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FINAL REPORT FOR DSSB

DIGITAL SCOTLAND SUPERFAST BROADBAND CONTRACT ONE BENEFITS REALISATION STUDY

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Contents

1 Executive summary

This study, undertaken by Analysys Mason and commissioned by the Digital Scotland Superfast Broadband programme (DSSB), provides an independent evaluation of the socio-economic benefits that are likely to be realised from fibre broadband deployment under the **DSSB Contract One** programme.[1]

1.1 Key findings

We conclude from our evaluation that the Scottish Government, HIE and the local authorities were justified in intervening to facilitate the deployment of fibre broadband to unserved areas. The programme has been a success, helping to cement Scotland's digital future, and the infrastructure that has been built will provide high-quality connectivity in Scotland for the foreseeable future. The key benefits are outlined below.

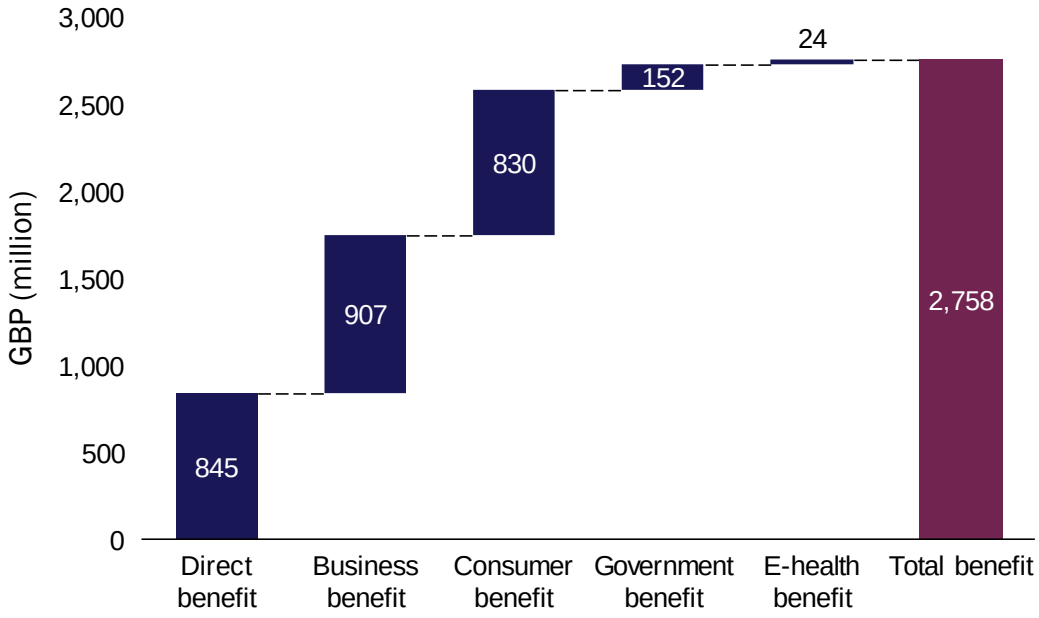
Public funding has been used very effectively: every GBP1 of public funding is estimated to deliver ~GBP12 of benefits to the Scottish economy

The **total benefit** associated with the DSSB programme estimated by this study is **GBP2.76 billion** (over 15 years), which represents a strong positive return on public funds used for the deployment (GBP259 million reported in Audit Scotland 2018). **The benefit-to-subsidy ratio is 11.60**.[2] This means that for every GBP1 of public funding, GBP11.60 of economic benefit will be produced, shared among businesses and consumers. A breakdown of the estimated economic benefits of the DSSB programme (over a 15-year period) is provided in Figure 1.1.

1 This study was finalised in April 2019, and its scope is only DSSB Contract One, covering premises passed up to March 2018.

2 This has been calculated using the total public-sector subsidy and the total calculated benefits from our evaluation (both discounted over the 15-year period).

Figure 1.1: Total estimated economic benefits of DSSB programme [Source: Analysys Mason, 2019]



The DSSB programme has brought several qualitative benefits that are of considerable importance to the economy and society of Scotland

Our research and analysis have also found several qualitative benefits, which although not capable of robust valuation at this time are still likely to confer significant benefit. Some key examples of qualitative benefits are:

- **Smart-home benefits** related to a reduction in heating bills, improved security and broader lifestyle benefits
- The benefits of **social inclusion and social cohesion** through the provision of NGA broadband
- The prospect of broadband use delivering **education and environment benefits**.

The DSSB programme has laid out a platform to realise the full potential of e-health and e-government benefits in the future

E-health benefits have yet to be fully realised due to the need for organisational and institutional changes, but the DSSB programme has provided a platform to unlock the potentially significant economic benefit in future.

Similarly, e-government savings for public-sector bodies have yet to be fully realised, as the scale of the benefit is largely dependent on the local e-government strategy.

The full e-health and e-government benefits are not recognised in our economic model, but the DSSB programme has created an enabler for such benefits to be fully realised in the future. If these benefits are realised (due to organisational changes and harnessing the power of digital services in the future), the total benefit could be much higher than the GBP2.76 billion quantified in this study.

The average broadband download speed in rural Scotland tripled between 2014 and 2017, and broadband usage per user in Scotland is higher than the UK average

The broadband connectivity landscape in rural Scotland improved significantly between 2014 and 2017 (with **average download speed tripling**, as shown in Figure 1.2),[3] much of which is directly linked to the DSSB programme. Without the DSSB programme, ~900,000 premises in unserved (typically rural) areas would not have had access to fibre broadband by March 2018, and Scotland would have continued to lag behind the rest of the UK average in terms of download speed.

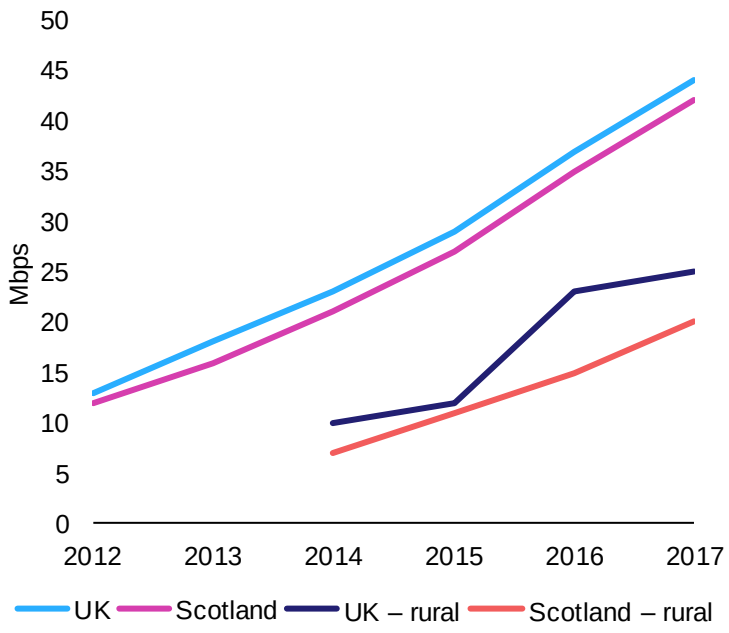


Figure 1.2: Average broadband download speed [Source: Ofcom, 2012–17]

Average **data usage** on fixed broadband **in Scotland was higher than the UK average in 2017**[4] (195GB/month in Scotland compared to 190GB/month across the UK), indicating that users (both consumers and businesses) clearly value their fixed broadband connections; again, the DSSB programme has played an important role in this.

3 According to Ofcom (2017), *Connected Nations 2017*, reporting average broadband speed for each nation.

4 *Ibid*.

DSSB Contract One has led to a network infrastructure that sets the foundation for other digital developments in Scotland

The DSSB programme has facilitated other benefits through the deployment of telecoms infrastructure where previously little was available, and through the creation of jobs associated with the network deployment. As part of the deployment, Openreach has installed approximately **11,000km of new fibre and copper cable,** including approximately **400km of new subsea cable** (e.g. connecting the Outer Hebrides to the mainland, and the Western Isles). The **improved BT backhaul network** across Scotland **provides the foundation for other digital developments**, such as full fibre networks or other connectivity.

Cost efficiencies, additional BT investment and higher broadband take-up rates from the DSSB programme have resulted in extended coverage

The DSSB programme has successfully delivered a fibre broadband network that is more ambitious than planned due to **cost efficiencies, additional BT funding of GBP20 million and income generated from greater-than-expected take-up** being invested to extend coverage. The high level of take-up is strongly linked to the demand stimulation programme run by the Scottish Government, which has been a considerable success.

1.2 Summary of conclusions

To summarise, the key reasons why the DSSB programme has been a success are as follows:

- Public funding has been used very effectively: every GBP1 of public funding is estimated to deliver ~GBP12 of benefits to the Scottish economy
- The DSSB programme has brought several qualitative benefits (e.g. social inclusion) that are of considerable importance to the economy and society of Scotland
- The DSSB programme has laid out a platform to realise the full potential of e-health and e-government benefits, which could be significant in future
- The tripling of average broadband download speed in rural Scotland between 2014 and 2017 is linked to the DSSB programme; and the fact that broadband usage per user in Scotland is higher than the UK average shows the value of broadband in Scotland
- DSSB Contract One has led to a network infrastructure that sets the foundation for other digital developments in Scotland
- Cost efficiencies, additional BT investment and higher broadband take-up rate from the DSSB programme have resulted in extended fibre broadband coverage extension (i.e. more premises have been passed than originally planned).

2 Context and objectives

2.1 Background to the DSSB programme

The commercial deployment of next-generation access (NGA) or fibre broadband networks from 2009/10 brought a step change in the broadband speeds available to users and thus the benefits that could be derived from using broadband. However, as deployment accelerated it became clear that the private sector did not find it commercially viable to deploy fibre networks in many rural and hard-to-reach areas. Amid concern that the 'digital divide' between urban and rural areas would increase, several policy initiatives were set up to 'intervene' in broadband deployment.

Policy commitments to increase broadband speeds in rural areas began at the turn of the last decade. In particular, the European Commission (EC) published its 'Digital Agenda for Europe' in May 2010, with a central aim of enabling all European citizens to have access to broadband speeds of 30Mbps by 2020. The UK Government also published its Digital Britain strategy, outlining the steps required to increase fibre broadband coverage, and this led to the 'Rural Superfast Broadband' programme, run by the Department for Digital, Culture, Media and Sport (DCMS) with the aim of facilitating fibre deployment across unserved areas. The programme, funded by GBP530 million of public money, had an initial target of covering 90% of UK premises with superfast broadband (greater than 24Mbps) by early 2016. This was later extended to cover 95% of UK premises by the end of 2017, with an additional GBP250 million of public funds.[5]

The Scottish Government had responsibility for designing and implementing fibre broadband roll-out in Scotland, which led to the Digital Scotland Superfast Broadband (DSSB) programme beginning in 2013. The programme was split into two projects – one focusing on the Highlands and Islands and the other covering the 'Rest of Scotland' (RoS). The technologies used within the programme have mainly focused on fibre to the cabinet (FTTC) and, to a lesser degree fibre to the premises (FTTP), as these technologies can be deployed at scale. However, for extremely remote premises other technologies have been deployed, such as wireless to the cabinet (WTTC), and alternative technologies (including satellite) used under the Better Broadband Scheme.[6]

5 Figures as reported in Ipsos Mori's economic evaluation report for DCMS/BDUK, *Evaluation of the economic impact and public value of the Superfast Broadband Programme*, August 2018.

6 Qualifying premises can apply for a grant of up to GBP350 towards the installation of broadband with speeds of over 2Mbps; see https://www.gov.uk/business-finance-support/better-broadband-subsidy-scheme-uk and https://www.scotlandsuperfast.com/media/1692/dssb_info_sheet_better_broadband_v4_aw.pdf

The DSSB programme has been funded from a number of sources, including the Scottish Government, the UK Government, the European Regional Development Fund (ERDF), local authorities and BT Group. The breakdown of funding from the various project partners is shown in Figure 2.1.

