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The economic impact of ICT: evidence and questions

Note

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1. Introduction

For fifty years after World War II the European economy witnessed a sustained period of strong GDP growth and rising living standards. Since the mid-nineties, however, the EU growth rate has been slowing down with a gradual decline in labour productivity growth. Productivity – the amount of output per hour of work – is a key determinant of competitiveness.

The bulk of the EU productivity downturn is widely believed to stem from an outdated and inflexible industrial structure: with an excessive focus on low-medium technology industries, slow to adjust to the pressures of globalisation and of rapid technological change. This resistance to change contributed to the slow adoption of Information and Communication Technologies (ICTs) and their integration into the business process in Europe.

At the end of the nineties ICTs were at the heart of the debate around the *new economy:* the idea that developed countries enter a sustained period of higher economic growth combined with low inflation and low unemployment. The burst of the Internet bubble diverted the attention from new technologies and ICTs have dropped from the policy agenda. Nevertheless, new technologies continued contributing to the economic well-being of modern economies. In the United States, for example, productivity growth almost doubled in the course of the past ten years. New information technologies are widely held to account for most of that acceleration. In the EU, despite low productivity growth rates, ICTs appear to explain half of the gains[1].

Re-visiting the significance of the economic impact of ICTs is crucial in the light of the economic slowdown and of the policy concerns addressed in the renewed Lisbon Strategy. The first part of the document reviews the economic literature on the impact of ICTs on labour productivity growth. The second part proposes a set of factors that enable a favourable environment to realise productivity gains from ICT investment, adoption and use. The paper concludes by raising questions for discussion.

[1] ICTs can be considered as a kind of General Purpose Technologies that spread throughout the economy and influence economic efficiency in different ways and in different sectors. Economic gains tend to accrue gradually, as the economy adapts to the structural changes. Historically, the deployment of ICT has been enhanced by the speed of technological change in semiconductors and consequently by the fast and continuing fall in semiconductor prices. The price decline has been immediately transmitted to the prices of products that rely on semiconductor technology, such as computers and telecommunications equipment. This technology also had significant spillovers into other sectors and helped reducing the costs of avionics, automobiles and a wide array of other products.

2. Evidence on the economic impact of ICTs

For most of the post World War II period the EU has enjoyed productivity growth rates[2] well above of those prevailing in the US. However, since the mid-1990s the EU has been on a lower productivity growth trend than the US. The US productivity growth more then doubled, whilst that of the EU declined by a half[3]. Recent industry analysis shows that the decline is related to overinvestment in certain traditional sectors (yielding lower returns) and to underinvestment in a number of more dynamic and higher productivity industries One of the most popular explanations for these diverging productivity fortunes of the two economies indeed focuses on the relative exposure to ICTs.

2.1 Three effects of ICT

ICTs impact on productivity through three main channels:

- First, efficiencies are realised through rapid *technological progress in the production of ICT goods and services in ICT producing industries*. Thus, the ICT sector is a driver of productivity growth for the whole economy. Efficiency gains in the ICT sector are also reflected in the fast price declines of ICT products.
- Second, *investments in ICTs* provide more capital for workers, which raises their productivity.
- Third, *greater use of ICTs* in all sectors in the economy helps firms to increase their efficiency.

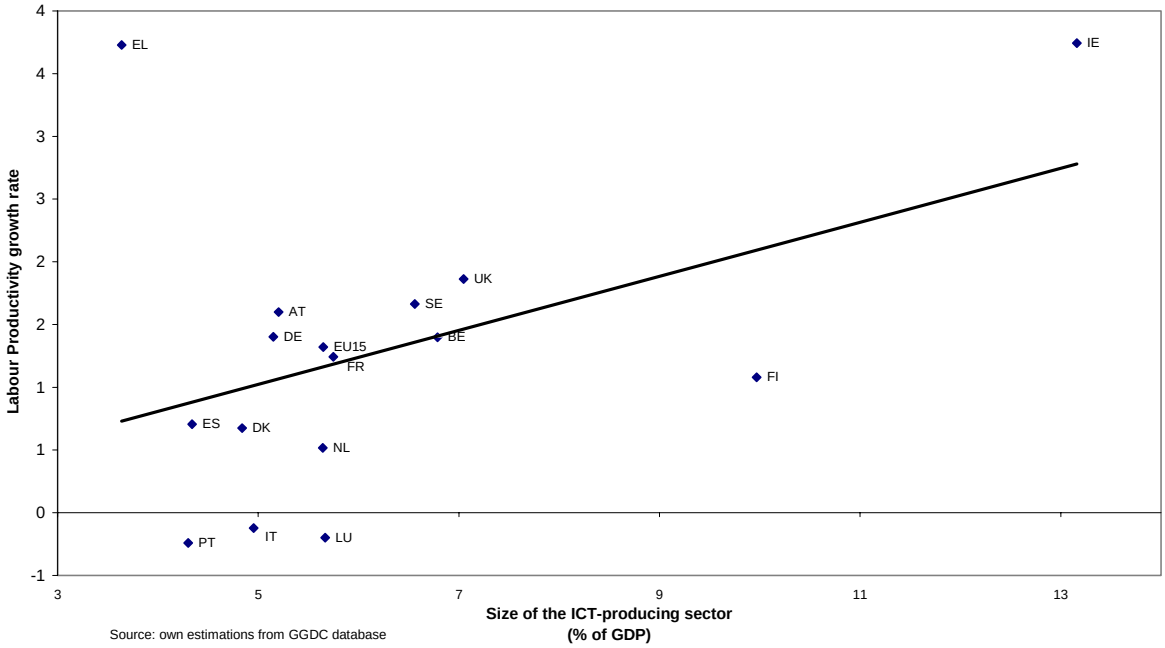
These three effects do not occur simultaneously. Investments translate into efficiency gains only after a time lag, as ICTs are used to reorganise the production process. Therefore, the impact of ICTs on the wide economy is expected in two waves: in the *short term*, reductions in the relative prices of ICT products increase investment; in the *longer term*, as the new technologies are adopted throughout the economy, new goods are developed and new modes of business organisation come into use.

