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BROADBAND AND THE ECONOMY

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FOREWORD

This report was presented to the Working Party on the Information Economy (WPIE) at its meeting in May 2007 as part of the work for the 2008 OECD Ministerial on "The Future of the Internet Economy". It was discussed and recommended to be made public by the Committee for Information, Computer and Communications Policy in October 2007.

The report was prepared by Desirée van Welsum, OECD Secretariat. It forms part of a larger body of work on the economic impacts of ICTs carried out in the Working Party on the Information Economy, under the overall direction of Graham Vickery, OECD Secretariat. It is published under the responsibility of the Secretary-General of the OECD.

TABLE OF CONTENTS

Boxes

BROADBAND AND THE ECONOMY

Summary

This report examines the way in which broadband networks interact with the economy, the role they play in creating the conditions for sustainable economic growth and prosperity, and the structural changes they enable. Emphasis is put on the economic impacts, in particular on growth, globalisation and employment.

Broadband networks are an increasingly integral part of the economy. As the technology evolves and bandwidth increases, the scope for broadband to act as an enabler of structural change in the economy expands as it affects an increasing number of sectors and activities. Direct effects result from investments in the technology and from rolling out the infrastructure. Indirect effects come from broadband's impact on factors driving growth, such as innovation, firm efficiency, competition and globalisation. Broadband facilitates the development of new inventions, new and improved goods and services, new processes, new business models, and it increases competitiveness and flexibility in the economy. More generally, broadband enables improved performance of information and communication technologies (ICTs) a general purpose technology (GPT) that is one of only a few technological improvements that fundamentally change how and where economic activity is organised. As such, significant impacts on the economy can be expected for example by enabling organisational change and enhancing co-ordination to reap productivity gains from overall investments in ICTs, although it may be difficult to clearly disentangle the economic impact of broadband from that of ICTs more generally. Furthermore, relative to other historical GPTs, such as railways and electricity, the impacts may be larger and materialise more rapidly.

Broadband has become an important part of almost every aspect of the knowledge economy and is especially so in activities that rely on the provision of data and information, particularly in service sectors. Many aspects of producing, delivering, consuming, co-ordination and organisation are now taking place over broadband communications networks. Broadband generates increased efficiency, productivity and welfare gains, and potentially contributes to job creation and occupational change. But it also gives rise to security and privacy concerns, and protecting users' security is increasingly important as the broadband-enabled Internet becomes part of the economic infrastructure.

Broadband is also increasingly important as an enabling technology for structural changes in the economy, most notably via its impact on productivity growth, but also by raising product market competition in many sectors, especially in services. ICTs and broadband are facilitating the globalisation of many services, with broadband making it feasible for producers and consumers of services to be in different geographical locations. ICT-enabled globalisation of services is having a fundamental impact on the way economies work and on the global allocation of resources, contributing to productivity growth by expanding markets, increasing business efficiency and reinforcing competitive pressure.

However, very few studies have examined the economic impact of broadband directly, partly because it is relatively recent and the technologies are evolving rapidly, and also because it is difficult to disentangle its impact from that of ICTs more generally. As a result, emphasis is put on potential rather than measured impacts in places in this study. The evidence suggests that the largest productivity gains come increasingly from the use, rather than the production, of ICTs. ICT and e-business skills, as well as

organisational changes enabled by ICTs play an increasingly pivotal role in achieving productivity gains. The diffusion of broadband and wireless developments are expected to encourage organisational changes and fuel associated productivity gains, and mobility is gaining importance, in particular with the diffusion of mobile broadband.

Broadband also helps to bring welfare improvements. For example, it enables more flexible work practices, hours and location, which may contribute to easing congestion and pollution challenges faced by large cities. These factors should enhance the welfare of employees over and above any net effects on employment. Broadband also generates further benefits to consumers by reducing search and information costs and giving greater access to information, making price comparisons easier, raising competition and creating downward pressure on prices. It also enables increased customisation of goods and services and improvements in product quality. More generally, broadband changes the role of individuals in production, facilitating user-driven innovation and the development of user-created content. Broadband can also enable small and medium-sized firms to co-operate and compete with larger firms in a wider range of markets and to re-organise and purchase services that were previously not accessible.

1. Introduction

Information and communication technologies (ICTs) have an important economic impact as shown in OECD analysis (see *e.g.* OECD, 2004b). This report goes further to consider the impact of broadband, a particular information and communication technology (see Box 1 for a definition). Broadband networks increasingly link other ICTs in ways that should ultimately have a significant and positive effect on economic activity, with potential benefits for productivity, growth and the quality of life. Notwithstanding the rapid growth of broadband take-up, the phenomenon is relatively new and difficult to disentangle from the overall impact of ICTs which is already a challenging area for measurement. Nevertheless, firm evidence of a positive impact[1] is increasing as studies from official statistical agencies or based on official statistics are developed in OECD countries.

The impacts of broadband are very wide and choices have to be made about which particular areas should be covered. This paper mainly considers the economic impact of broadband, and does not consider social impacts in detail. The report explores the ways in which broadband is becoming an integral part of OECD economies and some of the structural changes that result from this. The main focus is on the impact on businesses, via productivity, organisational innovations, increased competition and the opportunities for the globalisation of an increasing range of tasks, especially in services. All of these will impact on employment and labour market flexibility.

The impacts on individuals and small and medium-sized enterprises (SMEs) are considered separately (see extensive analysis in OECD, 2007d). Household use of broadband is also likely to have economic impacts, either by allowing workers to work from home (which allows flexible working hours and the productive use of non-traditional working hours) or by facilitating the establishment of home-based firms (contributing to the formation of new businesses and enhancing business dynamics and entrepreneurship). Other potential indirect benefits include the provision of online education and training, and improvements in the functioning of product markets. Internet access also opens up a wide range of new consumer services. Areas that have grown particularly rapidly include online shopping and banking and online job and housing search (Lehr *et al.,* 2006, and OECD, 2004a, 2006a).

This report does not consider the economic impact of e-commerce, the impact of broadband on business-to-consumer relations and the use of broadband by governments for on-line services. The evidence on e-commerce is mixed, but recent work (*e.g.* Alleman and Rappoport, 2007) suggests that

1 . See Roberts (2007) for a definition of "the impact of ICT".

online commerce may in fact be substituting for offline commerce, in which case total (retail) sales are unlikely to grow more rapidly as a result of broadband-enabled commerce, even if choice is broadened and efficiency increases. However, the move to on-line shopping does raise the share of economic activities that are now dependent on broadband. On the business side, Rincon *et al.* (2005) also find a positive productivity impact of e-commerce through e-buying and e-selling.[2]

Box 1. Defining broadband

The term "broadband" is typically used to denote an Internet connection with download speeds faster than traditional dial-up connections (at 64 kbit/s). The OECD began collecting data on broadband subscribers in 2001 and set the minimum threshold for bit rates at 256 kbit/s. The original OECD data collection included three categories: DSL, cable and other. In 2007, the OECD began separating out certain elements of the "other" category. Now fibre to the premises and apartment LAN connections are reported separately.

The OECD's broadband data and criteria can be found online at the OECD Broadband Portal: http://www.oecd.org/sti/ict/broadband. OECD (2007c) provides an overview of recent developments in broadband infrastructure, access and use.[3] Further background statistics are also available in OECD (2007g).

Source: OECD.

The report is organised as follows. The next section introduces the topic and sets out the issues. The third section examines broadband as a general purpose technology and as an enabler of structural change in the economy. The subsequent section examines the productivity impacts that have been attributed to information and communications technologies in general, to communications technologies in particular, and to broadband itself, as well as the productivity benefits arising from broadband and ICT-enabled globalisation. The following section examines the potential impact of broadband through its effect on globalisation, in particular of ICT-enabled services. The fifth section looks at the employment impacts of broadband. The sixth section looks at several other areas broadband can be expected to affect, in particular through its impact on individuals through changes in consumer surplus and quality of life, and on small and medium-sized enterprises (SMEs). The final section discusses policy issues.

2. The expected economic impact of broadband

This section introduces the various ways in which broadband and the economy interact as broadband and the Internet[4] are rapidly becoming an integral part of the economy. As the technology continues to evolve and bandwidth increases, the scope for broadband to act as an enabler of structural change in the economy expands as it affects an increasing number of sectors and activities.

Broadband, when combined with ICTs,[5] has many channels through which its effects can operate. Direct effects result from investments in the technology and rolling out the infrastructure itself. Indirect

2. Criscuolo and Waldron (2003) find further evidence that the productivity impacts are likely to differ according to the types of trade (buying or selling).

3. Many countries support the roll-out of broadband in remote and rural areas for social equity reasons, to reduce the digital divide, and to provide services to citizens and businesses on an equal footing (see OECD, 2007c).

4. The Internet is defined here as including all IP-based networks, including not only the public Internet but also private and Closed User Group networks, as well as Next Generation Networks, see OECD (2007e).

5. And vice versa: ICTs without broadband would not nearly be as effective and transformative. As Atkinson and McKay (2007, p. 15) put it: "without a World Wide Web to connect to, many computing devices acted as nothing more than glorified typewriters".

effects come from all aspects of economic activity affected by broadband and which drive economic growth and prosperity, *e.g.* firm efficiency and increased productivity, reduced costs,[6] innovation, globalisation, and new employment opportunities resulting from the gains achieved.

Broadband also enables the emergence of new business models, new processes, new inventions, new and improved goods and services and it increases competitiveness and flexibility in the economy, for example by the increased diffusion of information at lower cost, by improving market access to increasingly larger markets, by allowing people to work from multiple locations with flexible hours, and by generally speeding up procedures and processes, boosting the economy's dynamism. Finally, by their nature these technologies also create network externalities whereby the benefits that accrue from using them increase as diffusion spreads. There can be further spillovers too, for example when companies adopt broadband and ICTs that transform their supply chain and thereby prompt other companies to also change theirs, either because they are part of the chain, or because they copy the innovative leader. [7]

Broadband as a general purpose technology enabler

Economic growth is driven by many factors, including product, process and organisational innovations based on technological change.[8] Technological change usually comprises small incremental improvements. However, a few technological improvements fundamentally change how and where economic activity is organised. These are so-called general purpose technologies (GPTs). Historical examples of GPTs include printing with moveable type, electricity and the dynamo, the internal combustion engine, steam engines and railways. ICTs[9], including computers and the Internet, are generally considered to be a GPT. A GPT evolves over time with several phases of efficiency, applications and diffusion. It creates spillovers throughout the economy, not merely in the sector producing the GPT, it leads to fundamental changes in the production process of those using the new invention, and it spurs on further inventions and innovations.

GPTs are technologies that enable changes, which is also the case for ICTs, with broadband acting as the required infrastructure enabler (like the electricity transmission and distribution network in the case of electricity), and the Internet as the platform supporting an endless variety of applications. Thus, their effects are likely to build up over time. They can be expected to raise productivity, and give rise to network economies with network effects expanding over time. There will be new process, product and organisational innovations beyond what can even be imagined today. In fact, many new products, both goods and services, have already been created as a result of ICTs and have been fully integrated into everyday life, including working life.[10] Nevertheless, as broadband acts as the GPT (ICTs) enabler, its

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6. For example, Oracle has implemented a system allowing employees to file expense reports online, cutting costs by USD 15 per filing (from USD 25 to USD 10); IBM has implemented an Internet-based tool for booking employee travel with reported monthly savings of USD 2.5 million; and Cisco reportedly saves some USD 360 million per year by using the Internet for e-business (Atkinson and McKay, 2007).

7. This process is furthered for example when large firms impose on firms in their value and distribution chain to adopt new technologies and interoperable IT systems as has been the case *e.g.* for Wal-Mart and automobile companies, Other companies then have an incentive to copy this system and transform, in turn, their supply chains too (Atkinson and McKay, 2007).

8. Where "technology" comprises "the set of ideas specifying all activities that create economic value" (Carlaw *et al.,* 2007).

9. Defined by Carlaw *et al.* (2007) as "all technologies that deal with information, doing such things as communicating, analysing, transforming and storing it. These technologies include speech, writing, the printing press, and many more modern technologies, such as telegraph, telephone, radio and computer."

10. See Carlaw *et al.* (2007) for a detailed discussion of GPTs and ICTs as a GPT.

effects will be very difficult to disentangle from those of the GPT (ICTs), just as it would be extremely difficult to separate out the effect of the electricity transmission and distribution system from the overall impact of electricity.

GPT-type effects suggest that measured total factor productivity (TFP) should rise in ICT-using sectors, but probably with considerable time lags. However, ICT investment could even be associated with initial declines in TFP as reorganization and learning require resources (Basu *et al.,* 2003). This is also consistent with David's (1990) "delay hypothesis" or "learning hypothesis", reflecting the time taken to learn to use and apply new technologies. In fact, technological revolutions can occur without being reflected in major accelerations in measured productivity. Efficiency has been growing rapidly, but there are physical limits at least within the current types of networks, and it is difficult to imagine what next generation type technology/networks will look like and the changes they will bring about. Even though there is still room for further diffusion of existing applications, completely new applications appear all the time and in many different parts of the economy (Carlaw *et al.,* 2007).

Overall, it is very likely that broadband and associated ICT applications will replicate the hugely positive and transformative effects from previous GPTs and could possibly even exceed the effect of any GPT to date (Box 2). Indeed, the prices of ICTs have fallen more dramatically than the prices of other GPTs, such as electricity and the combustion engine, and the ensuing decline in the price of capital goods is unprecedented, even though like for these other GPTs, the required complementary investments and innovations driving change may take time to materialise and make their contribution (Fernald *et al.,* 2007). It is sometimes estimated that the evolution of the impact of ICTs may be today where that of electricity was in the United States in the 1920s (Carlaw *et al.,* 2007), but with ICTs, technological improvements are still taking place and broadband is enabling ever more applications. Similarly, only in the third quarter of the 19th century did the combined share of stationary steam engines and railways in the capital stock match that of ICT in the United States in the 1980s (Crafts, 2003).

Box 2. Comparison of the impact of broadband to that of historical GPTs

Electricity, steam and information technologies tend to be considered the most important examples of GPTs. The examples of electricity and steam illustrate that the initial productivity impacts of a GPT are typically very small and that the realization of its eventual potential may take several decades so that the largest growth effects may occur a long time after the technology is first introduced: electricity's major boost to economic growth in the US occurred about 40 years after the first commercial generating stations came on stream (David, 1990), and the lag following James Watt's steam engine was about 80 years (Crafts, 2003).

Furthermore, it is expected that the impact of ICTs may well exceed that of previous GPTs. For example, steam had a much smaller impact on annual productivity growth than ICTs even before the mid-1990s: at no time does steam's contribution match the 0.68% per year of ICT in the US in 1974-90 (Crafts, 2003). And these estimates do not include the extent of TFP spillovers, so the actual impacts will be even larger.

Box 2 Table: Contributions to UK labour productivity growth, 1830-1910 (% per year)

	1830-1850	1850-1870	1870-1910
Stationary steam engines	0.04	0.12	0.14
Railways	0.16	0.26	0.07
Steam technology	0.20	0.38	0.21

Source: Crafts (2003), Tables 5, 6, and 7, and the sources therein.

Box 2 Table 2: Contributions to US (non-farm business sector) labour productivity growth, 1974-2001 (% per year)

	1974-1990	1991-1995	1996-2001
Capital deepening	0.77	0.52	1.19
of which ICT	0.41	0.46	1.02
Total factor productivity	0.59	1.02	1.24
of which ICT sector	0.27	0.41	0.77

Source: Crafts (2003), derived from growth accounting estimates of equation (4) by Oliner and Sichel (2002); labour quality is included in other TFP.

Some attempts have been made to compare the impact on productivity of broadband for the UK to the impact of two historical GPTs, railways and electricity (*e.g.* the Broadband Industry Group, 2003). The concept of “social saving”, which includes consumer surplus as well as productivity gains, is used to provide an estimate of the quantitative impact of these GPTs. The first investments in railways in the UK took place in the early 1830s, but it did not peak until the late 1840s and investment was still significant by the 1870s. The estimated social saving for the UK by 1865, *i.e.* after some 35 years of investment in railways, is between 2 and 17%. For electricity (including electric power generation, distribution and use), which diffused relatively slowly, the estimated impact for the UK amounts to a 3.3% productivity boost by 1937, assuming that all of the productivity growth over and above the TFP growth before the invention of electricity was actually attributable to electricity. Like for broadband, which acts as an enabler of ICTs which constitute the GPT, much of the impact from electricity did not come so much from electrification itself but rather from the applications it enabled and the additional productivity gains they made possible. Finally, the estimated impact of broadband is of some 0.4-2.7% by 2015, and 0.8-5.7% by 2028. While these estimates suggest that the economic impact of broadband in the UK is potentially on the same scale as that of electricity, the impact of broadband is likely to come through much more quickly than that of railways and electricity.

Applications and Internet use generated by broadband

A huge number of applications already rely on broadband. Even though widespread use of the Internet has been around since the mid-1990s, faster speeds and greater bandwidth continue to increase the range of activities that can be carried out online. As a result, the Internet has become an increasingly integral part of our lives, society and economy. The Internet is inherently a global infrastructure and so changes in one country can have an impact on others.

Broadband has become an integral part of almost every aspect of the knowledge economy. For example, traditional telecommunications are increasingly taking place over broadband communications networks, in particular IP networks, rather than circuit switched networks, and people also increasingly use IP telecommunications (*e.g.* Skype). Public infrastructure increasingly depends on broadband communications networks, from traffic lights control, through control of sewage systems, as well as many forms of transportation, air traffic control, maritime and rail transport and logistics management systems. The government itself increasingly maintains relations online with citizens and firms through the provision of e-government services (*e.g.* applications for permits, tax authorities, providing information etc.). Military and defence systems are also affected by broadband and the Internet. Global Positioning Systems (GPS) and other navigation systems all rely on this type of information transmission and enable new applications such as the distance monitoring of patients and prisoners. Natural and other disaster prevention and warning systems also heavily rely on the Internet and broadband communication networks.

Many aspects of business are now taking place over broadband communications networks: for example, supply chain management, fleet management, e-procurement, e-invoicing, online recruitment, customer service, call centres, online payment systems, e-commerce, co-ordination of fragmented production processes both within and between firms, and the connection of teleworkers to their employers’ networks. Further gains can be expected as possibilities for the use of virtual private networks and video conferencing, for example, expand with increased bandwidth.[11] Broadband is especially important in all sectors that rely on the provision of information, especially in financial markets, insurance and accounting firms and systems. Other examples include consultancies, weather forecasts and reports, research (from school homework to professional and academic research and R&D activities), online databases, banking (offline and online) and ATM services, marketing, online advertising, advertising and graphics design industry, and news distribution (offline and online). Broadband and very high-speed networks are also playing a wider and important role in enabling innovation, another factor contributing to the conditions for sustainable economic growth (Box 3).

Box 3. Broadband and innovation

Broadband has an impact on innovation both through innovation in ICTs and through innovation enabled by ICTs, such as collaborative R&D networks,[12] virtual simulations, artificial intelligence, grid computing initiatives, and new work practices. Broadband enables both innovation through development of new applications and the diffusion and further development of existing innovations, and these two channels mutually reinforce each other. The broadband enabled combination of ICTs and other technologies (*e.g.* biotechnology and nanotechnology) may generate even more inventions and innovations in future (Carlaw *et al.,* 2007). There is also evidence that firms that use ICTs more intensively innovate more, creating larger spillovers and productivity gains (Koellinger, 2006). Such effects can be reinforced by broadband as it enables more intensive use of ICTs, enhancing the possibilities of their innovative use.

