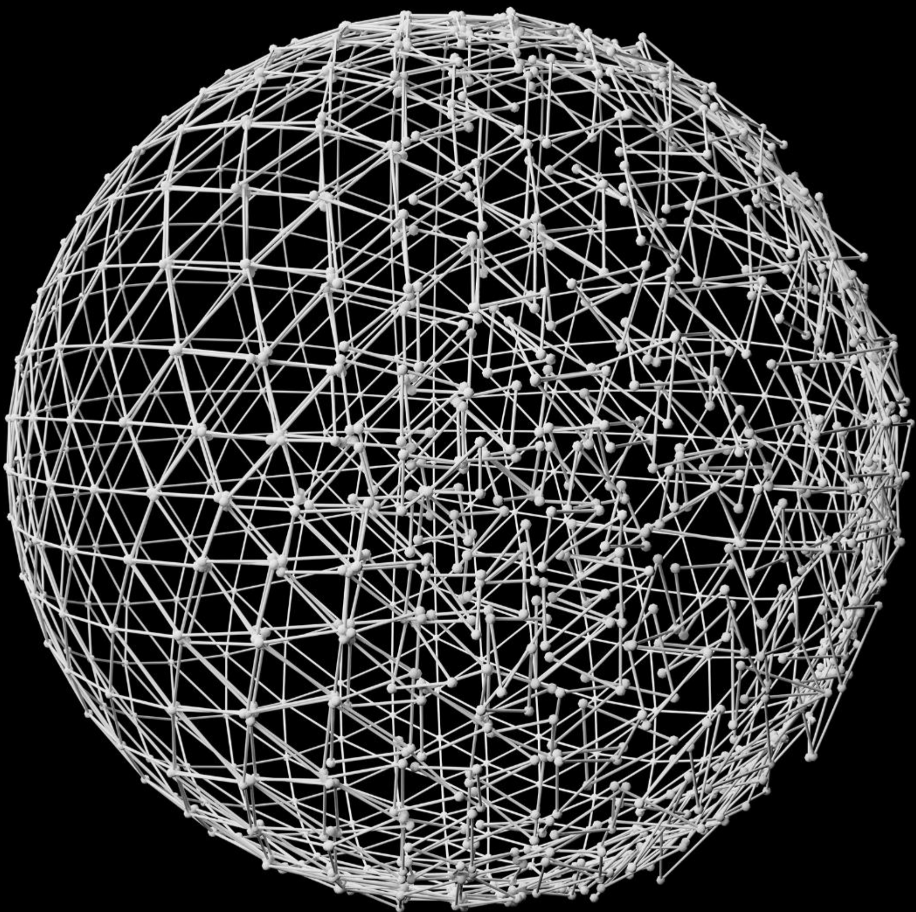


Economic impact of international connectivity and data centre development in Scotland

Final Report

21 September 2018

Important Notice

This Final report (the "Final Report") has been prepared by Deloitte LLP ("Deloitte") for Scottish Futures Trust's (SFT) in accordance with the contract with them dated 07 August 2018 ("the Contract") and on the basis of the scope and limitations set out below in the main report.

The Final Report has been prepared solely for the purposes of information, as set out in the Contract. It should not be used for any other purpose or in any other context, and Deloitte accepts no responsibility for its use in either regard

The Final Report is provided exclusively for SFT use under the terms of the Contract. No party other than SFT is entitled to rely on the Final Report for any purpose whatsoever and Deloitte accepts no responsibility or liability or duty of care to any party other than SFT in respect of the Final Report or any of its contents.

As set out in the Contract, the scope of our work has been limited by the time, information and explanations made available to us. The information contained in the Final Report has been obtained from SFT and third party sources that are clearly referenced in the appropriate sections of the Final Report. Deloitte has neither sought to corroborate this information nor to review its overall reasonableness. Further, any results from the analysis contained in the Final Report are reliant on the information available at the time of writing the Final Report and should not be relied upon in subsequent periods.

