

UK Broadband Impact Study

Literature Review

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SQW

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Executive Summary

Economic impacts

1. There is strong consensus in the literature that broadband has material positive impacts for national economies. The routes to economic impact include construction effects (associated with the network construction), and – more importantly - productivity growth (through enhanced business innovation, but also through increased international trade, and through teleworking enabling more productive use of some workers' time). Benefits take time to be realised, and are particularly dependent on managerial culture and skills.
2. The net enterprise-creation and job-creation impacts of broadband can be positive at a *local* level (varying by sector), but creative destruction and displacement effects make the net employment impacts more uncertain at larger geographies.
3. The few available empirical studies on *faster* broadband mostly point to a positive incremental economic impact. The *forward-looking* studies are generally optimistic re the impacts. However, some authors warn that the benefits of faster broadband in some areas (e.g. telehealth and telecare) will require substantial complementary public sector investments and reorganisation in order to be realised, and note the need to distinguish between the benefits of *faster* broadband and those of broadband in general.

Environmental impacts

4. Information and Communication Technology (ICT) is a major source of carbon emissions, and broadband networks are themselves significant consumers of energy (faster broadband networks can have higher emissions, though the energy efficiency of network technology is constantly improving). However, ICTs (and broadband in particular) offer opportunities to reduce emissions through a variety of mechanisms.
5. There are likely to be positive environmental impacts from faster broadband around teleworking, though these will be offset by some significant negative 'rebound' effects. There are also likely to be positive net environmental impacts associated with reduced business travel and through enabling a shift to (more energy efficient) cloud computing.

Social impacts

6. Broadband internet access has clearly had far-reaching positive social impacts in areas such as communication, entertainment, shopping, learning, health, access to employment, and interactions with government. On balance, the use of the internet is associated with higher levels of wellbeing.
7. The incremental social impacts of superfast broadband are likely to include an increase in time spent consuming video entertainment, and an increase in the use of video communications. For areas with poor current levels of connectivity, improvements in broadband speed will mitigate the extent of adverse impacts on the usability of the web, for these users, from the trend towards increased file sizes for webpages.

1. Introduction and summary of findings

- 1.1 In November 2012, the Department for Culture, Media and Sport (DCMS) commissioned a consortium led by SQW (with Cambridge Econometrics and Dr Pantelis Koutroumpis) to undertake the pre-rollout phase of the UK Broadband Impact Study.
- 1.2 To inform the model which will be developed by that study, this report summarises the findings from a review of the available evidence in the literature on the economic, environmental and social impacts of broadband – and of *faster* broadband.
- 1.3 There are many hundreds of papers of relevance to this subject, some of which are more robust and evidence-based than others. In many respects, there are quite widely divergent views represented in the literature, as to the extent of the impacts of broadband. In this literature review report, we have extracted and summarised what we feel to be the most interesting, reliable and relevant findings for the purposes of our study, using just over 100 of these papers and reports. We have attempted to present a reasonably balanced picture of the topic, reflecting the diversity of evidence in the current literature.
- 1.4 Our report is structured as follows:
 - section 2 considers the evidence on **economic** impacts
 - section 3 discusses **environmental** impacts
 - section 4 sets out selected findings on **social** impacts.

Summary of key findings

- 1.5 In the bullet points below, we set out the headline findings from our review. We have used this ‘storyline’ to structure our sub-headings for sections 2 to 4, with each finding discussed in turn.

Economic impacts

- There is a strong consensus in the literature that broadband has material positive impacts for national economies
- The routes to economic impact include construction effects...
- ...and productivity growth
- The net enterprise-creation and job-creation impacts can be positive at a local level...
- ...and these vary by sector
- But ‘creative destruction’ and displacement effects make the net employment impacts more uncertain at larger geographies

- Some studies suggest increasing returns from broadband at higher levels of penetration and ICT maturity...
- ...but there may also be a 'saturation effect', with diminishing returns beyond a certain point
- Broadband is an enabler for international trade...
- ...and for innovation...
- ...which takes time to convert into financial and economic impacts
- The extent of benefits realisation appears to be dependent on managerial culture and skills...
- ...and on the regulatory environment
- There is some firm-level evidence of productivity benefits associated with teleworking, enabled by broadband in the home
- There are very few empirical studies as yet on faster broadband, but they mostly point to a positive incremental impact
- The forward-looking studies are generally optimistic re the future impact of faster broadband...
- ...and of cloud computing (enabled by faster broadband)
- However, there are some cautionary and dissenting voices on the scale of faster broadband's impacts
- The construction effects may be stemming a decline in direct telecoms jobs, rather than boosting employment growth

Environmental impacts

- ICT is a significant source of carbon emissions...
- ...and broadband networks are significant consumers of electricity
- However, ICTs in general, and broadband in particular, offer opportunities to reduce emissions through a variety of mechanisms
- Faster broadband can lead to higher emissions, but the energy efficiency of network technology is constantly improving
- There are likely to be incremental environmental impacts (positive and negative) around teleworking
- There are also likely to be impacts associated with business travel...
- ...and cloud computing

- The incremental impacts of faster broadband around e-commerce are rather uncertain

Social impacts

- The broadband internet has clearly had far-reaching social impacts in areas such as communication...
- ...entertainment...
- ...shopping...
- ...learning...
- ...health...
- ...access to employment...
- ...and interactions with government
- On balance, the use of the internet is associated with higher levels of wellbeing...
- ...and some studies have developed estimates of the 'consumer surplus' associated with broadband
- The incremental social impacts of superfast broadband are likely to include an increase in time spent consuming video entertainment...
- ...and an increase in the use of video communications
- For areas currently lacking 2Mbps connectivity, improvements will mitigate the extent of adverse impacts for all web applications from increasing page sizes...
- ...and will mitigate the impacts of being increasingly perceived as unattractive due to relatively poor broadband

2. Economic impacts

Broadband

There is a strong consensus in the literature that broadband has material positive impacts for national economies

- 2.1 As an infrastructure investment, broadband network deployment produces spillover effects to all sectors of the national economy. The adoption of broadband by firms results in business process restructuring, more informed decision making, and productivity gains. Broadband also helps to support the creation of new businesses, and the easier access to market information helps to reduce barriers to entry. Continual improvements in broadband service offerings, for both business and consumer markets, stimulate innovation in business models, and this serves to improve overall productivity levels in the economy. Outsourcing of processes and operations is made easier for small businesses, which helps them focus on improving their core strengths while reducing operational costs.
- 2.2 Although mass market broadband services started to emerge in the late 1990s, the empirical evidence on the national economic impacts of broadband has only started to emerge relatively recently (from the late 2000s onwards), once adoption rates had increased and the first reliable time-series datasets had become available.
- 2.3 Most studies have considered advanced economies – for example, considering OECD¹ countries, European countries or the US. Various methodological frameworks have been used in this process, but the primary constraint facing researchers in this area has been the lack of comprehensive detailed micro-data across the geographies studied (for example on individual businesses' use of broadband, and individual firm performance) to enable a clear identification of the studied effects. Hence, researchers have either used aggregate national statistics or 'representative' survey samples. One important consideration in this area of research is the possibility of 'reverse causality': i.e. does broadband adoption stimulate economic growth, or does economic growth enable broadband adoption?
- 2.4 Several empirical studies have now managed to produce meaningful findings on the national economic impacts of broadband, using credible methodologies. However, it should be noted that the number and quality of controls introduced in each model are never easy to weigh or rank in a strict way. The evidence, even from these empirical studies, should therefore be considered as *estimates*, rather than 'fact'.
- 2.5 The World Bank produced one of the earliest studies on the impact of broadband on national economic growth (Qiang and Rossotto 2009). This work looks at a sample of 66 high-income economies for the period 1980-2002 (when in fact broadband was quite scarce and only the Republic of Korea, Canada and Hong Kong had achieved adoption levels beyond 10%). It found that – other things being equal – an additional 10 broadband lines per 100 people in high income economies increased the national Gross Domestic Product (GDP) per capita by 1.21% during that period.

¹ Organisation for Economic Co-operation and Development

- 2.6 Studies that looked into the same effects for more recent periods have generally found more conservative figures. For example, in his study on an OECD sample of 22 countries for the period 2002 to 2007 Koutroumpis finds a strongly positive and significant link for the impact of broadband adoption on GDP expansion (Koutroumpis 2009). He suggests that the annual GDP of the 'average' country in the dataset benefited by 0.24% from broadband adoption: this was equivalent to about 10% of annual GDP growth for these countries during the period 2002-2007. Czernich et al performed a similar exercise looking at a broader OECD sample between 1996 and 2007 (Czernich et al. 2011). They confirm that broadband adoption has a significant and positive impact on national GDP per capita, and estimate this to increase by 0.9% to 1.5% for every additional 10 broadband lines per 100 people. These last two studies control for reverse causality in explicit ways; they introduce structural models that disentangle the effects and perform several robustness checks.
- 2.7 More broadly, McKinsey recently estimated that the 'Internet' industry represented 3.4% of the GDP for 13 economies in 2009 (McKinsey 2011). In the sub-set of nine advanced countries, the impact of the Internet was found to be approximately 10% of all GDP growth in 1995-2009, but this doubled to 21% for the last five years of that period.
- 2.8 In a study for the International Telecommunications Union, Katz suggests that the variance across such findings on the economic impact of broadband can be attributed to a number of reasons (Katz 2012). He points to the different datasets used (e.g. different countries, and different time periods) and the varying model specifications. He also explains that the aggregation of relatively diverse samples can often affect outcomes if the right controls are not in place.
- 2.9 Of course, the impact of broadband never happens in isolation; an 'ecosystem' of complementary technologies, products/services and skills is at work. A chapter in a recent World Economic Forum report (Booz and Katz 2012) introduced the 'Digitization Index' to provide a holistic metric of the phenomenon, where *'digitization is defined as the social transformation triggered by the massive adoption of digital technologies to generate, process, share and transact information'*. The study identifies higher benefits for countries that score higher in the index and estimates an average impact of 0.60% on GDP for a 10% increase in digitisation. The authors suggest that the GDP impact from *digitization* is more than twice as large as the impact of *broadband* penetration.
- 2.10 A further report by Booz & Company (Booz 2012) takes a closer look at the effects of the Digitization Index for the UK. The purpose of the report was to identify the effects of digital leadership in Europe being aligned with the DCMS broadband strategy (DCMS, 2010). The authors estimated the potential returns using three different scenarios: first if the UK were to reach Norway's Digitization overall score (the highest reported), second achieving a world-class level (being ranked fifth in all aspects) and third getting to the top across all indicators (not just overall). Through their econometric framework they estimate an increase in the UK's 2011 GDP of £14 billion, had it reached Norway's score. Moving into fifth place for each metric would have added £26 billion to GDP. *'Finally, by achieving the top spot in digitization it could have increased its GDP by up to £63 billion, a 4.2 percent boost'*.

The routes to economic impact include construction effects...

- 2.11 As with every infrastructure investment the local and national economies experience a demand for goods and services associated with the infrastructure construction, until the project is completed, and this has an impact on employment and GDP (or, at sub-national levels, on GVA: Gross Value Added). There are:
- ‘direct’ impacts on employment and GDP associated with the telecommunications companies (telcos) undertaking the investment
 - ‘indirect’ impacts on employment and GDP associated with telcos’ supply chains – that is, the businesses from which the telcos purchase equipment such as optical fibre cable and electronics, and services such as civil engineering work, and in turn, those suppliers’ supply chains
 - ‘induced’ impacts on employment and GDP in the wider economy, as a result of the additional employees in telcos and their suppliers spending their wages in the local and national economies (e.g. retail, entertainment, accommodation expenditure).
- 2.12 A forward-looking study for Germany (Katz et al. 2010), supported by Deutsche Telekom, considers the potential economic impacts associated with a two-stage investment in broadband: an initial investment of €20.2 billion to ensure that 75% of German households have access to connections higher than 50Mbps by 2014; and €15.7 billion invested in 2015-2020 to bring Fibre to the Home (FTTH) connections to 50% of all households. They estimate that the network construction associated with these investments will create 541,000 job-years and will lead to an additional cumulative GDP of €33.4 billion over the decade.
- 2.13 Equivalent forward-looking estimates have been generated for the UK. The Government’s broadband strategy document *Britain’s Superfast Broadband Future* (DCMS and BIS 2010) cites a report by the London School of Economics (LSE) and the Information Technology and Innovation Foundation (ITIF) (Liebenau et al. 2009) which suggests that an additional £5 billion investment in broadband would create or retain 280,500 job-years in the UK; of these, the authors estimate that 211,000 job-years would be through the direct, indirect and induced impacts associated with the network construction.
- 2.14 The LSE/ITIF report for the UK is very similar to the analysis undertaken by ITIF for the US (Atkinson, Castro, and Ezell 2009) which estimates that a \$10 billion investment in broadband would create or retain 498,000 job-years in the US, of which 229,000 job-years would be through the direct, indirect and induced impacts associated with the network construction.

...and productivity growth

- 2.15 Of substantially more importance to long-term economic growth (than the construction effects), it is now widely accepted that the availability and adoption of affordable broadband plays an important role in increasing *productivity* in national economies – through, for example, increasing the information available to SMEs² and information workers, and – in

² Small and Medium Enterprises

conjunction with complementary investments in other ICTs³ and skills - enabling business process re-engineering to improve the efficiency and management of labour intensive jobs, and supporting the development of new - more efficient - business models.