Broadband also increases firms' ability to move more quickly from idea to product, for example by allowing around the clock R&D, "24x7x52", and concurrent R&D on multiple projects in different locations. Thus, ICTs and broadband have a transformative effect on the way innovative activity is carried out. New forms of ICT-related innovation processes are emerging, speeding the diffusion of codified knowledge and ideas, enabling relations based on tacit knowledge and personal relations, and linking research more closely to innovation. They lower barriers to product and process innovation,[13] accelerate start-ups, improve business collaboration, enable small business to expand their R&D and collaborate in larger R&D consortia, reduce cycle times, and foster greater networking.

The focus of ICT-related R&D has also shifted from computer hardware towards software, computer and related IT services, web services and digital content. Broadband is an enabler of innovation in these areas and can be expected to drive further innovations in the future, especially in broadband enabled services and digital content. Furthermore, with the diffusion of ICTs throughout the economy, ICT-related R&D is also increasingly carried out in other sectors.

With the diffusion of broadband Internet, people outside the boundaries of traditional institutions and hierarchies can also innovate to produce new goods and services. The role of network users and consumers in the innovation process potentially increases as they more actively contribute to new ideas (user-led innovation, or "the democratisation of innovation", von Hippel, 2005) and collectively develop new products (*e.g.* Wikipedia, open source software).

Consumers also increasingly make use of the Internet and broadband communications networks, for example for e-commerce, online reservations (holidays, airlines, trains, concerts, cinema, etc.), online airline check-in, online payment systems (bills, banking, retail), blogs, peer-to-peer networks, online auctions, and online entertainment services (*e.g.* games). In addition to efficiency gains, large cost savings can also be realised by governments and business. For example, estimates show that USD 2.15 is saved on each tax return filed electronically in the United States, in conjunction with a radical reduction in the error

11. However, asymmetric bandwidth could become a bottleneck for these so-called multiple-play services that require fast upload speeds. The move towards more symmetric bandwidth may be important as multiple play services increase usage of the upstream path (Okamoto and Reynolds, 2006).

12. For example, the development team for the Boeing 787 Dreamliner brings together companies from over 20 countries and 135 partner sites (Dassault Systèmes, 2006).

13. Survey results for EU10 countries show that ICTs are a key enabler and driver of process innovation in most industries. 32% of firms (by share of employment) reported that they had introduced "new or significantly improved internal processes" in the 12 months prior to the interview, and 75% of these claimed that these process innovations were "directly related to or enabled by ICT". *e-Business W@tch*, Chart Report 2006, Slide 8, http://www.ebusiness-watch.org/resources/charttool.htm .

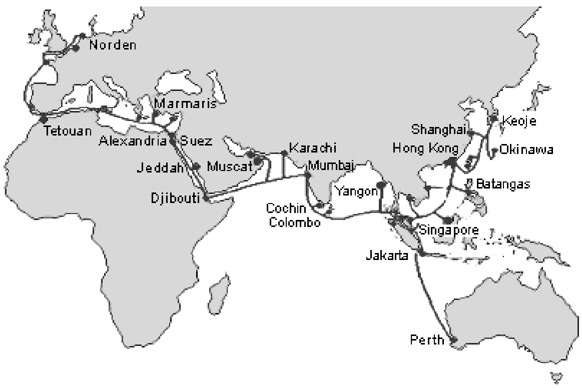
rate from 20% to under 1%, and the General Services Administration's "GSA Advantage" programme, which is an online purchase and acquisition system, provided between USD 90 and USD 240 of savings on administrative costs per transaction (US White House Office of Management and Budget, cited in Atkinson and McKay, 2007). In addition to greater ease and convenience, citizens can also save costs by using online government services. For example, it costs USD 1 to renew a driving licence online in the United States, compared to USD 8 for an in-person renewal (US White House Office of Management and Budget, cited in Atkinson and McKay, 2007). Putting in place these online processes requires investments not only in IT and broadband, but also in complementary factors, such as e-government (organisational capital) and ICT skills (human capital).

These examples show how pervasive the Internet has become, as would be expected of a GPT. It is increasingly vital for firms to have broadband Internet, but firms face a trade-off between productivity and efficiency on the one hand, and security and privacy on the other hand. Thus, protecting users' security is increasingly important as the Internet becomes *the* platform for voice, content, data and a core part of the economic infrastructure. Data security breaches in 2005 are estimated to have caused USD 100 billion in damages – more than the illegal drug trade in the US (Swindle, 2006, p. 18). In addition to security issues, damage to the physical infrastructure also has increasingly important economic ramifications given the importance of broadband and the Internet. Box 4 gives some examples about what happens when the cables stop working.

Box 4. What happens when the cables fail?

The importance of broadband to the economy can also be illustrated by what happens when Internet and broadband cables fail. The incidents have been relatively minor to date, but they give some idea of the kinds of activities that have been affected, and the duration of the disruptions. As more and more activities take place over these cables, any faults in the infrastructure will have increasingly wide and disruptive repercussions.

Internet activities, e-mail and telecommunications were affected when Telstra, Australia's biggest Internet Service Provider (ISP), lost around 60% of its Internet transmission capacity in 2000 as a result of damage to a major Internet backbone cable (see figure below), situated in less than 100 feet of seawater around 40 miles off Singapore. Initially Telstra was able to serve only 30% of its usual capacity, but after re-routing data around the damage it went up to 75% relatively quickly. To avoid disruptions of this kind, to improve service and provide increased network capacity and reliability for Telstra's retail and wholesale customers Telstra announced early 2007 it is investing in a new 5 600 mile deep-sea cable linking Australia to Hawaii, where it will connect to the US.[14]



The SEA-ME-WE 3 Cable: 23 600 miles long.

Source: Forbes, http://www.forbes.com/2000/11/21/1121disaster.html

Sri Lanka's link to the rest of the world, a single fibre connection, was cut in 2004 by a ship's anchor. News reports indicated that its Internet and long-distance phone service had been cut-off, which has some potentially big economic implications for Sri Lanka given the importance of its call centre activity.

14. http://www.businessweek.com/ap/financialnews/D8O5330O0.htm?chan=search

More recently, in mid-December 2006, hundreds of thousands of people in Iceland suffered severe disruptions to their use of the Internet and Iceland's universities and hospitals suffered a temporary shut-down of data-communications when a deep-sea cable break caused an interruption of CANTAT-3 services. During the period of repair the affected institutions relied on emergency connectivity obtained via local Internet providers.[15]

On 26 December 2006, an undersea earthquake and rockslides damaged undersea cables off Chinese Taipei's southern coast causing outages in Chinese Taipei, China, Korea, Japan and India. This incident, also dubbed "a digital tsunami"[16], disrupted financial markets, phone calls, online banking, computer kiosks at airport check-ins, ATMs, logistics companies, communications and Internet sites. Chunghwa Telecom, Chinese Taipei's largest telephone company, reported that all of the island's phone communications with other Asian countries had been disrupted and that capacity to the US had been cut by 60%. Japan's NTT reported damage to 1 400 phone lines and 84 international phone lines, disrupting its phone capacity to South East Asia. China's access to major international websites was also affected, as were phone calls to Chinese Taipei and Hong Kong (China). Korea's leading fixed line company KT reported that some 90 leased lines had been destroyed, but that telephone and Internet lines had been re-routed rapidly with minimal disruption. Overall, most network operators and data providers were able to re-route traffic without too great a disruption. For example, Cable & Wireless used back-up terrestrial circuits through China, and Reuters, whose main regional data centre is located in Singapore with a back-up in Hong Kong (China), restored services to Japan and Chinese Taipei on the same day and to Korea the following day. Bloomberg on the other hand suffered more from the outage as it supplies its information from New York. Hong Kong (China) based traders, investment bankers and Bloomberg's editors could not access the company's terminals for two days.[17]

This incident shows not only how much of data transfer relies on deep sea cables, but also that the network is quite resilient, with at least partial service being restored in most affected networks less than 12 hours after the quake by re-routing traffic. Companies also reverted back to using fax and mobile phones. The Hong Kong (China) stock market returned to normal after a few days, China Telecom had recovered 70% of its Internet service and all of its phone calls to Hong Kong (China) and Macau. Singapore Telecom's Internet access and voice services had also been restored. By 31 December, Indonesia's PT Indosat had 80% capacity.[18]

India is particularly aware of reliability and interruption issues given the huge demand created by its call centre, software and business process outsourcing industries which cannot afford to be offline for any extended period of time. During the December 2006 incident, only one company suffered a major outage which lasted around 8 hours; other big companies only suffered slight disruptions. This is because Indian companies rely on a multitude of telecom service providers and use four different cable systems that land in different Indian cities: diversity is the key to reducing impact from such deep sea cable outages.[19]

In general, Asia is a vulnerable area because of quakes and fault lines, emphasising the need for careful study of where the cables are being laid and to diversify cable loops and landing points. For example, the planned Trans Pacific Express cable system, linking the US to China and other countries in Asia will use a "mesh system" which will run three different loops connected at switching stations on land. This should make re-routing easier in case of a break. Geographical diversity in landing points is also important.

Repairs of breaks in deep-sea cables are complicated by the need for ships with special equipment, which may take some time to arrive in the area of the damaged cable, and are very costly. Also, the extent of the damage cannot be known until all the damage is fixed as the equipment can only scan cable up to the first breakage point. It is not possible to know how many further breaks there are beyond that point until they have all been fixed. Parts of severed cables can also end up far removed from the breakage point when dragged along by currents or moved further along by rock slides, for example. Thus, fixing cable breakages can be a costly and time consuming process.

15. http://en.wikipedia.org/wiki/CANTAT-3

16. http://www.wsws.org/articles/2007/jan2007/taiw-j09.shtml

17. *Financial Times*, 29 December 2006.

18. http://www.businessweek.com/magazine/content/07_03/b4017068.htm?chan=top+news_top+news+index_businessweek+exclusives, and http://www.wsws.org/articles/2007/jan2007/taiw-j09.shtml

19. http://www.businessweek.com/magazine/content/07_03/b4017068.htm?chan=top+news_top+news+index_businessweek+exclusives

Other causes of cable breakages include rats, drilling machines, and earth quakes. In New Zealand a rat was suspected of causing a telecoms blackout which closed trading on the Stock Exchange for several hours and severely hindered retailers and shoppers. Air travellers also experienced delays as, with Internet and e-mail down, check-in of passengers had to be carried out manually. At a "one-in-a-million" chance this incident coincided with a Powerco contractor also damaging another fibre optic cable while drilling a power hole.[20] Damage may also be intentional and it is possible to imagine scenarios where cables or servers become the object of criminal intentions.

Increasingly, efforts are being made to keep Internet traffic local, which not only lowers costs but also improves performance and reliability. As a result, data is sent directly between users in these areas and does not leave the region, whereas previously it might have travelled between continents (Gibbard, 2007).

Broadband is enabling the globalisation of services

Broadband is becoming increasingly important as an enabling technology for structural changes in the economy, most notably via the direct impact on productivity growth, but also by raising product market competition in many sectors, especially in the services sector. In particular, ICTs and broadband are facilitating the globalisation of many services, with broadband making it feasible for consumers and producers of services to be in different locations. ICT-enabled globalisation of services involves highly skilled and relatively higher value-added services as well as lower-skill services such as back-office and administrative functions and call centre activities. Examples of such ICT-enabled services include legal, accounting, advertising, design, R&D, IT-related services (such as software programming, IT support and consultancy), technical testing and analysis services, marketing and advertising, management consultancy, and human resource management and labour recruitment services.

The ICT-enabled globalisation of services is beginning to have a fundamental impact on the way economies work and on the global allocation of resources, contributing to productivity growth by reinforcing competitive pressure and increasing business efficiency as firms focus on their core competitive advantage activities and outsource/offshore the rest. Given that services are often intermediate inputs in other sectors, increased productivity in services because of globally fragmented value chains is likely to also improve productivity in the sectors purchasing these services. The globalisation of services may also have broader welfare benefits for consumers, increasing the range and variety of services available. Potential productivity gains might also arise from enhanced access to increased input varieties.

Increased broadband-enabled global sourcing can affect a country's services productivity in various other ways. If imports compete with domestic production, efficiency gains can be achieved when the least efficient firms are driven out of the market, while competitive pressure forces remaining firms to become more efficient and innovative. Furthermore, when global sourcing allows countries, or firms, to focus on the areas where they have a competitive advantage, overall productivity is likely to increase as well, reflecting the increased specialisation of tasks and activities.

In sum, the efficiency and productivity gains achieved through the ICT and broadband-enabled offshoring of services may enhance the overall growth and employment opportunities from the widespread domestic and business use made of broadband in both the domestic and host economies.

3. What's the evidence on the productivity impacts of broadband?

Very few studies look directly at the economic impact of broadband, especially since it is relatively recent and bandwidth continues to increase and the technologies continue to evolve. There are also very few studies with cross-country comparisons – most tend to be regional comparisons within a country. Most studies consider the impact of ICTs more broadly, but to some extent those results can be extrapolated to broadband, even though any impact of broadband will also depend on other ICTs and complementary

20. *New Zealand Herald*: http://www.nzherald.co.nz/section/1/story.cfm?c_id=1&objectid=10331826

factors. Indeed, with the very rapid advances in ICTs that have taken place, and are still taking place, productivity gains are no longer limited or dictated by the technology but rather by the use that is made of it and the (organisational) capacity to exploit the gains that it allows to achieve.

Productivity effects of ICTs

The productivity impacts of ICTs have been studied at the aggregate, sectoral and firm level. Macroeconomic studies of the impacts of ICTs on the economy can essentially be broken down into two types: growth accounting and country-level econometric studies. Overall the evidence supports a positive impact from ICTs on productivity.

In neoclassical growth accounting, productivity impacts from ICT-producing goods show up in measured total factor productivity (TFP), whereas ICT use leads to capital deepening which boosts labour productivity. There are drawbacks to using growth accounting techniques because of the limiting assumptions and hypotheses that are needed, data limitations especially for the data on ICT investment (which suffers from measurement problems), and the need for deflators adjusted for quality change (hedonic deflators). Even though measurement and international comparability have improved over time, international comparisons of impact results remain difficult. Many studies find that much of the acceleration of TFP comes from an acceleration in technology use rather than from the production of ICT goods and software (see *e.g.* Basu *et al.*, 2003, and Pilat, 2005, and the references therein).

There are essentially three channels through which ICTs have a productivity impact: *i*) through the ICT-producing sector, *ii*) through ICT investment in ICT-using sectors, and *iii*) through complementary factors, such as organisational capital, firm organisation, skills, and human capital. However, a set of macro factors also needs to be in place for the gains to be able to materialise. These include the competitive environment, the general macroeconomic climate and state of the economy. Competitive pressures have been shown to be important, especially in recent years (Oliner *et al.,* 2007). Studies have shown US affiliates in the UK to be more productive than UK firms because of their relatively more efficient use of ICTs (*e.g.* Bloom *et al.,* 2007; Oulton, 2001), but this has not necessarily been found to be the case in other countries, possibly due to a lack of incentives and competitive pressures for firms to perform better. It has also been suggested that the organisational structure of US companies gives them an advantage in exploiting the productivity gains offered by the use of ICTs. Thus, the productivity of US multinationals operating in the UK has been found to exceed that of non-US multinationals in the UK, and establishments that were taken over by US multinationals were found to increase the productivity of their IT, in contrast to those taken over by non-US multinationals (Bloom *et al.* (2007). The role of organisational capital and other intangible and complementary factors to ICTs is discussed further in Box 6.

The impact of ICTs on productivity may also change over time. Growth accounting estimates for the United States in Oliner *et al.* (2007), suggest that the direct impact of ICTs on labour productivity growth peaked in the period 1995-99, accounting for around three-quarters of productivity growth at that time. Nonetheless, the direct impact of ICTs remained substantial between 2000-05, accounting for around two-fifths of labour productivity growth. This latter period also saw a marked acceleration in multi-factor productivity growth outside IT-producing sectors, suggesting that the continued diffusion of ICTs and the move towards an increasingly broadband-enabled economy may well have had an important indirect impact on productivity growth. These results support the view that IT has been a key source of growth in the United States.

In Europe, much of the research has focused on explaining the productivity gap with the United States, and the role ICTs have played. Indeed, while labour productivity growth increased in the United States from the mid-1990s, it decreased in Europe, suggesting that Europe has not been able to reap the same benefits from ICT as the United States has (see Box 5 below). But even within Europe large differences can be observed (van Ark, 2006, Table 2). Comparative growth rates of labour productivity in the EU15 for the period 1995-2005 varied between -0.2% in Spain to 4.4% in Ireland (and 1.4% for the EU15 as a whole). For the ten new EU members it varied between 1.1% in Cyprus[21] and 7.5% in Estonia (and 4.2% for EU10 new). The growth rate of labour productivity growth for the EU25 was 1.7%. This compared to 2.3% in the United States, 2.0% in Japan, and 4.2% and 5.5% in India and China, respectively, over the same period. The heterogeneity in productivity growth rates cannot be explained at the aggregate level but requires an industry perspective. Timmer and van Ark (2005) find that within the EU, the drivers of productivity differentials are non-ICT related.

Box 5. The role of ICT in US-Europe growth differentials

Much attention has been devoted to trying to explain the growth differential between the US and Europe, and many studies have explored the role of ICTs specifically. Faster growth in the US has been attributed to a relatively larger US ICT producing sector and faster growth in the US in services industries that make intensive use of ICT. Lagging growth in Europe has been found to be concentrated in wholesale and retail trade and the securities industry (van Ark *et al.,* 2003). Retailing in particular has been identified as a service industry where Europe has not reached the same kind of economies of scale and scope that have promoted productivity in the US in this sector (Timmer and van Ark, 2005).

European firms have also greatly increased their ICT use, but still their productivity has lagged. Many have argued (*e.g.* Baily, 2003) that it's not the ICT but the regulatory environment that makes the difference as those European industries that are competitive and not overregulated use ICT in a way similar to that observed in the US in the same industries. Therefore, ICT use differences are likely due to differences in industrial structure and regulation and do not constitute the principal reason for explaining productivity differentials.

The point that structural impediments in product and labour markets have contributed to a relatively lower implementation and less effective use of ICTs in Europe has often been made by van Ark and others (*e.g.* van Ark, 2006) as product market regulations (PMR) and employment protection legislation (EPL) prevent the re-organisations necessary to fully exploit new technologies. The process of reallocating resources across the production process is a very important driver of productivity (Foster *et al.,* 2002). Therefore, factors that have an impact on this reallocation, such as market distortions, institutions and government policies, are important to productivity level and growth differentials. The US does indeed have relatively low indictors of PMR and EPL compared with most European countries (Appendix Figures 1 and 2), except for PMR in professional services. This prevents firms from implementing organisational changes that would enhance their productivity. It is also possible that the scale of ICT investment in Europe was not sufficiently large to generate the same kind of spillovers as were observed for the US, especially since network externality types of effects depend on a critical mass of users of the technology.

