable. The international trade-to-GDP ratio is over 50% for Ireland, Belgium, the Netherlands and certain eastern European countries. In contrast, it is only around 10% for the United States and Japan as well as the European Union when intra-EU trade flows are excluded.

High-technology industries are particularly closely integrated at world level.

Export ratios and import penetration rates for the United States, Japan and the European Union (excluding intra-EU trade) show that computers, aircraft, scientific instruments and radio and television communication equipment have high exposure to international competition, whereas exposure is low for paper, printing, metal products and food, drink and tobacco. Owing to international sourcing and intra-industry trade, strongly export-oriented industries can also have a high import penetration rate. This is the case for computers and electrical machinery in the United States and for scientific instruments and aircraft in Japan and the European Union.

A considerable share of trade takes place within firms or involves imports in order to export.

The share of intra-firm exports in total exports of manufacturing affiliates under foreign control ranges between 35% and 60% in the OECD countries for which data are available. Data for intra-firm exports and imports between US parent companies and their foreign affiliates show that such trade amounts to 25% of aggregate exports and 15% of aggregate imports. For imports, the ratio of intra-firm trade of US parent companies is highest with Singapore, accounting for 66% of total imports. In some countries, exports depend strongly on imports. In the Netherlands, for example, the import content of exports exceeds 40%. Japan and the United States are the least dependent on imports for exports. Between 1980 and 1997, dependency on imports for subsequent exports increased in Canada, Germany, Australia and the United States. It decreased in France, Japan, Denmark and the Netherlands.

Affiliates under foreign control make a large contribution to economic activity in some countries and a very small one in others.

The share of turnover under foreign control in the manufacturing sector ranges from about 70% in Hungary and Ireland to under 3% in Japan. For 1995-2000, however, the shares of foreign affiliates in manufacturing turnover rose in nearly all countries for which data are available. The shares of foreign affiliates in manufacturing employment range from around 50% in Ireland, Luxembourg and Hungary to 4% in Germany. The available data also indicate high export and import ratios for foreign affiliates in manufacturing. The share of turnover under foreign control is lower in services than in manufacturing, at over 20% for Hungary, Belgium, Ireland and Italy. In terms of employment, the share of foreign affiliates in services ranges from 19% in Belgium and around 14% in Hungary and Ireland to less than 1% in Japan.

The economic globalisation of OECD countries is also reflected in the internationalisation of technology…

Foreign affiliates also account for a growing share of R&D, ranging from less than 5% in Japan to over 70% in Hungary and Ireland. At over 30%, the share of R&D conducted by foreign affiliates is also high in Spain, Sweden, Canada, the Slovak Republic, the Netherlands, the United Kingdom, Australia and Portugal. In Hungary and Ireland, foreign affiliates carry out relatively more R&D than national firms. In

most other OECD countries, the opposite is true. As firms relocate research facilities abroad, an increasing share of technology is owned by firms of another country than the inventor's country of residence. In both the mid- and late 1990s, an average of 14% of all inventions in any OECD country were owned or co-owned by a foreign resident. Foreign ownership of domestic inventions is high in many small economies, as well as in Canada and the United Kingdom, where a large share of inventions is owned by US companies. Japan and Korea are much less internationalised in this respect.

... and in international co-operation in science and technology.

Scientific collaboration is generally much more widespread with large OECD countries than with smaller ones. The United States plays the leading role in international scientific collaboration, followed by the United Kingdom, France and Germany. By the late 1990s, about 6% of patents were the result of international collaborative research. Internationalisation is highest in small European countries. However, when intra-EU co-operation is factored out, researchers in the European Union have a lower propensity than US researchers to collaborate with foreign researchers. In Japan, there is very little international co-operation in science and technology.

Rapid productivity growth in the services sector contributes to growth in some countries

The United States remains the OECD leader in GDP per capita.

In 2002, GDP per capita in the OECD area ranged from over USD 35 000 in Luxembourg, Norway and the United States to less than one-third of that amount in Mexico, Korea and eastern Europe. For most OECD countries, income levels are 70-85% of US income levels. Relative to the United States, most OECD countries have higher levels of GDP per hour worked than GDP per capita owing to lower levels of labour utilisation. The difference between income and productivity levels is largest in European countries. Income levels in most countries have not caught up with the United States in recent years; Ireland and Korea are the most notable exceptions.

Rapid growth in some OECD countries over the 1990s has several sources.

Stronger growth in some OECD countries over the 1990s is due to several factors, including higher labour utilisation, capital deepening, notably in ICT, and more rapid multi-factor productivity growth. Investment in ICT accounted for between 0.35 and 0.8 percentage points of growth in GDP over 1995-2001. The United States, Canada, the Netherlands and Australia received the largest boost; Japan and the United Kingdom a more modest one; and Germany, France and Italy a much smaller one. Investment in software accounted for up to one-third of the contribution of ICT capital. In countries such as Australia and Japan, the rising contribution of ICT was accompanied by a decline in that of non-ICT capital. Over the second half of the 1990s, MFP growth also accounted for a considerable part of overall growth of GDP, particularly in Finland, Greece, Ireland and Portugal.

The services sector has grown strongly in several OECD countries,...

By 2000, services accounted for 70% of OECD GDP; manufactures accounted for about 18%. The share of services has been growing steadily for many years, and in many OECD countries, business services currently account for the bulk of labour productivity growth.

This is linked to increased use of technology, notably ICT, greater exposure to international competition, and a growing role in R&D. A large share of labour productivity growth in the non-agricultural business sector is attributable to knowledge-intensive activities, notably ICT services and high-technology and medium-high-technology manufacturing. In the United States, wholesale and retail trade also contributed significantly to aggregate productivity growth.

… owing in part to greater interaction between services and manufacturing…

Part of the increase in the services sector's contribution to value added reflects the manufacturing sector's greater demand for services, some of which is due to the outsourcing of services previously produced in house. Estimates of the amount of services embodied in one unit of final demand for manufactured goods show that it was significantly higher in the mid-1990s than in the early 1970s. In the Netherlands, it nearly doubled. The amount of services embodied in manufacturing also grew strongly in Japan, particularly between the mid-1980s and the early 1990s.

… although strong performance in some services sectors also reflects high enterprise turnover.

New indicators for nine European countries show that each year between 7% and 11% of all active enterprises enter the market, while about 8% exit. Entry rates are substantially higher in dynamic services sectors, such as business services or ICT-related industries, than in more mature industries such as manufacturing. While many new firms do not survive for long, those that do generally grow over time. In Spain, employment in new firms in 1998 increased from an initial average of 2.1 persons to 3.2 persons in 2000.

TABLE OF CONTENTS