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DELIVERING BRITAIN'S DIGITAL FUTURE: An Economic Impact Study

A report for BT

22 September 2015

This report has been prepared by KPMG LLP ('KPMG') solely for BT Group plc ('BT') in accordance with terms of engagement agreed by BT with KPMG.

This report, an initial assessment of the economic impact of BT's proposed ultrafast broadband investment and a consideration of the impact of structural separation of Openreach ('report') has been prepared by KPMG in accordance with specific terms of reference ('terms of reference') agreed between BT ('the Addressee') and KPMG. KPMG wishes all parties to be aware that KPMG's work for the Addressee was performed to meet specific terms of reference agreed between the Addressee and KPMG and that there were particular features determined for the purposes of the engagement. The report should not therefore be regarded as suitable to be used or relied on by any other person or for any other purpose. The report is issued to all parties on the basis that it is for information only. Should any party choose to rely on the report they do so at their own risk. KPMG will accordingly accept no responsibility or liability in respect of the report to any party other than the Addressee.

KPMG's work was conducted between 16 June 2015 and 18 September 2015, and the work comprised desk-based analysis of publicly available information, information supplied to KPMG by BT and discussions with BT staff. Note that KPMG has not sought the views of any other stakeholders as part of this work.

KPMG does not provide any assurance on the appropriateness or accuracy of sources of information relied upon and KPMG does not accept any responsibility for the underlying data used in this report. No review of this report for factual accuracy has been undertaken. For this report, BT has not engaged KPMG to perform an assurance engagement conducted in accordance with any generally accepted assurance standards and consequently no assurance opinion is expressed.

The opinions and conclusions expressed in this report are those of KPMG and do not necessarily align with those of BT.

DELIVERING BRITAIN'S DIGITAL FUTURE: AN ECONOMIC IMPACT STUDY

Ofcom's Digital Communications Review comes ten years after its last review of the sector which implemented the landmark regulatory framework of BT: equivalence of inputs and functional separation. This has helped to propel the UK to a relatively strong digital position globally. Over the next ten years there should be significant benefits to UK consumers and businesses from BT's continued investment in access infrastructure and the services it supports. We estimate this to be worth some £20-30 billion[1] to the UK.

Adopting a new model of competition in the UK based around structural separation of BT, and a revised regulatory framework, would be a major market intervention. It is not clear that such a change would deliver the same level of economic benefits. Significant hurdles would need to be overcome for structural separation to be an effective remedy. These hurdles present a material challenge. We would note that no other jurisdiction has successfully overcome these as a competition remedy.

Scope of our report

BT has asked us to provide an initial assessment in relation to two key issues:

- The economic impact of potential advancements in the UK fixed telecoms access infrastructure – a quantitative and qualitative assessment of the benefits to the UK economy
- The potential impact of structural separation of Openreach on the delivery of these benefits compared to a continuing evolution of the current regulatory model

Context for the DCR

In 2005 Ofcom concluded its inaugural review of the telecom sector – the Strategic Review of Telecommunications ('TSR'). The outcome of this review was the creation of Openreach in 2006.

In lieu of a potential reference to the Competition Commission, BT gave a set of voluntary undertakings to Ofcom which sought to deliver:

- Equivalence of inputs ('EoI') – the objective being to ensure all access seekers, including BT's retail business, would be offered the same products on the same terms
- Functional separation – designed to facilitate EoI and improve transparency around Openreach performance and help service users hold Openreach and BT to account for service and the costs of delivery

In addition to these undertakings Ofcom maintained price control regulation on Openreach copper access products (LLU and WLR) thereby protecting Openreach's customers from any potential uncompetitive pricing.

In agreeing to this framework, Ofcom acknowledged that certain elements of the UK access infrastructure were enduring bottlenecks (at least within the implicit forward looking time horizon of the TSR) and that the best way to promote competition in the interests of consumers was to focus regulation on these bottlenecks. This framework was intended to enable competition in the relevant downstream markets i.e. retailing to end consumers, businesses and wholesale.

1) All impact figures are discounted to 2015.

Context for the DCR (cont.)

This approach therefore did not aim to foster competition at all levels of the market, with aspects of access expected to remain bottlenecks, and regulation creating the conditions for healthy competition for retail customers.

The issues of investment in fibre (to enable next generation access ('NGA') services) and customer service were not directly considered in the TSR. Subsequently in March 2009[2] Ofcom introduced its regulatory framework for NGA, which supported BT's fibre roll-out. In Ofcom's most recent review of price controls for Openreach (2014 – Fixed Access Market Review[3]) Ofcom introduced for the first time specific service levels for certain products provided by Openreach. It is currently consulting on implementing service levels for Ethernet products in the Business Connectivity Market Review.

Ofcom's approach has been broadly successful and the evidence has been documented in its DCR consultation document[4] – UK consumers and businesses have benefited from:

- Strong retail competition
- The introduction of new products and services including superfast fibre broadband as a result of significant investment over the last ten years
- More recently improvements in service levels

Today's challenge

Ten years on, the question is: what has changed since the TSR and does this mean that a different regulatory framework is required?

With that reference the important issues are therefore:

- Whether access products provided by Openreach will continue to be enduring bottlenecks within the context of the next ten years
- If they are, whether the conditions for effective competition are best supported by the current regulatory framework, based on functional separation, EoI and price controls, or a different model based, for example, on structural separation
- If they are not, whether regulation should be lifted or lightened in some way

In the context of the effectiveness of the current regulatory framework there have been allegations of failure or limitations concerning the presence of discrimination despite EoI, and that the levels of service provided to Openreach users are poor in absolute terms.

We touch on these issues later in this report where we discuss a number of counterfactual scenarios, although it should be noted that our focus is on investment.

2) http://stakeholders.ofcom.org.uk/binaries/consultations/nga_future_broadband/statement/statement.pdf
3) http://stakeholders.ofcom.org.uk/telecoms/ga-scheme/specific-conditions-entitlement/market-power/fixed-access-market-reviews-2014/statement/
4) http://stakeholders.ofcom.org.uk/consultations/dcr-discussion/

DELIVERING BRITAIN'S DIGITAL FUTURE: AN ECONOMIC IMPACT STUDY

Our approach

Using economic impact analysis we have estimated quantitatively the benefits to the UK economy from BT's investment in ultrafast broadband[5]. We do this by considering recent relevant academic studies. These studies cover both assessments of total impact of average broadband speeds on economic growth and individual bottom-up analysis of individual channels through which that impact might occur, such as teleworking.

In addition we have qualitatively considered a number of counterfactual scenarios involving structural separation, to assess the potential benefits and risks associated with these scenarios.