In the period 2000-2003 higher productivity growth in the EU has occurred in the countries with higher share of the ICT sector in the economy (first channel, Figure 1). Productivity growth is also correlated with ICT investment rates (second channel, Figure 2). While the third channel is more difficult to measure, it seems, however, to explain most of the recent contrasting productivity experiences between the EU and the US.

[2] Productivity is a measure of efficiency of the use of factor of production: capital and labour. Labour productivity is the amount of output per hour of work or per worker. In the document these terms are used interchangeably as – in this context – they are not different.

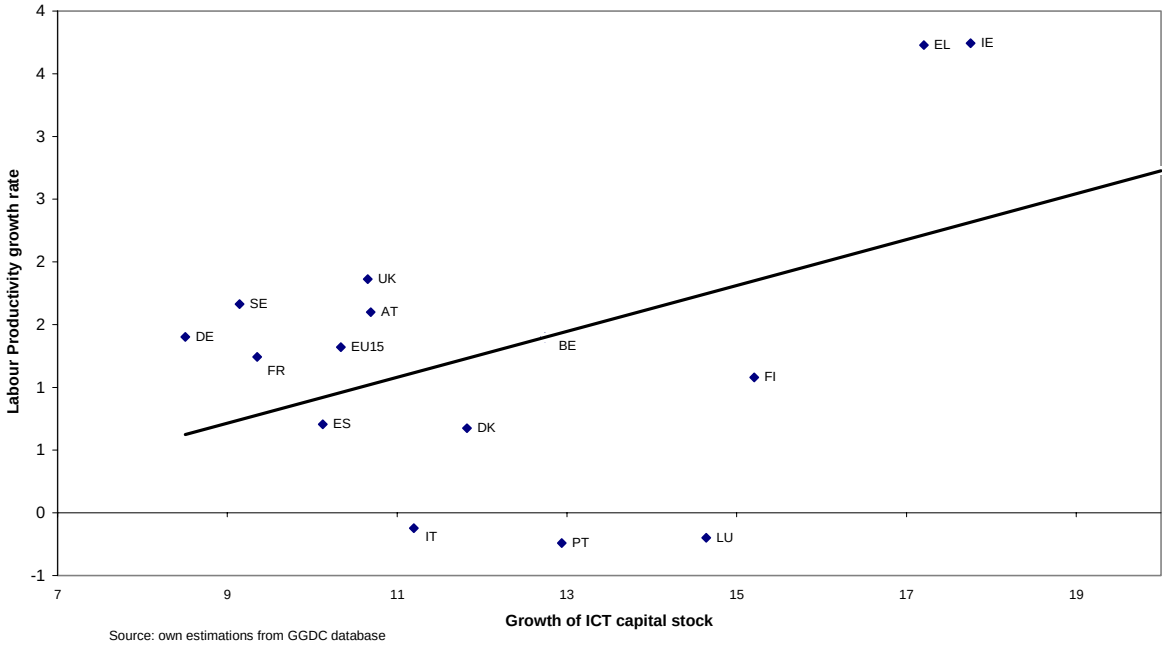
[3] While overall EU productivity growth has deteriorated over recent years, not all countries have followed the same trend. In particular, it is the deterioration in big four countries of the EU (DE, FR, IT and ES) which account for almost 80% of the euro area output.

Figure 1: Share of the ICT sector in the economy and labour productivity growth (2000-2003)



Source: own estimations from GGDC database

Figure 2: ICT capital stock and labour productivity growth (2000-2003)



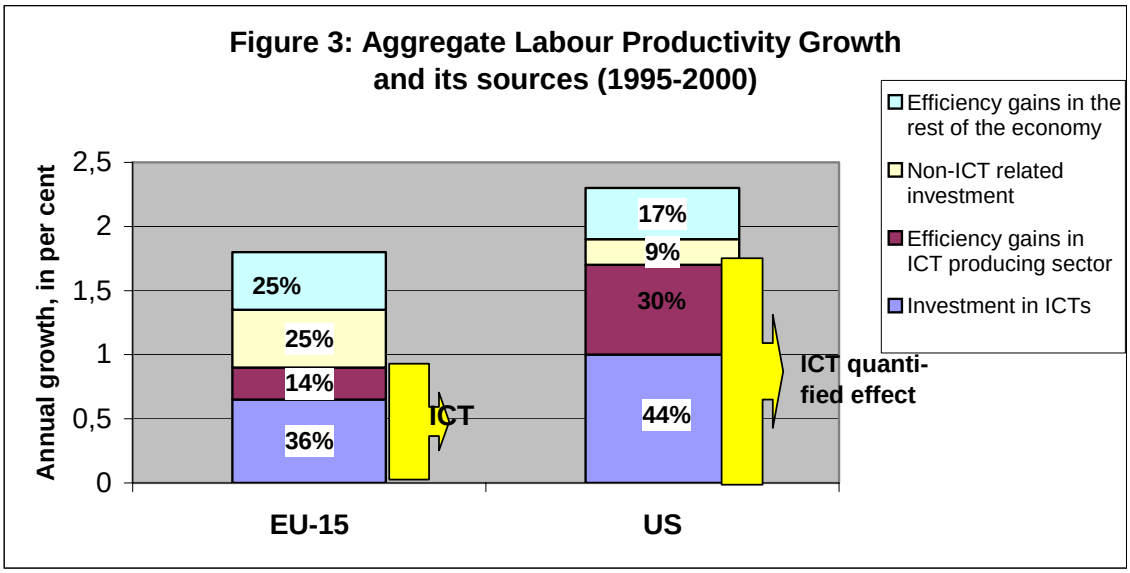
Source: own estimations from GGDC database