- 2.16 One of the first studies on this (Varian et al. 2002), which was supported by Cisco, used firm-level data from more than 2,000 businesses in the US, UK, France and Germany to assess the impact on cost savings and productivity gains through 'internet business solutions'. For the US, the authors estimated that these applications had contributed 0.17 percentage points to annual labour productivity growth in the period 1996 to 2000, but forecast that this would increase to 0.43 percentage points over the period 2001-2010 (compared with a total projected annual productivity growth rate of 2.1 percentage points). The study found a lower rate of adoption of internet business solutions in Europe than in the US (especially among smaller companies), and the estimates of annual labour productivity impact for the European countries studied were therefore lower: just 0.017 percentage point for 1996 to 2000, rising to 0.11 percentage points for 2001-2010.
- 2.17 More recently, empirical studies have emerged, such as the econometric analysis by consultants LECG Ltd (LECG 2009), which considered the impact of broadband in 15 developed countries over the period 1980-2007. The study concludes that, in the US, an annual productivity growth of 0.25 percentage points could be attributed to the adoption of broadband technologies over the period 1999-2007. They estimate that an additional 1 broadband line per 100 people leads to an increase of 0.1% in productivity, in 'medium or high ICT' countries. The study also compares the relative productivity performance of Italy and Sweden, before and after significant broadband deployments occurred. For the period 1980-1997 Italy enjoyed a higher annual productivity growth rate (1.96% versus 1.38% in Sweden); but during the next decade (1998-2007) Italy's annual productivity growth rate reduced to 0.39% while Sweden's increased to 2.32%. The authors suggest that *"Italy appears to be a much more business-conservative society in terms of embracing technology than Sweden and this conservatism might be exacting a price in terms of foregone economic growth"*.
- 2.18 A report prepared for the European Commission (MICUS 2008) provides forecasts of the impact of broadband-related productivity gains through e-business adoption for the continent until 2015. The authors estimate that a constant e-business adoption increase at 3% per year (2006 rates) *'yields an annual productivity improvement of 0.25% per year at the macroeconomic level'*.
- 2.19 A more recent econometric analysis from Frontier Economics (Frontier 2011) looked into the total factor productivity gains from increases in the capital stock of telecommunications (a proxy of broadband investment) for a European industry-level sample over the period 1990-2007. They find that every 1% increase in telecoms capital stock is associated with a 0.05% to 0.06% increase in productivity (though they note that direction of causality is not proven).
- 2.20 A further study on the impact of broadband (Grimes, Ren, and Stevens 2011) used a large New Zealand micro-survey (c. 6,000 firms, in 2006) linked to financial data on the firms to determine the impact of broadband on business productivity. The authors found a

³ Information and Communication Technologies

productivity effect of broadband (relative to no broadband) of approximately 7% to 10% across all firms, but noted that even this level of productivity increase tended to leave firms broadly within the same part of the productivity spectrum for its specific sector; i.e. the broadband effect *“does not by itself transform a firm from being a poor performer to a top performer within its sector”*. They also found that the effects were consistent across firm type: there was no significant difference, after controls, in the productivity impacts of broadband adoption for firms in urban versus rural locations or for firms in high versus low knowledge intensive industries.

- 2.21 In a project for the European Commission, Clayton et al linked firm-level data from various European Union (EU) surveys to infer the impact of ICT on productivity across countries (Clayton et al. 2008). Considering an analysis of data from the UK and the Netherlands, the report suggests that the *“effects of high speed communication used by workers are additional, over and above effects of measured IT investment, suggesting that fast internet use by employees may capture unmeasured (own account) software, knowledge management by employees, and more open, flexible methods of working”*. The report includes findings that firms in the higher quartiles of the productivity distribution in the manufacturing sector tend to have higher average proportions of workers using broadband, in each of the countries studied. However, *within* the productivity quartiles, it is far from the case that this broadband metric is always positively correlated with Total Factor Productivity (TFP): in fact, among firms in the *lowest* productivity quartile, higher broadband usage correlates *negatively* with TFP, whereas in the highest quartile, higher broadband usage correlates *positively* with TFP. Regarding the finding of a negative association between broadband and TFP for the firms in the lowest productivity quartile, the authors suggest that *“this may be because these firms take longer to learn the most effective way of using the new investment or do not have the necessary complementary investments in place, which themselves are correlated to better productivity”*.

The net enterprise-creation and job-creation impacts can be positive at a local level...

- 2.22 The evidence on the impact of broadband on enterprise creation and employment seems to be mixed. Several researchers suggest that broadband deployment leads to higher employment and more enterprises, but critics argue that business process improvement and increased productivity would rarely go hand in hand with increases in manpower.
- 2.23 Some of the differences may be due to the levels of geographies considered in different studies. At relatively *local* levels, the balance of evidence appears to suggest a broadly positive impact of broadband availability and use on growth in the number of enterprises and employment.
- 2.24 US data were available before European or Asian data, and this allowed researchers to look into the link between broadband availability and employment in the US sooner. One of the first substantive studies (Gillett et al. 2006) examined the impact of broadband availability at the zip code level (considering over 22,000 zip codes) for the period 1998-2002. Their results suggest that broadband added 0.5% to 1.2% to the growth in the number of local business establishments, and 1% to 1.4% in local employment growth over this period, for communities in which mass-market broadband was available by December 1999.

- 2.25 In a report prepared for AT&T, the Sacramento Regional Research Institute estimated the broadband employment effects in 39 Californian counties for the period 2002-2005 (Van Gaasbeck et al. 2007). In common with Gillett et al, they found a positive impact on local employment, estimating that 1 percentage point increase in the proportion of the adult population using broadband yields an increased employment growth rate of 0.025% to 0.075%. However, at this larger level of geography (counties, rather than zip codes) they found a significant *negative* impact of broadband adoption on the growth in the number of firms, with a 1 percentage point increase in the proportion of the adult population using broadband *decreasing* the growth rate in the number of firms by -0.104% to -0.062%. The authors caution that the findings for this variable are 'suspect and subject to specifications', but suggest that this effect could potentially be due to the adoption of broadband leading to higher rates of telecommuting and self-employment in California (and more so in California than in the rest of the US).
- 2.26 Mixed signals come from a more recent US study looking at a disaggregated dataset for 26,000 zip codes for the period 1999-2006 (Kolko 2011). The overall relationship between broadband expansion and employment growth in this period was found to be positive, especially for areas that had few or no broadband providers in 1999. He estimates that the introduction of broadband in an area (moving from having no broadband providers to having 1 to 3 providers) is associated with a 6% increase in employment, and a 5% increase in the number of firms over the 7 year period. The link is stronger in industries relying heavily on information technology, and in areas with lower population densities. However, Kolko argues that the benefits to local residents appear to be limited, as areas that experienced faster broadband expansion over the period did not have significantly better growth in employment *rates* (i.e. employed residents divided by the working age population) than other areas. He suggests that broadband does indeed create employment growth, but this encourages people to move or commute to areas where employment opportunities have been created, and the resulting increase in local labour supply prevents the additional labour demand from increasing local employment rates or average wages.
- 2.27 An analysis of data for Kentucky counties (Shideler, Badasyan, and Taylor 2007) found that broadband deployment has a significant positive impact on a region's overall employment growth. They estimate that contribution of broadband coverage to total employment growth in 2004/5 was between 0.14% and 5.32%. Broadband infrastructure contributes most to employment growth when counties are neither sparse nor 'saturated' in their deployment, with the highest impact on employment growth appearing in counties with around the mean level of coverage.

...and these vary by sector

- 2.28 An analysis of state-level data for 48 US states over the period 2003-2005 also found significant returns from broadband *adoption* on employment (Crandall, Lehr, and Litan 2007) - estimating that every additional 1 broadband line per 100 people added 0.2 to 0.3 percentage points to private sector annual employment growth in that period. In particular, their industry level analysis found statistically significant impacts of broadband adoption on employment growth in 2004 to 2005 in a number of industries, but that these impacts varied quite substantially; every additional 1 broadband line per 100 people added: 0.28 percentage points (pp) to annual employment growth in accommodation and food services,

0.37pp in health care and social assistance, 0.37pp in manufacturing, and 2.74pp in educational services.

- 2.29 Kolko's analysis of zip code-level data for the US found no statistically significant impact of increased broadband availability in either public administration or mining (Kolko 2011). There were significant positive impacts for all other industries, but these varied widely: the growth in employment over the period 1999-2006 associated with the introduction of broadband ranged from 5.7% in arts, entertainment and recreation, 6.1% in educational services, and 6.2% in manufacturing, to 12% in 'information', 14.8% in finance and insurance, and 16.4% in professional, scientific, and technical services. He found that employment tends to be stronger in industries where information technology services (internet publishing, telecommunications services, data processing, and related services) represent a larger share of an industry's inputs. Industries that rely more on technology inputs and on workers in computer specialist occupations - the industries that should benefit more from broadband - are those in which broadband expansion is associated with stronger employment growth.
- 2.30 The research on the impact of broadband in Kentucky counties (Shideler, Badasyan, and Taylor 2007) found that broadband deployment had statistically significant positive impacts on 2004/5 employment growth in: mining; construction; information; and administration, support, and waste management & remediation services. Interestingly, there was a significant negative impact of broadband availability on employment growth in one industry: accommodation and food services. The authors suggest that *"One explanation for this finding could be that individuals are relying more on the Internet for information about travel destinations and hotel arrangements rather than working through related service providers, which may decrease employment within the travel agency industry. An additional and broader explanation is that broadband access increases worker productivity such that employment declines when firms adopt broadband technologies. Given the typically low wages of this industry (which could be indicative of low productivity), it is possible that broadband availability enables firms to substitute technology for labor."*
- 2.31 We note that there are quite different findings across these studies regarding the relative impacts on different sectors. The variations could perhaps be explained by differences in the variables used (broadband coverage vs broadband adoption), different geographies and different time periods considered. It would be fair to conclude that there probably *are* different impacts of broadband on employment growth in different industries, but that there is no clear consensus as to the extent of these impacts per sector.

But 'creative destruction' and displacement effects make the net employment impacts more uncertain at larger geographies

- 2.32 The evidence above suggests that *local areas* with higher availability and/or adoption of broadband have experienced higher growth in the number of firms and employment than local areas with lower levels of broadband availability/adoption. However, displacement effects could be at work here, with some areas benefitting at the expense of others. As Kolko puts it: *"it is theoretically possible that broadband has no net effect on employment growth nationally, and the positive relationship between broadband expansion and local employment growth reflects a zero-sum game of economic activity shifting from broadband-poor to broadband-rich areas"* (Kolko 2011).

- 2.33 While Gillett et al found a significant positive impact of broadband on employment growth in the US at *zip-code* level, there was no significant impact in their *state*-level regressions (Gillett et al. 2006).
- 2.34 Furthermore, Clayton et al report that an analysis for 26 sectors across nine European countries found no clear relationship, at industry level, between ICT use metrics (internet and fast internet use by employees) and national employment growth (Clayton et al. 2008). They suggest that “*more intensive ICT use may increase the chances of growth at individual firm level, but this may be at the expense of competitors if overall industry effects are insignificant*”.
- 2.35 A recent study using data on over 86,000 establishments with more than 100 employees across 2,743 US counties for the period 1995-2000 (Forman, Goldfarb, and Greenstein 2012) found *no* significant association between firms’ investment in ‘advanced internet’⁴ and counties’ employment growth over the period, when all US counties were considered. However, there *was* a significant positive association for the counties with high levels of population, income, IT intensity and education; these counties (6% of US counties, but representing 42% of the US population) experienced employment growth 2.7 percentage points larger than all other counties as a result of investment in advanced internet. Moreover there was little evidence for significant impacts on either employment or wages outside these areas. Their findings suggest that spatial agglomeration effects may affect the extent of impacts, and indicate that the local employment and wage impacts of investment in broadband-enabled technologies are highest in areas with high population densities and high skills levels – which emphasises the crucial role of *human capital* in realising the benefits of broadband.
- 2.36 Broadband-enabled productivity improvements could potentially lead to job losses, as process re-engineering enables firms to ‘do more with less’. The introduction of broadband also enables new business models, which will lead to employment growth in the new and innovating businesses, but some other firms could be adversely affected by broadband expansion if online services compete with traditional operations. Retail is an obvious example, with increasing numbers of people choosing to shop online rather than at local high street retailers. Another could be the arts, entertainment and recreation industry, which could see less local demand for live or on-site events if broadband makes online substitutes available.
- 2.37 Quantified estimates of the ‘creative destruction’ effects of broadband at a European level are provided in the MICUS report for the European Commission (MICUS 2008). Taking 2006 as the base year, they estimate that broadband was responsible for 1.4 million jobs being created across the EU27 (440,000 through new activity in the business services sector, 549,000 through new activity in other sectors, and 435,000 through jobs being outsourced to Europe’s business services sector), but that 1.3 million jobs were lost (725,000 through jobs being outsourced, 103,000 from productivity improvement in the business services sector, and 491,000 through productivity improvements in other sectors). They therefore estimate a net positive impact of about 100,000 jobs being created in the year across Europe,

⁴ ‘Advanced internet’ looked for commitment to two or more of the following Internet-based applications: Enterprise Resource Planning, customer service, education, extranet, publications, purchasing, or technical support

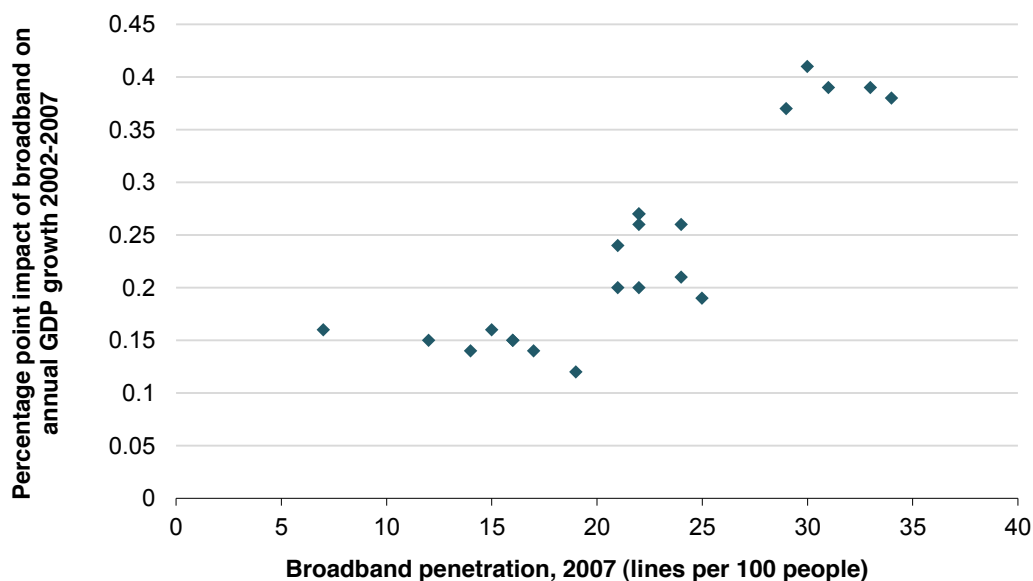
as a result of broadband-enabled innovation – though clearly the margin between their estimates of jobs created and jobs lost is not large.

