CHAPTER 2

THE DIFFUSION OF ICT IN OECD ECONOMIES

Dirk Pilat and Andrew Devlin[1]
Organisation for Economic Co-operation and Development

Abstract

This chapter examines the diffusion of ICT across OECD countries. The chapter uses recently developed official statistics that provide a sound basis for international comparisons. Certain ICT technologies, such as the Internet, have now diffused to almost all businesses of more than 10 employees in several OECD countries. Others, such as broadband technologies, are at an earlier stage of the diffusion process. The chapter also shows that large differences in the uptake of ICT technologies persist across the OECD, both between and within OECD countries. Cost differentials and structural differences are among the factors explaining these differences. The state of the business environment in different OECD countries is also an important factor as it affects the degree to which firms can take full benefit from the potential offered by ICT.

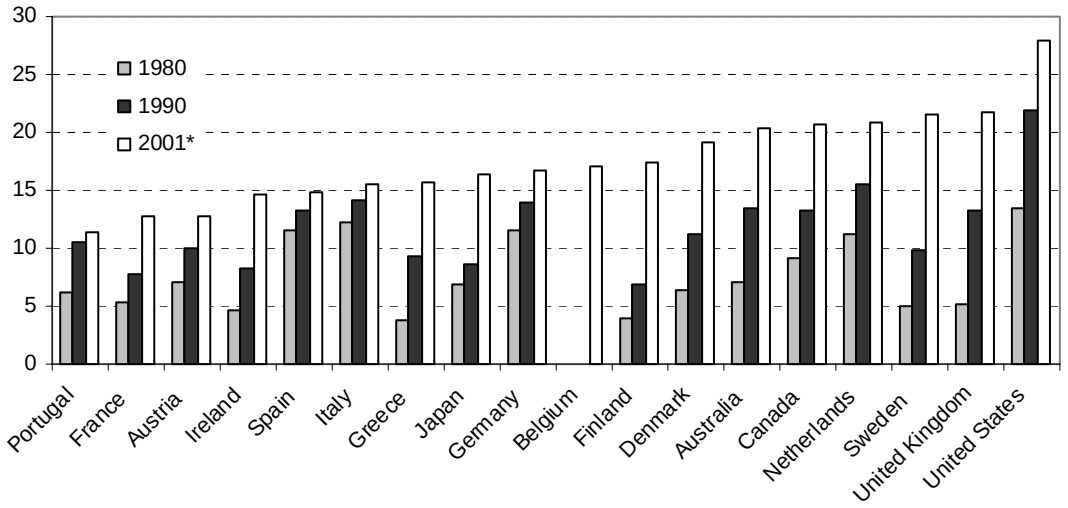
1. This chapter is a revised and updated version of Chapter 1 of OECD (2003*a*).

2.1 The state of ICT diffusion

The economic impact of ICT is closely linked to the extent to which different ICT technologies have diffused across OECD economies. This is partly because ICT is a network technology; the more people and firms that use the network, the more benefits it generates. The diffusion of ICT currently differs considerably between OECD countries, however, since some countries have invested more or have started earlier to invest in ICT than other countries. Investment in ICT establishes the infrastructure for the use of ICT (the ICT networks) and provides productive equipment and software to businesses. While ICT investment has accelerated in most OECD countries over the past decade, the pace of that investment differs widely. The data show that ICT investment rose from less than 15% of total non-residential investment in the early 1980s, to between 15% and 30% in 2001. In 2001, the share of ICT investment was particularly high in the United States, the United Kingdom, Sweden, the Netherlands, Canada and Australia (Figure 2.1). ICT investment in many European countries and in Japan was substantially lower than in the United States over the past decade.

Figure 2.1. **ICT investment in selected OECD countries**

(As a percentage of non-residential gross fixed capital formation, total economy)



*Or latest available year.

Note: Estimates of ICT investment are not yet fully standardised across countries, mainly due to differences in the capitalisation of software in different countries. See Ahmad (2003) and Chapter 4.

Source: OECD, Database on capital services.

The high growth of ICT investment has been fuelled by a rapid decline in the relative prices of computer equipment and the growing scope for the application of ICT. Due to rapid technological progress in the production of key ICT technologies, such as semi-conductors, and strong competitive pressure in their production,[2] the prices of key technologies have fallen by between 15 and 30% annually, making investment in ICT attractive to firms. The lower costs of ICT are only part of the picture; ICT is also a technology that may offer large potential benefits to firm, *e.g.* in enhancing information flows and productivity. Chapter 4 examines the impact of ICT investment on economic growth in more detail and discusses some key measurement issues related to this indicator.

2. Aizcorbe (2002) shows that part of the decline in the prices of Intel chips can be attributed to a decline in Intel's mark-ups over the 1990s, which points to stronger competition.

A second important aspect of the diffusion of ICT is the size of the ICT sector, *i.e.* the sector that produces ICT goods and services (Box 2.1). Having an ICT-producing sector can be important for ICT diffusion. For example, it may help firms that wish to use ICT, since the close proximity of producing firms might have advantages when developing ICT applications for specific purposes. In addition, having a strong ICT sector should also help generate the skills and competencies needed to benefit from ICT use. And it could also lead to spin-offs, as in the case of Silicon Valley or in other high technology clusters. Having an ICT sector can thus support ICT diffusion, although previous OECD work has shown that it is not a prerequisite to benefiting from the technology (OECD, 2001*a*).

Box 2.1. **OECD definition of ICT-producing industries**

In 1998, OECD countries reached agreement on an industry-based definition of the ICT sector based on International Standard Industry Classification (ISIC) Revision 3. The principles are the following: for *manufacturing* industries, the products of an industry must be intended to fulfil the function of information processing and communication including transmission and display, or must use electronic processing to detect, measure and/or record physical phenomena or control a physical process. For *services* industries, the products must be intended to enable the function of information processing and communication by electronic means. The following industries were included:

Manufacturing

3000	Manufacture of office, accounting and computing machinery
3130	Manufacture of insulated wire and cable
3210	Manufacture of electronic valves and tubes and other electronic components
3220	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
3230	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
3312	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
3313	Manufacture of industrial process control equipment

Services

5150	Wholesale of machinery, equipment and supplies
7123	Renting of office machinery and equipment (including computers)
6420	Telecommunications
7200	Computer and related activities (hardware consultancy, software consultancy and supply, data processing, database activities, maintenance and repair of office, accounting and computing machinery, other)

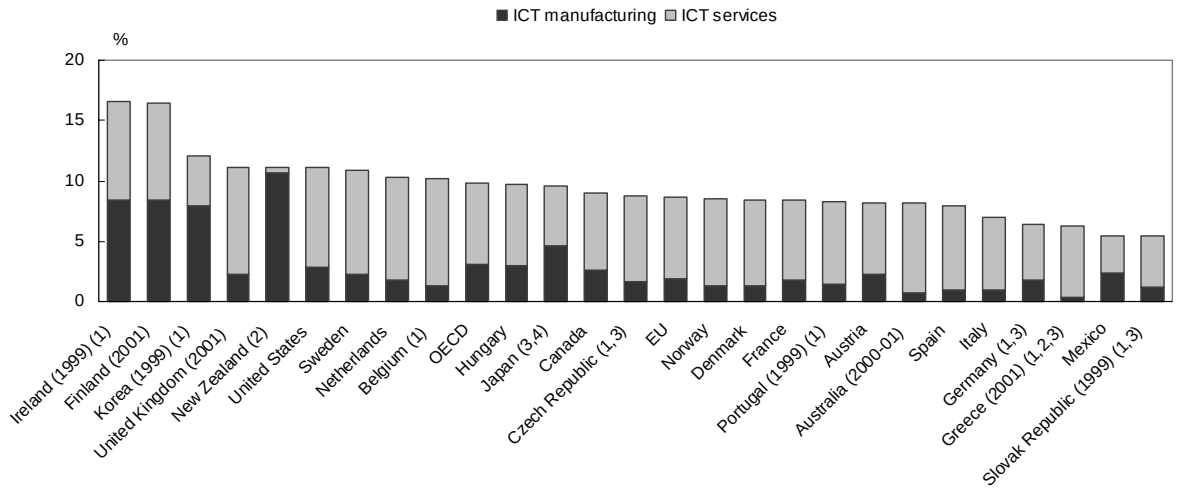
Source: OECD (2002*a*).