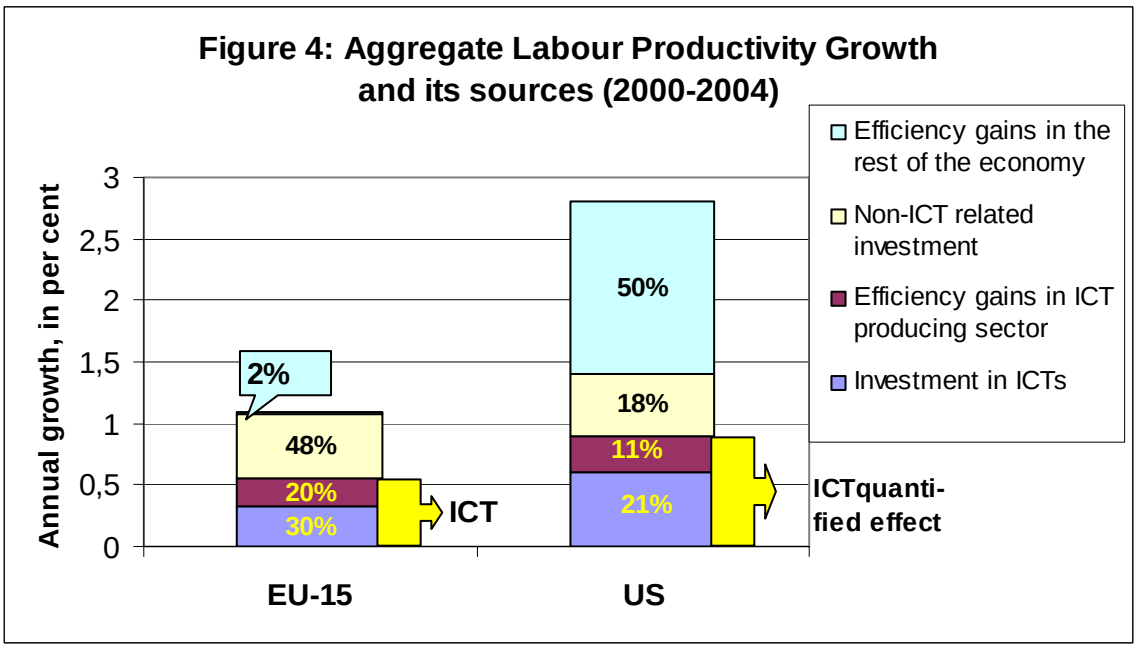
2.2 Macroeconomic evidence

Empirical studies on the economic impact of ICTs have been well-developed in relation to the US economy – mainly because of data availability. In recent years some work has been carried out also for the EU. The Groningen Growth and Development Centre[4] (GGDC) collected data on a number of countries and a set of 56 industries.

[4] Available at www.ggdc.net.

Recent empirical analysis[5] based on this dataset compares the impact of ICTs on the EU15 and the US labour productivity growth by decomposing it into (a) investment in ICTs (second channel); (b) non-ICT related investment; (c) efficiency gains in the ICT sector (first channel); and (d) efficiency gains in the rest of the economy. It should be underlined, that the last category does not distinguish between efficiencies stemming from ICT use and other, non-ICT related, efficiencies. As a result, it is not possible to quantify the impact of ICTs on the economy through the third channel described above. These measurement issues imply that the macroeconomic empirical analyses tend to underestimate ICT impact[6].





Source: B. van Ark and R. Inklaar, 2005.

[5] B. van Ark and R. Inklaar: Catching up or Getting Stuck? Europe's Troubles to Exploit ICT's Productivity Potential, GGDC, University of Groeningen, September 2005.

[6] There are also other possible deficiencies in measurement. For instance, as recent UK Office for National Statistics work shows, the software investment levels might have been under-estimated (see G. Chamberlin, Survey based measures of software investment in the UK, ONS, Economic Trends, no 627, February 2006).

ICTs contributed to about a half of European productivity gains in the second part of the 1990s (Figure 3) and in the first half of the present decade (Figure 4). They contributed to 74% of productivity gains in the US at the end of the 1990s and reduced their contribution in the following period to 32%.

In the second half of the 1990s ICTs were an important determinant of the divergence between the EU and the US performance. However, in the period 2000-2004, it was the efficiency gains in the rest of economy that explained most of the (growing) divergence. They account for 50% of productivity growth in the US, whereas in Europe they are negligible (2%). More in-depth analysis shows that significant part of these gains is attributable to ICT spillovers. Outside the ICT-producing sector, the industries that contributed most to productivity growth in the US are concentrated in trade and finance: wholesale trade, securities trade, retail trade, banking and other business services. These large market service industries are in the upper range of ICT users. It is not surprising that substantial investment in the ICTs carried out in the US in the second half of the 1990s has translated into sizeable efficiency spillovers in the market service industries.

2.3 Microeconomic evidence

Evidence on the efficiency gains from ICT use has been further gathered through firm-level studies. Microeconomic analysis finds positive spillovers and supports the link between investment and use of ICTs and companies' performance. For example, research undertaken in the UK[7] demonstrates that firms with higher investment in IT, higher use of computers, telecom services and e-Commerce also feature higher productivity rates. A Danish case study[8] of 700 enterprises demonstrates that e-Business oriented firms have higher productivity, are more innovative, employ more skilled labour force and more often involve themselves in the R&D activities. Surveys of the literature carried out by the OECD[9] confirm these conclusions for a number of non-European countries. These studies show that a number of factors influence firms efficiency or an efficient use of ICT: the size of the company, the activities of the sector, the firm skill endowment etc. Implementation of different information technologies also affects companies' efficiency to different degrees[10].