- 2.38 A recent McKinsey report provides a more positive view on the hypothesis that the internet is a catalyst for net job creation at national levels (McKinsey 2011). In an analysis of the French economy they estimated that the internet had destroyed 500,000 jobs over the past 15 years (1995-2010) but created another 1.2 million, resulting in a net addition of 700,000 jobs. This analysis was in line with findings from the McKinsey global SME survey, which estimated that the internet had created 2.6 jobs for every 1 job destroyed.

Some studies suggest increasing returns from broadband at higher levels of penetration and ICT maturity...

- 2.39 Telecommunications networks in general exhibit ‘network effects’, whereby the value of the network becomes greater to each subscriber, as more subscribers become connected (for example, it’s more valuable to have a phone if many other people have one).
- 2.40 There is evidence that the impacts of growth in broadband are greater in countries with relatively high levels of take-up. Koutroumpis identified a threshold of 30 lines per 100 people (50% of households), at which broadband yielded returns double those achieved at lower levels of penetration (Koutroumpis 2009). He found that the average impact of broadband on annual GDP growth in the period 2002-2007 increased from 0.15% in low penetration countries (such as Greece and Italy), to 0.23% in medium penetration countries (such as Germany and the UK), to 0.39% in high penetration countries (such as Norway and the Netherlands) – see the chart below. Furthermore, the marginal impacts associated with *growth* in broadband penetration were greater for higher-penetration countries: an additional 10 lines per 100 people led to 0.7% additional annual GDP growth in low penetration countries, 0.8% in medium penetration countries, and 1.0% in high penetration countries.

Figure 2-1: Relationship between the broadband's penetration and economic impact (for 22 countries)



Source: adapted from Koutroumpis (2009)

- 2.41 In their analysis for Kentucky counties (Shideler, Badasyan, and Taylor 2007), the authors suggested that a critical amount of broadband infrastructure may be needed to materially increase employment, but once a community is completely built out (i.e. when coverage is complete), additional broadband infrastructure will not further affect employment growth. They found that broadband's impacts on employment growth appeared to be highest in those counties around the mean level of broadband coverage.

...but there may also be a 'saturation effect', with diminishing returns beyond a certain point

- 2.42 Another line of thought argues that there is a saturation point after which the marginal benefit from each additional subscriber will diminish. Gillett et al suggest that early adoption implies higher economic returns for users whereas those joining later will 'realize a lesser benefit' (Gillett et al. 2006).
- 2.43 Katz blends the two approaches in a more meaningful general model (Katz 2012). He suggests that the economic impact of broadband on growth follows an inverted U-shaped path. In the early stages of adoption every additional subscriber significantly boosts the value towards others. Once a certain threshold is surpassed, however, the per capita returns begin to dwindle.

Broadband is an enabler for international trade...

- 2.44 With the web providing a channel to customers (and to suppliers) across the world, there is evidence that broadband adoption has had a significant impact on international trade.
- 2.45 For example, research by Maastricht University proposes that internet use does not explain economic growth directly, but does so through increasing a country's openness to

international trade (Meijers 2012). The author builds a structural model, using data from 1990 to 2008, that confirms a link between internet use and openness, and between openness and economic growth. Across the entire sample of 162 countries, a 10 percentage points increase in a country's internet use is estimated to lead to a 3.9 percentage points increase of the 'openness ratio' [(imports+exports)/GDP], which in turn leads to a 0.17 percentage point increase in GDP per capita growth.

- 2.46 Forzati and Larsen also examined the impact of broadband on international trade (Forzati and Larsen 2008). Analysing data from the year 2000 for 29 countries, they found a significant positive association between broadband adoption and international trade value between country pairs, though they caution that this is a correlation finding rather than a concrete causal link.

...and for innovation...

- 2.47 Empirical evidence has also emerged of broadband having a material impact on business innovation.
- 2.48 For example, using findings from a project supported by Deutsche Telekom, a recent report finds a causal impact of broadband internet on firm performance using a sample of German manufacturing and services firms (Bertschek, Cerquera, and Klein 2011). Their study looks at the early stages of broadband in the country (2001-2003), using detailed firm-level information on a sample of over 900 firms. Their findings suggest that broadband access had no significant effect on labour productivity, at that stage of its development in Germany, but that it had a substantial impact on their innovation activity. Broadband use (of this sample of German firms in 2002) had a positive and significant impact on the probabilities of both process innovation and product innovation in 2001-2003: i.e. firms that used broadband in that early phase of the market's development were more likely to reshape their business processes and to bring new or improved products and services to the market. Regarding the finding of no significant impact on labour productivity, the authors suggest that *"this process of reorganisation was accompanied by a phase of experimenting and learning, which is typical for the introduction of a general purpose technology. Broadband effects on labour productivity might arise in the long run"*.
- 2.49 Further evidence is available for the UK. Using data from the Community Innovation Survey for the 2002-2004 period, together with data from the E-Commerce Survey, Clayton et al report a strong link (in the UK) between use of broadband internet connections by employees and the level of firm innovation (Clayton et al. 2008). Everything else being equal, if the proportion of workers using broadband internet increases by 10 percentage points, then the innovative sales per employee increased by 3%.

...which takes time to convert into financial and economic impacts

- 2.50 The changes in business operations enabled by broadband, and associated ICT, do not happen immediately, however. In practice, it takes time for a business to realise the full benefits of new broadband connectivity.
- 2.51 One of the most widely cited pieces of research on the lag effect associated with ICT investments is a study looking at the effects of 'computerization' on productivity using data

from 527 large US firms over the period 1987-1994 (Brynjolfsson and Hitt 2003). The authors find that the long term impacts are substantially more important than the short term impacts: *“computerization makes a contribution to measured productivity and output growth in the short term (using 1-year differences) that is consistent with normal returns to computer investments. However, the productivity and output contributions associated with computerization are up to 5 times greater over long periods (using 5- to 7-year differences). The results suggest that the observed contribution of computerization is accompanied by relatively large and time-consuming investments in complementary inputs, such as organizational capital, that may be omitted in conventional calculations of productivity.”*

The extent of benefits realisation appears to be dependent on managerial culture and skills...

- 2.52 In realising the benefits of broadband, and associated ICT investments, much appears to be dependent on the culture and skills of companies' management.
- 2.53 A particularly clear illustration of this is provided by Bloom et al, who performed an analysis of multinationals operating in Europe over the period 1999-2006 (Bloom, Sadun, and Van Reenen 2012). They showed that US-owned multinational firms achieved significantly greater productivity gains through IT than non-US multinationals, and that establishments taken over by US firms achieved significantly greater productivity gains through IT than statistically similar establishments taken over by non-US multinationals. They also found that US-owned firms had higher levels of people management than their non-US counterparts, and that this accounted for their greater success in achieving benefits through the use of IT. The authors suggest that *“part of the IT-related productivity gains underlying the post-1995 period is related to the management practices of US firms rather than simple natural advantage (geographical, institutional, or otherwise) of being located in the US environment. US firms appear to have transplanted these management practices abroad, so that their overseas subsidiaries also enjoyed a productivity miracle.”* They estimate that this superior use of IT accounts for about half of the US-Europe difference in productivity growth in the ten years from 1995.
- 2.54 The differences between US and European firms in their exploitation of ICT may also be reflected in differences in their skills profiles. A study by O'Mahony et al analysed the impact of ICT on the demand for skilled labour in the US, the UK and France in the period 1979 to 2000 (O'Mahony, Robinson, and Vecchi 2008). In the European countries they found a stronger impact of the level of ICT intensity (measured by ICT capital divided by total capital) on the demand for IT workers than on the demand for highly skilled workers not in IT occupations. In contrast, in the US the impact of ICT intensity was much larger on the demand for non-IT workers with a degree than on the demand for IT workers. The authors suggest that this may reflect different phases of ICT adoption over that period, with European firms being at an earlier stage of adoption, requiring more ICT-specific human capital, whereas in the US the diffusion of technology had reached a point at which more general skills were required to undertake the necessary organisational changes in order to reap the full productivity benefits.
- 2.55 Previous research has established the complementarity between IT and skills, and between IT and organisational change. For example, Bresnahan et al analysed several indicators of IT use, workplace organisation and the demand for skilled labour using firm-level data over the

period 1987-1994 (Bresnahan, Brynjolfsson, and Hitt 2002). They found that the interactions between IT use, workplace organisation, and human capital (but not always levels of these variables individually) positively predicted firm productivity. Information technology created increased demand for skilled labour; but *organisational* changes induced by IT may have a much larger effect on skills than the technical change itself.

...and on the regulatory environment

- 2.56 Regulation can also have an impact on the extent to which benefits are realised from ICT. Using data from 13 countries from 1992 to 1999, Gust and Marquez found that burdensome regulatory environments in industrial countries impede adoption of ICT practices and the resulting productivity gains (Gust and Marquez 2004). They suggested that restrictive labour market regulation may protect workers from the process of job creation and job destruction (and protect existing firms from the entry of new firms), but that this also appears to have slowed the adoption of ICT in some countries, and this in turn played a role in explaining differences in productivity across countries in the 1990s.
- 2.57 Van Reenen et al came to a similar conclusion when analysing the link between ICT and productivity between the US and Europe, in a report for the European Commission (Van Reenen et al. 2010). They suggest that labour market regulations and product market regulations may be “*significant determinants of cross-country differences in the impact of ICT. High levels of labour and product market regulation are associated with a lower productivity impact of ICT. This effect seems to be most severe with respect to labour market regulation (LMR). The LMR effect offsets the main effect of ICT by approximately -45% while product market regulation (PMR) has a more limited offsetting impact of -16.2%.*”

There is some firm-level evidence of productivity benefits associated with teleworking, enabled by broadband in the home

- 2.58 As well as the productivity impacts for firms associated with the adoption of broadband connectivity at their sites, there may be productivity benefits for firms and economies associated with some employees teleworking – using broadband at home.
- 2.59 Various potential productivity benefits from teleworking have been suggested (Access Economics 2010a):
- the time and costs associated with commuting are reduced
 - office expenses may be avoided – through reduced office space, and reduced energy consumption in the office (though this may be offset by increased consumption in the home)
 - recruitment and retention may be improved, by reducing geographical constraints on where workers live
 - participation in the workforce may be increased – for example, by enabling people caring for children or ill family members to participate in part time or full-time roles.
- 2.60 Furthermore, teleworking can improve employees’ life satisfaction and work-life balance, which in turn may improve the performance of these employees in their roles.

- 2.61 Some evidence of the perceived benefits of teleworking comes from an initiative led by Cisco, the Telework Week, which encourages organisations and individuals to pledge to telework for a specific week. The report on the impact of this week in the US in 2012 (Telework Exchange and Cisco 2012) found that 71% of participating organisations reported increased productivity, and 75% of participating individuals said that productivity increased when teleworking: on average adding 2 hours of productive time per day.
- 2.62 There is more formal evidence of the productivity impacts of teleworking in the academic literature. For example, Sánchez et al explored the relationship between teleworking adoption, workplace flexibility and firm performance, using a survey of 479 Spanish SMEs (Sánchez et al. 2007). They found that the use of teleworking was positively associated with other aspects of organisational flexibility, such as the use of flexitime, the involvement of employees in job design and planning, and management by results. Furthermore, they found a very significant (positive) contribution of teleworking to firm performance, and the authors suggest that *“teleworking can increase organisational flexibility and generate sustainable competitive advantage”*.
- 2.63 A randomised controlled experiment conducted in a Chinese multinational travel agency (Ctrip) provides an interesting illustration of the practical benefits but also of the social issues associated with teleworking (Bloom et al. 2012). This study monitored the impacts of a voluntary work-from-home scheme, using a sample of 252 call centre workers (split between a treatment group and a control group) over a period of nine months. The experiment found a 13% performance increase for the teleworkers, of which about 9.5% was from working more minutes per shift (fewer breaks and sick-days) and 3.5% was from more calls per minute (attributed to a quieter working environment). On top of the tangible productivity effects, home workers also reported improved work satisfaction, and the job attrition rate in the treatment group was just half that of the control group (an important consideration in call centres, which typically experience high levels of staff turnover, and therefore high levels of induction training costs). While the experiment was largely successful, and led to the company promoting teleworking more widely to its employees, only half of the treatment group decided to continue working at home after the trial; most of those choosing to go back to office-based working cited social reasons, such as loneliness of working from home and a lack of opportunities to socialise during and after work.
- 2.64 The evidence on the impact of teleworking typically suffers from studies relying on individual case studies or relatively small samples of firms/employees. However, in a ‘meta-analysis’ of 46 studies on teleworking, Gajendran and Harrison confirmed that teleworking has small but significant beneficial effects on perceived autonomy, (lower) work–family conflict, job satisfaction, performance (as rated by supervisors), staff retention, and stress (Gajendran and Harrison 2007). Low intensity teleworking appeared to have no significant effect on the quality of relationships with co-workers, but higher intensity teleworking (2.5 days or more per week) had a significantly negative effect on these relationships.

