HIGHLIGHTS

There is a clear trend in the OECD area towards a knowledge-based economy…

The ability to create, distribute and exploit knowledge is increasingly central to competitive advantage, wealth creation and better standards of living. The STI S*coreboard* 2001 presents the latest OECD indicators on the knowledge-based economy. Many are new, and they are brought together for the first time in one publication. As a range of new indicators show, the knowledge-intensity of OECD economies is increasing. Investment in knowledge, particularly in R&D and software, is rising, as is investment in ICT. Moreover, the composition of investment is changing, particularly in R&D where a growing proportion is funded by business. Knowledge flows within and across OECD economies are increasing as well, as shown by growing co-operation in science and innovation, greater international mobility of high-skilled workers and continued globalisation of trade and investment. Information and communications technologies are also spreading quickly and support more rapid knowledge creation and diffusion.

… which is reflected in the economic and innovative performance of certain OECD countries.

The knowledge-based economy is also reflected in the economic performance of several OECD countries. High-technology sectors contribute to more rapid growth in some, and the share of these sectors – both in manufacturing and services – continues to grow. Moreover, the overall efficiency of capital and labour has increased in some OECD countries in the 1990s, partly owing to more rapid technological progress. Indicators of patenting confirm the swift pace of innovation.

Nevertheless, large differences continue to mark the move towards a knowledge-based economy.

While the overall trends are clear, large differences remain within the OECD area. The Nordic countries, notably Finland and Sweden, and the United States appear to be in the lead in the transition to a knowledge-based economy, as high investment in knowledge, rapid innovation and the pace of diffusion of ICT indicate. Countries such as Japan and several large European countries appear to lag in important areas, including investment in knowledge, innovation and growth of a high-skilled workforce. For certain OECD countries, openness to international knowledge flows also seems to lag. This suggests scope for further progress. However, the transition to a knowledge-based economy requires progress in many areas, and even countries that are ahead in many of them lag in others.

New indicators show that the knowledge-intensity of OECD economies is increasing

Investment in knowledge is growing more rapidly than investment in fixed capital…

Investment in knowledge, defined as public and private spending on higher education, expenditure on research and development (R&D) and investment in software, accounts for about 4.7% of OECD-wide GDP. It would exceed 10% of GDP if education expenditure for all levels was included. By this measure, Sweden, the United States, Korea and Finland are the four most knowledge-based economies. During the 1990s, investment in knowledge increased by 3.4% annually in the OECD area, while investment in fixed capital increased by 2.2%.

… and ICT has been the most dynamic element.

ICT hardware and software have been the most dynamic area for investment. The available data show that it rose from less than 15% of total non-residential investment in the business sector in the early 1980s to between 15% and 35% in 1999. Investment in software accounted for 25-40% of the contribution of ICT to overall investment growth.

Investment in education and skills underpins the growth of a skilled workforce.

Education and skills, which underpin the growth of a skilled workforce, account for the bulk of investment in knowledge. In 1999, 65% of the population aged 25-64 in the OECD area had completed upper secondary schooling. The share is more than 20 percentage points higher in the United States and Japan than in the European Union. In 1999, 14% of the OECD-area population aged 25-64 had university-level education.

Human resources in science and technology are expanding…

In 1999, there were about 38 million workers (about 25% of the labour force) in highly skilled S&T-related occupations in the European Union. The share was highest – about one-third – in the Nordic countries (Sweden, Denmark, Finland) and in the Netherlands, Germany and Belgium. Human resources in science and technology (HRST) grew significantly between 1995 and 1999 in southern Europe, Ireland and Finland. The growth rate of HRST was similar in European Union countries and the United States (about 3% annually).

… as is expenditure for R&D.

OECD-area expenditure on R&D has increased considerably over the past two decades. It has grown by almost 4% a year and has accelerated since the mid-1990s. Most of the increase between 1994 and 1999 was due to the United States. During the 1990s, R&D expenditure grew by more than 13% annually in Ireland, Mexico and Iceland. In 1999, OECD countries allocated about USD 553 billion to R&D, or approximately 2.2% of overall GDP. Since the mid-1990s, R&D intensity has increased continuously in Japan and the United States and has remained more or less stable in the European Union.

Innovation relies also on venture capital.

