European Commission

Unlocking the ICT growth potential in Europe: Enabling people and businesses

Using Scenarios to Build a New Narrative for the Role of ICT in Growth in Europe

FINAL BACKGROUND REPORT

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1. Introduction

At the end of 2012 The Conference Board was asked by the European Commission's *Directorate-General for Communications Networks, Content and Technology Knowledge Base* (DG Connect) to help develop a new narrative for the role of ICT in growth, and for ICT policy in growth policies. The goal was to describe a "high level story" on the opportunities and constraints for the role ICT can play in growth, in particular in a slow growth environment, and to produce the "30,000 foot view" that facilitates high-level policy makers to frame the growth agenda. The work resulted in two reports: (1) the Main Report: *Unlocking the ICT growth potential in Europe: Enabling people and businesses – Using scenarios to develop a new narrative for the role of ICT in growth in Europe*, which contains the new narrative and the scenarios and (2) the present report, which serves as a ***Background Companion Report*** to the Main Report.

The present report provides background to our study methodology and details about the sources we used to build the scenarios. Below we present the insights from experts (Chapter 2), combined with findings from the literature (Chapter 3) and available data (Appendix 4), which were used to develop the key drivers, uncertainties and barriers that determine how ICT shapes economic and business performance. Using different combinations of those factors, we built a set of scenarios on how ICT developments and economic growth may relate to one another for the remainder of this decade (Chapter 2 in the main report, *op cit.*). Our study has also identified areas for future research to help shape the research agenda (included in Chapter 3 in this report).

Below we first briefly describe some of the overarching insights from the Main Report.

1.1. A new narrative

A new narrative is needed because there is a heightened urgency to act. Indeed, ICT developments are taking place at unprecedented, and ever increasing, pace. Europe must take action to be an important player in this space and avoid ending up in a "Digital Desert" (Section 1.3, as well as Chapter 2 in the Main Report on "Using scenarios to develop a new narrative for the role of IT in growth in Europe"), watching from the sidelines how other regions reap the benefits ICT offers. At the same time, Europe still faces economic hardship, including with extraordinary high levels of youth unemployment in some countries, in a context where governments are also facing pressures to cut or restrain public spending. It is therefore absolutely crucial that the European economy becomes more dynamic and competitive, and ICT-related policies can help, including by implementing changes that do not require additional spending but by reforming the economy in a way that allows ICT to become 'the great enabler' it can be. This includes putting in place the framework conditions to benefit from the opportunities new technologies can continue to create, by not only looking after the infrastructure and supply side, but also by increasing focus on enabling the demand side.

Faced with a fairly wide range of estimates on the possible effects of new investments in ICT on growth, some policy makers question the evidence on the size of the impact on growth or employment. For example, with uncertainty around the size of the employment multiplier of ICT spending, it is difficult to argue a precise case on the extent to which increased spending on new technology will put Europe's economies in a better position to create more jobs. It is important to realise, however, that pinning down the economic impact of new technologies and innovations is always highly uncertain. Even if the direct investment effects can be measured, the productivity effects of increased ICT usage are notoriously difficult to measure. Some uncertainty therefore remains on the exact quantification, also because the impact ultimately depends on how different trends combine in the medium term and is also highly dependent on the broader economic, social and political context. Indeed, scenario analysis shows that the way ICT will affect economic growth will depend on such key factors as the pace of global growth and the speed at which Europe can accomplish the completion of the internal market, especially the Single Market for Services and even more specifically the Digital Single Market (Chapter 2 in the Main Report on "Using scenarios to develop a new narrative for the role of IT in growth in Europe", in the report to which this report is a companion). It is also important to note that the impact numbers in current published studies (Chapter 3 in this report) are likely to underestimate the true impact.[1]

1.2. Urgency to act now

From the evidence we examined, it became clear that there is a real urgency to fix the barriers and to unlock the potential that exists in Europe. First, the ongoing shifts in economic activity in the global economy are also showing up in the greater importance of technology related fields in emerging economies. At the same, as many of the larger emerging economies are on a slowing long-term growth trend, the pace of increase in global demand is coming under pressure forcing Europe to strengthen its own role in driving growth and demand. And, thirdly, as the scaling advantages of new technologies and offerings (such as big data and broadband) increase, the limits of fragmented digital markets and a lack of integration among key user segments in services industries across Europe, are becoming an ever bigger constraint. Indeed, users (both consumers and businesses) will play an increasing role in driving the impact of ICT on growth so it is crucial that the use side is fully enabled (through integrated markets that allow for scale and competition, but also by having people equipped with the right skills, not only for using and exploiting today's technologies, but also those of the future). European companies and citizens need to be able to benefit from Europe's internal economies to exploit the opportunities offered by ICT and to secure Europe's role as a global economic power.

[1] Indeed, there is a substantial time lag with which required data become available. As the technologies, and their use and applications, evolve very quickly and become ever more powerful, the impact can be expected to substantially increase over time to, subject to adequate adoption and integration. International data standards on "ICT" are also on the low end of the capacity of the technologies out there, again suggesting that the actual impact may be greater than what is being estimated using official statistics. The quality of the use is also difficult to measure, adding additional uncertainty to the size of the impact, as the actual impact of the technologies will depend on the use that is being made of them. Finally, recent research suggests that spill-overs and networks effects are not being captured, or are not captured accurately, also suggesting the true impact may be larger than what has been found in the literature so far. In addition, there is some evidence from new research suggesting that the US might benefit more from these effects than Europe.

1.3. Risking a Digital Desert in Europe?

Current evidence gathered from the experts, published studies and the available data, indeed suggests that the EU is currently not ready to embrace and fully benefit from new technology-enabled improvements in efficiency, competitiveness, and other socio-economic developments. This evidence was also used to identify the main drivers, barriers and uncertainties around the impact of ICT on growth, and was then used to underpin the modeling of their effects through the use of scenarios, and identify the risks that need to be managed and the opportunities to be leveraged (Chapter 2 in the Main Report on "Using scenarios to develop a new narrative for the role of IT in growth in Europe", to which this report is a companion). One possible future scenario identified is the "Digital Desert". Box 1.1 looks at whether Europe is at risk of ending up in such a Digital Desert.

Box 1.1: Is Europe at risk of becoming a "Digital Desert"?

Certainly many of the experts we engaged with have strongly argued this case, and many of the reviewed studies echo this concern. Indeed, increasing consumer and business Internet and mobile communications demand, notably with data heavy traffic such as video, requires investment upgrades and capacity increases. Data also show the shift towards mobile and mobile broadband and confirm increasing traffic volumes. Yet Europe is experiencing under-investment in infrastructure[2] and the calls for increased budget for infrastructure investment as part of the Digital Agenda for Europe[3] (notably through Connecting Europe Facility loans) were significantly reduced in what was granted. Europe's weak economy does not help, and regulation is said to stifle network investments. In addition, a lack of consolidation of the industry in Europe means there are many players, many of which cannot grow to sufficient scale.

Like the experts, Beardsley *et al.* (2013) argue that investment is urgent to keep Europe from falling behind and risking its competitiveness. They argue that unlike in Europe, telecommunication "players in the United States and Asia have already made massive investments to upgrade network technologies, focusing particularly on replacing the last mile of copper with fiber networks, which are much better for carrying big data." In addition, they point out that not only is Europe's telecommunication industry now lagging that of the rest of the developed world in many measures, it is also at risk of falling behind many developing countries that are rapidly leapfrogging older technologies. Failing to address too low investment in telecommunications puts Europe's competitiveness at risk, unable to reap the productivity, growth, and consumer benefits.

Curbing this development, they argue, would require "revising the European Union (EU) regulatory framework to allow revenues, profits, and thus rates of investment to recover." While they

[2] For example, a recent Wall Street Journal article argues that "Europe is losing the 4G race - Once a Pioneer in Cellphone Technology, the Region Trails Asia and the U.S. as Regulation Threatens Network Investment" (Vitorovich, 2013). And a recent New York Times op-ed reports that "Over the last three years America's broadband systems have doubled in speed, while Europe's have remained stagnant. And that will continue, because broadband companies [in the US] are installing advanced fiber-optic technology faster than Europe, and most of the world's users of the fastest mobile broadband technology, 4G/LTE, live in America." (Bennett, 2013). According to that same article, much the recent growth in infrastructure is the result of the US system of "facilities-based competition" whereby each service provider is responsible not only for broadband service but also for the underlying infrastructure, which encourages them to improve network quality to win customers. In contrast, many European providers still depend on telephone wires controlled by the local phone company, thus leasing infrastructure they cannot improve. More countries are seeking to move to more network-based competition.

acknowledge that even though “some Member States and the European Union as a whole have taken some encouraging policy steps, only bolder regulatory reform can release the scale of modernizing investment in telecommunications that Europe needs today if it is to re-establish its competiveness and enable future economic growth and consumer benefits.” In addition, the old funding models for financing infrastructure will no longer work. Indeed, margins have been reduced by competition, but operators are reluctant to invest in the face of uncertainty about changes to industry rules, while also trying to figure out a new revenue model for the industry. However, speed is of the essence here – in every sense of the word. Europe needs high speed fixed and mobile infrastructure to meet new and increasing demand, and it needs it quickly to avoid falling behind other regions which are already rolling out and deploying next-generation high-speed fixed and mobile telecommunication infrastructures.

How bad can it really be? Let’s look at some observations plain for all to see, such as those reported by Beardsley *et al.* (2013):

- “European-based companies lost 21 percent of the total industry profit pool between 2006 and 2011 to companies from other regions.
- In the handset market, European manufacturers lost 22 percent of their worldwide market share to Asian and North American companies between 2007 and the first half of 2012.
- Today’s industry leaders on the services and applications side are mostly from outside the European Union. Most of the leading Internet companies—including Google, Facebook, eBay, Yahoo, Baidu, and Tencent— are based in either the United States or Asia.
- None of the 10 most visited Internet sites hails from Europe.
- Five times more telecommunications-related patent applications are filed in the United States than in Europe.”

The following slides also demonstrate a notable absence of European firms in several aspects of the ICT side of the digital world.[4] For example, the slide below lists the top 25 Internet firms worldwide by market value. There is only one firm from the EU27 (from the UK) among them, ranked 25th:

[3] See Appendix 3 for the policy background.
[4] From a presentation by Mary Meeker and Liang Wu at the 2013 Internet Trends D11Conference, available at: http://www.slideshare.net/kleinerperkins/kpcb-Internet-trends-2013

Market Value = Google + Amazon + eBay + Tencent + Priceline + Yahoo! + Yahoo! Japan + Salesforce.com + LinkedIn Gain Y/Y… Apple + Baidu Fall

Rank	Company	Region	2013 Market Value ($B)	2012 Revenue ($MM)
1	Apple	USA	$416	$155,971
2	Google	USA	311	49,958
3	Amazon	USA	127	61,093
4	eBay	USA	76	14,028
5	Tencent	China	74	6,957
6	Facebook	USA	73	5,089
7	Priceline	USA	42	5,261
8	Baidu	China	33	3,540
9	Yahoo!	USA	30	4,987
10	Yahoo! Japan	Japan	29	3,304
11	Salesforce.com	USA	28	3,050
12	LinkedIn	USA	22	972
13	Rakuten	Japan	17	5,558
14	Netflix	USA	14	3,609
15	Liberty Interactive	USA	12	10,054
16	NHN	Korea	12	2,121
17	Yandex	Russia	10	926
18	Tripadvisor	USA	9	763
19	Netease	China	8	1,301
20	Verisign	USA	7	874
21	Mail.ru	Russia	6	682
22	Mercadolibre	Argentina	6	374
23	Groupon	USA	5	2,334
24	Nexon	Korea	5	1,359
25	Asos	UK	4	899
Total			$1,375	$345,064

KPCB

2013 market value data as of 5/20/2013. Source: FactSet, Google Finance, Morgan Stanley Research. 81

There are also no European firms among the top vendors of PCs, notebooks, tablets and smartphones:

Top Vendors Largely Same in Desktop & Notebook Cycles – Very Different in Tablet (& Smartphone) Cycles

Desktop PC Market Share 2000

	% Share
Compaq	13%
Dell	11%
HP	8%
IBM	7%
NEC	4%
Others	57%

Notebook PC Market Share 2010

	% Share
HP	19%
Acer	17%
Dell	12%
Lenovo	10%
ASUS	8%
Others	34%

Tablet Market Share 2012

	% Share
Apple	51%
Samsung	13%
Amazon	8%
ASUS	5%
Lenovo	1%
Others	20%

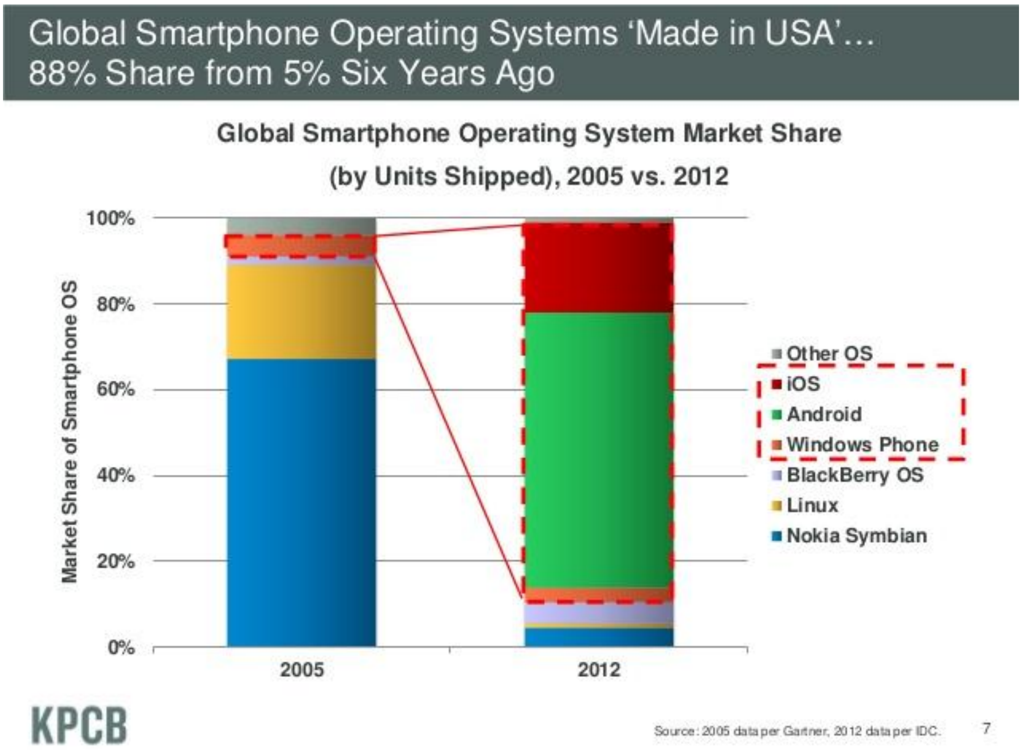
Smartphone Market Share 2012

	% Share
Samsung	30%
Apple	19%
Sony	5%
ZTE	5%
BlackBerry	5%
Others	37%

KPCB

Note: Notebook PCs include Netbooks.
Source: Morgan Stanley Research. Gartner. Data as of 4/13. 47

And European firms have lost much ground in the share of smart phone operating systems:



These observations, and it would not be difficult to come up with many more similar examples, speak loud and clear – unless Europe wants to find itself in a "Digital Desert", it needs to act now and step up its efforts to unlock infrastructure investments and to put in place the conditions it needs to benefit from what new technologies have to offer. Some progress has been made, as noted by Beardsley *et al.* (2013), notably in (i) supporting co-investment initiatives, (ii) allowing geographic diversification, (iii) providing public funding, (iv) maintaining the current wholesale price for access to "unbundled" copper connections, and (v) modernizing spectrum policies. They offer 4 additional ideas: (i) allowing a reduction in the number of fixed and mobile operators, (ii) allowing more price flexibility, (iii) restricting wholesale access regulation to a few basic services, and (iv) giving operators more spectrum in which to operate.[5]

In the current depressed economic climate characterised by downward pressure on government and European spending, implementing reforms that will safeguard having the infrastructure that will be absolutely key to ensuring future European growth and competitiveness is surely a cost-effective way of acting for a better future.

[5] In a similar vein, the Financial Times reported the 23rd of June 2013 on a letter from European telecoms executives to Mr Barroso, President of the European Commission, calling for "for a fundamental rethink of proposed market reforms, advocating deregulation of the market to secure future investment," and, specifically, for "the relaxation of regulations stopping mergers; the removal of fixed broadband network access at a wholesale level to rivals; and the end of "unequal treatment" of technology companies that have been able to exploit tax loopholes." According to the FT, the letter also stresses the European companies' sentiment that they are being stifled by excessive regulation preventing them to reach scale (and putting them at a competitive disadvantage relative to countries where consolidation provides greater scale, and that concerns about the need to upgrade the infrastructure (notably with investments in fibre and 4G networks) are not being heard. (http://www.ft.com/intl/cms/s/0/736fd224-dbe8-11e2-a861-00144feab7de.html#axzz2X6Uce7lO)

Commissioner Kroes, in charge of the Digital Agenda, has called for what some would consider "bold" measures. On the 30th of May she called on the European Parliament to end to mobile roaming charges in the EU by the time of the next European elections in 2014, and also argued that mobile network operators should no longer be able to block telecommunications services such as Skype. Commissioner Kroes said she would "fight with her last breath" to achieve this goal, which will directly help European citizens and businesses. Ms. Kroes argues that The Single Market is "the Crown Jewel", and that for the telecommunications sector in particular, borders should be meaningless. On the 4th of June 2013 Ms. Kroes also announced she would launch the first EU-wide strategy on net neutrality over the summer, arguing that "new European rules on net neutrality will oblige Internet service providers to be transparent about connection speed and stop blocking competing services such as Microsoft Corp.'s Skype". Ms. Kroes argued that "the strategy would provide 'a safeguard for every European, on every device, on every network—a guarantee of access to the full and open Internet.'" The telecom companies argue that rather than more rules and legislation, "Investments in additional capacity and technical solutions to meet growth in Internet traffic needs should be matched with operators' freedom to develop new economic models in the market." (Robinson, 2013)

In our engagements with the experts, all have stressed that ICT, and the Internet and the network-based innovations it enables, have reached a depth and breadth of scale and impact that no one can afford to ignore, businesses and governments and policy makers in particular. And yet… All of the experts also agree that Europe currently does not appear to be ready to embrace the changes taking place, and the promise of bigger changes ahead. However, while policy makers in Europe debate the size of the impact, other countries are steaming ahead and Europe is at risk of losing its competitive edge, something no country or region can afford to do.

It is important to realise this is happening, and happening fast. There are certainly issues about how to measure and quantify impacts that should not be ignored (Chapter 3.1), but the reality is moving fast, and will go ahead whether Europe decides to be a part of it or not. Europe can either act now and do the best it can to safeguard its competitiveness going forward, or it can wait, discuss, analyse, and debate some more, and let other countries run ahead and reap the benefits, potentially jeopardizing Europe's future competitiveness. The fast moving pace of change presents challenges to policy makers and regulators, but the time to act is now.

2. Insights from engagements with the experts: elements of a new narrative

2.1 Setting the stage

Europe's economic and social woes appear to be ongoing and policy makers search for solutions to take the economy out of recession in the short run, and to resume a healthier structural growth path for the medium and long term. A key part of the solution to generate faster growth is to unlock the existing ICT growth potential in Europe, enabling a larger role for technology and innovation, and its translation into the production of more and better goods and services, at lower prices, for Europe's domestic markets and the global economy.

But all that is easier said than done, especially given the current European economic environment that is threatened by short-term concerns of financial instability and budget constraints, and that suffers from a long term structural growth deficit as the result of incomplete market integration, lack of scale and weak incentives for greater competition. European citizens are well-connected, businesses that use ICT have generally improved their performance, and growth of the ICT sector has been reasonably strong in the past two decades. But it is urgent to act now to avoid the risk of falling behind if no serious policy action in the area of ICT is undertaken. Europe is at risk as its hard and soft infrastructures do not seem ready to cope with the future demands and requirements from the next technology and ICT wave. Market fragmentation continues to hinder firms in scalability, flexibility and being cost-effective. Businesses, and small innovative firms in particular, are discouraged by the many barriers they encounter, and which can be summarised according to three main pillars:

- Incomplete hard and soft infrastructure: shortage of high speed affordable and ubiquitous fixed and mobile broadband, network capacity, but also skills (including technical, user, and IT savvy business/entrepreneurial skills);
- Constraining framework conditions: fragmentation of markets, excessive and complex regulation, difficulty in obtaining finance, especially for smaller, riskier, and more innovative initiatives;
- A lack of readiness and willingness among business and citizens to adopt and integrate new technologies and applications, and the transformations they enable.

It is not possible to know or even imagine today all future impacts of ICT: some impacts will materialise over time, new impacts and channels will emerge, the technologies will continue to evolve, and new ones with new applications will come along (Box 2.1). Quantifying existing impacts remains an uncertain exercise (due to multiple reasons laid out in Chapter 3.1), and even if there are some doubts as to the size or direction of certain effects, the current economic struggle that has followed the financial crisis presents an opportunity for reform that should not be wasted.

As part of the process to identify important trends and uncertainties and the way they influence the impact of ICT on growth we engaged extensively with a number of experts from the business, academic and policy communities. Appendix 1 provides more detail about our study approach and details about the engagements with the experts, and Appendix 2 provides the lists of experts who participated in the various engagements.[6] We started the engagement process with a series of individual interviews (conducted over the telephone) where we asked each expert a series of questions, shared with them ahead of the interview. We summarised the information collected from these individual interviews in 'gross lists' of drivers and barriers which we then sent back to the experts, asking them to rank their top 5 in each category. The results are discussed in this chapter. Appendix 1 provides more details about this exercise, including the questions asked and the 'gross lists' of drivers and barriers we asked the experts to rank.

Box 2.1: Main "ICT trends" – what did the experts say?

Most experts listed high speed Internet, broadband and mobile broadband and "the cloud"[7] among the top ICT trends with the biggest economic (and social) impacts. The shift towards 'everything mobile' and 'always on everywhere' was deemed to be one of the main transformations that form part of the current ICT wave. In addition, developments such as ever increasing computing power, the advent of new –and 'smart' devices, combined with ever more storage, higher bandwidth and improvements in battery power collectively make technology more accessible and useful, generating more benefits.

Experts highlighted the importance of affordable high-speed ubiquitous Internet, increased functionality and capacity of the network, and "The Internet of Everything"[8]. There are many business implications from these trends. For example, ubiquitous real-time connectivity, combined with sensors, transforms supply chains and supply chain management. Big data was also consistently mentioned as an associated trend that will be truly transformative, in ways that cannot even be imagined today. Some businesses have already emerged figuring out new business models to generate business opportunities from the analysis of this new knowledge and information, and more will emerge. Big data analytics and data mining are seen as a new driver of innovation and competitiveness, and a factor that will distinguish businesses in how successful they are, especially in reaping the benefits from ICT. The implications of widespread use of the cloud and cloud computing are also profoundly transformative and "cloud computing is historically unique by simultaneously being an innovation ecosystem, production platform, and global marketplace" (Kushida *et al.*, 2012, 2011).

"Everything Mobile" is another closely related trend: mobile broadband, mobile Internet, mobile computing and mobile communications, will also radically change the way people live and work, shop, interact, and just generally go about their day-to-day life. Adding increased use of social media,

[6] We are very grateful to all the experts who have participated in our study project and who have generously donated their time and insights.

[7] One useful definition of 'the cloud' is as follows: "The provision of computing infrastructure, platform or application service as a utility, which can be consumed by any Internet connected device, using open standard protocols where variability in demand is satisfied through the dynamic and automatic provisioning of pooled hardware, network, and software service resources providing the illusion of infinite scalability and are generally billed for on a pay-as-you-go basis." Thus, there are essentially three layers of cloud computing: Infrastructure as a Service (IaaS), which is a computing resource management model; Platform as a Service (PaaS), which is a software development model; and Software as a service (SaaS) which is an application delivery model. Source: http://www.adamalthus.com

[8] For example, Cisco's John Chambers refers to the Internet of Everything as "the intelligent connection of people, processes, data, and things" (Bilbao-Osorio *et al.*, 2013).

including by businesses,[9] brings another layer of economic and social opportunities to the trend. For businesses too it will profoundly change the way work is organised and will transform the interactions with clients/consumers, suppliers and the workforce. The impacts on business-to-business interactions are expected to be large, but potentially dwarfed by how business-to-consumer relationships will change. Examples include (targeted) mobile advertising, mobile payments and mobile shopping, location-based services, and price and product comparisons. The visualisation of big data, knowledge, and information is seen as the next related trend. Being able to extract what is important from the gigantic volumes of data that are being generated, especially to be able to use it in real-time for business and policy decisions and for creating new business opportunities and improving policy making and the delivery of public services, will be a crucial capability and skill going forward. It creates new business opportunities for those who can 'make knowledge visible'.

Among the 'next trends', experts talked about the emergence of "Offering anything as a service", for example with people renting out a room or parking space they don't need, or don't need during certain times,[10] jet airplane engines that can be rented by the hour rather than having to buy them, and the increasing commoditisation of IT, including of IT-related services. Experts also speculated about the future of wearable computers, an emerging trend which has already seen the advent of the Google Glass and a range of fitness-tracker wrist bands. Apple is reportedly looking into watch-like devices, and other companies, including "non-IT" companies, are also toying with the idea. Even though there is much debate and speculation about what wearable computing will look like in the future, and if and how people will adopt it, "among the digerati, real-world uses for wearables are emerging" (Rusli, 2013). A next trend is also increased use of scanning and "scannables", e.g. the use of QR codes, for boarding passes, admission tickets, reward vouchers, payments, product information, nutritional labeling, price comparisons, and so on. The use of "flyables", such as mini-drones, could also be expanded, for example for capturing images at large events, crowd surveillance, first investigation after chemical accidents or other disasters, and crop surveillance in agriculture.

Other important emerging trends that were mentioned by the experts included increasing importance of voice recognition, the possibilities created by tracking eye-movements, increased customisation with real-time data on behaviour, for example, as well as Artificial Intelligence, agent technology and the performance (analysis) of systems, robots, machine learning, the Watson Computer, the driverless car, nano-technology, the miniaturisation of IT, leading to body-embodied-technology applications and a blurring of the boundaries between man and machine. Finally, 3D printing was also often mentioned, transforming manufacturing, and blurring the boundaries between manufacturing and services, for example by selling people the design for an object they can print rather than buying the object, with increased possibilities for customisation, and innovation in business models.[11] However, 3D printing has also received some negative press recently with the 3D

[9] Examples include the incorporation of social media features into digital communications, location-based services, mobile transactions, and products and services, with for example "like" buttons and options, location check-ins, and customer feedback and reviews.

[10] What The Economist referred to as "the rise of the sharing economy". See http://www.economist.com/news/leaders/21573104-Internet-everything-hire-rise-sharing-economy (last accessed 6 June 2013).

[11] 3D Printing is already being used in manufacturing, in some cases in what may seem surprising areas. For example, a representative for Mattel Inc., the company that makes Barbie and other toys, argues that 3D printing "allows [them] to be far more productive, efficient and innovative in designs". The Ford Motor Company is using 3D printing to prototype automobile parts for test vehicles, but also has a vision for the future where, for

printing of a gun and bullets capable of being fired. Some experts also pointed out that the “new” is not always found in “new products” but could also come from linking existing technologies and creating ‘”new combinations”.

In terms of the impacts and impact channels, the “change in the direction” was generally considered an important shift, with ICT becoming increasingly interactive and multidirectional. Collaborative tools and (work) organisational tools were also viewed as transforming the way businesses operate and organiser their work. Some of the ‘first generation benefits’ of IT have come from the automation of routine tasks. Today important benefits are being derived from people being able to work together in unstructured processes and communication using these new tools.

There are also some risks and uncertainties associated with these trends, and whether or not they will deliver on the promises they hold. These include: network capacity and the availability of spectrum, interoperability, regulation and legislation, privacy and security related issues, trust, and more broadly, the attitudes and willingness to adopt and use new technologies and applications, societal barriers – technology changes faster than people, and some more philosophical considerations about norms and values – what do we really value the most, or more, in our economies going forward? Governments and the European Commission have a big role to play in managing these risks and uncertainties and can take action on a number of them to ensure they do not hold back on the potential economic and social impacts and benefits of ICT.

2.2 Identifying the drivers of ICT growth impacts

There is a substantial degree of technological readiness in Europe, even though there are also some significant differences across individual countries as illustrated, for example, in the Global Information Technology Readiness Report’s ‘Network Readiness Index’ (Bilbao-Osorio *et al.*, 2013, and Appendix A4.1.4). It is very important not to be complacent and to keep investing in infrastructure to upgrade to high-speed networks and to embrace new technologies that enable faster Internet services such as surfing and video streaming for computers, tablets and smartphones, shown to represent a huge share of digital content (Appendix A4.3). There are concerns that while Europe was once a leader, it may now well risk becoming a laggard.[12] The experts have stressed that a lack of consolidation in the industry, with too many operators, and restrictive regulation together have resulted in underinvestment. This is a crucial point to address as having the infrastructure is a

example, “customers will be able to print their own replacement parts. Theoretically, a customer could log onto the Web, scan a bar code or print up an order, take it to a local 3D printer, and have the part in hours or minutes.” General Electric’s Aviation unit prints fuel injectors and other components within the combustion system of a jet engine, likely to be used on planes in the future. “Researchers at GE say that 3D printing could help cut the costs of manufacturing certain parts of the probe by 30%.” Of course there could also be some risks associated with these developments. For example, at Mattel they (currently) “draw the line at selling consumers software files that would enable them to print out their own toys on low-cost 3D printers as the company couldn't guarantee toys that consumers printed out would be safe for children, a "topic that the entire toy industry will have to face and embrace" as 3D printer use broadens at home.” (Boulton, 2013).

[12] This phenomenon is sometimes referred to as the “Law of the handicap of a head start” (http://en.wikipedia.org/wiki/Law_of_the_handicap_of_a_head_start)

pre-requisite to reaping the benefits of ICT and the innovations it enables, and it was also mentioned by the experts as one of the key 'technology' drivers of the impact of ICT on growth (Box 2.2).

Box 2.2: Some results from the expert rankings – main drivers of ICT impacts

A 'gross' list of main drivers, in 3 categories was established on the basis of the individual interviews with experts, who subsequently ranked them for discussion during the video conference (see the full list in Appendix 1). The main drivers identified in each category are listed below:

- Main 'technology' drivers:
  - The Cloud (definition *op cit.*)
  - Mobile Broadband
  - The Internet of Things[13]
- Main 'technology enabled use' drivers:
  - Big data/big data analytics and synthetics, data-driven innovation
  - Innovation in services and apps
  - Network based innovation, including: (1) ICT-enabled organisational and business model changes and innovation, (2) and Network and ICT-enabled product, process and supply chain innovation
  - ICT-enabled start-ups
- Main 'technology enabled demand' drivers:
  - Ubiquitous connection: high-speed and always on
  - ICT no longer a 'technology' but a 'utility' (like electricity, gas and water)
  - Households and consumers adopt earlier now than business
  - Cheap access

2.3 Identifying the barriers to ICT growth impacts

In addition to ensuring the right infrastructure is in place, it is also crucial to continue to encourage the diffusion, uptake and integration of ICT, notably in (smaller) businesses which have been shown to lag (Appendix A4.1.3).[14] Today it appears that, often, consumers are more eager and show a greater readiness to adopt new technologies, applications and devices than businesses. Thus, while the technologies and applications exist, there is often still a lack of societal or cultural readiness, which can include factors such as corporate or organisational culture, in businesses, as well as the public sector. It is thought that the arrival of the younger generation of Millennials in the labour force

[13] This concept refers to the fact that more and more objects (things) objects are embedded with sensors, enabling them to communicate with each other, or to and via other devices.

[14] Eurostat figures indicate that firms in Europe are making slow progress in adopting ICT for e-business integration (Giannakouris and Smihily, 2013). While most firms now use computers and have an Internet connection, perhaps even a web site, the use these are put to varies greatly (and is often not very sophisticated when it comes to transforming the way business is done). The rate of adoption decreases with the level of sophistication of the e-business technology (Appendix A4.1.3 Figure A4.7). The gap between large and small enterprises also increases the more advanced the ICT applications are (Appendix A4.1.3 Figure A4.8), which, given the prevalence of small firms, should be of some concern to policy makers and business leaders.

will also drive business adoption of technology as this generation will expect to be able to use the latest devices and technologies at the workplace (Mitchell, 2013).

Many of the bottlenecks are related to the implementation and adoption of the technology, not the technology itself, in turn often related to regulatory barriers and various types of skills barriers (such as a lack of vision and a lack of entrepreneurial skills and/or technical skills and awareness). Resolving the fragmentation of the European market resulting from the non-completion of the Single Market for Services and the Digital Single Market is crucial. It prevents companies from being able to achieve scale quickly, and adds to remaining fragmentation and inflexibility in labour markets, preventing companies from (cost-)effectively hiring the skills and talents they require. Empirical work has also confirmed that restrictive product and labour market regulation hampers the growth and productivity effects of ICT (for example, Bloom *et al.*,2010; see Chapter 3.1.1 for more details). All of these factors were also mentioned by the experts as important barriers to the impact of ICT on growth (Box 2.3).

Box 2.3: Some results from the expert rankings – main barriers to ICT impacts

A 'gross' list of main barriers, in 3 categories was established on the basis of the individual interviews with experts, who subsequently ranked them for discussion during the video conference (see the full list in Appendix 1). The most highly ranked barriers in each category are listed below:

- Main 'education and training' barriers:

➢ A lack of skills, and/or the wrong skills, in particular: (1) the management culture and lack of entrepreneurial skills, (2) ICT skills (especially: professional skills, skills to design high-level services and build apps, ICT users, e-leaders/e-business skills), and (3) language skills (use English as a 'common language')
➢ Outdated education systems and educators, not equipped to produce the right skills
➢ Lack of a clear common Long Term vision for Europe that people adhere to on how and why ICT should be used and integrated
➢ Lack of awareness of potential of ICT in Europe
➢ Many IT projects fail (because they are badly/not thought through, no vision or strategy what should be done once IT is in place, lack of skills) – it has given IT investment projects a bad reputation[15]

- Main 'organisation and cultural heritage' barriers:

➢ Lack of entrepreneurship (including cultural barriers and structural barriers: administrative barriers, access to finance, and lack of a supportive eco-system)
➢ Existing technologies and capabilities not fully exploited (including: lack of skills, ignorance, fear of IT, risk aversion; organisational structures of organisations; rules and regulations)
➢ Bringing new products (goods, services, apps) to market – Europe is not good at this[16]

[15] A recent example of a failed IT investment project is the BBC deciding to pull the plug on its Digital Media Initiative, the project to digitise its archive, after it had already cost GBP 98.4 million, but still failed to deliver. See, for example: http://www.theguardian.com/media/2013/may/24/bbc-digital-media-initiative (last accessed 6 June 2013).