Faster broadband

There are very few empirical studies as yet on faster broadband, but they mostly point to a positive incremental impact

- 2.65 While many developed countries have had over a decade of broadband availability, the introduction of mass market ‘superfast’ or ‘ultrafast’ services – i.e. *faster* broadband, normally delivered through fibre-based access infrastructure – has been relatively recent in most countries. We are still therefore at an early stage in terms of gathering evidence of faster broadband’s incremental impacts – over and above the impacts of broadband in general.
- 2.66 A study by the Chalmers University of Technology in Sweden, in collaboration with Ericsson and Arthur D. Little, undertook one of the first attempts to measure the impact on broadband speed on economic growth, utilising a combination of OECD data for 33 countries over the period 2008-2010 and a proprietary speed testing dataset (Rohman and Bohlin 2012). Their regression analysis found that the coefficient of average achieved downstream broadband speed was *not* statistically significant, but that the coefficient of broadband speed *squared* was significant and positive – suggesting a non-linear relationship between broadband speeds and GDP per capita growth. They interpreted their findings as suggesting that doubling the connection speed would contribute an additional 0.3 percentage points to annual GDP growth (the mean speed in the sample was 8.3Mbps⁵).
- 2.67 Another study, in a European country which introduced faster broadband services relatively early (Sweden), examined the socio-economic effects from FTTH deployments (Forzati and Mattsson 2011). Using a sample of 290 Swedish municipalities for the period 2007-2010, they found that a 10% increase in the proportion of the population with access to FTTH was associated with a positive change in municipality-level employment after 2.5 years of between 0% and 0.2%.
- 2.68 A forthcoming paper (Gruber and Koutroumpis 2013) looks at a 24-country European sample for the period 2005-2011. They confirm the positive impact of broadband adoption on economic output and find a relatively small but statistically significant impact from countries that offered higher broadband speeds. In particular they estimate a 0.2% increase in economic growth for countries with average speeds above 2Mbps compared to countries with average speeds lower than that threshold.

The forward-looking studies are generally optimistic re the future impact of faster broadband...

- 2.69 While the empirical evidence on faster broadband is rather sparse as yet, there are various forward-looking studies, which have considered the future impacts for national and local economies.
- 2.70 For the most part, the forward-looking studies are very positive about the case for upgrading to faster broadband, as superfast broadband is expected to offer many opportunities for firms and individuals. For example, a Convergys-sponsored report by the London School of Economics (Dini, Milne, and Milne 2012) asserts that “*Universal availability and widespread*

⁵ Megabits per second

use of high-speed broadband services will be fundamental to the future international competitiveness of the UK, as well as to social cohesion.”

- 2.71 Some studies have developed quantified estimates of the impacts of faster broadband. For example, drawing on previous estimates for South Korea (Lee, Oh, and Shim 2005), NESTA projected that the provision of universal super-fast broadband in the UK could create 600,000 new ICT-enabled jobs over four years, with a net GDP impact reaching £18 billion (NESTA 2009).
- 2.72 In addition to the jobs created/retained through network construction effects, the previously mentioned report by the London School of Economics and ITIF (Liebenau et al. 2009) estimated that a £5 billion investment in broadband in the UK would create/retain a further 69,500 job-years, since *“increased deployment of broadband infrastructure creates a network effect that spurs additional job creation. The reason is that broadband itself increases business productivity, spurs upstream investment (e.g., of higher speed computer equipment), and contributes to the creation of new industries.”* The authors assume a ‘network effect multiplier’ of 0.33; i.e. that these additional spillover jobs will amount to about a third of the total jobs associated with the network construction phase. This brings their total estimated impact of a £5 billion investment to about 280,000 created/retained job-years for the UK.
- 2.73 For Germany, Katz et al estimated a more substantial share for the spillover effects in a study supported by Deutsche Telekom (Katz et al. 2010). They estimated that an investment of €36 billion would generate a total of 968,000 incremental job-years over the period 2010-2020, of which 541,000 were associated with the network construction, and 427,000 were from ‘externalities’. The authors estimated that the total cumulative GDP impact over the period would be €171 billion, of which €33 billion was associated with the network construction, and €138 billion was from the externalities (in year 2020, the estimated annual GDP impact was about €18 billion).

...and of cloud computing (enabled by faster broadband)

- 2.74 One of the primary routes through which faster broadband is envisaged to have an economic impact is through ‘cloud computing’. This represents a fundamental change in the way computational power, storage and resources are distributed and used, potentially transforming the delivery of ICT products into elastic and demand-driven services. Faster broadband is an essential part of this change as it enables more seamless and real time two-way transfer of data between the user and the cloud service provider.
- 2.75 Some estimates of the economic impact of cloud computing have started to emerge. For example, Etro analysed the economic impact of the gradual introduction of cloud computing in the European Union, emphasising its role in business creation and competition thanks to the reduction of the fixed costs of ICT capital (Etro 2009). His calculations show a significant impact for the European Union, with the creation of 83,000 to 431,000 new SMEs across the EU in the medium term (7,000 to 35,000 in the UK), about a million new jobs, and a significant contribution to annual GDP growth - ranging from 0.1% to 0.3% in the medium term.

- 2.76 Considering five major European countries, a CEBR⁶ report commissioned by EMC (CEBR 2010) produced rather higher estimates of the impacts of cloud computing, finding that widespread adoption of cloud computing has the potential to generate over €763 billion of cumulative economic benefits over the period 2010 to 2015 (1.57% of CEBR's estimates of the total cumulative GDP of the five economies over the same period). For the UK, they estimated that cloud's annual GDP impact by 2015 will be €30 billion (€8.4 billion from business development opportunities, €3.5 billion from business creation, €7.8 billion from net cost savings, and €10.3 billion from indirect GVA through multiplier effects).
- 2.77 Looking to Australia, a KPMG report for the Australian Information Industry Association (KPMG 2012) estimates that cloud adoption will reduce annual ICT-related operational expenditure by 25% and ICT-related capital expenditure by 50%, for each unit of output. At cloud take-up levels of 50% to 75%, KPMG estimates a long run (after 10 years) impact on annual GDP of +0.15% to +0.23% for Australia.
- 2.78 A recent International Data Corporation (IDC) study for the European Commission (IDC 2012) reports that *"more than half of EU businesses and consumers already use some kind of cloud services, but full adoption of the cloud model is still far away, hindered by a wide range of bottlenecks and barriers."* According to this study taking a proactive policy stance can help to remove those barriers to cloud and significantly impact its adoption, and they note that *"slow connectivity emerged as a constraint to cloud adoption mainly for SMEs. Clearly, eliminating the coverage gaps of broadband networks across Europe and insuring high-speed networks diffusion is a key requirement for a cloud-friendly environment"*. The diffusion of cloud computing is expected to generate both direct and indirect impacts on economic and employment growth in the European Union. Without any intervention cloud adoption could generate up to €88 billion of contribution to the EU GDP in 2020, while a "policy-driven" scenario could generate up to €250 billion GDP in 2020. The potential of new jobs creation in the "policy-driven" scenario cloud-related workers could exceed 3.8 million, against some 1.3 million in the "No Intervention" scenario - though the authors acknowledge that they do not account for the job losses that this widespread adoption of cloud services could cause (i.e. these job estimates are gross, rather than net).

However, there are some cautionary and dissenting voices on the scale of faster broadband's impacts

- 2.79 Some commentators suggest, however, that the estimates of the impact of investment in fibre-delivered broadband have been over-stated.
- 2.80 For example, Kenny and Kenny warn against inappropriately using benefits of basic broadband to make the case for the upgrade to superfast broadband (Kenny and Kenny 2011), and they suggest that *"the conventional wisdom that FTTH will bring substantial economic and societal benefits and therefore deserves a subsidy is, at best, much overstated. The case has simply not been made that FTTH has sufficient incremental externalities over other forms of broadband."*
- 2.81 More recently, the Economist Intelligence Unit undertook a series of expert interviews about the impact of superfast broadband on the UK economy, for a study sponsored by Huawei

⁶ Centre for Economics and Business Research

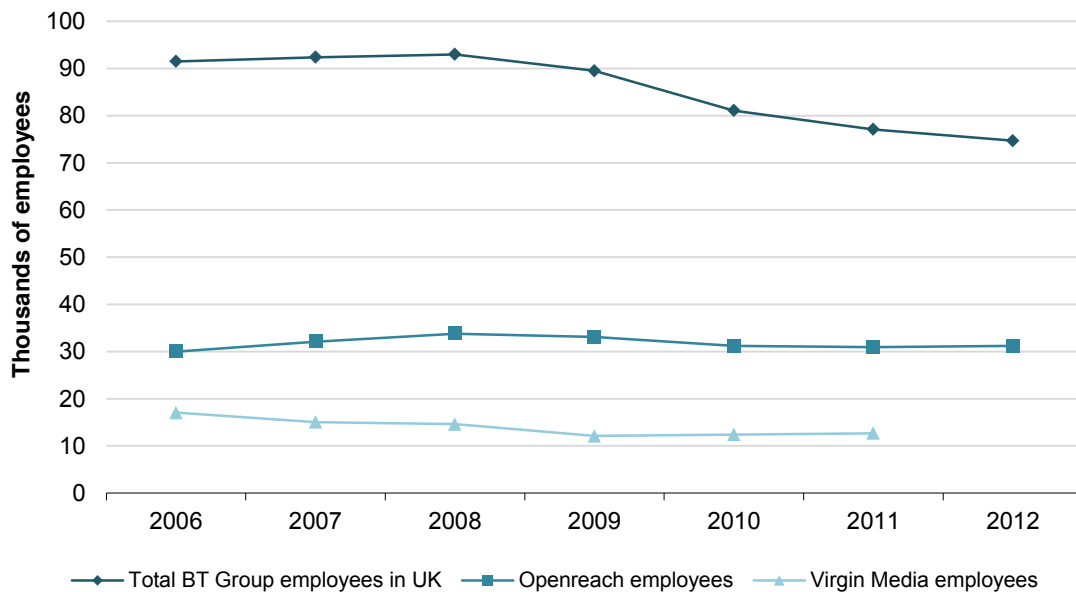
(Economist Intelligence Unit 2012). The report supports the hypothesis that the transition to high speed will have a measureable impact on economic growth and jobs, but expresses caution about the magnitude of these effects, especially in the short-term. Their key findings are that:

- *“The shift to superfast broadband will certainly deliver added growth and new jobs, but it is difficult to see how this impact will match that resulting from the earlier switch from dial-up to broadband Internet, at least in the near term.*
- *A short-term boost to jobs is inevitable, especially as the engineering work to build the networks gains pace. The longer-term, indirect impact on job growth is more difficult to project.*
- *Creation of jobs in some industries and regions may very well be partly offset by job losses elsewhere, for example.*
- *For many anticipated benefits, it is less a case of the pipe needing to change and more that of established systems, processes and skills needing to evolve. This applies across a range of sectors, including healthcare and education.*
- *In healthcare in particular, many anticipated benefits of telemedicine and remote diagnostics are realistic, but require wider reforms of the health system itself before they can be realised.*
- *In many areas, but especially within business, a shortage of skills is at least as big a hindrance to putting technology to good use as constraints on bandwidth.*
- *In the near term, ensuring pervasive Internet access to all parts of society—rural users, the elderly and others—will be at least as beneficial to society as a whole as upgrading to superfast broadband.”*

The construction effects may be stemming a decline in direct telecoms jobs, rather than boosting employment growth

- 2.82 Some of the previous studies on the impact of faster broadband put considerable emphasis on the direct, indirect and induced jobs created/retained through network construction effects. It is therefore worth examining the data on employment in major UK telcos over the last few years to see what, if any, trends can be observed since the start of superfast broadband roll-out (Virgin Media started offering a commercial 50Mbps service at the end of 2008; BT Infinity, initially offering up to 40Mbps, was first launched in January 2010).
- 2.83 The chart below illustrates the total employees in BT Group in the UK, BT Openreach, and in Virgin Media. Although superfast services are now available across Virgin Media’s cable network, and BT’s commercial roll-out is due to reach two thirds of the UK by Spring 2014, we do not appear to have had a major boost in *direct* telecoms employment during these roll-outs over the last few years (though note that these figures do not capture indirect jobs in these telcos’ sub-contractors).

Figure 2-2: Employment in major UK telcos (Virgin Media years are calendar years; BT years are to 31 March)



Source: SQW analysis of BT and Virgin Media Annual Reports.