The availability of cheap ICTs will only have a productivity effect if it fundamentally changes the way firms organise their production, and in a productivity enhancing manner. If the diffusion of ICTs leads to subsequent complementary innovations in ICT-using industries, increasing the demand for ICT capital, then innovations in ICT production can have important long-run effects before hitting diminishing returns (Basu *et al.,* 2003). A similar point can be made for diffusion and roll-out of broadband and ever increasing bandwidth.

21. **Footnote by Turkey**: The information in this document with reference to « Cyprus » relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognizes the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

Footnote by all the European Union Member States of the OECD and the European Commission: The Republic of Cyprus is recognized by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Box 6. The role of intangible capital and other complementary factors to ICTs

Basu *et al.* (2003) argue that the US – UK TFP differentials from 1995 onwards can be explained by a combination of unmeasured investments in intangible organisation capital and ICTs as a GPT, *i.e.* ICTs and the complementary investments and innovations they induce. The existence and importance of intangible capital contributes to the explanation of the Solow productivity Paradox of why productivity remained slow in the 1980s and early 1990s when ICT investment was strong, and can also explain why productivity growth remained strong after 2000 when ICT spending fell dramatically (Baily, 2003). The idea is that it takes time and resources to learn how to use ICT properly. Initially there may even be a fall in productivity as resources are allocated to learning ICT. ICTs alone are not sufficient, but when ICTs act to make other innovations effective they will provide gains. If ICT is used to do the same things in the same way as before the ICT spending occurred or if the real purpose of the investment in ICT has not been identified before the investment is made, its impact will be limited. Improvements in workplace organisation, enabled by ICT, have also improved productivity. The main driver of productivity improvements has not necessarily been the spending on ICT, but rather the changes and innovations that this ICT has enabled, such as the re-organisation and streamlining of existing business processes, for example order tracking, inventory control, accounting services, and the tracking of product delivery (Atrostic and Nguyen, 2006). When considering ICTs as a GPT with the power to transform most economic sectors, the expected economic impact will be far greater than what is predicted by just examining the capital investment associated with ICTs because this does not take into account the widespread complementary innovations enabled by ICTs (Brynjolfsson and Hitt, 2000).

Black and Lynch (2001) find evidence that organisational changes affect productivity. The way in which new work practices are implemented within establishments is found to be associated with higher productivity, and strong complementarities are found among work practices, workforce skills, and the share of the workforce using computers. Plant-level productivity is found to be higher in plants with relatively more-educated workers or greater use of computers by non-managerial employees.

The effects of organisational changes may rival the effects of changes in the production process in terms of their impact on productivity at the firm level. The ability to create economic value from intellectual assets is highly contingent on the management capabilities of individual firms and the implementation of appropriate business strategies (OECD, 2006b), and the ability of ICTs to enable complementary organisational investments such as business process and work practices constitutes a significant component of the value of ICTs. These investments, in turn, lead to productivity gains by allowing firms to reduce costs and increase output quality, for example in the form of new products or through improvements in intangible aspects of existing products, such as convenience, customisation, timeliness, quality and variety (Brynjolfsson and Hitt, 2000). However, the productivity effects of these complementary factors may take some time to appear. The longer term productivity and output contributions of computerisation at the firm level have been found to be up to 5 times greater than in the short run (Brynjolfsson and Hitt, 2003). The relatively better productivity performance of the affiliates of US multinationals compared to non-US owned establishments in the UK has also, at least in part, been attributed to a better use of IT in US firms. Establishments that were taken over by US multinationals also subsequently increased the productivity of their IT, whereas observationally identical establishments taken over by non-US multinationals did not. It is thought that the internal organisation of US firms allows them to exploit ICTs more efficiently, highlighting the impact of ICTs through the managerial and other organisational changes they allow to be implemented (Bloom *et al.,* 2007).

Quantitative study of the effects of intangible investments, such as organisational changes and management practices, on growth is relatively recent and requires new frameworks and measurement practices. Given the quantitative importance of intellectual assets, their inclusion in measures of economic activity (such as GDP) is important for obtaining an accurate picture of economic growth, productivity and cyclical developments (OECD, 2006b). Corrado *et al.* (2006) argue that the conventionally measured capital stock is underestimated by some USD 1 trillion and the business capital stock by up to 3.6 USD trillion.[22] Adding this capital to the standard growth accounting framework changes the observed patterns and sources of US economic growth significantly. In particular, the rate of change of output per worker increases more rapidly in the presence of intangible capital, and capital deepening becomes the dominant source of labour productivity growth. Oliner *et al.* (2007) also provide preliminary estimates of the growth contributions of intangible capital using an augmented growth accounting system. Intangible investment is estimated to have surged during 1995-2000, boosting growth in aggregate output, but then retreated during 2000-2006. The growth contribution from intangible capital deepening follows the general pattern for IT capital, high during 1995-2000 and then falling back. This similarity reflects the strong association between intangible capital and IT capital in the methodology. Nevertheless, intangible capital increases less rapidly than IT capital in each period as a result of the quality-adjusted declines in computer prices that lower the user cost for IT capital. This user-cost effect became more pronounced during 1995-2000 when a fall in the prices for IT capital goods was particularly marked.

22. An amount equivalent to around 29% of US GDP in 2005, or around 12% of US business capital stock.

Some argue that the role of ICTs in productivity growth has been over-emphasized in the macroeconomic growth accounting literature (for example Baily, 2003; Gordon, 2000). Nevertheless, most macroeconomic studies do seem to find consistent evidence of an impact of ICTs on productivity through the ICT-producing and ICT-using sectors as well as complementary factors such as skills and organisational capital. However, many of the cross-country differences in productivity are still not well understood, but are thought to stem from differences in ICT use and the capacity to exploit the potential benefits, especially in the services sector, underlining the importance of investment in complementary factors such as human capital, and ICT and e-business skills, for example. It is important to improve understanding of the role of skills and the regulatory environment in the way ICTs and broadband enable structural changes and productivity gains.

Studies using more disaggregated data (industry and firm-level) tend to provide useful additional insights. Productivity effects are likely to vary across sectors and firms and may be masked at the aggregate level where effects may cancel each other out. There may also be a role for firm entry-and exit over and above the productivity impact of IT when low-productivity firms exit and high-productivity firms enter the market (Foster *et al.,* 2002). A lack of competitive conditions may keep unproductive firms in business which may drive down aggregate productivity growth.

In spite of these cautionary arguments, overall there appears to be agreement that ICT has contributed to the faster growth observed from the mid-1990s, in particular in the United States. Rapid technological advances in the production of ICT goods have increased TFP growth in the ICT goods-producing sector. This has led to falling prices of ICT goods, which has increased their use and diffusion throughout other sectors with an ICT investment boom. This has added to the capital available to workers in ICT using sectors (capital deepening), making them more productive. Even though there may be a significant time-lag, ICT can be considered a GPT which will facilitate and induce organisational change which should help firms to become more productive, and which will continue to give rise to further innovation, in particular with ICT and broadband induced innovation in services (see also Box 3 above).

Most of the studies discussed were carried out at the aggregate level, while pointing out the importance of disaggregation to better understand the mechanisms and conditions for the effect of ICT on productivity to materialise. Overall the sectoral level evidence on the impact of ICTs confirms the same point as suggested by the aggregate level evidence, namely that investing in ICT alone is not enough to reap the benefits. However, as the level of aggregation becomes smaller, the effects identified can be larger as aggregation effects can sometimes hide substantial productivity and performance differences at the sectoral and firm level. At the sectoral level, the evidence tends to be mixed though. See Pilat (2005) for an overview.

As broadband is an enabling factor that impacts on the economy through its effect on drivers of growth, the potential impact through productivity in business services sector is examined in Box 7 below. Indeed, broadband can be expected to have a very large impact on the services sector as it enables fragmentation of production and international trade in services that were not previously tradable or contestable. Furthermore, the increased management, communication and information processing possibilities offered by broadband can also be expected to become especially important in the services sector.

Box 7. The productivity challenge in business services, and the role of broadband

The business services sectors are very intensive users of ICTs, and broadband has a great potential for enabling structural change and achieving efficiency gains in these sectors. As the importance of business services in the economy increases, so does the need to make this sector stronger and more dynamic, and to enhance the productivity gains that can be obtained. ICTs, and broadband in particular, are a very important instrument in realising these potential gains, directly by the re-organisation of business models and value chains with increased fragmentation of production, and indirectly through ICT-induced innovations in services.

The development of the business services sector across OECD countries is very heterogeneous. The business services sector as a whole (measured as ISIC[23] 71-74) tends to have approximately the same level of value added per person employed as that of the whole economy, except in France and Germany. At the same time, there is considerable variation within the business services sector. Computer services (ISIC 72) typically have above-average productivity levels, whereas R&D services (ISIC 73) are about average and other business services (ISIC 74) are below average in terms of relative productivity.[24] There are further performance differences within these categories (OECD, 2005a).

Estimates of productivity growth in business services also show diverging patterns. Several countries, such as Germany, France and Luxembourg, show negative productivity growth over long time periods, while others, such as Japan, the Netherlands, Denmark, the United Kingdom and Italy had slightly positive rates of productivity growth. In some countries, notably the United States, Canada and Australia, negative rates of productivity growth in the first half of the 1990s have turned into positive rates of productivity growth over the more recent period. These three countries have all experienced a broad improvement in productivity growth in services over the second half of the 1990s and the business services sector played a clear role in this broader improvement. Some of these measures of productivity growth may appear counter-intuitive, especially for services where rapid technological progress would be expected to lead to positive rates of productivity growth. The principal reason for the lack of measured productivity growth in these business services is likely to be poor measurement.[25]

The state of competition and regulation in the services sector is thought to have a major impact on the productivity performance of business services in particular. Regulatory reform of many services, ongoing liberalisation of trade and investment in services, and rapid advances in ICTs combined with widespread broadband diffusion have opened up service markets that were previously not contestable. This has increased the incentives for firms to improve efficiency, innovate and strive for greater productivity growth.

Other factors that are thought to be important for the productivity performance of business services include fostering entrepreneurship and the creation and growth of new firms (Bartelsman *et al.*, 2003), allowing scope for experimentation in the market with new products, processes and business models (which, in turn, may allow new ideas and innovations to appear more rapidly), and the functioning of labour market institutions which, when they are over-restrictive prevent firms from re-organising and experiment with new ideas or implement new technologies, and ICTs in particular. Indeed, seizing the benefits from ICT in business services crucially depends on complementary investments in organisational change, skills and innovation (OECD, 2004b). Many OECD countries still require further reform of product and labour markets to foster such a competitive environment that will allow them to fully reap the benefits of an ICT- and broadband-enabled economy. Finally, broadband enabled globalisation of services is likely to have a major impact.

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23. ISIC stands for International Standard Industrial Classification.

24. The fourth component of the business services sector, ISIC 71, which is the activity of renting of machinery and equipment, is very different than other business services, as it is highly capital intensive and is therefore not shown separately in Figure 5.

25. An alternative explanation in the case of computer services is that software companies, in particular, may have difficulties in appropriating the results of their innovative efforts, partly due to the lack of property rights for software inventions in many OECD countries. A major measurement problem for business services is that they tend to provide some sort of knowledge, *e.g.* in the form of legal or consultancy advice, R&D, or knowledge on how to install computers (Eurostat, 2000), the value of which is hard to quantify. Furthermore, many business services are unique, making it difficult to develop price indices for such services. The quality of knowledge services is often an important component of the service provided, which adds again to the complexity in measuring real output and productivity of this sector, especially since for many services the quality cannot be assessed until after consumption. Despite these difficulties, some progress is being made in the measurement of outputs and prices for some of these services, *e.g.* certain legal, accounting and consultancy services, as well as computer services, architectural and advertising services (Varjonen, 2005). Often reliable information about how prices of services have varied is not available either. This is especially important for business services, and in particular computer and information services, which have experienced large changes in quality and relative prices. International comparisons are also difficult because the composition of what is recorded under the category business services varies (Abramovsky *et al.*, 2004). See Pilat (2007) for more details.

The impact of the "C" in "ICT"

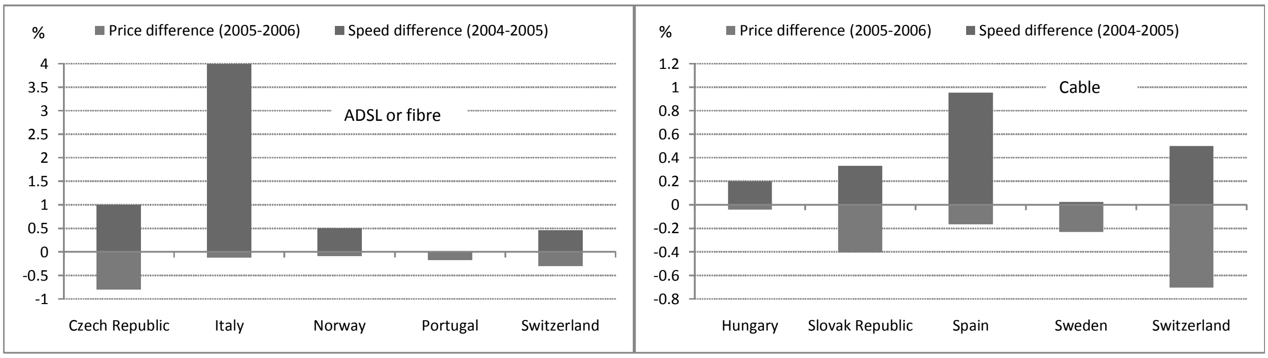
Whereas the previous section discussed studies examining the productivity impacts of ICTs in general, this section focuses on research that singles out the "C" in "ICT", *i.e.* the communication factor, and has examined its impact on productivity.[26] Whereas rapid developments in ICTs have tended to focus on advances in the "I" of ICTs, more recently the "C" has taken off, in particular with broadband and wireless (broadband) technologies. However, since these developments are recent and still evolving, and given measurement problems (see Box 8), it is still early to analyse the scale and scope of productivity benefits from these technological advances.

While initial productivity gains from ICT investment are most likely to have stemmed from investment in IT itself, investments in the "C" link these individual computers and result in gains from network effects and in productivity. The "C" has been dormant until relatively recently, but as a result of regulatory relief and technological advances in wired (particularly optical) and wireless networks, a whole new range of sources of potential productivity gains become possible, resulting not only from increased sharing and networking, but also from updating in real-time with new information, on-the-run decision making and more flexible working relationships than is feasible without the advanced "C" in ICT. The productivity gains from the "C" likely to lie ahead can be expected to be profound but will require even greater intangible investments, especially in organisational change as the "C" enables structural changes such as broadband-enabled globalisation of services.

Box 8. Measurement difficulties and the need for quality and speed adjusted prices

Trying to measure the economic impact of broadband is difficult, not only because it is hard to disentangle the effect of broadband from that of other ICTs, but also as with other ICTs there are considerable measurement problems. These stem from data collection, with the international standard set at 256kb, but also because the available statistics do not necessarily capture the fact that speeds tend to go up while prices tend to go down. This problem is similar to what was encountered in the analysis of ICTs and highlighted the need for quality adjusted measures and so-called hedonic price deflators.[27] In most OECD countries, speeds went up without a price increase, or speeds went up and prices went down (see chart below), illustrating the need for similar quality adjusted measures.

Chart: Changes in broadband prices and speeds, selected countries, September 2005-October 2006



Source: OECD (2007a)

An OECD analysis of 372 broadband offers in October 2006 shows that DSL broadband prices from the incumbent fell an average of 19% in one year from September 2005 to October 2006. The comparison looked at the same package, if available, or one that made the consumer better off one year later. At the same time, the comparable speeds of these packages increased 29% over the same period. Cable broadband prices followed a similar trend. The same broadband package from cable operators in October 2006 was 16% less expensive but 27% faster than just one year earlier (OECD 2007a).

26. Röller and Waverman (2001), in a study for 21 OECD countries over a 20-year period, find evidence of a positive and causal impact of telecommunications infrastructure on economic growth, especially once a critical mass of infrastructure, which appears to be near universal service, is in place.

27. The term "hedonic methods" refers to the use of regressions of prices on characteristics to adjust for quality changes (Moulton, 2001).

The importance of the absence of a one-to-one relationship between technological capability and price is also highlighted by Doms (2006), taking the example of developments in fibre optics between 1996 and 2001: the potential capacity of a strand of glass fibre basically doubled every year, while the price of the gear used to transmit information over fibre fell on average by 14.9% per year over the same period. It is likely that the price indices currently used in productivity analysis understate the actual price declines of communications equipment.

Lehr and Lichtenberg (1999) find that productivity in firms is closely linked to the number of PCs, whereas raw computing power appears less informative. The explanation offered is that more PCs suggests they are more widespread throughout the firm allowing employees to be on a network that enables them to communicate over applications such as e-mail. Atrostic and Nguyen (2002) for the United States and Criscuolo and Waldron (2003) for the United Kingdom find that computer networks have a positive impact on total factor productivity. Other studies have established a positive impact on labour productivity from using computer networks to link business processes in firms, especially in conjunction with the creation of intangible assets through investments in human and organisational capital, and with the effects varying by sector, (Clayton and Goodridge, 2004; Brynjolfsson and Yang, 1999). Fuss and Waverman (2006) also attribute Canada's lagging productivity growth relative to the United States[28] to a less intensive usage of ICTs, using a range of computer and telecoms related variables, such as telecom and PC penetration, mobile and fixed telecom retail and supply prices, IT prices, and digital mainlines.

Farooqui (2005) examines data on the use of telecommunications services by firms in the United Kingdom as a proxy for external relationships. He finds that employees' use of the Internet has a positive effect on productivity above that which can be explained by IT investment. The purchase of external infrastructure constitutes the bulk of spending on communications technology equipment for firms outside the communications sector (which in turn accounted for less than 15% of investment in telecommunications products). Telecoms use is found to have a significant and positive effect on output, both in manufacturing and services. Within the services sector the impact is greatest for distribution services with the interaction between IT and CT spending overtaking investment in IT as the main driver of productivity. The author interprets this result as evidence that the impact of IT through the management of complex supply chains and external links is greater than as a driver of internal efficiency.

Aral *et al.* (2007) find that the structure and size of workers' communication networks are highly correlated with performance. Richer communications structures are found to predict multitasking, which, in turn, drives productivity (up to a certain point). Both synchronous communication technologies (*e.g.* telephony and video-conferencing) and asynchronous communication technologies (*e.g.* e-mail based applications, sharing of large data and graphics files) support the ability of geographically dispersed groups to collaborate in a seamless manner. It is not the speed of communication that makes the difference, but also its use to re-organise work, so that tasks can be performed more efficiently. This confirms again a result often found, it is not just having ICT equipment but how ICT is used that matters.