We have evaluated the counterfactual of a different regulatory framework, i.e. structural separation, and its relative merits in terms of driving investment as well as other challenges associated with its implementation.

Economic benefits to the UK

Ofcom's approach to regulation does not focus directly on defining or delivering specific outcomes for consumers or businesses, rather it focuses on ensuring the conditions for effective competition are present and that competition will deliver the best outcome for consumers and businesses.

However, without a frame of reference for the specific outcomes and what impact they may have on consumers and the UK economy generally it is difficult to evaluate the significance and impact of changes to the current regulatory framework.

Continued commitment to enhance telecoms access infrastructure and services through BT's investment in access technologies including ultrafast broadband, will benefit the UK economy through increasing the average broadband speeds available, thereby improving the ability of businesses and consumers to use the network without constraint.

We expect improvements to the network to generate productivity and other 'spill-over' economic impacts, through:

- Increasing business productivity – access to faster broadband should enable businesses to execute production processes, make sales and analyse information more quickly. It should also enable them to embed more sophisticated software into their operations and allow them to restructure and streamline their operations to save time and costs
- Creating new businesses – a better business environment, thanks to improved telecom services, is expected to encourage the emergence of new businesses in the UK, particularly in sectors which are heavily reliant on those services. Other firms may find that their business models are no longer effective in such an environment, although the net effect on the UK economy is expected to be positive

5) In BT's case, the chosen investment route is via the G.fast technology, see http://home.bt.com/news/bt-life/bt-ceo-sets-out-ultrafast-broadband-vision-11363958493131.

DELIVERING BRITAIN'S DIGITAL FUTURE: AN ECONOMIC IMPACT STUDY

Economic benefits to the UK (cont.)

- Attracting Foreign Direct Investment (FDI) – transforming UK business infrastructure to make it more competitive vis a vis other world business centres is expected to attract more FDI to the UK, with the majority of global CEOs citing technologies that rely on broadband as strategically important to their business[6] and foreign investors ranking broadband infrastructure as a key factor in selecting a regional location within the UK[7]
- Enabling people to work more effectively from home and in transit – access to faster broadband will enhance the ability of people to work effectively from home, saving employees and businesses time and money. It will also enable more people, who have caring obligations or cannot travel away from the home to work for other reasons, the opportunity to participate in the labour market

Our approach to estimating the economic impact of these effects is set out separately in the appendix to this report. Following discussions with BT we have modelled a scenario where the additional investment results in the average broadband speed in 2025[8] reaching 100 megabits per second ('Mbps') more than would otherwise be the case.

We estimate that the combination of these productivity and other spill-over effects could add £3.6-6.2 billion per annum to UK gross domestic product ('GDP') by 2025, resulting in the UK economy becoming 0.22-0.38% larger than without such additional investment.

Looking over the whole period to 2025, a total of £20-30 billion in additional GDP is expected to be generated.

As with any forward-looking estimate, different assumptions could be used. However, we note that the central conclusion, that the potential economic benefits for the UK of this investment are large, is robust to reasonable sensitivities around these assumptions and consistent with the findings of other studies.

There are additional benefits not captured in our estimates of spill-overs to GDP. These are, nevertheless significant. We expect the consumer surplus to be £5-15 billion over the period to 2025. Consumer surplus is the difference between what a consumer would be willing to pay for a service over and above what they actually pay. It is a measure of increases in consumer welfare. Further, the extra investment will have an impact on output in the economy via the standard multiplier effect, although we have not quantified this in this report. There are also wider societal benefits which we have not estimated.

6) PwC. 'Annual global CEO survey', 2015
7) EY. 'UK attractiveness survey', 2015
8) The speeds used in the modelling are UK average speeds, not just those corresponding to customers on the Openreach network. The average speed is the average achieved speed, as opposed to the maximum speed available. The maximum available speed is likely to be significantly higher than the achieved speed.

Potential impact of structural separation

Structural separation is currently the subject of much debate. Those arguing for it cite increasing incentives to invest, quality of service, greater transparency over non-discrimination and pricing and a simpler model of regulation. Those arguing against believe it would reduce incentives to invest, would be disruptive, and would require greater complexity in the regulatory model. Much of the evidence to support allegations of the failure of the current system and of the impact of different regulatory models on the factors above has not yet been gathered or considered by Ofcom.

We discussed with BT three possible counterfactuals which differ in the way in which Openreach could be regulated.

Counterfactual 1: Openreach is structurally separate from the rest of BT and Ofcom maintains the current imposed regulatory obligations of EoI and price controls.

- A benefit of this scenario could be an increase in transparency: all stakeholders being more confident that BT would not have influence over Openreach's operations, including pricing and investment decisions
- Under this scenario, the risk to Openreach associated with a large investment could be raised compared to today since it is no longer possible to co-ordinate critical, large scale investments across the BT Group to de-risk or share the risk of its investments. As Ofcom noted in the DCR discussion document[9], integration provides Openreach with an 'anchor tenant' in BT Consumer, that provides guaranteed demand for new network investments. This helps de-risk investment and, all other things being equal, provides better incentives for upstream investment. The loss of an 'anchor tenant' for investment is an important factor when considering the impact of structural separation.
- Other communication providers (CPs) have argued that investment incentives would be enhanced as they could directly engage with Openreach in relation to their infrastructure needs
- This scenario could impose a risk through the lack of pricing freedom for a separate Openreach to negotiate individual terms with other CPs. Continued strict EoI obligations and price controls would be a barrier to creating equivalent investment conditions and incentives in a structurally separate model since Openreach would be unable to create different commercial agreements that guarantee demand for its products
- There is an increased risk of significant delay in investment or some investments not being made because of the lack of regulatory certainty during the process leading up to structural separation and the length of that process itself
- There would also be a number of potentially very significant operational challenges that would take time and cost to resolve (if indeed they could be resolved at all). These include how to separate BT's pension liability (including the scheme assets and liabilities, and the treatment of the Crown Guarantee, where the Secretary of State becomes liable, on the commencement of a winding up, to discharge any liability of BT for the payment of pensions), its assets, people, and systems. We have not undertaken a detailed assessment of these challenges but we believe they could prove to be significant hurdles to overcome

(9) See Figure 32, p130, http://stakeholders.ofcom.org.uk/binaries/consultations/dcr_discussion/summary/digital-comms-review.pdf

Potential impact of structural separation (cont.)