- ➢ Access to venture and angel capital: very difficult to get money for small innovative projects
- ➢ Legacy technologies/legacy systems and investments
- ➢ Available EU funding and support mechanisms too cumbersome for small players

- Main 'policy' barriers:

- ➢ Fragmented legal and regulatory frameworks not adapted to this digital age
- ➢ SME rules, regulation and legislation - need to be harmonised and changed - especially bankruptcy laws (must be 'allowed to fail' and still get to try again)
- ➢ Lack of flexibility (and mobility) on the labour market
- ➢ Not enough focus on developing demand side and use, too much focus on infrastructure
- ➢ Too much red tape (for creating a business/entrepreneurship/start-ups, to recruit, to get funding)

2.4 The important role for ICT-related policies in growth policies

Some additional arguments brought up by the experts, highlighting the importance of the role for "ICT policy" in growth policy, included:

- If nothing is done, one thing is sure: Europe will end up missing the boat on many of the benefits ICT can offer in the economy and society as a whole, and put its own future growth, innovation and competitiveness, as well as living standards for European citizens at risk. While some of the benefits or their quantified impacts may still be uncertain, what is certain is that doing nothing will jeopardise Europe's future prosperity (and risk ending up in a "Digital Desert").
- Many of the measures required are actually cost saving measures: they may reduce costs in the public sector and throughout the economy, and improve efficiency, productivity and effectiveness – all good arguments, especially in climate of austerity.
- Unlocking Europe's potential is largely related to removing barriers (regulatory, but also skills-related or cultural barriers, for example) and dealing with regulatory issues more generally, not all of which involves making big investments. More can be done with what already exists, in a "less is more" way, for example by reducing red tape, making information readily available, and by simplifying and harmonizing rules and regulations. This will reduce the costs businesses incur having to deal with administrative issues, and will help SMEs in particular.
- Enabling entrepreneurs also includes helping to facilitate access to capital for small initiatives and ventures, including EU funding – which is currently biased towards large players and large projects, harmonizing and changing bankruptcy laws to be

[16] Veugelers (2012) found that "the problem in Europe appears not to be so much in the generation of new ideas, but rather in bringing ideas successfully to market. Among the barriers are the lack of a single digital market, fragmented intellectual property regimes, lack of an entrepreneurial culture, limited access to risk capital and an absence of ICT clusters."

more suited to the new digital age, and facilitating mobile payments and cross-border transactions , including for small amounts. This will create a more dynamic and entrepreneurial business environment in which entrepreneurs can experiment (these last two bullet points, unlocking the potential and enabling people and entrepreneurs, may help to bring Europe towards a “Digital Rainforest” type scenario).[17]

Of course, some of the measures that are needed to unlock Europe’s potential also require smart and targeted investments, such as in infrastructure, education and skills. These investments will compete with other spending objectives. However, it is very important to note that (1) these investments, for example in infrastructure and skills, are a pre-requisite to benefiting from ICT and securing future competitiveness and growth in Europe, and (2) that these investments will come with associated multiplier effects throughout the economy, thereby providing a bigger return than that from just the initial investment. Indeed, having a high quality ICT infrastructure is crucial as it constitutes a platform for innovation and competitiveness in all sectors of the economy going forward. Without continued or even increasing innovation, growth in Europe will dwindle further. In today’s world, much innovation requires an ICT infrastructure – hard and soft – to produce the innovations that will lead to growth and job creation. Not making these investments and reforms now is putting Europe’s future at risk, especially since other countries and regions are blazing ahead.

2.5 Unlocking the existing potential requires an ‘across the board’ approach

There is a tremendous amount of ICT-related potential in Europe that experts feel people are not necessarily aware of. The crux will be in unlocking this potential and in enabling people and businesses to fully exploit the opportunities ICT can enable and create.

Unlocking this potential will require an ‘across the board’ approach. Indeed, today ICT affects and impacts almost every area of economic and social activity, and this is also reflected in the policy measures and actions that are required and that will have to come from almost all directions – government departments and ministries, and Directorate Generals and the European Commission. Indeed, unlocking the potential of ICT requires efforts from all departments to incorporate ICT related measures into their strategies: actions will be required from economics and finance departments, legal and justice departments, competition authorities, regulatory bodies, education and health departments, and government itself.[18] No single measure will be effective on its own – it

[17] These points would also help to address the concerns expressed by a number of Digital/Web Entrepreneurs who have provided input for this report (Appendix 2), and who voiced strong concerns about the barriers formed by factors such as excessive and/or uncertain and complicated regulation, regulation that is ill-adapted to new technologies and innovations thereby creating new restrictive hurdles, difficulties for small firms in particular in getting finance and procurement contracts – including from public sector bodies and the European Commission, difficulties in getting people with the right skills – especially when this would involve recruiting across borders, and a general concern with policy too heavily influenced by the large players and incumbents with strong lobbying power.

[18] Consider a few examples. At the European Commission, DG CONNECT deals with a multitude of ICT-related issues, including ICT policy, infrastructure, e-government, e-health, and digital inclusion. DG Research weighs in on the research aspects. DG Enterprise and Industry works on the diffusion of ICT to business and e-issues for competitiveness and innovation. Education departments and ministries are important for e-education, ICT in education, and of course general education and skills development – ensuring the employability of graduates and limiting skills gaps, in turn closely related to employment departments and ministries, and so on

is absolutely crucial to have a comprehensive and coherent long-term ICT strategy that cuts across all departments, and that all stakeholders adhere too – this point was also repeatedly stressed by the experts. The Grand Coalition for Digital Jobs[19] launched in March 2013 as part of the Digital Agenda for Europe (Appendix 3) is an example of an initiative that has led several of the European Commission's Directorate Generals to collaborate (in particular: Connect, Education, Employment and Enterprise) towards a common goal. The Grand Coalition initiative is a multi-stakeholder partnership led by the European Commission "to tackle the lack of ICT skills and the several hundred of thousands of unfilled ICT-related vacancies." More initiatives to work together on common goals and strategies, involving more and different combinations of Directorate Generals are needed to be able to address the digital and economic struggles Europe is currently facing in a comprehensive and coherent manner.

2.6 Examples of what governments and the European Commission can do

The role of governments and the European Commission, respectively, is crucial, notably in laying out a vision, reforming and investing where necessary, putting in place favourable framework conditions, using public procurement to further innovation, and leading by example:

- It is important to articulate a broad and cross-cutting vision that all departments can adhere to: (1) Where does Europe want to be 10 years from now? (2) What does it take to get there?
- Removing any regulatory barriers that are impeding businesses and people to unlock their potential (in some cases this may mean removing regulation that is hampering innovation and/or the transformation and dynamics ICT can bring about, in other cases it may mean regulating for these changes to occur). Regulation also plays a vital role in the performance of "the ICT sector" (Katz, 2011, and Box 2.4). It is also important to be aware of a risk of over-regulating, which will stifle innovation (for example when it prevents transformations or a learning process, and/or leads to unnecessary duplication), while some regulation will also stimulate innovation (by creating incentives, and/or allowing innovators and or those who take risk to capture at least some of the initial rent). In addition, we do not yet know all the future impacts of existing technologies, let alone of what comes next, so caution is required to not regulate things that are not yet fully understood as this may also create unintended side-effects that may not be desirable. In some cases it may be better to start off with some common sense rules or guidelines or codes of conduct for proper use, and let the technology evolve before trying to regulate 'into the future'.
- Dealing with funding and finance issues, including through public funding for research, which is often biased towards the large players, and against smaller, riskier and more innovative players and projects. Obtaining European funding in particular may be so complicated and costly (in terms of time and administrative procedures) that especially the smaller players just give up. The public sector can also fund more basic/fundamental and/or blue sky type

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for other departments, including Competition for competition and Single Market related issues, and Justice for issues related to e-commerce, online and/or dispute resolution, consumer protection, and cyber-security. Somehow, these and other departments and bodies, such as regulatory authorities, have to all come together more and work together towards a common goal, based on a common long-term strategy that all can adhere to and buy into.

[19] See http://ec.europa.eu/digital-agenda/en/grand-coalition-digital-jobs-0 (last accessed 7 June 2013).

research that might otherwise not find funding. It is important though that this funding is not biased in favour of incumbents, does not exclude small players and newcomers, supports technologies and applications rather than companies or business sectors, and that this funding takes these ideas closer to being able to bring them to market. Countries like the US and Israel have benefited from military-funded research. In European countries governments and the European Commission could step in to fill that space. One of the experts suggested the creation of "Transformation Zsars" who would act as the liaison, be a central focal point, in working together with the education sector, the corporate sector, and the research community to identify some key technologies and work on bringing this research to market, thereby driving innovation. Every country would need such a "transformation officer", and these officers should meet regularly, reporting to high-level government officials, and being evaluated against a set of clearly defined objectives to track progress. Emphasis would be on operation and execution, keeping the momentum going, aiming for short cycles.

- Putting in place the required framework conditions, such as the right investment climate and the right conditions to stimulate entrepreneurship and a dynamic business environment, as well as the hard and soft infrastructure, i.e. including ensuring the workforce is equipped with the right skills. It is crucial to allow for the creation of scale effects. This can take place at many different levels, for example by achieving the Digital Single Market in practice, creating a single market for content, by reducing barriers and by harmonizing regulation to reduce fragmentation in the markets which will create the scale that is necessary to benefit from network effects, or by increasing the use of English which may contribute to creating scale in the market for talent, especially if this is also combined with reducing barriers to cross-border recruitment and increasing the flexibility of labour markets. Removing barriers for firms, and SMEs in particular, to grow internationally is crucial as this will provide them with the scale they need to be able to grow. Reducing barriers to entry in markets is also an important aspect of getting the framework conditions right and ensuring healthy levels of competition, including by reducing the power of incumbents.
- Use public procurement to drive innovation and encourage the uptake of ICT. This can be done in a variety of ways. At a basic level, the adoption or delivery of certain technologies or application could be part of the specifications of procurement contracts. Governments can also reform their procurement practices and consider purchasing more from small and innovative companies. Procurement practices and procedures would also benefit from significant simplification, which may also make them more accessible to smaller companies.
- Lead by example: the public sector should move much of their activities online (more "e-government", more online public services, etc., implemented in a way that will also lead to an increased uptake of these services by citizens – see Chapter 3.3), re-organise and streamline their administrations, adopt new technologies and solutions, equip their worker with the right skills and include more IT-savvy people in government, including in high positions.

Box 2.4: The Impact of Public and Regulatory Policy on ICT Sector Performance

Katz (2011) argues that public policy is critical to the development of a high-performance ICT sector. Furthermore, even though the types of policies and practices may differ across countries, best practices are found to be relatively common across nations regardless of the specificities of the political system.

Key findings include:

- Government policy plays a critical role in enhancing performance of the ICT sector. The performance of the ICT sector (measured in terms of ICT adoption, quality, product innovation, and consumer benefit in terms of lower prices) is found to be statistically linked to **the adoption of pro-competitive policies**, guaranteed by regulatory independence and guided by an overarching vision for the ICT sector.
- The development of appropriate competition models for the telecommunications sector is a critical driver of sector performance. **Healthy competition** will lead to cost reductions in services offered and stimulate investment and innovation. Related measures include, for example, having mobile number portability, which, by reducing customer switching costs, increases the likelihood of product innovation, which results in more intense launch of mobile data applications. Similarly, case studies showed that platform-based competition is the primary driver of broadband development in Japan, Korea, and Sweden. However, sustainable competition embodies the presence of two or three vertically integrated players with sufficient capacity of innovation and investment. Limited competition resulting from a highly concentrated industry structure acts as an obstacle for the development of broadband, as in Mexico.
- **Telecommunications policies need to be integrated within an overall vision and blueprint of the target ICT sector**. This includes all other elements of the eco-system, such as software applications, content development, and computing. Examples of countries where telecommunications policy is generally inserted within a comprehensive framework linking the telecom sector to IT services include China, Korea, Estonia and Japan.
- **Infrastructure-oriented policies need to be combined with an emphasis on demand-side policies to stimulate ICT adoption**. Countries that have successfully implemented demand-side policies focused on enhancing digital literacy, subsidizing access to the disenfranchised, and developing applications that promote adoption include Sweden, Estonia and Korea.
- **Proactive and continuous government planning** is a key lever to drive performance improvement. Better ICT sector performance was positively linked to a commitment to the development of high-level planning combined with detailed multi-year sector planning in Sweden, Korea, Japan and Estonia, and that the likelihood of planning success increases with management practices, including disciplined follow-up and appropriate channels of communication between the public and private sectors.
- Policies and government planning need to be complemented with leadership and ownership from the executive branch. **Assigning the development and monitoring responsibility of the digital agenda to the highest levels of the executive branch** is found to be very important, even across countries with different political cultures (including Korea, China, Sweden, and Brazil) as this results in the ability to steer all branches of government and the administration in a coherent direction, and increases the scope for enforcing the fulfillment of the vision.

Source: Katz (2011).

2.7 New ICT trends bring new policy and regulatory challenges

Take for example “the cloud”. One important impact of the Cloud and high-speed broadband is that they level the playing field – everyone (anywhere, as long as you have access to the infrastructure, large and small companies, governments and private users) will have access to affordable computing - hardware, software, services – and everyone will have access to information and knowledge. Therefore, it is crucial to (1) have access and be a part of this development, and (2) be able to exploit it (and preferably be better at this than your competitors who will have access to the same sources and resources). In addition, it is important to have an infrastructure that not only promotes the diffusion of innovation and the productivity of the investments that are made, but also promote and diffuse the new ideas that result from the process as spill-overs are an important part of the diffusion process. For big data, access to the computing needed to analyse it is also vital. Some experts argue that it should be made available to those who use it. Recent data indicate that Europe’s high-performance computing (HPC) capabilities in industry are lagging relative to that in other regions, while relatively more of its HPC resources can be found in the academic world (Table 3.1.2 in Chapter 3.1.3), which should be an issue of concern for European policy makers.

Regulation and legislation covering the cloud and big data will be absolutely crucial.[20] On the one hand they need to safeguard privacy and security, which will also build trust and a greater willingness to adopt these technologies and applications, and on the other hand it is important not to over-regulate, especially since we do not know yet all the future possibilities and uses, for that might hinder innovation. Experts also highlighted that Intellectual Property (IP) regulation covering digital content should be technology neutral and not be biased against new storage and processing systems. Clear new trends are emerging in the use of these technologies, and to be able to benefit from the opportunities they create it is vital to enable and facilitate them, including through smart regulation and by removing barriers, while also safeguarding the rights and security of users.

In addition, it is very important to ‘get it right’. Indeed, as data and activities can flow across different locations, they may just bypass ‘bad regulation’ and go to places where regulation is favourable. The experts have also pointed out the importance of considering developments in emerging countries in this context as these countries may have less regulatory legacies to deal with, which may take time to evolve, and leapfrog to new regulatory frameworks that may be better suited to new technologies, and there may also be a different (cultural) attitude towards regulation.

Experts have pointed out that while high-speed broadband is a necessary infrastructure for having cloud services and for exploiting big data, it is about standards as much as technology, and the ability to set standards pushes the frontier. Some of the experts argue that the ability of industry to set standards is key to how fast broadband capacity will expand (and see also Corrado, 2011). In Europe, there could certainly be a role for the European Commission in this process to coordinate efforts in (industry in) different counties.

One additional complication pointed out by the experts is that the latent pace of innovation and the global nature of innovation outstrip the traditional historical frameworks managing commerce. For

[20] Europe is already acting to facilitate and enable the cloud as part of the Digital Agenda (https://ec.europa.eu/digital-agenda/en/european-cloud-computing-strategy), but there was some concern among experts that these proposals are not sufficiently far-reaching, and worse, that they will take far too long to be implemented in a coherent and comprehensive way in practice.

example, thinking about Intellectual Property in the traditional way does not make much sense now that much of the material covered is infinitely copyable and movable around without much/any ability to control it. This relates to another point often made by the experts, namely that the cloud is not borderless in practice, and that the regulatory and governance frameworks that apply may differ according to where the physical cloud data servers are located geographically. This adds huge complications that users should not have to deal with. The non-global nature of the frameworks is a problem, especially for global companies, and even users involved in cross-border digital actions and transactions. Different laws and regulations may apply to company headquarters locations and the locations where the servers that run their IT are based, which means you might be violating laws just by running content through different locations.

It is crucial that there is international coordination and collaboration on how the frameworks are evolving to avoid creating further barriers, including those that would come from the sheer complexity of having different rules and regulations in different countries. Within Europe addressing these issues should be a priority, but ideally it should be solved on a global scale. An additional problem is that these frameworks change very slowly, when the technologies and possibilities they offer race ahead. The regulatory frameworks in place in different geographical locations will also increasingly become a locational determinant for where cloud services providers and indeed their users and customers will want to see the servers built. Today, even in Europe, most cloud providers are American. European firms, including telecommunications companies, could revise their models and become providers of cloud services. Solving issues related to the internal market in Europe is crucial as this will provide companies with the scale they require, especially since it is a pretty competitive environment. There are also some issues related to data portability, and efforts are being made to establish standards across cloud providers in order to have robust competition where people and companies can move data between cloud providers. Even so, even with standardised technologies across cloud providers, it is still key to solve the issue of different regulatory regimes, and the legislation covering the cross-border flows of data, inside and outside the EU.

As the experts have pointed out though, these efforts should take place in parallel to a broader effort to improve the functioning of markets, and governments need to remove barriers so that companies can achieve scale quickly:[21] it should be easy to start online businesses, access to finance must be available, bankruptcy laws have to change, hiring and firing conditions need to be more flexible and harmonised, among what some experts called "a Tsunami of labour market regulations" that stifle

[21] A recent report by Accenture and the G20 Young Entrepreneurs' Alliance (2013) also echoes this: "governments need to do all they can to support fledgling entrepreneurs and remove the barriers that unnecessarily constrain them and stifle innovation." Especially since "the current wave of new technologies provides a favourable environment for entrepreneurs who aim to scale their business fast. Gaining access to and deploying those technologies easily and cost effectively can mean the difference between a success story and a compelling new idea that never sees the light of day." The report finds that "Young entrepreneurs demand active support from government to sustain their leadership in technology innovation." The report's key recommendations for governments are summarised under 3 pillars: (1) "Stimulate demand through the development of digital infrastructures, export support schemes, the digitisation and opening up of public procurement to small companies, and the digitalisation of public services (including open data policies that encourage companies to create innovative services for the public sector)."; (2) "Support entrepreneurs through efficient tax incentives, access to broader sources of funding, greater investment in STEM education and training, and facilitating the creation of clusters and incubators.", and (3) "Develop business friendly environments for technology innovation through personalised and simplified online administrative processes, a higher tolerance for failure, standards for cloud technology that reduce fixed business costs, and an attractive environment for entrepreneurs to set up new businesses."

the business dynamics, and with added complexities when hiring in different locations in different countries (which for ICT-related skills and talents may be even more important). Some argue that most, or even all, barriers are regulatory, and that they are very strong barriers – hence the urgency of dealing with them. Others argue that while regulation certainly is a big problem, inertia in society could be an even bigger problem. That even when technologies are in place and framework conditions are favourable, there is still a resistance to using them – for example out of fear of and reluctance to change, a lack of skills or awareness, or cultural differences. These factors are arguably even more challenging to address.

3. Recent Developments in Understanding the Impact of ICT on the Economy

Today, there can be little disagreement that Information and Communication is a genuine General Purpose Technology (GPT), as it represents a broad range of related and encompassing technologies with wide applications and much scope for incremental improvement across the economy (Bresnahan and Trajtenberg, 1995). Indeed it is difficult to think of economic activities that are not somehow impacted by ICT. This chapter discusses some of the salient issues around impact of ICT as a GTP, its measurement and analysis, areas that can be further exploited for greater impact, and remaining analytical issues.

Chapter 3.1 focuses on the measurement issues with regard to the impact of ICT on economic growth. While much is known about the impact of ICT investment on growth, the measurement of the productivity effects including externalities and spillovers, and especially the impact from the “C” in ICT, communication, is still in its early days. Chapter 3.2 articulates the role of demand vis-à-vis supply in around ICT. While the literature has amply emphasised the importance of the *use* of ICT as a driver for the economic success of the technology, much of the research has remained focused on the effects from *production and investment*. As the user (consumers and businesses) increasingly take centre-stage in determining the future of ICT, much of what we know is still anecdotal or buried in new research avenues, such as global value chain analysis. Finally, Chapter 3.3 zooms in on the role of ICT in the public sector. As the public sector makes up about 20-30 percent of the economy, much gain can be obtained from more investment and productivity in the public sector.

We also aim in this chapter to identify the knowledge and research gaps and provide suggestions for areas for future research. Many of the issues raised by studies in the economic literature echo the comments made by experts during the interviews (Chapter 2).

3.1 Measuring the economic impact of ICT

The measurement of ICT’s economic impact is a complex matter. Not only do we need to look at the impact of ICT investment on GDP, but there are also difficult issues around the measures of the productivity associated with ICT investments, the complementarities with intangibles, and the network and spillover effects. Additional major related issues are the measurement of the size of the “Internet Economy”, the measurement of consumer surplus and the role of job creation related to ICT.

3.1.1 Putting a number on the impact

There are many studies that have done extensive reviews of the literature on the economic and social impacts of ICT, including for the European Commission (Bloom *et al.*, 2010), Telefonica (van Ark, 2011), and the OECD (Kretschmer, 2012). Rather than doing another exhaustive survey, we will focus here on some recent work, as well as some unresolved issues and gaps in the literature and measurement fields.

There is no single number that demonstrates unanimously and unequivocally the economic impact of ICT on growth. The wide range of different studies represents different perspective and/or level of analysis, examining different aspects of the various technologies involved, and using a different methodology. As a result, they come up with different, though generally positive results. The absence of a single widely accepted impact number contributes sometimes to some reluctance on the part of policy makers, and others, to accept the importance of ICT for growth. In the absence of 'conclusive' evidence of the impact of ICT on growth, and without one single, and preferably large, number much ambiguity remains.

Nonetheless, as argued in this section, the impact numbers that do exist may well be underestimating the true impact as a result of measurement challenges and gaps. As is typical for a GPT, the technologies continue to evolve rapidly,[22] and slowly spread across the economy, while the effects may take some time to materialise. In addition, some effects are not necessarily captured in the measures traditionally looked at. For example, an increase in consumer surplus has a positive effect for consumers/users/citizens, but this is not reflected the numbers that estimate GDP, productivity or employment impacts. Other effects may include the impact on wages, different types of innovation (product, process, organisational innovation), quality and variety of products, degree of customisation or personalisation of goods and services, and social and/or democratic inclusion.

Part of the explanation for the wide range of results on the ICT impact is due to differences in the scope and methodologies of the analyses, as well as measurement issues with the data used. In particular, studies tend to differ according to three main dimensions:

1. Methodologies: econometric analysis, growth accounting, input-output, consumer surplus
2. Level of aggregation/unit of analysis: macroeconomic, sectoral, or firm-level
3. What is meant by ICT: IT (hardware, software), mobile telephony, broadband, the Internet, ICT as a General Purpose Technology (GPT)

While the ICT producing sector contributes to growth in its own right, the impact of ICT using sectors is even bigger. However, the productivity effects of the use of ICT are arguably even more difficult to capture, especially since the use of ICTs is also particularly important in the services sector, and ICT enables innovation, in particular non-technological forms of innovation (e.g. organisation change), all of which are notoriously difficult to measure.

More generally, when regressing productivity increases on the drivers of change, of which ICTs is one, it remains difficult to disentangle the ICT-specific effects and in many cases it comes down to an interpretation of the residual of the equation. "ICT" can also mean different things in different countries/organisations, and internationally agreed data standards take a long time to come about, and therefore they tend to be behind on the state of technology, which advances very rapidly. The meaning of "ICT" therefore also evolves over time, which may further complicate cross-country and over time comparisons of impact results.

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[22] For example, broadband is a relatively recent, but continuously evolving technology. While it has been difficult to measure the impact of broadband, and disentangle it from the impact of other ICTs (van Welsum, 2008), this may change as more and better data become available. For example, recent work for OECD countries has found a significant impact of broadband infrastructure on growth (Czernich *et al*, 2009).

The timeliness of the data themselves is also an issue as even recent studies tend to not have very recent data, which is crucial in a technology that evolves as quickly as ICT, in particular in its transformative capacity. For example, Spiezia (2012), estimating the contribution of three types of ICT investment (computer, software and communication) to growth in value added in the whole business sector in 18 OECD countries, could only use data for the period 1995-2006/2007. But even in 2006/2007, the ICT landscape was very different from the one we live in today, and the transformative capacity of ICT has hugely increased since then. The rise of the Internet Economy, further amplifying ICT as a GPT with ubiquitous wireless broadband quickly diffusing, adds to the challenges. As the technologies evolve and become more powerful, the depth and breadth of impact is also likely to change over time.

All this being said, with new data sources and new and better techniques of analyzing them, the body of empirical evidence is building up at different levels of analysis: macro-, sector- and firm-level. Indeed, to understand the links between ICTs and growth it is important to look at the effects and transmission mechanisms at each of these different levels of analysis. For example, increasing amounts of firm-level data are becoming available at rapid pace and these studies will usefully complement existing evidence, providing additional insights into the links between ICTs and growth.

Macroeconomic impact numbers

At the macro level, the links between ICTs and growth can be examined using both growth accounting and country-level econometric studies. Even though there is no strict consensus over the magnitude of the effect, overall the evidence points to 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. However, there are some drawbacks to using these techniques because of the limiting assumptions and hypotheses they involve, in addition to data limitations (in particular for ICT investment), and the need for deflators adjusted for quality change (hedonic deflators).

Some other unresolved econometric issues include the interaction of ICT with other variables, such as workforce skills or indicators of regulations that constrain either competition or the ability of firms to re-organise after acquiring ICT, or more generally, anything that affects the overall use made of ICT.

Keeping those caveats in mind, the survey by Kretschmer (2012) concludes that the evidence tends to point to significant and positive productivity effects which are increasing over time. “Of course having a significant effect does not mean that low performers can increase productivity by simply increasing ICT investment. ICT has to be embedded in complementary organisational investments.” Kretschmer also reports that the results vary with the methodology employed. “While growth accounting exercises show different ICT effects for the United States and Europe, with a lower impact in the latter, econometric estimations provide no significant country differences. Moreover, there is broad evidence that over the last two decades an increase of ICT by 10% translated into higher productivity growth of 0.5 to 0.6%.”

The evidence also shows that the impact of increasing ICT use now outweighs the impact of higher ICT production.[23] However, investing in ICT alone is not sufficient as, ultimately, the impact will

[23] See, for example, Bloom *et al.* (2010) and OECD (2004) and the references therein.

depend on the use that is being made of it.[24] These investments and impacts also depend on complementary investments in intangible assets (Chapter 3.1.2). There is also a growing literature on the economic impact of the 'C' in ICT, notably telecommunications infrastructure investment (see for example van Welsum, 2008, and the references therein), and related price measurement issues and scale and network effects (Corrado, 2011, 2012, and Chapter 3.1.3). These studies also tend to find evidence of a positive impact.

In Europe, many studies have sought to explain the differences in the extent to which Europe and the US have been able to translate ICT into productivity gains, and why apparently Europe has traditionally been less successful in reaping the benefits from ICT[25] (van Ark *et al.*, 2008; van Ark *et al.*, 2013). Some results have pointed to differences in the organisational structure of firms that enable US firms to better exploit the benefits and opportunities offered by ICT. Framework factors are also important, and from the evidence, notably from talking to experts, these are still very much hampering productive outcomes from the technologies in Europe, and are mainly related to legal and regulatory frameworks, such as inflexibilities in the labour market. Indeed, if a technology allows a firm to be more productive, and if translates into restructuring of employment, these benefits will only become apparent if the firm indeed has the ability to implement the efficiency gains and restructuring of the workforce. Thus, the framework conditions need to be supportive for the benefits of ICT to occur. While this is 'common knowledge', little has changed, and notably a lack of flexibility in the labour market, is cited by many of the experts as a huge barrier to reaping the benefit of ICT in Europe.

The importance of regulation

We looked at some of these studies in some more detail. Bloom *et al.* (2010) find that multinationals are more intensive users of ICT, that US subsidiaries in Europe use more ICT than other comparable multinationals, and that they also gain a higher return to this ICT. The results from their analysis of US multinationals in Europe suggest that "approximately half of the US-EU productivity differential over the 1995-2005 period can be accounted for by organisational capital."[26] This finding echoes earlier work by the same authors (e.g. Bloom *et al.*, 2007) suggesting that US multinationals have different organisational structures and management practices, particularly in the area of "people management", which enables them to better exploit the opportunities offered by ICT.

This work related to multinationals makes an important contribution as it links the findings on productivity (and the "above-normal" returns of ICT), organisational capital, and product and labour market regulation (see also Box 3.1.1). In addition, these are all factors mentioned by the experts as important in driving and hampering the growth and productivity impacts of ICT. Indeed, the experts often mentioned, and stressed the importance of reducing product and labour market restrictions, improving the overall business climate and access to angel and venture capital (see also

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[24] As Bloom, *et al.* (2007) put it: 'It ain't what you do, it's the way that you do IT'.

[25] Even within Europe there have traditionally been substantial differences in the extent to which different countries benefited from ICT. Van Ark finds that this heterogeneity in productivity growth rates cannot be explained at the aggregate level but requires an industry perspective. In particular in service sectors the differences between countries are relatively large and to a large extent related to differences in ICT investment and total factor productivity (van Ark *et al.*, 2008, 2013).

[26] For given levels of ICT. The rest of the gap can be explained by US firms having higher levels of ICT (accounting for approximately another 25% of the gap) and by other firm characteristics such as skills (which accounts for the remaining 25% for the gap).

Appendix A4.2), which have also been shown to play a role in innovation and competitiveness, the performance of start-ups (especially technology start-ups), and investment in intangibles. Similarly, a recent article by Grajek (2012) also found that “the areas in which the right policies could unlock the greatest ICT-led growth are product and labour market regulations and the European Single Market”. Other points stressed in his article include the need to tackle issues related to different technologies and platforms together, as they are not only complementary, but also face interoperability issues. Grajek argues that “The Digital Agenda for Europe is more relevant now than ever. But obstacles to potential productivity improvements and growth include low investment in network roll-out, a fragmented European digital market, ill-adapted copyright legislation and lack of interoperability and skills.”

Box 3.1.1: Growth differentials -- ICT, complementary assets and regulation

Many studies have sought to explain the growth differential between the US and Europe, often explicitly exploring the role of ICT. 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). Retail 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 the regulatory environment rather than ICT explains 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. Inklaar et. al. 2008; van Ark, et al. 2013) 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 many European countries (Appendix A4.2.1). 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 work on multinationals by Bloom *et al*. (2010) makes the links between productivity, complementary assets and regulation in 3 steps:

1. The evidence on management practices confirms the hypothesis that the above-normal returns to ICT are linked to complementary organisational capital.
2. The evidence that US firms have better endowments of organisational capital is closely related to the finding that labour and product market regulation affect the return to ICT. The mechanism behind this link is that lower levels of LMR and PMR contribute to lowering the costs of developing organisational capital.
3. Having developed this organisational capital, US firms can then export it to their subsidiaries in other countries. Hence they find in the European data that US firms are more productive with higher levels of organisational capital even in environments characterised by strict labour and product market regulation.

The existence of strong complementarities between ICT and organisational capital has a number of important policy implications. Indeed, as also repeatedly mentioned by the experts, removing barriers to the accumulation of these complementary factors (especially people management and decentralisation) is key to making more effective use of ICT in Europe. Bloom *et al.* (2010), as well as many of the experts who contributed to this study, suggest that this requires policies that promote product market competition, greater flexibility and faster adjustment in the labour market, and openness to trade.[27]

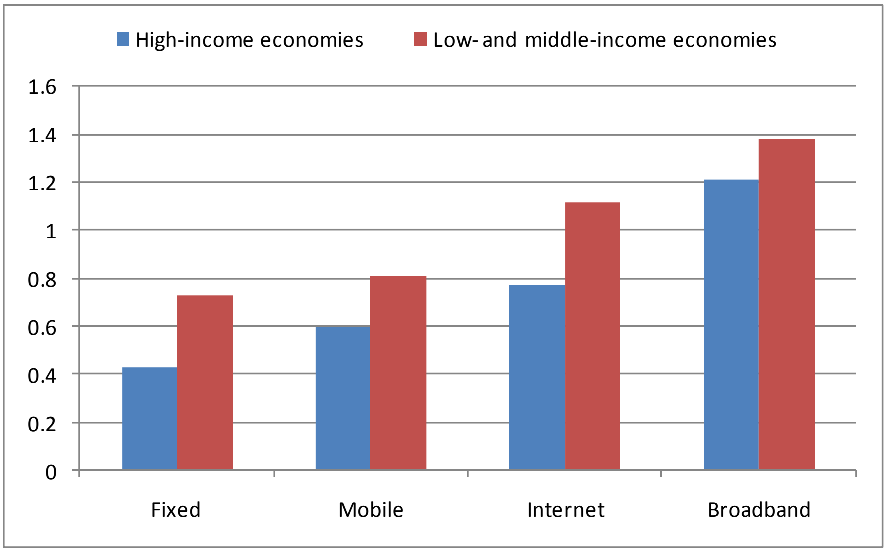
ICT effects by technology

Studies also vary in the technology they examine, especially as the 'prevalent' technology evolves quickly. For example, over the years studies have moved from looking at the impact of fixed telephones to mobile telephony, computers to networked computers and the Internet, then fast Internet with Broadband, then fixed broadband, and more recently mobile broadband (see Appendix A4.1.1 for some of these trends).

As an illustration of these differences, a 2009 World Bank study for 120 countries found that for every 10-percentage-point increase in the penetration of broadband services, there is an increase in economic growth of 1.3 percentage points (Qiang, 2009). This growth effect of broadband is significant and stronger in developing countries than in developed economies, and it is higher than that of telephony and the Internet (Figure 3.1.1).

[27] Bloom *et al.* (2010) find strong support for these types of policies based on new evidence at the microeconomic (firm) level. Furthermore, they do not find support for the alternative line for ICT investment policy based on technology spillovers and interventionist policies to correct market failures. Their evidence does not support the hypothesis "that firms can benefit significantly through spill-over effects at the regional or industry level, but evidence does support spill-over effects on ICT adoption from ICT usage by "neighbouring" firms through learning, network effects sand fostering the growth of skilled labour pools. The results also highlight the importance of ICT as a platform for and tool in innovation as the study finds that ICT is systematically used by firms as part of their strategies for product and process innovation. Trade is also found to be an important driver of innovation in general and ICT adoption in particular."

Figure 3.1.1: The growth effects of ICT by technology (percentage points)



Note: The y axis represents the percentage point increase in economic growth per 10 percentage point increase in telecommunications penetration.
Source: Qiang (2009)

Our best estimates of ICT's contribution to growth

Despite all the complexities and caveats when measuring the contribution of ICT to economic growth, can we get to a middle range estimate on how much ICT contributes to growth? The estimates below are based on detailed studies of ICT and productivity growth, but some assumptions were made on the basis of combined evidence from different studies.

There are essentially three channels on the supply side through which ICT impacts on economic growth:[28]

- A production effect, which focuses on multifactor productivity gains from the ICT-producing sector, including IT hardware, software, and telecom and other ICT services.
- An investment effect, which is the rise in labour productivity per hour due to greater investment in ICT products and services.
- A productivity effect, resulting from an efficiency rise in the use of ICT across the economy, which goes beyond its direct capital deepening effect.

[28] However, as Chapter 3.2 argues, more attention should also be paid to the role the demand side can play.

Table 3.1.1 shows the estimates derived from sources related to the EUKLEMS growth accounting project, The Conference Board Total Economy Database and, for the US, Byrne *et al.* (2013). The top-line row shows overall GDP growth and the second line shows labor productivity (measured as output growth per hour worked). The next three lines shows the percentage-point contributions to labor productivity from the three channels described above.

Overall, from 1995-2007, the ICT effects were on average 57 percent of labor productivity growth in the original EU-15 member states, compared to 64 percent in the United States. The U.S. contributions from ICT tended to be slightly higher for ICT investment and productivity from ICT producers, but the productivity contributions from ICT-use are not different.

The impact of IT investment on labor productivity is mostly larger than the role of multifactor productivity growth in ICT-producing industries. Europe's ICT-producing sector is of about the same size, in terms of GDP share in the economy, but its productivity growth is much slower due to more niche market focus and smaller markets in Europe. However, when combining the productivity effects from ICT-production and ICT-use across the economy, the joint contribution was about the same as the investment effects.

While the IT investment effects have held up reasonably well during the past decade, which included the economic and financial crisis at the end of the decade and the slow or no recovery since, the multifactor productivity effects have dropped off significantly, both in Europe and in the U.S.. In the EU-27 ICT accounted for only one third of productivity growth from 2006-2011, and in the U.S. for less than half. The overall %-point contribution from 2006-2011 was less than half compared to the 1995-2007.

From the perspective of GDP growth, ICT investment, production and use contributed 34 percent on average to GDP growth in the EU-15 from 1995-2007, which dropped to 27 percent for the EU-27 from 2006-2011.