In most OECD countries, the ICT sector is relatively small, although it has grown rapidly over the 1990s.[3] Its share in business employment ranges from between 3.7% (in Portugal) to 11.3% (in Finland) (OECD, 2003*a*). Its share in value added is slightly larger, indicating that it has an above-average level of labour productivity, and ranges from around 6% in the Slovak Republic, Greece and Mexico, to 16.5% in Ireland and Finland of business sector value added (Figure 2.2). ICT manufacturing is typically only a small part of this total and ranges between 1.3 and 14% of manufacturing employment, and between 1.6 and 23% of manufacturing value added. Finland and Ireland have the largest ICT manufacturing sectors, followed by Korea. Australia, Greece, Italy, New Zealand, Portugal and Spain, in contrast, have only a small sector producing manufactured ICT goods

3. These estimates are based on the OECD definition of the ICT sector. See OECD (2002*a*).

(OECD, 2003*a*). The relative size of the service part of the ICT sector also varies considerably across countries, with Germany, Japan, Korea and Mexico having a relatively small ICT service sector. Some of this variation is linked to the telecommunications sector, which is very large in the Czech Republic, Hungary and Portugal and quite small in Mexico, Korea and Italy. Another part is linked to computer and related services, the sector that accounts for much of the production of software. This sector is particularly large in Ireland, Sweden and Belgium (OECD, 2003*a*). Chapter 5 examines the contribution of the ICT-producing sector to economic performance in more detail.

Figure 2.2. **Share of the ICT sector in value added, non-agricultural business sector, 2000**



1. Excludes rental of ICT (ISIC 7123).
2. Includes postal services.
3. Excludes ICT wholesale (ISIC 5150).
4. Includes only part of computer-related activities.

Source: OECD (2003a), *OECD Science, Technology and Industry Scoreboard*, www.oecd.org/sti/scoreboard.

A third key aspect of ICT diffusion and the resulting impacts of ICT in different OECD countries is the distribution of ICT across the economy. In contrast to Solow's famous remark, "you see computers everywhere but in the productivity statistics" (Solow, 1987), computers are, in fact, heavily concentrated in the service sector. Evidence for the United States shows that more than 30% of the total stock of equipment and software in legal services, business services and wholesale trade consists of IT and software (OECD, 2003*a*). Education, financial services, health, retail trade and a number of manufacturing industries (instruments and printing and publishing) also have a relatively large share of IT capital in their total stock of equipment and software. The average for all private industries is just over 11%. The goods-producing sectors (agriculture, mining, manufacturing and construction) are much less IT-intensive; in several of these industries less than 5% of total equipment and software consists of IT.

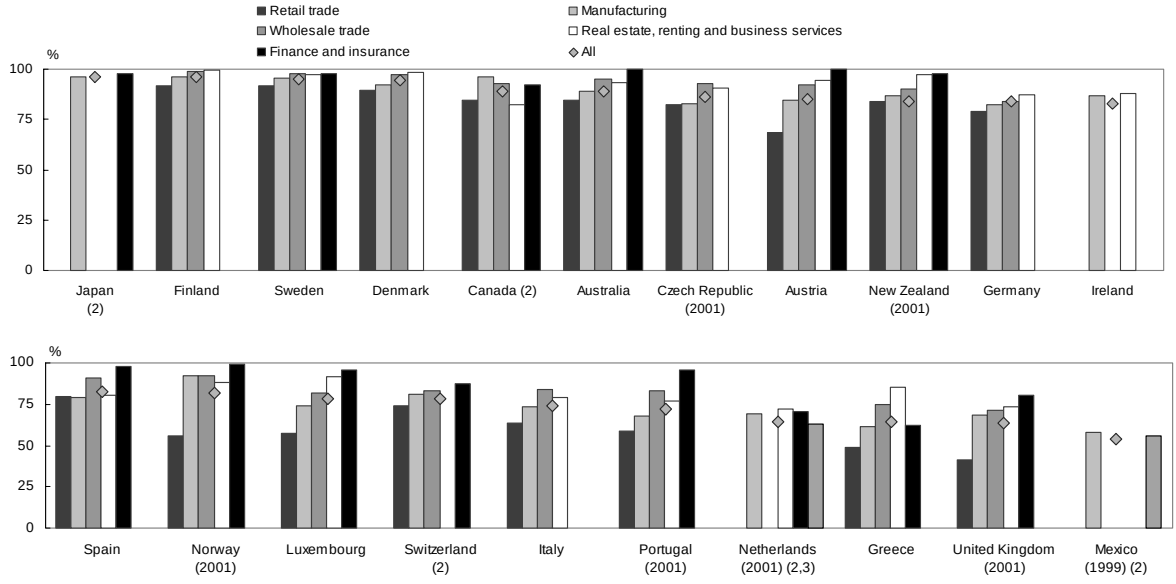
The relative distribution of ICT investment across sectors for other OECD countries is not very different for other OECD countries (Van Ark *et al*., 2002; Pilat *et al.*, 2002); services sectors such as wholesale trade, financial and business services are typically the most intensive users of ICT.[4] Indicators of the uptake of the Internet by economic activity also suggest a high uptake in certain service sectors, notably financial and business services, as well as real estate (Figure 2.3). These results suggest that any impacts on economic performance might be more visible in the services

4. Health and education are also intensive ICT users but are ignored here as their output is difficult to measure.

sectors than in other parts of the economy. Nevertheless, ICT is commonly considered to be a general-purpose technology, as all sectors of the economy use information in their production process (though not necessarily to the same extent), which implies that all sectors might be able to benefit from the use of ICT. Chapter 5 returns to the sectoral dimensions of ICT use.

Figure 2.3. **Internet penetration by activity, 2002 or latest available year**

Percentage of businesses with ten or more employees using the Internet[1]



1. In European countries, only enterprises in the business sector, but excluding NACE activity E (electricity, gas and water supply), NACE activity F (construction) and NACE activity J (financial intermediation), are included. The source for these data is the Eurostat Community Survey on enterprise use of ICT. In Australia, all employing businesses are included, with the exception of businesses in general government, agriculture, forestry and fishing, government administration and defence, education, private households employing staff and religious organisations. Canada includes the industrial sector. Japan excludes agriculture, forestry, fisheries and mining. New Zealand excludes electricity, gas and water supply, and only includes enterprises with NZD 30 000 or more in turnover. Switzerland includes the industry, construction and service sectors.
2. For Canada, 50-299 employees instead of 50-249 and 300 or more instead of 250 or more. For Japan, businesses with 100 or more employees. For the Netherlands, 50-199 employees instead of 50-249. For Switzerland, 5-49 employees instead of 10-49 and 5 or more employees instead of 10 or more. For Mexico, businesses with 21 or more employees, 21-100 employees instead of 10-49, 101-250 instead of 50-249, 151-1000 instead of 250 or more.
3. Internet and other computer-mediated networks.

Source: OECD, ICT database and Eurostat, Community Survey on ICT usage in enterprises 2002, May 2003.