Figure 2.1: Breakdown of funding from partners in the DSSB programme [Source: Audit Scotland 2018]

Project	Partner	Funding value (GBP million)
Rest of Scotland (original)	Scottish Government	21.5
	UK Government	50.0
	European Union[7]	20.5
	Collective council contributions	17.1
	Individual council contributions	50.7
	BT Group	106.7
Highlands and Islands (original)	Scottish Government	41.3
	UK Government	50.8
	Collective council contributions	22.9
	Highlands and Islands Enterprise	11.4
	BT Group	19.4
Further contributions	BT Group	20.0
	Highlands and Islands Enterprise[8]	2.8
	Scottish Government (RoS)[9] (re-investment through Gainshare[10])	15.6
Total	**Including the GBP8.5 million reduction in European Union funding**	**442.2**

The public funding contributions shown above were budgeted figures,[11] and Audit Scotland 2018 reports that only GBP259 million of public funding has been provided to BT Group for DSSB Contract One. This means that the actual project delivery by Openreach has been more cost efficient than originally planned, which is a positive outcome for the Scottish Government. Total private-sector funding (i.e. from BT

7 This funding was subsequently reduced by GBP8.5 million due to changes in the project's eligibility.

8 Generated through higher-than-expected take-up, which triggered repayments from BT Group to HIE. This was reinvested in the programme to increase coverage, through the Gainshare mechanism.

9 Generated through higher than expected take-up, which triggered repayments from BT Group to the Scottish Government. This was reinvested in the programme to increase coverage, through the Gainshare mechanism.

10 Higher-than-expected profit could typically lead to an income share between BT Group and the Scottish Government towards the end of the contract period (e.g. seven years), but BT Group agreed to conduct a review before the end of the contract. This resulted in the release of Gainshare funds to extend fibre broadband coverage in Scotland.

11 Total public funding figure is ~GBP286 million from Figure 2.1.

Group) is expected to reach GBP146 million by the end of the DSSB programme, including GBP126 million which was initially assigned (DSSB Contract One) and GBP20 million which was invested as a result of contract extensions. European Union funding, through the ERDF, was supplied to help improve broadband access for small and medium-sized enterprises (SMEs) in the DSSB programme area.

As the primary delivery partner of the DSSB programme, Openreach had responsibility for designing a network that was appropriate for the challenging geographies. During the programme Openreach has deployed 4,500 new fibre street cabinets and approximately 11,000km of fibre-optic and copper cable, including new subsea cable for 20 crossings to the Scottish Isles (as illustrated in Figure 2.2).

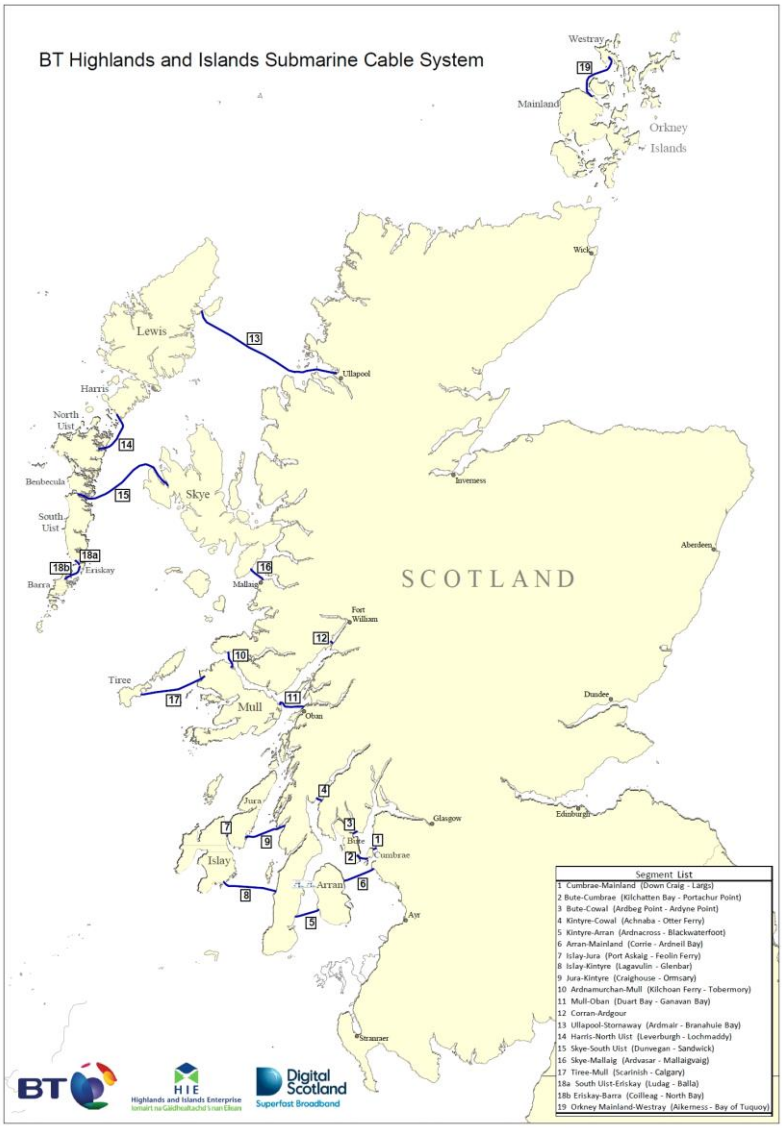
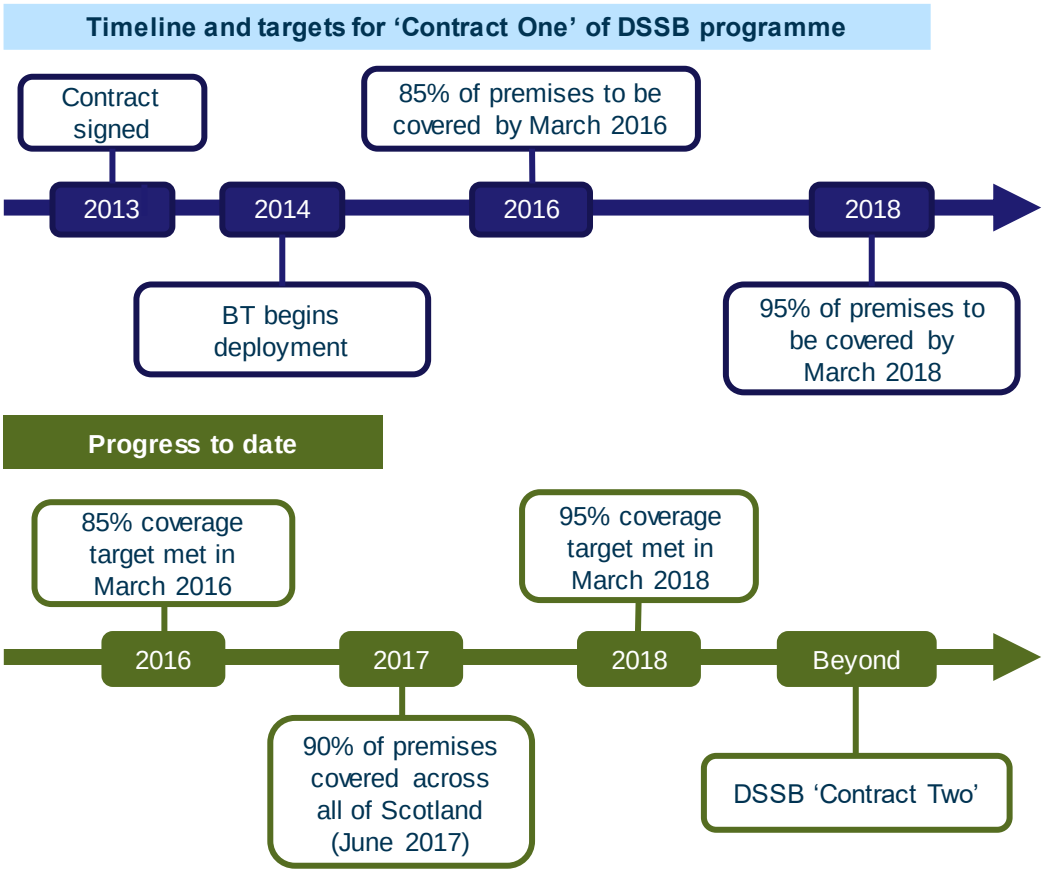


Figure 2.2: Openreach Highlands and Islands subsea cable system installed as part of the DSSB programme [Source: BT Group/ Openreach, HIE, 2018]

In 2012, the Scottish Government set out a policy ambition to deliver world-class digital access to all of Scotland by 2020, with the DSSB programme a major component of this policy. The Government set coverage targets for the DSSB

programme, with a generic interim milestone of producing a significant uplift in speeds for everyone in Scotland by 2015. The detailed coverage targets and progress for DSSB Contract One are explored in Figure 2.3.

Figure 2.3: Timeline and progress of DSSB Contract One [Source: Analysys Mason, Scottish Government, 2018]



In addition to covering 95% of premises in Scotland, the DSSB programme also met its target of providing 75%[12] coverage of fibre broadband to each local authority area. The DSSB programme has continued to deploy fibre broadband following the end of DSSB Contract One in March 2018. This has been possible due to savings made during the deployment and higher-than-expected take-up of services, which led to DSSB and its partners agreeing to extend fibre coverage. Additional funds were made available through the Gainshare mechanism and BT Group investing an additional GBP20 million of its own money, which was allocated to cover further premises.

12 Except for Eilean Siar, for which the target was 70% coverage.

2.2 Evaluation objectives

Before any publicly funded broadband infrastructure project gets underway, detailed cost–benefit analysis is undertaken to assess the likely socio-economic benefits of the project. It is then common practice to assess these benefits again at different stages of the programme. The aim of this study is to make an independent assessment of the socio-economic benefits that are likely to be realised from the DSSB programme. The study was commissioned by Digital Scotland (DSSB).

It is important to note that this study relates to **DSSB Contract One**, which includes premises covered up to March 2018, but not those premises covered through subsequent contract extensions or through commercial deployment during this period. The benefits modelling encompasses the 15-year programme period that started in 2014, and so it includes partly realised benefits as well as future benefits.

The rest of this evaluation report focuses on how broadband has developed in Scotland, discusses the types of benefit linked to fibre broadband, and estimates the value of economic benefits associated with the DSSB programme.

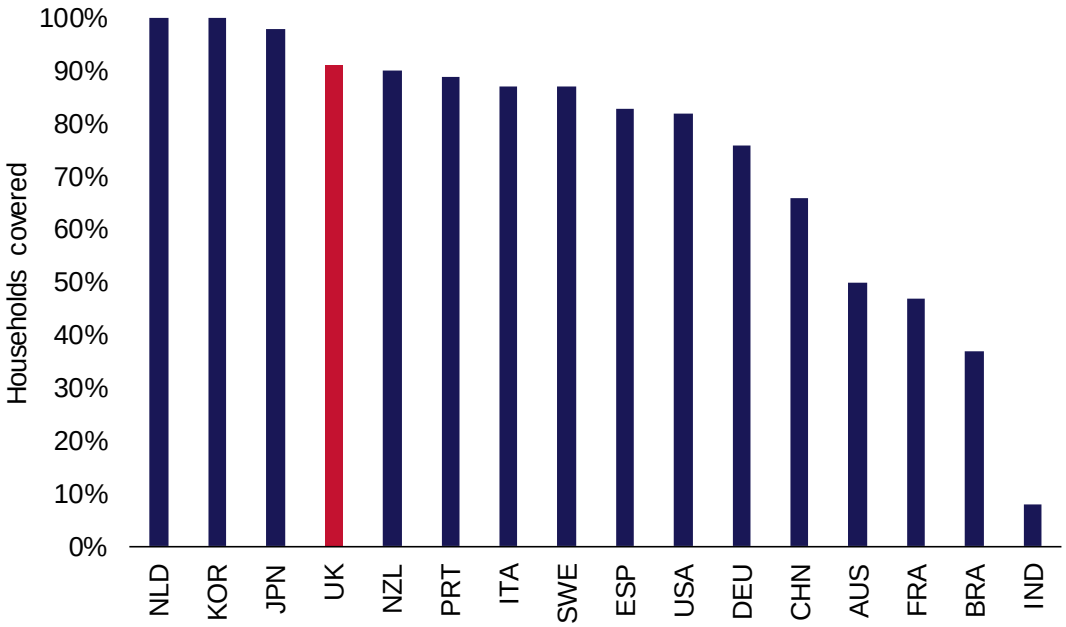
3 Developments in broadband provision in Scotland

3.1 Broadband connectivity in the UK

3.1.1 Comparison with other developed countries

The UK has made considerable progress on fibre broadband provision in recent years, due to a mixture of commercial and publicly funded deployments, and now compares favourably to other developed nations (as shown in Figure 3.1).