- When looking at international comparisons, we note that there are few relevant examples of structural separation of telecoms operators, fixed or mobile, in other markets and little evidence that the outcomes for consumers have been as good as those enjoyed by UK consumers over the past decade. Indeed, Ofcom notes in the DCR discussion document that the "*recent examples of structural separation are where it has been secured not as a competition remedy, but as a requirement made by governments for public funding for superfast broadband deployment.*[10]"

In summary, counterfactual 1 has some potential upsides and downsides, support for which is largely theoretical and for which quantitative evidence has not been provided. Alongside the potential for delay, a particular risk to investment arises due to the potential inability of Openreach to strike long term exchanges contracts with its customers.

Unless otherwise stated, the factors considered above, would apply to counterfactuals 2 and 3.

Counterfactual 2: Openreach is structurally separate and regulation is lifted entirely – this would ensure Openreach had the incentive to invest, so long as appropriate commercial deals with its users could be agreed. It is difficult to anticipate in advance how effective those incentives might be.

- Following the removal of EoI obligations (and potentially the current price control regime), Openreach would have greater ability to discriminate between wholesale users. This pricing freedom could result in non-cost-reflective prices, but this risk could be counterbalanced by an increase in the potential returns from investment, although the inability to co-ordinate major investments across the BT Group could also impact investment levels
- Discrimination may have the consequence of benefiting larger wholesale customers who have stronger buyer power than smaller customers – helping the larger customers deliver differentiation in the retail market. This could lead to Openreach determining the shape of the retail market – influencing who are the likely winners and losers in that market
- The same potential delay in investment could be associated with counterfactual 2 as counterfactual 1

In summary, while there may be some potential for upside on investment, relative to counterfactual 1, in the long term, as long as contracting could be agreed (and there would be uncertainty about the net impact on investment), there could be delays in implementation and concerns around efficient levels of pricing. This would come at the price of lifting the current regulatory obligation that requires Openreach to supply its products on an equal basis to all its customers.

Counterfactuals 1 and 2 present challenges to the effectiveness of structural separation. How exactly Ofcom should respond to this is unclear – should it, for example, become involved in commercial negotiations, potentially reviewing and approving different contracts under a Fair Reasonable and Non-Discriminatory (FRND) obligation?

10) See para 11.66 in http://stakeholders.ofcom.org.uk/binaries/consultations/dcr_discussion/summary/digital-comms-review.pdf

Potential impact of structural separation (cont.)

Alternatively, Ofcom could seek to introduce back-stop pricing and other terms in a set of reference offers, but this is again a difficult concept to implement – Openreach would need a degree of freedom in how it structures and prices commercial deals and regulatory intervention may undermine this ability and have unforeseen consequences. Moreover, structural separation may require Government to change Ofcom's duties to have regard to Openreach's financial viability and its ability to finance network investment (as is the case in respect of several other infrastructure sectors).

Counterfactual 3: Openreach is structurally separate and a new regulatory framework is implemented that attempts to strike a balance between allowing Openreach to differentiate between users on prices, product characteristics and services to support investment, but at the same time protecting Openreach's users from any abuse of its bottleneck status.

There is no example of a working model of this form of alternative regulatory regime and such a framework may not be compatible with the relevant EU directives (for example the model may need to provide regulatory certainty for longer periods than the current three year cycle of market reviews implies), and would require a lifting of the current obligation for Openreach to supply its products on an equal basis to all its customers.

In summary, this counterfactual may, after a period of delay, deliver the benefits identified under the current regulatory model. In addition to the possibility of delay, however, is the risk that this model will deliver less well and effectively than the current approach (if indeed it is possible to develop such a model), leading to sustained sub optimal levels of investment to the corresponding detriment of the UK's economic growth and competitiveness.

Conclusions and implications

Continued investment in upgrading telecommunications access infrastructure and services is critical to the UK economy – we estimate this could be worth some £20-30 billion over the next ten years.

The current regulatory framework for Openreach – functional separation, EoI and price controls has, since 2005, broadly operated effectively for consumers and supported the transformation of the broadband infrastructure in the UK. This model is now under scrutiny and several challenges have been raised concerning possible shortcomings.

Ofcom is considering whether structural separation is an appropriate way of addressing these shortcomings. There are potential long term upsides, downsides and risks associated with structural separation, some of which are difficult to quantify and likely to be highly subjective in nature. Any form of structural separation would also require a new regulatory framework the core details of which are currently uncertain. Set against this, the current regulatory model has produced clear benefits for the economy and UK consumers and can be expected to continue to do so; although changes to aspects of that model may be required to address some of the claimed shortcomings.

There are some clear execution risks and costs associated with the implementation of such a model, including the potential for delay in investment and the need to address some of the more challenging aspects of separation such as the Pension Scheme and the associated Crown Guarantee.

In order for structural separation to be an appropriate, proportionate approach in the long term, putting aside the impact of delay, there are some significant hurdles that would need to be overcome for structural separation to be an effective remedy:

- The establishment of a new regulatory model (along the lines of counterfactual 3 above) which would enable long-term contracts to be successfully negotiated, such that investors would be provided with long term certainty, without subjecting Openreach to higher levels of regulatory risk
- Any deficiencies in the current model cannot be resolved by Ofcom as part of its ongoing review processes
- That the economic incentives of the new owners of Openreach are aligned with those of its customers for the long term
- Practical issues (such as those relating to the Pension Scheme and the costs associated with separation) can be overcome

Taken together, these hurdles present a material challenge. We would note that no other jurisdiction has successfully overcome these as a competition remedy.

Adopting a new model of competition in the UK based around structural separation of BT and a revised regulatory framework would be a major intervention in the communications market. There has been much market commentary on the potential advantages and downsides of moving to such a model, with a degree of inevitable speculation in such commentary given that few other markets globally have adopted a similar approach.

Conclusions and implications (cont.)

Our analysis highlights the critical importance of continued investment in the UK's communications infrastructure. Evidence from Ofcom suggests that the competition/regulatory model established following Ofcom's first strategy review has performed relatively well. This is in contrast to Ofcom's conclusions on the state of the market at the time of the last review.

It is not clear that adopting a new competition/regulatory framework, with structural separation at its core, would deliver the same level of economic benefits as outlined above. It could also disrupt the market at a time when continuity and sustained investment in the UK's access infrastructure is more important than ever, given the increased reliance on connectivity, the fast pace of technological change and the need to maintain the UK's competitive effectiveness.

APPENDIX: AN ECONOMIC IMPACT STUDY

APPENDIX: INTRODUCTION

In this appendix we outline the methodology and assumptions underlying our estimates of future economic benefits of investment by Openreach in the roll-out of ultrafast[9]. These benefits are presented in the main body of this report. As part of the main report we quantify these economic benefits using a range of methodologies described in this appendix.

The economic benefits of the ultrafast investment over the period to 2025 estimated in this report can be summarised as:

£20-£30 billion addition to Gross Domestic Product (GDP) from spill-over benefits

£5-£15 billion in consumer surplus

These benefits are both cumulative to 2025 and are presented discounted to 2015.