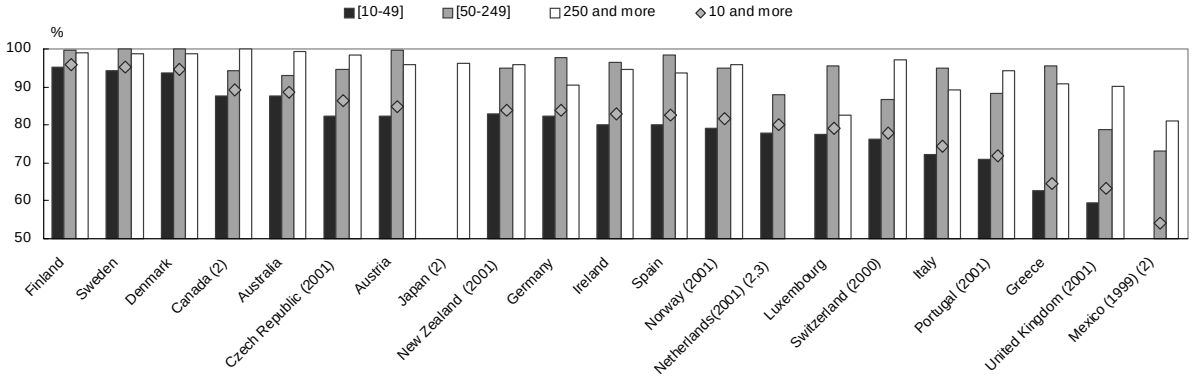
The distribution of ICT also differs according to the size of firms. Smaller firms are typically less ICT-intensive than large firms. This is illustrated in Figure 2.4 which shows the uptake of the Internet by size of firm. There are several reasons why large firms tend to be more ICT-intensive. First, they typically have greater scope to improve communication flows within the firm, *e.g.* by establishing intra-firm networks, or by outsourcing different tasks, *e.g.* through the creation of extranets. But large firms also invest more in ICT than small firms since ICT investment – and the changes that it may entail – is risky and uncertain, which may be more difficult to bear for small firms. This may obviously imply that the impacts of ICT use could be greater in large firms than in small firms.

The indicators shown in Figures 2.3 and 2.4 are also available for the economy as a whole. Figure 2.5 shows that in many countries almost all enterprises with ten or more employees are

connected to the Internet. Many of these also have their own Web site; in Finland, Denmark, Canada, Sweden and Ireland, two-thirds or more of all enterprises with ten or more employees have Web sites.

Figure 2.4. **Internet penetration by size of firm, 2002 or latest available year**

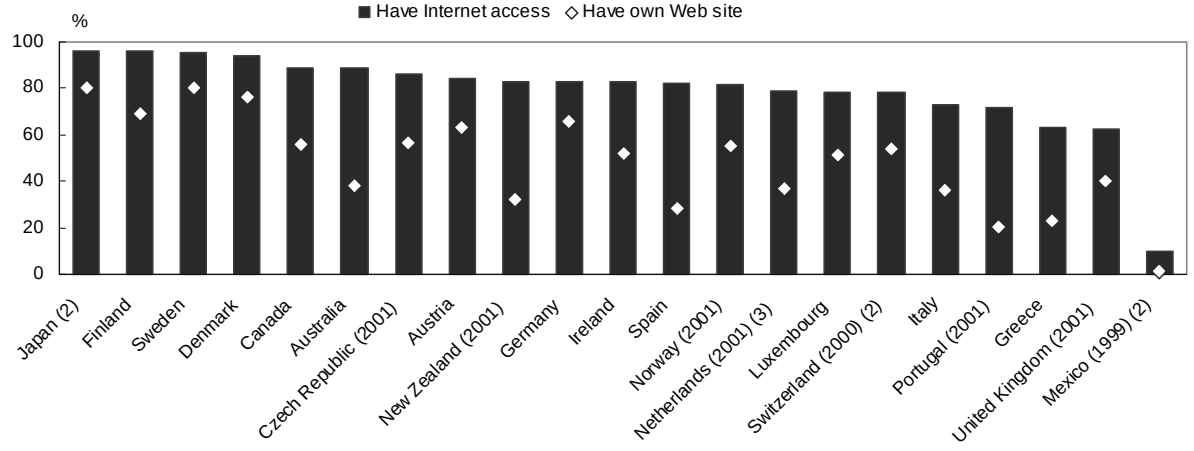
Percentage of businesses with ten or more employees using the Internet[1]



See Figure 2.3 for notes 1, 2 and 3.
Source: OECD, ICT database and Eurostat, Community Survey on ICT usage in enterprises 2002, May 2003.

Figure 2.5. **Business use of the Internet and Web sites, 2002 or latest available year**

Percentage of businesses with ten or more employees[1]



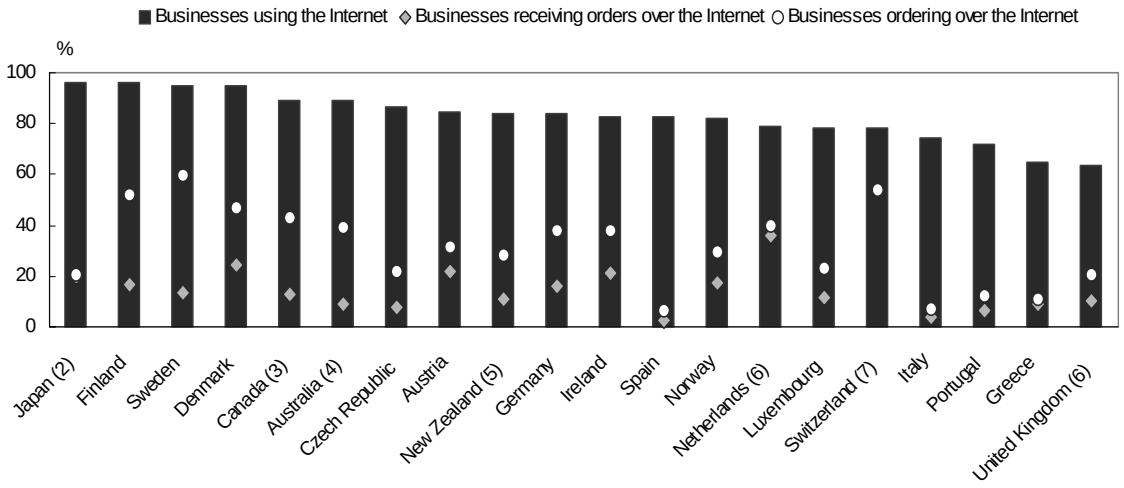
1. See Note 1 of Figure 2.3 for details.
2. For Japan, businesses with 100 or more employees. For Switzerland, five or more employees. For Mexico, businesses with 21 or more employees.
3. Internet and other computer-mediated networks.

Source: OECD, ICT database and Eurostat, Community Survey on ICT usage in enterprises 2002, May 2003.

One further indicator that points to the uptake of ICT is the proportion of businesses that use the Internet to make purchases and sales (Figure 2.6). This is not available for all OECD countries, but suggests that a large number of firms use the Internet for sales or purchases in the Nordic countries (Denmark, Finland, Norway and Sweden) as well as in Australia, the Netherlands and New Zealand. In contrast, only few firms in Greece, Italy, Portugal and Spain use the Internet for sales or purchases, even if many are connected to the Internet.

Figure 2.6. **Proportion of businesses using the Internet for purchases and sales, 2001 or latest available year**

Percentages of businesses with ten or more employees



1. In European countries, except the Netherlands, Portugal and the United Kingdom, the figures refer to orders received and placed over the Internet in 2001, while the use of the Internet refers to the beginning of 2002. Only enterprises with ten or more employees in the business sector, excluding NACE activity E (electricity, gas and water supply), NACE activity F (construction) and NACE activity J (financial intermediation), are included. The source for these data is the Eurostat Community Survey on enterprise use of ICT. All other countries, unless otherwise noted, refer to enterprises at the beginning of 2001 for Internet use and to 2000 for purchases and sales.
2. Data refer to 2002 and to enterprises with 100 or more employees. Agriculture, forestry, fisheries and mining are excluded.
3. Data refer to 2002 and include the industrial sector.
4. Data for Internet use refer to 2002 while data for sales and purchases refer to 2001-02. All employing businesses are included, except businesses in: general government, agriculture, forestry & fishing, government administration and defence, education, private households employing staff and religious organisations.
5. Data refer to 2001 and include enterprises with more than ten employees in all industries except electricity, gas and water; government administration and defence; and personal and other services.
6. Use, orders received and placed refer to Internet and other computer-mediated networks.
7. Data refer to 2000 and include industry, construction and services.

Source: OECD, Science, Technology and Industry Scoreboard 2003.