3. Factors determining the economic benefits of ICTs

The EU has not been able to exploit ICTs for productive purposes –, both as a user and as a producer – to the full extent. The EU invests less in ICTs[11], the ICT sector is less efficient, and the performance has been disappointing in ICT-using sectors.

[7] T. Clayton: IT Investment, ICT Use and UK Firm Productivity, Office for National Statistics, London, August 2005.

[8] Ministry of Science, Technology and Innovation: E-business, Innovation and Productivity – Case Study of 700 Danish Enterprises, Kopenhagen, October, 2005.

[9] D. Pilat, The ICT Productivity Paradox: Insights from Micro Data, OECD Economic Studies, No. 38, 2004/1; Pilat, The Economic Impacts of ICT – Lessons Learned and New Challenges, Eurostat Conference "Knowledge Economy – Challenges for Measurement", Luxembourg, December, 2005.

[10] One caveat of the microeconomic analysis is the issue of causality versus correlation. ICTs may be used in highly productive sectors and by better performing companies, but they are not bound to be the cause of their success. A simple correlation does not prove that ICTs are drivers of productivity growth, but remains an important indicator of a strong relationship between two variables.

[11] In the EU the contribution of ICT to capital formation is 15%. It is 25% of a greater investment rate in the USA.

Reaping benefits from ICTs is not straightforward. Policy should aim at the creation of a favourable environment to seize gains from ICT production and use. An enabling environment is made of a complex range of factors. Factors may concern both structural features of the wide economy and ICT-specific elements. All factors play important and interlinking roles in shaping the overall productivity environment.

3.1 Structural features

The contribution of ICTs to productivity points to the importance of the structural change aimed at boosting the production and adoption of new and knowledge intensive technologies. Enabling structural factors include:

- *Flexibility of the product market*, including light product market regulation (not to limit the exploitation of new technologies nor growth of efficient firms), low entry and exit costs, and a general competitive environment that provides the necessary incentives for companies to invest, adopt innovative technologies and enhance innovation. Competition policy, both at EU and Member States level, is crucial in this respect.
- The implementation of efficient *innovation systems* is a key underlying factor driving EU-US productivity differential[12]. The US innovation system has better linkages between different players, better quality and funding of its knowledge sector, and more favourable framework prevailing conditions. This system has been able to direct resources towards the newer high technology (often high productivity growth) industries. At the firm level, *entrepreneurial culture* is an essential component of an efficient innovation system. To be innovative, a firm must be able to recognise market opportunities, respond innovatively and have a large knowledge base. Finally, more flexible financial markets, making *venture capital* finance available to innovating firms, is key to an enabling innovative environment.
- The *flexibility of the labour market* is essential in the presence of technological change. Inadequate employment legislation may hamper the capacity of firms to reorganise and experiment with the new technologies, may limit the migration of skilled labour and the flexibility in working hours. To facilitate migration between jobs, flexible labour markets should involve life-long learning solutions and ensure the upgrade of skills.
- *ICT skills* are crucial both to the ICT industry and to the rest of the economy. The ICT industry relies on well educated scientists and engineers, while companies in all sectors need to implement new technologies and rely on a skilled labour force. In the last decade, the share of the labour force with ICT skills[13] has steadily increased. It has been estimated that around 20% of total employment in modern economies can be classified as ICT-skilled employment[14]. Educational and vocational training systems are hence necessary factors to successfully exploit the advantages of ICTs.

[12] European Commission, The Lisbon Strategy and the EU's structural productivity problem, European Economy Review, 2004.
[13] The definition of e-skills includes both practitioner skills required for developing, operating and maintaining ICT systems, as well as end-users required for the effective applications of tools in support of work.
[14] OECD Working Party on the Information Economy: New Perspectives on ICT Skills and Employment , DSTI/ICCP/IE(2004)10, Paris, December 2004.

3.2 ICT-specific factors

ICT-specific features of the economy also contribute to the profitable adoption of ICTs. Some of these factors are inherently linked to the structure of the ICT sector, while others are shaped by public policies. ICT-specific factors include:

- The *ICT sector* contributes to productivity growth through technological change. The sector is innovative and undertakes significant amounts of knowledge investments, with *R&D* shares largely exceeding the average shares of most other industries. ICT R&D effort in Europe is 25% of total R&D in the business sector, well above the weight of the sector in the economy amounting to 5% of GDP. Stimulating R&D in ICT is therefore crucial to the productivity revival.

- The fragmentation of the European market does not facilitate the creation of a large European ICT producing sector. The *Single Market* matters. The exploitation of economies of scale and a large market size facilitate ICT diffusion. The regulatory framework for electronic communications plays a fundamental role in the creation of a truly European single market for ICTs. But fragmentation might also come from the lack of cross-border interoperability or the multiplicity of regimes in fields such as intellectual property rights, standardisation or trust and security.

- SMEs make up a large part of Europe's economy and represent 99% of all enterprises. SMEs are therefore a major source of jobs, entrepreneurial skills, innovation as well as of economic and social cohesion in the EU. However, SMEs lag behind in terms of ICT adoption. An integrated eBusiness policy should stimulate the productive use of ICT by SMEs, targeting the specificities of the European industrial structure.

- Finally, *ICT adoption by governments and availability of modern online services* may stimulate the use of ICTs and enhance productivity gains by reducing start-up time and cutting red tape.

Annex

THE ECONOMIC IMPACTS OF ICT – LESSONS LEARNED AND IMPLICATIONS FOR POLICY

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Introduction

Information and communications technology (ICT) has proven to be the key technology of the past decade. The widespread diffusion of the Internet, of mobile telephony and of broadband networks all demonstrate how pervasive this technology has become. But how precisely does ICT affect economic growth? What are the conditions under which ICT can become a technology that is effective in enhancing growth and productivity? Why have some countries and regions thus far benefited more from ICT than others? What can policy makers do to seize the benefits from ICT?