This document also includes certain statements, estimates and projections provided by SFT with respect to anticipated future performance. Such statements, estimates and projections reflect various assumptions concerning anticipated results and are subject to significant business, economic and competitive uncertainties and contingencies, many of which are or may be beyond the control of SFT. Accordingly, there can be no assurance that such statements, estimates and projections will be realised. The actual results may vary from those projected, and those variations may be material. Whilst we have commented on such statements, estimates and projections and their implications, we accept no responsibility for their accuracy or completeness and they are the sole responsibility of SFT.

We have conducted scenario analysis based on projections provided by SFT (these comprise our scenarios). The results produced by our scenarios under different assumptions are dependent upon the information with which we have been provided. Our scenarios are intended only to provide an illustrative analysis of the implications of SFT's projections. Actual results are likely to be different from those projected by the regulatory scenarios due to unforeseen events and accordingly we can give no assurance as to whether or how closely the actual results ultimately achieved will correspond to the outcomes projected in the scenarios.

Any decision to invest, conduct business, enter or exit the markets considered in the Final Report should be made solely on independent advice and no information in the Final Report should be relied upon in any way by any third party. This Final Report and its contents do not constitute financial or other professional advice, and specific advice should be sought about your specific circumstances. In particular, the Final Report does not constitute a recommendation or endorsement by Deloitte to invest or participate in, exit, or otherwise use any of the markets or companies referred to in it. To the fullest extent possible, both Deloitte and SFT disclaim any liability arising out of the use (or non-use) of the Final Report and its contents, including any action or decision taken as a result of such use (or non-use).

Contents

Glossary

4G	4G is the fourth generation of cellular network technology, succeeding 3G. A 4G system must provide capabilities defined by ITU in IMT Advanced.
5G	Fifth generation wireless (5G) is a wireless networking architecture built on the 802.11ac IEEE wireless networking standard, which aims to increase data communication speeds by up to three times compared to its predecessor, 4G (IEEE 802.11n).
Additionality	The extent to which the outcomes of a particular intervention would have not occurred in its absence.
Asymmetric Digital Subscriber Lines (ADSL)	ADSL is a type of digital subscriber line (DSL) technology, a data communications technology that enables faster data transmission over copper telephone lines than a conventional voice band modem can provide.
Bandwidth	In the context of telecommunications, bandwidth refers to the maximum data transfer rate of a network or internet connection. It measures how much data can be transferred over a particular connection in a given time. It is often measured in terms of megabits or gigabits per second.
Broadband	A high-capacity transmission technique using a wide range of frequencies, which enables a large number of messages to be communicated simultaneously.
Cloud computing	The practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer.
Co-location data centre	A colocation (colo) is a data centre facility in which a business can rent space for servers and other computing hardware. Typically, a colo provides the building, cooling, power, bandwidth and physical security while the customer provides servers and storage.
Counterfactual	In economics, a counterfactual refers to what would have happened if a particular policy or business decision did not take place.
Data Centre	Buildings or part of buildings that house the servers that store, manage and disseminate data and information systems
Direct impacts	The jobs and GVA supported from the first-round of direct expenditure.
Edge data centre	Micro-sized data centres that cache data to end users and connected devices sending and creating it.
Fibre optic lines	A high-speed data transmission medium. It contains tiny glass or plastic filaments that carry light beams. Digital data is transmitted through the cable via rapid pulses of light.
Fibre to the Premise (FTTP)	A pure fibre-optic cable connection running directly to the user's home or business.
Fixed Broadband	A term used to refer to internet access to fixed premise locations.
Gross Value Add (GVA)	A measure of output that adjusts for intermediate inputs to give a true measure of economic value. It is either defined as either GO less intermediate inputs, or the sum of pre-tax operating surplus (profit) and total wage payments (including taxes).
Hyper-scale data centre	A scaleable data centre that can expand on the needs of the business.
Indirect impacts	The jobs and GVA supported through the supply chain demand of the direct expenditure.
Induced impacts	The jobs supported and GVA generated through the consumer wage spend of the economic activity.