Figure 3.1: Proportion of households covered by fibre broadband (i.e. NGA broadband, including FTTC and FTTP) [Source: Ofcom – International Broadband Scorecard, 2018]



According to Ofcom's latest International Broadband Scorecard (2018),[13] fibre broadband was available in 91% of UK households at the end of 2017. This represents a vast improvement since 2012, when reported coverage in the UK was below 60%.[14] This increase in fibre broadband availability was largely due to Broadband Delivery UK's Superfast Broadband programme (including the DSSB programme). The relatively high coverage of fibre broadband also means that the UK has higher fixed data consumption than other European countries, as shown in Figure 3.2. This level of usage indicates that consumers are fully engaged with

13 Published in December 2018, based on 2017 data; see https://www.ofcom.org.uk/__data/assets/pdf_file/0018/130842/International-Broadband-Scorecard-2018.pdf

14 See https://www.ofcom.org.uk/__data/assets/pdf_file/0025/45088/scorecard.pdf (Figure 28).

using their broadband connections and implies that households attach a high level of importance to broadband access.

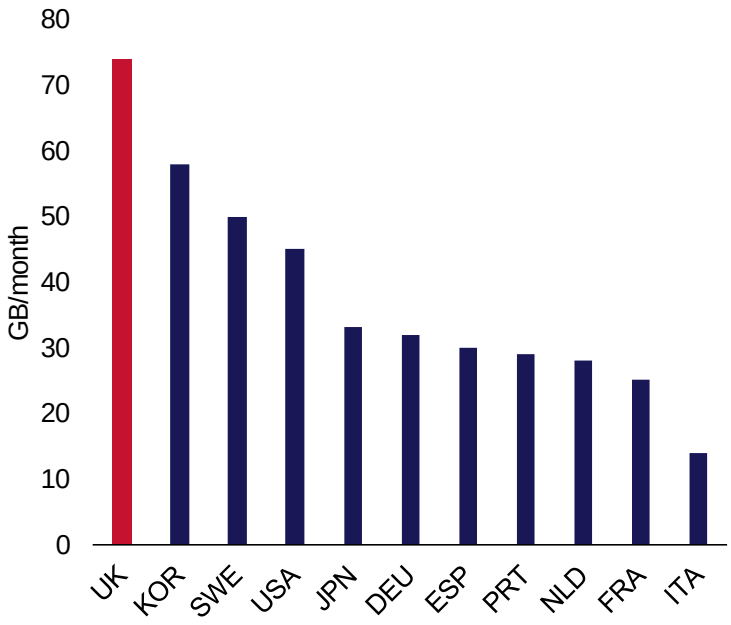


Figure 3.2: Per-capita monthly fixed data volumes [Source: Ofcom – International Broadband Scorecard, 2018]

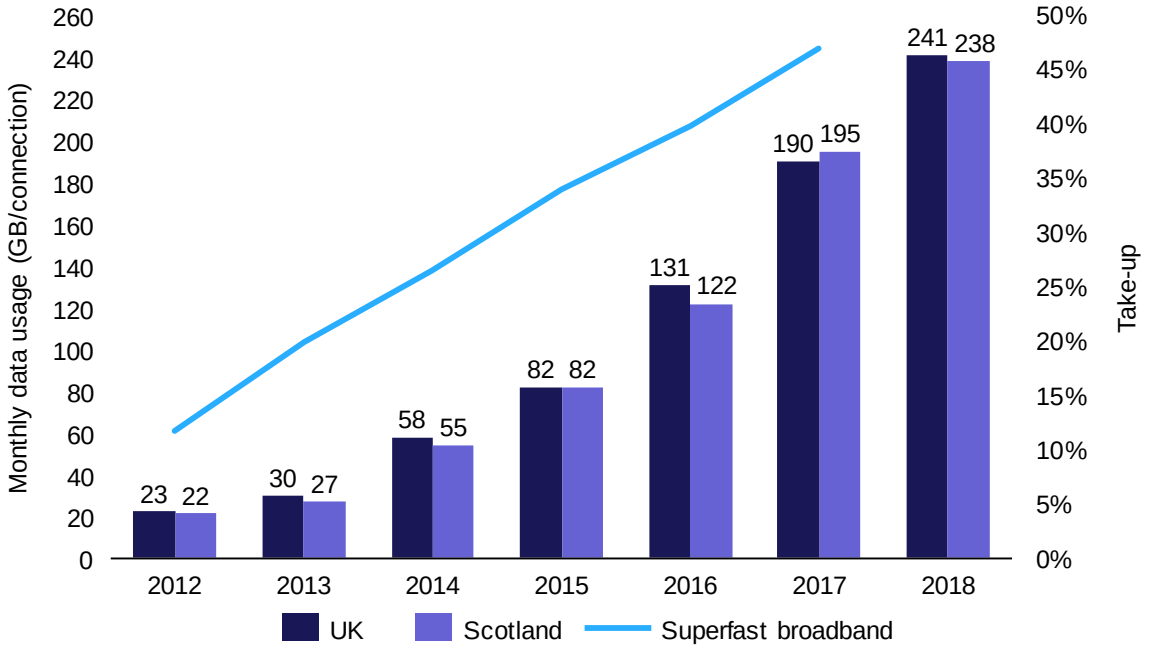
3.1.2 Fibre broadband take-up and usage in the UK

The recently published evaluation report for Broadband Delivery UK's (BDUK's) Superfast Broadband programme[15] states that approximately 3.5 million UK premises have now received access to fibre broadband that may not have done without intervention, which shows the importance of the programme. The report also states that, as of March 2017, take-up across the UK was 38% for 'BDUK Phase One' projects (before 2015) and around 20% for those included in 'BDUK Phase Two' (approximately after 2015). The take-up figures indicate that users value a superfast connection and provide clear evidence that the programme succeeded in its general aims.

As fibre broadband has become available to more premises across the UK, the take-up of these services has also increased. Moreover, consumers and businesses attach ever-increasing value to the availability of high-speed connectivity, as shown by an increase in data usage across both the UK and Scotland (see Figure 3.3).

15 Ipsos Mori (2018), *Evaluation of the economic impact and public value of the Superfast Broadband Programme*, Final Report.

Figure 3.3: Average monthly data usage per fixed connection in the UK and Scotland [Source: Ofcom Connected Nations reports, 2012–2018, Ofcom Communications Market Reports 2013–2018[16]]



Average monthly data usage in Scotland in 2018 was approximately in line with the UK average, which illustrates the importance that Scottish users place on their fixed broadband service.

3.2 Broadband connectivity in Scotland

The broadband landscape in Scotland has changed significantly since the DSSB programme began in 2013/14, with coverage, download speeds and data usage all increasing in line with, or more quickly than, the UK average.

The broadband connectivity landscape in Scotland improved significantly between 2014 and 2017. The average broadband download speed tripled in rural areas and doubled across the whole of Scotland between 2014 and 2017 (see Figure 3.4), much of which is directly linked to the DSSB programme. This increase in download speeds has allowed Scottish users to download more data per month (on average) than the rest of the UK (see Figure 3.3), which correlates with data from Ofcom that faster downloads lead to users downloading more data (although this relationship is not strictly linear).[17]

16 UK take-up data has been taken from Ofcom's *Communications Market Reports*, which are published each summer. Data on superfast broadband connections at the end of 2018 was not yet available as of 5 April 2019.

17 Ofcom (2017), *Connected Nations 2017* (Figure 20).

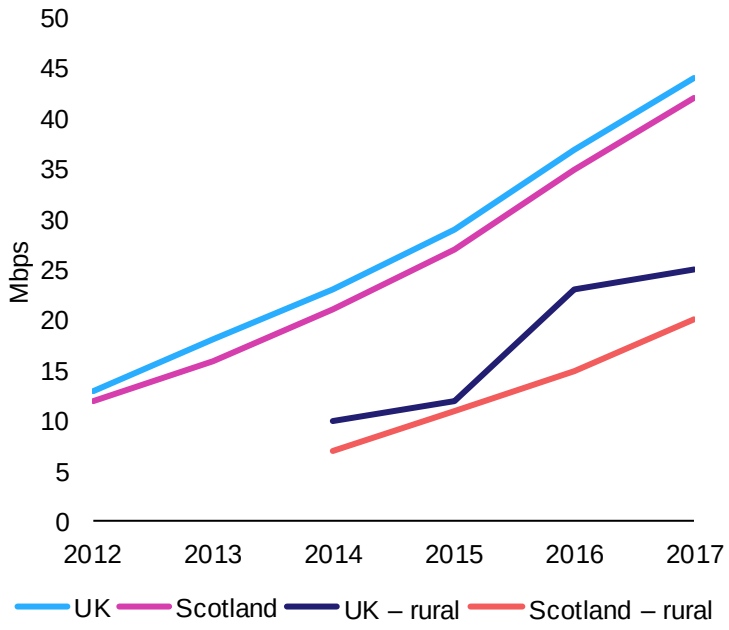
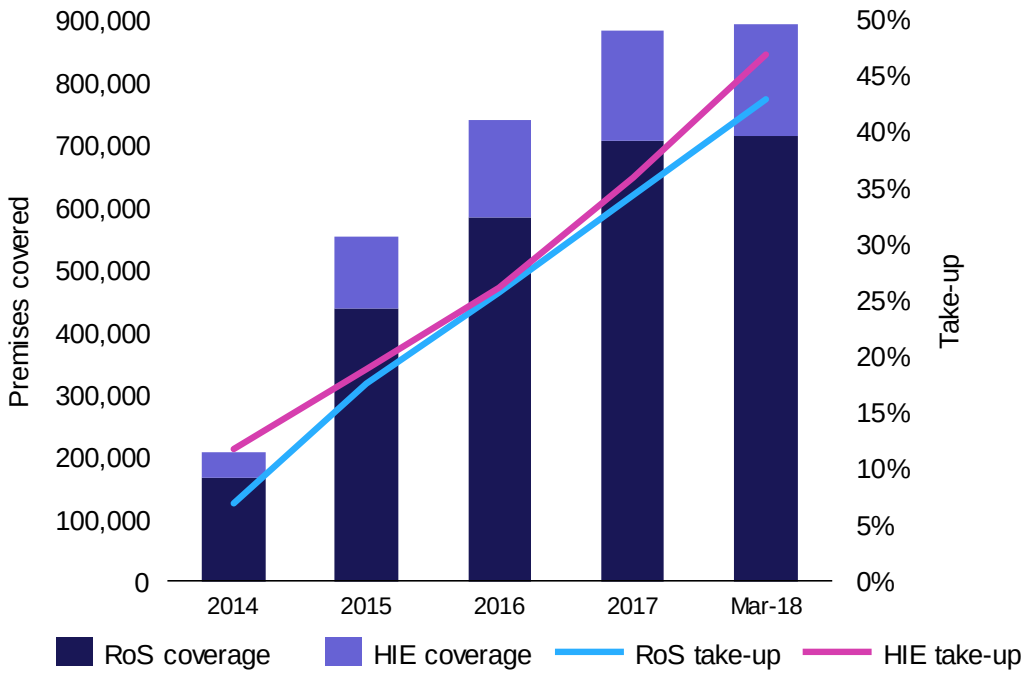


Figure 3.4: Average broadband download speed [Source: Ofcom, 2012–17][18]

The DSSB programme has played a major role in increasing coverage across Scotland, covering ~900,000 premises with fibre broadband up to March 2018.[19]

Figure 3.5: DSSB programme coverage (cumulative) and take-up [Source: Scottish Government, HIE, 2019][20]



18 Ofcom's *Connected Nations 2018* report does not provide average download speeds for each nation or a breakdown between urban and rural.

19 Due to geographical constraints, a small proportion of these premises receive speeds lower than the Scottish Government's definition of 'Superfast broadband' (24Mbps), but most have received a speed increase compared to the broadband previously available. A small number of premises (with FTTC) have not yet been able to benefit from any significant speed increase, due to long copper lines from the cabinet.

20 Rest of Scotland = RoS; Highlands and Islands = HIE.

Several factors have enabled the DSSB programme to reach more than 900,000 premises – including deployment efficiencies and higher-than-forecast take-up of fibre broadband services during the initial stages of the deployment, which enabled the programme to reinvest money to expand the coverage area or improve speeds. This highlights the continued success of the DSSB programme in enhancing broadband capability across Scotland. There are even some areas where take-up is close to, or over, 50% – including Midlothian, Argyll and Bute, Clackmannanshire and Aberdeenshire. One reason for this high take-up is a demand stimulation programme run by the Scottish Government in the RoS area, where community project officers engage with local authority contacts to undertake focused marketing activity aimed at driving awareness of the DSSB programme.