Oliner and Sichel (2000) and Oliner *et al.* (2007) specifically take communications equipment into account as a vital component of computer networks, in addition to computer hardware and software. These three components make up the growth contribution of the use of ICTs. The results are broken down for the periods 1973-1995, 1995-2000, and 2000-2006. Average annual labour productivity growth for these periods was 1.48, 2.48 and 2.81%, respectively. The contribution of ICT initially grew sharply, from 0.41 to 1.11 percentage points, but it declined to 0.69 percentage points in the most recent period. While computer hardware accounted for the largest contribution in each of the three periods, followed by software and then communications, the contribution of communication equipment to labour productivity growth increased relative to those of computer hardware and software, as the contributions of the latter two

28. Labour productivity growth over the period 1995-2001 was 1.76% in Canada versus 2.49% in the US, and the ICT contribution to labour productivity was 1.25% in Canada and 2.14% in the US (Fuss and Waverman, 2006).

decreased while that of communications equipment remained constant. For the period 200-2006, computer hardware accounted for 0.30 percentage points, software for 0.24, and communication equipment for 0.15. Baldwin and Sabourin (2002), in a study for Canadian manufacturing firms, also differentiate between three groups of advanced ICTs: software, network communications, and hardware technologies. They find that establishments that had adopted network communication technologies experienced significantly higher productivity growth than those that had not, and the largest gains were found for establishments that had adopted combinations of all three types of ICTs.

Fuss and Waverman (2005) attempt to capture the spillovers from greater diffusion of computers, software and telecoms by focusing on the networking capabilities of communications equipment. They model greater diffusion of telephones and computers as an augmentation to the capital stock and also account for the interaction between the digitisation of telecommunications networks and greater diffusion of computers, which is found to have a positive impact on productivity. In addition to a positive impact from ICT-related capital deepening, the spillovers are found to explain at least some of productivity differences between the United States and several other countries.

Most of the studies discussed so far have considered computers and ICTs as a form of capital to be used as an input into the production process. However, computers can also be used to transform business processes and in this context computer networks are examined as a productivity-enhancing technology by Atrostic *et al.* (2002) in a study covering Denmark, Japan and the United States. Different types of networks are distinguished, such as wireless, Internet, intranet, and EDI. The results for Japan and the United States indicate that manufacturing firms/plants with networks have higher labour productivity and tend to be larger than those without networks. Furthermore, the use of both intra-firm and inter-firm networks is found to be positively correlated with the level of TFP at the firm level. For Japan the productivity impacts are also shown to differ by type of network. In Denmark, firms with networks were found to achieve higher growth rates of value added but also of employment, leading to a lower rate of labour productivity growth. In Japan, firms with networks experienced less of a drop in labour productivity growth after the introduction of the network compared to non-network users.

Atrostic and Nguyen (2006) not only report further evidence confirming the positive link between computer networks and productivity, but they also disentangle some of the diverging effects of different types of network use. In particular, online supply chain activities, such as inventory control, order tracking, transportation and logistics management are consistently found to be positively linked to productivity. Furthermore, productivity impacts tend to be higher in newer plants. However, positive productivity effects are not identified for online processes related to production, sales and human resources.

The productivity impacts of broadband

There is relatively little empirical evidence of the economic impact of broadband, although research is growing. In part this is because the impact on the economy occurs indirectly as it acts on variables that, in turn, are drivers of growth. Broadband is an enabler of changes – it allows an impact on the economy and restructuring when it is combined with other ICTs, such as computer hardware and software, and complementary factors such as skills and organisational change. The study of the economic impact of broadband is complicated by data availability and measurement problems, reminiscent of the early days of the study of the impact of ICTs more generally and Solow's Productivity Paradox[29] (IT is everywhere

29. It is often argued (*e.g.* Lehr and Lichtenberg, 1999) that this Productivity Paradox is largely a measurement problem which is closely related to the problem of measuring output and productivity of the service sector, especially since computers are used most intensively in the service sector and in the 'service' functions of non-service sector firms (see for example van Welsum and Vickery (2005) and OECD (2004a, 2006a, Chapter 6). The same argument is likely to be valid for broadband.

except in the productivity statistics). Another factor further complicating the identification of the economic impact of broadband is that the impact can be expected to be large in the services sector (non-farm, non-manufacturing industries) where output and productivity changes are not yet well captured by the data. Furthermore, data on the availability and even the adoption of broadband do not necessarily adequately reflect its actual use – like for ICTs, merely investing in acquiring the technology does not suffice to achieve productivity gains – what matters is how it is being used. It is also difficult to establish any causality related to broadband as it is very hard to disentangle the effects between infrastructure availability and economic growth (and availability does not necessarily mean efficient use).

Recently, studies have started to emerge that look at the productivity impacts of broadband specifically. For example, Lehr et al. (2006) use a cross-sectional panel data set at the zip-code level for the United States to examine the impact of broadband on variables such as employment, wages and industry mix. They find some evidence that broadband positively affects economic activity. In particular, they find evidence of more rapid growth of employment and the number of businesses overall and in IT-intensive sectors. However, they also find a negative impact of broadband on the growth rate of salaries in zip codes having earlier access to broadband. This result is not yet well understood and is being investigated further.

Analysis for Australia[30] finds a positive productivity impact from ICTs but cannot disentangle broadband from ICTs. The analysis focuses on productivity effects in new industries, such as the film and animation industry, where broadband can be expected to matter even more than in "traditional industries". The analysis cannot distinguish an effect of broadband on e-commerce either, which is not very surprising given that a lot of e-commerce can also be done with narrow band. The results seem to confirm the result that what you do with ICT and broadband, and how you do it, matters more than just having it.

A project constructing ICT-related indicators based on microdata is currently under way under the auspices of Eurostat, and co-ordinated by the UK Office for National Statistics. The idea is to build a set of indicators of ICT intensity[31] and impact that are comparable across countries, which are compatible with macro databases such as EU KLEMS in order to attempt to bridge the gap between macro and micro data approaches, and which can subsequently be used in international comparisons and analysis.

Most of the studies looking directly at the impact of broadband tend to be carried out at the firm-level. There are essentially two ways in which broadband fosters firm-level impacts, depending on the type of use firms make of ICTs. Firms can use ICT to make existing processes more efficient and productive (by increasing the quality and lowering the cost of communication with clients and suppliers and of finding information) or to create new e-business processes and business models that transform the way business is done (*e.g.* in supply chain management, allowing increasingly globalised value chains etc.). The latter can be expected to have the greatest impact, but is also the more difficult to implement and can, at least initially, be costly, for example in terms of increased communication and co-ordination requirements.

One of the objectives of the micro data project is to help identify the impact of ICT readiness and intensity on firm-level performance. One of the participating countries is Sweden. Building on earlier analysis by Hagén and Zeed (2006), as more data points become available, new results[30] appear to point to a negative impact from faster broadband when looking at gross production multi factor productivity (MFP)

30. Presented at the joint OECD WPIIS/WPIE Workshop on "The economic and social impacts of broadband communications: From ICT measurement to policy implications", held in London on 22 May 2007. Programme and presentations available at: http://www.oecd.org/document/48/0,3343,en_2649_33757_38697712_1_1_1_1,00.html

31. The continued importance of using such indicators in analysis is illustrated by a recent study that found evidence for a link between IT intensity and the recent productivity acceleration in the US (Corrado *et al.,* 2007).

and to a positive impact on value added labour productivity in 2002. One possible explanation could come from simultaneous large capital investments. However, by 2004 the impact on both of these variables is positive suggesting the benefits of broadband can be obtained over time.

Data for the Netherlands show that by 2004, only 5% of firms had reached the highest level of ICT use. First results from analytical work show that broadband is very significant in determining the production frontier, but that, conditional on using broadband, the distance from the frontier is determined by ICT usage (the level of ICT maturity), but without a significant contribution from broadband intensity.

Sadun and Farooqui (2006) find broadband adoption to be related to e-commerce, ICT equipped labour intensity and external demand. Investment in hardware was found to be higher in regions and sectors with broadband availability especially for UK domestic firms in non-IT intensive industries. Broadband users are also more likely to have multiple business links, and multiple links with broadband technology improve labour productivity. Firms with a high broadband equipped labour share have higher productivity.

As there is currently a lack of data on broadband, and since broadband acts in complementarity with other IT tools, related measures can be looked at for an initial gauge at what broadband impacts might look like. There are several possible measures which are interlinked (Farooqui, 2005): IT investment, which supports IT enabled employees and computer networks, and use of telecommunications is required to equip the workforce with the Internet and e-commerce. Thus, data on the hardware capital stock, the software capital stock, and the number of employees using ICT, use of telecommunications services and e-commerce can each start to tell part of the story. The results for the United Kingdom in Farooqui (2005) show that the impact of IT varies greatly across sectors and is highest in the services sector. Firm age also appears to matter, to a degree, with younger manufacturing firms achieving greater benefits from IT than older firms. In the services sector, however, there is a time lag due to a learning effect: IT capital and networks are used together to build up knowledge bases of clients and services provision. A strong relationship is also found to exist between spending on telecommunication services and productivity as well as between IT investment and spending on communication technologies where the latter appears to reinforce the effect of the former.

The importance of attaching geographical location to the data on broadband is highlighted by Di Gregorio (2006). Anecdotal evidence also reveals that local businesses and home-office workers are experiencing increased benefits such as efficiencies in administration, purchasing and reduced time searching for information.

Overall, the empirical evidence to date on the productivity impacts of broadband is scant. This is mainly the result of measurement problems, time lags between implementation and impacts, and the difficulty to disentangle the effect of broadband from that of ICTs in general. Furthermore, as Lehr *et al.* (2006) point out, although broadband appears to have a positive measurable economic impact, to date it remains difficult to draw precise conclusions due to the lack of firm-level (and employee-level), geographically disaggregated, time-series panel data.

However, it is obvious that as broadband is spreading throughout the economy, transformations are taking place in the way business is done, work is organised, and resources are allocated. These effects are observable especially in some very large services sectors accounting for a large share of the total economy, such as communications services, financial services, business services, transportation, real estate, travel and tourism[32] and retail,[33] not to mention the growing impact on public services such as health,[34]

32. Over 20% of travel reservations, including airline tickets, are ordered online (Atkinson and McKay, 2007).

education[35] and government and addressing environmental challenges. Content provision and advertising are also rapidly changing in the face of broadband. As a result, larger effects than can currently be identified can be expected.

The impact from informational mobility

One relatively new aspect of ICTs rapidly gaining in importance is that ICT devices are becoming ever more portable (laptops and other portable devices), and widespread fixed and mobile broadband increasingly allows "informational mobility". This emphasises again the increasing importance of the "C" in ICT which is making this possible. Increased ICT penetration is no longer a major source of productivity growth in developed countries,[36] but new features of ICTs (such as portability and wireless connectivity) can boost productivity especially in activities where information and communication are important. Mobility has now become an integrated aspect of communications (Box 9).

Maliranta and Rouvinen (2006), in a study for Finland, find that a computer with only processing and storage capabilities boosts labour productivity by 9%, portability by 32%, wireline connectivity by 14% and wireless connectivity by 6%. As this study was carried out using data for 2001 when wireless connectivity was still in its infancy, the impacts can be expected to increase significantly as the use of wireless devices and mobile broadband intensifies. However, "selectivity" is an outstanding issue in the analysis as it could be the case that it's the more productive workers who get the better equipment. The impact of ICT on worker productivity is discussed in more detail in Box 10.

The economic benefits of mobile phones are often studied in the case of developing countries. McKinsey (2006), in a study for China, India and the Philippines, estimates that mobile phones may add as much as 8% to a nation's GDP. This contribution is made up of three components: a direct impact from mobile phone operators, and indirect impacts from other firms operating in the mobile sector (such as hardware, software, and handset vendors) and mobile content providers, as well as the surplus end users benefit from (*e.g.* through increased productivity for mobile workers, increased access to employer, family and friends, and improved security). Similarly, Waverman *et al.* (2005) find that mobile telephony has a

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33. Online retail, or e-commerce, was already strong for books, CDs/DVDs, and computers, for example, but is now starting to expand into other goods and services, such as clothing, automobile, housing, accountancy, legal services and contact lenses (Atkinson and McKay, 2007).

34. The impact of broadband communications networks in the health sector are multiple. For example, patients have greater access health-related information and e-consultations; medical research can be greatly enhanced by putting researchers in relation and combining their efforts; grids and distributed computing allow calculations bigger and faster than ever imagined before; diagnostics and second opinions are facilitated by electronic images; remote monitoring of patients can reduce costs and congestion in hospitals; improved patient surveillance enhances the quality of the care provided; better records may reduce the time patients have to wait, for example in the emergency room, for the appropriate specialist and also avoid possible drug interactions; and hospitals, medical practices and doctors offices can greatly improve the efficiency of medical records systems and save costs on administrative personnel.

35. There are many applications and uses of ICTs in education which can be enhanced by broadband, from young pupils searching for information on the Internet to do their homework to collaborative R&D networks and anything in between, such as accessing information online; online tutoring; educational services and software; online education; open and distance learning, production and access to scientific publishing with academic and educational journals and books, in particular for the diffusion and dissemination of, and access to, knowledge and research content.

36. As ICTs are now omnipresent, merely investing in ICT is unlikely to yield a competitive advantage. Instead, performance differences should depend on the way ICTs are being used (*e.g.* Atrostic and Nguyen, 2006).

significantly positive effect on economic growth and that this effect in developing countries might be twice that of the effect in developed countries. Furthermore, as mobile telephony will increasingly be related to wireless broadband, the potential future impacts could be even larger. It is estimated that in 2005 there were close to 2.2 billion mobile phone subscribers worldwide (OECD, based on ITU, 2006), and that by 2008, one half of the world's inhabitants will have access to a mobile phone (ITU, 2007). Mobile phones increasingly constitute a working tool, not only for communications but also because of the increasing number of applications and tasks they support, and the increasing capability for mobile Internet access. As mobile Internet access increases user flexibility in time and location of use, it can be expected to add additional benefits over and above those from fixed location Internet access (Box 9).

Box 9. Mobility has become an integrated aspect of communications

Mobile phones have become pervasive in people's everyday life and professional life. They allow people to make better use of their time spent travelling and waiting, keeping in touch with friends and family, or performing a range of work-related tasks. Thus, in addition to being a communications tool, mobile phones can increase worker flexibility, efficiency and productivity.

A survey in the US (Rainie and Keeter, 2006) has shown that 26% of mobile phone owners said they could not live without their mobile phone, 45% said they would miss it, but could do without it, and 29% said they could live without it. The use of mobile phones can increase the quality of life by providing a mobile communication tool that allows people to keep in touch more easily, and be more flexible with their time, and the truth: 22% of interviewed mobile phone owners admitted to not always being truthful about exactly where they are when they are on the phone. There are also some challenges associated with increased mobile phone use though. Some 28% of mobile phone owners admitted they sometimes do not drive as safely as they should while using their mobile devices, mobile phone use in public spaces can also be viewed as disturbing: 82% of all Americans and 86% of mobile users report being irritated at least occasionally by loud and annoying mobile phone users and 8% of mobile phone owners admitted they had been criticised or had attracted angry stares from others when using their phone in public. Finally, mobile phone users are also subjected to Spam: 18% report receiving unsolicited text messages on their phones from advertisers.

Mobile devices also increase worker flexibility. Many mobile phone owners use their mobiles to place calls while they are travelling or commuting, or while they are waiting, making otherwise unproductive time productive. Especially when the mobile phone can also be used for other tasks such as e-mail this allows workers increased flexibility and productivity. With mobile broadband an increasing number of tasks can be carried out over a mobile phone, and as this phenomenon becomes more pervasive, network externalities will ensure increasing benefits. Many people already use their mobile for tasks other than placing calls, and many more would like to expand their use of the mobile phone (Box 9 Table 1).

Box 9 Table 1: The mobile phone features people use and want, USA 2006

	% of mobile phone owners who use this feature now	% who do not use it now but would like to have it
Send and receive messages	35	13
Take still pictures	28	19
Play games	22	12
Access the Internet	14	16
Send / receive email	8	24
Perform Internet searches for e.g. movie listings, weather, stock quotes	7	24
Trade instant messages	7	11
Play music	6	19
Record own video clips	6	17
Get mobile maps	4	47
Watch video or TV programmes	2	14

Source: Rainie and Keeter (2006), based on Pew Internet & American Life Project, AOL cell phone survey, 8-28 March 2006. Sample survey: 1 503 adults (752 were interviewed on a land line phone, 751 on their mobile phone).

By mid-2005, 53% of mobile phone subscribers surveyed worldwide (up from 33% in early 2002) reported having phones that could access data services, such as mobile e-mail and browsing (A. T. Kearney, 2005). Japan had the highest level of access, with 83% of respondents reporting having Internet-capable phones, followed by 62% of respondents in Australia and New Zealand, 60% in Korea and China, 52% in Western Europe, 48% in North America and 46% in Scandinavia. While it has often been noted that many subscribers do not use the full capabilities of their mobile phones, no fewer than 56% of multimedia phone owners worldwide reported that they had used e-mail and/or browsed their operator's portal at least once a month, as had 92% in Japan, 60% in North America, 45% in western

Europe and 44% in Australia and New Zealand. All represented a significant increase over the previous year. The major reasons cited in the survey for not using, or not making greater use of, data services included cost and poor content, with 31% of data services users naming cost as the main barrier, compared with 27% of non-users; and 35% of non-users naming poor content as the main barrier, compared with 27% of users (OECD, 2007a).

It is estimated (eMarketer, 2007) that in 2006 there were already over 1 billion Internet users worldwide, and that less than 20% of these users are in the United States. It is also estimated that there currently are some 1.3 billion wireline telephones and 2.7 billion cell phone users, with the latter potentially rising to some 3 billion by the end of 2007. This means that there are some 2.5 mobile phone users for every Internet user, even though there is likely to be some overlap between the two categories. The vast majority of these mobile phone users are outside North America. The next generation of mobile phones and PDAs will have Internet access capabilities built in, and the importance of the Wireless and Mobile Platforms can only increase. If the most numerous or preferred Internet access device shifts from the desktop PC to a mobile PDA over the next 5 years, and the majority of the users are located outside the United States, this will have enormous long term policy consequences which will need to be recognised.

The expansion of broadband access is supporting the continuous development of new technologies and applications, such as Voice over Internet Protocol (VoIP); the number of registered Skype users reported at the end of 2005 was equivalent to around 50% of worldwide broadband subscribers. Mobile Internet access is also growing; an estimated 53% of cellular mobile phone subscribers worldwide have handsets capable of accessing data services, although only 56% are reported to be regular users of Internet services such as web browsing and e-mail. Mobile Internet access involves access via mobile phone-based technologies, which provide a more limited, slower speed access than fixed lines. It excludes wireless access from computers, *e.g.* Wi-Fi (OECD, 2007a).

Wireless devices can also have a huge impact on the productivity in transportation, delivery and courier services, for example. Mobile broadband devices can help drivers to identify optimal routes, in terms of delivery points, distance, traffic congestion etc., and increase the number of deliveries that can be made in any one day. Mobile devices, when used in conjunction with RFID technologies, for example, can also be used to download information about stocks in different sales/delivery points "while on the road" so that these can be managed more efficiently too.[37] In this way, wireless technologies further contribute to increasing efficiency and productivity in the economy. As wireless technologies become increasingly widespread, their ability to function anywhere in real time constitutes an additional factor in determining competitiveness.

37. For example, drivers of the Aramark snack company use wireless handheld devices allowing them to download information on purchased vending machine products, increasing their productivity by 40% over the two-year pilot scheme (Atkinson and McKay, 2007). Similarly, already in 1997 on-board computers in trucks allowed managers to better co-ordinate trucks and loads, thereby increasing capacity utilisation by 3% and saving USD 16 billion annually in the trucking industry (Hubbard, 2003). As broadband capacities and the ensuing applications become more sophisticated and powerful, further gains can be expected. Impacts have also been found in other transport sectors, such as rail transport when the stock of trains and their maintenance conditions can be managed more efficiently, in maritime transport where cost gains can be obtained when better co-ordination reduces the time ships have to stay in the port, and in the airline industry as routes and seat allocation, for example, become optimised.