2.84 Other evidence suggests that the longer term direct employment impacts from telcos upgrading their network infrastructures tend to be *negative*, as more modern, flexible and reliable networks need fewer people to operate and maintain them. For example, Majumdar examined the associations between average employment and wages in US local exchange companies and the extent of the use of optical fibre cabling in these telcos' networks over the period 1988-2001 (Majumdar 2008). The study found a significant positive effect of fibre deployment on *wages*, but a significant negative effect on *employment*: a 1 percentage point increase in the diffusion of fibre technology in the local exchange companies' networks was associated with a 3.5% to 5% decrease in average employment levels among the firms studied. Majumdar explains that "*as the quality of physical capital improves, more output is likely to be generated with the capital invested and, ceterus paribus, the levels of employment within a firm will decline. Yet, this decline in the quantity of employment will occur among those now relatively unskilled and untrained, and demand for those persons with training will rise.*"

3. Environmental impacts

Broadband

ICT is a significant source of carbon emissions...

- 3.1 ICT is a major contributor to greenhouse gas emissions globally. According to a recent 'SMARTer 2020' report from the Global e-Sustainability Initiative (GeSI and Boston Consulting Group 2012), the emissions associated with ICT rose from 0.53 Gigatonnes of carbon dioxide equivalents (GtCO_{2e}) to 0.91 GtCO_{2e} between 2002 and 2011, and are projected to rise to 1.27GtCO_{2e} by 2020. ICT's share of emissions is also increasing: it accounted for 1.3% of emissions in 2002, but this share is expected to rise to 2.3% by 2020.
- 3.2 The emissions are associated with the production of new and replacement ICT equipment and with the electricity needed to power the equipment.
- 3.3 According to the GeSI report, the 0.91 GtCO_{2e} emissions from ICT in 2011 constituted 0.55 GtCO_{2e} from end-user devices (such as PCs, printers and peripherals), 0.20 GtCO_{2e} from voice and data networks, and 0.16 GtCO_{2e} from data centres. The latter category is projected to have the highest growth over the next decade, with the Compound Annual Growth Rate from 2011 to 2020 projected to be 7.1% for data centre emissions (versus 4.6% for voice and data network emissions, and 2.3% for end user device emissions).

...and broadband networks are significant consumers of electricity

- 3.4 As noted above, voice and data networks contribute a significant and growing volume of emissions globally. Much of this is driven by increased coverage and take-up of broadband services. Within the European Union alone, the European Commission estimates that broadband networks could consume about 50 terawatt-hours (TWh) per year of electricity by 2015 (European Commission 2011a).

However, ICTs in general, and broadband in particular, offer opportunities to reduce emissions through a variety of mechanisms

- 3.5 While ICT is a significant source of emissions, it also has substantial potential to reduce emissions associated with a variety of activities. Indeed, the GeSI SMARTer 2020 report estimates that smart application of ICT could abate 9.1 GtCO_{2e} of annual emissions by 2020, (16.5% the projected total for the year): i.e. more than 7 times ICT's own emissions. The authors estimate the abatement potential in six categories:
 - 2.0 GtCO_{2e} abatement from 'Power' – through adoption of ICT in the power sector, in order to create a more dynamic, responsive market for power, allowing more effective integration of renewable sources into power supplies.
 - 1.9 GtCO_{2e} from 'Transportation' – through increased freight efficiencies (logistics network, fleet management and cargo transit efficiencies), and through increased teleworking and videoconferencing reducing the need for personal transport

- 1.6 GtCO₂e from 'Agriculture' – through environmental monitoring allowing efficient use of irrigation and fertilisation of crops, a reduction in land requirements for livestock and reduction in methane production, and better monitoring of environmental destruction, including rainforest loss.
- 1.6 GtCO₂e from 'Building' – with smart building design leading to efficient use of power, as well as integration of renewable sources.
- 1.3 GtCO₂e from 'Manufacturing' – with efficiencies in factories, including better automation of industrial processes.
- 0.7 GtCO₂e from 'Consumer & Service' – through e-commerce and more energy efficient packaging enabled by ICT software.

3.6 Considering the contribution of broadband in particular, a separate study for GeSI considered eight broadband-enabled domestic activities, for the United States and for a group of five European countries – the 'EU-5': France, Germany, Italy, Spain and the UK (Yankee Group and American Council for an Energy-Efficient Economy 2012). As shown in the table below, the study estimated that these eight activities could lead to a reduction in annual energy consumption of 123 million barrels of oil equivalent (MBOE) in the EU-5, and 250 MBOE in the US: substantially higher in the US, because of its more intensive consumption of energy. The authors say that this corresponds to a reduction of 39 million tonnes of annual carbon dioxide emissions in the EU-5, and 79 million tonnes in the U.S. Of the eight applications considered, telecommuting contributed the lion's share of emission reductions, according to this study: 83% of the net savings in the EU-5, and 86% in the US.

Table 3-1: Typical annual energy savings for eight ICT-related activities in the EU-5 and the US (in Million Barrels of Oil Equivalent)

	Online News	Music Streaming	Online Banking	Telecommuting	Online Shopping	Online Education	Digital Photos	E-Mail	Total
EU-5	0.2	2.1	5.1	102.0	5.2	1.1	5.2	1.8	122.9
US	0.2	1.8	7.8	214.6	8.6	2.0	11.3	3.4	249.7

Source: (Yankee Group and American Council for an Energy-Efficient Economy 2012)

Faster broadband

Faster broadband can lead to higher emissions, but the energy efficiency of network technology is constantly improving

3.7 A recent study, supported by Cisco, noted that “the majority of the energy used by the Internet today is consumed in the access network, and this will continue to be the case for the short-to mid-term future” (Baliga et al. 2011). The authors developed a model of the power consumption of various broadband access technologies, and found that FTTC⁷ ('FTTN' - Fibre to the Node – in their paper) and point-to-point FTTP⁸ ('PtP') technologies both had substantially high power consumptions per user, relative to ADSL⁹ ('DSL') technology. However, the Passive Optical Network (PON) configuration for FTTP had lower power

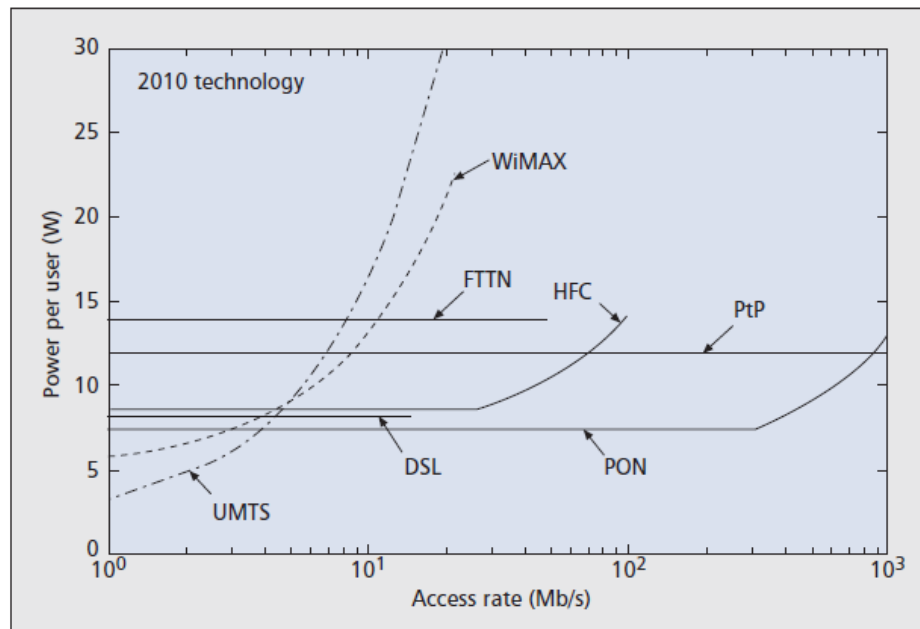
⁷ Fibre to the Cabinet

⁸ Fibre to the Premises

⁹ Asymmetric Digital Subscriber Line

consumption per user than ADSL, up to speeds of about 400Mbps, as illustrated in their chart below, which assumes 2010 technology for each. Wireless technologies – UMTS¹⁰ and WiMAX¹¹ – had relatively low power consumption per user at low bit rates, but this rapidly increased with bandwidth, exceeding ADSL’s power consumption for speeds above 5Mbps.

Figure 3-1: Power consumption of different technologies, as a function of access rate, using 2010 technologies¹²



Source: (Baliga et al. 2011). Re-used under licence from IEEE

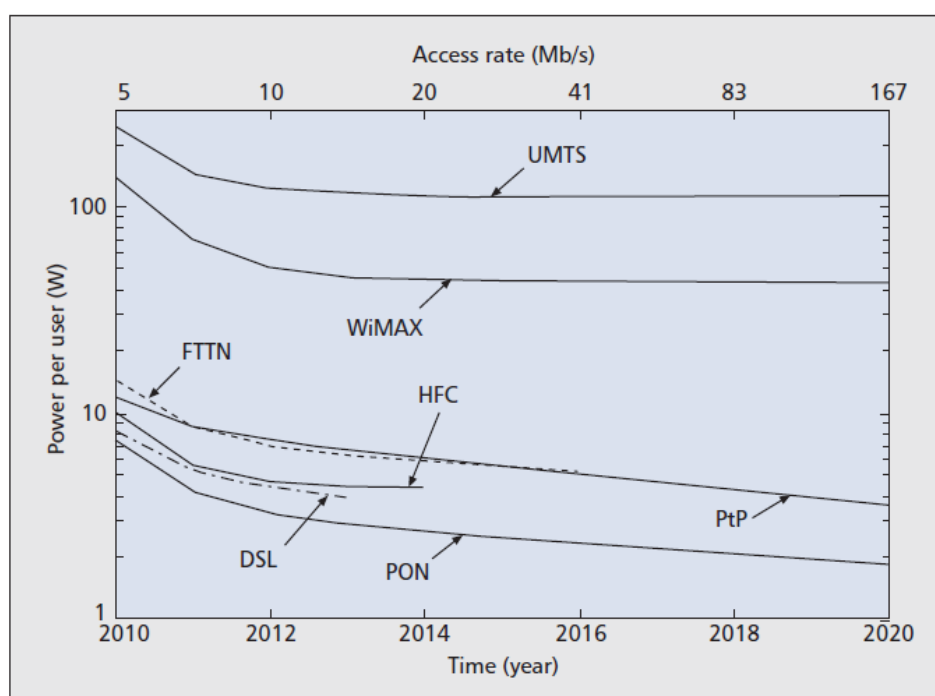
3.8 However, the energy efficiency of broadband equipment is constantly improving. Assuming 26% annual improvement in electronics, and 5% annual improvement in optical interfaces, Baliga et al developed the following chart of projected power consumption per user (the access rate was assumed to double every two years, from 5Mbps in 2010).

¹⁰ Universal Mobile Telecommunications System

¹¹ Worldwide Interoperability for Microwave Access

¹² HFC = Hybrid Fibre Coaxial (cable broadband technology). See text for other abbreviations.

Figure 3-2: Expected power consumption of latest generation equipment over time



Source: (Baliga et al. 2011). Re-used under licence from IEEE

- 3.9 The authors conclude that “the per-user power consumption of most high-speed access technologies (PON, PtP, FTTN, and WiMAX) should fall by around 70 percent from 2010 to 2020. Wireless technologies will continue to consume at least 10 times more power than wired technologies when providing comparable access rates and traffic volumes. PON will continue to be the most energy-efficient access technology.”
- 3.10 A further indication of the potential for improvements in the energy efficiency of broadband networks is given in the recent code of conduct on the energy consumption of broadband equipment (European Commission 2011a), which estimates that the anticipated 50TWh per year electricity consumption of broadband networks in the European Union could be reduced to 25TWh through implementation of that (voluntary) code of conduct.

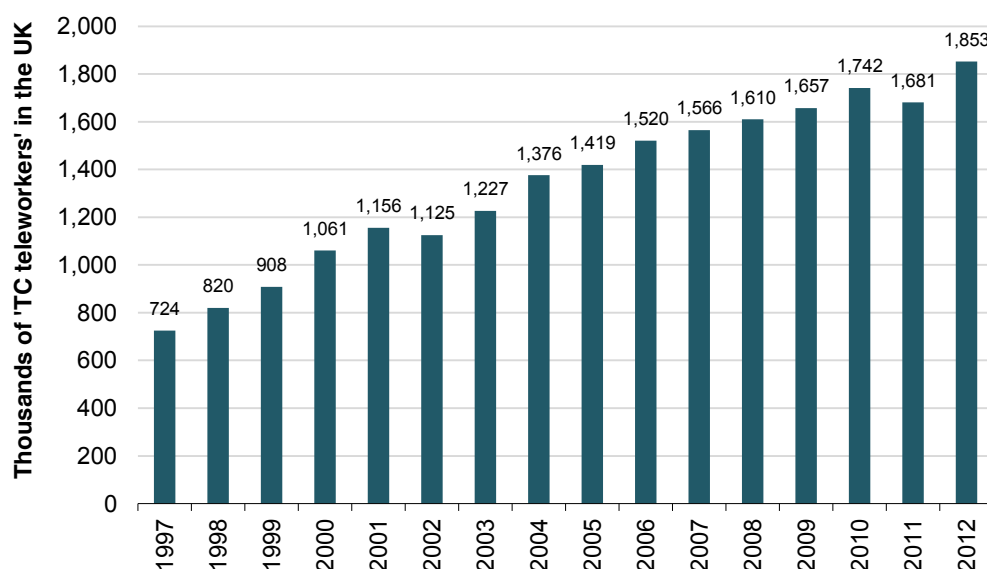
There are likely to be incremental environmental impacts (positive and negative) around teleworking

- 3.11 The most commonly cited environmental benefit of upgrading to faster broadband is that it enables more teleworking, and that this leads to lower carbon emissions. There are two important assumptions here, which we take in turn: that faster broadband will lead to more teleworking, and that teleworking reduces emissions.