Table 3.1.1. Our best estimates

	Europe					United States				
	EU-15	EU-15	EU-27							
	total economy 1995-07	market sector 1995-07	total economy 2001-05	total economy 2006-11	total economy 2001-11	total economy 1995-07	market sector 1995-07	total economy 2001-05	total economy 2006-11	total economy 2001-11
GDP growth	2.2	2.5	2.0	1.1	1.5	3.1	3.5	2.4	0.7	1.5
Labour productivity growth	1.3	1.6	1.6	0.9	1.2	2.0	2.6	2.0	1.2	1.5
Contributions to LP growth:										
IT investment/hour	0.4	0.5	0.4	0.3	0.3	0.7	0.9	0.5	0.4	0.5
MFP(ICT-production)	0.3	0.3	0.3	0.1	0.2	0.5	0.5	0.5	0.3	0.4
MFP(ICT-use)	0.1	0.2	0.0	-0.1	-0.1	0.1	0.5	0.1	-0.1	0.0
%-point IT contribution to LP	0.7	1.0	0.7	0.3	0.4	1.3	1.9	1.1	0.5	0.9
Total IT as % of LP growth	57%	60%	43%	32%	36%	64%	74%	54%	46%	55%
Total IT as % of GDP growth	34%	39%	34%	27%	30%	41%	55%	45%	78%	55%

Notes: The effects of multi factor productivity (MFP) from ICT production were obtained from Byrne, Oliner, Sichel (2013) for the U.S.. For Europe we assumed half of the U.S. effects, as was evidenced from the EU KLEMS database. The effects of MFP in ICT- using industries were based on the differential in labour productivity growth in ICT-using and non-ICT using industries from Mas (2012). LP denotes labour productivity.
Market sector equals total economy, excluding the government, education and health care sectors.
EU-27 refers to the 27 Member States prior to the accession of Croatia on 1 July 2013.
Sources: Building on van Ark (2013a, 2013b).

3.1.2 The importance of complementary investments in intangible assets for the impact of ICT[29]

There are several direct and indirect links between ICT and intangible assets (IAs). Some ICTs, such as software, are themselves classified as an IA. More generally, many IAs are implemented with the help of ICT and ICT acts as an enabler of productivity and growth effects of IAs. This is supported by the many studies that find that the use of ICT matters more for productivity than just acquiring ICT. ICT in and of itself is not sufficient to make a substantial difference, but when ICT acts to make other innovations effective there is a tremendous potential for economic gains. Indeed, the main driver of productivity improvements has not necessarily been the spending on ICT, but rather the changes and innovations that 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). As ICT enables the structural transformation of most economic sectors, the expected economic impact will be far greater than what is predicted by just looking at the capital investment associated with ICT as this approach fails to take into account the extensive complementary innovations enabled by ICT (Brynjolfsson and Hitt, 2000).

Studies of the economic impacts of ICT increasingly allow for the role of intangibles in explaining productivity impacts of ICT. For example, Basu *et al.* (2003) argue that the US–UK total factor productivity (TFP) differentials from 1995 onwards can be explained by a combination of unmeasured investments in intangible organisation capital and ICTs, and the complementary investments and innovations they induce. It has also been suggested that the internal organisation of US firms plays a role in their ability to use ICTs more efficiently, in particular through the managerial and other organisational changes they allow to be implemented (Bloom *et al.*, 2007).

Not only have ICT-enabled improvements in workplace organisation, and organisational change more generally, been found to improve productivity, but the way in which new work practices are implemented within establishments also matters. Strong complementarities have been found among work practices, workforce skills, and the share of the workforce using computers, and plants with relatively more-educated workers or greater use of computers by non-managerial employees exhibit higher productivity (Black and Lynch, 2001).

The effects of organisational changes on firm-level productivity may rival the effects of changes in the production process. The ability to create economic value from intellectual assets depends crucially on the management capabilities of individual firms and the implementation of appropriate business strategies (OECD, 2006, 2008). The ability of ICT to enable complementary organisational investments such as new business processes and work practices constitutes a significant component of the value of ICT. 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, for example because 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. The longer term productivity and

[29] Adapted from van Welsum (2008) and Corrado *et al.* (2014).

output contributions of computerisation at the firm-level have been found to be up to 5 times greater than those that may materialise in the short run (Brynjolfsson and Hitt, 2003).

The most common first step in assessing the totality of ICT impacts at the macroeconomic level is growth accounting, but complementarities in production are ruled out in this approach. Some researchers, then, look for ICT spillovers, i.e., impacts on output that are greater than implied by the standard contributions calculated in growth accounting. Using data from EUKLEMS, Inklaar *et al.* (2008) examined industry-level productivity in ten EU countries and the United States and found no evidence of spillovers from ICT, however. Another strand of the literature centers on measuring and analyzing the role of intangible capital *per se* (Corrado *et al.*, 2005, 2009). Using these estimates, Oliner *et al.* (2007) observed that the growth contribution of intangible capital deepening followed the general pattern for IT capital deepening in the United States.

In new research using newly available time series data for 10 EU countries from 1995 to 2007, Corrado *et al.* (2013) find robust econometric evidence that the marginal impact of ICT at the macroeconomic level is higher when it is complemented with intangible capital. The specific finding is that industries that are more ICT intensive have better productivity outcomes in countries that are relatively more intangible capital intensive. In this research, software is included in ICT (and intangible capital excludes it); organisational capital, employer-sponsored training, R&D, and design exhibit complementarities with ICT. The intangible capital data for the study grew out of work by The Conference Board and two European Commission-sponsored projects, COINVEST and INNODRIVE; the study also used data from EUKLEMS and WIOD.

The story on spillovers

Recently completed work by Carol Corrado of The Conference Board, Jonathan Haskel of Imperial College, London, and Cecilia Jona-Lasinio of ISTAT and LUISS, Rome, looks at the influence of intangible capital on market sector and industry-level productivity in 10 EU countries as a follow on to previous Conference Board work that suggested spillovers from intangible capital deepening contributed to productivity growth in a country's overall market sector (van Ark *et al.,* 2009).

The title of the related study by Corrado *et al.* (2013) is "Knowledge Spillovers, ICT and Productivity Growth." To understand the findings of this study as well as its relationship to the new results reported herein, it is important to be precise about what is meant by "spillover." Economic theory makes clear predictions about the magnitude of the impact of a change in an input on output: if markets are competitive and returns are constant, the impact of a percentage point change in an input is the input's share of income generated by all productive inputs. Factor income shares are relatively easy to measure compared with an approach that determines impacts via direct estimation of a production function.

For the 10 EU countries in the knowledge spillover study, the ICT capital share of market sector factor income averaged 4,5 percent from 1995 to 2007 (about half the size of the comparable share in the United States).[30] ICT capital input grew 12.4 percent per year during the same period and thus contributed 0.56 percentage points per year, on average, to growth in real market sector value

[30] The share and calculations reported in this paragraph are unweighted, i.e., each is a simple average over the 10 countries in the study: Finland, Germany, Italy, the Netherlands, Spain, and the United Kingdom (countries which were also included in the previous study), plus Austria, Denmark, France, and Sweden.

added in these countries. Real market sector value added grew at an annual average rate of 3.4 percent. Thus ICT investments directly accounted for 16.4 percent of the average rate of economic growth (market sector) in these 10 EU countries from 1995 to 2007.

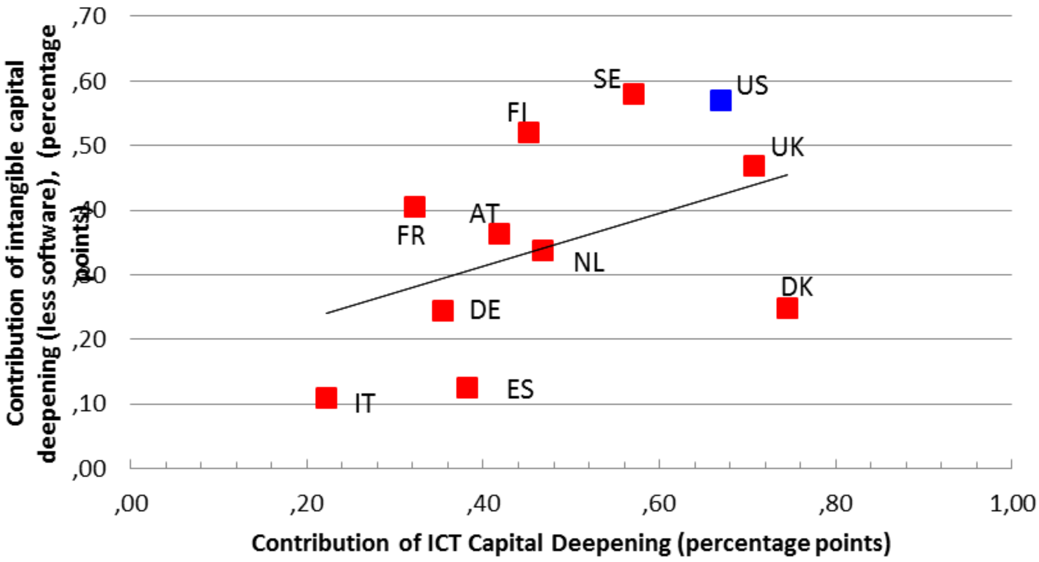
But economic reality can differ from economic theory's usual assumptions, in which case the true impact of ICT is possibly larger or smaller. For example, markets may not be competitive, or perhaps ICT capital has not always consistently been put to productive use; indeed, in some of the prior literature that has attempted to estimate the return to ICT capital, negative spillovers are found.[31] There are compelling reasons to think there may be positive spillovers, however: ICT capital could enjoy a return to scale in productive use via network effects as is hypothesised in our work on communications capital; or ICT may simply yield a "dividend" from ever larger investments as claimed in the Oxford study; or ICT may "complement" other factors, as hypothesised with intangible capital in a strand of the ICT literature associated with the work of Erik Brynjolfsson and Loren Hitt (2000, 2003; and with Shinkyu Yang, 2002).

Without going into details the related study uses productivity data and cross-country econometric techniques that reveal whether the impact of ICT capital on economic growth is larger or smaller than its estimated factor share; it also estimates simple production functions. The study finds *no* spillovers or increasing returns from investments in ICT capital *per se* but rather that *industries that are more ICT intensive* have better productivity outcomes in *countries* that are relatively more intangible capital intensive. (Organisational capital, employer-sponsored training, and design have stronger impacts on productivity growth differentials in ICT intensive industries compared with other intangible assets.) The study's estimated impacts are strongly significant and robustly identified.

Figures 3.1.2, 3.1.3, and 3.1.4 display the intuition behind these results. Figure 3.1.2 shows a correlation between the conventionally calculated contribution of ICT capital to growth and a similarly calculated contribution for intangible capital (excluding software, of course, as software is included in ICT). Now, Figure 3.1.3 shows a strong and positive correlation between productivity and intangible capital, consistent with spillovers to intangible investment. And as Figure 3.1.4 suggests, the finding displayed in Figure 3.1.3 is not spuriously due to a common factor boosting both types of investment and growth. Figure 3.1.4 shows little hint of a pure spillover relationship for ICT capital (and the same can be said for improvements in labour quality and investments non-ICT capital although these results are not charted).

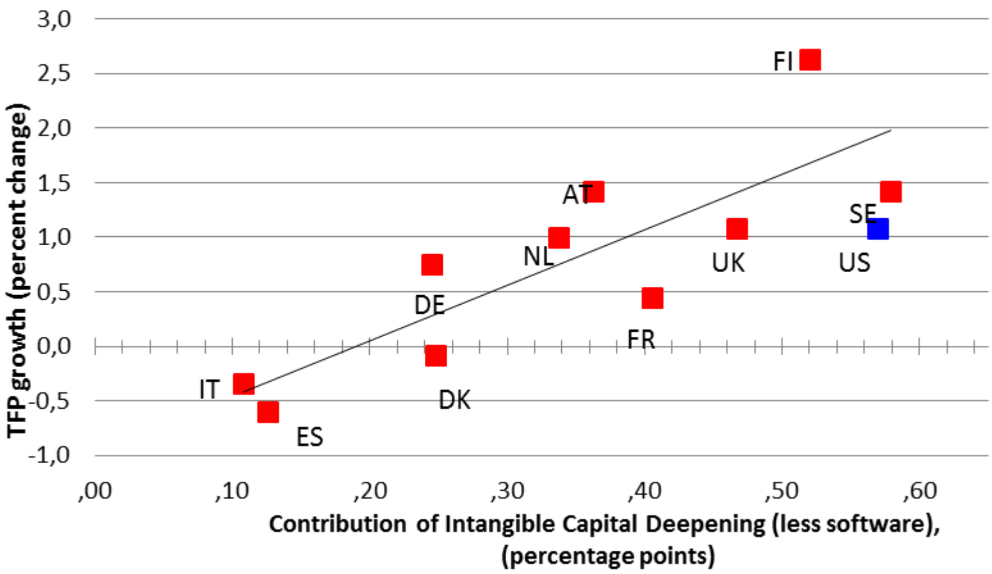
[31] For example, Inklaar *et al.* (2008) find a negative relation between high skilled labour share on TFP growth (once labour quality is accounted for), although the finding is statistically insignificant (see their Table 9). However, those results preclude ICT/intangibles complementarities. Once they are in the picture, the story on ICT changes. Corrado *et al.*'s work shows that there are spillovers to ICT when it is complemented with intangible capital.

Figure 3.1.2: ICT capital and Intangible Capital Contributions to Growth, 1995-2007



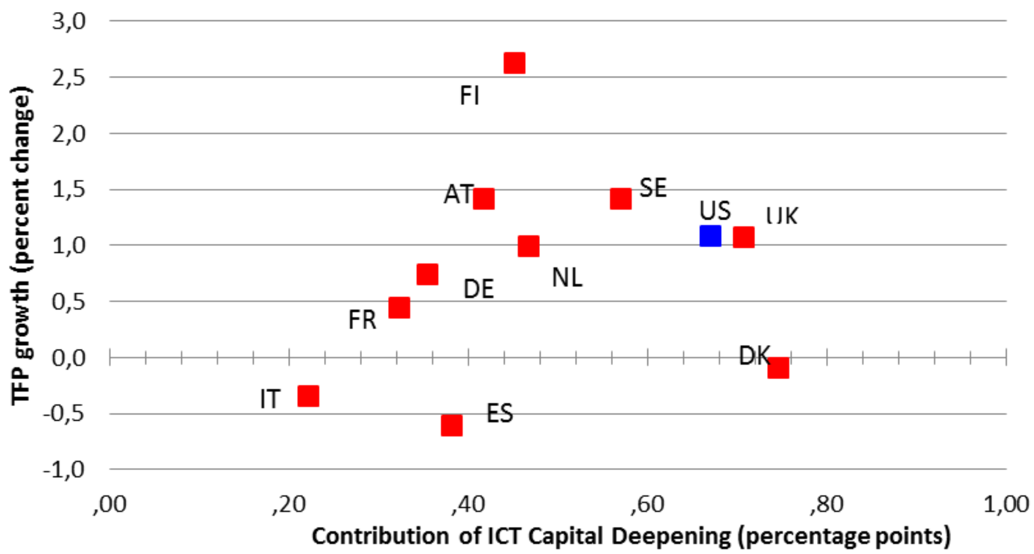
Note: Regression line is for the 10 EU countries only. Intangible capital excludes software.
Source: Corrado, Haskel, and Jona-Lasinio (2013) using productivity and capital estimates reported in Corrado, Haskel, Jona-Lasinio, and Iommi (2012) based on data from EUKLEMS, WIOD and INTAN-Invest.

Figure 3.1.3: Productivity (TFP) Growth and Intangible Capital Contribution, 1995-2007



Note: Regression line is for the 10 EU countries only. Intangible capital excludes software.
Source: Corrado, Haskel, and Jona-Lasinio (2013) using productivity and capital estimates reported in Corrado, Haskel, Jona-Lasinio, and Iommi (2012) based on data from EUKLEMS, WIOD and INTAN-Invest.

Figure 3.1.4: Productivity (TFP) Growth and ICT Capital Contribution, 1995-2007



Source: Corrado, Haskel, and Jona-Lasinio (2013) using productivity and capital estimates reported in Corrado, Haskel, Jona-Lasinio, and Iommi (2012) based on data from EUKLEMS, WIOD and INTAN-Invest.

The results reported by Corrado, Haskel and Jona-Lasinio make use of a new dataset on intangible investment and new productivity estimates calculated with these investments counted as output (Corrado, Haskel, Jona-Lasinio, and Iommi, 2012). Their results are important for showing that the growth impact of intangible capital—the knowledge capital of the firm—has very strong indirect effects. And also for showing that there are indeed salutary impacts from investments in ICT when such investments are complemented with investments in organisational change and staff training. Their study could only go so far, however, owing to the lack of comprehensive industry data on intangibles.

3.1.3 Measuring prices, and capturing spillover and network effects from communication technologies[32]

The “C” in ICT is gaining increased attention and importance, obviously in practice, as broadband availability and speeds continue to increase and with developments such as the rapid diffusion of mobile broadband the roll-out of fiber networks, but also from an analytical point of view. Indeed, it is ‘network’ effect of ICT that creates tremendous value (without the Internet, a computer would just be a glorified type writer). Studies have tried to disentangle some of the growth and productivity effects of the C in ICT from the IT in ICT, but research is now increasingly also focusing on capturing network effects and spillovers, as well as improving the (price) measurement, especially of the C in ICT (Corrado, 2011).

Katz (2012) provides an overview of the findings of some of the more recent studies looking at the impact of broadband on GDP growth. While these studies tend to confirm a positive effect, the results for the magnitude of the effect vary widely, with the contribution to GDP varying from 0.25 to 1.38 per cent for every increase in 10 per cent of penetration. The differences can be explained by the use of different data sets (country coverage, time period), model specifications and the treatment of some of the methodological challenges. There is also some evidence there may be a threshold or critical mass effect. For example, 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. Broadband has also been found to have a positive effect on productivity. Waverman (2009) found that for every 1 per cent increase in broadband penetration in high and medium impact income countries, productivity grows by 0.13 per cent. The work also reinforces the idea that for broadband to have an impact on productivity, the ICT eco-system has to be sufficiently developed.

A study by Oxford Economics (2011) used EUKLEMS data combined with a dynamic panel regression to obtain a measure of the impact of ICT investment on multifactor productivity (MFP) growth, which it claimed to be 0.08 percent for each 1 percent of permanent increase in the level of ICT investment. Compared to other investments, the higher return on ICT (the “ICT dividend”) is about one third of the 20-25 percent overall return on ICT investment they cite in their work. While the insights from the Oxford Economics study are very revealing and encouraging, the study does not identify the reasons for such large effects from ICT investment. One reason could be the network externalities that ICT generates via the Internet and wireless communications. Indeed, the Internet and mobile telephony are two of the 20th century’s greatest developments yet remain stepchildren in macroeconomic studies of the impact of ICT technology on the pace of productivity change.

[32] Section based on Corrado *et al.* (2014), a study underwritten by Telefonica S.A.

Enter network effects

With ever increasing speed and diffusion of high-speed broadband, it would be important to further disentangle some of the impacts and improve our understanding of the transmission channels how the technology contributes to growth and productivity, and what the barriers are. In addition, today, the Internet, mobile telephony and mobile broadband are still largely absent from the existing macro-productivity literature.

A recent study for the United States conducted by Carol Corrado at The Conference Board (2011), takes direct aim at quantifying the impact of the network effects created by developments in communication technology. The importance of network effects is most clearly explained by Metcalfe's Law that states that the value of a network increases with the square of the number of users of the network and leads to a situation where stocks of ICT capital within a sector or country are disproportionately beneficial to growth. A key feature of this new work is that it includes harmonised, quality-adjusted deflators for ICT production and investment in these countries. In particular, quality-adjusted prices for telecomm equipment are introduced to more accurately pin down trends in communications capital—the "C" in ICT.[33]

In addition to developing quality-adjusted price deflators for measuring communication capital, Corrado also broke the "C" out of ICT (called herein CT) and considered communication capital to consist of two components: one, *total capital* owned and used by the telecom/Internet service-providing industries (including, she believed, the industry in which you would find Google) + private CT in other market sector industries. The total capital owned and used by the telecom/Internet service-providing industries (hereafter, service providers) was adjusted to include auction purchases of wireless spectrum.

Corrado laid out a framework for identifying how the expansion and use of Internet and wireless networks leaves its footprints in productivity data. In the simplest of terms they include (1) the direct contribution of communication capital, which in the United States almost ½ of which capital of service-providers, and (2) the indirect effect (network externalities) in multi-factor productivity (MFP).

Part of the indirect effect is reflected in the MFP of service providers: After they invest to create the capital infrastructure of a communication network, providers are in a position to reap spillovers as the utilisation of the network increases (the size of which is determined of course by their regulatory environment). Corrado identified two indicators that signal an increase in service provider MFP is due to network effects: an increase in the industry's implied rate of return (relative to a market rate), as well as an increase in its capital productivity (its real output grows faster than its capital stock). Another part of the indirect effect is the spillovers from adaptive and innovative uses of a network, which are detected through econometric analysis.

[33] The new price deflator for telecomm equipment is based on research conducted by David Byrne and Carol Corrado (2009). They updated earlier work by Doms (2005) and Doms and Forman (2005) and developed new price indexes for wireless equipment, including cellular base stations and satellites, from 1963 on. Much, but not all, of the Byrne/Corrado work has been incorporated in the U.S. national accounts from 2003 on.

Corrado *et al.* (2014, forthcoming) examine whether Corrado's work and finding that network effects contributed substantially to the post-2000 acceleration in productivity growth in the United States can be extended and used to analyse recent and prospective ICT developments in selected European countries, using updated estimates of EU KLEMS, using the new NACE-2 classification and estimates for seven EU countries up to 2011 as well as the United States. The updated dataset enables more precision with regard to the role of country characteristics (e.g., telecom infrastructure, or overall communication capital intensity) on industry-level productivity growth. Why examine country-level characteristics? Recall that the spillover study described above looked at the influence of a *country's* intangible capital on *industry-level productivity* in 10 EU countries and was able to obtain conclusive econometric results. Knowing more about the effectiveness of a country's communication capital—whether inside businesses and homes or provided via publicly accessible networks—is relevant to policy-makers.

There is great potential this line of work, but it also comes with further challenges. For example, the data show a mild positive association between business CT capital deepening and service provider multifactor productivity change, which suggest the presence of network effects. But the recession and crises complicate working with recent data.

Looking ahead

Network effects and the ICT intensities of industries notwithstanding, innovative strategies and continued strong ICT spending and will be needed for business to meet the projected increases in Internet and mobile data traffic associated with what has come to be called the "Internet second wave" (social networks, smart phones, app stores, e-readers, and cloud computing). The current and projected rates of increase in Internet and wireless data traffic demand are very dramatic indeed—32 and 100+ percent per year, respectively, in coming years. For countries to reap a "dividend" from the Internet second wave, the capacity of a country's ICT infrastructure and innovation system must be up to the task of exploiting all that is possible from the vastly increased scale associated with these projected increases in Internet and mobile data traffic (see Section 3.1.3 for more on this).

The Conference Board's estimate of trend ICT capital per worker in five advanced countries (Germany, Japan, Spain, United Kingdom, and the United States) shows that the top two countries (the US and UK) employed nearly twice as much capital per worker than did the other three countries as of 2010. Estimated trend telecom capital per worker reveals a similar divergence: stocks per worker in the US and UK are twice the size of stocks in the other three countries. In terms of telecom capital per worker, certain emerging countries (e.g., Mexico) are more or less on par with the laggard advanced countries. As discussed in van Ark (2011) by this and other metrics, the overall gap between the advanced and emerging economies in terms of ICT capabilities is rapidly closing.

The size of the output per worker gaps between leading and laggard countries can be closed by physical means, that is, by more ICT investment on the part of the "catch-up" countries (and/or industries). It also can be closed by raising the productivity of existing ICT stocks by boosting investments in complementary forms of capital (human, intangible, other tangible, or public)—assuming of course that such complementarities are present. Firm-level studies and analysis clearly has associated the two (e.g., the line of work associated with Erik Brynjolfsson) and the recent Conference Board research just mentioned confirms the importance of the association at the macroeconomic level.

The Internet and CT capital have been important because they have made networked computing and improvements in internal and external business processes possible in a wide range of industries. As high performance computing moves closer to center stage as the IT strategy of the future, having the appropriate "connective tissue" for HPC business applications will be vitally important (Chapter 3.1.3).

Business Implications

All told, Corrado *et al.*'s work studied the impact of nearly 15 years of networked computing and business Internet engagement on business productivity and gleaned three lessons. First, for business to continue to make business process improvements, ICT investments need to be complemented with investments in intangible capital to reap a "productivity dividend." Second, continued investment in communication infrastructure—both by general businesses and by Internet and telecom services providers—is necessary to harness the Internet second wave, as data traffic is projected to grow at increasing exponential rates. Without further work we cannot say that such investments will generate pecuniary externalities in Europe as customers utilise expanded networks more intensively, but the U.S. experience of the 2000s suggests it is not unreasonable to expect that to happen.

Finally, the ICT spending and innovation associated with the "Internet first wave" ultimately stemmed from business *demand*, that is, individual businesses purchasing equipment and software to improve their competitive advantage in the marketplace. Many suggest that the reason for persistently lower ICT stocks per worker in Europe than in the United States is rooted in Europe's innovation system (e.g., lack of competition in its product and labour markets or of innovation in its financial markets). If so, Europe faces a similar challenge harnessing the Internet second wave, its data, and using HPC computing for competitive advantage. But Europe's universities and governments claim many top HPC installations. While generally only large firms possess the scale for HPC systems (e.g., Amazon has the 42nd ranked HPC system in the world, and IBM has had dozens on multiple continents for many years), providing HPC availability more broadly, especially to small and medium-sized business with intermittent needs, is feasible with cloud, M2M, and other Internet "second wave" forms of communication. See Chapter 3.1.3 for more on this.

Areas for research:

It is important to do more work on the impact of the Internet, mobile telephony and mobile broadband, and going forward the Cloud and big data. More work is also needed to improve the understanding of network effects and spillovers. Better price measurement is needed, including for Europe, along the lines of Corrado (2011/12).

The work by Corrado *et al.* (2013, 2014) should be enhanced and extended. The sample's rich industry dimension and improved ICT measures are central to what is accomplished in that work, but it has come at a cost of greater generality in the econometric analysis of this section. The sample currently lacks sufficient countries to reliably examine and test for country-level ICT effects, such as those pursued by Roeller and Waverman using a 20-year sample of 20 OECD countries, or interactions between the contribution of ICT at the industry level and country characteristics, such as those pursued in Corrado, Haskel, and Jona-Lasinio (2011, forthcoming in 2012 with revisions).

Studies at the country level (a “case study” approach, for example) would be needed to complement the research.

3.1.4 Going forward: new measurement challenges from Big Data and the Cloud

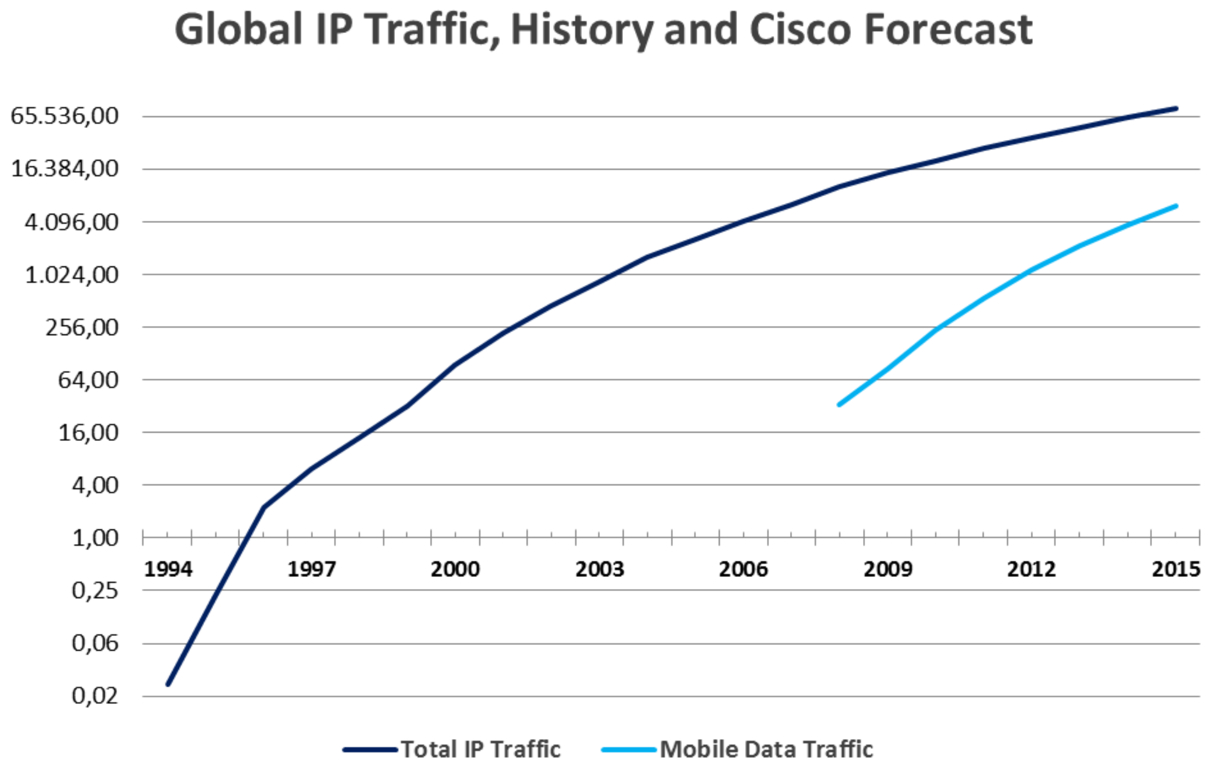
New technologies bring new measurement challenges. High-performance computing (HPC), Big Data and the Cloud will be platforms for innovation and continued productivity improvements, but measuring their importance in a meaningful way may be difficult. For example, with the sourcing of computing capacity and capabilities ‘on demand’ through the cloud, spending on these categories may not reflect the extent to which they will impact the ICT capacity and capability of firms.[34]

Innovative strategies and continued strong ICT spending and investments in complementary assets are needed to secure competitive advantage from the analysis of the new data generated by these systems, namely, “big data.” While demand for big data analysis is fairly abstract and intangible, one way of making it more ‘tangible’ is by looking at the demand for the high-performance computing (HPC) that it requires and, in turn, the specialised computer hardware and software that make HPC happen (Corrado, 2011). Describing all the relevant developments in the HPC world is beyond the scope of this report, but the question of “how much a country can “borrow” from the HPC world for solving “big data” business applications” is arguably at the heart of business ICT innovation and productivity going forward.

The “Internet second wave” (social networks, smart phones, app stores, e-readers, and cloud computing) will generate unprecedented amounts of data and being able to exploit them, and preferable better than competitors is going to be key to innovation and the creation of business opportunities. The current and projected rates of increase in Internet and wireless data traffic demand are very dramatic indeed (Figure 3.1.5). For countries to reap a “dividend” from the Internet second wave, the capacity of a country’s ICT infrastructure and innovation system must be up to the task of exploiting all that is possible from the vastly increased scale associated with these projected increases in Internet and mobile data traffic.

[34] One recent study suggests that the productivity growth enabled by cloud computing will contribute almost one third of total US GDP growth in the coming decade. The authors of that study also argue that their “findings should have bearing on policy discussions as governments across the world (including both the U.S. and the EU) consider and implement policies concerning the regulation of cloud computing. These regulations and decisions span a vast array of issues that, as we demonstrated, can have enormous impact on a country's ability to grow and remain competitive,” as reported on http://www.eurekalert.org/pub_releases/2012-11/ip-geg111412.php and http://www.kurzweilai.net/can-cloud-computing-boost-gdp (last accessed 27 June 2013).

Figure 3.1.5: Global IP traffic



Source: Based on Cisco's Visual Networking Index: 2010-2015 ("Entering the Zetabyte Era" 2011) for the total IP traffic figures and Cisco's "Global Mobile Data Forecast Update 2011-1016" (2012) for the mobile data traffic estimates.

The Internet and communication capital have been important because they have made networked computing and improvements in internal and external business processes possible in a wide range of industries. With high performance computing now rapidly gaining importance and becoming key to future ICT strategies, having the appropriate "connective tissue" for HPC business applications will be equally important.[35] HPC can and is now being applied beyond the product design and testing applications conducted in large industrial R&D labs—it is used for plant layout design, logistics and traffic monitoring, financial market pricing/trading/event monitoring, medical imaging/patient monitoring/disease tracking, as well as network traffic routing in telecom, among others. Generally only large firms possess the scale for HPC systems, though this is likely to change as the Cloud becomes more widely adopted in businesses. Indeed, providing HPC availability more broadly, especially to small and medium-sized business with intermittent needs, will undoubtedly require harnessing the Cloud and other Internet "second wave" forms of communication, a point also repeatedly made by the experts.

There are two key lessons of networked computing for business HPC computing. First, a country requires a communication infrastructure—both in its general businesses as well as it publicly

[35] Having the appropriate skills to exploit the new capabilities is also crucial.

accessible networks—to harness the power of IT, and this will be crucial as the data traffic on those networks continues to grow exponentially. HPC itself is a form of IT infrastructure and, and it should be of concern to European policy makers and business leaders that Europe's capabilities in industry are lagging while its resources in the academy are very rich indeed (Table 3.1.2).

Table 3.1.2. The most recent 1,500 Top500 computers by location and type of organisation

-	- Location			-
- Type of organisation	- Asia	- Europe	- Americas	- **Total**
- Academic	- 47	- 106	- 80	- **234**
- Research lab.[1]	- 64	- 71	- 193	- **328**
- Industry[2]	- 206	- 148	- 521	- **875**
- Government[3]	- 6	- 30	- 27	- **63**
- Total	- **323**	- **355**	- **821**	- **1,500**

- Source: Byrne and Corrado (forthcoming) based on data from www.top500.org accessed April 2012.

- Notes—The Top500 project ranks the most powerful known computers in the world on a biannual basis. Asia includes Oceania, Israel and the Middle East. Total includes Africa, not separately shown.

- 1. Includes government sponsored laboratories conducting defense, weather/climate, and other research.

- 2. Includes vendors with computers used for benchmarking.

- 3. Includes classified.

Second, the ICT spending and innovation associated with the "Internet first wave" ultimately stemmed from business demand, with individual businesses purchasing equipment and software to improve their competitive advantage in their marketplace. Although the United States may have experienced a virtuous cycle that gave an extra kick to these individual demands, the reason for persistently lower ICT stocks per worker in Europe than in the United States likely is rooted elsewhere in Europe's innovation system, e.g., labour and financial markets, as a large literature seems to suggest. In all likelihood, and echoing the comments made by the experts, Europe faces a similar challenge harnessing the Internet second wave and HPC computing for competitive advantage—much less reaping a "dividend" from the ICT investments that can make that happen.

3.1.5 The impact of ICT on employment

There are many ways in which ICT impacts employment (including through demand, supply, organisation of work and activities, evolution of skills, and the quality of jobs). The overall impact of technology/ICT on employment numbers remains the subject of unresolved debate among experts researching this area. As the impact of ICT on employment is such a vast subject we will just provide a brief overview of some of the issues. Indeed, some new technologies will be job creating, while others will destroy jobs,[36] but there is currently no agreement on what the net effect is likely to be.

Technology impacts the types of occupations in demand, as well as their skill content. Demand for new types of skills comes with new waves of technologies. There is some job creation and some job destruction, there will be some sectoral and occupational shifts, but the overall net impact at the aggregate level is not yet known. On the supply side, ICT improves labour productivity, enhances education and reduces the cost of continuous training (Manole and Weiss, 2011). ICT also impacts the geography and organisation of employment, in particular as an increasing number of tasks that do not require physical proximity can be carried out remotely, creating more flexibility in where, when and how these are carried out. This may lead to the development of clusters of skills and occupations in certain locations, while at the same time spreading different parts of a firm's value chain out over different locations. Finally, ICT also has an impact on the functioning of the labour market itself, notably acting as an intermediary, matching supply and demand, providing information, and by broadening the geographical reach in the search for certain talents and skills.