Monetary estimates of the importance of electronic commerce are also available for several OECD countries, although these are not yet entirely comparable, depending on the definition used and the coverage of different sectors. The available data suggest that electronic commerce is growing, albeit more slowly than envisaged in the late 1990s, but that it still accounts for a relatively small proportion of overall sales. For the few countries that currently measure the value of Internet or electronic sales, total Internet sales in 2001 ranged between 0.3% and 3.8% of total sales in the business sector. In the third quarter of 2003, 1.5% of all retail sales in the United States were carried out through computer-mediated networks, up from 1.3% in the third quarter of 2002. Sales via EDI (electronic data interchange) are generally higher than sales via the Internet, with almost all countries reporting EDI sales to be at least twice as high as Internet sales. In 2001, electronic sales (including those over all computer-mediated networks) were over 10% of all business sector sales in Ireland, Finland and Norway (OECD, 2003*b*).

There are many other indicators that point to the role of ICT in different OECD economies, most of which are available in separate OECD studies (OECD, 2002*a*; OECD, 2003*b*). In practice, the different indicators are closely correlated and tend to point to the same countries as having the highest rate of diffusion of ICT. These typically are the United States, Canada, New Zealand, Australia, the

Nordic countries and the Netherlands. From this perspective, it is likely that the largest economic impacts of ICT should also be found in these countries.

The diffusion of ICT in OECD countries has been relatively rapid compared to some other technologies, although technological diffusion typically takes considerable time.[5] For example, over 90% of firms with more than ten employees in Denmark, Japan, Finland and Sweden had Internet access in 2001, only six years after the introduction of the World Wide Web in 1995 (OECD, 2002*a*). Certain recent ICT technologies (such as the Internet) have thus already reached a large proportion of potential users only a few years after their introduction. Other ICT technologies (such as broadband) are in an earlier stage of the diffusion process, however.

The diffusion of ICT continues across OECD economies, despite the current economic slowdown. The share of ICT investment in total capital formation grew rapidly until 2000, and remained at a high share of investment even in 2001 and 2002, suggesting that ICT investment has not been affected disproportionally by the slowdown compared with other types of investment. Evidence for the United States shows that ICT investment was among the first areas of investment to recover in 2002 (BEA, 2003). The continued diffusion of ICT can also be observed in other areas. For example, the number of broadband subscribers in the OECD area rose from 33 million by the end of 2001, to more than 55 million by the end of 2002 and to over 70 million in June 2003. Large ICT networks are now in place throughout the business sector. These will have to be maintained and updated, and will increasingly be made to work and generate economic returns.

2.2 Factors affecting the diffusion of ICT

Why is the diffusion of ICT so different across OECD countries? A number of reasons can be noted. In the first place, firms in countries with higher levels of income and productivity typically have greater incentive to invest in efficiency-enhancing technologies than countries at lower levels of income.[6] In a more general sense, the decision of a firm to adopt ICT depends on the balance of costs (in the broadest possible sense) and benefits that may be associated with the technology. There is a large range of factors that affect this decision. Previous OECD work already noted several factors that might be important, such as lack of relevant skills for effective use of ICT, lack of competition, or high costs (OECD, 2001*a*). These have been confirmed by other recent studies. Caselli and Coleman (2001), for example, found that levels of education and the extent of manufacturing imports are both positively associated with ICT diffusion. Gust and Marquez (2002) found that restrictions in product and labour markets can also affect levels of ICT investment. Moreover, Guerrieri *et al.* (2003) found that financial conditions, income growth and comparative advantage affect ICT uptake. The discussion below examines some of the empirical evidence that may help explain the differences in ICT diffusion across OECD countries.

The costs of investment in ICT

A first factor concerns the costs of ICT. Since ICT investment goods are traded internationally, their prices should not vary too much across OECD countries. Evidence from international price comparisons suggests otherwise, however. Over much of the 1990s, firms in the United States and

5. Technological diffusion often follows an S-shaped curve, with slow diffusion when a technology is new and expensive, rapid diffusion once the technology is well established and prices fall, and slow diffusion once the market is saturated.

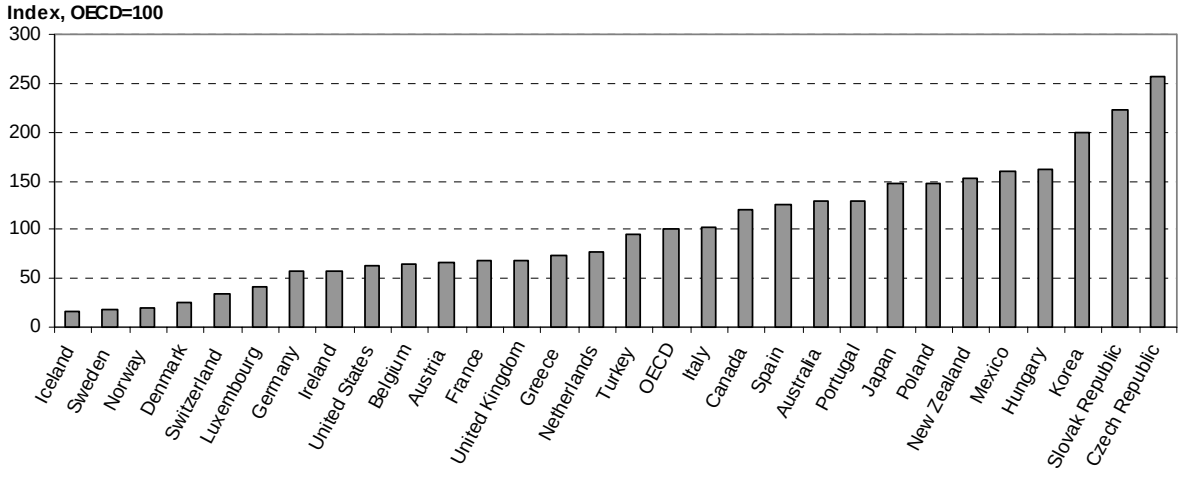
6. Cross-country panel regressions of the investment shares shown in Figure 2.1 tend to show that levels of GDP per capita have a positive impact on the share of total investment that is devoted to ICT.

Canada enjoyed considerably lower costs of ICT investment goods than firms in European countries and Japan (OECD, 2001*a*). The high costs in Europe and Japan may have limited investment in these countries. Barriers to trade, such as non-tariff barriers related to standards, import licensing and government procurement, may partly explain the cost differentials (OECD, 2002*b*). The higher price levels in certain OECD countries may also be associated with a lack of competition within countries. In time, however, international trade and competition should erode these cross-country price differences; prices of ICT investment goods in 1996 in European countries and Japan were already much closer to those in the United States than they were in 1993. By 1999, they had come down further across the OECD (OECD, 2002*c*).[7]

The investment and diffusion of ICT do not just depend on the cost of the investment goods themselves, but also on the associated costs of communication and use once the hardware is linked to a network. Increased competition in the telecommunications industry, thanks to extensive regulatory reform, has been of great importance in driving down these costs. Countries that moved early to liberalise their telecommunications industry now have much lower communications costs and, consequently, a wider diffusion of ICT technologies than those that followed later on. Despite the decline in telecommunication prices over the past decade in all OECD countries, prices in many countries remain high. For example, prices of leased lines, that are the building blocks of business-to-business electronic commerce, still showed great variation in the OECD in August 2002 (Figure 2.7).