As discussed in the next chapter, the socio-economic benefits associated with fibre broadband provision are directly related to actual connections (i.e. take-up). Demand stimulation programmes, like the one referenced above, are thus critical if an area is to realise the benefits associated with broadband by increasing take-up.

4 Socio-economic benefits: identification and consideration

4.1 Which benefits can be modelled?

4.1.1 Quantitative benefits

The benefits that we found were capable of quantification and are thus considered in the cost–benefit model (in Section 5) are listed in Figure 4.1 below.

Figure 4.1: Quantitative benefits included in the cost–benefit model [Source: Analysys Mason, 2019]

Area	Benefit	Description
Business	Employee productivity	• Benefit arising from increased employee productivity due to the provision of NGA broadband services, with productivity increasing over time to a maximum value • This is the main benefit to business with other benefits largely being zero-sum gains (for areas that gain benefit, another area loses)
Business	Teleworking	• Teleworking is changing the nature of the workplace as it grows in importance • Benefit arising from increased productivity through flexible working • Benefit only applies to private-sector services employees
Business	Farming (as a sub-sector of agriculture)	• Better connectivity helps with adoption of smart approaches, reducing administration and facilitates diversification of economic activity • Benefit arising from adoption of best practice and simplified administration
Consumer	Consumer surplus	• Consumer broadband benefit is derived from e-commerce savings as well as value assigned to factors like entertainment etc. • Consumer surplus is the benefit of broadband, above the subscription for the service
Public goods provision	E-health	• Savings arising from mechanisms such as telehealth, symptom monitoring, specialist consultation, etc. that benefit from the availability of high-speed broadband
Government	E-government savings	• Process efficiencies through broadband technologies • Savings arise from efficiencies gained by the Government

In addition to the quantifiable socio-economic benefits, the model also considers direct benefits, derived from network revenue and additional wider impacts (induced impacts), these are explored further in Section 5.3.2.

4.1.2 Qualitative benefits

Our literature review (findings from which are summarised in Annex A) has identified other benefits which, although not capable of being robustly valued at this time, are likely to confer significant benefit. These are:

- Smart-home benefits related to a reduction in heating bills, improved security and broader lifestyle benefits
- The benefits of social inclusion and social cohesion through the provision of NGA broadband.

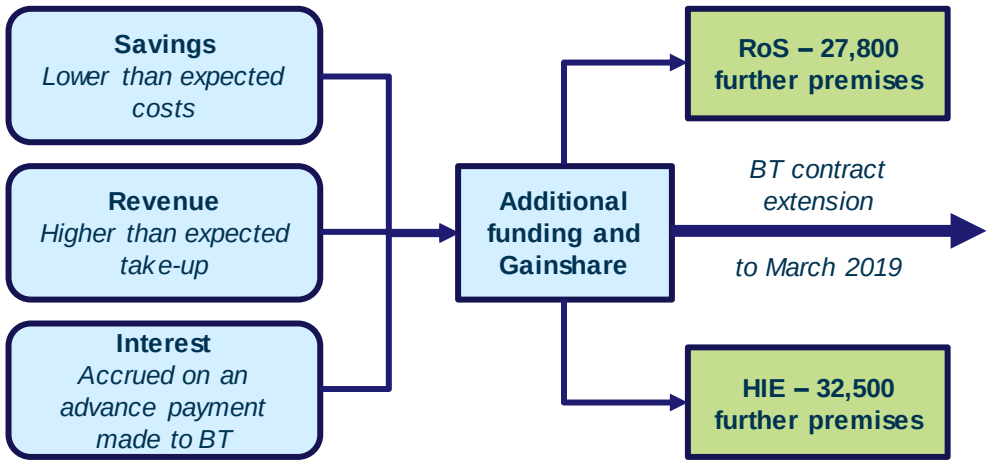
There is also the prospect of broadband use delivering benefits across education and the environment. Whilst we have not found sufficient evidence to include these benefits in our quantitative evaluation, it is possible that considerable net benefit could be derived across these areas in future, as the scale of broadband's reach across the economy and society is so comprehensive.

4.2 Other wider benefits

In addition to the socio-economic aspects discussed above, the DSSB programme has facilitated other benefits through the deployment of telecoms infrastructure where previously little was available, and through the creation of jobs for the network deployment. As part of the deployment, Openreach has installed approximately 11,000km of new fibre and copper cable, including approximately 400km of new subsea cable (e.g. connecting the Outer Hebrides to the mainland, and the Western Isles). The improved Openreach backhaul network across Scotland provides the foundation for other digital developments, such as full fibre networks or other connectivity.

Further benefits have been realised through the DSSB programme, due to cost efficiencies and higher-than-expected take-up (which led to one round of Gainshare funding being made available to extend fibre broadband coverage. The savings and additional funding (GBP20 million provided by BT Group) (summarised in Figure 4.2) have been used to extend the existing contracts between BT Group, the Scottish Government and HIE, to extend fibre broadband deployment to a further ~60,000 premises.

Figure 4.2: Contract clauses enabling further investment through the DSSB programme [Source: Scottish Government, HIE, BT Group, 2019]



5 Valuing the socio-economic impact of the DSSB programme

5.1 Principles of the cost–benefit model

To assess the quantifiable socio-economic benefits of the DSSB programme, we developed a cost–benefit model based on the following key principles:

- **Discounted cost approach** – used to understand the present-day value of the economic benefits of the programme. The discount rate applied has been taken from the HM Treasury's 'Green Book' for appraisal and evaluation[21] and has been set at **3.5%**
- **15-year programme period** – set from the start of deployment for 15 years, in line with previous cost–benefit studies for the UK Government on broadband network deployment
- **Literature review findings** – key benefit principles, as described in Section 4, have been parameterised based on the literature review findings and Analysys Mason's knowledge of the UK and Scottish broadband markets
- **DSSB programme coverage and take-up** – data supplied by the Scottish Government and HIE regarding coverage and take-up of fibre broadband is a key input to the cost–benefit model, as this drives the extent of socio-economic benefit.

5.2 Key inputs and drivers

5.2.1 Socio-economic parameters

Consumer surplus

The literature review suggested that the consumer surplus (the difference between the value a consumer pays and their willingness to pay) is GBP15 a month, per household, for fibre broadband. This is taken as a flat rate of GBP180 a year across the 15-year model period.

21 HM Treasury (2018), *The Green Book*, central government guidance on appraisal and evaluation.

Business benefits

As described earlier, the quantifiable business benefits are split into three areas: employee productivity, teleworking and farming:

- From the literature review, the rise in gross value added (GVA) per employee (estimation of productivity) due to the introduction of fibre broadband is assumed to increase to a maximum of 5% after 10 years.
- The benefit assumed from *teleworking* should only be applied to employees of private-sector companies in the service industry and is projected as a 2% increase in GVA per annum for employees within these companies. This benefit is available immediately and is therefore not scaled over time.
- Based on the literature review, the benefit that fibre broadband brings to *farming production* is scaled to delay benefit initially (to allow time for industry to adopt new technology) and then increase at 0.5% per annum to a maximum of 5%.

E-health

Fibre broadband networks provide a platform for e-health benefits, and given the benefits observed in other geographies it seems appropriate to include an estimate of potential benefit for Scotland. We have made prudent assumptions regarding the savings associated with e-health care, based on findings from the literature review and the relatively slow progress observed in this sector since 2012. The scaling of e-health savings will be initially delayed (i.e. no benefit), before increasing at 0.1% per annum to a maximum of 1% of local health spend. However, the most relevant point is that availability of fibre broadband is an enabler for e-health.

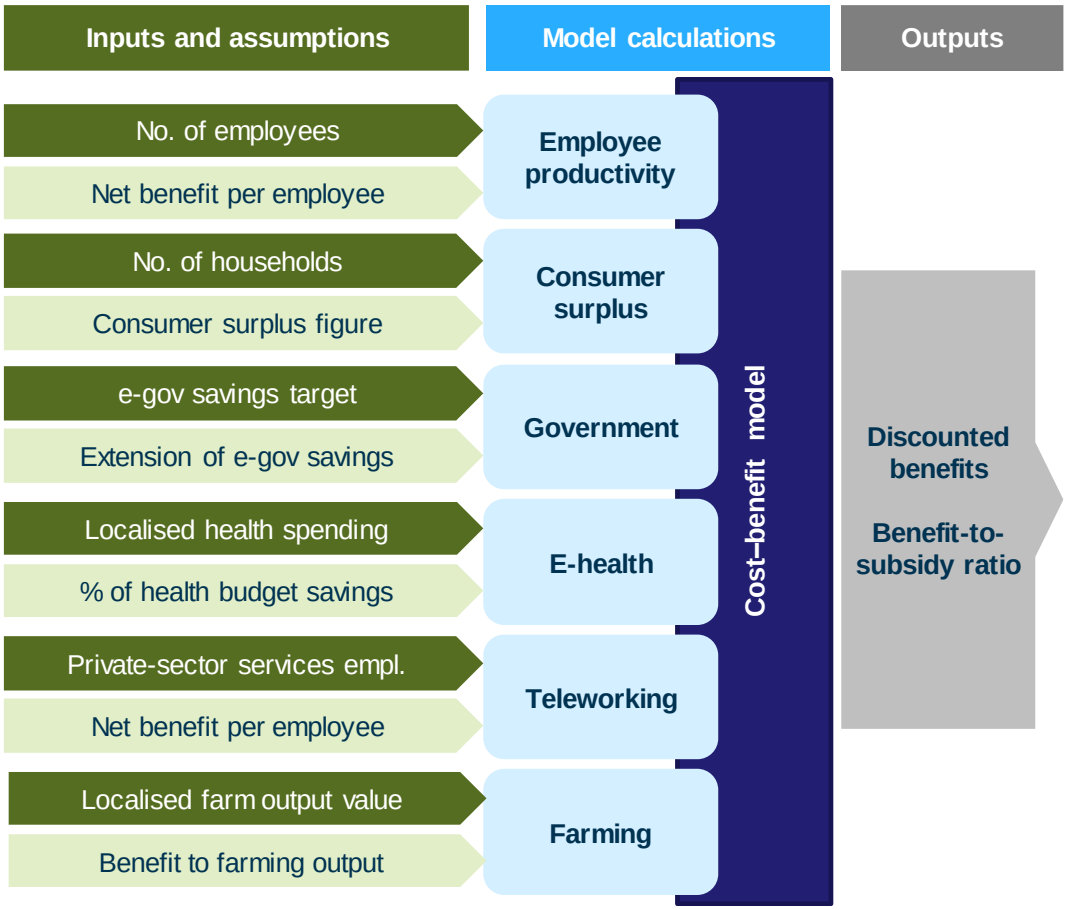
Government benefits

The benefit realised by Government will likely be derived from process efficiencies as defined by Scotland's e-Government policies. For the cost–benefit model, we have used the e-Government yearly savings from the Scottish Government, scaled down for the intervention area.

5.2.2 Modelling approach

A high-level summary of Analysys Mason's modelling approach for calculating the socio-economic benefits associated with the DSSB programme is provided in Figure 5.1. Further detail on the key input sources that were used in the model can be found in Annex C.

Figure 5.1: Approach to cost–benefit modelling [Source: Analysys Mason, 2019]



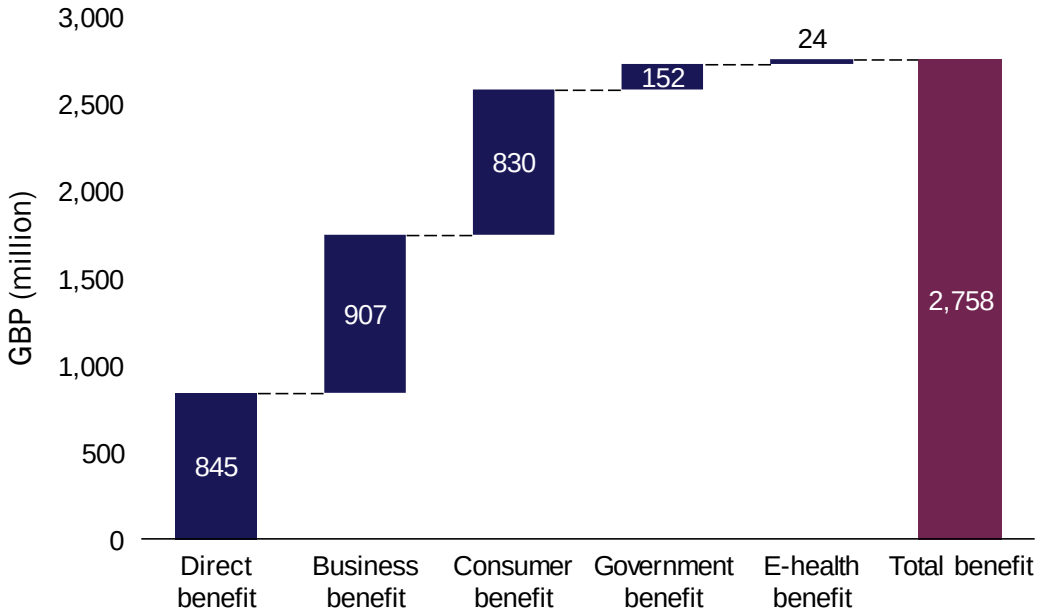
5.3 Quantitative benefits associated with the DSSB programme

The benefits presented in this section are the outputs from the cost–benefit modelling, in the form of cumulative estimates over the 15-year programme period.