Despite the slowdown of the economy over the past few years and the passing of the Internet bubble, these questions remain important to policy makers. This is because ICT has become a fact of (economic) life in all OECD economies. Almost all firms now use computers and most of them have an Internet connection. Moreover, a large share of these firms use computer networks for economic purposes, such as the buying, selling and outsourcing of goods and services. But despite the widespread diffusion of ICT, questions remain about the impact of the technology on economic performance and behaviour. Thus far, only few countries, including Australia, Canada and the United States, have clearly seen an upsurge in productivity growth in those sectors of the economy that have invested most in the technology, notably services sectors such as wholesale trade, financial services and business services. In many countries, including much of the European Union, these impacts have yet to become visible in the productivity statistics. Improving the understanding of the ways in which ICT affects economic behaviour and the factors that influence the potential impacts of ICT thus remains important.

This short note first briefly summarises some of the main findings on the impacts of ICT on growth and productivity. Next, it discusses some of the factors that influence the impact of ICT, including complementary investments, and discusses how these may affect the variation in country performance. Finally, it concludes by drawing some implications for policy.

What have we learned about ICT and economic growth?

In empirical analysis of economic growth, three effects of ICT are typically distinguished. First, investment in ICT contributes to capital deepening and therefore helps raise labour productivity. Second, rapid technological progress in the production of ICT goods and services may contribute to growth in the efficiency of capital and labour, or multifactor

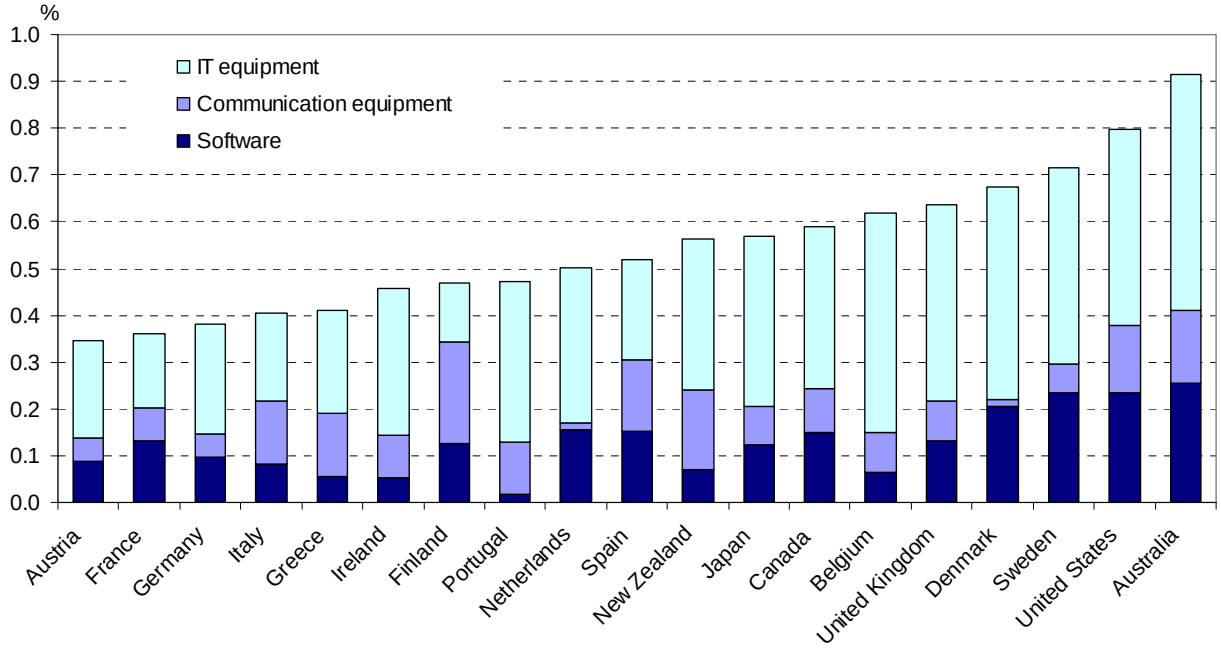
[15] This paper draws on previous OECD work which was carried out in collaboration with researchers and analysts in several OECD countries (see OECD (2004) and Pilat (2004)). Detailed references to the material quoted in this paper can be found in those studies. The paper reflects the view of the author and not necessarily those of the OECD or its member countries. Comments are welcome: dirk.pilat@oecd.org

productivity (MFP), in the ICT-producing sector. And third, greater use of ICT throughout the economy may help firms increase their overall efficiency, thus raising MFP. Moreover, greater use of ICT may contribute to lower transaction costs and more rapid innovation, which could also improve MFP. Some of the evidence on these three factors is summarised below.

ICT investment has boosted economic growth

Investment in ICT can make an important contribution in labour productivity growth. Investment expands and renews the existing capital stock and enables new technologies to enter the production process. While some countries have experienced an overall increase in the contribution of capital to growth over the past decade, ICT has typically been the most dynamic area of investment (*e.g.* Van Ark, *et al.*, 2003; Schreyer, *et al.* 2003). Studies show that ICT investment contributed to GDP growth in most OECD countries in the 1990s, accounting for between 0.35 and 0.9 percentage points of growth in GDP over the period 1995-2003 (Figure 1). In all countries but Finland, investment in ICT hardware accounted for the bulk of the contribution of ICT capital. In several countries, investment in software accounted for one-third of the total contribution of ICT capital to GDP growth. Differences in the measurement of the components of ICT investment are likely to affect these estimates.