Internet of Things (IoT)	The network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect and exchange data, creating opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions
Latency	The amount of delay (or time) it takes to send information from one point to the next. Latency is usually measured in milliseconds. It is also referred to (during speed tests) as a ping rate.
Mobile Broadband	A term used to refer to access to the internet via a tablet, smartphone or other mobile devices.
Next Generation Access (NGA)	This term describes technologies that can deliver superfast speers including Fibre to the Cabinet (FTTC) or Fibre to the Premises (FTTP).
Over-the-top Providers	A term used to refer to content and other service providers that distribute streaming media as a standalone product directly to consumers over the Internet, bypassing telecommunications, multichannel television, and broadcast television platforms that traditionally act as a controller or distributor of such content.
Power Usage Effectiveness (PUE)	This is a metric used to determine the energy efficiency of a data centre. The ratio of total amount of energy used by a computer data centre facility to the energy delivered to computing equipment. PUE is the inverse of data centre infrastructure efficiency (DCIE).
Productivity	GVA per unit of output
Redundancy	Network redundancy is a process through which additional or alternate instances of network devices, equipment and communication mediums are installed within network infrastructure. It is a method for ensuring network availability in case of a network device or path failure and unavailability. As such, it provides a means of network failover.
Resilience	In computer networking: resilience is the ability to provide and maintain an acceptable level of service in the face of faults and challenges to normal operation.
Submarine cables	Any kind of cable that is laid on the seabed, although the term is often extended to encompass cables laid on the bottom of large freshwater bodies of water.
Superfast broadband	While there is no single agreed definition of what constitutes superfast broadband, for the purposes of this report, superfast broadband is sued to describe any broadband service that offers speeds of more than 30Mbps.
Tier 1, Tier 2, Tier 3 and Tier 4 data centres	The Uptime data centre tier standards are a standardised methodology used to determine the availability in a facility. In a nutshell, this means it is easy to establish whether a particular data centre is suitable for the needs of your business as data centres are clearly staged in tiers.
Ultra-fast broadband	Ultrafast broadband is the term given to a broadband product that has download speeds in excess of 100Mbps.

1 Executive Summary

Modern economies rely on fast and reliable digital connectivity to:

Improve access to public services and information

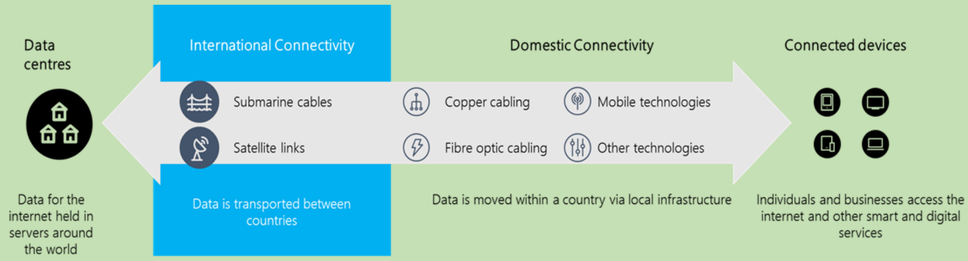
Take advantage of new technologies such as 5G, the Internet of Things and cloud computing

Provide new routes to market

Support innovation and new ways of working

The benefits of the resulting digitalisation include faster economic growth, more jobs, and savings and efficiencies for businesses.

A contributory factor to digitalisation is international connectivity which is the cables and links that connect and transmit data between countries.



Currently Scotland has fewer direct international connectivity links compared to similar economies.

Enhancing international connectivity into Scotland could:

Increase Scottish economic performance, by up to £0.4bn in additional GVA the long-term

Add up to 3,100 additional Scottish jobs in the long-term – many in highly productivity sectors

Raise productivity rates, new business growth rates and innovation

Improve Scottish competitiveness and internet resilience

Not enhancing international connectivity could result in lower long-term GVA, fewer jobs in high productivity sectors and lower digital resilience. Scotland risks being unable to take advantage of new technologies and not maximising its current competitive strengths.