5.3.1 Key outputs

The total economic benefits of the DSSB Contract One programme, both direct and indirect, are summarised in Figure 5.2.

Figure 5.2: Summary of DSSB programme benefits (discounted) [Source: Analysys Mason, 2019]



The total benefit associated with the DSSB programme is estimated to be GBP2.76 billion (discounted over the period), which represents a strong positive return on the GBP259 million of public funds used to facilitate the deployment. A common method of establishing the value of an infrastructure investment is to assess the benefit-to-*subsidy* ratio, to understand the payback per unit of public investment. The benefit-to-subsidy ratio for the DSSB programme is shown below (discounting the subsidy and benefits over the period).

The ratio of total benefit to total public subsidy over a 15-year term is 11.60.

The benefit-to-subsidy ratio clearly shows that the public investment in the programme will provide considerable benefits for businesses and consumers in the deployment areas. Whilst the benefits of the network have been measured over a 15-year period (typical length of UK Government cost–benefit analysis), the lifetime of the broadband infrastructure deployed is likely to be longer than this. Therefore, in all likelihood, the benefits associated with the network *will extend beyond the 15-year period* and so the benefit value estimated here is likely to be conservative.

Governments, policy makers and economists often seek to compare benefit ratios from multiple projects, but this can be fraught with difficulty due to the different ways in which studies calculate these ratios. For example, a recent UK Government report evaluating the BDUK Superfast Broadband programme estimated a benefit-

to-*subsidy* ratio of 1.96:1.[22] However, this value only related to the benefit realised up to June 2016 (i.e. approximately five years, in contrast to the 15-year period that has been used here). Therefore, the benefits calculated will inevitably be lower, as there is less time for benefits to materialise and users to take a fibre broadband service. However, scaling the benefits calculated for the DSSB programme over a similar time period to that used for the BDUK programme produces ratios broadly similar to those recorded for the BDUK interventions.

It is important to note that the benefit values estimated in this report can only be realised once consumers and businesses actually take a fibre broadband service. There is reduced benefit in deploying fibre broadband to an area if take-up is lower than expected. For this reason it is essential to stimulate demand in order to realise the full value of the benefits. This has been recognised by the Scottish Government, as demonstrated by the DSSB programme's expenditure of GBP2.2 million on initiatives to help increase take-up. This led to significantly higher take-up than expected, and attracted additional investment through the Gainshare mechanism.

5.3.2 Benefits of DSSB programme by category

Consumer benefit

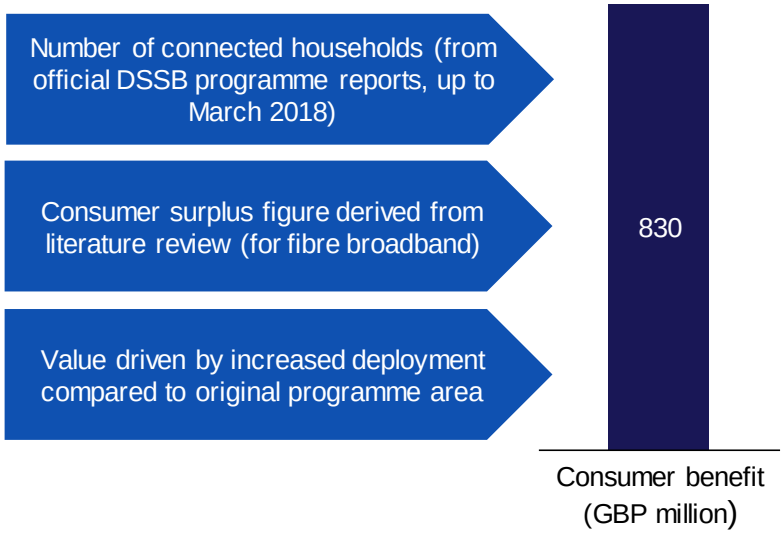


Figure 5.3: Consumer benefit (discounted) [Source: Analysys Mason, 2019]

The consumer benefit accounts for 43% of the total socio-economic benefit (30% of the total benefit associated with the DSSB programme and is driven by the number of households taking a service from the new network. The key driver of consumer benefit is consumer surplus, which is an economic method of valuing the full benefits of a service to a consumer.

22 See https://www.gov.uk/government/publications/evaluation-of-the-economic-impact-and-public-value-of-the-superfast-broadband-programme

It is clear from take-up data for the DSSB programme that consumers in Scotland[23] value high-speed broadband, with uses such as online education, video calling (i.e. social inclusion), e-commerce, smart devices (e.g. for security and convenience purposes) and online streaming/gaming all now a ubiquitous part of everyday life. This results in consumer benefit accounting for over a third of the estimated total socio-economic benefit.

E-health benefit

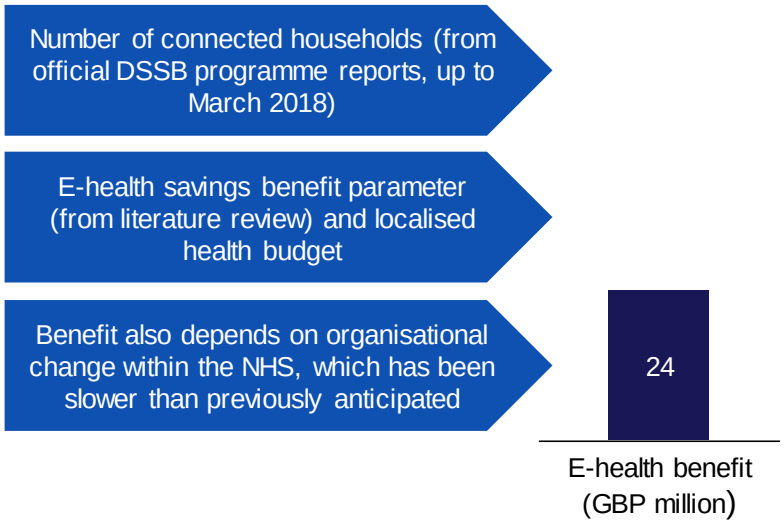


Figure 5.4: E-health benefit (discounted) [Source: Analysys Mason, 2019]

The e-health benefit represents a very small percentage of the total benefit associated with the DSSB programme, due to the major institutional change that still appears to be required across the public sector. The benefit shown in Figure 5.4 is a measure of the value of savings that can be achieved through activities such as remote monitoring, and is therefore driven by the number of households taking a fibre broadband service. Whilst e-health savings may currently be small, with appropriate policy initiatives and institutional change, it is possible that, in future, potential e-health savings on their own may be sufficient to justify broadband interventions, such is the potential value of this benefit.

23 See DSSB case studies: https://www.scotlandsuperfast.com/media/1707/stephen-hargreaves.pdf, https://www.scotlandsuperfast.com/media/1703/paul-neilson.pdf and https://www.scotlandsuperfast.com/media/1523/ dssb_case_studies_peter_rae_v4.pdf

Government benefit

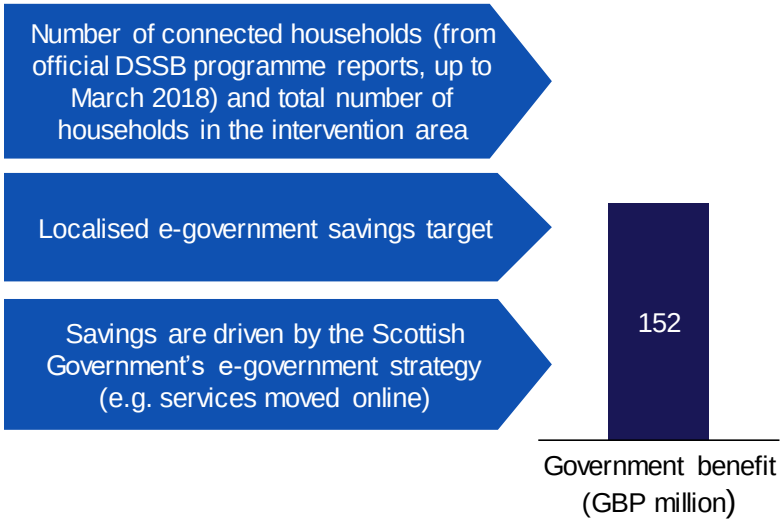
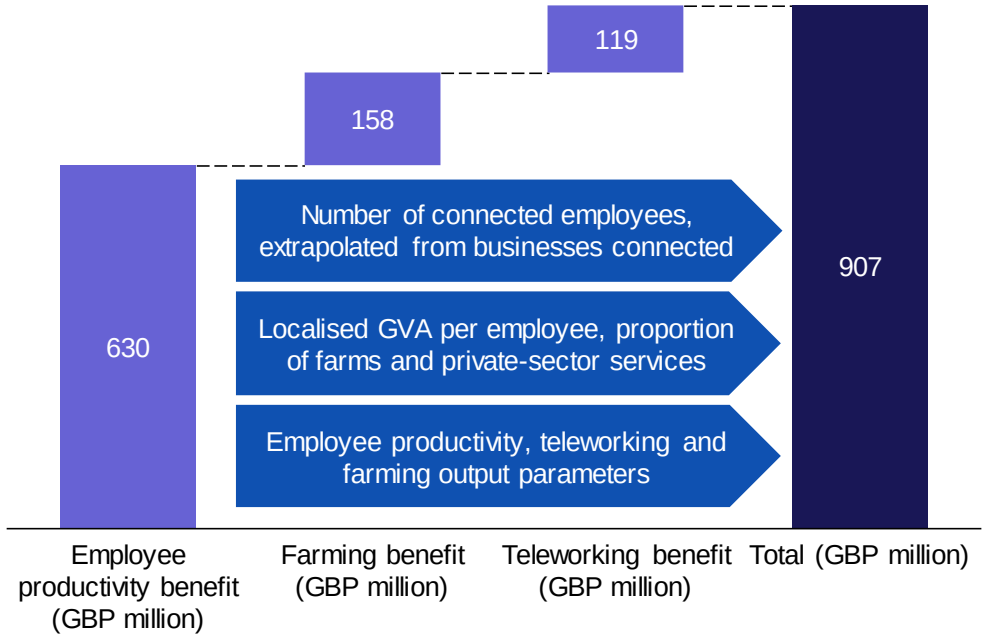


Figure 5.5: Government benefit (through e-government) (discounted) [Source: Analysys Mason, 2019]

Savings arising from e-government services (e.g. online transactions, customer service) are estimated to account for approximately 6% of the total benefit associated with the DSSB programme. The savings are driven by the Scottish Government's e-government strategy (which sets out the estimated budgetary savings associated with various digital programmes within Government), and have been scaled down for the intervention area. As with the other benefits, a household must be taking a service for the benefit to be realised. It is important to understand the value of this benefit, as savings can rise with increased provision of fibre broadband (i.e. the more individuals who use the service, the lower the unit cost), which can lead to communities benefiting from easier, faster and often cheaper services.

Business benefit

Figure 5.6: Business benefit (discounted) [Source: Analysys Mason, 2019]



The aggregate, benefit arising from business broadband accounts for approximately 47% of socio-economic benefit and is the largest driver of benefits associated with the DSSB programme (representing (33% of the total benefit). Business benefit is derived across three areas: employee productivity, farming output and teleworking productivity.