Despite a recent slowdown, venture capital remains a major source of funding for new technology-based firms. Between 1995 and 1999, it amounted to 0.21% of GDP in the United States and 0.16% of GDP in Canada and the Netherlands for early and expansion stages. Almost half of venture capital investment in the OECD area is for ICT, representing more than 67% in the United States and over 53% in Ireland and Norway. Biotechnology is also of growing importance, accounting for the bulk of venture capital investments in Hungary, and about 15% in the United States.

The role of business in R&D is increasing

Business is the main source of increased spending on R&D.

The business sector is the major source of R&D financing. In 1999, it provided more than 60% of domestic R&D funding in OECD countries, a slight increase from 1990. Over the decade, the business sector's share increased from 57% to 67% of total R&D funding in the United States; it remained stable in Japan at around 72% and increased from 52% to 55% in the European Union. In most countries, government's role in funding R&D declined over the 1990s.

More R&D spending is directed towards basic research…

Most countries spent a higher share of GDP on basic research in 1998-99 than in the early 1980s. Since 1995, the ratio of expenditure on basic research to GDP has been flat in the United States, but it has grown in Japan, France and Italy. Relative to GDP, Switzerland allocates close to 0.8% of GDP to basic research, almost twice as much as the United States or Japan. In Korea, Japan and Ireland, around one-third of basic research is performed by the business sector.

… with less going to defence…

During the 1990s, the share of defence R&D budgets relative to GDP dropped in most countries, largely owing to the overall reduction in military spending. France, the United States and Sweden experienced the strongest decline. Nonetheless, more than half of the US government R&D budget is

allocated to defence, as is around a third of the total R&D budget in the United Kingdom and around a quarter in France and Spain.

… and more to health…

During the 1990s, government support for health-related R&D rose quickly in Japan (10%) and the United States (8%), with growth rates about double that in the European Union (5%). Compared to the European Union and Japan, government support for health R&D is high in the United States. In 2000, it represented about 0.2% of GDP, far above the figures for the European Union (0.05% in 1998) and Japan (0.03%). This difference is partly due to institutional differences. When appropriate adjustments are made, however, Finland, Austria and the Netherlands have health R&D budgets relative to GDP similar to that of the United States. The difference in government support for health R&D between the United States and the European Union also narrows sharply.

… with a growing share for biotechnology.

A significant and increasing part of health R&D concerns biotechnology. Data for biotechnology R&D are currently only available for 20 OECD countries and do not include the United States and Japan. They show that, in 1997, public funding of biotechnology R&D amounted to approximately USD 3.4 billion. Germany (USD 1.0 billion), the United Kingdom (USD 0.7 billion) and France (USD 0.6 billion) account for the bulk of it. Belgium and Canada have the highest ratio of biotechnology R&D to total government budget appropriations for R&D (14% and 10%, respectively).

R&D in the ICT sector also contributes significantly to overall R&D.

ICT also accounts for a growing share of overall R&D. Data for 19 OECD countries indicate that, in 1998, R&D expenditure for ICT manufacturing was approximately USD 96 billion; for the ICT services industries, data for 11 OECD countries show expenditure of USD 18 billion. In 1998, Finland was the only country to allocate more than 1% of GDP to ICT-related manufacturing R&D. ICT-related R&D intensities of the large European economies are well below those of the United States and Japan. In the 1990s, the United Kingdom is the only large European country where ICT-related R&D increased slightly in manufacturing and services industries (by 1% and 3% a year, respectively). In manufacturing, ICT-related R&D decreased in Germany, France and Italy by 1%, 2% and 0.5%, respectively.

Knowledge flows within and across economies take on greater importance

Innovation increasingly relies on co-operation between firms and universities.

The use and generation of knowledge depend not only on the creation of knowledge but also on flows of knowledge within and among economies. Collaboration between business and non-business entities is rising, and the share of R&D performed by the higher education and government sectors and funded by the business sector is increasing. It represented 6.1% and 4.1% of higher education and government research, respectively, in 1998. Data from innovation surveys show that firms with co-operation arrangements with higher education or government institutes account for around 10% of total employment.

International co-operation in science and innovation is growing rapidly…

Production of scientific research and technological know-how also increasingly depends on research conducted in other countries. In the mid-1990s, 27% of scientific publications in the OECD area were the work of multinational teams and 7% of patents were the result of international co-operative research. In smaller European countries, such as Belgium, Denmark and Austria, over 40% of scientific publications have a foreign co-author. When intra-EU co-operation is factored out, researchers in the United States and the European Union have a similar propensity to co-operate with foreign researchers; in Japan, instead, international co-operation in science and technology is quite limited.