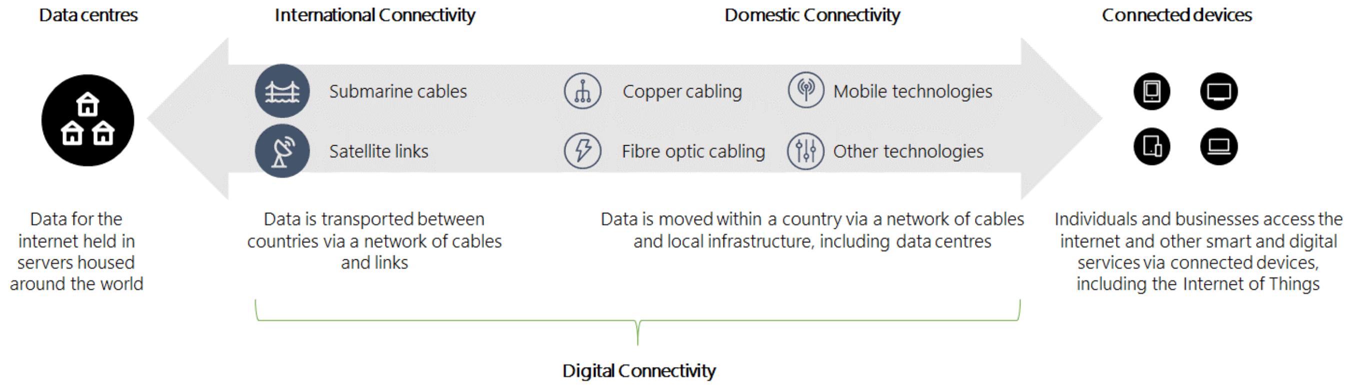
Taking steps to enhance international connectivity today and in a way that complements its existing Digital Strategy, can allow Scotland to create a mutually reinforcing circle of connectivity that allows it to deliver greater levels of prosperity quicker and across a wider area of the country.

1.1 Digitalisation and international connectivity

The evolution and successful transformation of the Scottish economy, brought about by new technologies, is dependent on access to fast and reliable broadband services ('digital connectivity'). The resultant benefits of 'digitalisation' are well known. Previous research by Deloitte[1] identified these as contributing to faster economic growth; creating more jobs; improving access to public services and information; and expanding markets. These benefits are realised as businesses, individuals and the government are able to realise the potential of cloud computing, 5G technologies, the Internet of Things (IoT) and Big Data, and new business models, products and services and working practices. Becoming a world-leader in digitalisation has been estimated as contributing to Scottish GDP rising by over £13bn by 2030.[2]

Two key infrastructure elements underpin a country's digital connectivity: the international connectivity network and the domestic connectivity network. The data required by the internet is not held in a single place or country; it is held in data centres distributed globally (see below), with the highest concentration in the USA. This means countries must connect to one another to access the data held in these data centres. Once this data and information lands 'onshore' inside a country's territory, it then needs to be distributed to end users. The interactions between the two elements of connectivity are shown below, ultimately supporting digitalisation via more connected devices.

Figure 1.1: International and domestic connectivity



Source: Deloitte analysis

The focus of this study is on international connectivity and data centre development in Scotland. Improvements in international connectivity can lead to improved performance in transferring data (latency) between countries, stronger internet resilience by having more cables serving a country and feed through into lower wholesale prices for service providers. These changes can ultimately lead to lower retail prices for business and domestic broadband services and increased take-up of services.

Currently there are three direct international submarine cables to Scotland, but only one of these carries data to/from Scotland directly (the other two bypass Scotland to go to London first). This situation contrasts unfavourably with other the rest of the UK and Nordic competitors where cables land and directly service domestic markets. In the UK, Northern Ireland has seven submarine cables and only one of these carries data to/from Northern Ireland directly; Wales has three submarine cables connected to England and Ireland; England has approx. 39 submarine cables and over half of the connections carries data to/from England directly.