Historically, technology has always destroyed the need for some types of jobs, while creating new ones, and ICT was no exception. The new wave of ICT currently arriving is creating new skills demands (such as for big data analytics and its visualisation, e-leadership and dual thinkers on the business and technical side, and including for Chief Information/Technology Officers – CIOs and CTOs; see Box 3.1.2), but also allows for a lot of efficiency gains and restructuring which tends to come paired with job losses. Perhaps this time the relative importance and distribution of the winners and losers is different. For example, companies like Facebook have created a tremendous amount of wealth, which goes to relatively few people,[37] and in comparison it has created relatively few jobs (see below for some direct and indirect job creation effects from Facebook). At the same time, this wealth still contributes to the economy, and every job created is better than no job created.

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[36] For example, some academics like David Autor, Erik Brynjolfsson and Andrew McAfee expect that certain technologies may have a negative effect on certain types of skills and occupations, and not just in what are traditionally considered to be low-skilled occupations (Autor refers to this as a 'hollowing out of the middle class' and a 'polarisation of the workforce'). Powerful new technologies, including new types of software applications and capabilities, robotics and automation are increasingly adopted not only in manufacturing, clerical, retail and customer services occupations but also in what are traditionally considered to be more highly skilled services sector occupations including in, for example, law, financial services, education, and health care. In addition, Brynjolfsson and McAfee refer to a phenomenon they observe (for the US) as 'the great decoupling': historically, productivity and employment moved more or less together, until 2000 when the trends began begin to diverge with productivity continuing to rise steadily, while employment wilted; by 2011 a significant gap exists between the two lines, showing economic growth no longer matched with a parallel increase in job creation. Similarly, Brynjolfsson also points out that while GDP is growing, the median wage (in the US) has fallen.

[37] One of the experts referred to this as "superstar-biased technological change."

Box 3.1.2: New skills requirements -- e-leadership skills

With the cloud levelling the playing field in providing access to computing resources no matter how big or small your needs are (e.g. for hardware, software, storage, and support), and with almost unlimited access to all kinds of information and knowledge, what will make a difference for companies and countries alike is how good you are at exploiting these resources. Having the skills to exploit all this information and turn it into business opportunities will create competitive advantages for those relatively better at doing so. This is likely to be heightened as "big data" will continue to gain importance, especially as more and more data will be created going forward as we move from Internet of people, to the Internet of Things, to the Internet of Everything, with machines, devices and people communicating to each other constantly. The increase in mobile broadband will also continue to add tremendous amounts of data as the use of mobile devices creates information about people's behaviours, preferences, locations and interactions. Being able to not only analyse this information but to also create new business opportunities out of it will be crucial for the competitiveness of firms going forward. It will require technical skills to process, analyse and visualise "big data", but it will also require business and management skills. Many companies will also have to go through a profound digital transformation and the skills required for imagining and implementation such a transformation are currently few and far between.

Thus, van Welsum and Lanvin (2012) argue that there will be an increasing need for "dual-thinkers": people who have the skills to identify and develop new business opportunities, and the technical skills that allow them to identify which technologies to use do so, and how, or even to spot new business opportunities directly in technologies and applications. So called "e-leaders" will need to combine an entrepreneurial mind-set with business skills and technical skills, at various levels of management and enterprise activity/organisation. This development is complementary to a changing role for IT in the business, moving away from having a cost-cutting function for the CFO to becoming a strategic weapon for the CEO.

Source: Adapted from van Welsum and Lanvin (2012).

The academic literature has long established that technological change impacts different skills groups in the labour market differently, and there will always be some 'winner and losers', at least initially while the adjustment process takes place.[38] For example, Autor *et al.* (2003), using a "tasks framework", find that computer technologies substitute for workers performing routine tasks that can readily be described with programmed rules. However, while those engaged in routine tasks are more vulnerable to having their jobs replaced by ICT through automation, those engaged in non-routine tasks see their productivity enhanced with ICT. In more recent work, Autor and Dorn (2012) find evidence of polarisation in the US labour market which they attribute to the interaction between consumer preferences, which favour variety over specialisation, and the falling cost of automating routine, codifiable job tasks. Acemoglu (2002) also finds that whenever the pace of technological

[38] More generally, technology also impacts different parts of society differently. For example, new technologies enable and support dramatic economic and societal changes and foster a new 'talent society' (Brooks, 2012), but in such a network society people with skills and talents are more likely to thrive, exploiting diverse opportunities and maximizing their creativity, whereas people that do not have these skills are likely to face challenges.

innovation increases the strategic importance of skills increases, further highlighting the importance of addressing the skills question, as also pointed out by many of the experts.

The economics of technical skills has profound implications for productivity, innovation, and employment structure - an important component of the impact of IT on growth. However, empirical research into the economics of IT labour remains underdeveloped to date, in part because the output of IT labour is difficult to measure directly. However, new data sources and analytical techniques are emerging and will contribute to improving the understanding of the mechanisms and magnitude of the impact of IT on growth. For example, Prasanna Tambe at NY Stern uses web-enabled data from online labour market intermediaries such as CareerBuilder and LinkedIn that capture the employment histories and job skills of a very large fraction of the US IT workforce, enabling the analysis, for example, of how IT skill demand is changing in response to globalisation and to the emergence of new technological innovations such as cloud computing and big data technologies (see Tambe and Hitt, 2012, 2010).

Tambe and Hitt (2012) look at the effects of offshoring on IT skill composition, based on earlier survey-based work in Tambe and Hitt (2010) focusing on the effects of offshoring on skill demand within the US IT workforce. The principal innovation of the research is the acquisition of data enabling detailed measurement of changes in IT skill composition at the firm level. The paper provides empirical evidence that IT tasks requiring "high-touch" or "personally" delivered services (e.g., hands-on support, network administration) face less offshore competition because the delivery of these services is substantially degraded if delivered over computer networks. The study empirically links offshoring with a shift towards an onshore US IT workforce that performs fewer tradable tasks and more personal or interactive tasks. This echoes findings by others arguing that the Internet economy is both global and local at the same time.

Research in progress by Tambe also explores the labour market changes associated with the recent surge in big data investment. Tambe tests the hypotheses that as an emerging IT innovation, investments in big data within the same labour pool a) exhibit strategic complementarities that will b) dissipate as the skills and know-how required to support big data implementations become more broadly available. Tambe uses a new data source—the LinkedIn skills database—enabling direct measurement of changes to the skill content of labour markets, including emerging skills such as Hadoop, Map/Reduce, Apache Pig, and HBase. His findings include that, relative to other technical skills, big data skills are highly concentrated in a few labour markets. Big data investment, measured through the employment of Hadoop engineers, is also found to be associated with 2% faster productivity growth for employers in big data intensive labour markets, but he did not find a measurable return from investments in labour pools with average levels of investment, where firms' labour pools are directly measured using worker flows.

Measuring the overall impact on employment

There is currently much debate among academics and experts regarding the size of the employment multiplier of technology, and in fact, there is some debate as to whether the overall impact might even be negative – could it be that with the new emerging technologies more jobs may disappear than new ones will be created along the lines of what Brynjolfsson and McAfee (2011) argue? Indeed, with technology enabling efficiency gains, automation, restructuring and outsourcing and offshoring, some jobs may disappear. But many argue yet more jobs will be created, for example through the new business opportunities created by new technologies, and the spillover effects this creates throughout the economy, across all sectors, including those supporting the new businesses that will be created, and the income spent from those activities. It is unlikely that a consensus on what the net effect will be can be reached until more data becomes available and until analysis from both sides of the spectrum will improve our understanding of the mechanisms and magnitudes of the effects. Secondary job creating and spill-over effects may also take longer to materialise.

Moretti (2012), using data on 11 million workers in 320 areas in the US during the past 30 years, shows that for each new high tech job in a metropolitan area, 5 additional jobs are created outside high tech in that geographical area. Specifically, he argues that for each job in the software, technology and life-sciences industries, five new jobs are indirectly created in the local economy, with 2 out of 5 in highly skilled professional occupations (such as doctors and lawyers) and 3 jobs in "non-professional", less highly skilled occupations (such as waiters, barbers and store clerks). He also finds that these workers earn higher salaries than their counterparts in other areas.

While job creation in most sectors creates such multiplier and spillover effects, these results suggest that in the innovative / technology sector the effects are far greater than for any other sector. By comparison, the multiplier in the manufacturing industry was found to be 1.6. Thus, Moretti argues that technology innovators are one of the most important engines of job creation in the U.S. One potential implication for policy outcomes is that attracting innovative companies with high skilled workers to a city or region also generates spillovers in the form of the creation of jobs for less highly skilled workers. Moretti's findings also suggest that in spite of technology offering the possibility for an increasingly borderless world, in practice geography still matters. Workers in innovative activities in particular tend to benefit from physical proximity and interpersonal interactions rather than ICT-enabled communication alone, echoing those arguing that the Internet economy is both global and local at the same time. It also highlights the importance of eco-systems, which in addition to innovative companies, funding sources, and highly educated workers also are supported by having a strong service economy.

We briefly review some of the multiplier effects reported in the literature, starting with some of the macroeconomic studies looking at the multiplier effects of investments in broadband, and then moving to more narrowly defined impacts of the app economy and of Facebook.

Employment multipliers have been used to look at the impact of broadband (Table 3.1.3). There are two types of multipliers: Type I multipliers measure the direct and indirect effects (direct plus indirect divided by the direct effect), and Type II multipliers measure Type I effects plus induced effects (direct plus indirect plus induced divided by the direct effect). Results for broadband investment multipliers are summarised in Katz (2012) as follows:

Table 3.1.3: Employment multipliers from investment in broadband networks

Country	Study	Type I	Type II
US	Crandall *et al.* (2003) Atkinson *et al.* (2009) Katz *et al.* (2009)	NA NA 1.83	2.17 3.60 3.42
Switzerland	Katz *et al.* (2008)	1.38	NA
UK	Liebenau *et al.* (2009)	NA	2.76
Germany	Katz *et al.* (2010)	1.45	1.92

Note: Crandall *et al.* (2003) and Atkinson *et al.*(2009) do not differentiate between indirect and induced effects, therefore Type I multipliers cannot be calculated; Katz *et al.* (2008) did not calculate a Type II multiplier because induced effects were not estimated.
Source: Katz (2012), Table 3.

Katz (2012) notes two takeaways from these results: (i) European economies appear to have lower indirect effects than the US, and (ii) the decomposition suggests that a relatively important job creation induced effect occurs as a result of household spending based on the income earned from the direct and indirect effects.

Other studies have used multipliers to look at more narrowly defined impacts. For example, Mandel (2012) and Mandel and Scherer (2012) use employment multipliers to look at the size and impact of the app economy,[39] which they find to have created some 519,000 jobs in the US between the 2007 introduction of the iPhone and April 2012. Mandel (2012) uses what he calls “a conservative multiplier of 1.5” (meaning that every app economy job generates another 0.5 jobs in the rest of the economy).[40] Furthermore, they find that app jobs are being created throughout the economy – in all sectors and across geographic locations, in the public and private sectors, in small and large companies. In fact, they find that the app economy is pretty much borderless and unencumbered by traditional locational determinants: anyone with a computer and an Internet connection can become an app developer. The number of apps has been increasing rapidly, as have the associated jobs: not just app developers themselves, but also all those who work upstream and downstream in the app eco-systems to deal with infrastructure, technical issues related to security, compatibility, interoperability, but also marketing, sales, and customer service, for example.

As the App Economy is such a recent development, official statistics, including employment statistics, will not adequately capture its size. Instead, Mandel (2012) and Mandel and Scherer (2012), in their study of the US app economy, use The Conference Board HWOL database, a compilation of online

[3939] Mandel and Scherer (2012) describe the app economy as “simultaneously global, local, and intensely personal”, “like nothing we have seen before.” Indeed, mobile apps create opportunities for businesses and individuals to communicate and interact as customers, suppliers and employees through the smartphone in their hand, irrespective of where they may be. Mandel (2012) identifies the following five key platforms in the app economy: Android, anchored by Google; Apple iOS, anchored by Apple; Blackberry, anchored by RIM; Facebook, anchored by Facebook; and Windows Phone and Windows Mobile, anchored by Microsoft. It is noteworthy that even though the app economy is global in nature with worldwide users, none of these platforms are European, in fact, they are all North-American.

[40] The size of the job multiplier is a subject of great disagreement among academics and researchers. Some would find Mandel’s ‘conservative 1.5’ too high, some think the multiplier may be negative with technology destroying more jobs than it is creating, and yet others suggest the multiplier may be far greater. For example, Hann *et al.* (2011) use multipliers of 2.4, 2.5 and 3.4 in their study of the employment impact of Facebook app development, and Moretti (2012) argues that the multiplier is as high as 5 – every high-tech job would create an additional 5 non high-tech jobs in the economy.

help-wanted ads that reflects "the full universe of all online advertised vacancies which are posted directly on Internet job boards or through newspaper online ads".[41]

Looking at App Economy jobs by US states, Mandel and Scherer (2012), unsurprisingly, find the largest numbers of app economy jobs in California (with companies such as Apple, Google, and Facebook) and Washington (home to Microsoft and Amazon). However, many app economy jobs are also created in other states. Looking at the "App Intensity" of each state (the percentage of App Economy jobs in a state as a percentage of total jobs, indexed to the national average) shows that in addition to Washington and California, the app economy is also important to states such as Massachusetts, Oregon, Georgia, New Jersey, and New York. The economic impacts at state level are also considerable, "conservatively estimated" (in April 2012) at USD 8.2 billion in California, USD 2.7 billion in Washington, USD 2.3 billion in New York, and over USD 1 billion in states like Texas, Massachusetts, New Jersey and Georgia.

A yet more narrowly focused study by Hann *et al.* (2011) looks at the employment impacts of "the Facebook app economy". As the Facebook Platform is open, the Facebook ecosystem is available to a broad community outside of Facebook, generating opportunities for entrepreneurs to create new businesses and jobs. The studies uses anonymised data provided by Facebook to look at both the jobs created by the Facebook app economy and the value it contributes to the U.S. economy by looking at three impact channels[42]: jobs created in the app industry (direct employment),[43] jobs created in other sectors of the economy (indirect employment), and the economic value of those jobs. The app economy induces employment creation in other sectors through two channels: those that supply the app developers, and through the income spent by app developers and their suppliers. The study reports using employment multipliers found in the literature, namely:

(1) A 2.52 employment multiplier in the communication sector for the U.S. economy (one job in communication sector creates 2.52 additional jobs in other sectors) from Bivens (2003).
(2) A 2.42 employment multiplier from the broadband stimulus program in the US at national level from Katz and Suter (2009).[44]
(3) The US Bureau of Economic Analysis (BEA) provides employment multipliers for specific industries on the state level in their Regional Input-Output Modeling System (RIMS II), a general equilibrium model of the economy. The employment multiplier for "Internet and other information services," in California is 3.41.

Hann *et al.* (2011) find that the direct employment effect is 53,434 jobs, and depending on the multiplier being used the indirect and induced employment effects are estimated at 129,310, 134,654, and 182,210 jobs, respectively. Thus, their conservative estimate of the employment impact of developers building apps on the Facebook Platform in the United States in 2011 is 182,744 full

[41] See http://www.conference-board.org/data/helpwantedonline.cfm for more information.
[42] Additional impacts may occur for example through related industries, branding, advertising, consumer surplus etc., but these are not taken into account in the study.
[43] The study measures the employment impact of the Facebook Canvas application economy, but does not attempt to quantify the impact of applications built on external websites, where Canvas Apps are "web apps that are loaded in the context of Facebook" in a Canvas Page: https://developers.facebook.com/docs/guides/canvas/
[44] Katz and Suter (2009) estimate the creation of 128,000 jobs resulting from network construction jobs over the period 2009-2012. However, there is greater uncertainty around the size of the indirect impact which they range between 0 and 270,000 jobs over the 2009-2012 period, with a 136,000 mid-point, and "with anecdotal evidence and calibration with other research pointing to the lower end of the distribution" (Katz, 2009). These numbers represent a 1.83 multiplier for the direct and indirect effects from network construction, and as much as 3.42 when induced effects are added. For the externalities the multiplier is estimated at 1.06.

time jobs, resulting in a total employment value of Facebook's app economy of USD 12.19 billion. Their boldest estimate suggests that the Facebook App Economy created 235,644 jobs, adding a value of USD 15.71 billion dollars to the U.S. economy.

Areas for research:

It is important to get better estimates of impact on employment, and especially in Europe. Building a database similar to Help Wanted Online (HWOL) for Europe would create tremendous opportunities for further analysis, in particular on issues related to skills, talent, and shortages.

More research is also needed on big data related impacts, especially in view of a risk that we are moving from a 'digital divide' to a 'big data divide'.

Given the strategic importance of these new technology trends, and given that being able to reap their benefits in part also depends on having the required skills, and given a global competition for talent, it would be very important to also analyse these questions in the European and global context.

3.1.6 The size of the Internet economy

Today, the Internet is a key economic infrastructure, transforming economic activities as much as social interactions, completely changing the way many things are done, and crucially also serving as a platform for innovation. As a result, the Internet now plays a vital role in driving growth and competitiveness.

Several studies have attempted to estimate the size of the so-called Internet economy[45] as a way of representing its impact (including BCG, 2012, 2010; and OECD, 2012). There is currently no single commonly agreed way to define and measure the size and impact of the Internet economy, and methodologies range from looking at the more narrow 'infrastructure' aspect (e.g. the number of Internet users, the number of connections and connected devices, IP addresses, fiber miles, or the volume and content of data traffic), to broadly estimating what percent of GDP (and/or employment) the Internet directly or indirectly accounts for or contributes to, or what its impacts on productivity and innovation are.[46]

According to BCG (2012), by 2016 there will be some 3 billion Internet users (half of the world's population, and up from 1.9 billion in 2010), and the Internet economy in the G-20 economies will be worth USD 4.2 trillion (up from USD 2.3 trillion in 2010). To put this number into perspective: if the Internet were a country, it would rank 5th in the world in terms of its "GDP", after the US, China,

[45] The term reflects the observation that the Internet has now very much become a part of the economic and social infrastructure and now affects most sectors and activities one way or another.
[46] The OECD is developing a method for categorizing different approaches to measuring the Internet economy (with three approaches aiming to capture direct, dynamic, and indirect impacts); the next steps will be to develop cross-country harmonised data measures, but this is likely to take years to come about (see OECD, 2012, Annex A).

Japan and India, but ahead of Germany. The BCG study also estimates that the Internet contributes to as much as 8% and over 12% of GDP in South Korean and the United Kingdom, respectively. The BCG study also predicts that while the economy as a whole is slow in most of the G-20 countries, the Internet economy will grow at an annual rate of 8%, far outpacing growth in more 'traditional' sectors. The Internet's contribution to GDP is estimated to increase to 5.7% in the EU and 5.3% for the combined G-20 countries by 2016 (Table 3.1.4). Overall, it is estimated that the Internet economy in the G-20 will double in size between 2010 and 2016, with the fastest growth taking place in developing markets hoping the reap the benefits from investments in broadband infrastructure. In most countries, consumption will be the main driver of "Internet GDP". These findings are very similar to what other studies find. Even though the order of magnitude may differ as a result of somewhat different definitions and methodologies, all results point to the Internet contributing substantially to both the level and growth of GDP, and to consumption generally being the most important driver of the Internet's contribution to GDP, for now at least.

Table 3.1.4: Value of the Internet Economy, % of GDP by country and source, in 2009, 2010, 2016

	IDC, 2009	BCG, 2009	McKinsey, 2009	IDC, 2010	BCG, 2010	BCG, 2016
France	4.0		3.1	4.6	2.9	3.4
Germany	4.3		3.2	4.7	3.0	4.0
Italy			1.7		2.1	3.5
Sweden			6.2			
UK	5.8	7.2	5.4	6.2	8.3	12.4
Total EU27	3.7			4.1	3.8	5.7
Brazil			1.5		2.2	2.4
Canada			2.7		3.0	3.6
China			2.6		5.5	6.9
India			3.2		4.1	5.6
Japan			4.0		4.7	5.6
Russia			0.8		1.9	2.8
South Korea			4.6		7.3	8.0
USA			3.8		4.7	5.4
G8+5[47]			3.4			
G-20					4.1	5.3

Source: IDC (2011), BCG (2012, 2010), McKinsey (2011).[48]

A sub-set of the Internet economy – measuring the size of the App Economy

[47] On average for the 13 countries studied: the G8 (Canada, France, Germany, Italy, Japan, Russia, United Kingdom, United States) + Brazil, China, India, South Korea, Sweden. McKinsey (2011) finds that while the Internet accounted for 3.4% on average for the 13 counties studies, there were substantial differences, even among countries with similar levels of development, and the Internet contributed less than 4% to GDP in 9 of the 13 countries included in the study.

[48] In addition, OECD (2012a) finds that "at least 3% and up to 13% of business sector value added in the United States in 2010 could be attributed to Internet-related activities depending on the scope of the definition".

There are basically three measures to gauge the size of the app economy (Mandel, 2012): (1) the number of apps, (2) the amount of revenue generated by app sales, and (3), more difficult to estimate, the employment generated by the app economy, directly and indirectly. Other spill-over effects onto the economy are also likely to be generated but even more challenging to capture.

For example, Mandel and Scherer (2012) report that as of August 2012, The Apple App store contained more than 700,000 active apps, up about 40% since the end of 2011, and that the number of apps for Android increased at about the same pace over the comparable period.

A detailed view of Apple App availability is shown in Table 3.1.5, showing a very rapid increase:[49]

Table 3.1.5: The total number of apps available in the App Store at given dates in the past

Jan. 2013 - 775,000 (300,000 native to iPad)	May 2010 - 200,000 (5,000 native to iPad)
Sept. 2012 - 700,000 (250,000 native to iPad)	April 2010 - 185,000
June 2012 - 650,000 (225,000 native to iPad)	Jan. 2010 - 140,000
April 2012 - 600,000 (200,000 native to iPad	Nov. 2009 - 100,000
Oct. 2011 - 500,000 (140,000 native to iPad)	Sept. 2009 - 85,000
July 2011 - 100,000 native to iPad	July 2009 - 65,000
June 2011 - 425,000 (90,000 native to iPad)	June 2009 - 50,000
March 2011 - 350,000 (65,000 native to iPad)	April 2009 - 35,000
Nov. 2010 - 400,000 (40,000 native to iPad)	March 2009 - 25,000
Sept. 2010 - 250,000 (25,000 native to iPad)	Sept. 2008 - 3,000
June 2010 - 225,000 (8,500 native to iPad)	July 2008 - 800

By April 2013, a different source reports that the iOS app store had well over 800,000 active apps, Google Play more than 600,000, and the Amazon app store about 75,000. These apps are published by some 210,000 developers to Apple's iOS app store, some 180,000 developers using Google Play, and some 19,000 developers are publishing apps to Amazon.[50] According to yet another source, Google and Apple apps have reached similar download numbers at around the same time, but Apple's App Store accounts for much more of the revenue.[51]

Additional apps are being developed for different environments, such as Facebook, Windows and Blackberry. For example, by April 2012 there were reportedly some 9 million Facebook apps,[52] some 120,000 Blackberry apps were available as of mid-May 2013,[53] and some 50,000 Windows Apps by March 2013.[54] All of this development puts a lot of software developers to work who develop their skills in different ways, innovate and make income from publishing their apps to the various environments.

[49] Reported on http://ipod.about.com/od/iphonesoftwareterms/qt/apps-in-app-store.htm (last accessed 19 May 2013).
[50] Reported on http://venturebeat.com/2013/04/25/why-developers-choose-the-amazon-app-store-fewer-apps-ease-of-porting-and-pending-global-expansion/ (last accessed 19 May 2013).
[51] As reported on http://investorplace.com/2013/04/whos-really-winning-the-app-store-battle/ (last accessed 19 May 21013).
[52] As reported on http://www.insidefacebook.com/2012/04/27/facebook-platform-supports-more-than-42-million-pages-and-9-million-apps/ (last accessed 19 May 2013).
[53] As reported on http://news.cnet.com/8301-1035_3-57584346-94/blackberry-live-by-the-numbers-120000-apps-available/ (last accessed 19 May 2013).
[54] As reported on http://www.pcmag.com/article2/0,2817,2416983,00.asp (last accessed 19 May 2013).

3.1.7 Consumer surplus

One aspect of the impact of ICT not captured in GDP, productivity and most other "impact numbers" is the impact on consumers surplus / consumer welfare, but some studies try to estimate the size of these effects. For example, BCG (2012) estimates that for the G-20, the average value consumers "believe they receive over and above what they pay for devices, applications, services and access" is $1,430 per person (ranging from $323 pp in Turkey to as much as $4,453 pp in France).[55] Furthermore, it appears from their study that consumers in countries such as France and Germany with relatively lower numbers of "Internet GDP" tend to put a relatively higher value on it. In another study for the US, BCG also found that US consumers derive more value from online media than from offline media (BCG, 2013).

Using a different methodology to try to capture welfare from consumption of a good or technology based on time spent rather than expenditure may yield higher estimates of consumer surplus. Using "time spent" Goolsbee and Klenow (2006) found that consumer surplus from the Internet may be around 2% of full-income, or several thousand dollars, higher than the result would be using expenditure data.

Greenstein and McDevitt (2011) focus on estimating the revenue growth and consumer surplus affiliated with broadband's diffusion to households in 7 countries: Brazil, Canada, China, Mexico, Spain, the UK, and the US. They find that countries with large Internet economies, such as the United States and China, are receiving large economic bonuses from investment in broadband. Countries with smaller Internet economies—such as Canada, the United Kingdom, and Spain—receive bonuses that are small but that are proportionate to their scale of Internet use.[56]

Part of the issue with measuring the impact of the Internet economy, certainly in terms of value, is that a lot of content and apps are 'free', certainly in monetary terms, though not in terms of time spent. For example, according to Erik Brynjolfsson, there is some USD 300 billion in free goods and services on the Internet, including the TED talk where this reference came from,[57] and this is not captured in GDP. Some of the experts interviewed for this study suggested that having to sift through vast amounts of information to find what is relevant and/or of high quality could be seen as "the price to pay" for having so much free content available. Though at the same time, this has also created new business opportunities with apps that summarise information,[58] for example. Other

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[55] The BCG study takes into consideration "the value derived from communication, content (entertainment, news and social media), search, commerce and job searches."

[56] In their study, The extra value from broadband consists of two components:

1. Incremental revenue paid by households for the service (this is included in GDP); and
2. Consumer surplus, or the amount consumers would have been willing to pay for broadband in excess of what they actually are paying. Consumer surplus is measured using the observed increases in broadband diffusion in each country during the 2000s as its real price dropped during the decade.

[57] Watch Erik Brynjolfsson's TED talk on: http://www.ted.com/talks/erik_brynjolfsson_the_key_to_growth_race_em_with_em_the_machines.html

[58] British teenager Nick D'Aloisio who sold his app company to Yahoo. His app "Summly" summarises content from news and other sites for small screens. See for example

ways in which we pay for free content is by providing information about our preferences and behaviours, explicitly or implicitly (for example by the sites we visit, the amount of time we spend looking at them, “clicks”, online purchasing behaviour, “likes” on Social Media sites such as Facebook, the use of location-based services and information, etc.) which may lead to some privacy and data ownership/use concerns. One question is, for example, how people feel about the use of targeted advertising, and if and how it affects their behaviour. Some interviewees said “their feeling” is that people appreciate the use of personal information for targeted advertising and customised service offerings, but that they would object to their personal data and information begin sold for commercial purposes and/or to other parties, and to data bases with different types of personal data being linked (e.g. no linking of health, financial/banking, consumer preference information). One concern they expressed though is that people may not necessarily be aware that they are giving up personal information just by the use of their mobile devices, or the extent/amount of information they give up.

Areas for research

It would be important to understand how much welfare people derive from ICT, the Internet and digital content, and how this relates to other ICT impact estimates, as well as what the policy implications would be. In part this would depend on policy priorities, taking into account that value to consumers increases welfare. There may also be a need for raising awareness about personal data through use of mobile devices etc., and its implications. How much information are (well-informed) consumers ready to ‘give up to pay for free content’. Raising awareness about these issues is important, also for policy makers. Areas for research would include developing work on alternative measures of impact, such as time spent, the value of free content, and “the price to pay for free content”.

3.2 Articulating supply and demand

3.2.1 Introduction

Much of the work of the impact of ICT on growth has been focused on the supply side. For example, at the macro level, the detailed data work and analysis through EU KLEMS, focusing the attention on the issues with regard to efficient ICT use in service industries in the EU, has brought great insights. On the supply side, ICT has been found to have three main effects (van Ark, 2011): (1) a production effect through the ICT-producing sector, (2) an investment effect in ICT using industries, and (3) a productivity effect from an efficiency rise in the use of ICT which goes beyond its direct capital deepening effect.

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http://www.guardian.co.uk/technology/2013/mar/25/summly-sold-yahoo-teenage-creator , http://www.nytimes.com/2013/03/26/business/media/nick-daloisio-17-sells-summly-app-to-yahoo.html?_r=0 , or http://articles.latimes.com/2013/mar/26/business/la-fi-teen-millionaire-20130326 (last accessed 20 May 2013).

At the micro level, many valuable insights have been obtained from firm level analysis, including research on the role of R&D and organisational investments and management capabilities to exploit the benefits offered by ICT. A recently completed project has also contributed new insights by linking micro data on ICT use (Box 3.2.1). But what is still a gaping hole in research and policy making is the role of the demand side, with, for example, little understanding of the major demand shifts in ICT and ICT-enabled goods and services as new technology applications emerge, and their impacts. Indeed, ICT-enabled demand shifts can result, for example, from the shift to 'everything mobile,' the increased analysis of big data, or from the diffusion of technologies such as 3D-printing which changes the dynamics of the manufacturing sector (which can range from consumers asking to have their own designs printed, to printing parts on demand to reduce the need for storage space, etc.).

Box 3.2.1: Linking of Microdata on ICT Usage Project (ESSLimit)

The ESSLimit project represents an exploration of the use and impact of ICT in the business sector, including the way in which ICT transforms business behaviour, decisions, and market outcomes, and how this changes over time. The aim of the project was twofold: to link microdata and to analyse the impact of ICT.

ESSLimit is the second round of a 3-phase undertaking. The first phase results (from the ICT Impacts project) indicated a strong link between broadband enabled employees and firm performance, and especially among manufacturers. ESSLimit has found clear indications that effects are more widely spread across services firms, but that if manufacturers are affected they tend to be so more strongly. It was also found that while the 'simpler' gains from ICT, such as investments in PCs and broadband, naturally wear out over time, it is followed by that of more complex systems, such as the interaction with organisational setups, specific skills, and innovations. The effect of ICT usage was also found to be more persistent at industry than at firm level, though this result is not yet well-understood. While the project has not (yet) addressed the question of the overall impact on employment, the results currently seem to indicate that while technology, and innovation will have an impact on the demand for factor inputs, this may manifest itself through changes in skill requirements, including through demand for new types of skills, rather than through a decrease in overall employment.

The linking of micro data sources has made the analysis richer, and includes changes in market structures through increased dissemination of networked ICTs, and changes at the firm level through uses of more complex structures of ICT, including organisational capital, innovations and skills. Thus, the ESSLimit project examined ICT in dimensions not earlier available nationally or internationally. The project uses a firm-level and analysis and builds on information derived from business registers, production surveys, e-commerce surveys and innovation surveys. By linking these different microdata sets, richer information can be extracted from existing data sources and composite indicators can be constructed. The project used three levels of analysis: (1) common micro-level analysis undertaken in each country separately (micro), (2) analysis of cross-country distributed microdata indicators (DMD), and (3) common analysis of microdata enhanced with aggregate indicators from the cross-country dataset (micro+). The project has created a new ICT indicator that goes beyond single indicators from surveys, and which takes a host of ICT features of firms into account. This indicator can be used for classifying firms, for example in ICT versus non-ICT-intensive industries.

The project will also produce a new cross-country data set for research purposes. Indeed, ESSLait, phase three of the project, is mainly concerned with updating of linked national microdata sets that are merged into the cross country EUKLEMS industry level dataset, meant to be released for research purposes (the Micro Moment Database). The analytical work will also be continued.

Source: Hagsten *et al.* (2012).

The combined analysis of the supply and demand side is also crucial to deal with the main concern about the lack of employment-creating capacity of the latest innovations in ICT, as developed most clearly in Erik Brynjolfsson's recent book "Race Against The Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy" (Brynjolfsson and McAfee, 2011).[59] If we do not develop a better understanding of the scaling opportunities at the demand side, which are generated by some of the key demand shifts mentioned above, we will end up in a Luddite argument that technology only kills old jobs rather than create new ones.

3.2.2 An increased role for the use and demand side to generate ICT impacts

On the supply side, EU policies have tended to focus on infrastructure and stimulating research, but not on the aspect of bringing the outcomes to market[60], and not enough has been done to deal with the fragmentation of markets, hampered by the fact that the Digital Single Market and the Single Market for Services have still not been achieved in practice. More policy attention could also be paid to the demand side aspects of policies traditionally considered to be part of the supply side, which has tended to include providing for hard (pipes) and soft (skills) infrastructure.

Indeed, as diffusion of high-speed networks continues globally, including to mobile devices, consumers are ever more empowered and can drive demand in new ways, such as through the possibility for increased customisation of goods and services (including in combination with other technologies, such as 3D printing), or reviews and 'likes' and other forms of interaction through social media which can influence consumer behaviour and preferences, and location-based services open up new business opportunities. The increased use of mobile devices contributes to the amounts of data being generated, and when combined with other sources of data, including from machine-to-machine communication, huge volumes of data become available for analysis and exploitation ('big data' analytics, including, for example, predictive analytics of consumer behaviour), not only to run a business but also to fundamentally change it.

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[59] Brynjolfsson and McAfee argue that "technological progress is accelerating, with profound impacts on skills, wages, and jobs, and with potentially grim employment prospects, because people and organisations are not keeping up with technological advances."

[60] This is important though as illustrated by Veugelers (2012) who found that "the problem in Europe appears not to be so much in the generation of new ideas, but rather in bringing ideas successfully to market. Among the barriers are the lack of a single digital market, fragmented intellectual property regimes, lack of an entrepreneurial culture, limited access to risk capital and an absence of ICT clusters." These points also made and stressed by many of the experts.

These developments need to be matched with skills on the user side, both for consumers and businesses. Consumers and businesses need to be equipped with the skills to exploit today's and tomorrow's technologies, for example by stimulating ICT-enabled entrepreneurship and the capabilities required to use ICTs in innovative ways in business to develop new business models, new products, new ways of delivering them, new ways of interacting with suppliers, customers, and staff. There is a role for policy in equipping people with the rights skills, which will require some combination of technical and user/business skills that allow them to identify new user/business opportunities in what will increasingly be a data-driven business environment. There is a role for education and training systems to work with the technology and business communities to respond to and anticipate on skills needs, for the public sector to lead by example – including by bringing people through the provision of online public services and on new and mobile devices, and by raising awareness and educating people on online privacy, trust and security issues that they may have and which might be holding them back in developing different types of use (banking, shopping, online tax or other administration, etc.).

Of course, these measures need to be accompanied by measures that contribute to ensuring a high-speed affordable infrastructure is available, with sufficient amounts of spectrum made available to respond to increasing traffic volumes. They also need to be matched with the right framework conditions that foster an energised and dynamic business environment, with flexible, open and competitive markets that allow for scale for successful firms to grow, and that support access to finance, tolerating and trial and error, including for those who innovate, take risks, and fail. Such an articulation of matched demand and supply side policies will greatly enhance the scope for ICT to contribute to growth.

Past research (by Bart van Ark and others) has established that, relative to the US, Europe has a less efficient ICT growth model, with less specialisation in ICT producing sectors, relatively smaller contributions from ICT to growth resulting from less efficient ICT use, and lagging private expenditure on research and development into ICT goods and services (for example, Foray and van Ark, 2008). This trend is also confirmed in new TCB research which finds that relative to other regions, proportionally less of Europe's high-performance computing (needed for the analysis of so-called "big data", which offers huge potential efficiency gains– see below) sits in industry compared to in academic institutions and research labs (see Table 3.1.2 in Chapter 3.1.3). The use impacts are difficult to capture, and existing measures show that the ICT impacts from using sectors are even greater than those from producing sectors.