9) In BT's case, the chosen investment route is via the G.fast technology, see http://home.bt.com/news/bt-life/bt-ceo-sets-out-ultrafast-broadband-vision-11363958493131.

APPENDIX: SPILL-OVER EFFECTS TO INCREASE GDP BY £20-30 BILLION

The spill-over effects from the investment in ultrafast are those impacts that arise as a consequence of households and businesses using faster broadband

We calculated the £20-30 billion in spill-over benefits by considering how the increased broadband speeds, available as a result of further investment in broadband infrastructure, will contribute to growth in GDP between 2015 and 2025. Faster broadband speeds will enable businesses to execute tasks more quickly and embed increasingly sophisticated software into their processes. It will also allow firms to develop new products and services to offer to consumers. All of these will add to GDP.

Quantification of the economic impact resulting from higher broadband speeds is a relatively new field of research. At present there are only a handful of studies which look specifically at the total impact of increasing speeds, as opposed to increased broadband coverage, where most of the research has focussed. As a consequence, there is still uncertainty and debate around the magnitude of gains from increasing broadband speeds.

Whilst we link broadband speeds directly to GDP, a number of other studies take a more bottom-up approach; identifying and quantifying the individual channels through which faster broadband speeds impact the economy, such as teleworking, use of internet based software or business productivity. We discuss these approaches below.

Our analysis was kept as close as possible to the approach and findings of the academic work in this area, although, as with all studies of this nature, we have had to make some assumptions to feed into the framework used. We believe these assumptions to be reasonable and relatively conservative, given the current thinking around broadband technology. As with other forms of technology and other types of infrastructure, interactions with the economy are complex and difficult to fully reflect within the confines of a model.

Broadband's impact on the economy is contingent on a number of things, such as the development of new software, management's willingness to change the way a business operates, and consumers adopting new behaviours. These in turn are influenced by a variety of factors other than broadband speeds. This makes empirical research in this area challenging. Our analysis draws on the empirical evidence that we believe to be the most complete. The remainder of this section details how we incorporated empirical evidence into our modelling to arrive at our estimate of GDP impact.

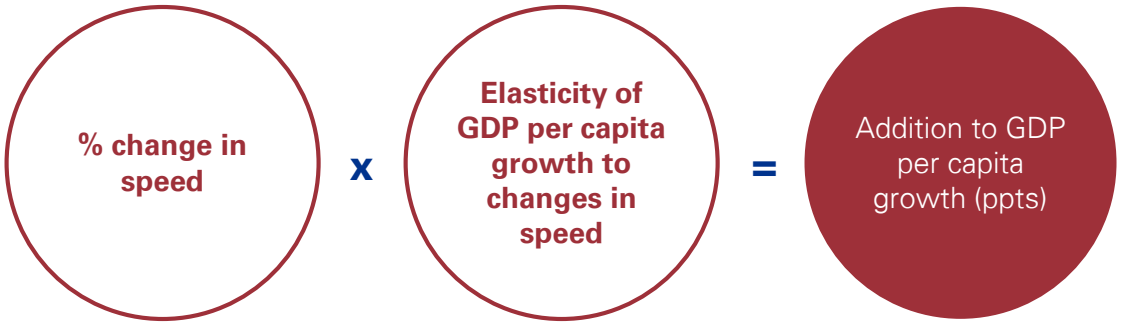
APPENDIX: SPILL-OVER EFFECTS TO INCREASE GDP BY £20-30 BILLION

Our estimate of £20-30 billion impact, reported in 'Delivering Britain's Digital Future: An Economic Impact Study', represents the discounted sum of the GDP impacts in each year between 2015 and 2025. To arrive at the impact in each year, we compare a projection of GDP out to 2025 for a baseline scenario in which investment in ultrafast does not take place and an investment scenario where it does. The defining feature of the investment scenario is that average speeds achieved by broadband users increase to a higher level as ultrafast technology becomes available.

Higher speeds lead to increases in GDP. The precise relationship used in the model is shown in Figure 1 below. Changes in speed are linked to GDP per capita growth using an elasticity. Changes to GDP per capita growth are then converted into changes in GDP in each year.

The elasticity measures the addition to GDP per capita growth, in percentages points (ppts), for a given percentage increase in speed. The calculation is done for each year in both the baseline and investment scenario.

Figure 1: Spill-over estimate methodology



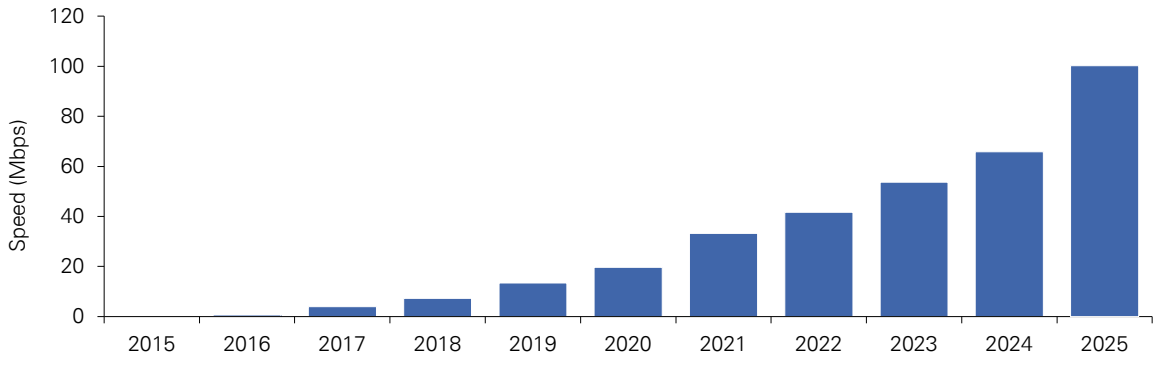
APPENDIX: SPILL-OVER EFFECTS TO INCREASE GDP BY £20-30 BILLION

Speeds

The speeds used in the modelling were UK average speeds, not just those corresponding to customers on the Openreach network. The average speed was the average achieved speed, as opposed to the maximum speed available. The maximum available speed is likely to be significantly higher than the achieved speed.

BT provided us with a set of assumptions to use for uptake and speeds of different technologies in the modelling. These assumptions were intended to represent a plausible but conservative scenario for uptake of broadband technologies with and without the investment, rather than being a projection. From the uptake assumptions a national average speed was calculated for the baseline and scenario. Increases in speeds are primarily driven by customers choosing to move to better technologies when they become available, (for example, from ADSL to Fibre or to G.fast). However, based on the experience of introducing new technologies in the past, we do not assume 100% of people with access take up the fastest broadband products available. Despite an expectation of much wider access, the investment scenario that we model sees just over 20% of broadband subscribers using ultrafast broadband by 2025 and 43% using superfast. That leads to an increase in the national average broadband speed in the investment scenario of 100 Mbps by 2025, compared to the no investment scenario. Were we to assume that 100% of people with access to ultrafast used it, average speeds and hence economic impact would be substantially higher.