Figure 2.7. **OECD price basket for national leased line charges, August 2002**

Index, OECD=100 for lines of 2 Mbit/s



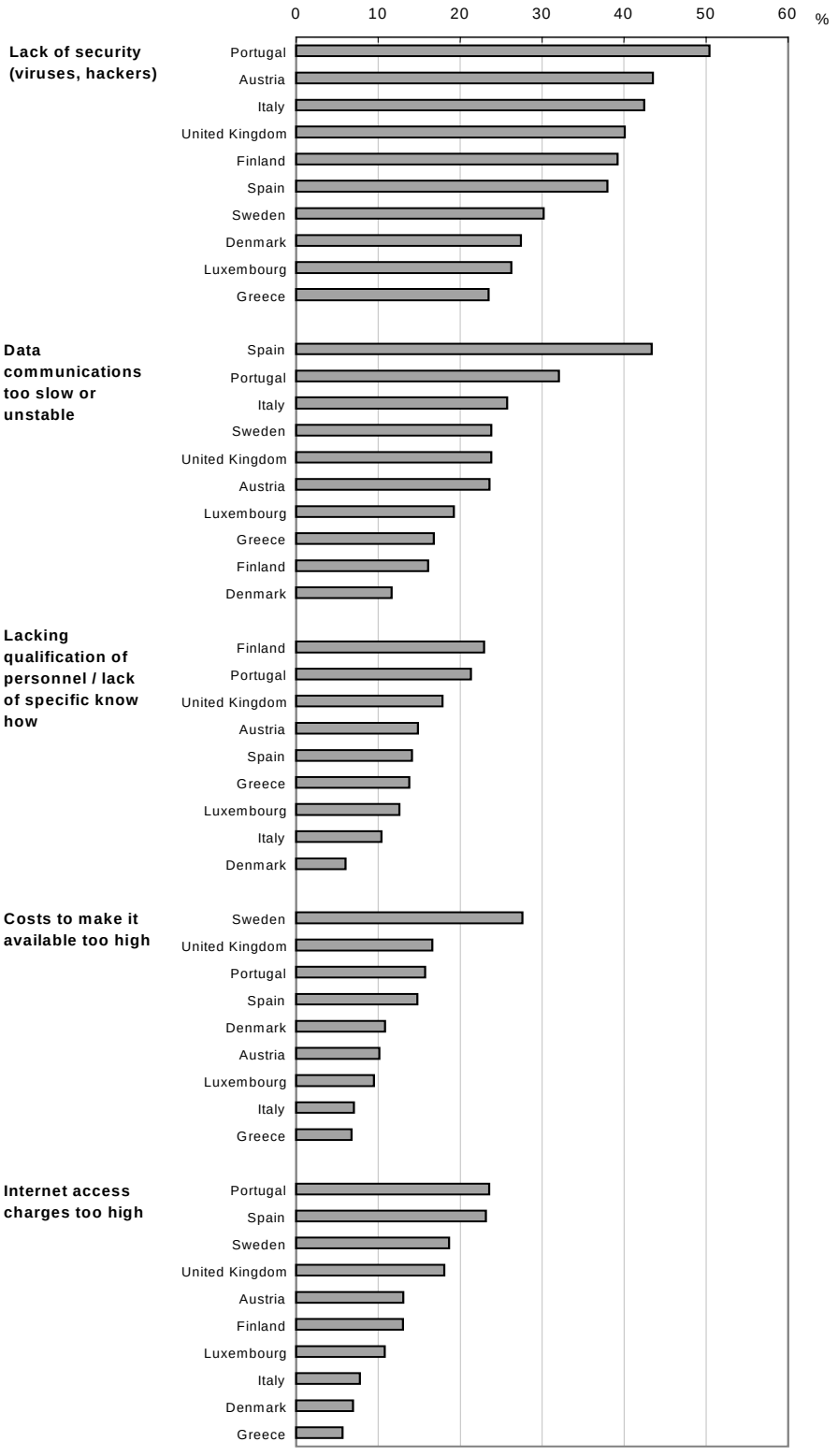
Source: OECD, *Communications Outlook 2003*, based on OECD and Teligen.

Firm-specific barriers to ICT use

Costs of the technology itself are only one factor and not necessarily the most important for the decision made by firms to invest in ICT. There are many other barriers that may affect the uptake and use of ICT. Firm-level surveys for the year 2000 point to a broad range of such factors. They show, for example, that lack of security and slow or unstable communications were considered the key problems in accessing the Internet in European countries (Figure 2.8).

7. These comparisons derive from the OECD's work on purchasing power parities (PPPs). They are only undertaken for benchmark years, the latest one being 1999. Work on a comparison for 2002 will be released in 2004.

Figure 2.8. **Perceived barriers to Internet access and use in the business sector, 2000**



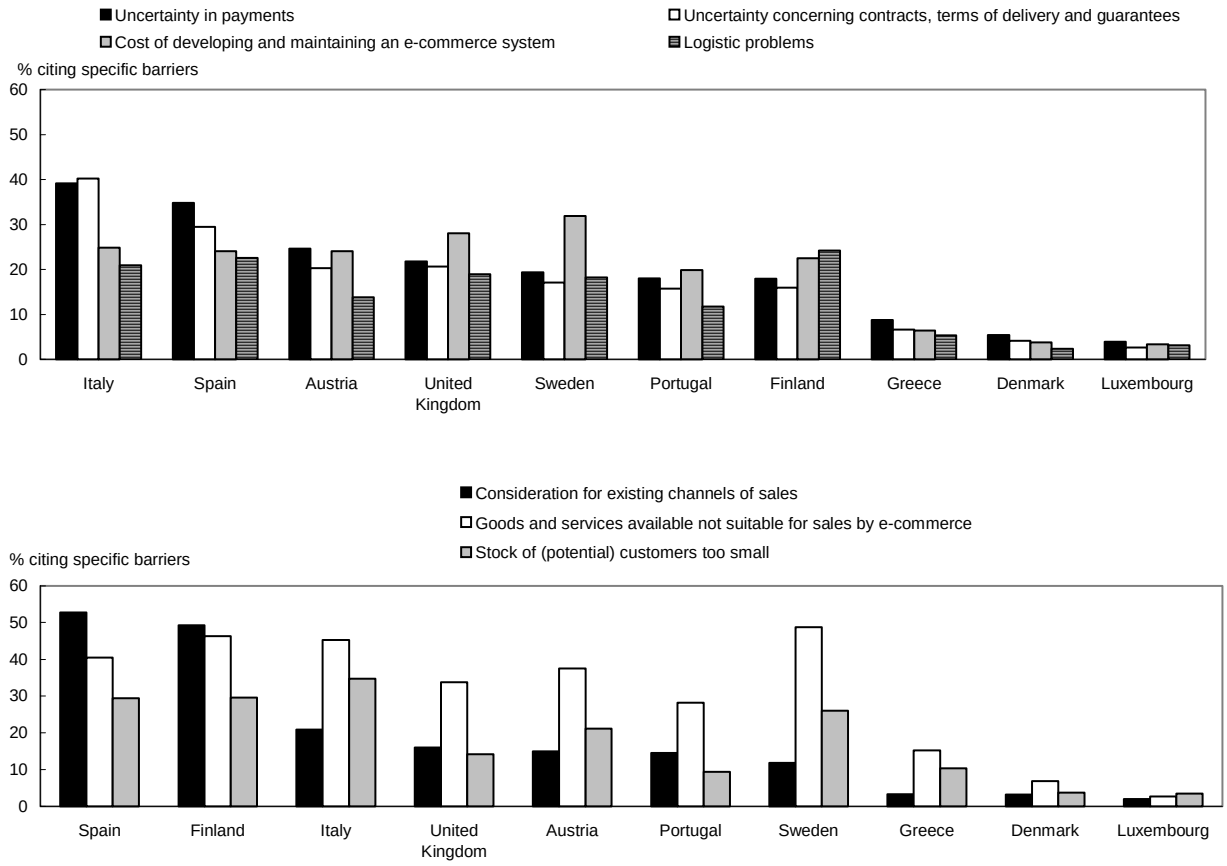
Source: OECD (2002*a*), *Measuring the Information Economy*, based on Eurostat, E-commerce Pilot Survey.

Other problems, such as lack of know-how or personnel, high costs of equipment or Internet access, were considered less important. These barriers also differ by the size of firms; large firms tend to face fewer problems in getting qualified personnel or know-how than small firms. However, large firms tend to regard security issues as a more important barrier than small firms, perhaps because large firms tend to use the Internet more actively than small firms. These barriers may also differ by activity; the perceived benefits of Internet use vary considerably across activities (and also differ across countries).