Will faster broadband lead to more teleworking?

- 3.12 It is clear that teleworking has become more common over the last decade, following the emergence of mass market broadband services. The Office of National Statistics estimates that there are now about 1.9 million ‘TC teleworkers’ in the UK (people who mainly work in their home, or in different places using home as a base, in their main job, and who could not do so without using both a telephone and a computer) – up from 0.7 million in 1997.

Figure 3-3: Number of 'TC teleworkers' in the UK (people who mainly work in their home, or in different places using home as a base, in their main job, and who could not do so without using both a telephone and a computer)



Source: ONS Labour Force Survey

- 3.13 The 2012 figure represents about 6.3% of UK workers, but by focusing on people who work *mainly* at (or from) home, these statistics do not, however, capture less intensive levels of teleworking – e.g. employees working one or two days a week from home. A report on a large European survey conducted in 2005 (European Foundation for the Improvement of Living and Working Conditions 2010) found that teleworking for at least a quarter of working days was about four times more common than full-time teleworking.
- 3.14 Various studies have highlighted the importance of adequate ICT provision in facilitating teleworking. For example, a qualitative study with 49 teleworkers by the National Centre for Social Research for the Department for Transport (Penfold et al. 2009) noted that *“ICT acts as a key facilitator for teleworking, with those who have good provision being able to work from home more efficiently, effectively and ultimately more frequently.”*
- 3.15 There is some evidence emerging of faster broadband leading to a higher propensity to work from home. A 2011 online survey of over 1,000 FTTH users and over 1,000 users of other broadband services in the US, conducted for the FTTH Council, found that the average numbers of days worked from home per month was 12.8 days for FTTH users who work from home, compared with 11.5 days for cable users and 10.2 days for DSL users (RVA 2011). While some caution needs to be applied to these results (as they do not control for other factors affecting propensity to work from home), the users of higher speed services within the FTTH sample were much more likely to have ever worked from home: 67% of those with services of at least 50Mbps, versus 30% for the FTTH sample as a whole.
- 3.16 Intuitively, it would make sense that the availability of faster broadband services will tend to stimulate teleworking further. A study for the Australian Government (Access Economics 2010a) set out various reasons for believing that the introduction of their National Broadband Network (NBN) may have an impact on the extent of teleworking in the future, as

the improved technology would lead to employers viewing remote working in a more positive light, stimulating uptake of teleworking by employees:

- Fibre is a more reliable technology than existing broadband infrastructure. The improved quality and reliability will reduce uncertainty about whether it is possible for teleworkers to remain as productive as when they are in the office and encourage employers to utilise teleworking as part of their business.
- The ubiquity and cross-network reliability of the NBN will ensure that the workload will be spread more evenly among teleworkers, as there will no longer be discrepancies among teleworker productivity due to differences in household technology.
- New applications that will make it easier to work remotely – such as quality video conferencing - will become available under the NBN.
- The speed of data transfer will facilitate more reliable use of remote servers, as files can be downloaded and uploaded faster.
- The NBN is likely to widen the potential for teleworking, with some industries and careers opened to teleworking for the first time as new applications become available.
- The NBN will facilitate a more collaborative workplace across businesses and offices, in which teleworkers can participate, as easily as office-based workers.

Does teleworking reduce carbon emissions?

- 3.17 There are numerous studies making the case that teleworking can be used to reduce carbon emissions. For example, Fuhr and Pociask estimated that US telecommuting could save 588 million tons of greenhouse gas emissions over ten years, with 248 million tons from less driving, 312 million tons from less energy use by businesses, and 28 million tons from less construction (Fuhr and Pociask 2011). The Telework Research Network estimates that twice-weekly home-working (for the 50% of the workforce with jobs that could be performed at least partly from home) could reduce the UK's greenhouse gas emissions from transportation by 4%: saving 6.2 million tonnes p.a., which is the equivalent of taking 2.4 million cars off the road (Lister and Harnish 2011).
- 3.18 There is some empirical evidence to support the hypothesis that teleworking reduces the amount of travel. For example, a study using data from a survey of 19,000 employed people in Finland found that telework reduced the total kilometres travelled in Finland by 0.7% (Helminen and Ristimäki 2007).
- 3.19 Some case studies confirm that large organisations have made significant savings in real estate costs and carbon emissions, by reducing the amount of floorspace required in their offices, through telework combined with hot-desking. Various examples are collated in a recent paper by Workplace Unlimited (Oseland and Webber 2012), including: BT reducing property costs by 30% (£104 million per annum) through the rollout of flexible working practices in its Workstyle 2000 programme; Microsoft being able to accommodate 30% more people in the same amount of space due to flexible working; and PwC implementing

flexible working in their Birmingham office, which resulted in the occupational density increasing from 11.5 sq m per person to 7.5 sq m per person.

3.20 However, many studies on teleworking's environmental benefits appear to underplay or ignore significant 'rebound' effects. Notably that:

- not all of the miles notionally saved through reduced commuting are actually saved, as teleworkers may make trips for activities which would have otherwise been completed in the course of their commute (for example, for shopping, or for dropping children off at school)
- teleworkers consume energy during the working day at home, that may not otherwise have been used – especially space heating, during the winter.

3.21 In a study for BT, researchers from the University of Oxford (Banister, Newson, and Ledbury 2007) found that, for an average journey about 80% of the travel cost savings from teleworking were lost through heating and lighting for the home, based on one room being used. However, these figures are dependent on whether teleworkers are changing the heating patterns at home, and whether they only heat the one room. They also note that *“teleworking has lower home energy heating costs in the summer and this is when teleworking should be encouraged.”* The type of office building is also an important consideration. Banister et al note that naturally ventilated cellular offices use only a quarter of the energy per square metre of air conditioned 'prestige' offices.

3.22 Regarding the miles saved through teleworking, Banister et al state that evidence from the US and EU suggests that 40% of teleworkers would make no additional use of their car (i.e. 0% rebound), and that the other 60% would make a 75% saving (i.e. 25% rebound). They also note evidence from the European-funded SusTel project, which found average rebound travel effects in case study organisations ranging from 14% of commuting savings (for a regional authority in Italy) to 73% (for a public sector organisation in Denmark).

3.23 Qualitative research for the Department for Transport in 2007 (Penfold et al. 2009) found that travel patterns were displaced *in time* for some groups of teleworkers – avoiding rush-hour commutes by working part of the day at home, or making shopping trips at lunchtime rather than en route to/from work – and the authors suggested that the overall travel-related carbon footprint for these households would not be reduced, while noting that other groups' overall travel needs *would* reduce (especially in households with low personal and business travel needs).

3.24 The same report also highlighted the interaction between teleworking and home locations, noting that *“teleworking, or the option to telework, meant a wider geographic area could be considered when choosing where to live. For some participants, their pattern of teleworking had been preceded by moving home further away from their workplace (and often to rural locations), thereby extending their commute. For these participants, reducing the number of times they needed to commute to work was a clear motivation for teleworking.”*

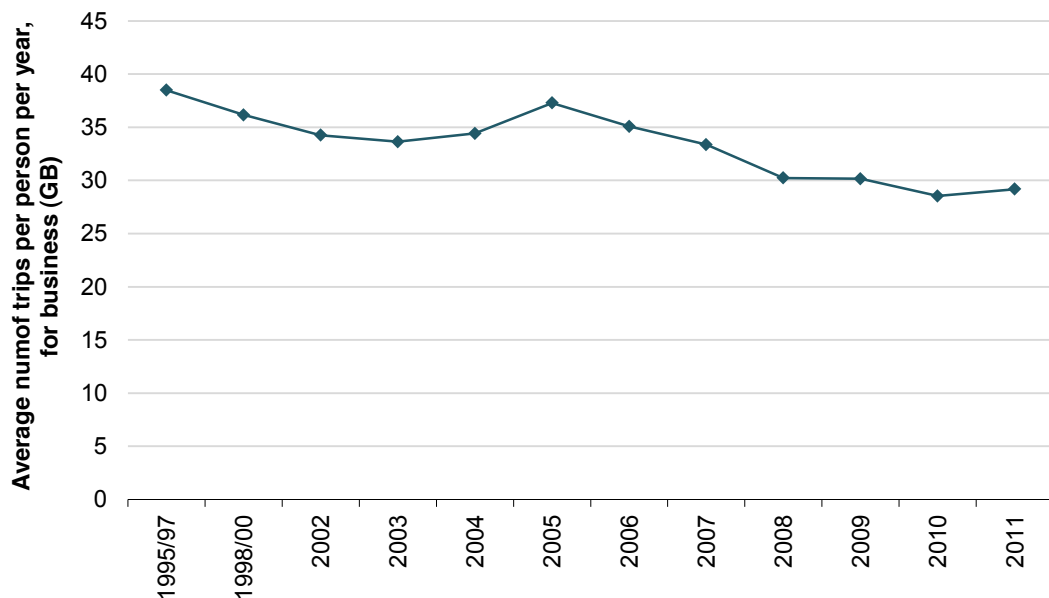
3.25 Data from the National Travel Survey confirms that average commute trip *length* has been increasing over the last several years in Great Britain (from 8.2 miles per trip in 1995/97 to 8.9 miles in 2011) – though the direction of any causality between commuting distance and teleworking is unclear (does teleworking lead to people living further away from work, or

does living further away from work lead to more teleworking?). It should also be noted that the average *number of commuting trips* per person p.a. has reduced markedly (from 174 in 1995/97 to 147 in 2011) – which would be consistent with (though not proof for) the hypothesis that teleworking reduces commuting trips. Overall, the combination of an increase in commuting trip length with a decrease in the number of commuting trips has led to a decrease in the *total average commuting distance* per person p.a. (an 8% decrease from 1,425 miles in 1995/97 to 1,308 miles in 2011).

There are also likely to be impacts associated with business travel...

3.26 Business travel has been reducing since 2005 in Great Britain, as illustrated in the chart below.

Figure 3-4: Average number of trips per person per year, for business, in Great Britain



Source: National Travel Survey

3.27 It is unclear what, if any, net contribution broadband has made this reduction. On the one hand, a survey of 100 FTSE350 companies found that 85% of firms believed that videoconferencing has the potential to reduce their company’s business flying (WWF 2008), and there are case studies of large corporates which have made substantial reductions in their business travel through more intensive use of videoconferencing and other broadband-enabled conferencing and collaboration applications. For example, Cisco reports that its Cisco employees conducted 1.37 million immersive TelePresence meetings from 2006 to 2012, of which 22% (302,400) resulted in avoided travel. They estimated a total of \$1.21 billion in travel cost avoidance over that period, \$454 million in productivity gains from reclaimed travel time, and 653,000 fewer tonnes of emissions (Cisco 2012a). While videoconferencing has primarily been used in large corporations to date, the availability of affordable faster broadband makes videoconferencing an increasingly viable option for SMEs, and its usage can be expected to increase over the next few years amongst these smaller businesses.

- 3.28 On the other hand, it can be argued that, by opening up firms to new customers and suppliers further afield, the broadband internet may actually be *increasing* international air travel. A study by the Civil Aviation Authority reports that business air travel increased from 43 million to 63 million passengers from UK airports between 1996 and 2007 (including domestic and international-to-international connections), a compound annual growth rate of 3.4% (Civil Aviation Authority 2011), and notes that *“improved international communications, whether via telephone, email or the internet has, in the past, done at least as much to increase the pace of globalisation and the demand for business travel as it has to suppress the need to travel to meet clients or colleagues”*.
- 3.29 In practice, the relationship between ICT and business travel is a complex one; for example, Haynes suggests that *“business sectors which seem ideally placed to substitute information and communication technology (ICT) for travel, are actually generating more physical travel than other sectors”* (Haynes 2010). Using the Irish software industry as a case study, he characterises a complex relationship between ICT and business travel, involving a cycle of substitution (of ICT for travel), generation (ICT use stimulating the growth of business travel or acting as an enhancing feature in business development, which requires increased international business travel), and modification (through which the needs of business travel impact on, and shape, the development and use of ICT – such as the development of mobile devices). He puts the case that *“physical travel and ICT use are mobility allies: interdependencies that modify each other and change the conditions in which working practices occur, rather than being communication substitutes”*.

...and cloud computing

- 3.30 As previously noted, faster broadband is a critical enabler for the take-up of cloud computing by SMEs. This has substantial potential to reduce the carbon emissions associated with a company’s use of ICT, because it uses shared computing resources – typically involving higher utilisations, and more modern energy efficient hardware. A study for Microsoft (Accenture and WSP 2010) estimated that, for three Microsoft applications (Exchange, Sharepoint and Dynamics CRM), the carbon emissions per user for cloud-based implementations would be more 90% lower than those for small on-premises implementations (100 users), 76% to 90%+ lower than for medium on-premises implementations (1,000 users), and 20% to 81% lower than for large on-premises implementations (10,000). It notes that key factors enabling the cloud to reduce energy use and carbon emissions include: reducing wasted computing resources through better matching of server capacity with actual demand; flattening relative peak loads by serving large numbers of organisations and users on shared infrastructure; operating servers at higher utilisation rates; and using advanced data centre infrastructure designs that reduce power loss through improved cooling and power conditioning, etc.
- 3.31 A more recent study confirms that the cloud has significant potential to reduce carbon emissions, but points out that some clouds are greener than others, and that some of the best on-premises implementations for SMEs can actually have lower carbon emissions per user than some of the worst practice cloud implementations (Natural Resources Defense Council and WSP 2012). The report describes the impact that server virtualisation can make on improving the utilisation and energy efficiency of on-premises equipment. On average, however, it found that the carbon emissions per user can be reduced by 82% by moving

from a relatively efficient on premises implementation (with virtualisation) to a public cloud solution for utility applications (reducing from 7.9 to 1.4 kgCO₂e per user per year).