Even though use impacts might be difficult to measure, new technology trends suggest an ever increasing role for the use side in generating such impacts. For example, many of the business opportunities generated by 'big data' – including real-time information – are often generated through various use-side factors (such as 'likes' on social media platforms that reveal preferences and consumer sentiment, and location-based information from people using their mobile telephones not only for communicating, but also for price comparisons, purchasing goods and services, and finding and reviewing information). With technologies such as 3D printing, this affects not only services sectors, but also more traditional manufacturing sectors. The ability to exploit real-time data and predictive analytics will also transform logistics and supply chains, advertising and marketing campaigns, and many other aspects of any business. Indeed, many businesses have started to realise that if they want to be where the consumer is, they need to be online and mobile (Box 3.2.2).

Box 3.2.2: Mobile devices and their role in consumption

According to BCG (2012), mobile devices (smart phones, tablets) will account for 80% of broadband connections in the G-20 countries by 2016. In addition, they argue that in most countries, consumption will be the main driver of "Internet GDP". Their research found that ROPO (research online purchase offline) is an important activity in all countries, and developed markets especially, but that consumers in different countries tend to research different products. Mobile shopping is expected to go up (with the possibility to identify deals, research and compare products and prices, and seal the deal while on the go, especially when mobile payment systems will take off). There are also more and more apps that make these actions easier. However, there are some uncertainties that may impact the speed and depth of these developments, including some that can be influenced by policy, including regulation, infrastructure for online and brick-and-mortar retail, Internet penetration, credit card use, and consumer confidence in online payment systems, delivery, and fulfillment (consumer protection rules can help here too). As a mirror image to these developments, increasing shares of advertising budgets are now also be allocated to online and mobile advertising.

It is important to increase policy focus on developing and enabling the use / demand side, especially since these days it seems that users are earlier adopters of new technologies, and may therefore drive business adoption of new technologies. While some Digital Divide issues remain on the access/infrastructure side, new divides are emerging on the use and impact side, for example when it comes to having the right skills required for exploiting the benefits from ICT. A recent Wired article argues that the digital divide between companies who embrace new technologies (and are good at it), and those who do not, will increase going forward as the use of big data and apps grows in importance for doing business (Kirschner, 2013).

The role of the consumer cannot be sufficiently stressed in creating an environment in which ICT and related innovations can flourish. Consumers react strongly to better price-quality relationships in ICT products and services, and are quick to react as new opportunities turn up in this area. Consumer surpluses, as discussed before, are large as it comes to picking up on ICT applications. Therefore, e-readiness is an important measure of consumer sophistication, and connectivity is a key condition to realising consumer demands for ICT.

3.2.3 The role of global demand and global value chains

In a global context, much could also be learnt from understanding the impact from external (global) demand from the perspective of a decomposition of global value chains (GVC) in ICT, answering questions such as: Who captures the value (added), and where? Where does the innovation take place? Who benefits (most) from this innovation?

For example, Dedrick *et al.* (2009) found that while Apple managed to capture value from the innovation embodied in the iPod, this appears to be more challenging for notebook makers who were found to capture a more modest share of the value from PC innovation. They find that most of the differences can be explained by factors such as industry evolution (for example, whether or not the market has embraced a dominant design for a new innovation), complementary assets (related to interoperability, as well as, for example, the availability of complementary products that enhance the innovation's value), appropriability (influenced by firm strategy and coordination as well as, for example, the ability to set standards), system integration (which technologies and features are part of the core product), and the degree of bargaining power in the supply chain.

Understanding what determines who captures the value of innovation is important also in the context of ICT, and perhaps especially in the parts of the ICT sector where the main disruptive innovations come from firms outside the EU. Can EU firms still benefit from these innovations by also partly capturing the financial value it generates if they are part of the production chain, and if so, how? As Dedrick *et al.* argue, while the highest rewards are likely to go to the innovation pioneers, some of the value generated from the innovations tends to be "shared with a combination of component suppliers, intellectual property owners, providers of complementary products and services, competitors, and consumers. This is all the more true as firms focus on a set of core activities and rely on a network of allies and suppliers to help them create and produce innovative products." In that case, the key question becomes, "who captures the most value from innovation, and why?"

To analyse this question, Dedrick *et al.* (2009) use a new methodology to measure the value captured by firms across the supply chains for the Apple iPod and notebook PC makers, both of which are "globally innovated products that combine technologies from the United States, Japan, and other countries, and are all assembled in China." Their product-level methodology allows them to break out the financial value embedded in each product and examine how it is distributed across the main participants in the supply chain. They find that that Apple's gross margins for its high-end iPod tend to be higher than those earned by notebook PC makers, and that Apple captures more of the value of the innovation embedded in the iPod than that captured by the notebook PC makers from the innovation in their supply chain. One of the key differences they identify is that Apple has stronger bargaining power within its supply chain[61] (as a result of the large market opportunity it provides), whereas notebook PC makers are part of a business ecosystem that they coordinate but do not control. Two suppliers—Microsoft and Intel—were found to stand out for making higher profits – both have been able to gain and keep control key software and hardware standards, strengthening their bargaining position in supply chains.

One key difference between the iPod and notebook PC 'profit from innovation' models is that notebooks are not sold tied to a particular associated method of content delivery or brand-specific accessories. While a notebook may come with some pre-installed software, the user can decide which applications to use on the notebook and which networks to join for accessing content. Most accessories also conform to industry-wide interface standards that are supported by all brands so notebook PC users face no penalty from choosing a different brand of notebook PC at their next purchase (e.g. USB storage devices, headphones or an external mouse can all be used on different brands of notebooks, whereas for Apple you are committed to the Apple software and Apple iTunes,

[61] Apple announced at the end of May 2013 that it would switch part of its production away from Foxconn, the company with which it has a long-standing relationship and which made nearly all of the world's iPhones and iPads, to Pegatron. This move gives Apple a greater supply chain balance, and is also seen by some analyst as a move to mitigate risk following some manufacturing glitches in Foxconn's production of the iPhone 5 (Dou, 2013).

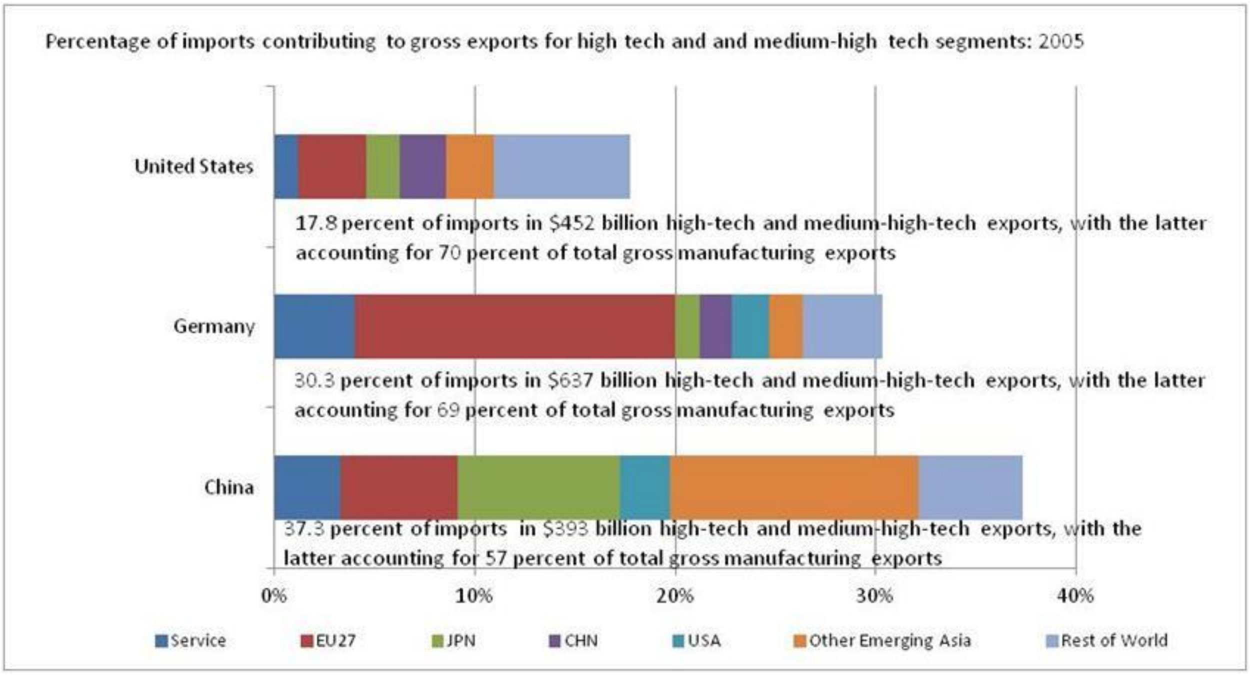
even though it is now Windows compatible, and most accessories are device specific. Furthermore, unlike for most notebooks, Apple has also kept control over the key elements of the iPod, such as the user interface, and the interfaces between the iPod, iTunes software, and the online iTunes Store. Apple's brand image is a good example of a complementary asset strengthening the value of the product and the innovation, and the company has greatly invested in this (intangible) asset. Contrary to what is sometimes thought, Dedrick *et al.* also argue that manufacturing is largely a complementary asset in the electronics industry: outsourcing is not universal, often the manufacturing equipment can relatively easily be converted from one product line to another. This is further reinforced by relatively short product design cycles (1-2 years) which may bring about manufacturing and supply chain changes. Apple has kept the supply of some strategic complements internal so as to always be able to secure the required complements (e.g. some of the specialised software). The physical Apple Stores also provide a strong complement, setting the iPod aside from other devices which are sold among many other brands and devices in stores that sell electronics and consumer goods.

Dedrick *et al.* (2013) draw several interesting conclusions, which provide some insights into opportunities and challenges for European (and other) firms to profit from innovation in the electronics industry. First, as the electronics industry is a vast, open platform, a common set of complementary technologies is available to all firms. This levels the playing field on the one hand, and implies firms need to carve out specific assets and advantages if they want to be among the lead firms. Second, branding, marketing, industrial design, rapid product development, business model, and channel strategy are important strategies for lead firms (and in particular those working within a dominant design) to be able to build advantages. Third, component suppliers will have to rely on unique strategies to improve their customer's value capture prospects, for example through new functionality, lower cost, or shorter time-to-market.

Ali-Yrkkö *et al.* (2011) also look at who captures value in global supply chains by looking at the geography of value added in the case of a Nokia N95 smartphone circa 2007. The authors found that the phone was assembled in Finland and China. When the phone was assembled and sold in Europe, EU27 accounted for 68% of the value added. When the phone was assembled in China and sold in the United States, Europe still captured as much as 51% of the value added, even though it played little role in supplying the physical components but because Finland and other EU countries played a key role in the branding, development, design, and management, highlighting the importance of services and other intangible aspects of the supply chain in global value chains. While much of the final assembly has moved offshore (accounting for 2% of value added in the case study), developed countries continue to capture much of the value added generated in global value chains.

There are several important takeaways from this analysis. One, it illustrates that the line between manufacturing and services is blurring, and in many respects has become fairly meaningless as much manufacturing relies on services and vice versa. Two, the finding that most of the value added generated in the value chain does not necessarily come from 'physical' manufacturing and assembly activities, and that much of the value generated from other parts of the value chain is largely accruing to developed countries should put at ease some of the concerns expressed by certain policy makers about the importance of having 'physical' manufacturing based locally. Finally, it is important to keep in mind that traditional trade statistics may be misleading when looking at distributions of global value chains as trade in services is difficult to record, there is much intra-firm trade which is not captured in most trade statistics, and more efforts are needed to improve statistics on trade in value added along the lines of the efforts that are being made by the OECD and the WTO.[62] The new database created by those organisations, and especially also combined with the new World Input-Output Database (WIOD), [63] opens up a broad scope of analysis. Indeed, direct trade only tells part of the value chain story, as illustrated by Figure 3.2.1, showing the key role imports from Europe play in Chinese exports in high-tech and medium-tech segments. Clearly, much more research needs to be undertaken to improve our understanding of the role of global demand and global value chains in driving (the distribution of) ICT impacts.

Figure 3.2.1: Trade inside the value chain



Source: van Ark (2012), based on World Input-Output Database (WIOD).

Areas for research

Supply-side analyses need to be complemented by an analysis of demand side channels and distribution channels. The investments in equipment, software, and technology are made only because businesses and governments expect that they will help to satisfy demands for better and cheaper goods and services. A broader study of ICT-enabled demand shifts and the demand side's role in economic growth patterns would require additional information on demand decompositions from consumers, businesses, and foreign buyers; relative price movements of ICT and non-ICT products and services; and the distribution of labour and capital compensation in ICT industries

[62] See http://www.oecd.org/industry/newoecd-wtoanalysishighlightschangingfaceofglobaltrade.htm and http://www.oecd.org/sti/ind/measuringtradeinvalue-addedanoecd-wtojointinitiative.htm (last accessed 29 May 2013).

[63] For example, the data availability from WIOD (international IO tables, and consistent labour market, energy and environment dataset), as well as the demand analysis along the global value chain, would allow us to analyse issues such as (i) Induced employment by ICT sector/investment; (ii) upgrading labour skill structure based on the ICT-induced employment, and (iii) ICT investments' direct and indirect energy- and environment-related impacts on other sector and economy.

relative to the aggregate economy. This analysis would greatly contribute to making a connection to the study of social and cultural aspects of ICT, as it would help identify the beneficiaries of the new technologies and therefore assess the gains in social and cultural value and the improvement of living standards. Improved understanding of ICT-enabled demand shifts, how they can transform business, and how policy and framework conditions will enable these transformative forces to further the impact of ICT on growth will be extremely valuable.

It is also of crucial importance to better understand how domestic and external demand impact on the use of ICT. Using new data on trade in value added and so far largely unexploited data from the WIOD, new analysis could help to understand the role of demand for ICT goods and services within Europe and externally in the global value chain, as well as other issues that will develop a better understanding of the (role of the) demand side for ICT.[64] Improving our understanding of the link between supply and demand, related to the fragmentation of markets is also important. [65]

Improving our understanding of the link between supply and demand, related to the fragmentation of markets is also important. Product and labour market restrictions, as indicated in OECD work, also play a role here. In addition, non-achievement of the Digital Single Market and the Single Market for Services could act as an important main barrier to effectively match and grow demand and supply and may imply a huge cost in terms of slowing the scope for European growth and hampering its competitiveness.

Work using the World Input-Output Database (WIOD) may provide a range of new insights in this context as it offers the possibility to examine where domestic and external demand for ICT originates from (sectors and countries). For example, using the WIOD data offers the possibility to perform an analysis for ICT-related industries and products for 40 countries. Using Global Value Chain analysis, it is possible to trace where and how internal and external demand emerges and how countries and sectors are integrated in global value chains in ICTs.

3.3 The public sector

ICT has the potential to profoundly impact the performance of the public sector and change the way its activities are organised. However, even though some progress has been made, much more remains to be gained. In addition, indicators that exist to measure progress, for example for e-government, may measure things like the number of computers and Internet connections, the percentage of people working with a computer and with Internet connections, or the number government departments with a web site, and the number of services offered online. However, the

[64] See, for example, van Ark *et al.* (2013a) for new work on 'Recent Changes in Europe's Competitive Landscape. How the Sources of Demand and Supply Are Shaping Up'.

[65] SMEs are also important in this context. Indeed, with ICTs opening access to both in- and output markets globally, and enabling firms to source talent internationally, ICT gives rise to what Varian calls the 'micro-multinational', and he argues that, while large companies were among the first to benefit from the changes enabled by ICTs, their impact on SMEs "may yet turn out to have the most impact on the economy." Varian (2005).

quality of the services offered and delivered and the intensity of their use are often not yet measured.

The impact of ICT in public sectors can occur through multiple channels. For example for e-government, it can allow government agencies to become more efficient, reduce costs and waste, and become more productive, deliver new and better services, and increase their engagement with citizens. The extent to which these effects will occur depends on the agencies and their ICT implementation, but also on the user side, whether or not citizens have the infrastructure, skills, willingness and trust to engage with their government agencies online, though this, in turn, can be affected by government policies and promotional and informational campaigns.

Especially in the current economic climate in which governments are under pressure to reduce expenditure, and are faced with rising costs, for example related to aging populations, the possibility "to do more with less" should seem attractive. Yet there is also much resistance to change within these organisations, often also coupled with a lack of vision and/or skills to implement ICT and digital (organisational) transformations. ICT-enabled technological and organisational innovations also allow governments to offer new and better services and deliver them in new ways. In addition, by improving the efficiency of administrative procedures, for example applying for permits and doing taxes online, and by providing more and better information, businesses also stand to gain from reduced red tape and administrative burden from dealing with government agencies in their business operations.

Finally, historical productivity data for the US suggests that ICT productivity impacts first occurred in the private sector before showing up in the public sector (Table 3.3.1).

Table 3.3.1: Historical productivity evidence suggests that ICT first 'hit' the private sector, and then migrated.

U.S. Aggregate Productivity Growth	**1987 to 1995**	**1995 to 2001**	**2001 to 2007**
1. Private industries*	0.8	1.1	1.7
2. excl. Health and Education	.9	1.3	1.9
3. Health 4. Education	-1.8 -.2	-.4 -1.0	.3 -.7

Note. All changes calculated as log differences. Figures do not account for increases in labour quality.
* Unpublished update to Corrado et *al.* (2007) using BEA industry data. Excludes real estate.

Thus, there is tremendous scope for gains from (digitally) transforming public sectors such as government, health care, and education. Without aiming to be exhaustive in these areas, we will touch on a few issues and findings from research, and also identify some areas for further research.

3.3.1 Government

E-government has been among the political aspirations of many governments and organisations, but the outcomes in practice appear to be lagging the ambitions. In addition, in practice the supply of (sophisticated) e-government services and their use appear to only be weakly correlated. te Velde (2011) analyses how ICT impacts the efficiency, effectiveness and quality of government services from a user (citizen and enterprise) perspective. He notes that technological and societal developments often go hand-in-hand, with resistance to change in the latter often holding back changes in the former. te Velde argues that in the public sector in particular, existing social patterns, such as the status of civil servants, may hamper the transformative implementation of ICT.

In addition, while the technological infrastructure may be in place to supply e-government services, there may be a resistance on the demand side from the users, for example related to so-called 'soft factors' such as awareness, skills and trust. In recent years, many e-government programs have seen a paradigm shift from government-centric supply driven e-government to one that is more citizen-centric and demand-driven.

Over the past decade or so, the public demand for more responsive, efficient, effective, and participatory government has gradually increased, adding to increasing weight being given to e-government with governments perceiving the use of IT as a "silver bullet" that could simultaneously improve the quality, effectiveness, and efficiency of public service delivery and reduce costs. By 2009, crucial services for enterprises like value-added taxes, corporate taxes, customs declarations, and social contributions were fully available online in almost every EU country.

te Velde (2011) finds that online citizen interaction with government is correlated to general frequency of Internet use, as well as specific uses for banking and social purposes. Government prioritisation of ICT is a readiness factor that drives uses through improvement in the telecom infrastructure. While this prioritisation improves perceived ICT efficiency, it does not guarantee high use of online public services, unless the necessary computer and ICT skills are present among citizens.

te Velde's approach sought to determine which of the various "readiness factors"—good telecommunications infrastructure, size of government spending, the priority placed on ICT by a government, and the quality of online public services—had the most and least impact in terms of improved government service, more efficient service, and higher citizen trust in government. These are all mediated by various "use factors", such as the frequency of Internet use, accessibility to broadband connections, and the ages and education levels of users.

The finding that the provision of online public services itself does not necessarily lead to the use of such services is crucial. As also echoed by the experts, one critical element is the overall IT strategy into which the provision of online public services is embedded. Some e-government initiatives fall short of their goals because they are conceptualised and implemented in a piecemeal manner, rather than comprehensively and from a "whole government" perspective. The lack of a coherent long-term vision for e-government that all stakeholders subscribe to was highly emphasised by the experts as an important barrier to the impact of ICT on growth.

te Velde (2011) finds that the prioritisation of ICT is the most important policy indicator which drives the quality of the basic telecommunications infrastructure and broadband penetration, has a strong impact on the use of online public services by citizens, and is directly related to ICT-induced efficiency improvements. However, a high uptake of online public services requires a strong presence of computer and ICT skills among the intended users of these services. te Velde finds that these skills are the strongest driver of use of online public services and are related to the frequency of Internet use, provided that they are combined with government priority on ICT. This implies that it is very important for government and policymakers to not only roll-out the technology into government functions, but to also make sure that it is explained to the public to make sure the services offered are taken up by the citizens.

3.3.2 Health

There are many ways in which ICT can positively impact the health sector, and increasingly so as technologies continue to evolve (for example, big data analytics contribute to broadening the vast scope for research, innovation and productivity improvements in the health sector) and new applications are being invented continuously. Example of positive impacts include more efficient diagnosis and administration (not only of the medical side, but also on the organisational and administrative side of health care delivery providers),[66] better diagnosis, remote care and monitoring which reduces need for patients to come in, advances in preventive care – notably through the use and analysis of big data (which is now also used in predictive modeling about illnesses, for example), consolidated health records which makes life easier for doctors and patients (including, for example, when travelling) and should improve diagnosis and medication, and with more information available (on the Internet) for both patients and doctors (although this can be good and bad, for example when patients 'self-diagnose' with information found on the Internet, and then provide a biased account of their symptoms to the doctor).

The next trends that can be important here, as also mentioned by the experts, include further development in big data analytics, body technology, advanced materials and robotics. However, there are also some potential downside risks which may come from concerns about data ownership and use, privacy and security, attitudes of patients and professionals to new developments, and interoperability of systems,[67] especially also internationally, which is very important for continued

[66] While this should in theory reduce costs, there are some studies and ad-hoc examples that show costs may actually increase, or at least initially. For example, te Velde *et al.* (2011) find that e-health increases rather than decreases the expenditure on health care. There are also example of cost saving. For example, MGI (2013) cites the example of "New York's Mount Sinai Hospital which in a venture with General Electric, uses smart tags to track the flow of hundreds of patients, treatments, and medical assets in real time. The hospital estimates it could potentially treat 10,000 more patients each year as a result and generate $120 million in savings and revenues over several years."

[67] European Commission (2010) studied the socio-economic and financial impacts of interoperable electronic health records and e-prescribing systems with several case studies in Europe and the United States. Using a cost–benefit analysis it was found that the socio-economic gains to society exceeded the costs in each case. Interoperability between electronic health records and other clinical and non-clinical systems was found to be a principal driver of benefits. Health provider organisations were found to benefit most, with an average of 61%t of the benefits, and patients and medical staff each gained 17%, on average, though benefits may take some time to materialise (on average seven years before a net positive benefits were found to occur).

progress in the application of ICT to health. In addition, te Velde *et al.* (2011) also find that in order to reduce government expenditure on health care it may be even more important to invest in streamlining intersectoral processes than to invest in ICT. These points are also echoed by the experts.

Ronchi *et al.* (2013) argue that the effective implementation of ICT health care offers tremendous opportunities, not only for providing better health care at lower costs, but also for economic growth. It is often argued that ICT in health can lead to higher quality, safer health care that is more efficient and responsive to patients' needs, with a potential reduction in medication errors and supporting the development of new, innovative models of care delivery. However, the global market for ICT health products and services is also growing. In Europe, according to Ronchi *et al.* (2013), this sector includes a number of large European-based companies, as well as some 5,000 SMEs operating in various e-health sub-sectors. As the sector is believed to have a great growth potential, it also carries the hope that increased adoption of health ICT will increase demand for developers and e-health related skilled workers to implement, support, and use these technologies. Indeed, health care may well be a sector where technology and various types of skilled employment are likely to be complements rather than substitutes.

Changing demographics in most European (and OECD) countries, notably with aging populations, is increasing the cost of healthcare, at a time where governments are facing pressure to reduce to spending. Aging populations, and an increase in illnesses related modern life-styles, are likely going to increase the size of the health sector. This, in turn, is likely to increase in demand for workers in the sector (for example because an aging population requires increased care). ICT is likely to impact these developments in several ways. While some ICT may reduce the need for on-site healthcare workers by enabling remote (home) monitoring, testing, imaging reading and interpretation, diagnosing of patients (potentially delaying the time when they need care in health care facilities), greater adoption of ICT will also increase demand for those directly supporting the development of the new platforms and applications, their implementation, and their upkeep. It will also change the way doctors and nurses work, changing the skills set required of them, and potentially creating new jobs for healthcare professionals who can use newly available data to identify opportunities to improve health care performance. Indeed, as Ronchi *et al.* argue, "the movement toward accountable care and larger, integrated delivery systems—a movement facilitated by a greater use of ICTs—is spurring investment in data, analytics, and care management platforms in many OECD countries."

However, in spite of this promising outlook, integrating ICT in health in practice has proven challenging,[68] for a variety of reasons, which include the financial and organisational structure for healthcare providers (which can create disincentives to using ICTs to increase efficiency and quality and reduce redundant utilisation), and a lack of governance and leadership in the implementation of ICT. To date, many ICT projects in health have been delayed or failed, often because there was no long term vision for ICT in health that all stakeholders adhered to, because of a lack of skills, or unrealistic expectations. Other explanations include a lack of interoperability of systems and

[68] For example, Ronchi *et al.* (2013) report that in 2009 only 46% of US doctors used electronic medical records, compared with over 90% of doctors in Australia and the United Kingdom, and that according to a recent survey of European Union countries, on average, only 6% of general practitioners reported using e-prescribing (with the exception of Denmark, Sweden and the Netherlands where the percentages were 97%, 81% and 71%, respectively (see Ronchi *et al.* and the references therein).

standards, and failing to manage the transition to a digital information environment, notably with integrating privacy policy, security, and technological requirements for access and the exchange of healthcare information into ICT health systems. Increased health data generation (for example with digital imaging, the use of mobile devices, remote monitoring etc.) and electronic health records, combined with increasing scope for big data analytics, also raises some concerns about data ownership and access, and has a number of privacy implications (for example, if health care data were to be combined with financial or insurance type data bases, potentially impacting the possibilities and costs of obtaining a mortgage or insurance, or even a job).

te Velde *et al.* (2011) draw a number of interesting conclusions from their study, which are important in thinking about ICT and health going forward, including:

- Internet diffusion has greatly boosted the adoption of ICT and health care and has helped the move from stand-alone applications to networked solutions, although the use of networked e-health applications is not necessarily sequential to the use of standalone e-health applications and the two tend to exhibit different diffusion and adoption patterns.
- Telemedicine has not yet delivered on its promises and much more remains to be gained.
- GDP is the most important determinant of the outcome of healthcare systems, with ICT only making a modest contribution. However, the impact of ICT is directly related to how it is being implemented and used.
- Doctors and patients perceive the obtained efficiency gains differently, the former frequently citing it as adding to their workload and a potential deterioration in the quality of the service provided, while the latter are more appreciative and find the benefits outweigh the potential deterioration. The doctor-patient relationship more generally is also being altered by the Internet, which has greatly empowered and emancipated patients.

Ronchi *et al.* (2013) argue that improved measurement of ICT in health and its impact, combined with the study of best practices and particular cases of success and failure, will improve future decision making. The OECD has made some progress on this, taking stock of existing surveys and measures, and working with countries to develop a measurement framework. As a starting point, the OECD has collaborated with Harvard School of Public Health, the World Health Organisation, and the European Commission to establish a number of indicators as an illustration of what could be included in a harmonised survey, organised in 4 categories in which the measurement of availability and use represent today's policy priorities for OECD countries: (1) provider-centric electronic records systems, (2) patient-centric electronic records systems, (3) health information exchange, and (4) telemedicine.

Areas for research

Especially in light of the advent of big data, it is important improve understanding of how greater adoption and integration of ICT in health can contribute to reducing health care expenditure and increase the sector's performance, improving health outcomes and safety, job creation, and innovation in health care delivery.

3.3.3 Education

Education represents another (largely non-market) sector with great potential for ICT to profoundly change its activities, potentially even reshaping the relations among the main players while also increasing the scope for new entrants. According to MGI (2013), education represents 4.5% of global GDP. In addition to its potential impact on the efficiency and productivity of the administrative and organisational side of the educational system and its establishments, ICT can impact education in various ways, including by changing educational methods, improving the educational performance of children, and enabling remote education. At the same time, educational levels are also a factor in the diffusion and adoption of ICT and the Internet in particular, with a positive correlation between Internet use and the level of education (which is one determinant among others, such as age, gender and employment status).

ICT use has also been found to have an impact on educational outcomes, including from a young age, but so far the impact appears to have been greater from home use of ICT rather than from ICT in school. Indeed, studies have found that household computer ownership increases children's educational performance (Schmitt and Wadsworth, 2004), as does the frequency of computer use, though the effect in many countries is larger for computer use at home than for usage at school (Spiezia, 2010). This may of course change over time as ICT use becomes increasingly integrated in classrooms and teaching. ICT familiarity matters for educational performance. OECD (2010) finds that performance differences associated with the length of time students have been using a computer remain once socio‑economic background is accounted for. ICT is found to enhance and complement other academic skills and competences, but has little impact if that background is not present. Furthermore, the report notes that it is important to realise that even though students increasingly appear to be technologically "savvy" (as they use the Internet, games, social media and ICT devices with increasing ease even from a very young age), "this does not mean that they have developed the skills and competences that will make them responsible, critical and creative users of technology."

ICT is changing class rooms, with the tools that are being used for teaching and those used by students (including interactive white boards, laptops and tablets), the way students are being taught, access to increasing amounts of information at students' and teachers' disposal, and technologies that may enhance the performance of teachers.[69] Game technologies are increasingly being used to develop software that makes learning more interactive and fun for students, and is more customised to their individual needs and progress. Global massive online open courses (MOOCs),[70] including

[69] Teacher performance may be enhanced for example through forms of online collaboration and exchange with colleagues, access to best-in-class pedagogies, and being able to better track the performance of student students allowing them to intervene sooner and in a more targeted and personalised way.

[70] For example, in the US in May 2012, Harvard and MIT announced a new non-profit partnership, called edX, to offer free online courses from the two universities rewarded with a course certificate (and to be overseen by a non-profit organisation governed equally by the two universities, both having committed $30 million to the project). In addition, Stanford, Princeton, the University of Pennsylvania and the University of Michigan announced their partnership with a new commercial company, Coursera (https://www.coursera.org/), with $16 million in venture capital. And by May 2012, more than 200 000 students had already registered for the six courses available from Udacity (http://www.udacity.com/), the company founded by Sebastian Thrun, the Stanford professor who made the news headlines in the fall of 2011 when 160 000 students signed up for his Artificial Intelligence course (Lewin, 2012). See also Appendix A4.4.

from the highest rated academic institutions, increasingly offer university-level courses online available to all students no matter what their location is.

However, a number of factors are holding back progress, including a lack of vision and/or commitment to the vision by the main stakeholders, reluctance to change, and a lack of skills among teachers to teach in new ways and using new technologies and tools. In addition, curricula are also notoriously slow to change and are often behind the technology curve. It has been said by experts that while in many professions, the way work is being done today is so profoundly different from how it was done say 20 years ago that someone who retired, for example, would not be able to come back and pick up where they left off, except in teaching in many classrooms to date. Indeed, it seems that despite the promise of transformation held by ICT in providing better education to more people more efficiently, and despite the substantial investments in ICT in education in most countries, the education sector has not seen the pervasive and revolutionary changes that have occurred in industries such as music, travel, and news (Jager *et al.*, 2011). Jager *et al.* also suggest that one possible explanation is that even though the hard infrastructure may be in place (computers, Internet connections), the soft infrastructure (organisational changes and skills) is often still lacking, and teachers in particular need to not only be proficient users themselves, but also be able to fully integrate ICT into their teaching. This is also a point made the experts: it is very important to put the ICT – and responsibility for adopting and integrating ICT into teaching - in the hands of the educators rather than the "IT department" – those who will be using the ICT have to buy into the vision for ICT in education and must have a willingness and readiness to use ICT, otherwise the ICT investments will be wasted and ICT projects will fail. It is important to address this issue quickly, not least because 'old style' classroom teaching will be less and less appropriate as a learning style for younger generations of "digital natives". Jager *et al.* also found that while ICT has a positive association with the attitude towards math and science, it appeared to have a negative relationship with reading.

Using data from PISA 2006 to analyse the impact of investments in technology on educational outcomes, OECD (2010) finds that there is a second digital divide in education in addition to the one relating to access to technology, namely one between those who have the right competencies to benefit from computer use, and those who do not. These competencies and skills are closely linked to the economic, cultural and social capital of the student.

OECD (2010) concludes that there are important implications for policy and practice, and notably that governments should clearly convey the message that "computer use matters for the education of young people and do their best to engage teachers and schools in raising the frequency of computer use to a level that becomes relevant." Only then will clear correlations between technology use and educational performance emerge. In addition, as well as the need stated by experts to have a clear long term vision for the use of ICT, OECD (2010) also stresses the need for adopting holistic policy approaches to ICT in education. In addition to the actual ICT investment, environmental factors matter for the use of ICT in schools, such as "the inclusion of ICT in curriculum design or strong leadership and commitment from teachers and headmasters to implement ICT-rich teaching". However, the report finds that "among the limitations of many educational ICT policies is that most countries have not developed holistic policies for the educational use of ICT."

OECD (2010) also notes that "data availability remains one of the main handicaps for understanding the role of ICT in education. New data could give a more nuanced picture of the availability and use of ICT and its effects on educational attainment, the quality of the teaching and learning process, and the development of the 21st century competences."

Areas for research

It seems that, overall, there is limited measurement and analysis of the impact of ICT on education, though it is generally thought there is still great potential for ICT to improve efficiency in education and for improving educational outcomes, for example by providing new tools for teaching and learning processes and by providing the skills needed in a society that increasingly relies on ICT in all domains. Research in this area should help to understand the impacts on educational outcomes and skills, and should improve decision making around investing in and implementing ICT in education.

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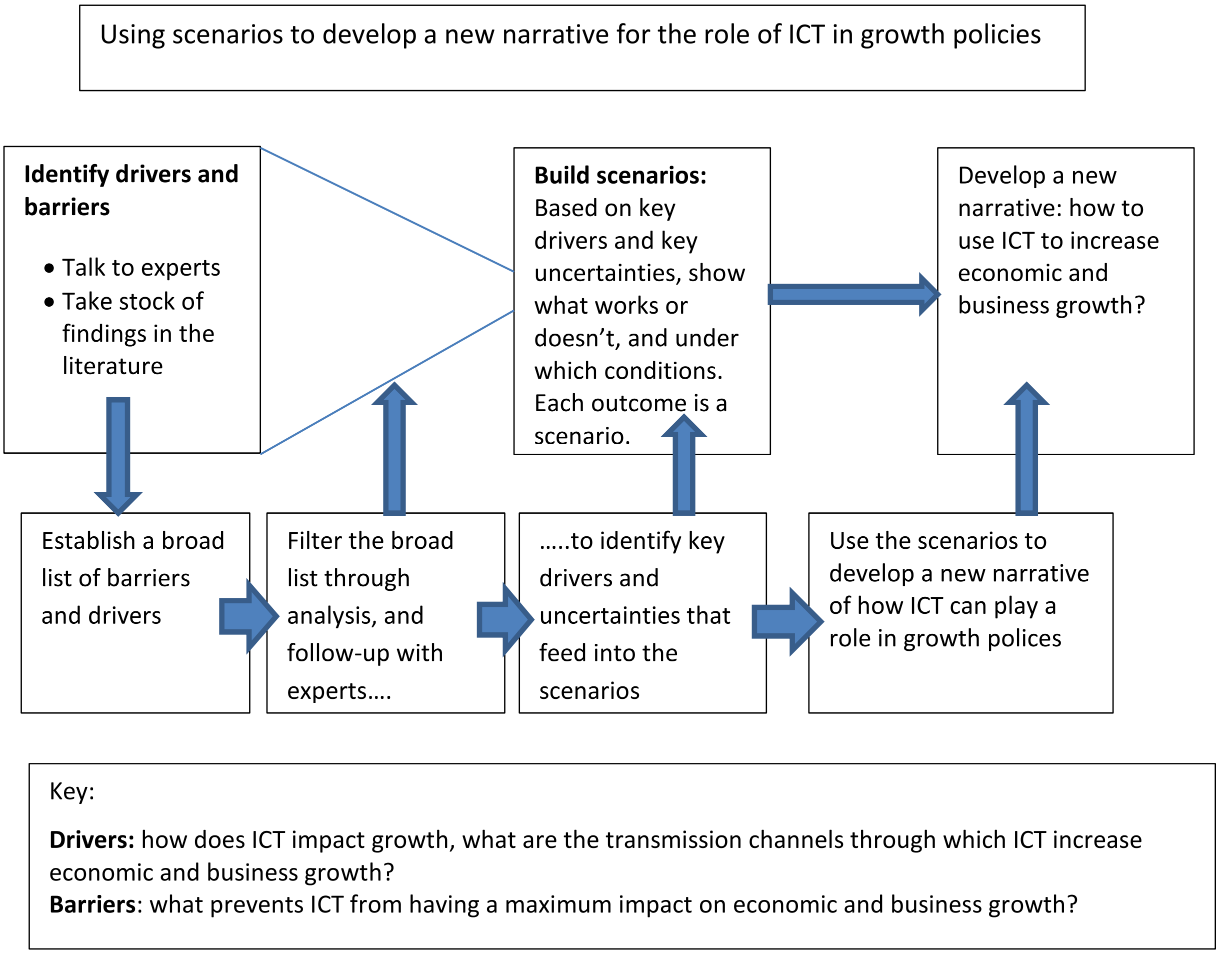
Appendix 1: Study Methodology

The Conference Board was commissioned by DG Connect to "use scenario analysis to build a new narrative for the role of ICT for growth in Europe. The study should bring together existing knowledge about ICT and growth to build scenarios, assessing which environments are most conducive to growth benefits induced by ICT", and offer the greatest scope for ICT policy in growth policy, to be used as an input into the development of a new policy agenda. Knowledge and research gaps were also to be identified, making suggestions for areas where more research is needed to help shape the next research agenda.