Figure 2: Average achieved speed, difference between baseline and investment scenarios



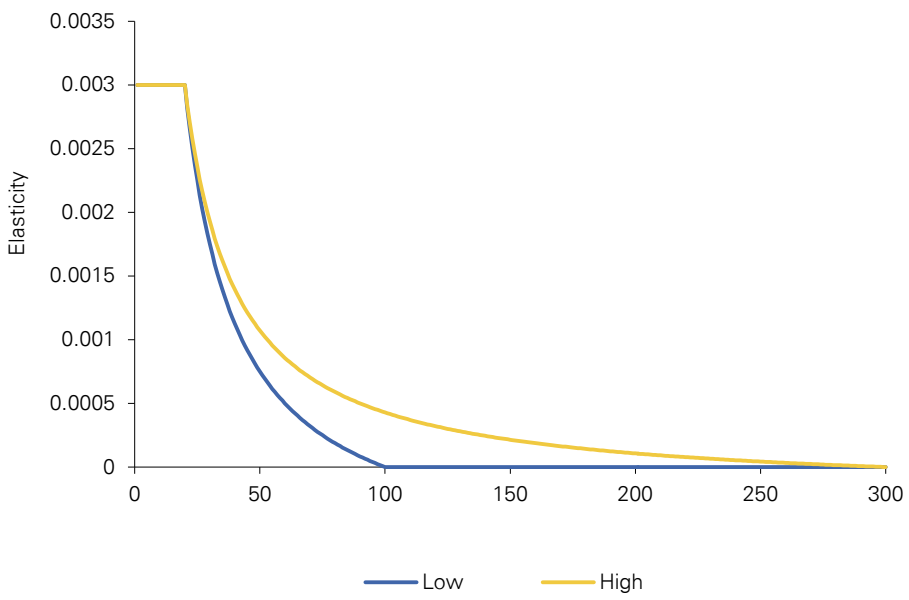
Source: KPMG calculations based on discussion with BT

APPENDIX: SPILL-OVER EFFECTS TO INCREASE GDP BY £20-30 BILLION

Elasticity

An elasticity estimate is used to link changes in achieved broadband speed with GDP per capita growth. Our model has an elasticity estimate of 0.003 when average speed is less than 20 Mbps, which gradually declines after 20 Mbps until it eventually reaches zero at either 100 Mbps or 300 Mbps, according to our two scenarios (see Figure 3 below). This means that at speeds below 20Mbps each time average broadband speed increases by 1%, 0.003 percentage points are added to GDP per capita growth. Once average speeds are higher than 20Mbps, the addition to growth for each 1% increase in speeds becomes smaller.

Figure 3: Elasticity and speed assumptions



Source: KPMG

The assumption of a 0.003 elasticity at speeds less than 20 Mbps is consistent with the findings of Rohman and Bohlin (2012), who studied the impact of difference in speed on GDP per capita growth in 25 OECD countries. The highest national average achieved speed in their study was 20Mbps, hence we deploy this elasticity assumption up to 20Mbps.

There were no studies available that measured directly how speeds beyond this level impact on GDP. We therefore sought to incorporate a prudent hypothesis of diminishing marginal benefits to ever higher speeds, given the current expected evolution of technology[a]. Once individuals and SMEs[b] reach the point at which they don't increase output or expenditure in response to higher speeds, then there will be no resulting impact on GDP.

(a) See Kenny and Broughton (2013) and Kenny and Kenny (2011) for discussions of cases of potential diminishing returns.

(b) Given that we are only looking at 'mass market' broadband we are not considering the needs of large businesses requiring their own Ethernet services, but SMEs who are likely to have bandwidth demands similar to households.

APPENDIX: SPILL-OVER EFFECTS TO INCREASE GDP BY £20-30 BILLION

The point at which the need for further bandwidth will be exhausted was estimated based on a number of factors. Work by Kenny and Broughton (2013) projected future demand for bandwidth up to 2023. They concluded, in their 'aggressive scenario', that the median household would require 38 Mbps in 2023 on the basis of a range of assumptions including a software download time of 5 minutes, a video download time of 10% of the actual length of the film and that households were willing to tolerate a slower service than this for 4 minutes per month.

The analysis by Kenny and Broughton, however, is restricted to the use of products and services that are available today, and does not consider the potential bandwidth demands of products and services that haven't yet been developed. These may include (but are not limited to) developments in areas such as:

- Telepresence – In future people may be able to more regularly meet 'face-to-face' in cyberspace with no travel necessary.
- Augmented reality – Developments in virtual reality technology could make gaming and social interaction via the internet a far more vivid experience, with users experiencing virtual worlds in 3D and perhaps through all senses.
- Smart houses and factories – Household appliances or firm machinery interact to optimise efficiency and convenience.
- Real-time personalized information – In future we may all wear technology that allows constant monitoring of ourselves, for health or social purposes, requiring continuous analysis of large amounts of data.

Some of these technologies are so far from market that it is difficult to put a number on bandwidth requirements of future undeveloped technologies. However Zhuang at al (2013) examined the requirements of some technologies currently in development under the Mozilla Ignite program. They found that most of the projects would require speeds of 38 Mbps to 74 Mbps, with some requiring 77 Mbps to 148 Mbps, suggesting that demand for broadband could well be much higher than Kenny and Broughton (2013) projected. Even the study by Zhuang et al. doesn't consider the generation of technologies that will come later, potentially demanding additional bandwidth.

APPENDIX: SPILL-OVER EFFECTS TO INCREASE GDP BY £20-30 BILLION

Table 1: Projected bandwidth for future technologies

Area	Project	Projected Bandwidth (Mbps)	Users
Manufacturing	Remote process control using reliable communication protocol	38 – 74	Manufacturers
	Cloud computing for collaborative advanced manufacturing	38 – 74	Manufacturers
	Consumer 3D Content Creation	77-148	Customers
Public safety	Real-time emergency response	10-18	Emergency responders
Education and Workforce Technologies	Engage 3D video conferencing	77-148	Students and workers
	Banyan – share collaborate and publish scientific research	38 – 74	Scientists and researchers
	Software lending library	38 – 74	Scientists, inner city residents, entrepreneurs, researchers
	CIZZLE (collaborative science learning environment)	77-148	Scientists and researchers
Healthcare Technologies	euMetrica – a remote monitoring and notification system	38 – 74	Doctors and patients
	Brief+Case health	38 – 74	School tele-health programs

Source: Zhuang et al (2013)

Given the uncertainties involved, we have opted for two scenarios with alternative an assumptions of 100 Mbps and 300 Mbps as the national average achieved speed at which there are no further impacts on GDP growth. It is important to note that this analysis does not imply that businesses and individuals will not want or enjoy having the extra speeds, rather they will no longer be changing their behaviour or their activities in a way that will impact GDP growth.