The increase in *employee productivity* (which includes any innovation-driven effect, i.e. a situation where broadband provision allows a company to adopt new methods of working), is the largest contributor to business benefits. The key drivers behind an increase in productivity are the number of business taking a fibre broadband service, the localised GVA per employee and findings from the literature review that productivity increases take time to materialise. It is apparent from the take-up rates across the DSSB programme area that Scottish businesses, large and small, value a high-speed broadband connection. The broadband intervention has enabled businesses to expand their areas of operation, make increased use of videoconferencing, take advantage of cloud storage and reduce costs, to name just a few examples.[24]

Farming benefit is measured in terms of an increase in farming output (based on the current farming output of Scotland, scaled to the intervention area) and driven by the estimated fibre broadband take-up rate among farming businesses (which

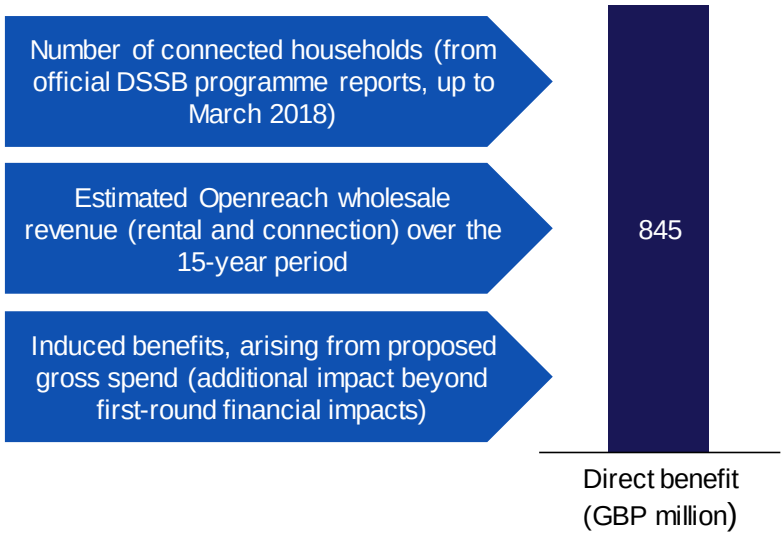
24 See DSSB case studies: https://www.scotlandsuperfast.com/media/1697/james-f-stephen-architects.pdf, https://www.scotlandsuperfast.com/media/1438/dssb_case_study_tom_madden.pdf, https://www.scotlandsuperfast.com/media/1713/mandarin-business-solutions.pdf and https://www.scotlandsuperfast.com/media/1726/trs-ribbons.pdf

we assume is in line with the broadband take-up rate of businesses). The value of fibre broadband to farmers in the intervention area is that it can act as a facilitator of new technologies, help reduce administrative burdens (e.g. farming passports and payments) and increase the variety of economic activity in and around farms.[25]

Teleworking allows workers to save time and costs associated with commuting and may lead to an increase in participation (i.e. part-time work, fewer sick days) from the workforce, therefore increasing productivity. The primary drivers for calculating the teleworking benefit are the number of private-sector services employees in the intervention area (estimated using data for the whole of Scotland) and the number of businesses taking a fibre broadband service. The value placed on teleworking, and therefore the fibre broadband which enables it, has increased significantly in the last few years. Workers in Scotland who have a fibre broadband service identify reduced travel, increased internet speed (e.g. sufficient to allow videoconferencing) and a better work–life balance as key reasons why they now telework.[26]

Direct benefit

Figure 5.7: Direct benefit (discounted) [Source: Analysys Mason, 2019]



The value derived from direct benefit accounts for 31% of total benefits associated with the DSSB programme. This benefit comprises of revenue associated with the fibre network, which has been estimated[27] based on the number of connections. The direct benefit includes the creation of jobs through network construction and

25 See DSSB case study: https://www.scotlandsuperfast.com/media/1595/dssb_case_study_willie_harper_v1.pdf

26 See DSSB case studies: https://www.scotlandsuperfast.com/media/1690/jonny-anderson.pdf and https://www.scotlandsuperfast.com/media/1693/dawn-henderson.pdf

27 We have estimated revenue by analysing current broadband wholesale pricing and extrapolating this across the forecast period.

operation, as well as induced benefits from these employees spending their wages in the economy.

5.4 Challenges of quantifying socio-economic impact

Broadband is perhaps unique in the challenges that it presents in evaluation. In general, when evaluating publicly funded initiatives it is sufficient to review the objectives, inputs, activities, outputs (directly delivered) and outcomes (impacts on desired areas of public policy) for economy, efficiency and effectiveness.

However, all these aspects are problematic for broadband interventions, such as the DSSB programme. Objectives that are framed in technical terms (e.g. connectivity speeds to be achieved) may be rendered irrelevant due to technology advancement, and given the future is necessarily unknowable it is difficult to frame objectives made at a set point in time. A key issue for a project that involves both the public and the private sector is the balance of contribution: for instance, should the private sector have contributed more, or would it have carried out the deployment eventually without subsidy if the market had been more developed or proven? It is always difficult to determine the counterfactual: that is, the provision that would have emerged in the absence of the intervention. For example, there remains uncertainty about how the fibre broadband network is being used, and thus what its full impact has been.

The inherent challenges within the DSSB programme have been addressed by:

- a procurement process that minimised the public contribution
- mechanisms to ensure cost effectiveness in delivery
- a ‘Gainshare’ arrangement to ensure that better-than-projected take-up would lead to greater private investment, to extend provision further.

Overall, this evaluation acknowledges that, alongside concrete evidence of use (e.g. strong take-up of the fibre broadband), there are still areas of benefit that have yet to be appreciated. It is too early to identify all of the benefits, as some will be dependent on other actions. For example, further benefits from e-health and smart homes are likely to arise in the right conditions, but these are currently uncertain. Our analysis has purposefully been conservative, to recognise benefit only where there is a strong evidence base. However, it is possible that the actual value of socio-economic benefit realised will be higher than modelled in our analysis.

6 Was public intervention the correct action in Scotland?

6.1 Has the DSSB programme been a success?

The DSSB programme has successfully delivered a fibre broadband network that is more ambitious than planned due to project efficiencies, further investment and higher-than-expected take-up. This led to an agreement with BT Group to review the Gainshare mechanism earlier than planned, whereby income generated from greater than expected take-up was invested to cover additional premises or increase speeds. From a technical perspective, the roll-out has delivered connectivity, on plan, on schedule and on budget, to areas which previously relied on slow broadband connections. From a commercial standpoint, DSSB Contract One has achieved a higher level of premises passed and connections than originally forecast. In terms of managing the delivery of a complex project that involved considerable challenges (e.g. a large number of islands, a geographically dispersed population), the programme has been a success.

However, the focus of this evaluation is on the economic return to Scotland: that is, has the DSSB programme, specifically DSSB Contract One (up to March 2018), justified the public resources invested in it? This requires a comparison of wider-ranging benefits with costs – and while the latter are relatively easily identified the former are less so.

With actual take-up exceeding the programme's original projections, the number of beneficiaries (both consumers and businesses) has similarly surpassed its targets. Through our cost–benefit analysis, business benefits, including productivity (crucial to business impact), farming benefit and the potential of teleworking, have been estimated at approximately GBP907 million.

While the scale of potential benefits associated with telecare and other healthcare strands is repeatedly confirmed in studies in the UK and elsewhere, this potential remains untapped. The e-health benefits have yet to be fully realised due to the organisational and institutional changes that are required,[28] but the DSSB programme has provided a platform to unlock potentially significant economic benefit in future. Therefore, the deployment of fibre broadband is a key step in allowing e-health benefits to be realised quickly, once institutional change does begin.

28 These changes include not only technological issues but also: acquiring and prioritising resources; managing change across systems, people, equipment and premises; and addressing concerns over privacy, supplier responsibilities and interoperability with other systems

Consumers have signalled their approval of the offerings available from the fibre broadband network through rapid take-up (running above projections); this, coupled with the literature review findings on consumer surplus, provides an estimated consumer benefit of GBP830 million.

Another aspect that could be considered is the extent to which those parts of Scotland not covered by the DSSB programme will benefit. In particular, firms that employ people who live in the DSSB area will benefit from better communications and the potential for teleworking; some areas will see increased tourism (leading to greater hospitality and accommodation spend in many towns); all taxpayers will benefit from the geographical extension of e-government opportunities (which reduce the administrative costs of public services); and all residents will benefit from e-health programmes that can only be economically and equitably justified if provided throughout Scotland.

The total economic benefit associated with the DSSB programme has been estimated at GBP2.76 billion over its first 15 years. Our analysis estimates that for every GBP1 of public subsidy, GBP11.60 of economic benefit is realised. In addition to these quantifiable benefits, there are numerous qualitative benefits (discussed in Annex A.6), including education, social inclusion and possible environmental benefits. Therefore, the true value of the benefits associated with the network deployment may be considerably higher than estimated here.

The conclusion of this evaluation is that the Scottish Government, HIE and the local authorities were justified in intervening to facilitate the deployment of fibre broadband to unserved areas. The programme has been a considerable success, helping to cement Scotland's digital future and the infrastructure that has been built will provide high-quality connectivity in Scotland for the foreseeable future.

6.2 Future initiatives

The DSSB programme (e.g. Contract Two) will continue to deploy fibre broadband to unserved areas until March 2019, due to contract extensions between BT Group and the Scottish Government and HIE, which have brought further investment from BT Group. One reason that the contract extensions have been possible is higher-than-expected revenue (i.e. higher take-up), which meant that BT Group agreed to release a share of the income generated for reinvestment. It is estimated that this extension will cover approximately 60,000 additional premises.[29]

The provision of broadband connectivity in unserved areas undoubtedly brings economic benefit to those areas and thus remains a policy priority for both the Scottish and UK Governments. For example, the Scottish Government is currently

29 Audit Scotland (2018), *Superfast broadband for Scotland: Further progress update* (September 2018).

in the procurement phase of the 'Reaching 100%' programme, which will commit GBP600 million of public funds to extend superfast fibre broadband coverage to an estimated 147,000 rural premises that do not currently receive at least 24Mbps. The procurement has been split into three lots (Highlands and Islands, Central Scotland and South Scotland), with the aim of encouraging multiple bidders. The procurement is expected to end in 2019, with contracts for deployment to be announced thereafter.

The recently published Future Telecoms Infrastructure Review indicates a commitment to deliver ultrafast broadband (above 300Mbps), through FTTP, to all UK premises by 2033.[30] This is further backed up by the EU Digital Agenda ambition for all European households to have download speeds of at least 100Mbps by 2025. This continued push for faster download speeds and ubiquitous broadband provision indicates a virtually universal recognition of the socio-economic benefits associated with broadband intervention programmes.

30 DCMS (2018), *Future Telecoms Infrastructure Review* (July 2018).

Annex A Summary of literature review findings

A.1 Context and challenges

Context

Broadband has become an integral part of everyday life, both in the workplace and at home. Conducting business would be unthinkable without the simple and instantaneous communication and access offered by broadband connectivity. At home, broadband has become an indispensable utility with multiple uses, providing opportunities such as distance learning, access to information, e-commerce, community engagement through social media, and numerous forms of entertainment.

The true impact of broadband varies from area to area and we note from our literature review that different stakeholders have different perceptions about the perceived benefit of broadband provision. Early studies tended to assume that benefit would simply be a series of measurable impacts, which could be aggregated to give the total benefit associated with broadband. However, more-recent literature on broadband increasingly finds that the impacts of broadband provision are complex, with benefit often being abstruse. In addition, there is also the rise of some claimed disbenefits relating to broadband which should be taken into account when measuring the overall benefit. However, the overall literature landscape indicates that broadband has a significant positive effect on day-to-day life, driven by local behaviours and context.

Challenges

The primary challenge of the socio-economic modelling is to set the analysis within a Scottish context: that is, going beyond a simple scaling of population, premises and businesses to try to incorporate business 'culture'. We have considered this by examining the actions of bodies responsible for economic development in Scotland. Local case studies have also been examined for insights into recognition of opportunity, acceptance of the need for change and the innate capability to exploit that new potential.

We have reviewed more than 120 studies from the UK and internationally, with our assessment of benefit driven by the balance of evidence within those studies. We have captured learnings from studies globally, to supplement the limited information on broadband benefits specific to Scotland in the literature. This approach has allowed us to identify inputs for our socio-economic benefit modelling for Scotland. We appreciate that there are likely to be particularities of Scotland that are difficult

to model accurately, but overall our modelling approach is reasonable and widely used. Comprehensive evaluation would involve waiting years for all impacts to emerge, be identified, quantified and valued. Instead, the focus here is to assess the benefits that are already emerging and possibly to shape policies to obtain further benefit.

A.2 Business benefits

The near-universal adoption of broadband, and rapid take-up of NGA broadband products, demonstrates that Scotland's businesses believe there is a compelling business rationale for enhanced connectivity. Coupled with the supportive environment provided by Scotland's national, regional and local economic development agencies, along with assistance from broader partners (notably councils and educational bodies), there are grounds for asserting that the impact on Scotland's businesses will be favourable.