Mapping out ICT's impact on the future economy and the business environment is an inherently uncertain exercise, especially given the rapid pace of continuous technological change and increasing technological convergence. Therefore, rather than starting from a static outlook for ICT trends or economic growth dynamics, the approach of this study was to develop multiple scenarios on how ICT developments and economic growth may relate to one another for the remainder of this decade. In addition to a review of the available empirical evidence, insights from experts were used to develop the key drivers, uncertainties and barriers that determine how ICTs shape economic and business performance. The scenarios were developed using different combinations of those factors, and were used to articulate a "high level narrative" that describes the several, most compelling different roles ICTs can play in growth, and, in particular, in stimulating a slow growth environment. The purpose of the narrative is to help policy makers frame the growth and ICT development agenda for Europe.

The study approach is depicted in the diagram below. Much emphasis was put on the engagement with experts from the business, policy and academic communities through individual interviews, a video panel discussion, an in-person scenario brainstorming meeting, and several follow-up discussions with individual experts. In addition, we also talked to a group of young professionals and technology enthusiasts, and a round table was set up to gather the input from a group of digital web entrepreneurs.

Figure A1.1: Summary of the study methodology



The interviews

We conducted 41 individual phone call interviews with experts from the business, policy and academic communities (see Appendix 2 for the list of names). The following questions were used to guide the interview conversations, and they were shared with the interviewees in advance of the call:

1. How does ICT – its development, production, and/or usage – most impact economic growth?
2. What ICT trends will, could or should have the biggest impact on economic growth in the period up to 2017?
3. What looming or foreseeable new technologies, product or services related to ICT could have the biggest impact on economic growth in the future?
4. How are countries and governments succeeding or failing to leverage ICT to its fullest potential in driving economic growth?

5. What role can government policy play (if any) in maximizing the potential for ICT to drive economic growth?
6. In a context of austerity and competing policy and fiscal objectives – can and how should one convince those who are skeptical about the role government can play in ICT at all?

The video conference

In preparation for the video conference we summarised the information from the then 32 interviews conducted and drew up a broad list of drivers and barriers that we sent the experts and asked them to rank their top 5. These rankings were discussed at the video conference which took place on the 27th of February 2013. By the time of the video conference we had conducted 37 interviews. The video conference used a technology called BlueJeans, and 36 experts participated from 27 different locations. This was the first time we brought the experts together to discuss the main drivers, barriers and uncertainties that had been identified from the individual conversations.

The gross list of drivers and barriers that experts were asked to rank is included below. In total we received 26 rankings back from the experts (24 ahead of the video conference). These rankings were used to draw up the lists with the main drivers and barriers used for the rest of the study, and listed in Box 2.2 and Box 2.3 in Chapter 2.

Which 5 of the randomly listed drivers/enablers – as mentioned by the experts - are the most important in your view: assign 1, 2, 3, 4, 5 points – with 5 points going to the most important (and feel free to add a 'wild card' at the bottom of the list for something not mentioned):

<table>
<tr><td>1-5</td><td>Gross list of drivers/enablers of the impact of ICT on growth</td></tr>
<tr><td></td><td>"Technology"

Cloud
High speed Broadband
Fibre
Mobile Broadband/mobile Internet
3D printing
New materials
Robotics, machine learning
Internet of things
Advances in coordination technologies

"Technology enabled use"

Big data/data analytics and synthetics/data driven innovation
Innovation in services and apps
Network based innovation
1. ICT enabled organisational and business model changes and innovation
2. Network and ICT enabled product, process and supply chain innovation
ICT-enabled start-ups
Scalability
Local content and services
Location-based services

"Technology enabled demand"

Ubiquitous connection: high-speed and always on
Latent demand: people don't know they need it until they have seen it
Households and consumers adopt earlier now than business
Governments lead by example in 2 ways:
1. Procurement, 2 ways:
a. government biggest buyer of IT in most countries
b. favour smaller business contracting
2. Adoption of the cloud: can push the cloud and ICT more broadly throughout the economy
Improved and increased exploitation of existing technologies and applications
Cheap access
ICT no longer a 'technology' but a 'utility' (like electricity, gas and water)
Have 'a gorilla' drive a push of a whole industry/sector onto a platform/solution – e.g. US Walmart, in Europe can be government – need the scale effect</td></tr>
<tr><td>Wild card</td><td></td></tr>
</table>

Which 5 of the randomly listed barriers – as mentioned by the experts - are the most important in your view: assign 1, 2, 3, 4, 5 points – with 5 points going to the most important (and feel free to add a 'wildcard' at the bottom of the list for something not mentioned):

1-5	Barriers to achieving the impact of ICT on growth
	"Education and training" Resistance to change Lack of / wrong skills: 1 language (everyone should speak English), 2 ICT: professional, design high-level services, build apps, users, e-leaders 3 management culture Lack of standardisation of education and ICT competences Outdated education systems and educators Lack of awareness of available EU funding and support mechanisms Available EU funding and support mechanisms too cumbersome for small players Lack of awareness of potential of ICT in Europe Lack of a clear common Long Term vision for Europe that people adhere to on how and why ICT should be used and integrated Many IT projects fail (because they are badly/not thought through, no vision or strategy what should be done once IT is in place, lack of skills) – gives IT investment a bad reputation ***"Organisational and cultural heritage"*** Existing technologies and capabilities not fully exploited 1 lack of skills, ignorance, fear of IT, risk aversion 2 organisational structures of organisations, 3 rules and regulations; Lack of entrepreneurship 1. cultural, 2. structural: a. administrative barriers, b. access to finance c. lack of a supportive eco-system Legacy technologies/legacy systems and investments Access to (venture and angel) capital – very difficult to get money for small innovative projects Availability of data centers in Europe (in town no space, in rural areas not enough power, and not sufficient broadband speed and connectivity) Bringing new products (goods, services, apps) to market – Europe not good at this Available EU funding and support mechanisms too cumbersome for small players ***"Policy"*** Fragmented legal and regulatory frameworks not adapted to this digital age Not enough focus on developing demand side and use, too much focus on infrastructure Rolling out infrastructure: wrong investment incentives, ubiquitous fibre must become a reality Next page SME rules, regulation and legislation – need to be harmonised and changed – especially bankruptcy laws (must be 'allowed to fail' and still get to try again) International trading and payment systems

	Lack of standardisation Lack of portability of data Lack of flexibility (and mobility) on the labour market No harmonised cross-border payment systems No harmonised cross-border tax systems EU funding biased towards large projects in large established organisations EU funding mechanism too complicated and cumbersome to apply for Too much red tape (for creating a business/entrepreneurship/start-ups, to recruit, to get funding)
Wild card	

The Scenario Brainstorming meeting in Brussels

On the 6th of March 2013 a scenario brainstorming meeting was held at DG CONNECT's premises in Brussels, attended by 20 participants (see Appendix 2 for a list of participants). The group discussed the policy context of the study, the main drivers and barriers, as well as the first set of 'starter scenarios' that had prepared following the video conference the week prior to the scenario brainstorming meeting.

The morning session consisted of a group discussion of the study findings up to that point (notably the main drivers, barriers and uncertainties), and a presentation of the starter scenarios. The group was then split into two subgroups, each working on 2 scenarios, discussing the implication of 'being in the scenario situation'. The discussion and observations of what the implications of each scenario would be were then reported back to the group and discussed. In the afternoon the group split again into two subgroups each discussing two scenarios, but now thinking about what policy actions would get us to each scenario situation, or would avoid us getting there. The two subgroups then reported back to the group discussing the findings for each scenario. Implications for revising the starter scenarios were also discussed. The agenda for the day is included below.

Based on the feedback and discussions at the scenario brainstorming meeting, the initial set of starter scenarios was revised and discussed within the study team, as well as with several experts over the course of follow-up discussions. Those scenarios were again revised, taking the outcomes of those follow-up discussions into account, and leading to the final set of scenarios, outlined in detail in Chapter 2 of the Main Report.

Agenda: Scenario Brainstorming Meeting, Brussels, 6 March 2013

9.00-9.30	Arrive at the venue
9.30-10.00	Welcome by Commission and TCB, tour de table, and plan for the day
10.00-11.00	Session 1: Presentation of the project context, the starter scenarios and Q&A
11.00-11.30	Break
11.30-12.15 Break-out	Session 2. Discussion and brainstorming in two subgroups to discuss implications for Europe for each of the starter scenarios, and identify opportunities and challenges.
12.15-13.00	Two subgroups report back and sharpening up of scenarios
13.00-14.00	Lunch break (main room)
14.00-15.30 Break-out	Session 3. Discussion and brainstorming in two sub-groups to discuss trajectories for change to tackle challenges and seize opportunities for each of the scenarios in European policy context.
15.30-16.00	Break
16.00-16.45	Two subgroups report back to identify implications for the high level policy narrative
16.45-17.00	Wrap-up by Commission and TCB

Appendix 2: List of experts

We are extremely grateful to all of the experts who have contributed to this study, participating in the individual interviews, one or several meetings, and follow-up discussions. We hope to be able to continue the conversation with all in the future.

The interviews took place between 8 February 2013 and 19 April 2013. The experts interviewed in individual interviews are listed below in the order of the date they were interviewed. “Affiliation” refers to whether their current principal activity is in P=policy, B=business, or A=academia. There were 22 experts currently in the business community, 10 experts working in policy, and 9 experts from the academic world. It should be noted, however, that several of the experts in the business community have in the past worked in policy and/or in academia, or continue to do so today.

Individual interviews		
	Name	Affiliation
1	Constantijn van Oranje	P
2	Antoine Aubert	B
3	David Almstroem	B
4	John Zysman	A
5	Peter Hagedoorn	B
6	Richard Simpson	P
7	Duncan Hine	B
8	Joost van der Vleuten	P
9	Eric Bartelsman	A
10	Aurelien Renard	B
11	Michael Robinson	B
12	Jean-Jacques Sahel	B
13	Emmanuel Benoit	B
14	Ken Ducatel	P
15	Paul Timmers	P
16	John Rose	B
17	Hossein Eslambolchi	B
18	Hal Varian	B
19	Erik Brynjolfssen	A
20	Werner Schultheis	B
21	Paul Berriman	B
22	Christine Voigtlaender	B
23	Taylor Reynolds	P
24	Reinhilde Veugelers	A
25	Francisco Blanco	B
26	Bruno Lanvin	A
27	Jonathan Murray	B
28	Tony Clayton	P
29	Jean-Claude Burgelman	P
30	Detlef Eckert	P
31	Carol Corrado	A
32	Marc Vancoppenolle	B
33	Cristiano Codagnone	A
34	Megan Richards	P
35	Miguel Jimenez	B
36	Michael Bender	B
37	John VanReenen	A
38	Soumitra Dutta	A
39	Javier Santiso	B
40	Peter Haynes	B
41	Jose Alvarez	B

Next, 36 people participated from 27 different locations in the video conference organised on the 27th of February 2013, including 4 from The Conference Board Team:

Video Conference 27 February 2013	
1	Jon Spector
2	Bart van Ark
3	Wim Overmeer
4	Desiree van Welsum
5	Emmanuel Benoit
6	Joost van der Vleuten
7	Ken Ducatel
8	Paul Timmers
9	Jacek Starczewski
10	Lucilla Sioli
11	Katja Viertio
12	Alexander Riedl
13	Constantijn van Oranje
14	Sylwia Giepmans
15	David Almstroem
16	John Zysman
17	Peter Hagedoorn
18	Richard Simpson
19	Aurelien Renard
20	Michael Robinson
21	Jean-Jacques Sahel
22	John Rose
23	Hossein Eslambolchi
24	Hal Varian
25	Werner Schultheis
26	Christine Voigtlaender
27	Jonathan Murray
28	Tony Clayton
29	Carol Corrado
30	Marc Vancoppenolle
31	Martin Fleming
32	Francisco Blanco
33	Miguel Jimenez
34	Carmen Cuesta
35	Peter Haynes
36	Megan Richards

Then, 20 people participated in the scenario brainstorming meeting in Brussels on the 6th of March 2013, including 4 from The Conference Board Team:

Scenario Brainstorming Meeting, Brussels	
1	Jon Spector
2	Bart van Ark
3	Willem Overmeer
4	Desiree van Welsum
5	Lucilla Sioli
6	Katja Viertio
7	Alexander Riedl
8	Gianluca Papa
9	Megan Richards
10	Joost van der Vleuten
11	Sylwia Giepmans
12	Peter Hagedoorn
13	Aurelien Renard
14	Jean-Jacques Sahel
15	Reinhilde Veugelers
16	Tony Clayton
17	Marc Vancoppenolle
18	Cristiano Codagnone
19	Miguel Jimenez
20	Fabien Curto Millet

We also interviewed 7 ‘young professionals and technology enthusiasts’ who work for McKinsey in the U.S. (all but one in the Business Technology Office):

McKinsey - technology enthusiasts	
1	Stephen Guerin
2	Anup Dhalwani
3	Otis Reid
4	Daniel Spector
5	Glynnis Kearney
6	Rahil Jogani
7	David Levitch

Finally, on 13 May 2013 Tony Clayton (UK IPO) and Sara Kelly (COADEC) hosted and facilitated a Round Table in London with Digital Entrepreneurs, an academic expert, and a representative from the Federation of Small Business, Innovation and Enterprise to provide input for the study, and which was attended by:

Digital Entrepreneurs Round Table	
1	Tony Clayton
2	Sara Kelly
3	Georg van Graevenitz
4	Danny Jeremiah
5	James Knight
6	Dominique Lazanski
7	Shiva Attah
8	Brian Hole
9	Matt Smith
10	Alex Guest
11	Brian Taylor
12	Eze Vidra
13	Saskia Waltzel

Appendix 3: The policy context

We briefly set out the policy context, with the current scope of ICT policy, and ICT policy in growth policy.

The Annual Growth Survey

The text of the 2013 Annual Growth Survey (AGS) reflects the delicate task European and national policy makers are currently facing in their challenge to achieve a growth-friendly rebalancing and restoring of Europe's competitiveness, while being mindful of social and environmental objectives. Policy makers face pressure to implement austerity measures, but at the same time they are asked to keep investing, and at times even increase productive investments, to support growth and ensure a sustainable growth path in the future.

The AGS text identifies 5 priorities, and ICT can play a direct and/or direct role in achieving each of them. However, the current AGS text sells the potential for the role of ICT in growth short, considering only three channels: broadband, ICT and jobs/skills, and e-government. Below we highlight other channels through which ICT can play a much more ambitious role with a much broader scope, even within the priorities currently framed in the text of the AGS.

1) ***Pursuing differentiated, growth-friendly fiscal consolidation***

ICT has an impact on fiscal consolidation by making the economy more efficient, improving scope for the efficiency of reforms and scope for cost cutting, increasing productivity and growth, and improve efficiency and effectiveness of spending. The AGS's recommendation that "*Investments in education, research, innovation and energy should be prioritised*" represents a dual opportunity for growth impacts from ICT as, in addition to direct effects on growth, this will also improve the impact of ICT on fiscal consolidation, and ICT can contribute to making the delivery of these objectives more cost efficient. The same points apply about the AGS recommendations health care and age-related expenditure ("*reforms of healthcare systems should be undertaken to ensure cost-effectiveness and sustainability, assessing the performance of these systems against the twin aim of a more efficient use of public resources and access to high quality healthcare*.") notably through E-health which includes digitizing the administration, service and delivery of service through new e-health applications. ICT can also help to "*ensure greater efficiency of tax administration*", for example by continuing to move declarations and other tax formalities and payments online.

2) ***Restoring normal lending to the economy***

ICT can have an impact on Europe's financial health through some of the existing recommendations, such as, for example, "*Promoting new sources of capital, including business-to-business lending, providing more possibilities to issue corporate bonds and facilitating access to venture capital.*" Indeed, ICT can help identify and provide new sources of funding, including though crowd-financing. At the same time, these recommendations (access to capital, venture capital) will also help the development and adoption of new ICT-related technologies, products and services and therefore contribute to growth.

3) ***Promoting growth and competitiveness for today and tomorrow***

ICT has a direct and indirect impact here by enabling a profound restructuring of economic activities, increasing innovation and competitiveness, growth and productivity. The priorities that are listed in the text for the framework conditions can all be enhanced and improved with ICT, and at the same time they also improve the framework conditions for being able to better exploit ICT for growth. The importance of achieving the Single Market (especially for services) is highlighted in the AGS text, and this is also important for developing the ICT and ICT (enabled) services sectors. There are some specific mentions in the text of the AGS relating to both improving network industries and ICT, among others, notably:

> *The performance of network industries across Europe also has a critical knock-on effect on the rest of the economy and can be significantly improved by:*
>
> - *Developing the right incentives for the rapid country-wide roll-out of high-speed Internet infrastructure and the development of mobile data traffic. Frequency bands for wireless broadband need to be freed up by governments.*
> - *In line with the e-commerce directive, applying harmonised rules on transparency and information requirements for businesses and consumers.*
>
> And: "*The performance of product markets would also be greatly improved if national standardisation bodies deliver the objectives set at the EU level, in particular to move from national to European-level standards. Full use should be made of the notification of technical rules for ICT products and services to facilitate their circulation in the single market.*"

4) ***Tackling unemployment and the social consequences of the crisis***

ICT can have direct and indirect impacts on relieving the unemployment situation and other social pressures. Direct impacts can arise when ICT helps to create new sources of growth and new business opportunities. While there is currently much debate about the (lack of) employment generating capability of ICT, there are other important labour market effects to consider, such as more flexible working environments, including remote working arrangements and more flexible hours. These capabilities come with a need to enhance entrepreneurship and e-leadership skills, as well as ICT user skills more generally. Indirect effects come from boosting growth which will create more jobs. The AGS section on *Preparing for a job-rich recovery* also specifically mentions ICT: "*To tap the job potential of expanding sectors, such as the green economy, healthcare and ICT, through a future-oriented and reliable legal framework, the development of adequate skills and targeted public support.*" ICT can also contribute to increasing employability more generally, and especially of young people.

5) ***Modernising public administration***

ICT can have a direct impact on more efficient government, including digitizing the public sector and through e-government. The AGS text mentions: "*many Member States have undertaken measures to increase the efficiency of their public services as well as the transparency and quality of their public administration and judiciary. Such reforms have been particularly far-reaching in countries in financial distress. Examples include reorganising local and central government, the rationalisation of the public sector pay system and of the governance of state-owned enterprises, reform of public procurement processes, regular comprehensive expenditure reviews and the promotion of efficiency measures* *across the public sector, such as a greater use of shared services and information technology solutions.*" ICT can directly and indirectly contribute to implementing these reforms and enhance their impact.

The AGS text further mentions some additional factors where ICT can also play a role directly and/or indirectly. Indeed, "*the Commission considers the following to be particular contributors to growth:*

- *Employing sound financial management by making full use of public procurement opportunities in support of market competition and developing e-procurement capacities across the single market. Such actions not only contribute to greater efficiency and fairness but also help to combat corruption.*
- *Simplifying the regulatory framework for businesses and reducing the administrative burden and red tape, particularly at national level.*
- *Ensuring the widespread, interoperable digitalisation of public administration, aimed at fostering user-friendly procedures for service providers and recipients, as well as administrative simplification and transparency. Cross-border interoperability of online services and research centres throughout the EU is particularly important.*" (pp.12-13)

The Digital Agenda

The Digital Agenda is one of seven flagship initiatives[71] launched by the Commission to help meet the objectives of "Europe 2020" and the areas it prioritised, including innovation, the digital economy, employment, youth, industrial policy, poverty, and resource efficiency.

The "Digital Agenda for Europe"[72] identified the key challenges preventing Information and Communication Technologies (ICT) from unleashing their full growth potential. These include a lack of investment in new fast broadband networks, the fragmentation of digital markets, the lack of ICT skills in the population, trust and security, the low level of research and innovation, as well as the lack of interoperability. The Digital Agenda for Europe (DAE) was launched in May 2010 and aimed "to help Europe's citizens and businesses to get the most out of digital technologies." The original DAE contained 101 actions, grouped around seven priority areas: (1) A vibrant digital single market; (2) Interoperability and standards; (3) Trust and security; (4) Fast and ultra-fast Internet access; (5) Research and innovation; (6) Enhancing digital literacy, skills and inclusion; and (7) ICT-enabled benefits for EU society.

According to OECD (2012b), the DAE would "provide a coherent legal framework for the integration of economies online, including a pan-European licensing for online rights management, strengthening EU data protection rights of consumers, updating the e-Signature directive, and ensuring interoperability of secure e-authentication systems."

[71] See http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/flagship-initiatives/index_en.htm
[72] See http://ec.europa.eu/digital-agenda/digital-agenda-europe

While the original goals and actions remain valid, a review published on 18th December 2012 identified "7 key areas for further efforts to stimulate the conditions to create growth and jobs in Europe:

1. Create a new and stable broadband regulatory environment
2. New public digital service infrastructures through Connecting Europe Facility loans
3. Launch Grand Coalition on Digital Skills and Jobs
4. Propose EU cyber-security strategy and Directive
5. Update EU's Copyright Framework
6. Accelerate cloud computing through public sector buying power
7. Launch new electronics industrial strategy – an "Airbus of Chips"."

European Commission Vice President Neelie Kroes in charge of the Digital Agenda is very vocal and passionate about the DAE goals and achieving the impacts they can have. On the 30th of May 2013 she called on the European Parliament to make a real difference for European citizens by aiming to end to mobile roaming charges in the EU by the time of the next European elections in 2014, and also argued that mobile network operators should no longer be able to block telecommunications services such as Skype.[73] Commissioner Kroes said she would "fight with her last breath" to achieve this goal,[74] which will directly help European citizens and businesses. Ms. Kroes argues that Europe is currently facing an unacceptable economic and social threat of "a lost generation" with Europe's unemployment rates and especially youth unemployment hitting new records.[75] She argues passionately that The Single Market is "the Crown Jewel", and that for telecommunications sector in particular borders should be meaningless: "Europe cannot afford to have meaningless objects standing in the way to the good quality services delivered over the devices European citizens own." These arguments are clearly underpinned by the idea of creating and using a strong digital economy to leverage the economic impacts of ICT to help Europe overcome the crisis. On the 4th of June 2013 Ms. Kroes also announced she would launch the first EU-wide strategy on net neutrality this summer, arguing that "new European rules on net neutrality will oblige Internet service providers to be transparent about connection speed and stop blocking competing services such as Microsoft Corp.'s Skype". Ms. Kroes argued that "the strategy would provide "a safeguard for every European, on every device, on every network—a guarantee of access to the full and open Internet."" The telecom companies on the other hand are against new or additional rules and legislation, arguing that "Investments in additional capacity and technical solutions to meet growth in Internet traffic needs should be matched with operators' freedom to develop new economic models in the market." (Robinson, 2013)

The Grand Coalition for Digital Jobs[76] was launched in March 2013 and constitutes an example of a cross-cutting initiative where multiple stakeholders, including several of the Commission's Directorate Generals (Connect, Education, Employment and Enterprise) work together towards a

[73] See http://www.euractiv.com/infosociety/commission-moves-abolish-roaming-news-528144 .
[74] Watch Commissioner Kroes' speech at; http://www.youtube.com/watch?v=b-RDh2vf26A
[75] The belief that high youth unemployment poses a threat to economic peace and prosperity, and represents an incredible waste of precious resources, also echoes the words of Franklin Delano Roosevelt (the 32nd US President, 1933-1945): "No country, however rich, can afford the waste of its human resources. Demoralisation caused by vast unemployment is our greatest extravagance. Morally, it is the greatest menace to our social order."
[76] See http://ec.europa.eu/digital-agenda/en/grand-coalition-digital-jobs-0 .

common goal, namely to "tackle the lack of ICT skills and the several hundred of thousands of unfilled ICT-related vacancies." More initiatives to work together on common goals and strategies, involving more and different combinations of Directorate Generals are needed to be able to address the struggles Europe is currently facing in a comprehensive and coherent manner. Vice-President and Commissioner Kroes was one of the main initial driving forces behind this initiative, which brought high-level representatives together for the launch. Indeed, Ms. Kroes was joined by President José Manuel Barroso, Vice-President Antonio Tajani, Commissioners László Andor and Androula Vassiliou, as well as Richard Bruton, the Irish Minister for Jobs, Enterprise and Innovation. This high-level participation at the initiative's launch illustrates the sense of urgency attached to this issue, as well as a willingness to work together and with multiple stake-holders.

Some of the interactions between different European initiatives and stakeholders are illustrated in Figure A3.1.

Figure A3.1: The Grand Coalition for Digital Jobs

Source: http://ec.europa.eu/commission_2010-2014/kroes/en/blog/coalition-digital-jobs .

Appendix 4: Background data

The data in this section show some key trends around several of the drivers and barriers discussed in the report, and notably on:

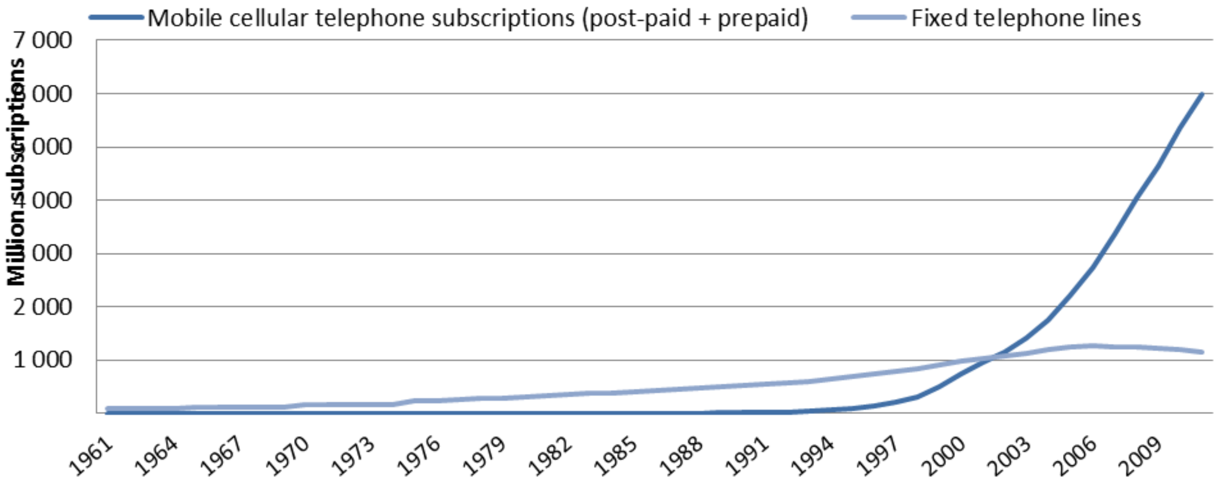
- ICT diffusion:
    - Shift to mobile – mobile telephony and mobile broadband
    - Internet diffusion to households and Internet users
    - ICT diffusion to business
    - Network Readiness Index
- Entrepreneurial conditions
- Digital content
- Other related trends

A4.1 ICT diffusion

A4.1.1 The shift to mobile

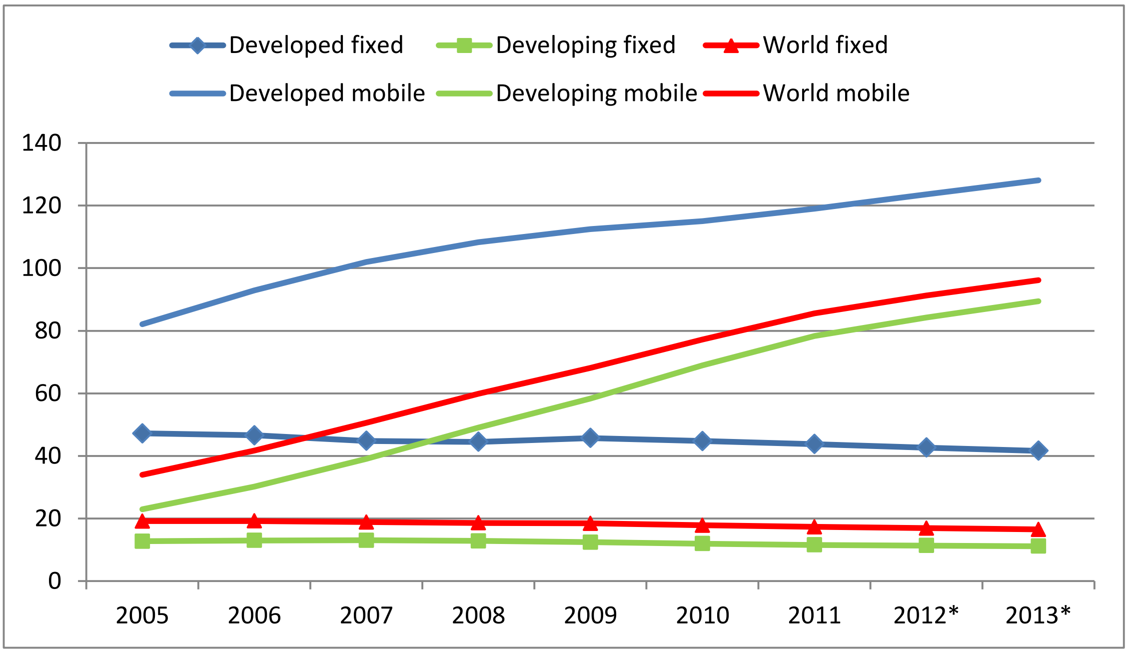
According to OECD (2012a), the number of mobile phone subscriptions worldwide has more than doubled since 2005, with particularly strong growth in non-OECD countries where the number has tripled (Figure A4.1, and Figure A4.2 shows a breakdown by developed and developing countries). The share of smartphones and other wireless devices in the subscriptions is still relatively small, but increasing rapidly, bringing new challenges for operators: as these wireless devices generate more traffic, fixed networks need to be brought closer to users in order to offload this traffic. A similar shift can be seen from fixed to mobile broadband (Figure A4.3).

Figure A4.1: Worldwide telephony subscriptions, 1961-2011



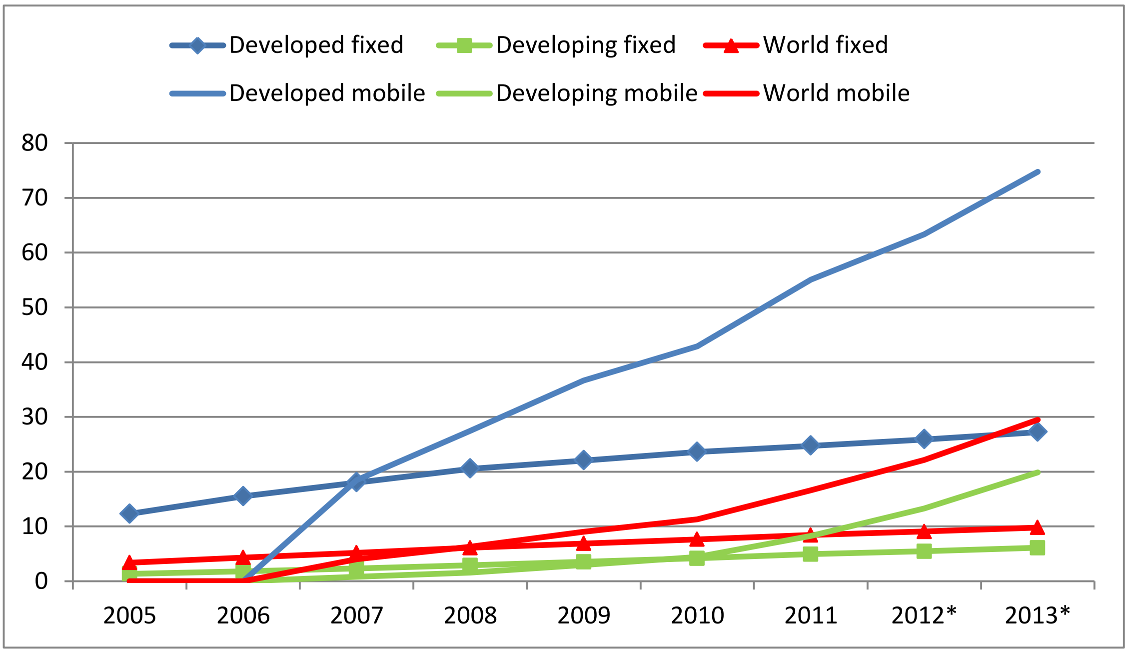
Source: OECD (2012a).