Survey information on the barriers to Internet commerce, as opposed to Internet access, also provides useful information. They suggest that legal uncertainties (uncertainty over payments, contracts, terms of delivery and guarantees) are important in several countries (Figure 2.9). Business-to-consumer transactions are typically hampered by concerns about security of payment, the possibility of redress in the online environment and privacy of personal data. For business-to-business transactions, the security and reliability of systems that can link all customers and suppliers are often considered more important. Issues of system security and reliability are a major concern in Japan; almost one out of every two Japanese businesses rated viruses as the major reason for not using the Internet (Tachibana, 2000*)*. Cost considerations remain an important issue for businesses in several countries, while logistic problems were also cited frequently.

Figure 2.9. **Barriers to Internet commerce faced by businesses, 2000**

Percentage of businesses using a computer with ten or more employees



Source: OECD (2002*a*), *Measuring the Information Economy*, based on Eurostat, E-commerce Pilot Survey.

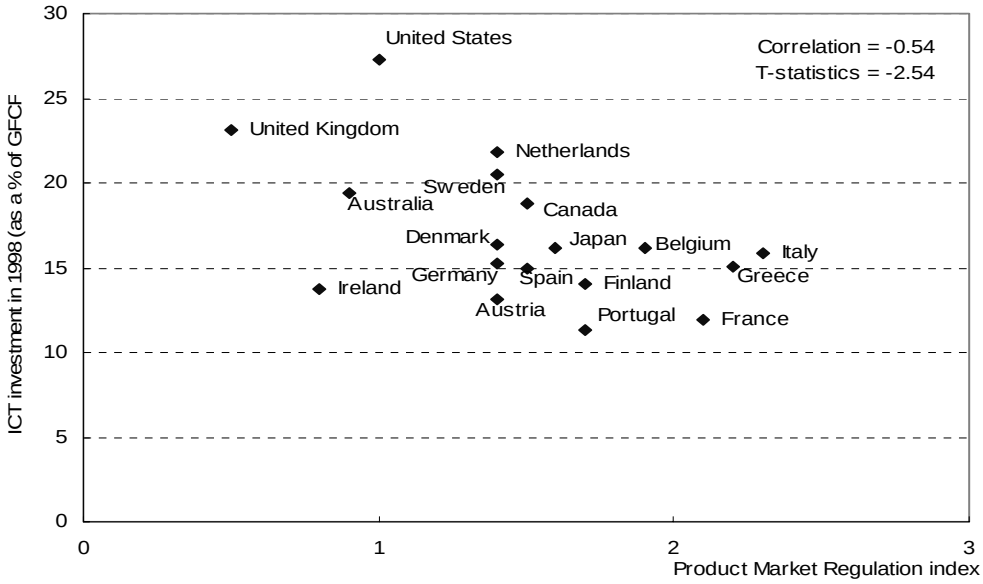
Commercial factors were also cited by many businesses as a factor in not taking up Internet commerce. Many businesses in Finland and Spain found that Internet commerce would threaten existing sales channels. Existing transaction models or strong links with customers and suppliers along the value chain may discourage businesses from introducing new sales models. In many cases, the goods and services on offer by a particular firm were not considered suitable for Internet commerce. In Canada, among businesses that did not buy or sell over the Internet, 56% believed that their goods or services did not lend themselves to Internet transactions; 36% preferred to maintain their current business model. And firms in several countries, notably Italy, considered the market too small. Some of these considerations differ by the size of firm and the activity; large firms found logistical barriers more important than small firms did. However, barriers related to Internet payments and the costs of setting up Internet commerce did not differ in a consistent manner across OECD countries. There also differences across activities; many firms in real estate and hotels and restaurants did not consider their products and services suitable for Internet commerce, whereas only few firms in the financial sector considered this to be the case. More elaborate analysis of this type of survey evidence can provide important insights in the factors explaining ICT uptake (see Chapter 3).

The role of the business environment

The survey evidence outlined above already suggests that the broader business environment plays a role in firm's decision to adopt ICT. This is further illustrated in Figures 2.10 and 2.11. While not demonstrating causality, Figure 2.10 shows that there is a link between ICT investment as a share of total capital formation in 1998 and product market regulations, as measured by an OECD index of the state of these regulations in 1998. The graph shows that countries that had a high level of regulation in 1998 had lower shares of investment in ICT than countries with low degrees of product market regulation. This may be because product market regulations can limit competition. Competition is important in spurring ICT investment as it forces firms to seek ways to strengthen performance relative to competitors. Moreover, competition may help lower the costs of ICT, which stimulates diffusion. Sector-specific rules may also be important. Since ICT offers firms new capabilities, *e.g.* in selling or purchasing on-line, firms may be able to enter markets and introduce products and services that were not feasible before. For example, selling books on-line enables companies to sell in markets that they could not easily enter before. This may be in conflict with the regulations that are in place in such markets, simply because such electronic selling was not possible before. In certain cases, ICT might thus enable the introduction of competition in markets that were previously characterised by low competition, for example a national or regional monopoly. Product market regulations may also reduce the incentives for firms to innovate and develop new ICT applications (OECD, 2002*d*).

Figure 2.11 shows the link between ICT investment and an index of employment protection legislation for 1998. The correlation between levels of ICT investment and labour market regulations may be related to the organisational factors that are required to make ICT work; if firms cannot adjust their workforce or organisation and make ICT effective within the firm, they may decide to limit investment or relocate activities. These links between regulations and ICT investment have been confirmed through econometric analysis; Gust and Marquez (2002) find that regulations impeding workforce reorganisations and competition between firms hinder investment in ICT. Bartelsman *et al.* (2002) confirm these findings.

Figure 2.10. **Countries that had strict product market regulations in 1998 had lower ICT investment**



Notes: The scale of indicators is 0-6, from least to most restrictive. Based on the situation in or around 1998. The components are weighted to show their relative importance in the overall indicator. Since 1998, many countries have implemented reforms in product markets.

Source: ICT investment from sources quoted in Figure 2.1; regulations from Nicoletti *et al.* 1999.

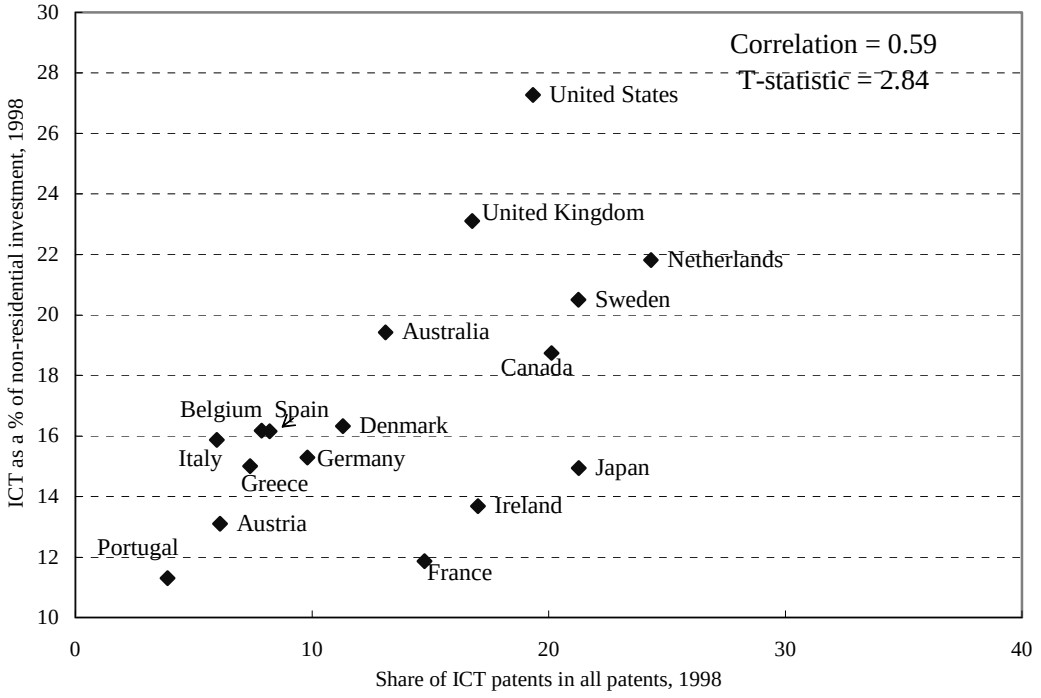
Figure 2.11. **Countries with strict employment protection legislation in 1998 had lower ICT investment**

Notes: The scale of indicators is 0-6, from least to most restrictive. Based on the situation in or around 1998. The components are weighted to show their relative importance in the overall indicator. Since 1998, many countries have implemented reforms in employment protection legislations.