Productivity

> "*Fibre broadband is really great news for our firm. It is improving our productivity, helping us provide better customer service*" (Rollos in Cupar, DSSB programme connection)

The default assumption in the majority of the literature is that connectivity makes firms more productive. A 2016 study[31] of German manufacturing and services firms found that productivity increased significantly when more employees had mobile internet access. In Wales, a 2017 report[32] argued that SMEs using superfast broadband are characterised by higher growth in labour productivity and are more likely to engage in innovation activity.

> "*As a self-employed bagpipe maker, my website, videos and product photos are used to sell my hand-crafted pipes all over the world. Since upgrading to fibre broadband, I can instantly send progress pictures and videos to my customers. It used to take all night to upload website updates and videos*" (Ross, Lochalsh Pipes, Ross-shire, DSSB programme connection)

Many studies find that business applications are capable of increasing productivity significantly, but only when associated with appropriate changes in business conduct.

31 Bertschek, I. & Niebel, T. (2016), "Mobile and More Productive? Firm-Level Evidence on the Productivity Effects of Mobile Internet Use", *Telecommunications Policy*.

32 WERU (2017), *NGA broadband business exploitation project: Economic impact report*, Cardiff University.

The blunt assessment is that poorly managed firms make poor use of broadband, while high-performing firms make good use of it. This is unsurprising, and yet a reminder to policy makers and others that provision of access is only part of the story. The DSSB programme's business impact is as much associated with the economic performance and potential of firms in the DSSB area at its outset as with the actual investment in infrastructure.

In terms of scale, a report[33] prepared by the EC in 2015 provided forecasts of the impact of broadband-related productivity gains of 5% in manufacturing and 10% in services. A 2011 study[34] in New Zealand found a productivity effect from broadband of 7% to 10% across all firms, regardless of type, whether urban or rural, or with high or low knowledge intensity. These international studies affirm that connectivity will drive business productivity that encourages investment and raises wages, though effects take some time to be fully realised.

In 2015, a study[35] with a special focus on workers' skill levels in Norway found that increased broadband availability had a significant positive impact on hourly wages and employment of skilled workers, though there was a negative effect on the wages of low-skilled workers. A clear conclusion from the literature is that not all firms, or regions, or indeed their workers, benefit equally: that is, broadband networks will tend to bring greater benefit to the already successful.

However, other hoped-for impacts of broadband are sometimes illusory: for every supplier gaining a long-distance customer a local company may lose some market share. As a result, some apparent benefits of a global market may be overstated, as this may lead to a zero-sum game. It should be noted that we have not seen evidence of this being the case in Scotland.

The provision of broadband through the DSSB programme can be seen as an enabler for businesses across Scotland to reap economic benefits. However, as discussed above, the value of this benefit is likely to be driven by the underlying performance of individual businesses. Consequently, the key business benefit to be quantified and carried forward to the cost–benefit model (in Section 5) is productivity.

33 European Commision (2015), *Socio-economic benefits of high speed broadband*.

34 Arthur Grimes, Cleo Ren and Philip Stevens (2011), "The Need for Speed: Impacts of Internet Connectivity on Firm Productivity", *Journal of Productivity Analysis* 37 (2) (July 23): 187–201. doi:10.1007/s11123-011-0237-z.

35 Akerman, A., Gaarder, I. & Mogstad, M. (2015), "The Skill Complementarity of Broadband Internet", *Quarterly Journal of Economics*, 130(4), pp. 1781–1824.

Employment

Ultimately, the employment impact of the DSSB programme is likely to be varied, with some areas seeing long-standing businesses challenged while others gain new establishments offering considerable employment. In general, it is the attractiveness of an area (i.e. its liveability) which will determine the degree of enhancement in that particular locality. This depends on a combination of national issues (such as taxes and regulations) and intensely local factors (such as natural and built heritage, planning policies and even the availability, or otherwise, of public transport).

Overall employment in Scotland is unlikely to rise significantly as a direct result of the DSSB programme, as higher productivity will lead to fewer workers, unless output grows even faster. However, workers will benefit from higher wages and more-secure employment.

Attracting new investment and business start-ups

There is growing evidence, including some recent studies related to the deployment of NGA broadband infrastructure, that improved connectivity in an area will attract investment and increase the level of business start-ups. Whitacre et al (2014)[36] found that rural parts of the USA with higher broadband speeds were more successful in attracting knowledge economy firms; and studies in Sweden[37] and France[38] made similar findings for ultrafast deployment, with the French study noting that very high-speed broadband networks enhanced the attractiveness of municipalities for new business creation.

Tourism

> "*Residential customers, wedding guests and visitors to our restaurant and bar all now enjoy a better overall experience at the hotel*" (Inchture Hotel, Inchture, Dundee, DSSB programme connection)

Tourism is a vital part of Scotland's economy, critically so in parts of the DSSB intervention area, and broadband is particularly valued in this sector. The DSSB programme provides an opportunity to increase and spread current tourism activity

36 Whitacre, B., Gallardo, R. & Strover, S. (2014), "Broadband's Contribution to Economic Growth in Rural Areas: Moving Towards a Causal Relationship", *Telecommunications Policy*, 38(11).

37 Mölleryd. B. (2015), "Development of High-speed Networks and the Role of Municipal Networks", *OECD Science, Technology and Industry Policy Papers*, No. 26, OECD Publishing, Paris.

38 Hasbi, M. (2016), *Impact of Very High-Speed Broadband on Local Economic Growth: Empirical Evidence*, Chalmers University of Technology.

across the intervention area, creating a better experience for tourists and encouraging more and longer stays, thus benefiting the Scottish economy overall.

> "*Before getting fibre broadband, we had to warn visitors to the B&B that they might only be able to check emails from the internet here. We have a regular visitor, a graphic designer from the US who can now extend her trips to work in Scotland using our broadband"* (Jayne, B&B owner, Ross-shire, DSSB programme connection)

Business benefit from teleworking

There is no doubt that teleworking is changing the nature of the workplace as it grows in importance, though putting a value on this is particularly challenging as some of the claims made for it relate to an improvement in work–life balance or other aspect that is hard to value in economic terms.[39]

Firms do benefit from employees who telework (i.e. using their broadband connection at home). Various potential productivity benefits from teleworking have been suggested,[40] as the time and costs associated with commuting are reduced, office expenses avoided, recruitment and retention improved, and participation in the workforce made easier for carers and those with a disability. It is also argued that teleworking can improve employees' life satisfaction and work–life balance, which in turn may improve their work performance.

A 'meta-analysis'[41] of 46 studies found that teleworking had small but significant beneficial effects related to perceived autonomy, job satisfaction, performance, staff retention, and a lowering of both stress and work–family conflict. These are all important benefits in today's working environment. The analysis also stated that low levels of teleworking appeared to have no significant effect on relationships with co-workers.

> "*Since upgrading to fibre I have seen an incredible increase in the speed of my connection and this has revolutionised the way I can work from home*" (Jonny Anderson, Kelso, Scottish Borders)

39 It should be noted that the minimum download speeds required for teleworking vary by job. We have assumed that the majority of premises served by the DSSB programme are able to benefit from basic teleworking requirements, such as teleconferencing and videoconferencing.

40 Access Economics (2010), *Impacts of Teleworking Under the NBN*.

41 Ravi S. Gajendran and David A. Harrison (2007), "The Good, the Bad, and the Unknown About Telecommuting: Meta-analysis of Psychological Mediators and Individual Consequences", *The Journal of Applied Psychology* 92 (6) (November): 1524–41. doi:10.1037/0021-9010.92.6.1524.

Farming

It has been difficult to provide farms with broadband connections, since as well as being inherently rural they also typically lie well outside settlements, often with a final lane to the farmhouse and ancillary buildings. However, farms are significant businesses in their own right, and have a particular importance for the sustainability, environmental and social aspects of rural communities. The farming sector is a key pillar of Scotland's overall economy.

Analysis of the current National Broadband Plan for Ireland by PwC[42] put considerable emphasis on the opportunity that enhanced connectivity can confer on farmers. It identified a reduced administrative burden, improved herd and crop performance (through smart approaches to feeding and fertilising), plus the potential for reduced waste and pollution. Perhaps a less obvious benefit of broadband in this sector is the ability of a farmer to review live CCTV images of an animal while working elsewhere, and share them with a veterinary surgeon. It is also possible that faster broadband speeds will give farmers greater access to digital opportunities, such as wider funding mechanisms.

> "*I regularly use the internet for farming passports and payments which are now all done online, fibre broadband has made a big difference to me as a farmer as well as my family*" (Willie Harper, Bridge of Weir, Renfrewshire)

The PwC study quotes an Australian study which found that a 'smart farm' can be 30% to 59% more productive than a traditionally operated one. This scale of impact is perhaps best treated as the upper bound of what may be achieved by the average farmer. Given that the sector is typified by a large number of small entities and widespread use of traditional techniques, it is unlikely that broadband connectivity will completely change working methods within the medium, or perhaps even the longer, term. However, better access to information will inevitably contribute to a more productive and sustainable sector.

High-speed connectivity can also act as a facilitator or gateway to a wider variety of economic activity such as renting out land for events, creation of camp sites and selling produce direct to consumers, all of which makes the countryside more diverse, sustainable and economically active.

A.3 Consumer benefits

Broadband has become an indispensable utility in the home (increasingly so as speeds have been revolutionised with fibre deployment), by providing access to

42 See https://www.dccae.gov.ie/en-ie/communications/topics/Broadband/national-broadband-plan/state-intervention/Pages/Strategy%20Dec%202015.aspx

communication (to reduce social isolation), distance learning, smart homes, e-commerce opportunities, plus an ever-expanding offer of entertainment activities. In addition, the shift away from a single home computer to today's plethora of devices has provided added impetus for increased connection speeds.

> "*All three of us can be online at the same time now, without noticing any difference in the fast internet speeds*" (Graeme Blackie, Houston, Renfrewshire)

Valuing all this is challenging, not least since although the benefits may be very substantial, many have alternatives – ranging from accessing the internet elsewhere to combining broadcast television with a hard-disk recorder or Blu-ray player. One driver of broadband usage is the appeal of e-commerce, offering vastly wider choice and often lower prices. Online comparison tools allow consumers to make major savings on utility costs along with better deals on mortgages, savings accounts and insurance (especially those individuals who could not previously access such services, due to geographical or mobility barriers).

The recently published evaluation of the whole UK Superfast programme (run by BDUK) estimated an increase in the sense of 'wellbeing' (which, in this context can be read as consumer surplus, defined as the extra value users obtain above and beyond what they pay) of GBP19 per household per month when moving from basic to NGA broadband.[43] Another study, by KPMG, estimates that NGA broadband provision is associated with an incremental rise in consumer surplus of between GBP3 and GBP10 a month over a period of eight years.[44]

The available literature provides a very wide range of estimates of consumer surplus relating to NGA broadband provision, all positive, with some reporting a very high level of benefit. We have adopted a prudent approach in our cost–benefit analysis, by assuming a conservative benefit value.

A.4 E-health

Opportunities provided by NGA broadband connectivity are potentially transformative in the delivery of health, particularly for those living a long distance from hospitals and other healthcare centres. Telehealth, or the remote monitoring of health, is the obvious starting point. For example, the remote monitoring of elderly individuals with low care needs can defer the need for institutional care and reduce hospital admissions. Remote monitoring can also be used for those with care

43 Ipsos Mori (for BDUK) (2018), *Evaluation of the economic impact and public value of the Superfast Broadband Programme*.

44 See https://www.ofcom.org.uk/__data/assets/pdf_file/0025/84724/bt_annex_delivering_britains_digital_future_-an_economic_impact_study_kpmg.pdf

needs, such as intellectual disability, and individuals suffering from chronic ailments. A recent study[45] for Ofcom included a case study reference to NHS Scotland and its use of the Scottish Wide Area Network (SWAN), noting that the next stage of evolution was to expand this to serve premises (e.g. homes, clinics) that require high broadband speeds to support relevant applications.

There is little doubt that provision can be effective. A 2011 study[46] in the UK, for example, focused on three long-term (and hence costly) conditions: diabetes, chronic obstructive pulmonary disease and coronary heart disease, establishing a clear evidence base in favour of telehealth and telecare.

A report for Ofcom's Advisory Committee on Older and Disabled People[47] illustrated how connectivity 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 their own communities. An Australian report[48] estimated the net benefits from widespread adoption of telehealth in Australia to be between AUD2 billion and AUD4 billion per annum (approximately GBP1–2 billion).