Figure A4.2: Fixed and mobile telephony by development level, 2005-2013



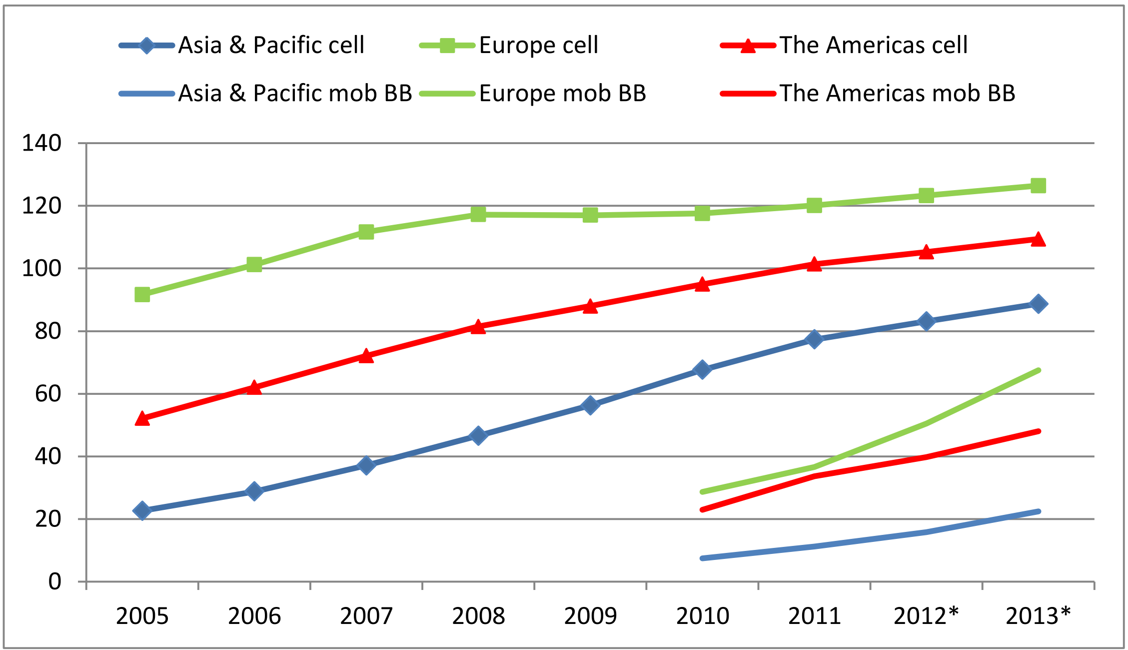
Source: http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

Figure A4.3: Fixed and mobile broadband by development level, 2005-2013



Source: http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

Figure A4.4: Mobile telephone and mobile broadband by region, 2005-2013



Source: http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

Table A4.1 Fixed wired penetration by technology, June 2012

Rank		DSL	Cable	Fibre/LAN	Other	Total
1	Switzerland	28.1	11.8	1.4	0.4	41.6
2	Netherlands	20.1	17.5	1.8	0.0	39.4
3	Denmark	21.4	10.6	6.0	0.2	38.3
4	Korea	4.6	10.0	21.6	0.0	36.2
5	Norway	17.8	10.9	7.3	0.1	36.1
6	France	33.0	2.2	0.4	0.0	35.5
7	Iceland	27.7	0.0	6.6	0.0	34.3
8	Germany	28.7	4.8	0.2	0.1	33.8
9	United Kingdom	26.0	6.6	0.9	0.0	33.6
10	Belgium	16.9	15.7	0.0	0.0	32.7
11	Sweden	15.6	6.3	10.3	0.1	32.3
12	Luxembourg	28.3	3.1	0.6	0.1	32.1
13	Canada	13.5	17.9	0.5	0.0	31.9
14	Finland	20.4	5.1	0.6	3.6	29.7
15	United States	10.0	16.1	2.0	0.3	28.4

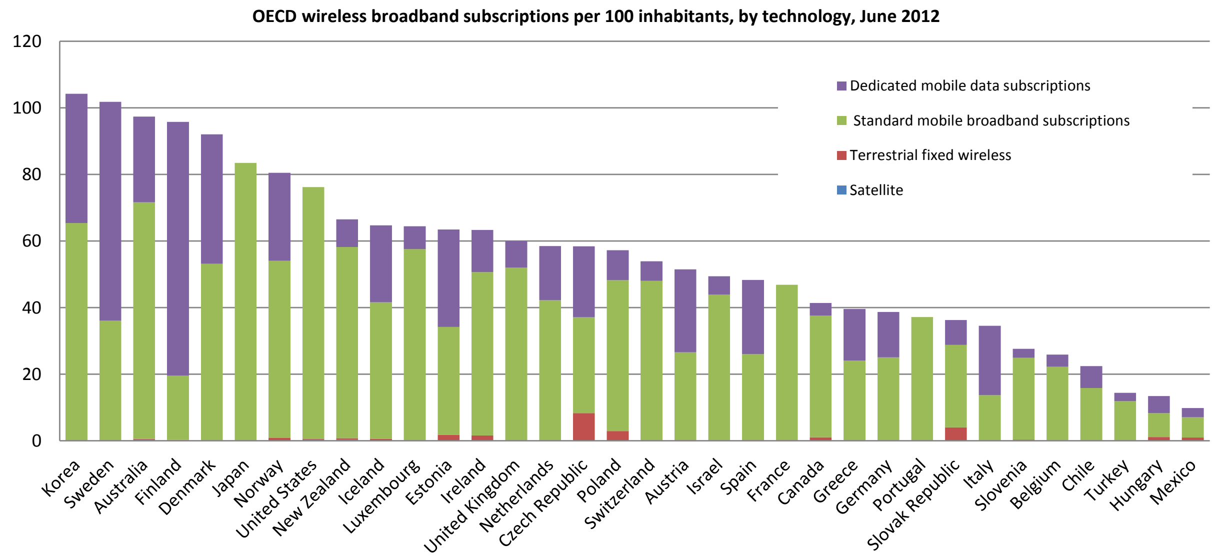
Note: Available for 34 OECD countries; top 15 shown here.
Source: http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm

Table A4.2 Terrestrial mobile wireless broadband penetration, June 2012

Rank		Satellite	Terrestrial fixed wireless	Standard mobile broadband subscriptions	Dedicated mobile data subscriptions		Total
1	Korea	0.0	0.0	65.4	38.8		104.2
2	Sweden	0.0	0.0	36.1	65.8		101.8
3	Australia	0.4	0.1	71.1	25.7		97.4
4	Finland	0.0	0.3	19.3	76.2		95.8
5	Denmark	0.0	0.2	53.0	38.9		92.0
6	Japan	0.0	0.0	83.5	0.0		83.5
7	Norway	0.0	0.8	53.3	26.4		80.5
8	United States	0.4	0.2	75.6	0.0		76.2
9	New Zealand	0.3	0.4	57.5	8.3		66.6
10	Iceland	0.0	0.5	41.1	23.1		64.7
11	Luxembourg	0.0	0.0	57.6	6.8		64.5
12	Estonia	0.0	1.8	32.4	29.3		63.5
13	Ireland	0.2	1.5	49.1	12.7		63.4
14	United Kingdom	0.0	0.0	52.0	8.0		60.0
15	Netherlands	0.0	0.0	42.2	16.3		58.5

Note: Available for 34 OECD countries; top 15 shown here.
Source: http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm

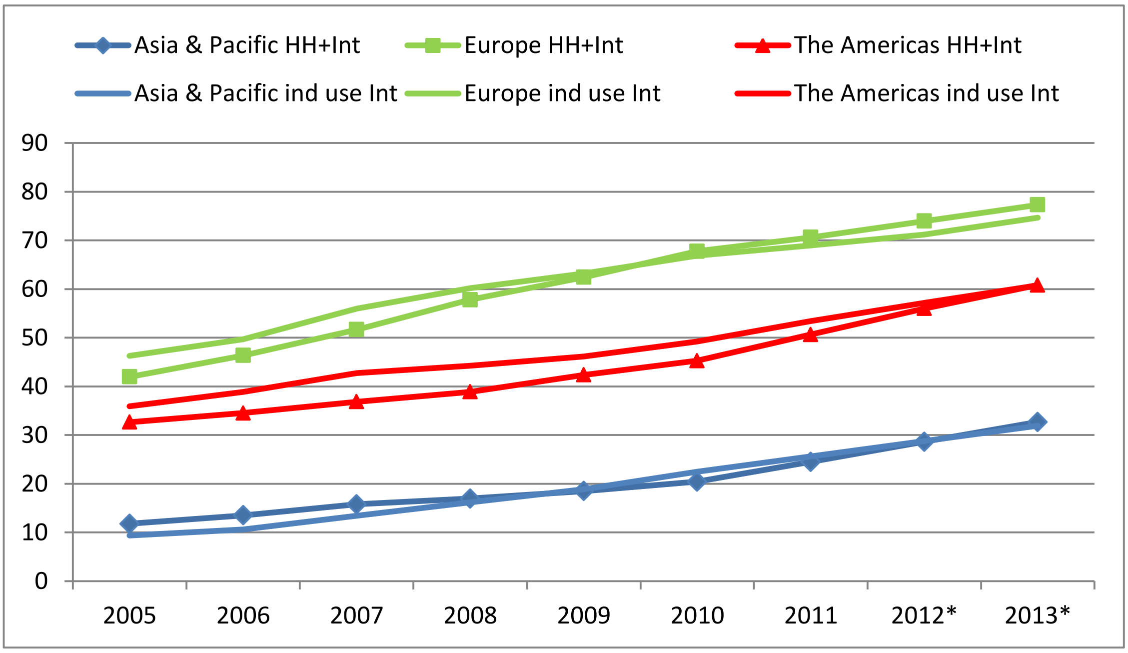
Figure A4.5: Wireless broadband subscriptions, June 2012



Source: Source: http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm

A4.1.2 Households with access to the Internet and individuals using the Internet

Figure A4.6: Households with access to the Internet and individuals using the Internet



Source: http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

A4.1.3 ICT in business

According to OECD (2012a), businesses were among the earliest adopters of Internet connectivity and were also among the first to upgrade their connections to higher speeds, quickly switching to broadband when it became available. While in 2003, less 40% of companies had broadband access in the EU15, by 2009, this proportion had increased 90%. In addition to some cross-country differences, SMEs also tend to still lag larger firms somewhat. It is important to address this as smaller firms in particular stand to gain much from high-speed connectivity (Box A4.1).

Box A4.1: The diffusion of ICT to SMEs

It seems that these days, private consumers and users of IT are more eager and ready to adopt new technologies and devices than businesses are. Some barriers to the diffusion of ICT, in particular to small businesses, remain. It will be important to resolve these as soon as possible as this will increase the demand for ICT and ICT enabled change and business processes, which will increase productivity and efficiency, but also because smaller firms arguably stand to gain the most from ICT (Varian, 2005).

When discussing "users", the focus is usually on 'private users', or consumers. However, there are also 'business users' who require basic and advanced user skills, as well as e-business and e-leadership skills. Think, for example, of very small locally operated SMEs who will use ICT for their communications (e.g. email), send out bills or invoices (electronically, or even prepared on a computer and then printed), but nothing more sophisticated. At the same time, there are also advanced users, who, without being ICT professionals, have skills and a technological awareness that enable them to use ICT in a way that creates value for their firm, for example by finding new ways of doing things, or doing new things. Such skills are also key to many entrepreneurs at the head of start-ups, and those working in SMEs with a high innovative and growth potential.

The diffusion of ICTs to SMEs is often hampered by what can be perceived as four main hurdles (van Welsum and Vickery, 2005), essentially related to skills issues one way or another: (i) a lack of awareness regarding the possibilities that ICT can offer in terms of changing business processes and conducting e-commerce, (ii) a lack of both knowledge and experience in the field of ICT applications, (iii) a lack of trust in e-commerce and e-business, and (iv) a lack of resources and capacity for innovation. These concerns overlap with commonly cited barriers to the adoption of ICT by SMEs, including: lack of skills (including a lack of awareness of what ICT can offer, or internal ICT and management knowledge), mistrust regarding ICT and ICT vendors and service providers, costs, network infrastructure issues (access and interoperability and legal uncertainties), lack of financial viability of e-Commerce, and a lack of a "one-shop facility" to get advice on their ICTs needs and access to reliable experts (e.g. Kapurubandara and Lawson, 2007; Gatautis and Vitkauskaite, 2009).

It is of concern that the uptake of ICT by small businesses still suffers from such barriers since significant economic impacts, including on innovation, can be expected to arise from the business use of ICT. Without this, countries miss out on opportunities to improve their growth potential, and hamper their creativity and innovative capacity, putting current and future competitiveness of the country's firms and economy at risk. In addition, ICT may enable SMEs to become a part of global value chains, reach new markets, and purchase goods and services they may otherwise not have been able to afford.

The ability to source work, talent, skills and ideas globally lies at the heart of the internationalisation of the operations of SMEs, giving rise to so-called micro-multinationals (Varian, 2005), and is a pre-requisite for these companies to be able to grow, mature, and create local jobs. Varian argues that while large companies were among the first to benefit from the changes enabled by ICT, the impact on SMEs "may yet turn out to have the most impact on the economy."

According to McKinsey (2011), some USD 8 trillion is traded in e-commerce globally annually and about one-third of SMEs use Web technologies. As part of their research, the authors of the study interviewed 4,800 SMEs in 12 countries and found that those with a strong Web presence grew more than twice as quickly as those with minimal or no presence, the share of revenue derived from exports was also twice as large, and they created more than twice the number of jobs. In addition, McKinsey's global SME survey found that for every job destroyed by the emergence of the Internet, 2.6 new jobs were created. The same survey also found that 75% of the economic impact of the Internet comes from 'traditional' companies that do not consider themselves to be "pure Internet players". Those with the biggest value benefited from productivity enhancing innovation. In order to maximise the benefits from the Internet eco-system, McKinsey (2011) recommends that efforts should focus on four crucial aspects: (i) promote human capital, (ii) improve access to capital, (iii) develop the infrastructure, and (iv) create an attractive business environment. All of these recommendations were also among strong points made by the experts.

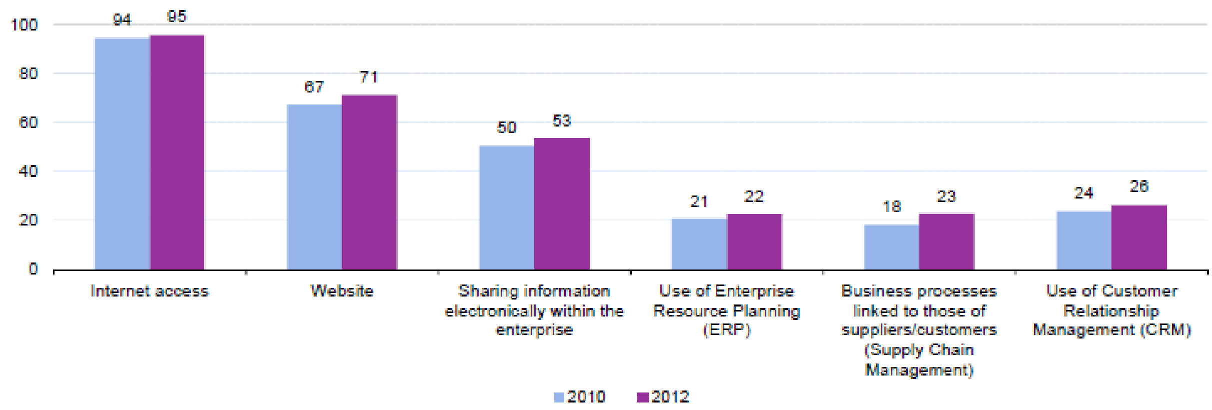
Dean *et al.* (2012) comes up with very similar results, notably that the Internet is driving sales and job growth in SMEs, and recommendations. They also find that companies increasingly encourage their employees more to do new things, and especially in cases where owners/founders are not familiar or comfortable with Internet or social media. The report recommends companies to build a social media presence in order to further exploit ICT-enabled business opportunities, and to establish "digital balance sheets", taking stock of their digital assets and liabilities in order to identify the best strategies towards making the most of IT. The report also has five main recommendations for policy makers, namely: (i) invest in affordable infrastructure, (ii) give priority to education and skills building, (iii) encourage innovation and entrepreneurial activity, (iv) facilitate global talent mobility, and (v) look out for bottlenecks to innovation and adoption of new technologies. Again, these recommendations are strongly echoed in the points made by the experts.

Source: adapted from van Welsum and Lanvin (2012).

Eurostat figures indicate that firms in Europe are making slow progress in adopting ICT for e-business integration (Giannakouris and Smihily, 2013). SMEs form an important part of the European business landscape. In Europe in 2008, 99.8% of firms were SMEs (<250 employees) and 92% were micro-enterprises (<10 employees), accounting for 66.7% and 29.0% of employment, respectively, and for 58.6% and 21.8% of value added. Apparent labour productivity is lowest in micro-enterprises though: 75.3% relative to total, compared to 87.8% in all SMEs, and 124.5% in large enterprises (Eurostat, 2011), suggesting that much can be gained from the increased adoption and integration of ICT in business, and in particular in SMEs.

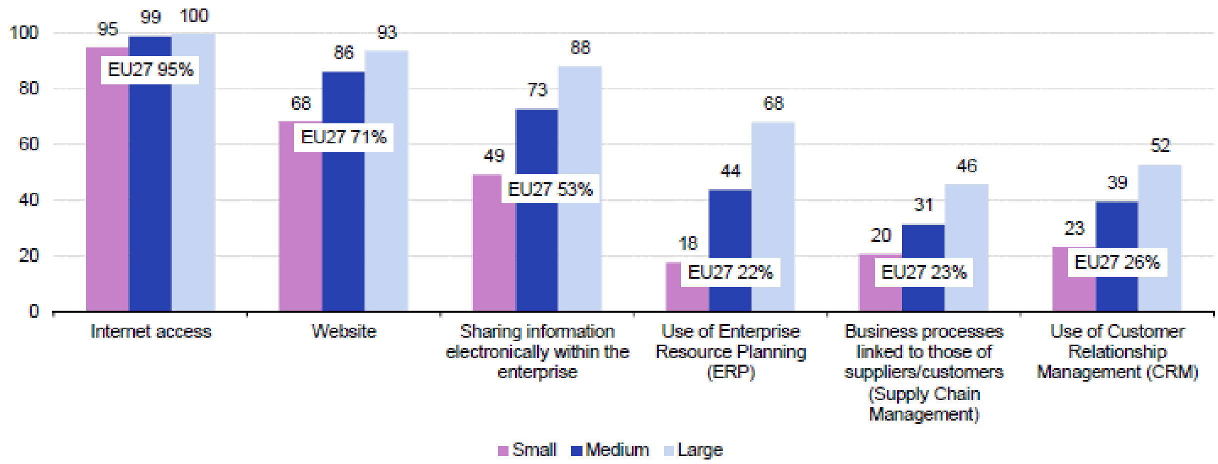
While most firms now use computers and have an Internet connection, perhaps even a web site, the use these are put to varies greatly (and is often not very sophisticated when it comes to transforming the way business is done). The rate of adoption decreases with the level of sophistication of the e-business technology (Figure A4.7). The gap between large and small enterprises also increases the more advanced the ICT applications are (Figure A4.8), which, given the prevalence of small firms, should be of some concern to policy makers and business leaders.

Figure A4.7: Adoption of e-business technologies in enterprises, EU27, 2010 and 2012 (% of enterprises)



Source: Giannakouris and Smihily (2013), Figure 1.

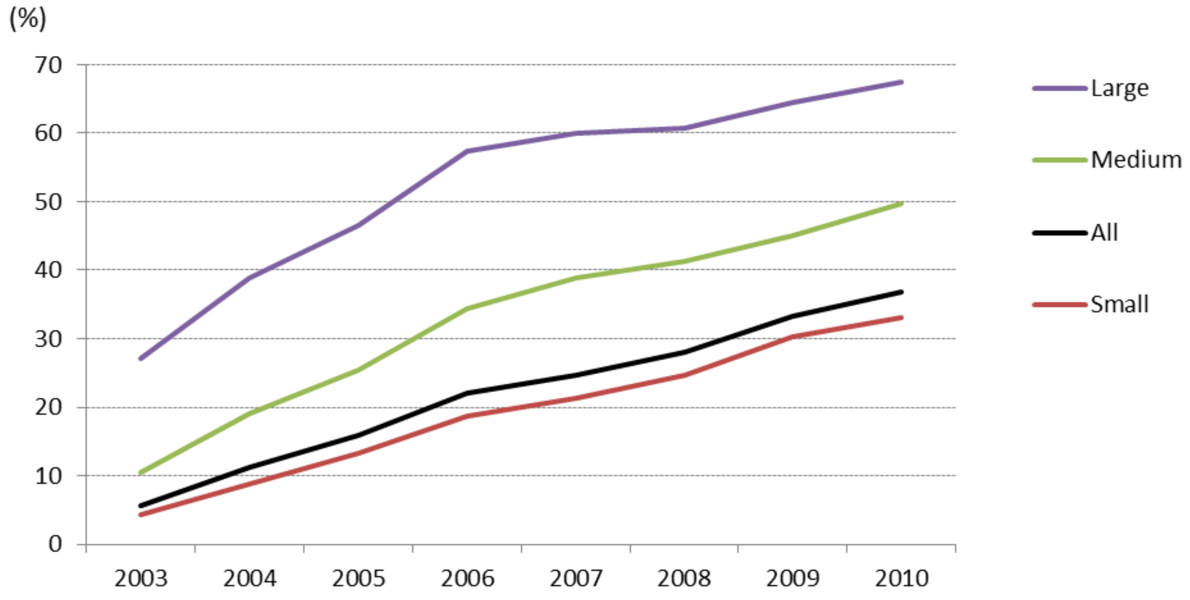
Figure A4.8: Adoption of e-business technologies in enterprises by size class, EU27, 2010 and 2012 (% of enterprises)



Source: Giannakouris and Smihily (2013), Figure 2.

Wireless connectivity is also gaining importance in the business context. OECD (2012a) reports that wireless applications have come to play an important role in internal ICT deployment, providing flexibility and mobility to employees. In the European Union, by 2010, close to 37% of companies had deployed internal wireless connectivity (Figure A4.9). The data also show that while many large firms operate their own intranet (more than 80% in EU15 in 2010), the numbers are still very low for smaller firms (25% of small firms in EU15 in 2010).

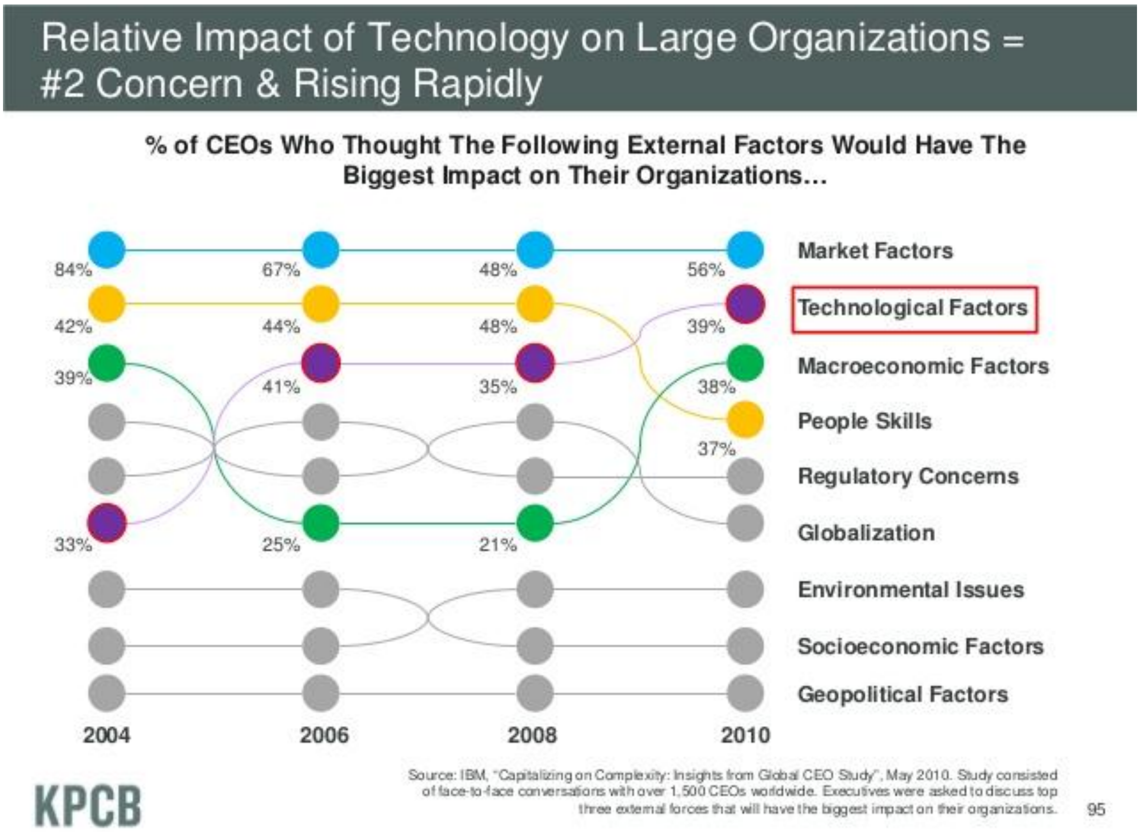
Figure A4.9: Wireless access use within internal computer networks in the EU15, 2003-10
(Percentage of companies by size)



Source: OECD (2012a).

Over time, firms have increasingly adopted more sophisticated e-business technologies, notably also business-to-business applications over the Internet, but these developments are concentrated in large firms. It is possible that smaller firms start to use more of these technologies with increased adoption of the cloud which levels the playing field in terms of access to ICT and ICT-related resources. Large firms report that technology is increasingly a concern for them (Figure A4.10)

Figure A4.10: Technology is increasingly a factor of concern for (large) firms:



Source: From a presentation by Mary Meeker and Liang Wu at the 2013 Internet Trends D11Conference, available at: http://www.slideshare.net/kleinerperkins/kpcb-Internet-trends-2013

A4.1.4 Network Readiness Index

The GITR's Network Readiness Index (NRI) includes "features related to access and usage that cover not only affordable ICT infrastructure but also digital resources, including software and skills. In addition, the NRI includes proxies for assessing some of the economic and social impacts accruing from ICTs. Thus, the Index facilitates the identification of areas where policy intervention—through investment, smart regulation, and/or incentives—could boost the impact of ICTs on development and growth" (Bilbao-Osorio *et al.*, 2013).

The NRI is composed of 4 sub-indices, covering 10 pillars composed of 54 individual indicators in total:

A. Environment subindex

1. Political and regulatory environment
2. Business and innovation environment

B. Readiness subindex

3. Infrastructure and digital content
4. Affordability
5. Skills

C. Usage subindex

6. Individual usage
7. Business usage
8. Government usage

D. Impact subindex

9. Economic impacts
10. Social impacts

The Networked Readiness Index 2013

Rank	Country/Economy	Score	2012 rank (out of 142)
1	Finland	5.98	3
2	Singapore	5.96	2
3	Sweden	5.91	1
4	Netherlands	5.81	6
5	Norway	5.66	7
6	Switzerland	5.66	5
7	United Kingdom	5.64	10
8	Denmark	5.58	4
9	United States	5.57	8
10	Taiwan, China	5.47	11
11	Korea, Rep.	5.46	12
12	Canada	5.44	9
13	Germany	5.43	16
14	Hong Kong SAR	5.40	13
15	Israel	5.39	20
16	Luxembourg	5.37	21
17	Iceland	5.31	15
18	Australia	5.26	17
19	Austria	5.25	19
20	New Zealand	5.25	14
21	Japan	5.24	18
22	Estonia	5.12	24
23	Qatar	5.10	28
24	Belgium	5.10	22
25	United Arab Emirates	5.07	30
26	France	5.06	23
27	Ireland	5.05	25
28	Malta	4.90	26
29	Bahrain	4.83	27
30	Malaysia	4.82	29
31	Saudi Arabia	4.82	34
32	Lithuania	4.72	31
33	Portugal	4.67	33
34	Chile	4.59	39
35	Cyprus	4.59	32
36	Puerto Rico	4.55	36
37	Slovenia	4.53	37
38	Spain	4.51	38
39	Barbados	4.49	35
40	Oman	4.48	40
41	Latvia	4.43	41
42	Czech Republic	4.38	42
43	Kazakhstan	4.32	55
44	Hungary	4.29	43
45	Turkey	4.22	52
46	Panama	4.22	57
47	Jordan	4.20	47
48	Montenegro	4.20	46
49	Poland	4.19	49
50	Italy	4.18	48
51	Croatia	4.17	45
52	Uruguay	4.16	44
53	Costa Rica	4.15	58
54	Russian Federation	4.13	56
55	Mauritius	4.12	53
56	Azerbaijan	4.11	61
57	Brunei Darussalam	4.11	54
58	China	4.03	51
59	Mongolia	4.01	63
60	Brazil	3.97	65
61	Slovak Republic	3.95	64
62	Kuwait	3.94	62
63	Mexico	3.93	76
64	Greece	3.93	59
65	Georgia	3.93	88
66	Colombia	3.91	73
67	Macedonia, FYR	3.89	66
68	India	3.88	69
69	Sri Lanka	3.88	71
70	South Africa	3.87	72
71	Bulgaria	3.87	70
72	Trinidad and Tobago	3.87	60
73	Ukraine	3.87	75
74	Thailand	3.86	77
75	Romania	3.86	67
76	Indonesia	3.84	80
77	Moldova	3.84	78
78	Bosnia and Herzegovina	3.80	84
79	Seychelles	3.80	n/a
80	Egypt	3.78	79
81	Cape Verde	3.78	81
82	Armenia	3.76	94
83	Albania	3.75	68
84	Vietnam	3.74	83
85	Jamaica	3.74	74
86	Philippines	3.73	86
87	Serbia	3.70	85
88	Rwanda	3.68	82
89	Morocco	3.64	91
90	Dominican Republic	3.62	87
91	Ecuador	3.58	96
92	Kenya	3.54	93
93	El Salvador	3.53	103
94	Lebanon	3.53	95
95	Ghana	3.51	97
96	Botswana	3.50	89
97	Liberia	3.48	n/a
98	Gambia, The	3.47	101
99	Argentina	3.47	92
100	Guyana	3.45	90
101	Iran, Islamic Rep.	3.43	104
102	Guatemala	3.42	98
103	Peru	3.39	106
104	Paraguay	3.37	111
105	Pakistan	3.35	102
106	Cambodia	3.34	108
107	Senegal	3.33	100
108	Venezuela	3.33	107
109	Honduras	3.32	99
110	Uganda	3.30	110
111	Namibia	3.29	105
112	Tajikistan	3.29	114
113	Nigeria	3.27	112
114	Bangladesh	3.22	113
115	Zambia	3.19	109
116	Zimbabwe	3.17	124
117	Suriname	3.13	121
118	Kyrgyz Republic	3.09	115
119	Bolivia	3.01	127
120	Côte d'Ivoire	3.00	122
121	Gabon	2.97	n/a
122	Mali	2.97	126
123	Benin	2.97	117
124	Cameroon	2.95	125
125	Nicaragua	2.93	131
126	Nepal	2.93	128
127	Tanzania	2.92	123
128	Ethiopia	2.85	130
129	Malawi	2.83	116
130	Burkina Faso	2.80	135
131	Algeria	2.78	118
132	Libya	2.77	n/a
133	Mozambique	2.76	120
134	Timor-Leste	2.72	132
135	Mauritania	2.71	139
136	Swaziland	2.69	136
137	Madagascar	2.69	134
138	Lesotho	2.68	133
139	Yemen	2.63	141
140	Guinea	2.61	n/a
141	Haiti	2.58	142
142	Chad	2.53	138
143	Sierra Leone	2.53	n/a
144	Burundi	2.30	137

A4.2 Entrepreneurial conditions

A4.2.1 Ease and cost of doing business

The 2013 Doing Business indicators (Table A4.3) suggest there is still plenty of room for improvement in facilitating and enabling doing business in most European countries. Denmark is the highest ranked EU27 country in the overall ranking (4th), followed by the UK (7th) and Finland (11th), and the 3 lowest ranked EU27 countries are Italy (73rd), Greece (78th) and Malta (102nd). Looking at the sub-ranking for "starting a business", the 3 highest ranked EU27 countries are Ireland (10th), the UK (19th) and France (27th), and the 3 lowest ranked are Czech Republic (140th), Greece (146th) and Malta (150th).

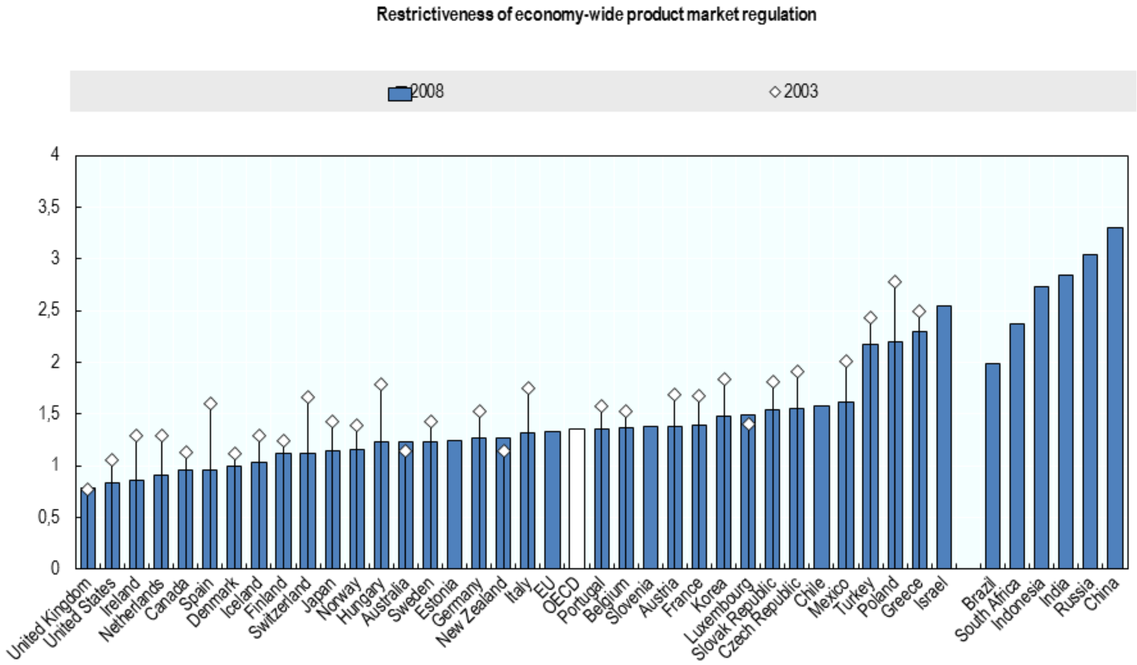
Table A4.3: Ease of doing business, EU27 and selected countries, 2013

Economy	Ease of Doing Business Rank	*Starting a Business rank*	*Procedures (number)*	*Time (days)*	*Cost (% of income per capita)*	Registering Property rank	Getting Credit rank	Protecting Investors rank	Paying Taxes rank	Trading Across Borders rank	Enforcing Contracts rank	Resolving Insolvency rank
Albania	85	***62***	*4*	*4*	*22.1*	121	23	17	160	79	85	66
Australia	10	***2***	*2*	*2*	*0.7*	37	4	70	48	44	15	18
Austria	29	***134***	*8*	*25*	*4.9*	34	23	100	77	26	7	12
Belgium	33	***44***	*3*	*4*	*5.2*	176	70	19	75	29	18	7
Bosnia and Herzegovina	126	***162***	*11*	*37*	*14.9*	93	70	100	128	103	120	83
Brazil	130	***121***	*13*	*119*	*4.8*	109	104	82	156	123	116	143
Bulgaria	66	***57***	*4*	*18*	*1.1*	68	40	49	91	93	86	93
Canada	17	***3***	*1*	*5*	*0.4*	54	23	4	8	44	62	4
China	91	***151***	*13*	*33*	*2.1*	44	70	100	122	68	19	82
Croatia	84	***80***	*6*	*9*	*7.3*	104	40	139	42	105	52	97
Cyprus	36	***37***	*6*	*8*	*12.4*	99	53	32	31	18	108	25
Czech Republic	65	***140***	*9*	*20*	*8.2*	27	53	100	120	68	79	34
Denmark	5	***33***	*4*	*6*	*0.2*	6	23	32	13	4	34	10
Estonia	21	***47***	*5*	*7*	*1.6*	14	40	70	50	7	31	72
Finland	11	***49***	*3*	*14*	*1*	24	40	70	23	6	9	5
France	34	***27***	*5*	*7*	*0.9*	146	53	82	53	27	8	43
Germany	20	***106***	*9*	*15*	*4.9*	81	23	100	72	13	5	19
Greece	78	***146***	*11*	*11*	*20.5*	150	83	117	56	62	87	50
Hungary	54	***52***	*4*	*5*	*8.9*	43	53	128	118	73	16	70
Iceland	14	***45***	*5*	*5*	*3*	9	40	49	41	82	3	11
India	132	***173***	*12*	*27*	*49.8*	94	23	49	152	127	184	116
Ireland	15	***10***	*4*	*10*	*0.3*	53	12	6	6	28	63	9
Israel	38	***41***	*5*	*21*	*4*	144	12	6	82	10	94	47
Italy	73	***84***	*6*	*6*	*16.5*	39	104	49	131	55	160	31
Korea, Rep.	8	***24***	*5*	*7*	*14.6*	75	12	49	30	3	2	14
Latvia	25	***59***	*4*	*16*	*2.3*	31	4	70	52	16	24	33
Lithuania	27	***107***	*7*	*20*	*1.1*	5	53	70	60	24	14	40
Luxembourg	56	***93***	*6*	*19*	*1.9*	134	159	128	14	32	1	52
Macedonia, FYR	23	***5***	*2*	*2*	*1.9*	50	23	19	24	76	59	60
Malta	102	***150***	*11*	*40*	*8.9*	80	176	70	27	34	121	67
Montenegro	51	***58***	*6*	*10*	*1.6*	117	4	32	81	42	135	44
Morocco	97	***56***	*6*	*12*	*15.5*	163	104	100	110	47	88	86
Netherlands	31	***67***	*5*	*5*	*5.1*	49	53	117	29	12	32	6
New Zealand	3	***1***	*1*	*1*	*0.4*	2	4	1	21	25	17	13
Norway	6	***43***	*5*	*7*	*1.7*	7	70	25	19	21	4	3
Poland	55	***124***	*6*	*32*	*14.4*	62	4	49	114	50	56	37
Portugal	30	***31***	*5*	*5*	*2.3*	30	104	49	77	17	22	23
Romania	72	***68***	*6*	*10*	*2.8*	72	12	49	136	72	60	102
Russian Federation	112	***101***	*8*	*18*	*2*	46	104	117	64	162	11	53
Serbia	86	***42***	*6*	*12*	*7.7*	41	40	82	149	94	103	103
Slovak Republic	46	***83***	*6*	*16*	*1.8*	8	23	117	100	98	69	38
Slovenia	35	***30***	*2*	*6*	*0*	83	104	17	63	57	56	42
South Africa	39	***53***	*5*	*19*	*0.3*	79	1	10	32	115	82	84
Spain	44	***136***	*10*	*28*	*4.7*	57	53	100	34	39	64	20
Sweden	13	***54***	*3*	*16*	*0.5*	35	40	32	38	8	27	22
Switzerland	28	***97***	*6*	*18*	*2.1*	15	23	169	18	35	20	45
Tunisia	50	***66***	*10*	*11*	*4.1*	70	104	49	62	30	78	39
Turkey	71	***72***	*6*	*6*	*10.5*	42	83	70	80	78	40	124
United Kingdom	7	***19***	*6*	*13*	*0.7*	73	1	10	16	14	21	8
United States	4	***13***	*6*	*6*	*1.4*	25	4	6	69	22	6	16

Source: Doing Business: http://www.doingbusiness.org/ .