Box 10. Could ICTs reduce worker productivity?

Even though it is generally assumed that ICTs will increase worker productivity and make tasks easier, paradoxically, it might have the opposite effect, for example because of multiple distractions and online activities (banking, shopping, news, games…), information overload, and inefficient multitasking. Mark and Gonzalez (2007) examined how people deal with working on multiple projects with different goals, deadlines and resource constraints. They found that the activities of managers and professionals were very fragmented, spending an average of around 3 minutes on a task and about 2 minutes on any electronic device or paper document before changing tasks. Informal interaction with colleagues constituted the main perceived source of interruptions. About half of interruptions come from external sources, but the rest of the time people were found to interrupt themselves, for example by checking e-mail. The increasing number of devices and their increased generalised usage are creating interruptions and increasingly fragment work, which may not contribute to workers' productivity. This way of working has some implications for the design of new applications and systems, which should take into account that people work on multiple projects and devices. It should be easy to switch between different tasks and projects, and it should be possible to link them electronically, rather than having to use paper post-its with reminders and "to-do" lists, and spending time opening and closing different applications, searching for files etc. (Mark *et al.,* 2005). New systems and applications should support electronic multitasking in multiple collaborative environments (*e.g.* people work with different people on different projects, but some synergies can be obtained).

Aral *et al.* (2007) find that information flows and the use of ICTs do predict higher levels of productivity, but they find an inverse-U relationship between multitasking and productivity, most likely as a result of a trade-off between workload and efficiency. Beyond a certain point, juggling too many projects and tasks at the same time means work gets backed up and productivity is adversely affected. Furthermore, while multitasking may slow work, ICT use also shifts out the production function, allowing greater levels of output for all levels of multitasking without a corresponding loss of efficiency.

On the other hand, Grossman and Rossi-Hansberg (2006) argue that ICT-enabled offshoring of tasks should allow workers to become more productive as it allows them to focus on doing the tasks they are best at.

The productivity impact of ICT and broadband-enabled globalisation

Some of the beneficial effects of offshoring in the services sector are emphasized by Mann (2003), who suggests that the globalisation of production of IT and ICT-enabled services should result in lower prices for ICTs and ICT-related goods and services, thereby encouraging their diffusion and use throughout the economy and enhancing productivity. Abramovsky and Griffith (2005), in a study using data for the United Kingdom, argue that the positive effects from services offshoring arise in the form of productivity gains stemming from the increased fragmentation and specialisation enabled by ICTs.[38] Amiti and Wei (2006) also find positive effects of services offshoring on US manufacturing productivity (contributing around 11% to labour productivity growth, versus only about 5% from materials offshoring).

There are, to date, only a few studies looking at the productivity impacts of services outsourcing and offshoring.[39] In part this reflects definitional and measurement problems and data limitations (quality and availability). Furthermore, as Amiti and Wei (2006) point out, a key estimation issue is the possible endogeneity of services offshoring. It is not clear which way the potential bias goes. It could be that the more productive firms engage in offshoring as part of their global production strategies, but alternatively, it

38. Abramovsky and Griffith (2005) report that establishments using the Internet outsourced about 10.6% more than those that did not use the Internet. There is an endogeneity issue though when firms start to use the Internet to place orders if they anticipate starting to outsource. Similarly, using the Internet increased the probability of offshoring by about 2%. Their results suggest that when a firm either invests in ICTs or uses the Internet it increases the probability it offshores by 6%. When it does both the probability it offshores increases by about 12%.

39. In the absence of official data and measures on outsourcing and offshoring each of these studies use slightly different proxies, making comparisons difficult.

could be the least productive firms engage in offshoring in an effort to increase productivity. Measurement errors in services offshoring could also lead to a downward bias.[40]

Görg *et al.* (2005) find that plant-level heterogeneity matters when analysing the productivity effects of international services sourcing. In a plant-level study for Ireland they take characteristics such as plant ownership (domestic or foreign) and whether or not the plant is an exporter into account. They find positive effects from both material and services outsourcing, but only for foreign-owned (foreign multinationals) exporting plants. While there is a positive effect from materials outsourcing for domestic exporters, no such effect is observed for services outsourcing. Görg *et al.* offer several possible explanations. Being part of a foreign multinational and an international production network may provide advantages in the form of better knowledge about how and where to procure competitively priced services, resulting in lower search costs. It may also provide negotiating advantages with suppliers, further lowering the price of intermediate services, and there may be output economies of scale lowering the unit cost of sourced services.

Plant level-heterogeneity is also found to be important in Criscuolo and Weaver (2005). They find, in a study using establishment level data for the United Kingdom, that while firms which offshore services are mainly exporters of services and part of domestic and foreign multinationals, the positive productivity effect from offshored services is evident mainly for firms that do not export and are not part of a multinational.

This section argues broadband is very important for realising the potential benefits from ICTs. Broadband is instrumental in achieving efficiency and productivity gains and increased competitiveness not only from ICTs, and in enabling the complementary factors that increase efficiency and raise productivity, such as innovation and organisational change.

4. The impact of broadband on trade in services and global restructuring

The role of broadband in the international restructuring of services activities and enhanced competition in this sector is increasing as more and more services can be traded as bandwidth increases. Broadband thus enables increasing economic integration and, as a result, countries face increased international competition in sectors and jobs that were previously uncontested. New global electronic networks with ever-increasing capacity and pervasiveness are to the 21st century knowledge economy what railroads, steamships, telegraphs and postal systems were to the 19th century industrial economy.

Rapid advances in ICTs have contributed to growth of trade in business services

Services now account for around two-thirds of output and foreign direct investment in most developed countries, and for up to 20-25% of total international trade. The importance of services in international trade remains comparatively modest to date because many services have only recently become tradable, and many others remain non-tradable. However, rapid advances in information and communication technologies (ICTs), in particular rapid broadband diffusion and increasing speeds and bandwidth, and the ongoing liberalisation of trade and investment in services have increased the tradability of many service activities, especially business services, and created new kinds of tradable services. Many types of business services are thus becoming increasingly internationalised, with ICTs and broadband enabling the

40. To resolve this bias and the endogeneity issue, Amiti and Wei (2006) use an instrumental variable estimation, with the number of Internet users in the countries that are the source of most of the US services imports reflecting the change in technology that enables services offshoring.

production of services to be increasingly location independent. This has facilitated ICT-enabled offshoring of business services.[41]

The extent to which business services activities are becoming globalised and their increasing tradability can be measured in part by statistics on trade in services. International trade in ICT-enabled services can be approximated by combining trade in the IMF balance of payments categories "Other business services" and "Computer and information services". Data on computer and information services are not available for all countries, and in others, such as India, they are already included in "Other business services". The shares of IT and ICT-enabled services in the "Other business services" category vary across countries.[42] Although there are no official statistics measuring the extent of ICT-enabled offshoring of business services, the data on trade in services give some idea of its development and potential as the offshoring of services activities from one country (the country of origin) to another (the country supplying services) should result in a return flow of services to the country of origin. This return flow should be recorded in the balance of payments statistics on trade in services, although it is not possible to identify trade directly related to offshoring separately.

Most exports and imports (around 80%) of business services and computer and information services (hereafter grouped as "business services") originate in OECD countries, and OECD countries account for the largest shares of exports and imports of these services in current USD. But other countries, especially China and India, have begun to account for a significant and increasing share (van Welsum and Xu, 2007).

However, despite the increasingly rapid growth in business services trade, it continues to represent only a small, though generally increasing, percentage of total trade and of GDP (Table 1).

41. Offshoring includes both international outsourcing (where activities are contracted out to independent third parties abroad) and international insourcing (to foreign affiliates). The cross-border or geographical aspect is the distinguishing feature of offshoring, *i.e.* whether services are sourced abroad – not whether they are sourced within the same company (insourcing) or from external suppliers (outsourcing). There tends to be a time aspect to this definition with offshoring often referring to activities which were previously carried out in the domestic economy. Offshoring includes trade, the movement of production not financed by domestic sources (*i.e.* borrowing abroad) and FDI, but FDI can also include activities that were never previously undertaken in the home country, so FDI and offshoring overlap only partially. Even though offshoring has existed for many years in the manufacturing sector, it is a more recent phenomenon in the services sector, where it is now increasingly enabled by ICTs.

42. As the data are reported in current USD, they may also be affected by currency movements.

Table 1. Share (%) of exports and imports of business services[1] in trade and in GDP, 1995 and 2003

	exports of business services				imports of business services			
	in total exports		in GDP		in total imports		in GDP	
	1995	2003	1995	2003	1995	2003	1995	2003
Australia	1,7	3,3	0,3	0,6	2,8	2,8	0,6	0,6
Austria	13,3	12,2	5,0	6,3	11,1	15,0	4,3	7,6
Canada	3,1	4,1	1,2	1,6	3,3	3,9	1,2	1,3
China	2,5	3,8	0,5	1,3	5,1	2,5	1,0	0,8
Denmark	7,2	12,9	2,6	5,8	5,8	11,5	1,9	4,5
Finland	6,2	4,4	2,3	1,7	10,3	6,8	3,0	2,1
France	6,6	5,5	1,5	1,4	5,4	5,6	1,2	1,5
Germany	3,5	4,5	0,9	1,6	4,7	6,1	1,1	2,0
India	5,6	16,9	0,6	2,4	5,6	9,3	0,7	1,5
Ireland	2,8	16,6	2,1	13,9	10,8	21,8	6,9	14,9
Italy	4,5	5,8	1,2	1,5	6,7	7,1	1,5	1,8
Sweden	2,7	9,9	1,0	4,4	3,1	10,6	1,0	3,9
UK	5,7	11,5	1,6	3,0	3,0	4,6	0,9	1,3
USA	4,0	6,8	0,4	0,6	2,1	3,0	0,2	0,4

1. For some countries, such as India, it is not possible to isolate business services. As a consequence, for India, the category includes total services, minus travel, transport and government services (*i.e.* including construction, insurance and financial services as well as business services). However, Indian firms are now extensively exporting ICT-enabled services and business process services and the remaining services included in the category are likely to be small in comparison. Furthermore, data on overseas revenues from annual reports of top Indian export firms show patterns similar to the IMF data.

Source: Based on IMF Balance of Payments Database (March 2006).

Non-OECD countries emerge as important players

Firms increasingly offshore a range of business functions to countries with relatively lower labour costs and a talented workforce. India, some Eastern European and Baltic countries and more recently China are often mentioned as prime locations for receiving offshored services activities. Some countries often mentioned as potential locations to supply offshored services, including China and India, are experiencing rapid growth of exports of ICT-enabled services, which is one indication of their emergence as “offshore locations”. However, the exports of some of these countries are growing from a relatively low base, OECD countries are also experiencing strong growth, and most countries also experience growth of their imports of these services, reinforcing the idea that services globalisation is a two-way street.

Due to the wage-cost advantage and the large pool of English speaking skilled labour, India in particular has become a prime location for IT and ICT-enabled services offshoring in recent years. India’s services companies are also becoming more globalised, establishing themselves, *inter alia*, in Eastern Europe, the United Kingdom and United States (OECD, 2006a, Chapter 3). Many Indian companies are also establishing software development centres in other emerging market economies in close proximity to clients, including development centres in Eastern Europe to service the western European market and Latin American countries to service the United States, Spain and Portugal. This geographical strategy is referred to as “near-shoring”, which may help to overcome language and cultural barriers as well as certain restrictions to movement of service suppliers. The latter are of particular concern to the Indian IT industry since the global delivery model is dependent on frequent circulation of service professionals between home and client offices.

The emergence of locations such as China and India as bases for supplying ICT-enabled services is also illustrated by the responses from firms when asked where their R&D investments currently take place and where they are planning to invest in the future (UNCTAD, 2005). China and India were the locations with the highest increases in planned investments. While the share of ICT-enabled R&D services in R&D

investments is not known, much R&D is ICT-enabled. The growth of R&D services also illustrates the general shift into more highly skilled services activities.

A. T. Kearney's annual ranking of the most attractive locations for "offshoring" of service activities, ranks India and China first and second in 2005. Some OECD countries, in particular Canada and the United States, also rank highly largely due to a favourable business environment and a skilled labour force. In Europe, the Czech Republic and other eastern European countries have become more favoured locations.

Trade in broadband and ICT-enabled services has important physical infrastructure requirements (see Box 11 below). Other factors, such as economy-wide framework conditions (such as the cost and ease of setting up a business, the procedures for enforcing contracts, patent applications and urban population), human resources and skills are also important. While countries such as India and China have a large supply of workers, all may not have the right skills; in fact, a large proportion do not necessarily have the required ICT, language and other skills, thus limiting the current scope of ICT-enabled offshoring (OECD, 2006a, and van Welsum and Xu, 2007). In addition, quality of service is an increasingly important issue in decisions to begin and to continue offshoring of ICT-enabled services. Within overall quality of services, information security and privacy concerns are important in shaping the scope and limitations of ICT-enabled offshoring (OECD, 2006a).

Box 11. The physical infrastructure of broadband and ICT-enabled trade in services

The availability and quality of basic ICT-related infrastructure are very important for determining the location of globalised services activities. The quantity and quality of infrastructure and their prices vary greatly across countries (see the Table below). Some countries have large absolute amounts of infrastructure, which is one indication of national capacity for receiving ICT-enabled offshored services. For example, China has more PCs than Germany and more Internet subscribers than the United States. Brazil, India and Russia each have about as many PCs as Canada or Italy, and Brazil and India have slightly fewer Internet subscribers than Canada. However, apart from China, these countries' broadband subscriber numbers are much lower, and broadband costs are much higher than in most OECD countries in all of them. Furthermore, while some of the numbers appear very favourable for some countries, *e.g.* China, when they are scaled to the population it is obvious that the potential for further growth in the diffusion of ICTs and ICT infrastructure is huge. Overall the stock of ICT-related infrastructure in countries often seen as potential recipients of offshored services activities suggests enormous potential, but there is still a long way to go before these countries, including the largest, can match OECD countries in terms of the intensity and quality of infrastructure. Furthermore, India, the major supplier of ICT-enabled services, has neither the largest stock of ICT-related infrastructure nor the cheapest broadband costs among the BRICs. The source of India's comparative advantage lies instead in the availability of ICT-trained engineers, entrepreneurial domestic firms, linguistic advantages, global ties, recent economic liberalisation, etc. (OECD, 2006a). One area where Indian firms have become leaders is in their ownership and operation of undersea cables. Collectively, Indian firms are now the largest player in this global market. OECD (2007f),

Box 11 Table 1: Indicators of the stock of ICT-related infrastructure, selected countries, 2004

	PCs (000s)	Internet subscribers (000s)	Dial-up (%)	BB subscribers (000s)	Internet hosts total (000s)	Fixed telephone lines (000s)	Cellular mobile subscribers (000s)	Lowest sampled BB cost - USD per 100kbit/s
Australia	13720	5741,0	77,4	1548,3	3939,3	10872	16449	3,57
Canada	22390	8131,7	30,7	5631,7	3562,5	*20068*	14984,4	1,05
China	52990	71713,0	64	25785,0	162,8	312443	334824	1,93
Czech Rep.	2450	*2276,1*	96,7	75,7	384,6	3450	10771,3	3,99
Estonia	1242	171,5	34,9	111,7	63,6	444	1255,7	3,96
France	29410	11936,5	43,4	6754,0	2335,6	33870,2	44551,8	3,67
Hungary	1476	741,8	49,9	371,8	483,8	3577,3	8727,2	11,3
India	13030	5450,0	95,7	235,0	143,7	43960	47300	3,67
Japan	69200	*33883,9*	56	19097,2	16445,2	58788	91473,9	0,07
Latvia	501	90,0	45,4	49,1	59,1	631	1536,7	15,21
Lithuania	533	512,2	83,8	82,9	94,5	820	3421,5	5,53
Morocco	620	102,6	37	64,7	4,1	1308,6	9336,9	5,49
Poland	7362	2511,2	67,7	811,8	271,8	*12292,5*	23096,1	4,28
Sri Lanka	530	93,4	96,3	*3,4*	2,1	991,2	2211,2	3,25
United Kingdom	35890	15800,0	60,4	6255,5	2130,8	33700	61100	1,35
United States	220000	*63703,0*	40,5	37890,6	195138,7	177947	181105,1	0,49

Note: Numbers in italics are estimates or refer to years other than 2004.
Source: OECD (2006a), based on ITU (2005). Data for all OECD countries can be found in "The future of the Internet Economy", A statistical profile, OECD (2007g).

A lot of ICT-enabled trade in services takes place over deep-sea cables. Experiments with deep-sea cables started in Europe and Japan in the mid-1980s, but the large-scale laying of optical deep-sea cables by specialised ships took off back in 1996-1997. At the time, the demand for International bandwidth was driven by simple Internet connections, wireless and wire line voice traffic. Ten years later, Internet video traffic on peer-to-peer networks and sites like YouTube are driving demand. Whereas deep-sea networks are experiencing strong growth, there has been little build-up in terrestrial networks. Instead of adding more cables, some carriers (such as Level 3 and Global Crossing) are using next generation optical gear from companies like Infinera to send more bandwidth over their existing fibre, cheaply. This phenomenon does not yet exist in the deep-sea sector, which may explain the increase in the number of cables being laid under sea.[43] In recent years investment in the deep-sea cable market has shifted to South Asia, and two of the largest owners of deep-sea cable networks are in India: Reliance (FLAG) and VSNL (Tyco).[44]

The deep-sea build-up is taking place globally, and some of the upgrades and installations are justified (see Appendix Table 1 for some examples), especially in underserved areas such as Africa. For example, the upgrades such as the Atlas Offshore cable between Morocco and France or the East Africa Marine System between Kenya and the UAE, are desperately needed. However, the largest amount of construction activity is happening on the trans-Pacific route, which is getting as crowded as the trans-Atlantic corridor was in the last bubble. According to Telegeography estimates, only 18% of the potential trans-Pacific capacity is lit at present. The total potential capacity on existing cables is about 17 terabits per second (Tbps), but since some 75% of it is on one single cable – VSNL Transpacific - global carriers are looking for second and third sources. Therefore, four new cables are being proposed that would increase the potential capacity to about 39.8 Tbps. Only one has a certain future – Trans Pacific Express (TPE) which is expected to go live in the third quarter of 2008, and will connect China, Korea, and Chinese Taipei to the US (see below). The other three cables are the Asia America Gateway (AAG) project, the EAC Pacific and FLAG NGN-Pacific.[45]

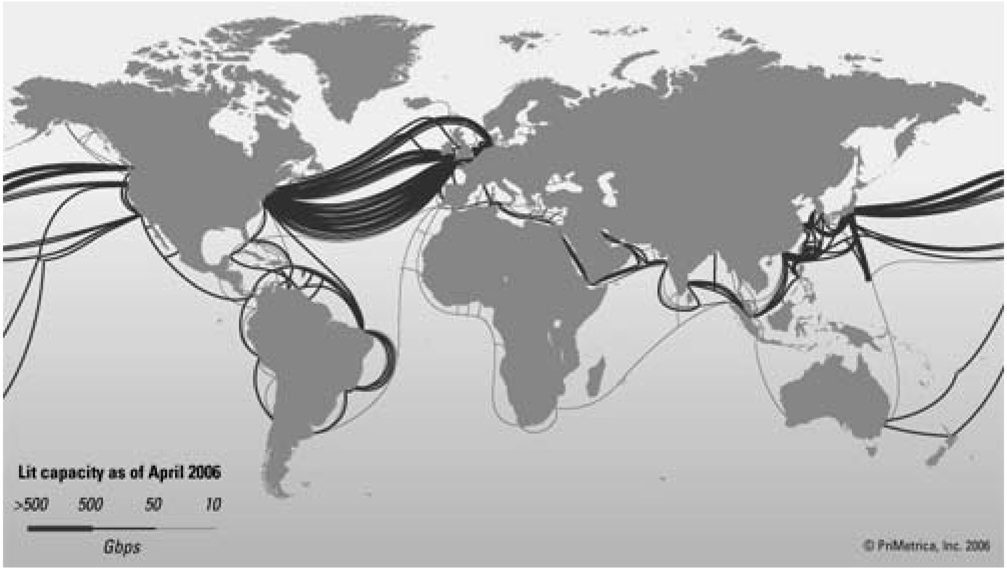
The TPE is an over USD 500 million network with a 18 000 kilometre cable system and a capacity of up to 1.28 terabits/second, which should eventually upgrade to over 5 terabits per second, created by Verizon Business with a multitude of Asian telecom operators including China Telecom, China Netcom, China Unicom, Korea Telecom, and Chunghwa Telecom of Chinese Taipei. The network will land on Nedonna Beach (OR), on the US side and will hit China at Qingdao and Chongming. It will also have landings in Tanshui, Chinese Taipei, and Keoje, Korea.