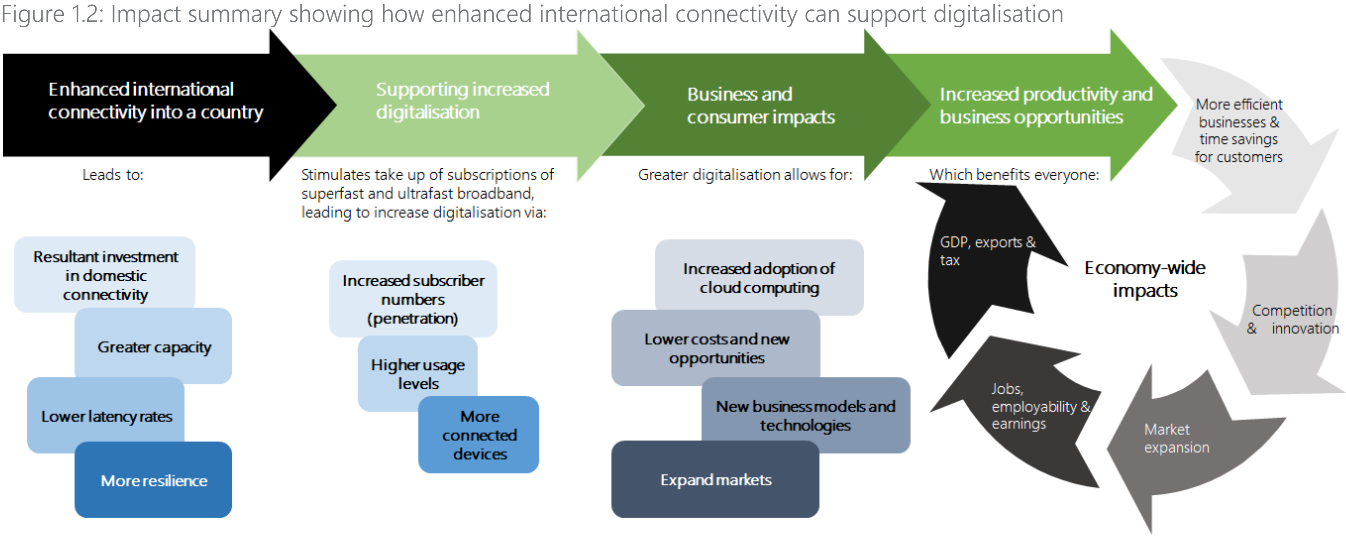
The Scottish Futures Trust has identified a strategic benefit from enhancing international connectivity, developing a strong domestic datacentre sector and improving domestic connectivity. Deloitte has considered whether there is evidence that this strategic case could result in economic benefits for Scotland.

Based on the academic literature, stakeholder discussions and examples from analogous sectors, we have created a framework linking changes to international connectivity and improvements in digitalisation. The benefits of international connectivity through digitalisation have been modelled as contributing to an increase in the number of people and businesses in Scotland subscribing to fixed and mobile broadband services in Scotland due to improved quality of service, better value-for-money and greater resilience.[3] This in turn supports increased digitalisation through increased penetration of broadband, a better quality of service driving higher

[1] See *The economic and social impacts of enhanced digitalisation in Scotland*, 2015, available at: https://www.scottishfuturestrust.org.uk/storage/uploads/impact_of_digitalisation_in_scotlandcompressed.pdf
[2] Quoted in above.
[3] In particular, services that offer superfast and higher speeds.

usage of more connected devices, which ultimately drives improvements in economic outcomes such as GVA and employment via productivity uplifts, new business growth and innovation.[4]

Figure 1.2: Impact summary showing how enhanced international connectivity can support digitalisation



Source: Deloitte analysis

Further follow-on benefits of international connectivity beyond digitalisation include supporting accelerated growth in the local data centre industry. Here, businesses can take advantage of reduced barriers to entry and growth enabled by lower latency rates for data transfer to expand and invest in data centres, creating jobs and spill over benefits. Currently, less than 5% of the UK's data centre industry is located in Scotland, with Gartner noting that some of Scotland's largest private sector organisations currently choose data centre providers in London, even though Scotland has a number of relative advantages to the rest of the UK through lower average temperatures and access to renewable energy sources.

1.2 The economic benefits of enhanced international connectivity in Scotland

Given the inherent uncertainty and lack of available evidence on the precise relationship between changes to international connectivity and digitalisation and data centres, Deloitte has worked with SFT to develop three potential scenarios. These scenarios seek to provide an indication of the level of economic benefits that could arise from investments in enhanced international connectivity under different modelling assumptions. The likelihood of each individual scenario has not been considered as this will depend on further details on the nature and size of investment in enhanced connectivity and supporting initiatives.