Source: ICT investment from sources quoted in Figure 2.1; regulations from Nicoletti *et al.* 1999.

Another important dimension of the business environment for ICT concerns innovation. Several studies point to an important link between the use of ICT and the ability of a company to adjust to changing demand and to innovate (see also Chapters 6 and 7). The complementary role of innovation for effective use of ICT derives from the literature on co-invention (Bresnahan and Greenstein, 1996), which argues that users of ICT help make their investment more valuable through their own experimentation and invention. Without this process of "co-invention", which often has a slower pace than technological invention, the economic impact of ICT may be limited. This link is also visible in aggregate data; those countries that have invested most in ICT also have the largest share of patents in ICT (Figure 2.12).

Figure 2.12. **ICT investment is accompanied by rapid innovation in ICT**



Source: ICT investment from Figure 2.1; ICT patents from OECD (2002), *Measuring the Information Economy.*

A final important aspect of the business environment relates to the availability of appropriate skills. Countries with a high share of highly skilled ICT workers in total occupations have had higher investment in ICT than those with fewer highly skilled ICT workers (OECD, 2003*a*). Moreover, cross-country panel regressions indicated that the share of ICT investment in total investment in a country is associated with the share of the population that has attained tertiary education.[8] The important role of education and skills is also borne out in firm-level studies (see Chapter 3 and Chapters 6 to 13). There are several reasons why education and skills are important for ICT investment. For example, certain skills may be needed to use ICT in an effective way throughout the workplace; their availability in different OECD countries may thus affect the returns that can be drawn from investment in ICT. Moreover, specific skills may be needed for the implementation of ICT, *e.g.* in companies designing software and e-business solutions. Finally, the availability of human capital affects a firm's capability to assess new technological opportunities (see Chapter 3).

8. These results are available from the authors.

Does it help to have an ICT sector?

Is investment in ICT affected by having a large ICT-producing sector? Previous OECD work suggested that having an ICT sector may not be a prerequisite for growth based on new technology (OECD, 2001*a*). Indeed, several countries (notably Australia and Canada) that are characterised by high ICT investment and use, as well as high multi-factor productivity (MFP) growth, do not have a large ICT sector. And one or two other countries that do have a large ICT sector have not been among the high growth countries of the 1990s.

On the other hand, cross-country panel regressions of ICT investment shares suggest that having a large ICT-producing sector has a positive and significant impact on the share of investment that is devoted to ICT.[9] This may simply be because the ICT-producing sector itself invests considerably in ICT. But it may also be because having a strong ICT sector may help firms that wish to use ICT, since their close co-operation might have advantages when developing technologies for specific purposes and in assisting in the process of co-invention. Moreover, having a strong ICT sector may help generate the skills and competencies needed to benefit from ICT use.

All of this shows that having an ICT-producing sector may be beneficial to growth in the digital economy for more reasons than the direct benefits of ICT production. However, this does not imply that countries without such a sector should try to deliberately develop an ICT-producing sector. Proximity to hardware producers may not be as important for ICT users as proximity to software producers and service providers, which are useful to firms needing skills and advice to implement ICT-related changes. Moreover, much of the production of ICT hardware is highly concentrated, because of its large economies of scale and high entry costs. A hardware sector can therefore not simply be set up, and only a few countries will have the comparative advantage to succeed in it.

2.3 Diffusion in the OECD area - some conclusions

This chapter has shown that ICT has diffused rapidly across OECD countries, and is continuing to spread despite the recent slowdown. However, large cross-country differences persist, also across firms and activities within countries. The United States, Canada, New Zealand, Australia, the Nordic countries and the Netherlands typically have the highest rate of diffusion of ICT. From this perspective, it is likely that the largest economic impacts of ICT should also be found in these countries. However, previous studies have shown that having the equipment or networks is not enough to derive economic impacts. Other factors play a role and countries with equal rates of diffusion of ICT will not necessarily have similar impacts of ICT on economic performance. In addition, it is possible to invest too much in ICT and some studies suggest that firms have sometimes over-invested in ICT in an effort to compensate for poor performance.

The chapter has pointed to several factors affecting the diffusion of ICT, namely:

- Factors related to the direct costs of ICT, *e.g.* the costs of ICT equipment, telecommunications or the installation of an e-commerce system.

- Costs and implementation barriers related to enabling factors and the ability of the firm to absorb new technologies. These factors include the availability of know-how and qualified personnel, the scope for organisational change and the capability of a firm to innovate.

9. These results are available from the authors.

- Factors related to risk and uncertainty, *e.g.* the security of doing business online or the uncertainty of payments, delivery and guarantees online.

- Factors related to the nature of the businesses. ICT is a general purpose technology, but is more appropriate for some activities than for others. ICT may not fit in all contexts and specific technologies, such as electronic commerce, may not be suited to all business models.

- Factors related to competition and the regulatory environment. A competitive environment is more likely to lead a firm to invest in ICT, as a way to strengthen performance and survive, than a more sheltered environment. Moreover, competition puts downward pressure on the costs of ICT. Excessive regulation in product and labour market may also make it more difficult for firms to draw benefits from investment in ICT and may thus hold back such spending.

These categories point to several areas that are relevant for policy development, most of which have already been the subject of OECD work over the past years. For example, measures to increase competition can help bring down costs, effective labour market and education policies may help reduce skill shortages, and risk and uncertainty may be tackled by the development of a well designed regulatory framework.

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TABLE OF CONTENTS

Chapter 1.	Introduction and Summary	7
Chapter 2.	The Diffusion of ICT in OECD Economies	19
Chapter 3.	The Decision to Adopt Information and Communication Technologies: Firm-level Evidence for Switzerland	37
Chapter 4.	ICT Investment in OECD Countries and Its Economic Impacts	61
Chapter 5.	ICT Production and ICT Use: What Role in Aggregate Productivity Growth?	85
Chapter 6.	The Effects of ICTs and Complementary Innovations on Australian Productivity Growth	105
Chapter 7.	ICT, Innovation and Business Performance in Services: Evidence for Germany and the Netherlands	131
Chapter 8.	Firm Performance in the Canadian Food Processing Sector: The Interaction between ICT, Advanced Technology Use and Human Resource Competencies	153
Chapter 9.	Information Technology, Workplace Organisation, Human Capital and Firm Productivity: Evidence for the Swiss Economy	183
Chapter 10.	ICT and Business Productivity: Finnish Micro-Level Evidence	213
Chapter 11.	Enterprise E-commerce: Measurement and Impact	241
Chapter 12.	Productivity Slowdown and the Role of ICT in Italy: A Firm-Level Analysis	261
Chapter 13.	IT, Productivity and Growth in Enterprises: New Results from International Micro Data	279
	List of Contributors	301

CONTRIBUTORS

Nadim Ahmad joined the OECD in 2000, after a four-year spell at the UK Office for National Statistics and Her Majesty's Treasury. He studied at the University of Salford (UK) where he undertook a statistical doctorate, in collaboration with the UK Ministry of Defence, investigating the system performance of sonar. He has extensive experience of the national accounts and input-output tables in particular, on which he has published a number of articles.

Spyros Arvanitis is a senior research economist in KOF ETH (Swiss Institute for Business Cycle Research, Swiss Federal Institute of Technology Zurich), where he is head of the research group for competition and market dynamics. Dr. Arvanitis holds doctoral degrees from the University of Zurich (economics) and the Swiss Federal Institute of Technology Zurich (chemistry). He has published on economics of innovation, technology diffusion, firm performance and market dynamics.