43. http://gigaom.com/?p=8540&akst_action=share-this

44. http://www.terabitconsulting.com/public/downloads/20061212_Boston_University_Presentation.pdf

45. http://gigaom.com/?p=8540&akst_action=share-this

Lit capacity as of April 2006



Source: http://gigaom.com/?p=8540&akst_action=share-this.

Indian companies have also been buying up large chunks of the cable market. For example, VSNL, an Indian company owned by Tata Group, bought the Tyco Global Network. It is likely VSNL will upgrade its networks, to meet capacity demands and face the challenge posed by the new China-U.S. network (see above).[46] Spice Telecom, Indian State Karnataka's oldest cellular service provider which is close to receiving both national and international long distance (ILD) licences, is also reportedly looking at using Telecom Malaysia's ILD infrastructure to tap the market.[47] Spice Telecom is also reported to be setting up three ILD points of presence (POPs) – the US, Britain and Singapore - to use, together with its two National Long Distance (NLD) POPs in the country for distributing its traffic all over India. The company plans to offer the contract for the equipment required to set up the long distance facilities to Wipro of India after receiving the licences. This will allow Spice to compete with other ILD majors, like BSNL, Bharti, Reliance and VSNL, especially in the enterprise segment. Telecom Malaysia (TM), which has a large stake in Spice Telecom, is a consortium member of all submarine cable systems that land in Malaysia, with access to capacity in other submarine cable systems globally. It also has co-location facilities at major data centres and tele-houses. Because of the relationship between Spice and TM, Spice can expect to access those cable systems and facilities. This, combined with Spice's IDL licences should help TM tap the enterprise and managed services business sector in India.

Scope and limitations of ICT-enabled globalisation and offshoring of services

Competition helps to create a self-reinforcing dynamic process. Once one or two firms shift to lower-cost locations and move the cost/quality frontier, others must follow. However, as activities are moved offshore, relative wages will adjust and slow the offshoring process, at least the part that is driven by exploiting arbitrage opportunities. The extent to which activities can be moved offshore will also depend on the supply of skilled labour overseas and the potential for undertaking service activities at a distance. In addition to liberalisation of trade and investment in services, the scope for further ICT-enabled globalisation of services will depend to some extent on further technological developments in ICTs and their diffusion, the availability, quality and cost of the physical infrastructure, and framework conditions such as the procedures for setting up new businesses, as well as on the availability of the skills required to use ICTs for trading services (OECD, 2006a).

46. http://gigaom.com/2006/12/19/big-fiber-is-back/

47. The Economic Times, as quoted in http://www.bernama.com.my/bernama/v3/news_business.php?id=252266

In some countries there may be a lack of workers suitable to work in the sector of internationally traded services and in multinational companies more generally. Although the stock of workers may be very large in these countries, there can be a lack of language skills and knowledge of Western corporate culture. Competition for talent in the ICT services industry in countries such as China and India, as well as other emerging countries in the region, is increasing but Indian companies in particular are adopting new strategies to get around the labour scarcity issue, trying to address increasing attrition rates and salary inflation (OECD, 2006a). These factors, combined with concerns about information security and privacy and IPR infringement could potentially hamper growth of global services sourcing if not addressed in a satisfactory manner.

There is scope for further growth though. Many existing services sectors have expanded, new services have emerged, and with ongoing technological developments and services trade liberalisation it is likely yet more are to be created (see Box 12 for a discussion of geography and the Internet). Furthermore, with the elasticity of demand of internationally traded services greater than one (*e.g.* Mann, 2004; Pain and van Welsum, 2004; van Welsum, 2004), rapid growth in countries such as India and China should also lead to reinforced exports from OECD countries. The offshoring phenomenon itself will also create new jobs in the domestic economy.

Box 12. Geography and the Internet

Does geography still matter in the context of the Internet? Can a so-called "death of distance" be observed or expected? While the Internet in theory allows unlimited cross-border trade, in practice some barriers effectively resurrect "borders" into cyberspace and, in certain cases, prevent customers in one country from purchasing goods and services online from suppliers based in another country. For example, in some cases subscriptions to certain types of online services, online prize draws, or the purchase of some online goods and services require an address in the particular country, or payments are only accepted using a credit card from a bank account in that country.

There are two aspects of geography that are of particular importance: Internet *diffusion* itself and Internet enabled international *trade*.

Diffusion: Forman *et al.* (2005) show that Internet adoption decisions vary by location.[48] The technological opportunities provided by GPTs vary across establishments and locations. Three modes of diffusion are distinguished: global village (the Internet lowers communication costs and breaks down geographical barriers between firms: Internet technology is a substitute for agglomeration), urban density (the Internet follows a traditional pattern of diffusion, starting with urban areas where complementary technical and knowledge resources that lower the costs of investing in new frontier technology are present: Internet technology is a complement to agglomeration) and industry composition (demand for the Internet increases with location size because of the concentration of information-intensive firms in urban areas). Forman *et al.* find some evidence for the global village theory on basic access and Internet network participation, but no evidence for the urban density theory. They also find a significant role for the prior geographic distribution of industry on business use of the Internet. Basic diffusion and adoption were rapid and widespread as the costs were relatively low and the benefits great. However, more advanced forms of use that are technology enhancing are more costly and time-consuming to develop and implement and will therefore diffuse more slowly and less widely.

48. There is no consensus on the role of geography and population distribution in broadband penetration. While there is no firm evidence of a correlation between these factors in OECD countries (OECD, 2007c), this should not suggest that geography does not affect broadband penetration. Many large countries, which would be the most difficult and expensive to connect, already have very extensive coverage by one or multiple technologies. In the United States for example, high-speed cable modem service is available to 96% of end-user premises where the cable systems offer cable television and xDSL service is available to 79% of end-user premises where the incumbent local exchange carrier offers local telephone services. Instead, other factors such as the level of competition and pricing may play a much more prominent role in determining take up.

Trade: Freund and Weinhold (2002) show that the Internet had a positive effect on US imports of other private services, and its effect is even stronger when looking at business, professional and technical services alone. Moreover, the effect of the Internet variable was greater for imports than for exports of services. These findings imply that the development of the Internet has facilitated imports of services into the US, and they are consistent with international outsourcing taking place in the services sector, resulting in an increased flow of imports of ICT-enabled services into the US. The disaggregated data for business services used by Freund and Weinhold exclude intra-firm trade, which they assume will bias their results against finding a strong role for the Internet as many problems related to web-based service provision can be overcome in the shared ownership environments in which intra-firm trade takes place. Therefore, the actual effect of the Internet could potentially be even greater than what they found. Increased Internet access in developing countries has also been found to increase their exports to developed countries (Clark and Wallstein, 2006).

Death of distance? To quote Nick Crafts ***"Like steam, ICT rearranges geography but does not abolish it"*** (The Economic Impact of ICT: A Perspective from the Age of Steam)

5. Employment impacts

Employment and ICT and broadband-enabled globalisation

Historically, automation of the production process has involved various substitutions: animal power for human muscle power, mechanical energy for animal power, machinery for human labour, and most recently, computerisation can act both as a substitute and a complement to human labour. Computerisation and globalisation have similar impacts on employment, which is not very surprising given that ICTs and broadband enable much of the new wave of globalisation.

A priori, the overall effect of broadband on employment is ambiguous (see Box 13 for some estimates of the impact of broadband on employment). Whilst broadband is thought to enhance growth and thus create employment opportunities, it also facilitates capital-labour substitution, slowing employment growth, at least for a while. Furthermore, as broadband is likely to affect different industries in different ways it is likely there will be some sectoral and occupational employment changes and, as a result, the net effect on total employment is hard to identify.

Technological developments, in particular in communication technologies, have significantly reduced (tele)communication costs, have enabled trade in services that were not previously traded and have brought about "a new paradigm in international trade": a form of "high-resolution globalisation" where competition takes place all the way down to the task level (Baldwin, 2006). Thus, ICT-enabled trade in services means that tasks carried out by workers in different countries are increasingly in competition with each other. One result of this is that current relationships between skills groups and winners and losers break down, making it harder to predict who will be the future winners and losers from the new wave of globalisation. The jobs or tasks that are affected by international competition through ICT-enabled offshoring can be ones that exist in many sectors, both labour and capital intensive sectors (*e.g.* data entry).

In addition to increased uncertainty about the distributional outcomes of globalisation, two additional changes are taking place. There can be sudden drastic changes in the types of activities that can be offshored, and increasingly individuals are affected rather than firms, sectors or skill groups.

Wage differentials (see Table 2 for an example for software programmers) are often mentioned as a driver for offshoring of services and they can constitute a factor in the location decisions of firms, although other factors, such as skills and talent also count. However, wage differentials to some extent reflect differences in productivity and therefore wage differentials between countries such as China and India and OECD countries are likely to be bigger than overall unit labour cost differentials. Furthermore, in addition to direct labour costs, the offshoring of services activities also involves other types of costs, including overhead, organisational and transactions costs. Furthermore, countries such as China and India, in turn, face competition from other relatively low wage cost countries, and pressure is mounting on China in particular to comply with core labour standards to reduce criticism of unfair competition (van Welsum and Xu, 2007).

Table 2. Average annual salaries of software programmers, 2002

Country	Salary range (USD)
Poland and Hungary	4 800 – 8 000
India	5 880 – 11 000
Philippines	6 564
Malaysia	7 200
Russian Federation	5 000 – 7 500
China	8 952
Canada	28 174
Ireland	23 000 – 34 000
Israel	15 000 – 38 000
US	60 000 – 80 000

Source: *CIO* magazine, November 2002, Smart Access Survey, Merrill Lynch, as reported in Bardhan and Kroll (2003).

Grossman and Rossi-Hansberg (2006) build a theoretical framework to model trade in tasks, which can take place at different levels of skill. The production process is conceptualised as a continuum of tasks carried out by each of the factors of production. Factor-cost savings motivate firms to offshore tasks, acknowledging that some tasks are more suitable to be carried out from remote locations than others.

Such a distinction is also made by van Welsum and Vickery (2005) who classify occupations according to their "offshorability attributes": *i*) intensive use of ICT; *ii*) output that can be traded/transmitted via ICTs; *iii*) highly codifiable knowledge content; and *iv*) no need for face-to-face contact. Other authors have similarly distinguished different types of tasks that are more or less suitable for offshoring. For example, Autor *et al.* (2003) and Levy and Murnane (2004) distinguish routine (easier to offshore) and non-routine tasks[49], Leamer and Storper (2001) identify tasks that require codifiable (easier to offshore) or tacit information, and Blinder (2006) distinguishes between activities that require physical proximity or that can be delivered "impersonally" from a distance (easier to offshore).

To get an idea of the "outer limits" of employment potentially affected by offshoring, van Welsum and Vickery (2005) calculate the share of people employed who are mainly performing the type of functions that could potentially be carried out and supplied from any geographic location (on the basis of "offshorability attributes, see above), using data on employment by occupation by industry. This analysis suggests that up to 20% of total employment in OECD economies carries out functions or tasks that are of a type potentially suitable to international sourcing of IT and ICT-enabled services.

49. Autor *et. al.* (2003) argue that the tasks most vulnerable to being substituted by technology are those where information processing can be described in rules. If a significant part of a task can be described by rules, this increases the likelihood of the task being offshored, since the task can then be assigned to offshore producers with less risk and greater ease of supervision.

Box 13. Some estimates of the impact of broadband on employment

A recent study by Crandall, Lehr and Litan (2007) finds evidence of a positive impact of broadband deployment on employment: for every 1% increase in a state's broadband penetration rates, employment increases at a rate of 0.2 to 0.3% per year. If these figures are aggregated to the national level, this increase could lead to an additional 300 000 new jobs per year. At the sectoral level, broadband penetration is found to be positively related to both manufacturing and services, in particular finance, education and health care.

Based on forecasts of capital expenditures by DSL and cable broadband providers, Criterion Economics (2003) estimates that an average of close to 61 000 jobs could be created on average per year in the US between 2003 and 2021. Crandall and Jackson (2001) had estimated that the widespread adoption of broadband could create up to 1.2 million jobs per year in the United States.

ACIL Tasman (2004) in a study of the economic impact of broadband in Victoria, Australia, predicts the average annual growth in the number of persons employed in Victoria as a result of broadband adoption to be 0.5% over the period 2004-2015. Furthermore, the contribution of broadband to employment growth is expected to peak in 2008, in real numbers, with an increase of 18 000 in the number of employed persons in Victoria in that one year alone.

Telework

Telework is a significant and growing phenomenon and with rapid technological developments ever increasing broadband diffusion and bandwidth, it can be expected to grow further. There are different interpretations of the concept “telework”. In this report, telework is understood to mean work that relies on ICTs to be carried out from “remote” locations, *i.e.* other than the site of production or the office, away from colleagues, employers or clients. Taxonomies of different types of telework(ers) are based on characteristics such as the location from where work is carried out (home, subsidiary offices, “in the field”, while travelling, etc. and combinations thereof), the amount of time that work is carried out away from the office, per day, per week, per month etc., and the type of contractual relationship with the employer. Broadband is a vital factor in telework as it allows workers to remotely connect to their employers, to clients, and have access to and store information, and allows them to communicate. Increasing bandwidth continues to increase the possibilities, for example through tele- and video-conferencing.

Broadband connections also increasingly allow people to carry out tasks at times and places they could previously not. For example, people can make phone calls and check their e-mail while travelling or while waiting.[50] As some say, “the professionals are going bedouin”, facilitated by a corporate culture which is increasingly output-oriented rather than location- or time-oriented. While increased flexibility is likely to have a positive impact on workers’ productivity, companies can also start to save costs on office space. The office space is also changing to reflect the new more flexible working environment. Procter and Gamble have recently revamped one of their offices into a “bar like space” with bar stools and brass, and coffee instead of spirits, because an employee survey found that a bar environment is where people felt most comfortable interacting with other people. Deloitte & Touche have put in place a system of “hoteling” in their offices whereby employees phone up an office ahead of their arrival to reserve a space. The service is complete with “concierges” providing office supplies, laptop and iPod plugs and cell-phone chargers (Conlin, 2006).

Telework is often thought to improve flexibility and quality of life for workers, relieve congestion problems and reduce pollution.[51] A recent survey among small businesses in the United Kingdom carried out by BT (2007) confirms the flexibility and quality of life argument: broadband is revealed as a key enabler in flexible working, with 78% of businesses surveyed citing speed and flexibility as the reason for

50. Rainie and Keeter (2006) found that 41% of cell phone owners use their free time when travelling or waiting for someone to make phone calls.

51. There are many economic and social issues related to ICT-enabled teleworking (such as working conditions, union representation, degree of managerial supervision, and access to training) but these are not dealt with in this report.

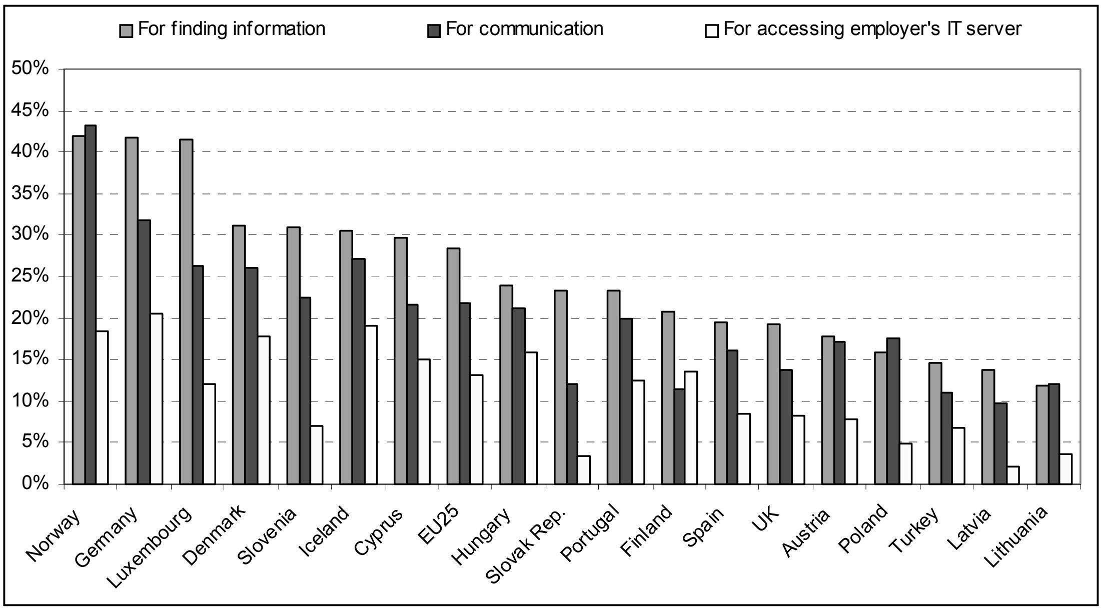
broadband uptake. More than 95% of people questioned had broadband in their home, allowing them the freedom to work away from the office with alternative working patterns better suited to the demands of their lifestyle and commitments than the traditional 9-5 office hours. The impact on congestion, pollution and, indirectly, on climate change depends on the types of teleworkers, whether people stay at home to avoid a commute, adopt flexible hours in order to avoid peak travel/traffic hours, or work normal hours and commute normally but do extra work/overtime using telework (Garrett and Danziger, 2007).