Figure 1: **The contributions of ICT capital to GDP growth, 1995-2003**[2]
In percentage points



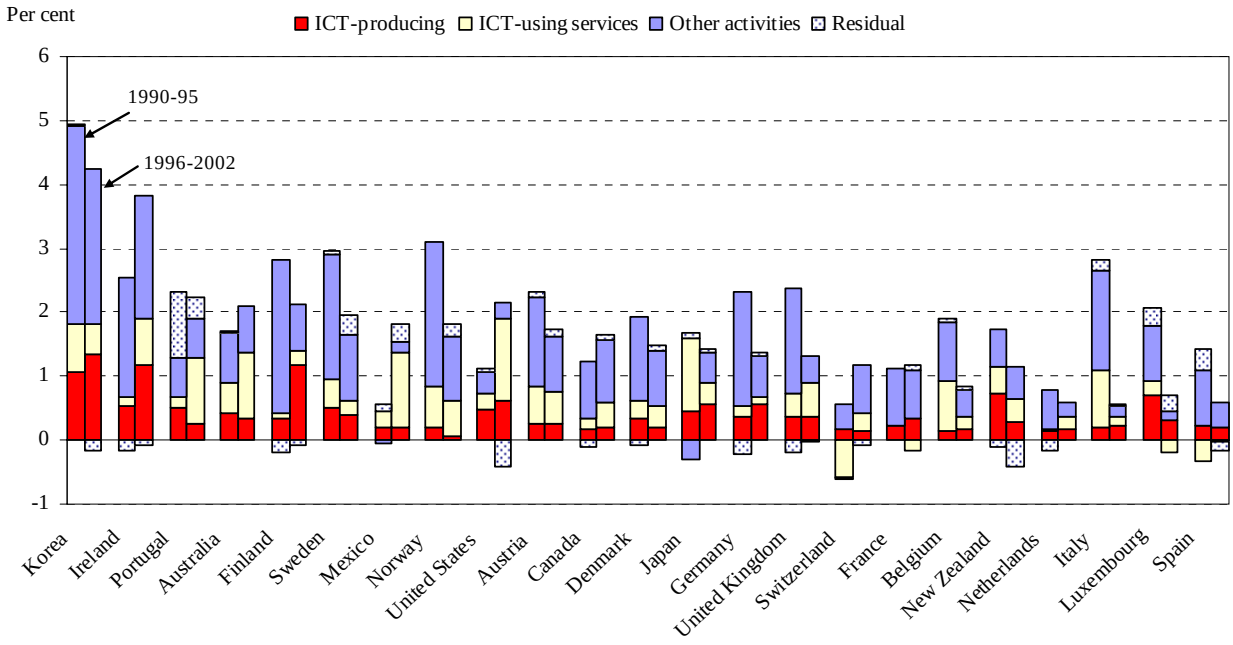
Source: OECD, *OECD Compendium of Productivity Indicators 2005*, Paris.

ICT -using services have only experienced more rapid growth in some OECD countries

Studies at the industry level (O'Mahony and Van Ark, 2003; Inklaar, *et al.*, 2003; Pilat and Wölfl, 2004) show that the ICT-producing manufacturing sector contributed substantially to labour productivity and MFP growth in certain OECD countries such as Finland, Ireland and Korea (Figure 2), and that the United States benefited more from the ICT-producing manufacturing sector than the European Union (O'Mahony and Van Ark, 2003). They also

show that ICT-using services in the United States and Australia experienced an increase in productivity growth in the second half of the 1990s (Figure 2), which seems partially associated with their use of ICT. Few other countries have thus far experienced similar productivity gains in ICT-using services (OECD, 2003). Moreover, most studies show that the European Union lags behind the United States in experiencing an increase in productivity growth in ICT-using services (O'Mahony and Van Ark, 2003; OECD, 2004; Van Ark and Inklaar, 2005).

Figure 2: **Contributions to aggregate labour productivity growth**[1]
In percentage points



1. Annual average contributions to the growth of value added per person employed. The residual reflects adding up differences in aggregating from industry to the aggregate economy level. ICT-producing includes ICT manufacturing and ICT-producing services; ICT-using services include wholesale and retail trade, finance, insurance and business services.
Source: OECD STAN database, see Pilat and Wölfl (2004).

ICT has positive impacts on firm performance

While aggregate and industry-level evidence is often inconclusive about the impacts of ICT, firm-level studies show that ICT use has a positive impact on firm performance in almost all OECD countries. For example, a study with Australian firm-level data (Gretton *et al.* 2004) found that the use of computers has a positive effect on MFP growth in the mid-1990s, *i.e.* before the peak in ICT investment, with considerable variation across industries. A series of recent studies for the United Kingdom (Clayton, 2005) finds significant returns to ICT investment, higher in services than in manufacturing. These studies are confirmed by many others (see OECD, 2003; 2004). For example, firms using ICT typically pay higher wages. Moreover, the benefits of ICT appear to depend on sector-specific effects and are not found in equal measure in all sectors. The available studies also suggest that some ICT technologies may be more important to strengthen firm performance than others. Computer networks may be particularly important, as they allow a firm to outsource certain activities, to work closer with customers and suppliers, and to better integrate activities throughout the value chain. These technologies are often considered to be associated with network or spill-over effects.

The evidence also suggests that the use of ICT does have positive impacts on firm performance, but primarily, or only, when accompanied by other changes and investments. This includes expenditure on skills and organisational change. Some findings on these complementary factors are discussed below.

Effective use of ICT requires appropriate skills

Many firm-level studies confirm the complementarity between technology and skills. A study for Canada (Baldwin, *et al.*, 2004), for example, found that a management team with a focus on improving the quality of its products by adopting an aggressive human-resource strategy – by continuously improving the skill of its workforce through training and recruitment – was associated with higher productivity growth. For Australia, Gretton *et al.* (2004) found that the positive benefits of ICT use on MFP growth were typically linked to the level of human capital and the skill base within firms, as well as firms' experience in innovation, their application of advanced business practices and the intensity of organisational change within firms. The data for Australia also showed that the earliest and most intensive users of ICTs and the Internet tended to be large firms with skilled managers and workers. Similar studies exist for European economies.