APPENDIX: SPILL-OVER EFFECTS TO INCREASE GDP BY £20-30 BILLION

Calculation of the overall spill-over impact

Projections of GDP per capita growth and GDP were generated for both the baseline and the investment scenario based on the speed changes in each year and the elasticity values at each speed. These are shown in Table 2 below:

Table 2: Speeds, GDP per capita, GDP growth rate, and impacts.

Year	Difference in GDP per Capita	Total Discounted GDP impact (£ billion)
2015	£0	£0
2016	£1 – £2	£0.1 billion – £0.1 billion
2017	£7 – £8	£0.4 billion – £0.5 billion
2018	£15 – £17	£0.9 billion – £1 billion
2019	£25 – £29	£1.4 billion – £1.7 billion
2020	£34 – £43	£1.9 billion – £2.4 billion
2021	£45 – £59	£2.5 billion – £3.3 billion
2022	£54 – £76	£2.9 billion – £4.1 billion
2023	£61 – £92	£3.2 billion – £4.8 billion
2024	£68 – £109	£3.4 billion – £5.5 billion
2025	£73 – £126	£3.6 billion – £6.2 billion
Cumulative (2015-2025)		£20 – £30 billion

Source: BT, KPMG

By 2025, the investment is projected to deliver over £3.6-6.2 billion of spill-over benefits per year to the UK economy, this is equivalent to 0.22-0.38% of GDP in 2025 and an addition to annual growth of 0.01-0.05 ppts by 2025.

The impact of speed increases on GDP rises over time, with the cumulative impact between 2015 and 2025 estimated at £20-30 billion, on a discounted basis.

APPENDIX: SPILL-OVER EFFECTS TO INCREASE GDP BY £20-30 BILLION

Comparisons of our impact estimates to other studies

Academic studies that have looked at average broadband speed suggest that for a 10% increase in speeds there is an increase of 0.1 – 0.8% in GDP per capita levels, according to Kongaut et al (2014), and a 0.4% increase in household income levels according to Rohman and Bohlin (2013). These compare with 0.22-0.38% increase in GDP per capita as a result of a much larger increase in speed by 2025 in our analysis in 2025.

Other studies of broadband impact on the UK economy arrive at a range of estimates. Our estimates of £20-30 billion from spill-over effects compare to the approx. £60 billion[a] of cumulative benefits to 2024 estimate of the BDUK scheme (SQW, 2013). An assessment[b] of BT's roll out of superfast broadband estimated a potential 0.3-0.5% increase in annual GVA for places benefitting from the scheme[c], compared to a 0.22-0.38% increase in national GDP in our estimates in 2025.

a) BT. 'Boosting Business and the UK Economy.' Superfast Broadband, 2012.
b) GVA is estimated as GDP + taxes on products – subsidies on products
c) http://www.consultancy.uk/news/1884/virgin-high-speed-internet-adds-77-billion-to-economy [Accessed 26-08-2015

APPENDIX: SPILL-OVER EFFECTS TO INCREASE GDP BY £20-30 BILLION

The nature of spill-overs covered in our analysis

Our estimates covered a range of spill-over effects that are expected from faster broadband. Whilst we have only quantified the overall estimate of spill-overs, this section discusses some of the evidence of individual effects.

Business productivity

Access to faster broadband will enable businesses to execute production processes, make sales and analyse information more quickly. It also enables firms to embed more sophisticated software into their operations and allows them to restructure and streamline their operations to save time and costs.

There is evidence that business productivity can increase significantly for firms using broadband. Canzian et al (2014) found that six months extra exposure to ADSL 2+ led to a 25.7% increase in revenue over two years for businesses in rural Italy, whilst Grimes et al (2011) reported that the move to broadband from other slower connections raised firm productivity by 7-10% for a group of firms in New Zealand.

Similarly, there is evidence that the use of internet based services and products enhances productivity. Fornefeld et al (2008) report an average increase in overall productivity of 0.29% through firms adopting internet or 'e' processes in the EU. Colombo et al (2012) also report that greater use of software that requires internet made firms more productive. Atrostic and Nguyen (2002) estimate an increase in productivity of 5% for manufacturing firms that make use of e-processes.

Not all studies that looked at business productivity found a significant impact of broadband use or higher broadband speeds (see, for example, Haller and Lyons (2012), and De Stefano et al (2014)). Such findings are likely to be related to the fact that the realisation of gains from broadband speeds will depend on a variety of other factors, such as competitive pressures, existing skill levels, and business culture. They may also take varying lengths of time to play-out in full, depending on the location and circumstances of the firms in question.

Notwithstanding difficulties in measuring impacts, the importance of broadband speed for firm productivity is recognised by those who run businesses, with 83% of the members of the Institute of Directors saying that significantly faster fixed-line and mobile internet services would improve the productivity of their business (Institute of Directors, 2013), whilst 79% of businesses reported time and cost savings from moving to Superfast broadband in Cornwall (SERIO, 2013).

New business catalyst

A better business environment, thanks to improved telecom access, infrastructure and services, is expected to encourage the emergence of new businesses in the UK, particularly in sectors which are heavily reliant on telecom infrastructure.

Increased broadband speeds will allow firms to offer a quicker service to customers, as well as new products and services. This will mean increased revenues for firms and new firms being created, many of which wouldn't have been viable without access to higher broadband speeds.

APPENDIX: SPILL-OVER EFFECTS TO INCREASE GDP BY £20-30 BILLION

The nature of spill-overs covered in our analysis (cont.)

New business catalyst (cont.)

Evidence from Gillet et al (2006) found an increase of 0.5-1.2% in the growth of businesses in areas where broadband had been rolled out, compared with similar areas without broadband access in the US. Similarly, the Superfast Cornwall evaluation reported new businesses being set up as a result of access to Superfast broadband.

Some firms will lose out as a result of new services replacing old technologies, with more competition where market entry has been restricted (for example Uber versus traditional Taxi drivers).

Attracting Foreign Direct Investment

Transforming UK business infrastructure to make it more competitive vis a vis other world business centres is expected to attract more Foreign Direct Investment (FDI) to the UK, with firms in high growth areas, such as technology, citing broadband infrastructure as one of the key factors affecting their location decisions.