The literature on the impact of teleworking on travel behaviour tends to point to a reduction in travel. Cairns *et al.* (2004) cite some estimates of both commuting and total traffic reductions: from a study in 2000 for the United Kingdom, commuting traffic is down by 10% in 2005 and 15% by 2010 and a total traffic reduction of 2% and 4% respectively. A study for Belgium points to a 2.4-8.4% reduction in car commuting trips by 2011, and 5% of commuter trips and 1% of all trips in the Netherlands (see Cairns *et al.* (2005) and the references therein).[52]

Some minimum ICT skills are required for teleworkers to use a computer, connect to the Internet and download files. Enabling technologies include (laptop) computers, (mobile) phones, Internet, broadband, (remote) e-mail, and access to the company's network. According to ATAC (2005), IP Virtual Private Network (VPN), which replicates the office environment at a remote location, is expected to become the "must have" technology for teleworkers. Data on Internet users in European countries in 2004 show that use of the Internet for (ICT-enabled) teleworking outside the employer's premises is most common in Norway, Germany and Luxembourg. In all countries except Norway, Poland and Lithuania, finding work-related information was the main reason for using the Internet, followed by communication purposes such as using e-mail (except in Finland) and accessing employers' IT servers (Figure 1). While the last of these uses is still relatively rare, presumably because it tends to require a relatively more advanced IT infrastructure, its importance can be expected to increase in the future (OECD, 2006a).

52. There is also a related literature on the effect of ICT and e-commerce on transport, for example with some theoretical studies examining online retail operations and which find a reduced transport demand from online retailing. However, this benefit (in terms of energy/resource use) is cancelled out in sustainability terms by other non-transport additional activity. See UK Department for Transport, Local Government and the Regions (2002/3) and the references therein.

Figure 1. Proportion of Internet users (employees) performing selected work activities outside the premises of their employer (past 3 months), 2004



Notes: For Austria "employees" includes "self-employed and family workers".

Source: Eurostat (2006), Community Survey on ICT usage in households and by individuals.

A survey in the United States,[53] conducted from 15 August to 1 September 2005, found that out of 135.4 million US workers, some 45.1 million (about one-third of the total) telework from an average of 3.4 locations (home, clients or customers, plane/car, outdoors, etc.). [54] Of these, 26.1 million reported working from home at least once a month and 22.1 million at least once a week. The increase in the ability to work anywhere comes, in part, from the increased availability and lower cost of portable devices and high-speed communication technologies. The survey found that "the use of broadband in the home by teleworkers increased by over 60% during the past year resulting in 25.6 million home-based teleworkers with high-speed access."[55] The increasing importance of services, which can be traded with the help of ICTs, also plays a role.

According to the Canadian Telework Association (www.ivc.ca/cta/), studies for Canada show there is still a wide discrepancy between the desire to telework and the ability to do so.[56] Nevertheless, the Gartner

53. The Dieringer's 2005 American Interactive Consumer Survey, which is used by the Dieringer Research Group in its research conducted for the International Telework Association and Council (ITAC) (www.workingfromanywhere.org/). This survey is the longest-running primary research survey of US Internet user and multi-channel consumer behaviours and trends.

54 . There are different approaches to promoting high-speed connections in different countries. For example infrastructure-based competition has been seen to help promote investment in fibre in the US. Others have emphasised that the overall level of competition in the market is more important – highlighting that Japan leads the OECD in fibre rollout even though there is only limited infrastructure-based competition.

55. www.workingfromanywhere.org/news/pr100405.htm.

56. www.ivc.ca/studies/canadianstudies.htm.

Group[57] reported that 10% of employees in Canada engaged in telework in 2004 and that 6.4% did so at least eight hours a week (an increase from 5.9% and 3.6% respectively in 1998). Furthermore, the Gartner Group predicts a further increase to 13% and 8.4%, respectively, by 2008.

ATAC (2005) reports that around 11% of employed workers in Australia regularly worked from home in 2000. Teleworking is concentrated in service sectors, in larger firms, and in managerial or professional occupations (followed by associate professionals and advanced clerical and service workers). While there are still relatively few formal teleworking agreements, the uptake of technologies enabling teleworking has increased so that the incidence of teleworking is expected to increase as well. In 2004 some 80% of firms offering flexible work arrangements also provided the enabling technologies and 53% also offered access to the company network.

According to the Japan Telework Association,[58] Japan had 10.4 million (15.6% of total workforce) teleworkers (7.5 million employed and 2.9 million self-employed) in 2002, of which 4.1 million (6.1% of total workforce) teleworking more than eight hours a week. For employed teleworkers, most teleworking time was spent on data and information gathering, writing reports, compiling and analysing statistics, and communicating with their manager and colleagues. For self-employed teleworkers, occupations were divided into three categories based on the degree of dependence on ICTs: *i)* jobs that depend on the diffusion and use of ICTs, such as website design and programming, *ii)* jobs for which the diffusion of ICTs has changed how the job is done, such as design or finance jobs that were previously paper-based, and *iii)* jobs for which the diffusion of ICTs has had a minor impact on how the job is done, such as jobs which entail physically handling goods or those that require face-to-face contact with customers. Among the self-employed, the first category accounted for 5% of total, the second for 34% and the third for 61%. The Japan Telework Association provides a useful table comparing telework in Japan and in several EU countries (Table 3).

57. Gartner Group Paper: “Teleworking: The Quiet Revolution” (2005 Update), as reported on www.ivc.ca/studies/canadianstudies.htm .

58. www.japan-telework.or.jp/english/pdf/english_010.pdf .

Table 3. Importance of telework in several EU countries and Japan, 2002

% of total workforce

	Regular teleworker (at least 1 day/week	Occasional teleworker (less than 1day/week)	Total
Finland	10.8	6.0	16.8
Sweden	8.0	7.2	15.2
Netherlands	8.3	6.3	14.6
Denmark	6.6	3.9	10.5
United Kingdom	4.8	2.8	7.6
Germany	4.4	1.6	6.0
Ireland	1.9	2.6	4.5
Italy	2.9	0.7	3.6
France	2.3	0.6	2.9
Spain	2.0	0.8	2.8
Average EU10	4.1	2.0	6.1
	Teleworker (8 or more hours a week)	Teleworker less than 8 hours a week	Total
Japan	5.8* (6.1)	9.1* (9.5)	14.9* (15.6)

* Adjusted to be comparable with EU figures.
Notes: The EU defines a non-regular teleworker as an occasional teleworker. In the Japanese survey, a regular teleworker teleworks 8 hours or more a week, while an occasional teleworker teleworks less than 8 hours per week. The EU calculates the teleworker ratio relative to the total workforce (the sum of the employed and the unemployed). For comparison purposes, Japan's teleworker ratio is recalculated as the ratio of telework population relative to total workforce. The teleworker ratio is shown in parentheses.
Source: Japan Telework Association, www.japan-telework.or.jp/english/pdf/english_010.pdf.

These data show that telework, is a significant and growing phenomenon. With rapid technological developments (which make many services tasks storable and transportable and therefore candidates for distance work) and the increase in broadband roll-out, it can be expected to grow further. Distance work could, in theory, also help increase labour market participation of people in remote locations, women and the handicapped,[59] but, to date, there is little empirical evidence.[60] In fact, telecommuting has historically been negatively correlated with worker's age, and there are both studies that find gender effects (although with opposite conclusions, sometimes telework being dominated by female workers and other times by

59. An increasing number of devices and applications help handicapped people use computers, and other devices, such as GPS, allow them to become more mobile. For example, quadriplegics can operate computers with the help of blink and eye-brow operated software, infrared headsets enable the use of computers without a keyboard or mouse, Braille printers and voice recognition applications help the blind and visually impaired (Atkinson and McKay, 2007). Further techniques and applications of ever increasing sophistication are being developed every day enhancing the possibilities for handicapped people to exploit the possibilities offered by ICTs and broadband in particular.

60. It is possible that increased labour market participation could depress productivity growth if the share of relatively lower skilled and less productive workers in the labour force increases (*e.g.* OECD, 2007b). However, ICTs may facilitate increases in participation rates across the skills spectrum, and especially in medium and high skilled jobs. At the same time, ICTs are likely to enable the automation of an increasing amount of routine tasks that would otherwise have been carried out by relatively lower skilled workers so it is difficult to estimate what the net impact, and the part that could be attributed to broadband roll-out, would be. Furthermore, broadband and the automation and offshoring of routine administrative tasks it enables are likely to increase productivity, thereby enhancing growth and creating new employment opportunities. Even though these structural changes come with adjustment costs in the short term, provided the appropriate mechanism for retraining and re-skilling are in place, there should be long term net benefits.

male workers) and studies that find no relationship between gender and telework at all (Garrett and Danziger, 2007).

6. Other areas and channels with a promise of great broadband impacts

The main part of the report has focused on the impacts of broadband on growth, globalisation and employment. This section considers some other areas where broadband is likely to have a big impact. This is not an exhaustive list as broadband is likely to have an effect on almost every aspect of fully ICT-enabled economies. Among the impacts not considered in detail here are climate change, energy, water management, health, demographic challenges, and education, although health and education are discussed to some degree. This section discusses some of the impacts on individuals and SMEs.

6.1 Impacts on individuals and their role in economic processes

Broadband has a positive impact on consumer surplus, and changes the role of individuals in the productive process, facilitating user-created content and user-driven innovation.

Consumer surplus

High speed broadband networks bring about lower search and information cost and greater access to information, which makes price comparisons easier, increases competition and creates a downward pressure on prices. They also enable the increased customisation of goods and services and the ensuing improved and/or better adapted quality. This process not only affects online commerce but also can affect offline shopping when people search for information and compare prices online before going to a shop to make the actual purchase. The resulting empowerment of the individual through the use of broadband networks constitutes a very important economic impact and brings about a restructuring of the relationship between customers and suppliers, notably by increasing the consumer surplus (see Appendix Figure 3).[61] There are also new broadband enabled services that give consumers direct access to lower cost services abroad. For example, an Indian company is offering tutoring services to pupils for less than half the price of those available in the United Kingdom. All that is needed is a broadband connection, a headset, and the software provided by the company.[62] Some examples of estimates of consumer surplus and cost savings are given in Box 14.

Increasingly, triple play offers allow consumer surplus gains as data, voice and video (even "quadruple play" offers which also include mobile voice) can now all be obtained through one subscription with a single provider.[63] Broadband is a great enabler of these offers as higher-speed connections open the possibilities for new data-intensive services such as video conferencing, high-quality voice transmission and TV over IP. At the same time, not all high-speed data connections can support all services (Okamoto and Reynolds, 2006).

61. However, an alternative scenario can be imagined whereby firms can increasingly personalise and customise goods and services, allowing, in the extreme, to charge each consumer his/her reservation price thereby capturing the consumer surplus. Selling over broadband may bring firms closer to being able to do this. See also Appendix Figure 3.

62. http://business.timesonline.co.uk/tol/business/industry_sectors/support_services/article1686694.ece.

63 . Okamoto and Reynolds (2006) identified the prices of triple-play offers available from 48 providers in 23 OECD countries in September 2005, as well as the prices of their data, voice, and video services offerings.

Box 14. Some estimates of potential consumer surplus gains and cost savings

Crandall and Jackson (2001) have estimated the potential consumer benefits of universal broadband adoption at around USD 300 billion per year in the US alone.

Criterion Economics (2003) estimate two types of effects. First, the direct benefits derived from future demand for greater high-speed connectivity. Indirect benefits flow from the new services that households can obtain with faster Internet connections and more powerful home computing, allowing additional consumer surplus to be derived from new services in addition to time savings and gains on commuting allowed by high speed broadband. Projected rise in consumer surplus in the US of USD 234-351 billion per year (the largest contribution being made by shopping, followed by entertainment, telephone services, telemedicine and commuting). An additional USD 20 billion per year is associated with broadband-stimulated purchases of household computers and networked equipment. As broadband uptake has increased since then, this estimate would, everything else being equal, now also be higher. Plus, there may be additional benefits from new services and applications being offered as speed and bandwidth increase.

Cost savings and output expansion brought about by the use of broadband by Americans with disabilities or those older than 65 have been estimated by Litan (2005) to amount to USD 927 billion[64] (lower bound estimate; 2005 dollars) over the period 2005 to 2030. The gains would be achieved through lower medical costs, lower costs due to delayed or avoided institutionalised living arrangements, and additional output generated through increased labour market participation by individuals in these two groups. With policies aimed at accelerating broadband use to benefit these groups the total estimated benefits are claimed to become even larger.

ICTs and broadband contribute to increasing consumer choice, including by allowing increased customisation. Companies also increasingly allow customers to customise their products online, from cars to computers to shoes to cakes. This increased customisation of products (goods and services) is sometimes referred to as the “long tail economy”, with the Internet revealing markets for products for which previously too little demand existed for them to be commercially viable and broadband amplifying this potential. For example, already in the year 2000 the number of book titles available at Amazon.com was more than 23 times larger than the number of books on the shelves of a typical Barnes & Noble superstore, and 57 times greater than the number of books stocked in a typical large independent bookstore. This increased choice was estimated to have added some USD 731 million to USD 1.03 billion to consumer welfare in the year 2000, which is between 7 and 10 times as large as the consumer welfare gain from increased competition and lower prices in this market (Brynjolfsson *et al.,* 2003). Similarly, large gains can also be expected for other products sold online and that require large stocks (in the case where they are sold on physical supports) such as music, movies, consumer electronics, and computer software and hardware. As online commerce develops, supply chain and inventory management becomes more sophisticated, and additional ways of online retailing develop, *e.g.* with sites such as e-Bay, consumer surplus can be expected to continue to increase.

Quality of life

Quality of life is becoming an increasingly important concern of policy makers. However, to date there are little or no statistics measuring and comparing indicators of quality of life and welfare. More generally, a culture of evidence-based decision making has to be promoted at all levels, to increase the welfare of societies and quality of life. In the information and digital age, welfare depends in part on transparent and accountable public policy making which is greatly enhanced by the use of ICTs and broadband communications tools. Furthermore, the availability of statistical indicators of economic, social, and environmental outcomes and their dissemination to citizens can contribute to promoting good governance and the improvement of democratic processes. International organisations such as the OECD, World Bank and the United Nations Development Programme and representatives from OECD countries and from African, Asian, Latin American and Middle-Eastern countries expressed their commitment to join forces in an endeavour to create and disseminate such indicators. ICTs and broadband networks are central to the realisation of such a global project. For example, the OECD is considering creating an

64. An amount equivalent to a little over 7% of US GDP in 2005.

Internet site based on Web 2.0 “wiki” technologies for the presentation and discussion of international, national and local initiatives aimed at developing indicators of societal progress. By making indicators accessible to citizens all over the world through dynamic graphics and other analytical tools, this initiative would aim to stimulate discussion based on solid and comparable statistical information about what progress actually means.

Measuring the social impact of ICTs

Measuring the social impact of ICT may be even more complicated than measuring the economic impacts, especially because boundaries between social and economic impacts are often blurred. For example, ICT enabled health applications such as mobile services and remote monitoring, while delivering productivity improvements to the health sector, also improve the wellbeing of citizens. There are many other examples of widespread adoption of new technology changing the way we live, work or consume, which pose challenges for both economic and social statistics. The scope of “social impact” can also be very large as individuals, families or society as a whole may be affected and impacts can be temporary or permanent, positive or negative, and direct or indirect (Siddhartha De, 2007).

Until recently, measurement of the social impact of ICT has received less attention from official statisticians than the measurement of economic impacts, but measures of ICT are increasingly appearing in social surveys. These surveys reveal that ICTs impact many aspects of people’s everyday life, for example, how and where people work, what they study and what jobs they do, how they do everyday activities such as shopping, banking, dealing with business and government, how they spend their income, how they spend their time, how they obtain information, and how they relate to family and community (Siddhartha De, 2007).

An often highlighted aspect of broadband impacts is that it enables more flexible work practices, both in times and hours worked and in location from where people can work. This is also confirmed in smaller surveys, such as the one from BT research.[65] Broadband is revealed as a key enabler in flexible working, with more than three quarters of businesses surveyed (78%) citing speed and flexibility as the reason for broadband uptake. The report also shows that one third of smaller companies (33%) and almost half of sole trader businesses (48%) are starting to create a better work-life balance, by spending a greater proportion of their working hours away from the office.

The social and cultural impact of broadband-enabled user created content (UCC)

The creation of content by users is often perceived as having major social and cultural implications (Wunsch-Vincent and Vickery, 2007). The Internet as a new creative outlet has altered the economics of information production and led to the increasing democratisation of media production and changes in the nature of communication and social relationships. Changes in the way users produce, distribute, access and re-use information, knowledge and entertainment potentially give rise to increased user autonomy, increased participation and increased diversity. These may result in lower entry barriers, distribution costs and user costs and greater diversity of works as digital shelf space is almost limitless.

"Long tail" economics allow a substantial increase in availability and a more diverse array of cultural content to find niche audiences. UCC can also be seen as an open platform enriching political and societal debates, diversity of opinion, free flow of information and freedom of expression. Transparency and some “watchdog” functions may be enhanced by decentralised approaches to content creation. Citizen journalism, for instance, allows users to correct, influence or create news, potentially on similar terms as newspapers or other large entities. Furthermore, blogs, social networking sites and virtual worlds can be

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65. http://businessclub.bt.com/stateofthenation.pdf.

platforms for engaging electors, exchanging political views, provoking debate and sharing information on societal and political questions.

ICT-enabled innovation driven by individuals

The trend towards the so-called democratisation of innovation[66] applies not only to information products, such as software, but also to physical products. However, especially in the case of services and knowledge and information products, the process is enabled and greatly enhanced by the use of broadband communication networks (see Box 15 for an example).

ICTs and broadband create new ways for companies to exploit the creativity and innovativeness of their workforce. Blogs, wikis, podcasting, tagging technologies, and lessons of community and social networking sites are increasingly seen as important tools to improve the efficiency of employees (Bughin, 2007; The McKinsey Quarterly, 2007; Wunsch-Vincent and Vickery, 2007). An important advantage, especially in the case of IT-related products, is that innovation by users allows a more adequate response to the heterogeneous needs of users (von Hippel, 2005).

Box 15. Open Source Software – an example of user-driven innovation and the role of broadband communication networks

The case of an open-source software project illustrates the ICT tools required and the way in which broadband enables the required interactions. Necessary tools and infrastructure available to participants in an open source project include e-mail lists for specialised purposes that are open to all and are publicly archived. Programmers contributing to open source software projects tend to have essential tools, such as specific software languages, in common. These are generally not specific to a single project, but are available on the web. Basic toolkits held in common by all contributors also tend to greatly ease interactions. Furthermore, version-control software allows contributors to insert new code contributions into the existing project code base and test them to see if the new code causes malfunctions in existing code. If so, the tool allows easy reversion to the *status quo ante*. This makes "try it and see" testing much more practical, because much less is at risk if a new contribution inadvertently breaks the code. These toolkits used in open source projects have evolved with practice and are continuously being improved by user-innovators. Individual projects can now start up using standard infrastructure sets offered by sites such as Sourceforge.net.

Source: von Hippel (2005, p. 100-101).

6.2 SMEs and broadband

SMEs are very important in the economy as they tend to represent a very large share of businesses. Broadband can help to empower small and medium-sized firms, enabling them to compete with larger firms in an increasing number of markets and purchase services they previously could not afford.