… as is cross-border ownership of inventions.

More and more technology is owned by firms from a country other than the inventor's country of residence. In the mid-1990s, an average of 14% of all inventions in any OECD country were owned or co-owned by a foreign resident. Likewise, OECD countries owned around 15% of inventions made abroad. Foreign ownership of domestic inventions is high in several small OECD countries, but also in Canada and the United Kingdom, where US companies own a large share of inventions. Domestic ownership of foreign inventions is also high in small countries; 39% of all inventions owned by Swiss residents were invented abroad. In the United States, the share of foreign inventions in the patent portfolio is only 13%. Japan and Korea are the least internationalised in this respect.

Worker mobility supports the flow of knowledge across borders…

Knowledge flows also result from migration. In the United States, for instance, the largest number of scientists and engineers (S&Es) with S&E doctorates who were born elsewhere in the OECD area are from the United Kingdom and Canada; relatively few are from Germany or Japan. However, three times as many foreign-born scientists are from China and twice as many from India as from the United Kingdom. In 1998, for the 14 European countries as a whole, non-national HRST amounted to only 3%. However, European countries differ widely; Luxembourg employs by far the largest share of non-nationals (33%), followed by Austria, Belgium and the United Kingdom.

… as does student mobility.

International mobility of students also represents a potential flow of qualified workers. Five countries are host to more than 70% of all foreign students in OECD countries. The United States attracts 29% of foreign students, followed by the United Kingdom (14%) and Germany (12%). English-speaking countries account for over 50% of the OECD total. In Switzerland, Australia, Austria, Belgium and the United Kingdom, foreign students represent more than 10% of total enrolments. In Korea, Mexico and Poland, they account for less than 1%.

The globalisation of the knowledge economy is apparent in the rapid growth of international transactions.

National economies also integrate in other ways. Financial transactions (*e.g.* direct investment and portfolio investment) constitute the fastest-growing segment of international transactions. The upsurge in direct investment and portfolio investment was especially rapid in the second half of the 1990s. However, such investment flows have proven highly volatile. The lowering of trade and non-trade tariff barriers has also contributed to a steady rise in international trade.

Trade is growing rapidly, particularly in services…

The share of trade in international transactions has remained persistently high, averaging 15% of OECD GDP in the 1990s. That of trade in goods is four times that of trade in services, despite the acceleration of the latter. In the second half of the 1990s, international trade in services as a share of GDP picked up slightly, partly as the result of the growing tradability of certain services, *e.g.* software, financial services and accounting. The trade-to-GDP ratio is only around 10% for the United States, Japan and the European Union when intra-EU trade flows are excluded. During the 1990s, the international trade-to-GDP ratio grew on average about 2% in the European Union and the United States but declined slightly in Japan.

… and foreign direct investment has picked up in recent years...

Flows of foreign direct investment (FDI) have surged in recent years, owing to renewed dynamism in the world economy and a favourable international investment environment. FDI flows as a percentage of GDP are high for Belgium-Luxembourg, New Zealand, Sweden, the Netherlands, Switzerland and the United Kingdom. They remain small in Turkey, Korea, Japan and Italy. In Germany, Japan and the United Kingdom, outward investment greatly exceeds inward investment, while Australia, Hungary, Poland and Spain receive more foreign capital than they invest abroad.

… partly owing to increases in mergers and acquisitions.

Mergers and acquisitions are the most common form of FDI. During the 1990s, cross-border mergers and acquisitions increased more than five-fold worldwide on a value basis. The United States was the main target during the 1995-99 period, attracting on average four times as many deals in terms of number than the United Kingdom, the second target country. Germany and France took third and fourth place. During the 1990s, the most active sectors at global level were oil, automotive equipment, banking, finance and telecommunications.

Multinational firms also account for a growing share of activity in many countries…

The share of turnover under foreign control in the manufacturing sector ranges from about 70% in Hungary and Ireland to under 2% in Japan. In the period 1995-98, the shares of foreign affiliates in manufacturing turnover rose almost everywhere. In terms of manufacturing employment, their shares range from around 50% in Ireland, Luxembourg, and Hungary to 1% in Japan. In the second half of the 1990s, when manufacturing employment typically declined in national firms, it rose in foreign affiliates in all countries except Germany and Netherlands. In most cases, this reflected changes of ownership owing to buy-outs and acquisitions.