B.K. Atrostic is a senior economist at the Center for Economic Studies (CES) of the United States Census Bureau. She joined CES in 1999 after conducting microeconomic analyses at other statistical, research, and policy institutions on a range of topics including consumer demand, health care, and tax policy. At CES, she has worked primarily on ICT and its contribution to productivity. She holds a Ph.D. in economics from the University of Pennsylvania in the United States.

John Baldwin is Director of MicroEconomic Analysis at Statistics Canada. He has written widely on topics related to Industrial Economics, Technology and Trade. He is the author of The Dynamics of Industrial Competition and Innovation and Knowledge Creation in an Open Economy, both produced by Cambridge University Press. He holds a Ph.D from Harvard University.

Tony Clayton is Head of New Economy Measurement at the UK Office for National Statistics, which he joined in 2001 to develop work on ICT impacts and measurement to support policy development. Before this he was a director of PIMS Associates in London, consulting on innovation and business performance for major international firms. He has published on various aspects of innovation, has a BSc in physics, and an MA in economics from Sussex University.

Chiara Criscuolo is a researcher at the Centre for Research into Business Activity (CeRiBA), since September 2001. She is currently a PhD student at the Department of Economics at University College London. Her current research interests focus on the performance and productivity of multinational corporations, the relationship between ownership structure and productivity; the role of innovation and ICT for firms' productivity.

Andrew Devlin is a statistician at the OECD. He joined the OECD in 1998 and in recent years worked on the impact of ICT. Prior to working at the OECD he was a health statistician in the New Zealand Ministry of Health. Andrew has a MSc in statistics from Canterbury University.

Jyothi Gali is a senior research economist with the Productivity Commission. She joined the Commission in 2001 and has undertaken empirical analyses of regional trading agreements and productivity. Before joining the Commission, Jyothi was with the Queensland Department of Primary Industries working on issues relating to the agricultural industry and its structure. Jyothi received a doctor of philosophy in agricultural economics from the University of Queensland in 1998.

Peter Goodridge joined ONS in 2003, with a first class degree from Cardiff University. Peter has worked on price and productivity effects of electronic markets.

Paul Gretton heads the Trade and Economic Studies Branch within the Productivity Commission. He has lead a range of projects on matters relating to the assistance to Australian industry, analysis of the effects of trade and policy reform, land degradation and rural adjustment in Australia, and industry productivity and economic growth. This work has been published in a wide range of Productivity Commission inquiry and research reports.

Thomas Hempell is an economist at the Centre for European Economic Research (ZEW Mannheim). After studies of economy and philosophy in Hamburg and Barcelona, he joined the ZEW in 2000, initially to work with the Mannheim Innovation Panel. In 2001, he joined the newly founded ICT Research Group. He has worked on the impacts of ICT on firm productivity, focusing on the role of complementary firm strategies, like innovation, skills, human capital and organisational change.

Dr. Heinz Hollenstein heads the research group "Innovation, Growth and Employment" of the Swiss Institute for Business Cycle Research at the Swiss Federal Institute of Technology Zurich (KOF ETHZ). His research interests cover the economics of innovation and new technology; ICT; "New Workplace Organisation", evaluation of technology policy, and internationalisation of R&D. He is also a permanent consultant of the Austrian Institute of Economic Research (WIFO), and has been on several policy-oriented expert groups advising ministries of the Swiss Federal State.

George van Leeuwen is researcher at the Methods and Informatics Department of Statistics Netherlands. Previously he worked at the Netherlands Bureau of Economic Policy Analysis (CPB) as a researcher for the CPB project ICT and Labour Productivity. In recent years he has primarily worked on firm-level data analyses of innovation, ICT and firm performance.

Mika Maliranta, Ph.D. (Econ.), is a head of unit at the Research Institute of the Finnish economy (ETLA). He has done research with various types of micro-level data in the fields of productivity, job and worker turnover and firm dynamics. More recent research interests include ICT and the role of skills in technological development.

Carlo Milana graduated in economics at the University of Rome. He is Research Director at ISAE (Istituto di Studi e Analisi Economica) of Rome and was a member of the National Price Committee in the Italian Ministry of Treasure. He was Research Director at ISPE (Istitute di Studi per la Programmazione Economica) in Rome from 1972 to 1998. His major experience is in the fields of productivity, indices of cost of living, accounting for structural changes of the economy, economic policy in industrial economics, foreign and international trade, regulation of prices in public utilities.

Kazuyuki Motohashi is Associate Professor at the Institute of Innovation Research of Hitotsubashi University and Senior Fellow of the Research Institute of Economy, Trade and Industry. Until this year, he worked for the Ministry of Economy, Trade and Industry of the Japanese Government, as well as the Directorate for Science, Technology and Industry of the OECD. He was awarded a Master of Engineering from University of Tokyo, an MBA from Cornell University and a Ph.D. in business and commerce from Keio University.

Sang V. Nguyen is a senior economist at the Center for Economic Studies (CES) of the United States Bureau of the Census. He joined CES in 1982. His research includes studies on mergers and acquisitions, production, costs, inventory demand, energy, productivity and IT. He holds a Ph.D. in economics from the State University of New York, Binghamton, USA.

Dean Parham is an Assistant Commissioner with the Productivity Commission in Canberra, Australia. Over recent years, he has led a stream of work that has examined Australia's productivity performance, the factors affecting it, and the implications for Australian living standards. This work

has been presented and published in numerous Productivity Commission research reports, journal articles and conference papers and volumes.

Dirk Pilat is a senior economist in the Directorate for Science, Technology and Industry of the OECD. He joined OECD in 1994 and initially worked on unemployment, regulatory reform and product market competition. In recent years, he has primarily worked on productivity, the contribution of ICT to economic growth, and the role of firm dynamics. He holds a PhD in economics from the University of Groningen in the Netherlands.

Petri Rouvinen is a research director at ETLA, The Research Institute of the Finnish Economy. He holds a PhD in economics from Vanderbilt University. His research interests include ICT and technology in general, innovation, R&D, globalization, competitiveness, and economic policy. He has served as a referee for and published in several scholarly journals.

David Sabourin is Chief of the Corporations Returns Act and Analysis Section of the Industrial Organization and Finance Division at Statistics Canada. He has co-authored several studies on advanced technology and innovation.

Paul Schreyer is head of the Prices and Outreach Division in the OECD Statistics Directorate. He joined the OECD in 1988, after working for the IFO Institute of Economic Research in Munich and the Institute for Economic Theory at Innsbruck University. He studied at the Universities of Birmingham (UK) and Innsbruck where he obtained a doctorate in economics. He has focused on productivity measurement and analysis, on which he published a number of articles and monographs.

David Smith holds a Masters of Economics from Dalhousie University, and is interested in technology's impact on both firm performance and industry structure.

Kathryn Waldron joined ONS in 2002 with a first class degree from Birmingham University. Kathryn has worked on e-commerce adoption patterns.

Henry van der Wiel is economist at CPB Netherlands Bureau for Economic Policy Analysis (the Netherlands), where he is head of the project group ICT and Productivity. He has primarily worked on research on technology, innovation and productivity. Recently, he has worked on measuring the effects of ICT and other sources on productivity growth. Since 2003, he is associated with OCFEB, the Dutch Research Centre for Economic Policy. He is a member of various national advisory committees in the area of productivity, innovation and national accounts.

Anita Wölfl is an economist in the OECD Directorate for Science, Technology and Industry. Before joining the OECD, she was research associate at the Halle Institute for Economic Research, Germany. She holds a Masters degree in economics from the University of Regensburg (Germany) and Maastricht (the Netherlands), and a postgraduate certificate from the Advanced Studies Programme for International Economic Policy Research, at the Kiel Institute for World Economics, Germany, 1997.

Alessandro Zeli is a senior statistician in Structural Statistics on Enterprises Department of the ISTAT (Italian Institute of Statistics). He joined Istat in 1996. At the beginning he was involved in survey on economic accounts of SME; in 1998 he was entrusted with the management of the survey on economic accounts of larger enterprises. In recent years he worked on productivity, the estimation of efficiency frontiers and the dynamics of total factor productivity. He holds a *Dottorato di Ricerca* (Italian PhD level) in economics from the University of Roma "La Sapienza" in Italy.