Figure 4 on the next page outlines average download speeds in 2013 and FDI stock as a share of GDP for a range of countries, showing a potential positive relationship. However, given the multitude of factors that affect FDI, it wouldn't be valid to directly confirm that there is a causal link between broadband speed and FDI.

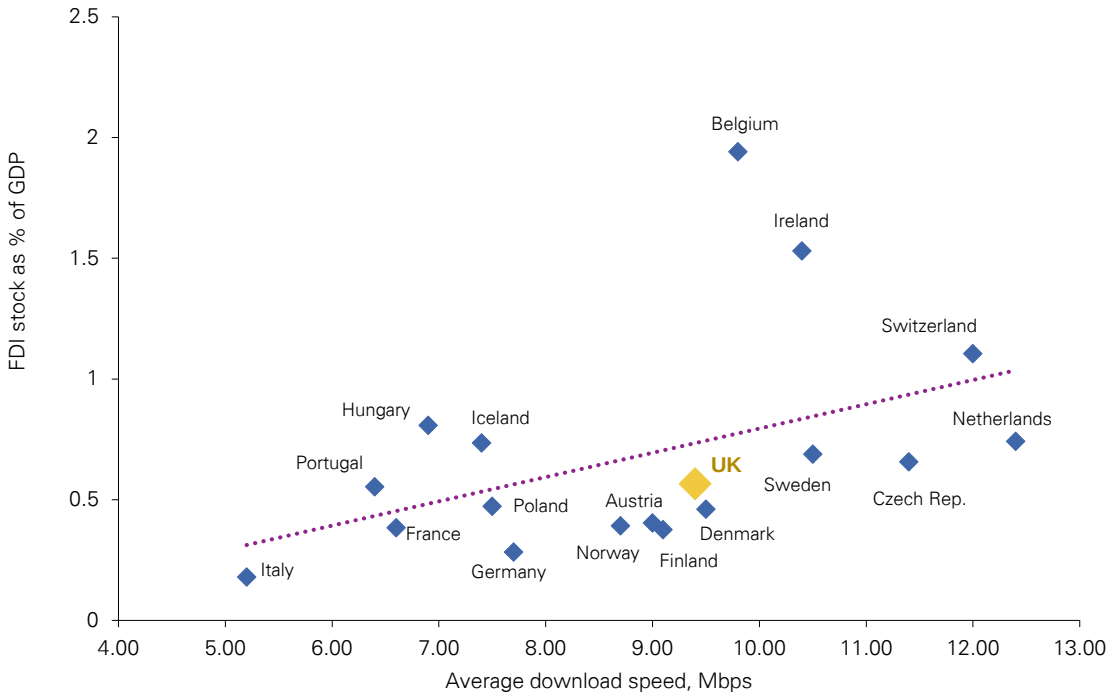
A number of studies have found a positive impact of broadband on FDI. For example, M. Falk (2012) reports a significant statistical relationship between R&D FDI and broadband penetration, although he does not address the impacts of speed.

Qualitative studies have recorded the importance that businesses place on IT infrastructure and broadband. The EY UK Attractiveness survey reports that telecommunications and technology infrastructure are among the most common key criteria for foreign investors selecting a regional location within the UK, ranking above availability of government grants and local quality of life (EY, 2015). In the 2013 Cisco Global IT Impact Survey 82% of respondents said the "*user experience with standard business applications, as well as Web, files services and email, is impacted by network performance*" (Cisco, 2013). Access to a high quality broadband network will also be key to addressing the future strategic priorities of global CEOs: The PwC global CEO survey 2015 revealed that 65% of CEOs believed that the internet of things was somewhat strategically important or very strategically important to their business, while 60% believed that cloud computing was important (PWC, 2015).

APPENDIX: SPILL-OVER EFFECTS TO INCREASE GDP BY £20-30 BILLION

The nature of spill-overs covered in our analysis (cont.)

Figure 4: FDI as share of GDP and average download speed (2012-2013)



Source: IMF, Eurostat, Akamai State of the Internet Report (2013) and KPMG

Labour market impacts

Enhancing worker productivity through the adoption of broadband technologies could lead to higher wages and employment, with the UK's relatively flexible labour market well placed to pass through any productivity gains into higher employment.

Forzati and Mattsson (2012) report that an increase in the ratio of the population that lives within 353 metres of a fibre-connected premise contributes positively to employment. The Superfast Cornwall evaluation also estimates a net increase in jobs as a result of increased access to Broadband.

However, technologies can be disruptive and lead to a reorganisation of the labour market, with some inevitably losing out. As the findings of Akerman et al (2013) suggest, broadband often has a positive impact on high skilled labour, but can be used as a substitute for lower skilled labour. They find access to broadband increases the wages of highly skilled workers, but reduces that of lower skilled workers.

APPENDIX: SPILL-OVER EFFECTS TO INCREASE GDP BY £20-30 BILLION

The nature of spill-overs covered in our analysis (cont.)

Remote working

Access to faster broadband will enhance the ability of people to work effectively from home, saving employees and businesses time and money. It will also enable more people, who have caring obligations or cannot travel away from the home to work for other reasons, the opportunity to participate in the labour market.

Effective working from home will be facilitated by access to faster broadband networks. While current speeds may be sufficient for basic collaboration via email and voice – faster download and upload speeds will improve the quality of these connections and allow the sharing of far larger files and documents than is currently possible.

The benefits of teleworking can come from:

a) Saving commuting time for employees

b) Increasing working time for current employees

c) Allowing more people who are currently excluded from work to join the labour market

d) Reducing the infrastructure burden from commuting

For current employees choosing to telework, the time savings from reduced commuting could be devoted to both more work and leisure. The average length of time a journey to work takes in the UK is 28 minutes (DfT, 2011). Reclaiming this time for teleworkers would raise welfare, and if they choose to devote this time to work would raise the productivity of UK workers.

Faster broadband speeds will enable those who cannot leave their home to participate in the labour market through teleworking. The benefits of social inclusion are difficult to value in monetary terms, but together with commuting time savings the benefits to UK GDP could reach £1.8 billion by 2024 according to some estimates (see SQW, 2013).

We also expect that a greater share of teleworking employees would reduce both the required capacity and the cost of transport infrastructure. Again, we cannot value this component precisely in monetary terms, but the gains to society could be important.