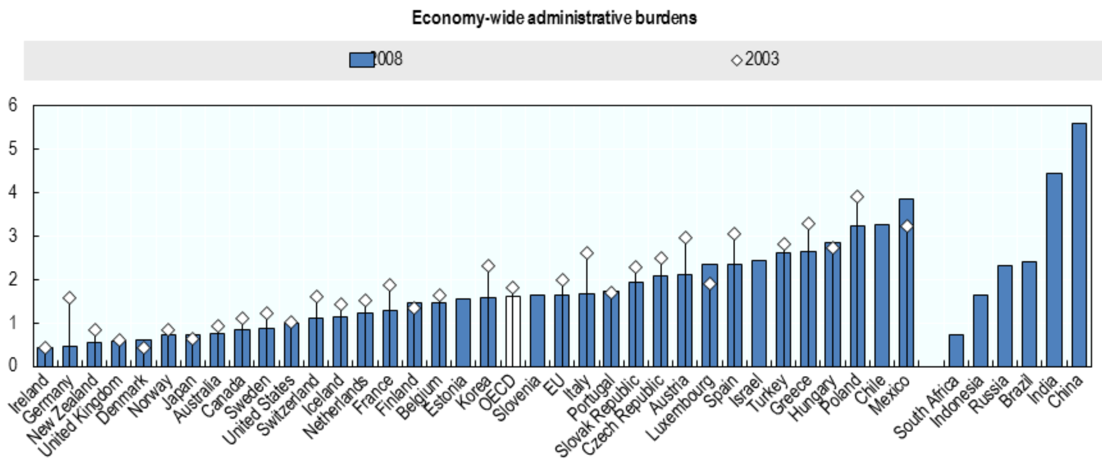
The OECD product and labour market regulation indicators also show there is some variability across European countries, with room for improvement in many countries (Figures A4.11 – A4.13).

Figure A4.11: Product Market Regulation



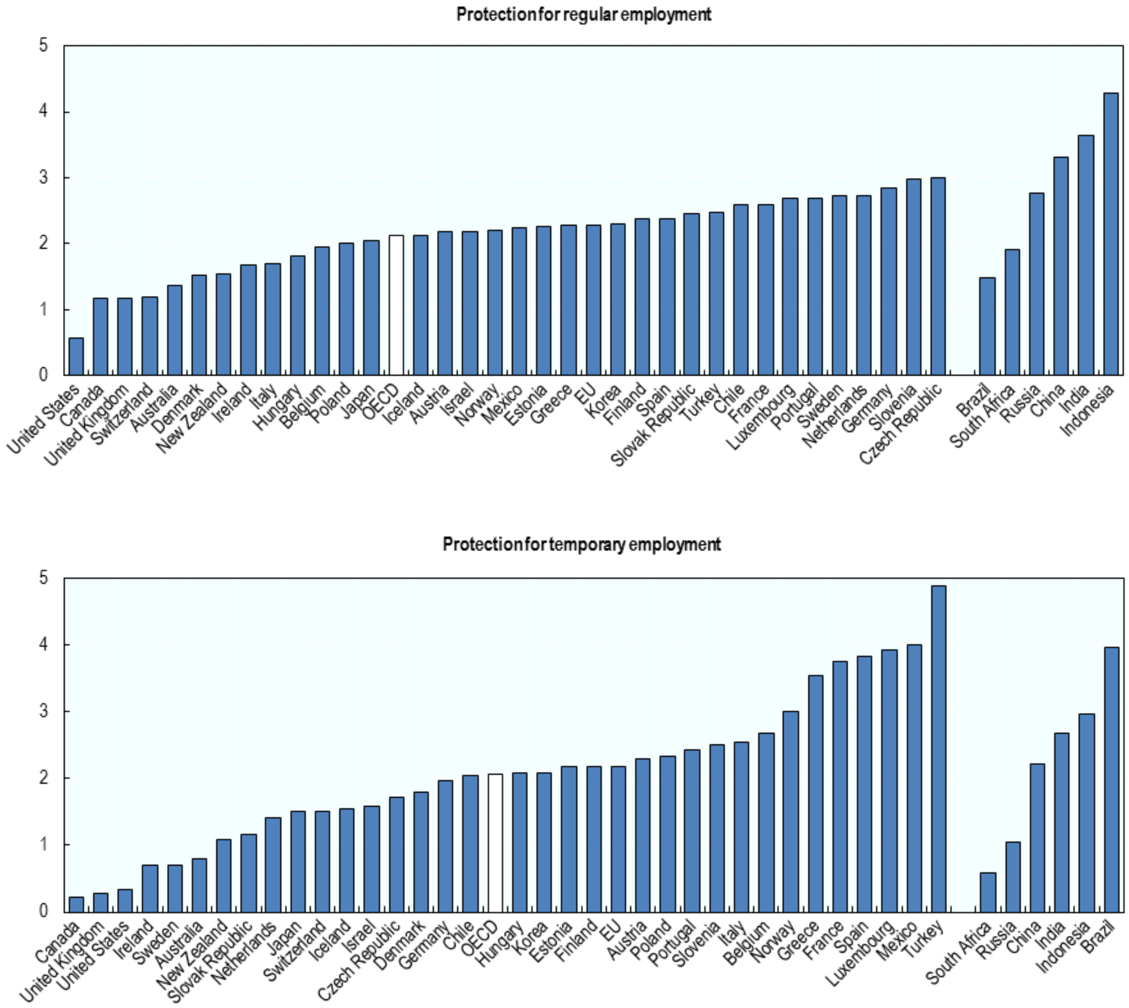
Note: Index scale of 0-6 from least to most restrictive.
Source: OECD (2013).

Figure A.12: Administrative burden on start-ups



Note: Index scale of 0-6 from least to most restrictive.
Source: OECD (2013).

Figure A4.13: Employment protection legislation for regular and temporary employment

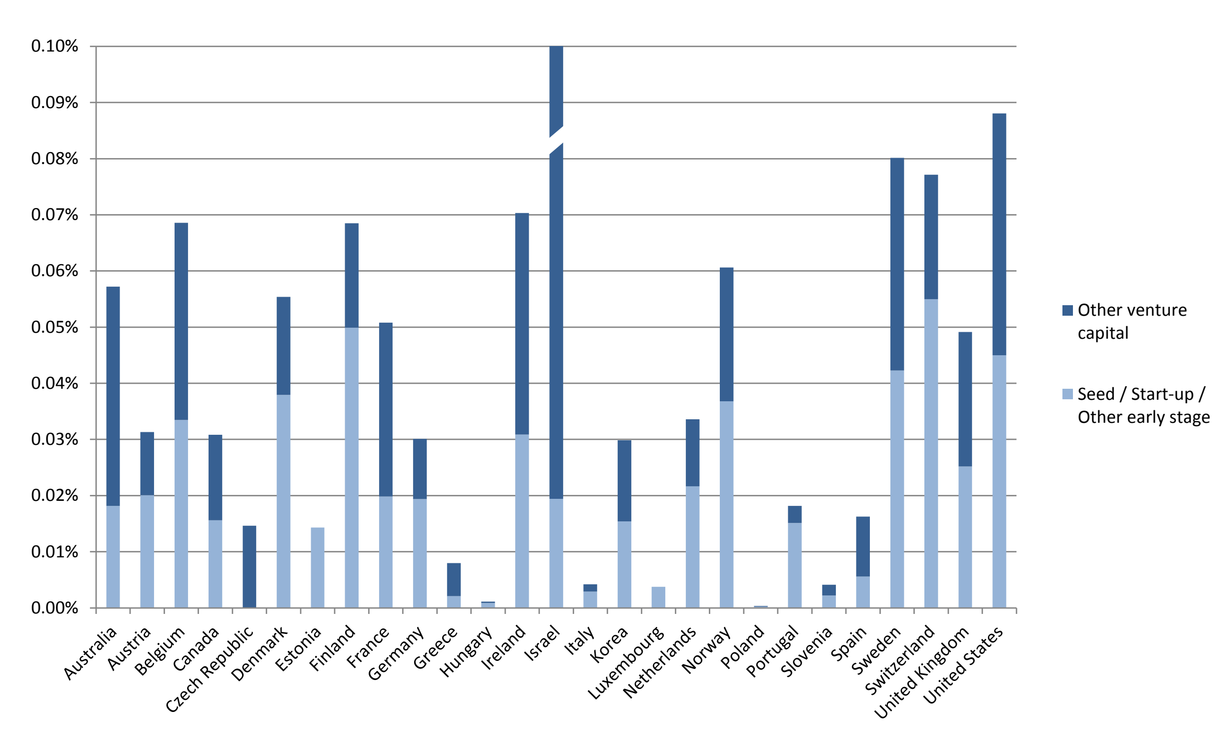


Note: Index scale of 0-6 from least to most restrictive.
Source: OECD (2013).

A4.2.2 Access to finance: Venture capital

Venture capital (VC) is considered to play a vital part in the financing of young firms with a high innovation and growth potential, replacing or complementing more traditional forms of financing obtained through the banking sector. Therefore, the development of the VC industry, and access to VC, are seen as crucial to stimulating entrepreneurship. VC investment as a percentage of GDP measures the sum of seed and start-up capital and early development capital in a country's GDP (Figure A4.14). VC investment as a share of GDP is still very small in most countries, but VC markets are relatively more developed in Israel, Sweden, Switzerland, the UK and the US. As capital markets and many financing mechanisms and instruments are international and even global in nature, and as firms from EU countries increasingly tend to compete with firms globally, non-EU countries have been included in this figure to provide a broad and comparative perspective.

Figure A4.14: VC as a % of GDP (2009)



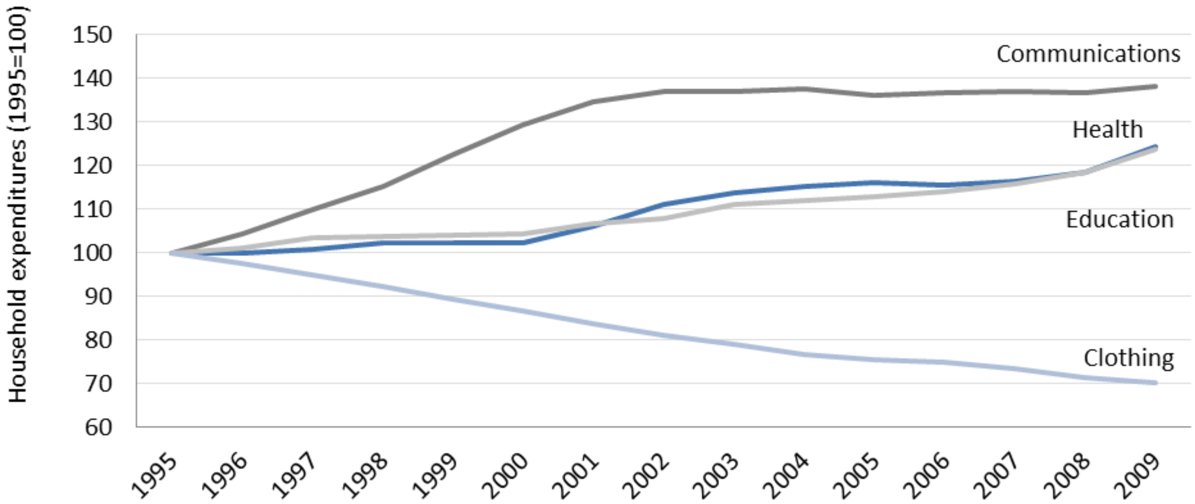
Source: OECD (2011), Part II, Figure 21.1.

A4.3 Digital content

Increasing speeds and decreasing prices for Internet connections are two key trends driving developments in the digital content eco-system. Over the period 2008-11, the advertised speeds of DSL and cable broadband increased annually by 32% and 31% respectively in OECD countries. At the same time, prices declined by 3% and 4% (OECD, 2012a).

OECD data show that the proportion of household expenditure on communications has grown rapidly in OECD countries since 1995 as a result of better Internet connectivity, improved content availability and lower prices (Figure A4.15).

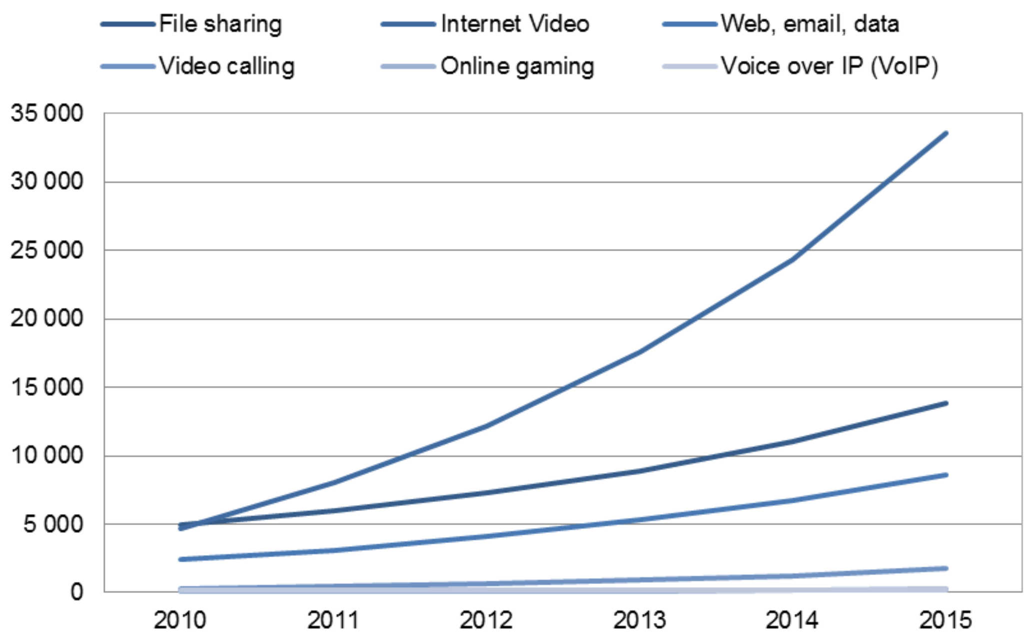
Figure A4.15: OECD household expenditure by category



Source: OECD (2012a).

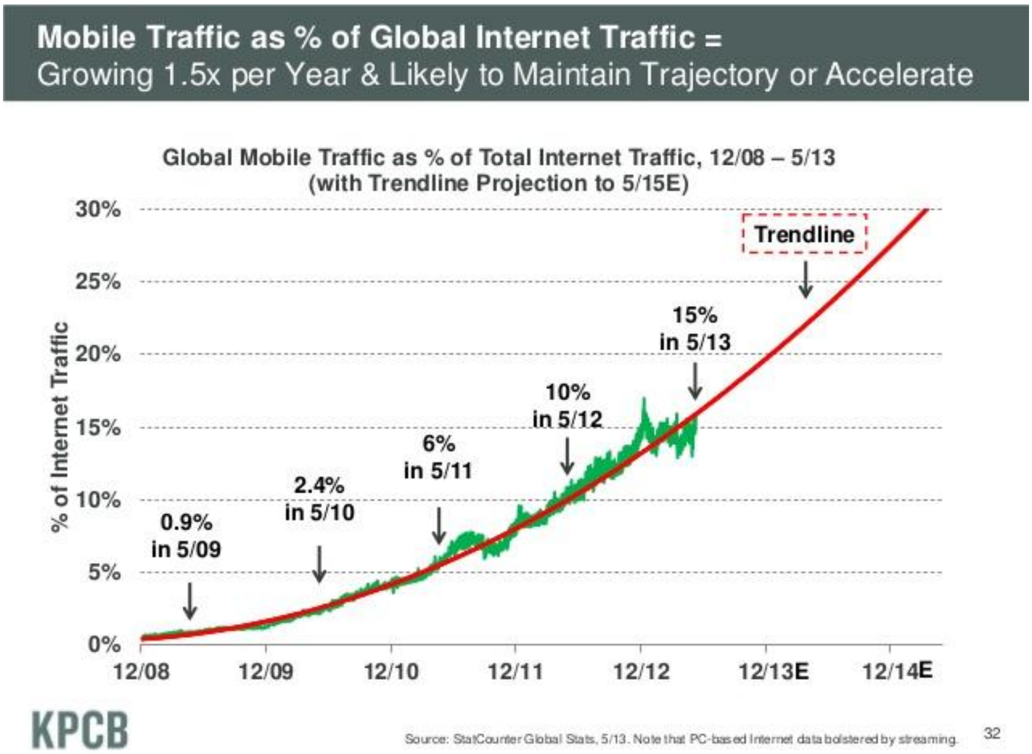
OECD (2012a) reports that "greater online interactivity and the willingness to share, contribute and to create online communities are changing the media consumption habits of Internet users, in particular, among younger age groups. According to Cisco's VNI Index, global Internet video traffic surpassed global peer-to-peer (P2P) traffic in 2010, and by 2012 Internet video will account for over 50% of consumer Internet traffic (Figure A4.16). Globally, Cisco predicts that mobile data traffic will increase 26 times between 2010 and 2015, and that IP traffic in Latin America will grow at a compound annual growth rate (CAGR) of 50% between 2010 and 2015, followed closely by the Middle East and Africa."

Figure A4.16: Global Internet traffic (PB per month)



Source: OECD (2012a).

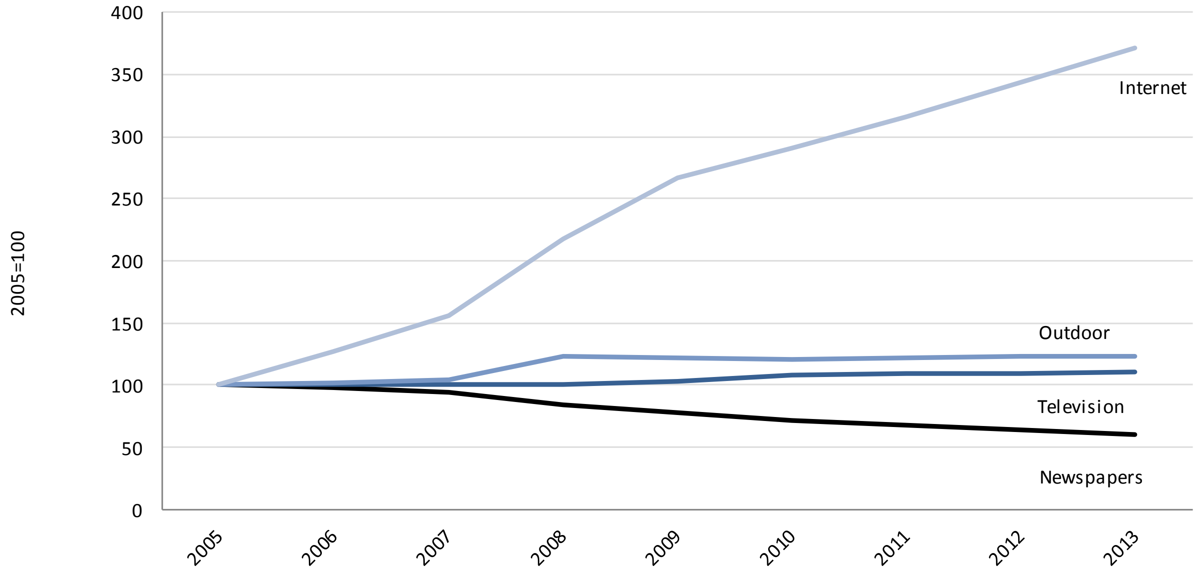
Figure A4.17: Mobile traffic as % of Internet traffic:



Source: From a presentation by Mary Meeker and Liang Wu at the 2013 Internet Trends D11Conference, available at: http://www.slideshare.net/kleinerperkins/kpcb-Internet-trends-2013 .

In addition to astronomical amounts of user created content that is being uploaded to the Internet every day (see OECD, 2012a, for some interesting examples[77]), many industries are also moving their content online and business models are being profoundly transformed, for example in news, media, music, movies, TV, radio, and advertising (Figure A4.18). From OECD (2012a): "The advertising market has evolved with the Internet in a way that has completely transformed the industry in just a matter of 15 years. According to Zenith Optimedia, Internet advertising will increase its share of the advertising market from 14.4% in 2010 to 18.9% in 2013, when it will overtake newspapers to become the world's second-largest medium behind television. Although television accounted for 46% of new advertising dollars globally between 2010 and 2013, the Internet is growing much faster than any other medium, at an average of 14.6% a year between 2010 and 2013."

Figure A4.18: Advertising expenditure by medium

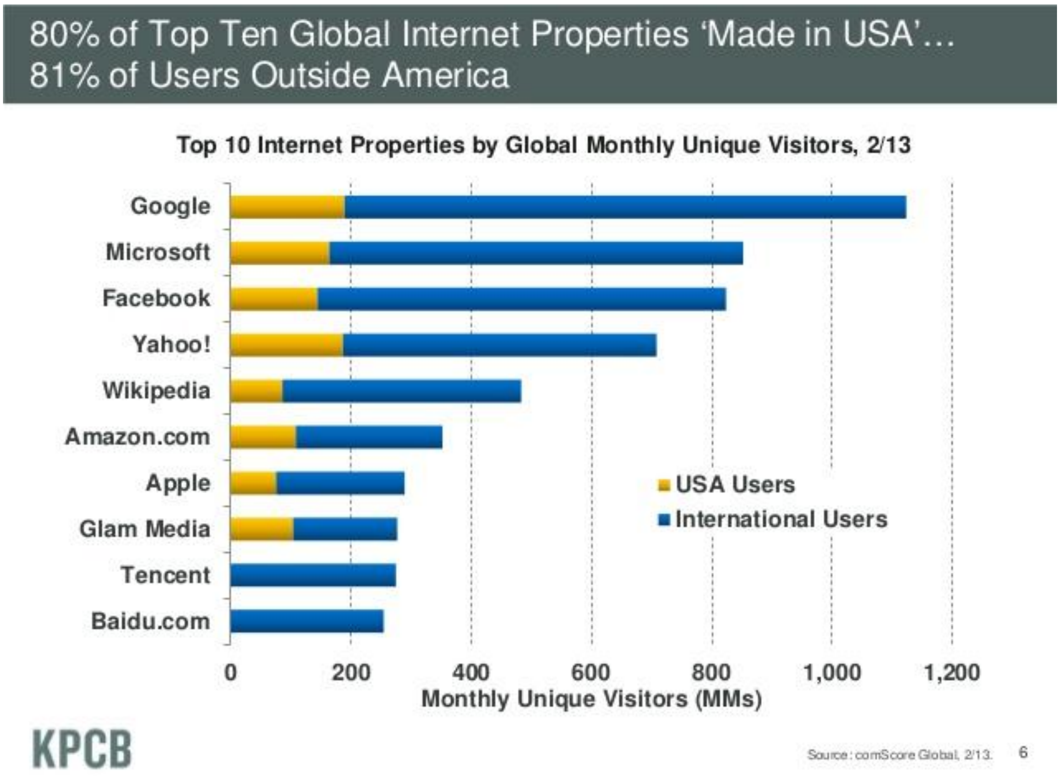


Source: OECD (2012a).

Even though most of the top Internet content firms are US-based, their users are largely global (Figure A4.19).

[77] For example, as reported in OECD (2012a), "according to Google, over 48 hours of video are uploaded to YouTube each minute. Google has also calculated that YouTube users create and upload more video content each month than the combined output of all three major US television networks for the past 60 years. The YouTube audience views approximately 2 billion videos each day."

Figure A4.19: Global users of Internet firms

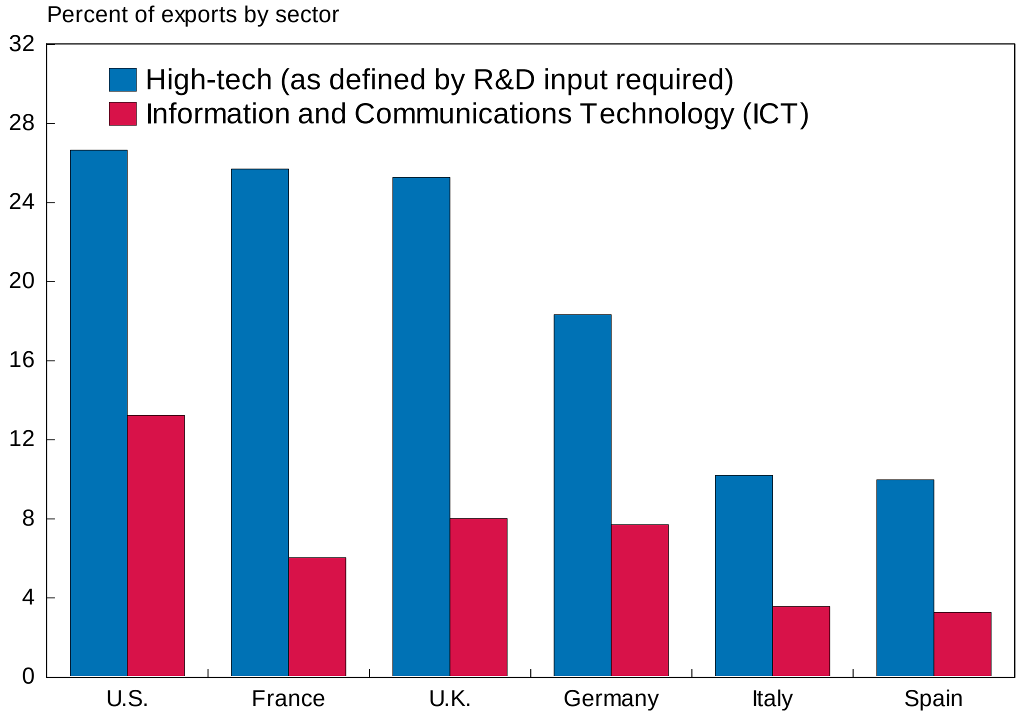


Source: From a presentation by Mary Meeker and Liang Wu at the 2013 Internet Trends D11Conference, available at: http://www.slideshare.net/kleinerperkins/kpcb-Internet-trends-2013 .

A4.4 Other related trends

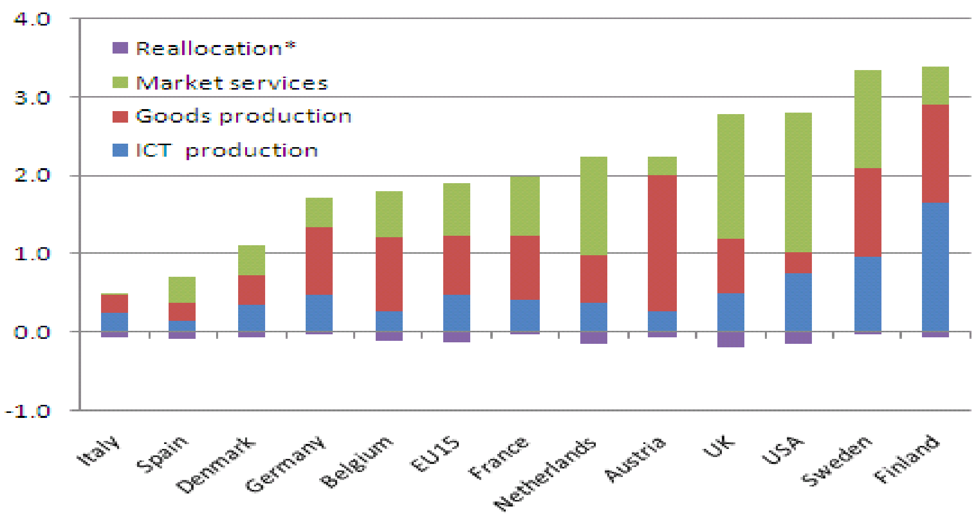
Continental Europe has generally lagged behind the U.S. and U.K. in developing competitiveness in emerging sectors, and in the contribution of market services to productivity growth (Figure A4.20 and Figure A4.21, respectively).

Figure A4.20: Competitiveness in high-tech and ICT



Source: TCB, based on OECD.

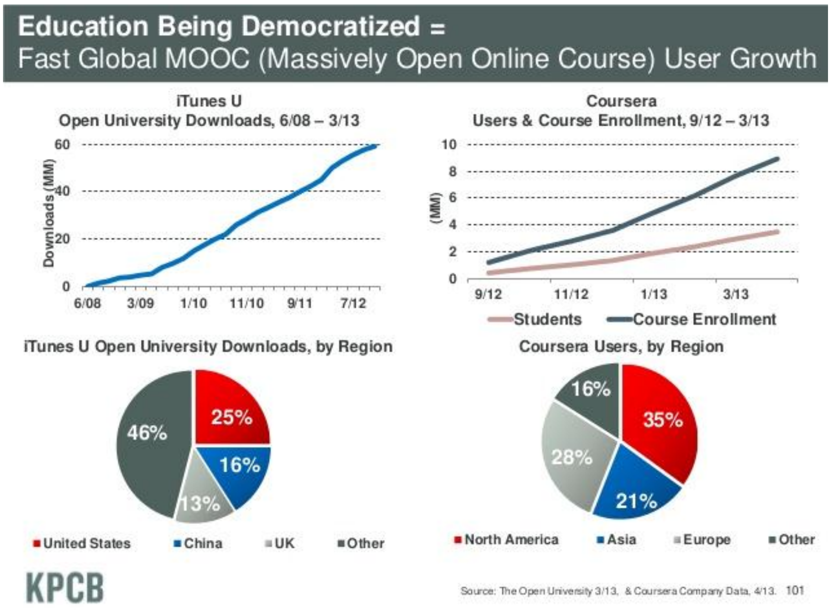
Figure A4.21: Contributions of market services to productivity growth



Source: The Conference Board Total Economy Database (http://www.conference-board.org/data/economydatabase/) .

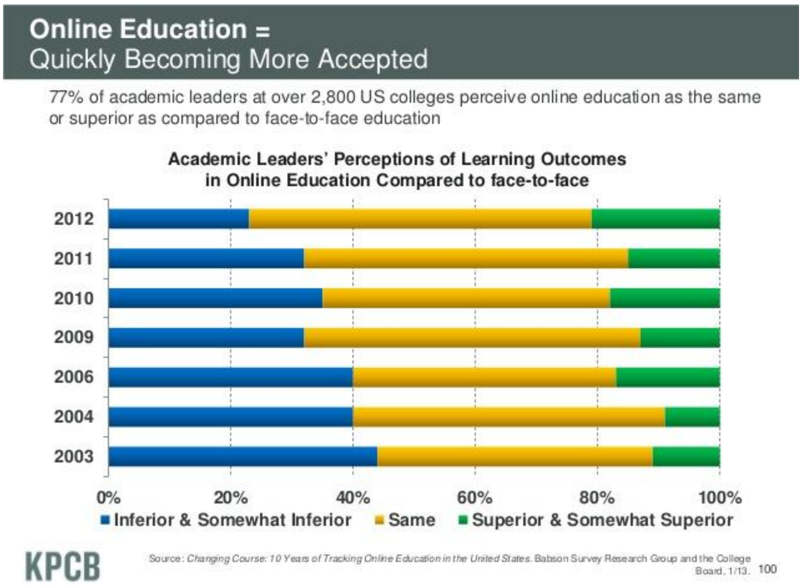
Massively Open Online Courses are starting to gain importance (Figure A4.22) and how they are being perceived is improving over time (for the US: Figure A4.23).

Figure A4.22: The democratisation of education through MOOCS



Source: From a presentation by Mary Meeker and Liang Wu at the 2013 Internet Trends D11Conference, available at: http://www.slideshare.net/kleinerperkins/kpcb-Internet-trends-2013 .

Figure A4.23: The perception of online education (in the US)



Source: From a presentation by Mary Meeker and Liang Wu at the 2013 Internet Trends D11Conference, available at: http://www.slideshare.net/kleinerperkins/kpcb-Internet-trends-2013 .

About the authors

This report was prepared by Desirée van Welsum, Willem Overmeer, and Bart van Ark.

Desirée van Welsum is an economist, managing The Conference Board Business Scenario Program. She has over ten years of experience in applied economic research and policy analysis on private and public sectors in the economy. Prior to joining the Conference Board, she worked at the OECD, the UN (UNCTAD and ITU), and the UK National Institute of Economic and Social Research (NIESR). She has also worked as a consultant for the RAND Corporation, INSEAD, the European Commission, and the World Bank. She holds a PhD from Birkbeck College (University of London), an MSc from the University of Nottingham, and a Maîtrise from the University of Paris IX Dauphine. She is fluent in English, French and Dutch.

Desirée van Welsum has worked on many research topics, such as the economic impacts of Information and Communication Technologies (ICT), including on growth and economic performance, the globalisation of services activities and trade, foreign direct investment and offshoring in ICT-enabled services, and business location choices; measuring ICT skills and employment; measuring employment and activities potentially affected by ICT-enabled globalization and offshoring; factors enabling and supporting the knowledge economy; e-skills for competitiveness and innovation, e-leadership skills, and technology-driven changes in skills demand. She has published widely in these areas.

Willem Overmeer is a senior fellow with The Conference Board's Business Scenario Program. He works closely with individual Conference Board members, as well as across members, in identifying and selecting key medium-term trends in the corporate environment, and in translating these trends into scenarios that shape entrepreneurial challenges and opportunities.

Wim Overmeer has a distinguished background in global business strategy and general management in a variety of roles ranging from Corporate Planner, Researcher, Business School Professor, and Management Consultant. He worked closely with senior executive teams to redesign businesses in shifting global environments in a variety of industries and countries, ranging from telecommunication, construction and real estate development, to insurance, consumer-branded products, retail, and healthcare.

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Bart van Ark is executive vice president and chief economist of The Conference Board. He leads a team of almost two dozen economists in New York, Brussels and Beijing, who produce a range of widely watched economic indicators and growth forecasts, as well as in-depth global economic research. A Dutch national, he is the first non-U.S. chief economist in the 97-year history of The Conference Board.

Bart van Ark is an expert in international comparative studies of economic performance, productivity, and innovation. He continues to steward the longstanding research collaboration of The Conference Board with the University of Groningen in the Netherlands; a professor there since 2000, he holds the university's chair in Economic Development, Technological Change and Growth.
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Bart van Ark has been extensively published in national and international journals, and is frequently featured in major international business media, including Bloomberg, CNBC, the Financial Times and The Wall Street Journal.

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