The importance of SMEs

SMEs account for a very large share of businesses in OECD economies. For example, in 2003, 99.8% of enterprises in the enlarged EU were SMEs (< 250 employees) and small enterprises (<50 employees) accounted for over 95% of manufacturing enterprises and an even higher share in many service industries in OECD countries. In many OECD countries, micro-enterprises (< 10 employees) account for more than 90% of enterprises in computer services and related activities, and also for very large shares in the R&D

66. The democratisation of innovation means "that users of products and services—both firms and individual consumers—are increasingly able to innovate for themselves. User-centered innovation processes offer great advantages over the manufacturer-centric innovation development systems that have been the mainstay of commerce for hundreds of years. Users that innovate can develop exactly what they want, rather than relying on manufacturers to act as their (often very imperfect) agents. Moreover, individual users do not have to develop everything they need on their own: they can benefit from innovations developed and freely shared by others." (von Hippel, 2005)

sector. SMEs tend to generate two-thirds of private sector employment, are the principal creator of jobs and are vital for innovation and R&D activities. High firm entry rates have been recorded in dynamic services sectors, such as business services or ICT-related industries, health and age-related services, although the survival rate of these new enterprises is relatively low. ICTs and e-business applications can offer SMEs a wide range of benefits in terms of efficiency and market access, reducing the costs and increasing the speed and reliability of transactions. However, even though ICT connectivity (PCs and Internet) is widespread in businesses of all sizes, small businesses tend to be slower than large ones in the adoption of new ICTs and e-business applications, mainly because of a perceived lack of applicability and uncertain profitability (OECD, 2005b; Vickery, 2005).

In the United Kingdom 99.3% of all 4.3 million business enterprises employ less than 50 people, 72.8% have no employees and solely consist of self-employed owner managers. In a survey conducted among UK SMEs by BT research (http://businessclub.bt.com/stateofthenation.pdf, cost and security were found to be more of an issue for companies with 21-50 employees than for smaller SMEs. Better work-life balance was cited by 82% of SMEs, and 78% cited speed and flexibility as a reason for broadband uptake. Voice over Internet Protocol (VoIP) is used by 20% of SMEs and a further 23% indicated an intention to start using VoIP within a year. VoIP use appears to decrease with the size of the SME.

The Canadian Survey of Electronic Commerce and Technology (SECT) data show generally high connectivity levels for Canadian businesses, with broadband connectivity now the norm, and the use of ICTs, *e.g.* for website development and use, and purchasing online (which only requires the seller to have a transactional website) has increased substantially over the period 2000-2006. However, the growth of more sophisticated e-business activities, *e.g.* transactional applications like selling online, remains slow and concentrated among large firms and a few specific sectors. These findings emphasise the need to translate business connectivity to more value-added and productive online activities, which would help firms strengthen their competitive advantage and improve their business performance. ICTs in general, and e-business activities in particular, impact on firm and sector-level productivity and competitiveness. Therefore the lag in the adoption of e-business applications and solutions by SMEs, and the nature of the perceived barriers, raises some concerns. Targeted sector-specific interventions may be necessary in some cases, both by governments and the private sector, to help SMEs in lagging sectors to realise the business potential of connectivity (Neogi *et al.,* 2003; Neogi and Brocca, 2007).

The impact of ICTs on SMEs

ICT and broadband-enabled trade in services allows SMEs to buy services they previously could not afford, for example, remote security surveillance rather than hiring a security guard on the premises, IT services rather than an IT technician, and similar examples for legal services, accounting, advertising etc. Other examples include managed services provided by broadband providers, such as VoIP services, IP VPNs, website hosting, managed e-mail accounts, Internet security (business network security features such as virus and spam protection and firewalls), data storage, archiving and back-up, desktop management, software as a service (SaaS, also known as managed software, on-demand software and application service provision ASP), Web conferencing, surveillance, monitoring and closed circuit TV (http://research.analysys.com/default.asp?Mode=article&iLeftArticle=1234&m=&n=). A study by Analysis as reported in The Register (http://www.theregister.co.uk/2007/03/05/sme_broadband_demand/) based on a survey with 184 European SMEs in France, Germany and the United Kingdom found that SME spending on broadband managed services amounted to some EUR 5.7 billion in 2006 and is forecasted to increase by more than EUR 4 billion in western Europe by the end of 2011.

At the same time, broadband and ICT-enabled trade in services also offer SMEs increased market access abroad and opportunities to become part of the value chain of production of other, larger, firms. A survey by Value Leadership (2005) among European SMEs in the IT sector present in India found that for them the advantages included lower costs, ease of hiring talented workers (in fact, size, flexibility and quality of the labour pool was found to be at least as important as labour cost advantages), greater flexibility and scalability of operations, market access, and shorter product development cycles.

Broadband increasingly enables people to start small businesses from home, which will contribute to a more dynamic and entrepreneurial business sector.

ICTs and broadband networks also increasingly allow small firms to increase their R&D activities and to participate in larger research networks. Broadband thus reinforces the democratisation of R&D which started in the early 1980s, in particular in the United States, when computing power became accessible to small firms with the arrival of PCs and microprocessors. ICTs have reduced entry barriers thus allowing the large scale entry by small firms, and SMEs have increased their R&D investments. Some argue that most of the doubling of the R&D to GDP ratio in the United States between 1980 and 2000 can be attributed to SMEs (Hunt and Nakamura, 2006).

7. Policy implications

ICTs as transformative technologies

ICTs and broadband communications networks have diffused widely in OECD countries, most of which are now moving towards fully ICT-enabled economies. While ICTs have been employed for many decades, it is only relatively recently that widespread networking of ICTs has taken place across all parts of the economy and society. Networked ICTs are now an integral part of the economy, playing an increasingly pivotal role in an ever rising number of activities. This development has been enabled and greatly enhanced by the roll-out of high-speed broadband Internet. Notwithstanding achievements to date, the full potential has not yet been realised. Future technological and commercial developments will continue to extend the capabilities and reach of networks.

Broadband and ICTs more generally are general purpose technologies with a promise of significant and far-reaching growth impacts that may arise more quickly than from other GPTs in the past. Almost every aspect of economic activity and everyday life is already affected by broadband enabled ICTs, and with rapid technological developments and a continuous stream of new applications the pervasiveness of ICTs is likely to increase. While these developments are key to facing the longer-term environmental, energy, education, health and demographic challenges, there may be some short-term adjustment costs arising from associated structural changes, for example in employment and the geographic location of economic activities. It is important to accompany these changes by policies that facilitate and enable them while supporting the adjustment process.

Economy-wide impacts of ICTs and broadband

While it is important to optimise the macro-economic climate, the evidence presented in this report shows there is significant heterogeneity in the use of ICTs and broadband at the sectoral and firm-levels. As yet, not all the mechanisms are well understood and the role played by skills and other intangible assets in particular warrant further investigation. The studies discussed in this report also suggest that failing to achieve optimal diffusion and use of this enabling technology would mean a significant foregone benefit to society as a whole, in terms of productivity and efficiency gains and welfare gains.

The opportunities offered by the increased use of broadband may also help ease some of the major problems many OECD countries face. Flexible working practices enabled by broadband might help to increase labour market participation, and reduce problems related to transport (*e.g.* pollution and congestion). They could help address concerns related to the environment and aging populations, and ease bottlenecks in the health sector, for example by monitoring patients at a distance. Broadband-enabled organisational change and enhanced co-ordination help reap productivity gains from overall investments in ICTs, but they are also driving global restructuring and offshoring of goods and services production, raising the challenge of how OECD countries adjust to a new global environment with rapidly growing economies such as China and India.

Investment, innovation, competition and collaboration

Policies and practices encouraging innovation, investment and competition in the development of infrastructures and the delivery of services are necessary. Moreover, some barriers to advanced uptake and use may not yet have been resolved and would benefit from supporting policies. These policies should aim at reaching complete diffusion and mainstreaming of ICTs and broadband where this has not already taken place. A competitive business environment is also needed to stimulate innovation, the development and delivery of improved products and services and productivity gains in flexible and efficient markets. To help ensure sustainable economic growth and prosperity it is also important to resolve the digital divide of ICT use between and within countries.

The move to fully ICT-enabled economies will have direct and indirect implications, and many areas of policy are involved, going well beyond the roll-out of the physical infrastructure. Key elements of the infrastructure were not originally intended for the many and varied purposes they are put to today, which places strains not only on infrastructures but the regulatory environments in which they operate. In addition to economic policies, and broader considerations such as environmental challenges and aging societies, issues such as legal frameworks, security and privacy concerns, cross-border transactions and co-operation, and the protection of intellectual property will be affected.

Policy interactions will need to be carefully considered. For example, stimulating competition in the provision of broadband may be beneficial as it will reduce prices and encourage wider use. However, greater use requires greater supply, and hence it is important for policy to also consider the incentives for service providers to invest. Digital broadband content provision constitutes another example since increased content can bring benefits to businesses and consumers, but there is also a case for some content regulation, for example for consumer protection, the protection of children online, and to avoid harmful content and address security and privacy breaches.

Employment and skills impacts

Policies should aim to maintain open and competitive markets and to equip people and businesses with the tools required to exploit the opportunities offered by ICTs and broadband. This includes not only providing top of the range infrastructure and broadband at low costs, but also the skills required to maximise their use. Digital literacy is the key to being able to reap the benefits of ICTs and broadband. This is true for firms as well as for individuals and governments. This report has discussed the increasing amount of evidence suggesting that what matters is not having ICTs but how and where they are used.

ICT-enabled global restructuring, in particular of services activities, is also having an impact on employment in OECD economies. In addition to de-regulatory steps that improve the business climate, it is important to give people the means to re-skill in education and training programmes to respond to ICT-driven changes in labour demand. In the long-term, investing in knowledge and education is vital, and scientists, engineers and entrepreneurs can be considered to be engines of wealth creation in fully ICT-enabled economies. Investment in human capital is essential for the benefits of broadband to be realised fully.

Efforts to increase the stock of ICT skills, as well as science and technology-oriented skills more generally, need to start from a very young age, for example with mathematics teaching requirements in primary and secondary schools. Attracting more girls and women into these more technical fields is also important, especially in the context of the need to raise labour market participation in many countries. Providing financial incentives might be necessary in some cases to encourage people to take up certain types of training or consider career changes. On the side of business, competitive pressures should contribute to the profitable and innovative take-up of ICTs and broadband enabled networks, with the new business models these changes support. Broadband will also help enable the necessary organisational change to reap productivity gains from overall investments in ICTs.

The role of government(s)

The government's role in maximising the economic benefits of broadband is multiple. Governments not only help create the macroeconomic framework conditions for a favourable innovation and investment climate, but they also play an important role as regulators, standards makers, infrastructure providers, customers, and in research. Government funded basic research has often led to the development of ICT-related innovations, including TCP/IP, the web and the browser. Governments are now at the forefront of grid applications in research and in applying Web 2.0 to science as well as being major funders of basic research.

New broadband enabled technologies and platforms, products and services, skills and jobs continue to emerge, bringing about new and increasingly user-driven ways of consuming, producing and innovating. Additional investigation is needed to examine ways in which existing policies and legal frameworks can support and further stimulate these changes.

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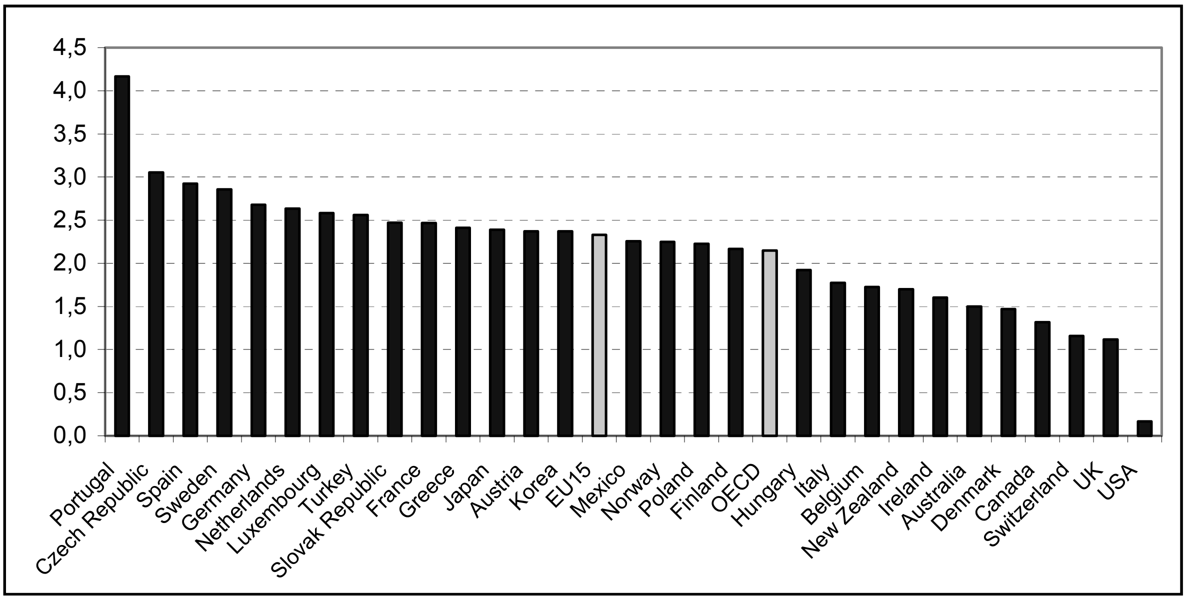
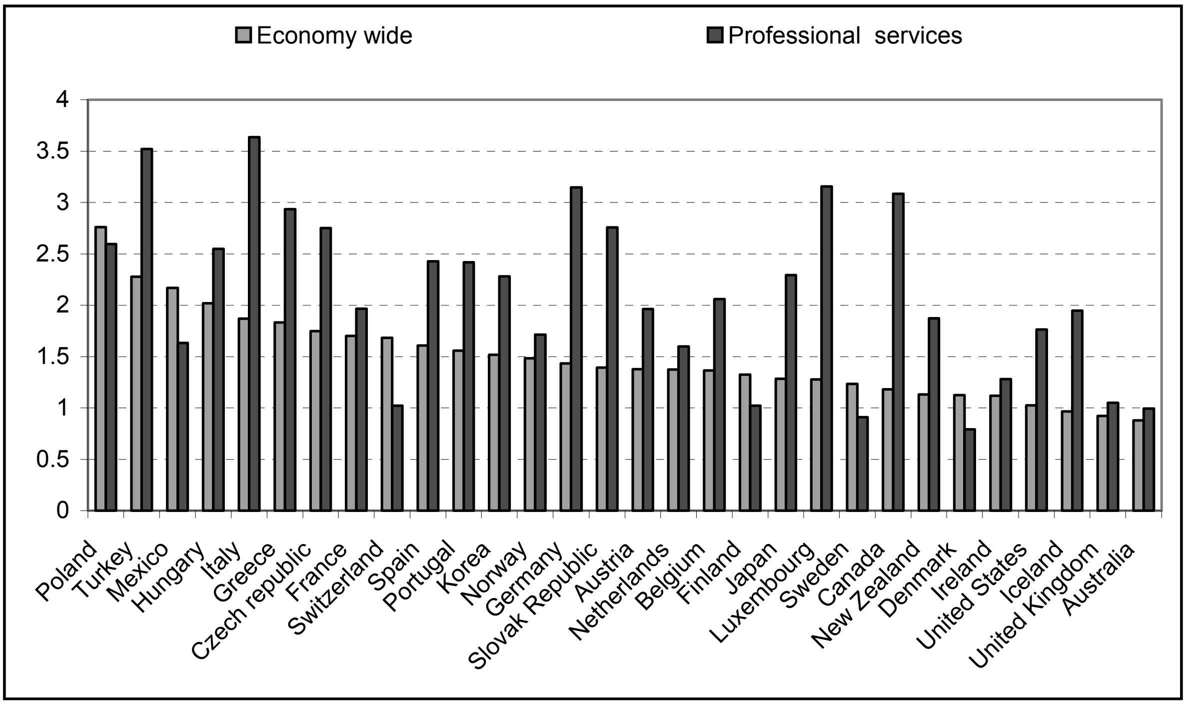
APPENDIX

Appendix Figure 1. Employment protection legislation indicator, 2006



Source: OECD.

Appendix Figure 2. Product market regulation indicator (economy wide and professional services), 2003



Source: Conway *et al.* (2005) and Conway and Nicoletti (2006).

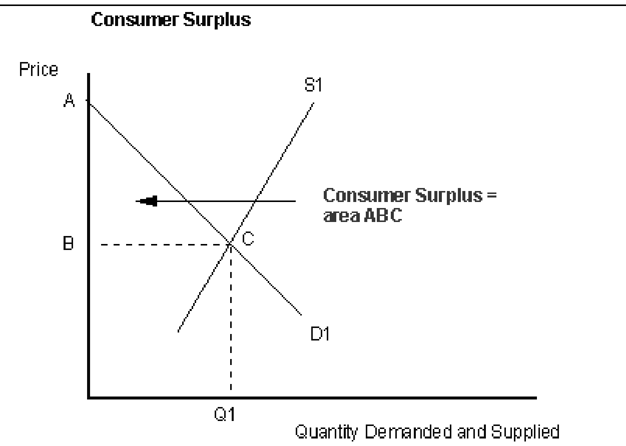
Appendix Table 1. Some examples of cable upgrades that took place 2006

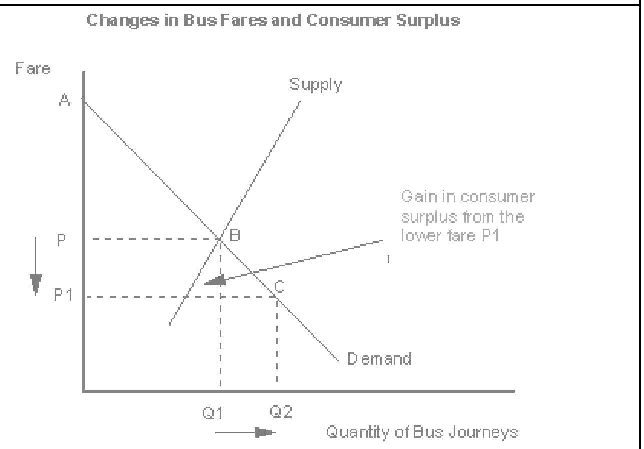
VSNL Transpacific, which at year-end 2005 had capacity of 460 Gbps and by year end 2006, that capacity had leapt up to 960 Gbps. (Potential Capacity - 7,680 Gbps)
South America-1, which is a Telefonica-owned ring around South America, that saw its capacity double to 160 Gbps by end of 2006. (Potential Capacity - 1,920 Gbps)
SAT-3/WASC, a consortium cable from Europe down the West African coast to South Africa, tripled its capacity by end of 2006 to 120 Gbps. (Potential Capacity - 185 Gbps)
FLAG Atlantic-1 increased its capacity from 320 Gbps at end of 2005 to 530 Gbps. (Potential Capacity - 2400 Gbps)
EAC, an Intra-Asian system owned by Asia Netcom saw its capacity increase to 160 Gbps at end of 2006. (Potential Capacity - 2,560 Gbps)

Source: http://gigaom.com/?p=8540&akst_action=share-this.

Appendix Figure 3. Illustration of consumer surplus

Consumer surplus: the difference between what consumers are willing to pay and the price they actually pay	Price decrease: consumer surplus increases





Source: http://www.tutor2u.net/economics/content/topics/marketsinaction/consumer_surplus.htm.