The incremental impacts of faster broadband around e-commerce are rather uncertain

- 3.32 Clearly, e-commerce has grown rapidly over the last few years, and this has coincided with a reduction in the average number of shopping trips per person per year – from 214 in 2002 to 192 in 2011, according to the National Travel Survey.
- 3.33 There is some evidence to suggest that online shopping is more carbon efficient than traditional shopping. For example, a comparative analysis of shopping for non-food goods by Heriot-Watt University (Edwards, McKinnon, and Cullinane 2010) found that *“the home delivery operation is likely to generate less CO₂ than the typical shopping trip.”* Focusing on the ‘last mile’ in the delivery chain, which they argue will dominate the differences in carbon intensity between the types of shopping, the authors found that a person would need to buy 24 non-food items in one standard car-based trip for this method of shopping to be less carbon intensive than having one non-food item delivered (on the first attempt) to their home by a parcel carrier. However, the comparison is dependent on the mode of transport, and they found that carbon emissions per item for intensive/infrequent shopping trips by bus could match online shopping/home delivery. Furthermore, they note the various other factors which could alter the comparison: *“Some online customers, for example, may continue to shop as much by conventional means, but merely buy less on each trip, effectively increasing the carbon intensity of each item purchased by this means. Others may use the internet not just for purchasing goods but to inform their conventional shopping decisions, allowing them to select products and shops in advance and thereby rationalise their shopping-related travel”.*
- 3.34 However, given that e-commerce has already gained a very substantial share of the retail market in the UK (when the adoption of superfast broadband services is as yet rather low), there is some doubt over the extent to which *faster* broadband will serve to increase the sales through this channel. Online retailers configure their sites to be as quick and easy to access and navigate as possible, for as many users as possible (which in the medium term will include many users of standard broadband).
- 3.35 Furthermore, an international comparison of online shopping trends does not appear to support the hypothesis that faster broadband inevitably means more online shopping. Ofcom found that consumers in the UK spent more than £1,000 per person on internet shopping in 2011, which was more than in any other of the comparator nations surveyed (Ofcom 2012a). The value of £1,083 per head p.a. in the UK was well ahead of the values for Sweden (£747), the Netherlands (£462) and Japan (£527), all of which have considerably more developed fibre markets than the UK.

4. Social impacts

Broadband

The broadband internet has clearly had far-reaching social impacts in areas such as communication...

- 4.1 Largely steered by users, social computing applications such as blogging, podcasting, collaborative content, social networking and online gaming exploit broadband internet connectivity to support communications and the networking of people and content. In the history of communication, there are very few examples of such fast growth in such a short time (European Commission 2009).
- 4.2 There have been various studies on the social impacts of this improved communication. For instance, Selouani and Hamam provided examples of the positive changes that broadband can have on lives (Selouani and Hamam 2007). The research demonstrated the importance of broadband in performing operations such as keeping contact and communicating with relatives and friends. The authors found evidence that conducting activities online, such as communication using email, webcam and videoconferencing, could improve the quality of life since it allows many tasks to be completed from home. Similarly Jones and Rowbottom show how communication technology can be used to improve the quality of life and decrease social exclusion for older people (Jones and Rowbottom 2010). Increased well-being and health promotion can be achieved by the utilisation of telecommunication to create a virtual presence to overcome the limitations of people's mobility and the geography of their environment.

...entertainment...

- 4.3 Broadband has enabled the growth of online entertainment through the digital delivery of newspapers, games, music and films through services such as YouTube, iTunes, iPlayer, etc. This has significantly changed the way in which people access and consume entertainment. The latest Ofcom data on media usage (Ofcom 2012b) shows high usage of the internet for a range of entertainment related activities.

Table 4-1: Media usage (% of internet users)

	2009	2011
Ever use internet to find out information about leisure time activities	81%	79%
Ever use internet to watch or download TV programme or films	33%	48%
Ever use internet to look at news websites	66%	67%
Set up a social network profile online	44%	59%
Daily use of a social network profile online (of those with profile)	41%	67%

Source: (Ofcom 2012b)

- 4.4 Social networking and watching/downloading TV programmes or film are areas where there has been considerable recent growth – both the proportion of internet users with a social

network profile and the proportion of internet users who have used it to watch or download TV programmes or films have increased by 15 percentage points over a two year period.

- 4.5 The latest Oxford Internet Survey (Dutton and Blank 2011) reports that the most popular leisure and entertainment activities on the internet in Britain are listening to music (61%), downloading music (54%), and playing games (51%). The largest increase was in playing online games: up to 51% in 2011, from 44% in 2009. About 15% of respondents said that they view sexual content using the internet (up from 12% in 2009), and 13% said that they use the internet for gambling (up from 11% in 2009).
- 4.6 An Australian study provides evidence of changing patterns in entertainment consumption, noting increased “information snacking” from broadband users – whereby the user accesses bite-sized chunks of information or media all at once, through opening multiple browser windows or tabs simultaneously (Wilken, Arnold, and Nansen 2011).
- 4.7 Changing patterns in entertainment usage, in terms of media substitution and time replacement, are also evident in a study by the European Commission’s Joint Research Centre (European Commission 2009). The study found that internet use has been shown to have a negative impact on TV viewing and reading of national newspapers, especially among young users. Likewise Anderson finds evidence of a reduction in time spent watching television, and an increase in email in use and time spent online with broadband (Anderson 2008). The Oxford Internet Survey also found that the internet has become the most important entertainment medium for some people; while internet users and non-users spending comparable amounts of time reading books and socialising in person, internet users report watching less television (Dutton and Blank 2011).

...shopping...

- 4.8 As previously noted, Ofcom reported that internet shopping is now more popular in the UK than any of the comparator countries surveyed (Ofcom 2012a). In 2011, the per-head spending on e-commerce was £1,083 in the UK, up 14% from £950 in 2010. Recent ONS retail sales estimates show that spend online in November 2012 (£711 million weekly) was 8.1% higher than the level in November 2011, and now accounted for 10.8% of all retail spending, excluding automotive fuel.
- 4.9 A recent study for the European Commission (Civic Consulting 2011) showed that consumers benefit from e-commerce in many ways, such as: enabling them to find cheaper products; saving them time; making price comparison easier; offering more choice; or the possibility to become better informed about specific products. A comparison of online and offline prices in the study confirmed that it costs less to buy goods online. Even with the inclusion of delivery costs, the study found that in 13 out of the 15 product categories tested, online prices were lower than offline prices. These findings echo an earlier European Commission publication which reported that in a basket covering 100 goods, consumers could save €745 by buying cross-border goods online within the EU (European Commission 2011b).
- 4.10 In the UK, SQW estimated that the direct (gross) financial benefits of broadband in the home – predominantly through reduced household spending - were about £70 per month for the

average UK household, ranging from £23 per month for the 10% of households with the lowest income to £148 per month for the 10% with the highest incomes (SQW 2008).

...learning...

- 4.11 While broadband at home and at school has clearly made it easier for learners to access a variety of learning resources, the evidence is decidedly mixed as to the net impact of the use of computers and broadband internet on attainment.
- 4.12 A recent study on a cohort of nine-year old children in Ireland found that using a computer was positively and significantly associated with children's reading and mathematics score in standardised tests (Casey et al. 2012). However the study did find that the use of different applications can cause different effects. Surfing the internet for fun, doing projects for school and emailing are associated with higher reading and maths test scores; whereas instant messaging and downloading music or watching movies are *negatively* associated with both reading and maths scores.
- 4.13 The evaluation of the Home Access Programme in England (SQW, London Knowledge Lab, and Ipsos MORI 2011) also found broadly encouraging signs that the intervention was leading to improved outcomes in terms of enhanced use of ICT for education – while noting that it was still too early to judge the impact on attainment. Beneficiary learners were using the computer at home for 10.1 hours per week, on average, of which 4.7 hours were on learning-related activities. There was strong agreement amongst interviewed children that the computer was making learning more interesting, and helping them to do better at school. The potential adverse outcomes were largely being avoided, though the report noted that there was a minority of beneficiaries for whom the use of the computer and broadband internet access was potentially displacing other valuable activities to an excessive extent.
- 4.14 In a study in 12 schools in England in 2004, Valentine et al found that the *educational use* of ICT outside of school was positively associated with a modest rise in pupils' attainment in specific subjects, as well as bringing wider benefits including motivational effects (Valentine et al. 2005). However, they also found a statistically significant association between pupils' use of ICT out of school for *leisure* purposes and *decreases* in attainment. This effect was over twice as large an effect as the positive association of using ICT for educational purposes. The authors suggested that it is not access or general use of ICT per se that could raise attainment, but rather how the technology is used that matters. The more time pupils spend playing computer games, the less time they may have available for other tasks such as homework.
- 4.15 More recently, a working paper on a study on North Carolina public school students (Vigdor and Ladd 2010) reports a modest but statistically significant negative association between the introduction of home computer technology and students' scores in reading and maths. But an experiment conducted by the University of California, Santa Cruz (Fairlie and Robinson 2011) found no statistically significant impacts of home computers on attainment – either positive or negative. The authors report that “*we find no evidence of positive effects on a comprehensive set of outcomes such as grades, test scores, credits, attendance, school enrollment, computer skills, and college aspirations. The estimates also do not indicate that the effects of home computers on educational outcomes are instead negative. Our estimates are precise enough to rule out even modestly-sized positive or negative impacts.*”

...health...

- 4.16 One key area in which broadband has already had a substantial impact is that many people are now using the web as an important source of information on health. For example, NHS Direct reports that the number of visits to its website rose from 1.5 million a year in 2000 and 2001, to approximately 18 million in 2009.
- 4.17 There is also much optimism around the potential to exploit broadband for healthcare delivery, in areas such as telehealth and telemedicine.
- 4.18 For example, a report for Ofcom's Advisory Committee on Older and Disabled People (i2 media research 2010) has illustrated what broadband can do for older people and how emerging broadband-related products and services can improve the delivery of healthcare, and provide better social participation. Telemedicine applications that enable remote screening, diagnosis, treatment and monitoring allow people to receive quality care in the communities in which they work and live.
- 4.19 Access Economics (Access Economics 2010b) estimated the net benefits from widespread adoption of telehealth in Australia to be worth AUD2 billion to AUD4 billion per annum (approximately £1.1 - £2.3 billion).
- 4.20 However, it is worth noting some important barriers to realising healthcare benefits through broadband. Kenny and Kenny note that telehealth is primarily for the elderly (Kenny and Kenny 2011), and that this is one of the demographic groups least likely to be online. If the elderly are to use applications through telehealth there is a possible cost of unwanted connectivity and also costs of familiarisation, training and considerable ongoing technical support. Also this study points out that it is essential to take into account the required changes within the healthcare system itself: even when broadband is available, a massive investment and change in behaviour is required from healthcare providers. This sentiment is shared in the recent EIU report (Economist Intelligence Unit 2012), which states that many anticipated benefits in the provision of healthcare—for example, from telemedicine and remote diagnostics—are realistic but require wider reforms of the health system itself before they can be realised. Broadband speed alone is not enough to effect a transformation.

...access to employment...

- 4.21 The internet has become important channel for matching employers with job-seekers. A recent survey for the Department of Work and Pensions (Institute for Employment Studies and Ipsos MORI 2012) found that two-thirds of employers who had placed a vacancy with Jobcentre Plus use the internet for recruitment.
- 4.22 Furthermore, the use of the internet for recruitment has changed behaviours of both recruiting employers and job-seekers. The Joseph Rowntree Foundation reports that many employers have now ceased to advertise job vacancies in the press and have switched to the internet on grounds of cost (Joseph Rowntree Foundation 2012). The increasing use of the internet for recruitment means some employers advertise vacancies online and close them as soon as they have sufficient applicants. However, not all jobseekers are aware how active and speedy they need to be in responding to online job adverts. The authors suggest that those without access to the internet at home or who can only search sporadically for jobs will be at a disadvantage.

4.23 The use of broadband internet at home may also play a role in opening up job opportunities for people who would otherwise find it difficult to participate in the labour market. In a recent survey of over 1,000 working age people not currently employed, a study for the Australian Government found that 76% of people with family or caring commitments, and 70% of people with a disability would take up a teleworking employment opportunity, if it was available (Colmar Brunton Research and Deloitte Access Economics 2012). These groups indicated a preference to work from home the majority of the week, but still have some connectedness to the office to overcome issues of isolation.

...and interactions with government

4.24 As the large majority of UK households now have access to broadband internet, this has presented opportunities for national and local government to offer online access to many public services, in order to improve the service to users, and to reduce transaction costs.

4.25 The use of e-government services in the UK has grown in recent years, and the recent Digital Efficiency Report (Cabinet Office 2012) outlines the major potential savings from moving more government transactions online, and provides some examples of current popular e-government services, such as those in the table below.