… and increasingly in the services sector as well.

The share of turnover under foreign control in the services sector is over 20% for Hungary, Belgium, Ireland and Italy. In terms of employment, the share of foreign affiliates ranges from 19% in Belgium and around 14% in Hungary and Ireland to less than 1% in Japan. In all countries except Norway and Finland, the share of turnover of foreign affiliates was greater for manufacturing than for services.

Information and communications technologies are diffusing rapidly

The knowledge-based economy is accompanied by the rapid diffusion of ICT, especially the Internet.

The diffusion of information and communications technology is a key enabler of the knowledge-based economy. Access to ICT has grown rapidly over the past years. At the end of 1999, OECD countries had more than one network access channel for every two inhabitants and several countries had more than one access channel per inhabitant. The Nordic countries maintain a clear lead over the rest of the OECD area when connectivity provided by wireless networks is taken into account. Internet technologies are diffusing very rapidly. At the end of 1999, there were nearly 50 million Internet subscribers in the United States, close to 11 million in Japan and in Korea, 9 million in Germany, 7.4 million in the United Kingdom and 6.2 million in Canada. A ranking of countries in terms of Internet subscribers per 100 population shows high levels of take-up in Korea, Sweden, Denmark, Canada, the United States, Netherlands, Iceland and Norway.

Access to the Internet is soaring in most countries…

Personal computers are still the main device used by households to access the Internet. In most countries for which data are available, more than half of all households now have computers. In 2000, there was a noticeable gap between northern European countries such as the Netherlands (69%), Denmark (65%) and Sweden (60%) and southern European countries such as Italy (28%), France (27%) and Turkey (12%). Internet access in households is soaring everywhere, especially in Italy where the access rate grew by 144% between 1999 and 2000, as well as in the United Kingdom (75%), Japan (74%) and France (73%).

… as is its use, but Internet transactions remain limited.

The share of adults using the Internet from any location is also increasing rapidly. More than half of the adult population now uses the Internet in Sweden (68%), Denmark (62%), Finland (54%) and Canada (53%). The Internet is still mostly used to search for information, and the propensity to carry out transactions over the Internet varies widely. In Sweden, 43% of Internet users purchase over the Internet, followed by the United Kingdom (33%), the

United States (30%) and Denmark (29%). Business use of the Internet is increasing very rapidly. Internet penetration in businesses with ten or more employees has reached 80-90% in the Nordic countries, Australia, Canada, the Netherlands and the United Kingdom. In the Nordic countries, over 40% of employees use the Internet in their daily work. The use of the Internet to conduct transactions, although rising fast, is limited. The value of Internet sales in 2000 ranged between 0.4% and 2% of total sales, while electronic sales (including those over all computer-mediated networks) reached almost 6% in the United Kingdom.

The rate of diffusion differs between users and across countries…

Internet penetration in households is strongly affected by household income. The difference between Internet access in households belonging to the lowest and highest income quartiles is highest in the United States and lowest in Denmark. Internet usage rates are much higher in large than in small enterprises and vary in different economic sectors. The most intensive business users are generally firms in finance and insurance, business services and wholesale trade.

… partly owing to differences in access costs.

A key determinant of cross-country differences in the diffusion of the Internet and electronic commerce is access cost. There are large differences in prices of leased lines, which provide the infrastructure for business-to-business electronic commerce. The Nordic countries have the lowest charges, at about one-fifth the OECD average. Differences in Internet access cost for consumers are even more marked. At peak times, countries which traditionally have had unmetered local calls – Australia, Canada, Mexico, New Zealand, the United States – are among the least expensive.

The structure of OECD economies and of trade reflects the increasing role of knowledge

As knowledge has grown in importance, so has the share of knowledge-intensive industries…

By the end of the 1990s, high- and medium-high technology manufacturing accounted for about 9% of total OECD value added. The share of high- and medium-high technology industries was largest in Ireland, where they accounted for over 16% of value added, and in Korea (12.6%). Among the G7 countries, Germany and Japan had the largest shares of such industries, at 11.7% and 10.7% of total value added, respectively. In many OECD countries, including the United States, this sector has grown rapidly over the 1990s.