However, studies are not yet conclusive on the issue of cost effectiveness. For example, one meta study[49] of peer-reviewed studies found that only 13% "*concluded telehealth provides benefit in terms of reduced costs or utilisation".* Some sceptical researchers[50] note that telehealth is primarily for the elderly, but since this is one of the demographic groups least likely to be online,[51] there will be costs related to familiarisation, training and considerable ongoing technical support. This study points out that it is essential to consider the changes required within the healthcare system itself, a sentiment that is widely shared.[52]

45 See https://www.ofcom.org.uk/__data/assets/pdf_file/0016/111481/WIK-Consult-report-The-Benefits-of-Ultrafast-Broadband-Deployment.pdf

46 See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/215264/dh_131689.pdf

47 i2 media research (2010), *Next Generation Services for Older and Disabled People*; available at https://www.ofcom.org.uk/__data/assets/pdf_file/0017/3275/acod-ngs.pdf

48 Access Economics (2010), *Financial and Externality Impacts of High-speed Broadband for Telehealth*.

49 Totten, A.M., Womack, D.M., Eden, K.B. et al. (2016), *Telehealth: Mapping the Evidence for Patient Outcomes from Systematic Reviews*, prepared for Agency for Healthcare Research and Quality.

50 Robert Kenny and Charles Kenny (2011), "NGA Broadband: Is It Really Worth a Subsidy?", *Info* 13 (4) (June 28): 3–29. doi:10.1108/14636691111146127.

51 Ofcom (2016), *Access and Inclusion*; see https://www.ofcom.org.uk/__data/assets/pdf_file/0030/98508/access-inclusion-report-2016.pdf

52 See, for example, Economist Intelligence Unit (2012), *NGA Britain? Myths and Realities About the UK's Broadband Future*, which notes that "Broadband speed alone is not enough to effect a transformation".

A study[53] in Sweden and Finland looked at the socio-economic impact of NGA-based digital home-care services, in terms of cost savings and quality-of-life impact. The benefit per capita was larger in rural areas, as the time saved by staff who avoided having to travel to provide care is greater than in more densely populated areas. Therefore, it is likely that in general, national averages of the benefit of telecare will understate its contribution to justifying new broadband networks in rural areas. Since Scotland has significant rural areas, the benefits related to e-health (from the deployment of NGA broadband) are likely to be greater than the national averages.

Although benefits realised from e-health are dependent on the organisational processes and set-up within health departments and institutes, the DSSB programme has created an infrastructure that is an enabler for e-health benefits in the future.

A.5 Government

Government benefits from the development of e-services (e.g. online tax submission, providing information and resources for citizens online), which reduce administration costs. The scale of benefit (in this case cost savings) is largely dependent on the local e-government strategy, which should identify potential benefits as well as setting delivery and operational goals.

Potential e-government benefits are also dependent on organisational processes and set-up across several departments within both central and local government. Regardless of the maturity of e-government services at a particular level, however, the DSSB programme has created an infrastructure that will enable the realisation of full e-government benefits in the future. This is a significant positive outcome for Scotland, even though it cannot be fully quantified at the current time.

A.6 Other benefits

Smart homes

The use of smart devices in the domestic setting is gathering pace, for a range of applications (such as home heating, security and other appliance control, from turning up the lights to scheduling the washing machine and submitting meter readings). Such smart-home benefits are sufficiently new that they were not identified as a significant area of benefit in the 2011 projections that underpinned the business case for the DSSB programme.

53 Forzati, M. and Mattson, C. (2014), *FTTH-enabled digital home care – A study of economic gains*, Department for Networking and Transmission, Acreo AB.

To date, studies appear focused on theoretical technical capability; simply case studies or exercises in future prediction. This excessive focus on the technology, instead of considering broader issues around privacy and control, is noted[54] within the literature.

Quantitative analysis is limited; one small 2015 study[55] on heating and energy use noted that while home owners believed a smart home would deliver efficiency in energy use they had overlooked the energy consumption of new applications (e.g. sensors, multimedia systems, security systems).

One study[56] does quantify potential savings from better control of heating, finding that this could lower bills by as much as 28%. However, this study notes that everyone uses energy differently and so considerable further progress is needed before the use will generate mass benefit.

Smart-home technologies will provide real consumer benefits (and in some cases environmental benefits), as the average annual household energy cost (excluding transport) in Scotland is around GBP1080.[57] A saving of only one-third of the 28% reduction suggested above would represent an annual saving of around GBP100. It is likely that smart-home heating savings will grow to substantial levels in the coming years, particularly as heating appliances are replaced with new 'smart' versions. There is likely to be a tipping point where mass adoption becomes the norm, not the exception, but it is unclear whether this will happen in 5 or 15 years.

Education (connectivity at home)

Education in schools and colleges has benefited greatly from connectivity, allowing pupils and students to access a vast range of educational material and resources that can make the learning process more engaging and productive.

The effect of bringing improved connectivity to the homes of students provides a mix of evidence. A 2012 study[58] on nine-year old children in Ireland found that using a computer for surfing the internet, doing projects for school and emailing improved

54 Charlie Wilson, Tom Hargreaves and Richard Hauxwell-Baldwin (2015), "Smart homes and their uses: a systematic analysis and key challenges", in *Personal and Ubiquitous Computing*.

55 Tom Hargreaves, Richard Hauxwell-Baldwin, Charlie Wilson, Mike Coleman, Tom Kane, Lina Stankovic, Vladimir Stankovic, David Murray, Jing Liao, Steven Firth and Tarek Hassan (2015), *Smart homes, control and energy management: How do smart home technologies influence control over energy use and domestic life?*, European Council for an Energy Efficient Economy (ECEEE).

56 Gabriele Lobaccaro, Salvatore Carlucci and Erica Lofstrom (2016), *A review of systems and technologies for smart homes and smart grids*, MDPI Energies.

57 *Energy in Scotland 2018: Data, Charts and Sources*: see figure 7.7; available at https://www.gov.scot/Topics/Statistics/Browse/Business/Energy/EIS/EIS2018data

58 Alice Casey, Richard Layte, Seán Lyons and Mary Silles (2012), "Home Computer Use and Academic Performance of Nine-year-olds", *Oxford Review of Education* 38 (5) (October): 617–634. doi:10.1080/03054985.2012.731207.

children's reading and mathematics scores, but did note that access to social media and entertainment could be negatively associated with attainment. There appears to be general agreement that connectivity raises core digital skills, although a recent study[59] on providing school pupils with connectivity finds little compelling evidence of considerable benefit.

It is clear that the academic literature in this area has struggled to keep up with the rapidly changing environment and the evidence base is insufficiently established to enable a benefit value to be quantified at present. However, there may be certain scenarios where benefits can be realised (e.g. distance learning that could significantly reduce travel time).

Environment

The use of broadband technology is generally considered to be positive in terms of minimising the environmental impact of individuals and companies, through the obvious efficiency of moving data, instead of people or things.

A case study[60] by BT reported on the environmental impact of the NGA broadband Cornwall project, which has some similarities to the DSSB programme. It found that the cumulative effect was an estimated annual saving per subscriber of one tonne of CO_2. Against this, ICT is a major global contributor to greenhouse gas emissions. The Global e-Sustainability Initiative (GeSI) found[61] that the emissions associated with ICT arising from data centres double every decade.

Crypto-currencies are also driving exceptional demand for electricity, with Bitcoin alone estimated[62] to account for 0.29% of global electricity consumption in May 2018. Growth in NGA networks has undoubtedly aided explosive growth in crypto-currency mining, whose carbon footprint is now estimated at an astounding 428kg (of CO_2) per transaction.

A UK study[63] suggested that twice-weekly homeworking for half the workforce could reduce UK greenhouse gas emissions by the equivalent of 2.4 million cars. However, researchers[64] from the University of Oxford found that 80% of the travel

59 See, for example, the LSE *CentrePiece Autumn 2016* discussion of research; available at cep.lse.ac.uk/pubs/download/cp480.pdf

60 See https://www.globalservices.bt.com/static/assets/pdf/case_studies/EN_NEW/superfast-cornwall-case-study.pdf

61 GeSI and Boston Consulting Group (2012), *GeSI SMARTer 2020 : The Role of ICT in Driving a Sustainable Future*.

62 See www.digiconomist.net/bitcoin-energy-consumption

63 Kate Lister and Tom Harnish (2011), *The Shifting Nature of Work in the UK: Bottom Line Benefits of Telework*.

64 David Banister, Carey Newson and Matthew Ledbury (2007), *The Costs of Transport on the Environment – the Role of Teleworking in Reducing Carbon Emissions*.

savings from teleworking were lost due to extra heating and lighting for the home, although the net effect was still positive.

By providing new opportunities for firms further afield, broadband may lead to increased international air travel. One study[65] argues that the sectors where substitution for travel should be easiest are in fact those seeing the greatest growth in travel. Ultimately, environmental impact will be shaped by the way broadband is used: a world that values sustainability and shares best practice in research on relevant topics will see positive transformation; whereas ever-rising 'social' and speculative uses will have a negative impact.

Social inclusion

Pervasive deployment of NGA broadband removes the inequality in access between those in well-served areas (principally urban), and those elsewhere (mostly in rural locations). Access to NGA broadband has the effect of reducing barriers to communication, such as distance or (most) disability. In turn this opens connections to education, work, culture and relationships.

The explosive rise of online gaming has shifted what was typically a solitary pursuit into one with a strongly social (albeit virtual) dimension. One study[66] found that conducting activities online could improve quality of life, since it allows many tasks to be completed from home, or at times that might otherwise be wasted. One report[67] shows how communication technology can be used to improve quality of life and reduce social exclusion for older people.

Wellness

Data[68] for Luxembourg found that non-internet users are less satisfied in their life than internet users. Internet use has a marked influence on life satisfaction, with positive effects stronger for low-income and young individuals, both important groups for social cohesion. A survey across Europe[69] found that having an internet connection at home is associated with significantly higher levels of wellbeing. This

65 Paul Haynes (2010), "Information and Communication Technology and International Business Travel: Mobility Allies?", *Mobilities* 5 (4) (November): 547–564. doi:10.1080/17450101.2010.510337.

66 Sid-Ahmed Selouani and Habib Hamam (2007), "Social Impact of Broadband Internet : A Case Study in the Shippagan Area, a Rural Zone in Atlantic Canada", *Journal of Information, Information Technology, and Organizations*, vol. 2.

67 Martin Jones and Chris Rowbottom (2010), "The Role of Telecare in Overcoming Social Exclusion in Older People", *Journal of Assistive Technologies* 4 (3): 54–59.

68 Thierry Pénard, Raphael Suire and Nicolas Poussing (2011), *Does the Internet Make People Happier?*

69 Georgios Kavetsos and Pantelis Koutroumpis (2011), "Technological Affluence and Subjective Well-being", *Journal of Economic Psychology*, 32 (5) (October): 742–753. doi:10.1016/j.joep.2011.05.004.

is reinforced by the Oxford Internet Survey,[70] which found evidence that the internet has helped build and maintain relationships with friends and family, increasing contact with those who live far away.

70 William H. Dutton and Grant Blank (2011), *Next Generation Users: The Internet in Britain – Oxford Internet Survey 2011 Report*.

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Figure B.1: List of sources used [Source: Analysys Mason, 2019]

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Annex C Key modelling inputs and assumptions

Figure C.1: Key modelling inputs and assumptions [Source: Analysys Mason, 2019]

Input/assumption	Source	Note
Premises coverage	HIE and Scottish Government	Regular reporting on the status of the DSSB deployment (split by residential and business)
DSSB programme take-up	HIE and Scottish Government	Regular reporting on the status of the DSSB deployment (split by residential and business)
Social discount rate (3.5%)	HM Treasury Green Book (https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent)	Used to calculate the net present value of the socio-economic benefits
Average number of employees per business	Estimate derived from data from the Office of National Statistics (ONS)	Estimate based on average number of employees across SMEs and micro businesses
E-government savings	Estimate derived from UK Government and Scottish Government figures	Scaled for the intervention area
GVA per employee	ONS data for Scotland	Scaled for the intervention area
Health budget	Scottish Government budget for 2018/19	Scaled for the intervention area
Farming output	Scottish Government agriculture statistics	Scaled for the intervention area
Private-sector services employees	Estimate derived from the ONS	Scaled for the intervention area
Financial information	Openreach, Scottish Government, HIE	As reported in Audit Scotland report, September 2018