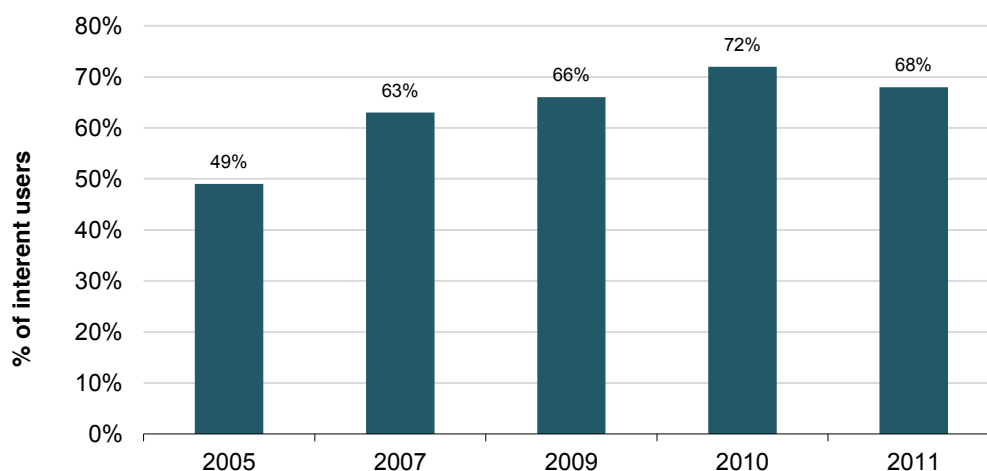
Table 4-2: Case studies of popular e-government services

Department – agency	Service	Volume	% digital	Customer	Function
BIS- Companies House	Filing accounts	2,060,000	41%	Businesses	Providing information
DfE	Free school meal applications	858,000	40%	Challenged consumers	Requesting benefits
DfT – DVLA	Vehicle excise duty	43,630,000	47%	Mainstream consumers	Making a payment
DWP	Job Seekers' Allowance new claims	3,415,000	39%	Challenged consumers	Requesting benefits
HMRC	PAYE (end of year returns)	8,948,000	100%	Businesses	Making a payment

Source: (Cabinet Office 2012)

4.26 However, the most recent data suggest we may have reached something of plateau in the proportion of internet-using adults who are using the internet to find information about public services, as illustrated in the chart below.

Figure 4-1: Use of the internet for finding information about public services provided by local and national government (% of adult internet users)



Source: (Ofcom 2012b)

- 4.27 There is mixed evidence as to broadband internet’s impact on civic engagement. Some argue that the internet provides a platform for citizens to become more engaged in civic and political issues; but others maintain that the distractions and entertainment opportunities offered by surfing the internet lead to people engaging less in civic life. A meta-analysis of 38 studies (Boulianne 2009) concluded that there was strong evidence against the internet having a *negative* effect on engagement, but that the positive impacts were rather small.

On balance, the use of the internet is associated with higher levels of wellbeing...

- 4.28 While there are, of course, negative aspects to internet usage as well as positive benefits, the evidence suggests that the internet has made a net positive impact on wellbeing.
- 4.29 For example, using data for Luxembourg from the European social survey Penard et al found, in a regression analysis controlling for other factors, that non-internet users are less satisfied in their life than internet users (Pénard, Suire, and Poussing 2011). This study also found that first level of the digital divide (whether people use the internet or not) generates more inequality in life satisfaction than the second level of the digital divide (between light and heavy internet users). They found that internet use is more influential on life satisfaction than on happiness (suggesting that digital use has long-term effects), and that the positive influence of internet use is stronger for low income and young individuals.
- 4.30 Similarly, Kavetsos and Koutroumpis analysed the impact of information technology on subjective wellbeing, using a pooled cross-sectional dataset of European countries (Kavetsos and Koutroumpis 2011). They found that having a computer with an internet connection at home is associated with significantly higher levels of wellbeing.
- 4.31 The Oxford Internet Survey also found evidence that the internet has helped build and maintain relationships with friends and family (Dutton and Blank 2011). In their 2011 survey, a considerable proportion of internet users said that access to the internet had

increased the contact they had with friends (46%) and family (43%) who lived far away, though fewer said it that it had increased contact with nearby friends (24%) and family (16%).

- 4.32 There is also evidence that the internet can enhance the mental health of older people. An analysis of over 7,000 elderly retired Americans found that internet use had a very significant impact on reducing incidences of depression: internet usage was associated with about a 20% reduction in depression (Ford and Ford 2009).

...and some studies have developed estimates of the 'consumer surplus' associated with broadband

- 4.33 With intense competition between broadband providers, in terms of price and speed, much of the value created by broadband has accrued to consumers, for whom a broadband internet connection can be much more valuable than the price they are actually paying for it.
- 4.34 Some studies have attempted to estimate the 'consumer surplus' associated with broadband: i.e. the total difference between the amount consumers would theoretically be 'willing to pay' and the price they are actually paying. An early example was a study for Verizon Communications by Criterion Economics (Crandall and Jackson 2001), which estimated that if broadband service were to become truly ubiquitous, similar to ordinary telephone service, the additional value to US consumers – over and above their expenditures on the service – would be \$284 billion to \$427 billion per year.
- 4.35 A more recent study, for the Internet Innovation Alliance (Dutz, Orszag, and Willig 2009), puts a much more modest value on the consumer surplus from household use of broadband in the US: in the order of \$32 billion per year, up from an estimated \$20 billion in 2005. This increased consumer benefit corresponds to a changing perception over time by users on the value of broadband, with it increasingly seen as a necessity for which users will find a way to pay, i.e. become more price inelastic. This study estimated that with even higher speeds, broadband would provide consumers even greater benefits – at minimum an additional \$6 billion per year.
- 4.36 The changing perception of users on the value of broadband is also illustrated by a recent study (Rosston, Savage, and Waldman 2011) which found that the demand for broadband internet is less elastic now than estimates in previous studies using older data. This means consumers are less willing now to give up broadband service if prices increase, because they value it more highly than they had previously. In 2003 the representative US household was willing to pay about \$46 per month for reliable broadband service compared to about \$79 in 2010. Given that the price of broadband has not changed much in this period, these estimates suggest experienced households get more for their money today than in the recent past - meaning that monthly consumer surplus per household has increased substantially between 2003 and 2010.
- 4.37 An OECD paper (Greenstein and McDevitt 2012) study also finds evidence of increased consumer surpluses associated with broadband among OECD countries. Many countries have experienced increased consumer surplus because they simultaneously experience large improvements in broadband quality and declining real prices. For example, in the Netherlands, the typical DSL subscriber paid \$75 per month in 2005 for a download speed of

8Mbps; in 2010, that same consumer paid \$50 per month for 40Mbps – a 33% price decline combined with a fivefold quality improvement. The quality-adjusted new consumer surplus from broadband (over dial-up counterfactual) for the UK increased from \$14 billion in 2006 to \$45 billion in 2010.

- 4.38 The above studies illustrate the very wide variation in the estimates of consumer surplus – e.g. for the US in 2009, Greenstein and McDevitt estimated a quality-adjusted consumer surplus of \$95 billion, whereas Dutz et al put the consumer surplus for that year at \$32 billion. Such variation is perhaps to be expected when estimating consumer surplus in a market in which quality (i.e. speed) has been increasing - and prices reducing - so rapidly.

Faster broadband

The incremental social impacts of superfast broadband are likely to include an increase in time spent consuming video entertainment...

- 4.39 Video is a bandwidth-hungry application, and a fast-growing source of internet traffic. One of the most significant social impacts of superfast broadband is likely to be the increased consumption of video entertainment over broadband connections.
- 4.40 Cisco forecasts that global internet video traffic will be 55% of all consumer internet traffic in 2016, up from 51% in 2011 (Cisco 2012b) – and this excludes video exchanged through peer-to-peer (P2P) file sharing. They forecast that the sum of all forms of video (TV, video on demand, internet video, and P2P) will be approximately 86% of global consumer traffic by 2016.
- 4.41 In Western Europe alone, Cisco estimates that traffic from consumer internet video will increase by an average of 34% per annum, from 2.3 to 11 Exabytes¹³ per month between 2011 and 2016.

...and an increase in the use of video communications

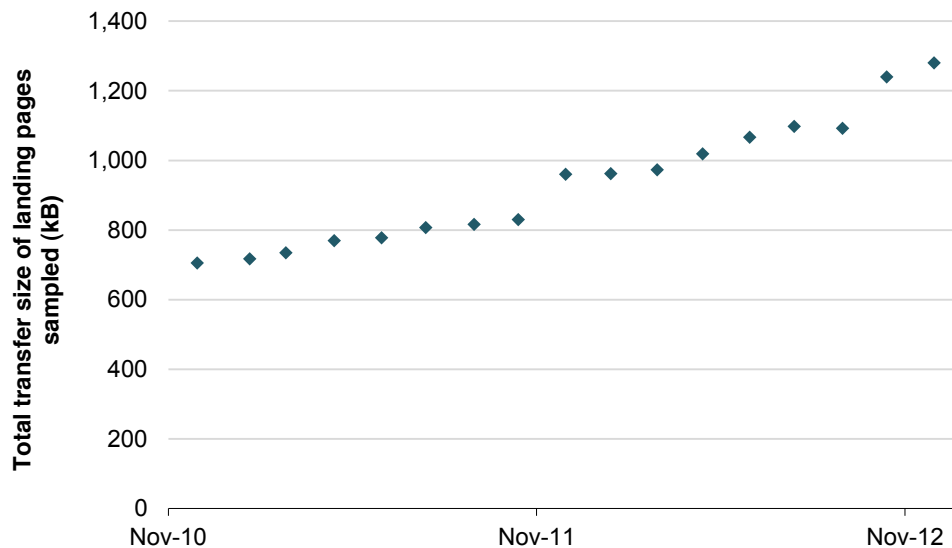
- 4.42 The social use of video chat applications (such as Skype video, Google Talk and Apple's iChat) has become increasingly common over recent years, and the consumer market is arguably ahead of the business market in its use of this form of communication.
- 4.43 A recent report (TokBox 2012) cites: information from Skype in 2011 that 75% of their users had made a video call; projections from NPD In-Stat that the total number of video calling minutes of use will approach 550 billion minutes in 2015 (up from 141 million minutes in 2010); and information from Pew Research Center that 37% of internet users aged 12-17 participate in video chats with others. In a survey of 610 US consumers, 44% of people surveyed said that they use video calling/video chat. When asked what would make them use video communications more often, the most frequently cited response was higher quality - suggesting that the higher video quality enabled by faster broadband will help to stimulate growth in video calling.

¹³ An Exabyte = 1 billion Gigabytes

For areas currently lacking 2Mbps connectivity, improvements will mitigate the extent of adverse impacts for all web applications from increasing page sizes...

- 4.44 While many of the benefits of broadband are available through standard broadband, and do not necessarily require superfast broadband, it should be noted that the size of a typical web page is getting bigger. The size of an average page in December 2012 was just under 1.3MByte according to HTTP Archive, and a typical web page now carries a 'payload' that is double the size it was two years ago.
- 4.45 The chart below demonstrates the growth in average page size over the period November 2010 to December 2012. This growth has been fuelled by the increased use of images and JavaScript. Also the higher screen resolution of some new equipment (such as the new iPad) may also encourage the use of higher resolution images in the future.

Figure 4-2: Total webpage transfer size (kilobytes)



Source: Data extracted from 'Total transfer size trends', available from <http://httparchive.org/trends.php>

- 4.46 While websites can adapt to an extent to different connection speeds, the increasing size of web pages can have a material impact on the user experience for subscribers with relatively low broadband speeds. To fully load an average landing page for a website (1,300kB), it would take about: 20 seconds at 0.5Mbps, compared with 5 seconds at 2Mbps, 1.3 seconds at 8Mbps, and 0.3 seconds at 30Mbps.
- 4.47 This ongoing growth in webpage size means that the user experience will gradually deteriorate in areas without 2Mbps connectivity, relative to the experience of those able to access higher speeds.

...and will mitigate the impacts of being increasingly perceived as unattractive due to relatively poor broadband

- 4.48 Broadband availability and quality are likely to be increasing factors in the attractiveness of an area to live, especially rural locations.

- 4.49 There is some limited (though not conclusive) empirical evidence of local differences in the availability and quality of broadband having an impact on property prices. For example, Gillett et al found that the effects of broadband availability by 1999 could be observed in higher property values in 2000 (Gillett et al. 2006).
- 4.50 In a recent study of 2,000 home-buyers for Delaney's estate agents, Broadbandchoices¹⁴ found that a good broadband connection is now more important than off-street parking and local amenities, and that one in five of recent movers arranged an internet provider before connecting gas or TV. Setting up broadband was second only to connecting to electricity. The study also found that one in ten prospective buyers have walked away from properties with bad internet connections, one in five checks out broadband speeds whilst evaluating a property, and one in five said that they would pay more for a property with a high-speed broadband connection.
- 4.51 Research for the FTTH Council in the US (RVA 2012) found broadband impacts on house price in the order of 2%: *"non FTTH users say if they were considering two \$300K homes of equal interest except for broadband capability, a home that doesn't already have very high speed internet from a direct fiber optic line and advanced inside wiring would have to be discounted an average of \$5,337 more to be considered. Current FTTH owners said it would take a \$6,451 discount on average."*

¹⁴ Reported here: <http://www.telegraph.co.uk/property/propertynews/9570756/Fast-broadband-more-important-to-house-buyers-than-parking.html>

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