… and knowledge-intensive services.

Knowledge-based "market" services accounted for 18% of total value added in the OECD area. Post and telecommunications, finance and insurance and business services are typically the most intensive technology users among market services. These sectors accounted for almost 25% of total value added in Switzerland. Among the G7 countries, the United States and the United Kingdom had the largest knowledge-intensive services sector. In Mexico and Greece, this sector accounted only for about 10% of value added. If knowledge-intensive "non-market" services (education and health) are included, knowledge-intensive services account for about 29% of total value added in the OECD area.

The changing structure of OECD economies is also reflected in business R&D.

Services have a much smaller share in R&D than in GDP. In 1998, they accounted for about 17% of total business sector R&D in the OECD area, an increase of 2% from 1992. Countries differ widely, however. In Norway, 48% of total business R&D is carried out in the services sector, 37% in Denmark and 31% in the United States. Although the share of services R&D increased over the 1990s in Germany, France and Japan, these countries still have the lowest share of services R&D (less than 10%).

The ICT sector has grown very rapidly in several OECD countries.

The ICT sector makes a substantial contribution to the economy. In 1999, ICT value added represented between 5% and 14% of business sector value added in OECD countries. The importance of ICT supply has been increasing, not only in countries like Hungary, the Czech Republic and Mexico, which are catching up in terms of infrastructure, but also in Finland, Sweden, Norway, the Netherlands and the United Kingdom. In Finland, the ICT sector's share of value added increased by 4.7 percentage points over the 1995-99 period. It now represents over 13% of total business sector value added. The ICT sector is a major source of employment growth. OECD employment in the sector grew by over 12% in the 1995-99 period, *i.e.* an average annual rate of over 3% a year, double that of overall business sector employment. ICT services are driving this growth.

International trade in high-technology goods is also rising rapidly…

The growing importance of knowledge-intensive industries is also visible in the structure of OECD manufacturing trade. The share of high-technology industries in total OECD trade increased from 18% in 1990 to one-quarter in 1999. The highest growth rates in OECD manufacturing trade in the 1990s were in high-technology industries: pharmaceuticals, radio, television and communication equipment and computers. The shares of medium-low- and low-technology industries have gradually declined.

… although only a few OECD countries have a strong comparative advantage in high-technology industries.

In spite of the growing importance of high-technology industries in overall trade, few OECD countries specialise in high- and medium-high-technology industries. In 1999, the structural surplus in these industries represented more than 15% of total manufacturing trade for Japan, about 7.5% for Switzerland and around 5% for Germany, Mexico and the United States. A considerable number of OECD countries still have a strong comparative advantage in medium-low-technology and low-technology industries. The structural surplus of Turkey, New Zealand and Iceland in these industries accounted for more than 20% of total manufacturing trade. For most OECD countries, these specialisation patterns have changed little over the past decade.

Knowledge and innovation increasingly underpin economic performance

Innovation is a key driver of economic growth…

Recent patterns show that knowledge and innovation make a large contribution to growth. A high share of investment in fixed capital goes for ICT. Moreover, the overall efficiency of the use of capital and labour in the production process, or multi-factor productivity (MFP), increased rapidly in Ireland, Finland, Australia, Canada and the United States in the second half of the 1990s. More rapid MFP growth points to faster technological progress. Furthermore, rapid productivity growth in high-technology sectors such as ICT has contributed strongly to growth in several countries.

… and patenting is accelerating, although differences among OECD countries are large.

Indicators of patenting confirm the brisk pace of technological progress. Over the 1990-97 period, patent applications at the European Patent Office increased annually by 5.7% for the European Union, 4.8% for the United States and 1.1% for Japan. During the 1990s, growth rates for patents in ICT (8%) and biotechnology (10%) for the OECD area were almost twice that of total patent applications (5%). Indicators of patent families – patents taken at the European Patent Office, the US Patent and Trademark Office and the Japanese Patent Office to protect a single invention – show that there were about 32 000 patent families in the OECD area in 1995. The United States accounted for about 35%, followed by the European Union (32%) and Japan (27%). When population size is taken into account, Switzerland patents the most by far in the OECD area. In 1995, there were close to 100 patent families per million population in Switzerland, far above Sweden (74) and Japan (69).