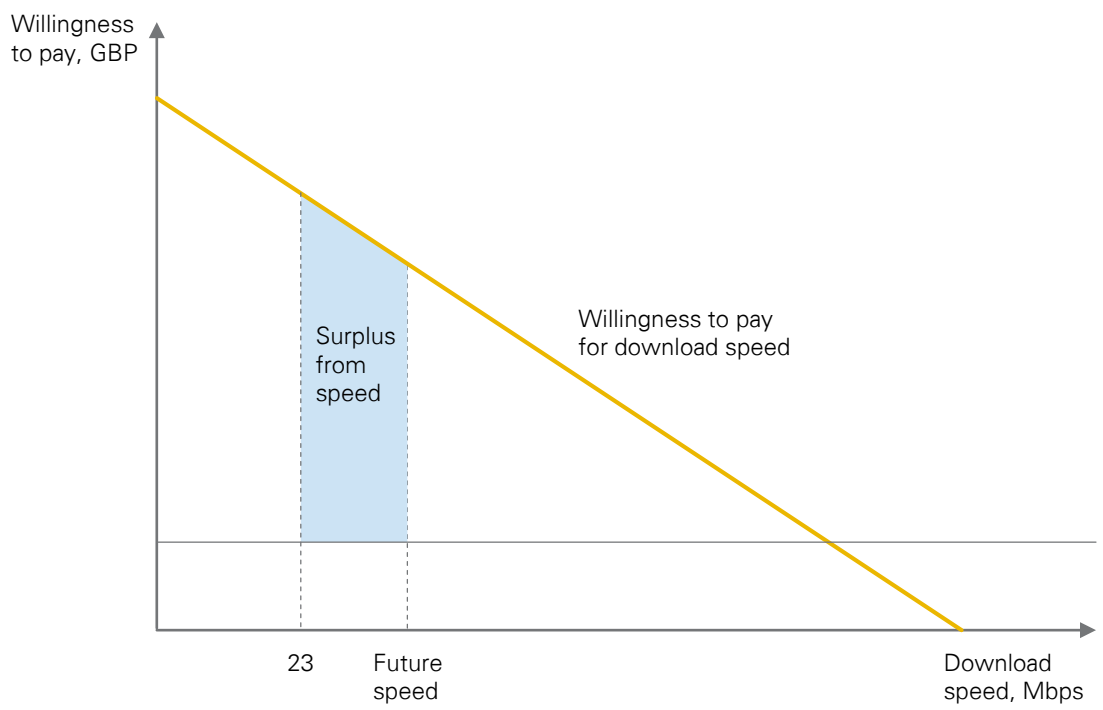
APPENDIX: £5-15 BILLION OF CONSUMER SURPLUS

In addition to the £20-30 billion of GDP resulting from increasing broadband speeds, there will be a benefit to consumers beyond what is captured by this number, since consumers are expected to receive a benefit above what they might pay for an enhanced service. This is identified as consumer surplus.

Consumer surplus is defined as follows: for any consumer purchasing a good, there is a price at which he/she would be indifferent between buying the good and keeping the money for other purchases. This price is termed the willingness to pay, and if that consumer pays less than this, the difference is the value that is created for the consumer, called consumer surplus.

The diagram below illustrates the consumer surplus. It depicts a situation of increasing the current average download speeds of 23 Mbps to the level marked 'Future speed'. The downward sloping line is the willingness to pay for increases in download speeds. This line traces the maximum people would be willing to pay for an additional megabit of speed. The horizontal line labelled 'Price of speed improvements' shows the price paid by the consumer for obtaining an extra megabit. The shaded area is the value of the consumer surplus –the difference between what a consumer would be willing to pay and what he or she actually pays for the improvements in speed.

Figure 5: Willingness to pay and consumer surplus



APPENDIX: £5-15 BILLION OF CONSUMER SURPLUS

We estimated the willingness to pay (the purple line) using the results of a survey for broadband packages. The survey was carried out for the Australian government in 2014 (Department of Communications, 2014). In this survey, respondents were asked to choose from a set of hypothetical broadband plans, and their choices were used as inputs into a model which allowed a value to be placed on the connection speed of broadband plans. The study found that as speed increased, people were less willing to pay for further improvements. We used the parameters estimated by the study to estimate willingness to pay for extra speed, which we applied to estimate consumer surplus from the increased speeds achieved as a result of the ultrafast investment.

The parameters estimated by the authors of the study imply that marginal willingness to pay falls to 0 between 73 and 111Mbps, depending on the group of respondents to the survey. In reality, consumers are likely to go on obtaining a surplus from speeds higher than 73-111 Mbps in future. Current estimates of willingness to pay do not capture possible new ways of using the internet that may require higher speeds, which may emerge in the decade to 2025. We have therefore included two scenarios in our analysis, one where consumer surplus extends to 73-111 Mbps and one where these limits triple.

In our model, we assumed that the willingness to pay line differs for different groups of broadband users. Faster broadband packages, such as ultrafast will generally be taken up by those who place a higher value on broadband speed. To allow for this, we adjusted our estimates of willingness to pay upwards for this group of customers. Likewise, we reduced the willingness to pay for those on lower speeds packages, in order to maintain the average willingness to pay in line with the parameters in the study.

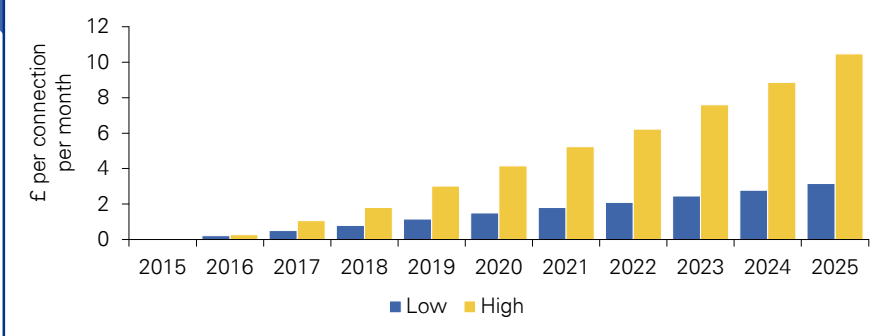
We also adjusted the findings of the Australian study to the UK context by rescaling the costs and benefits of broadband by the difference in average income between Australia and the UK.

Our estimates should be read as the additional consumer surplus gained from higher broadband speeds. We do not claim to quantify the total surplus today, but rather the incremental addition to that surplus from higher speeds in the future.

Figure 6 shows the consumer surplus of higher speeds for each year between 2015 and 2025 in terms of average monthly benefit in the two scenarios.

Our analysis shows that the cumulative consumer surplus between 2015 and 2025 could reach £5-15 billion, depending on the scenario selected. Our estimates of consumer surplus over the next decade assume that consumer preferences remain unchanged from 2015.

Figure 6: Additional discounted marginal benefit from speed in the investment scenarios



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