Organisational change is key to making ICT work

Closely linked to human capital is the role of organisational change. Studies typically find that the greatest benefits from ICT are realised when ICT investment is combined with other organisational changes, such as new strategies, new business processes and practices, and new organisational structures. The common element among these practices is that they entail a greater degree of responsibility of individual workers regarding the content of their work and, to some extent, a greater proximity between management and labour. For Germany, Falk (2001) found that the introduction of ICT and the share of training expenditures were important drivers of organisational changes, such as the introduction of total quality management, lean administration, flatter hierarchies and delegation of authority.

Maliranta and Rouvinen (2004) found that organisational factors are important in Finland since the productivity effects of ICT in the manufacturing sector seem to be much larger in younger than in older firms. Some other studies have shown that the productivity of capital (primarily non-ICT) tends to be higher in *older* plants, which is possibly due to learning effects. While such learning effects undoubtedly also exist with ICT, the finding for Finland is consistent with a view that it may be even more important to be able to make complementary organisational adjustments. Such changes are arguably more easily implemented in young or new firms.

Scope for experimentation may help in seizing benefits from ICT and other new technologies

In a competitive economy, the effective use of ICT may help efficient firms gain market share at the cost of less productive firms, raising overall productivity. For example, Maliranta and Rouvinen (2004) point to the role of firm selection in Finland. While most of the increase in ICT use in Finland is driven by growth within firms, restructuring (the growth of some firms and decline of others) also plays an important role. This is notably the case among young firms, where some succeed and grow, and many others fail. Several studies also point

to the role of competition and of foreign firms. A recent study by Clayton (2005) found that subsidiaries of US multinationals in the United Kingdom received the largest productivity gains from the use of computers. For Germany, Bertschek and Fryges (2002) found that international competition was an important factor in driving a firm's decision to implement B2B electronic commerce.

A closely related issue is that of experimentation. A recent comparison between the United States and Germany (Haltiwanger *et al.* 2003) distinguished between different categories of firms according to their total level of investment and their level of investment in ICT. It found that firms in all categories of investment had much stronger productivity growth in the United States than in Germany. Moreover, firms with high ICT investment had stronger productivity growth than firms with low or zero ICT investment. The study also found that firms in the United States had much greater variation in their productivity performance than firms in Germany. These differences may occur because US firms engage in much more experimentation than their German counterparts; they take greater risks and opt for potentially higher outcomes (see Bartelsman, *et al.*, 2003). This may be related to differences in the business environment between the two regions; the US business environment permits greater experimentation as barriers to entry and exit are relatively low, in contrast to many European countries.

ICT use is closely linked to innovation

Several studies point to an important link between the use of ICT and the ability of a company to innovate. Bresnahan and Greenstein (1996) argued that users help make investment in technologies, such as ICT, 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. For example, work for Germany, based on innovation surveys found that firms that had introduced process innovations in the past were particularly successful in using ICT (Hempell, 2002). Firms that introduce new products, new processes or adjust their organisational structure can reap higher benefits from ICT investment than firms that refrain from such complementary efforts. The results also show that innovating on a more continuous basis seems to pay off more in terms of ICT productivity than innovating occasionally. Baldwin, *et al.* (2004) finds that such characteristics are also important in Canada. The innovation strategy of a firm, its business practices, and its human-resource strategies all influence the extent to which a firm adopts new advanced technologies. A central theme emerging from the Canadian evidence is that a strategic orientation on high-technology is often the core of a successful firm strategy.

The impacts of ICT use often only emerge over time

Given the time it takes to adapt to ICT and make the necessary complementary investments, it should not be surprising that the benefits of ICT may only emerge over time. This can be seen, for example, in the relationship between the use of ICT and the year in which firms first adopted ICT. Evidence for the United Kingdom shows that among the firms that had already adopted ICT in or before 1995, close to 50% bought using electronic commerce in 2000 (Clayton and Waldron, 2003). For firms that only adopted ICT in 2000, less than 20% bought using e-commerce. The evidence presented by Clayton and Waldron suggests that firms move towards more complex forms of electronic activity over time; out of all firms starting to use ICT prior to 1995, only 3% had not yet moved beyond the

straightforward use of ICT in 2000. Most had established an Internet site, or bought or sold through e-commerce. Out of the firms adopting ICT in 2000, over 20% had not yet gone beyond the simple use of ICT.

Management plays a role

A recent study by Bloom, *et al.* (2005) for the United Kingdom found that US-owned establishments have a significantly higher productivity of IT capital than either non-US multinationals or domestically owned establishments. The study points to the great degree of organisational devolvement in US firms that enables workers to make more effective use of ICT, as it increases information flows in the firm, improves monitoring and allows decision making at lower levels. The study also found that good management practices in US firms contribute to the higher return to ICT capital, as this enables these firms to adjust to new technologies.

Explaining the differences between Europe and the United States

Overall, the evidence discussed above demonstrates that turning investment in ICT into higher productivity is not straightforward, and that many EU countries still have not experienced an uptake in productivity growth. This may be because turning ICT investment into productivity growth typically requires complementary investments and changes, *e.g.* in human capital, organisational change and innovation. Some of these changes may not yet have occurred to a sufficient degree in Europe. Since many studies point to a lag before the returns from investment in ICT become evident (OECD, 2004), this explanation would imply that the returns of ICT investment on productivity could still emerge in the near future.

However, this is a rather unsatisfactory explanation for the lack of aggregate productivity impacts of ICT in many European countries. There is also evidence that the firm-level benefits may be larger in the United States (and possible also in Australia) than in other OECD countries, and thus show up more clearly in aggregate and sectoral evidence. For example, Haltiwanger *et al.* (2003) suggest that the impacts of ICT are smaller in Germany than in the United States. This may be since the conditions under which ICT is beneficial to firm performance, such as having sufficient scope for organisational change, experimentation or process innovation, are more firmly established in the United States than in many other OECD countries. Small firm-level benefits in European countries might thus lead to relatively small productivity benefits at the aggregate level.

Product market regulations may also play a role as they can limit firms in the ways that they can extract benefits from their use of ICT. For example, product market regulations may limit firms' ability to extend beyond traditional industry boundaries. 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. The impact of product market regulations on ICT investment is confirmed by recent OECD work (Conway, *et al.*, 2006) and in other studies (Gust and Marquez, 2002; OECD, 2003*a*). Countries with a high degree of product market regulation have also not experienced the same pick-up in productivity growth in ICT-using services than countries with low levels of regulation.

Moreover, firms that are successful in implementing ICT may be better able to gain market share and grow in a competitive market such as the United States than in less competitive markets. This would contribute to greater overall impacts of ICT in the United States. For example, some of pick-up in US productivity growth over the second half of the 1990s can be attributed to the growth in market share of Wal-Mart, a company that replaced many less efficient retailers, partly owing to its effective use of ICT throughout the value chain. If the most efficient firms in Europe find it difficult to expand and gain market share, even if they do benefit from ICT, the overall impacts on productivity might be more limited than in the United States.

Lack of complementary process innovation in the service sector may also limit the gains from ICT in European countries (OECD, 2003*a*). Innovation is important since firms often make their investments in ICT more valuable through their own experimentation and innovation, *e.g.* the introduction of new processes, products and applications. In the absence of this process of "co-invention", which often has a slower pace than technological innovation, the economic impact of ICT could be more limited in European countries than in the United States.

Policy implications

The evidence discussed above demonstrates that turning investment in ICT into higher productivity is not straightforward. It typically requires complementary investments and changes, *e.g.* in human capital, organisational change and innovation. Moreover, ICT-related changes are part of a process of search and experimentation, where some firms succeed and grow and others fail and disappear. Countries with a business environment that enables the necessary complementary investment and change may be better able to seize benefits from ICT than countries where such changes are more difficult and slow to occur. As a result of this conclusion, the following areas appear particularly important for European countries to seize greater benefits from ICT, notably in fostering stronger productivity growth in the services sector:

1. ***Continue with regulatory reform of services markets***. Many successful services companies owe their existence and success to the opening up of markets. Opening services markets will create fresh opportunities for firms to develop new, often ICT-related, services and meet emerging global demands. It will also increase the incentives for companies to innovate and improve productivity. While progress has been made in opening services markets, further steps are needed, *e.g.* in reducing the degree of public ownership in competitive industries such as air transport, in addressing anti-competitive practices in professional services, and in opening international markets.

2. ***Foster entrepreneurship and experimentation.*** Most of the countries that have benefited from ICT-driven growth have low barriers to entry and exit, enabling firms to experiment and test business models. Moreover, the competitive environment in these countries allows successful firms to grow and gain market share, while enabling poorly performing firms to exit the market. Having scope for experimentation may be an advantage in times of great technological uncertainty, when firms need to learn in the market place about what works and what does not. The current period of ICT-driven growth might be such a period. OECD peer reviews have recommended to several European countries to reduce regulatory

barriers to business start-ups and to reduce compliance costs, especially for small businesses. Policies to address barriers to exit may also be important to foster a business environment that enables experimentation.

3. ***Reform labour markets to enable organisational change.*** Firm-level evidence highlights the importance of factors internal to a firm in explaining success, notably the organisation of work, the motivation and skills of workers, and the company culture. These factors differ considerably across firms, but may include the decentralisation of responsibilities and flat hierarchies, compensation according to performance or compensation aimed at achieving worker loyalty (*e.g.* through profit sharing or stock options). Overly strict employment protection legislation in many European countries may reduce the capacity of firms' to reorganise, experiment with new ideas or implement new technologies. An easing of EPL has been recommended for several countries in OECD peer reviews, with the aim of finding an appropriate balance between worker's need for protection and economies' capacity to adjust and create new jobs.

4. ***Adapt education and training policies to rapidly changing requirements for new skills.*** Since most services involve direct contact with customers, human resources are key to services. Education policies are important to help provide the qualifications that are needed in services, including ICT skills. However, they need to be supplemented with actions, partnerships and co-financing by firms, workers and governments to foster life-long learning. This will require improved incentives for private financing of life-long learning and actions to ensure equitable access to formal and on-the-job learning.

5. ***Adapting innovation and ICT-related policies to the growing importance of process innovation in the services sector.*** The opening up of services markets may enable new entrants to do something completely new and different. Such innovation – either in terms of processes or products – helps firms to differentiate themselves from other, often more traditional firms. Examples are the development by FedEx of a hub-and-spoke model for overnight package delivery or the development by Southwest of a business model for passenger transportation at low cost. In many cases, successful services firms were also pioneers in introducing ICT and developing applications, such as airline reservations without physical sales points, interactive TV or digital tracking of packages. The innovations pioneered by such firms often lead to additional productivity effects, due to the entry of other firms and responses by incumbent firms. To foster ICT-related process innovation, policy action could be required as follows (OECD, 2005):

    - *Innovation policies* remain ill adapted to the growing importance of innovation in services, and to the new potential for product and process innovation that is due to information and communications technology (ICT). For example, public spending on basic R&D, in both public laboratories and universities, does not typically address the long-term knowledge requirements for services, *e.g.* in improving the understanding of how technology should be deployed and used or of how people work in groups.

    - *Specific ICT-related policies* are also important. To seize the benefits of ICT for services, governments should continue to encourage effective competition in ICT infrastructure, network services and applications, notably for broadband. They

will also need to increase the trust in electronic business, *e.g.* by developing effective regulatory frameworks. Regulatory barriers, *e.g.* to digital delivery and digital content, also require further reform, as they are not adapted to the new potential offered by electronic business. Moreover, governments can take action themselves, by developing public services and digital content.