Across three modelled scenarios with different rates of subscriber take-up impact and data centre investment levels, quantitative analysis by Deloitte suggests that enhancements in Scottish international connectivity[5] might be expected, alongside other important contributory factors, such as investments in local telecommunications infrastructure, to result in annual Gross Value Add (GVA)[6] being between £0.2bn and £0.4bn higher each year in the long-term. Deloitte also estimates that between 1,300 and 3,100 additional jobs could be created across Scotland in the long-term across different scenarios.[7] Below, these impacts are presented as disaggregated across their three contributory drivers (i.e. the core economic impacts from more fixed line subscribers, more mobile line subscribers and more data centres). The differences in estimated impacts stem from different assumptions around how long-lasting the impact on subscriber numbers is[8] and the size of data centre investment.

[4] Given data availability, the impact of enhanced international connectivity has been modelled as a change in the number of broadband subscribers. This is a proxy approach to how international connectivity has a tangible impact on metrics – alternatives might include the quality and speed of connection.
[5] In addition to the impact of previous digitalisation scenarios.
[6] GVA is analogous to GDP.
[7] Of this figure, between £90m and £200m is additional and over and beyond the previous £13bn estimate, coming from data centres taking advantage of enhanced international connectivity. The estimate of jobs created per data centre of between 90 and 140 is comparable to the 157 jobs quoted per data centre in the USA in a recent publication *DataCentre Job Creation 'Fact Fest' Throwing Numbers at IT.* Job numbers refer only to operational jobs in the long-term, i.e. not jobs involved in constructing a new cable or new data centres.
[8] That is to say, at what point after the initial enhancement do subscriber numbers cease to grow due to improved international connectivity.

Figure 1.3: Scenario Summary of enhanced international connectivity in Scotland in long-term (2030)

		Fixed Connectivity impact	Mobile Connectivity impact	Data Centres impact	Total impact
Scenario one – one-off connectivity improvement and incremental data centre growth					
Total (direct, indirect and inducted impacts)	Employment	30	260	980	1,270
	Value Added (£m)	10	60	90	160
	Expenditure (£m)	20	110	150	280
Scenario two - persistent connectivity improvement and accelerated data centre growth					
Total (direct, indirect and inducted impacts)	Employment	170	530	1,420	2,120
	Value Added (£m)	60	120	130	310
	Expenditure (£m)	100	220	210	540
Scenario three – persistent connectivity improvement and very significant growth in data centres					
Total (direct, indirect and inducted impacts)	Employment	170	530	2,400	3,090
	Value Added (£m)	60	120	210	390
	Expenditure (£m)	100	220	350	690

Source: Deloitte analysis. Note numbers do not sum precisely due to rounding. Full results and methodological details are provided in the body of the main report and Annex 1. Our estimates are additional to the baseline of no enhanced international connectivity. This baseline assumes 'business as usual' for digital connectivity in Scotland. This builds on the 'efficient markets' thesis that assumes commercially available forecasts for the Scottish economy factor in publicly-known, planned investments by the Scottish Government under the Digital Scotland Superfast Broadband (DSSB) programme. Value added here refers to profits and wages; expenditure also includes intermediate consumption.

The jobs and GVA growth will be achieved through a combination of mechanisms, including the formation of new businesses to take advantage of enhanced connectivity and digitalisation, expansion of existing businesses into new markets or offering new products, improved domestic competition stimulating economic activity and Scotland becoming a more attractive place to invest. While there may be creative destruction effects of firms that do not take advantage of digitalisation being out-competed, this is likely to be offset by new firms emerging and overall increases to productivity. We expect that over the three scenarios, over half of the new jobs created due to fixed and mobile connectivity impacts could be achieved via new business creation; this is equivalent to 13% of all the additional jobs, that is between c.200 and 400 jobs. Most jobs created by data centre expansion will be from existing firms rather than new firms, based on stakeholder discussions that most new data centres will be developed by existing providers.

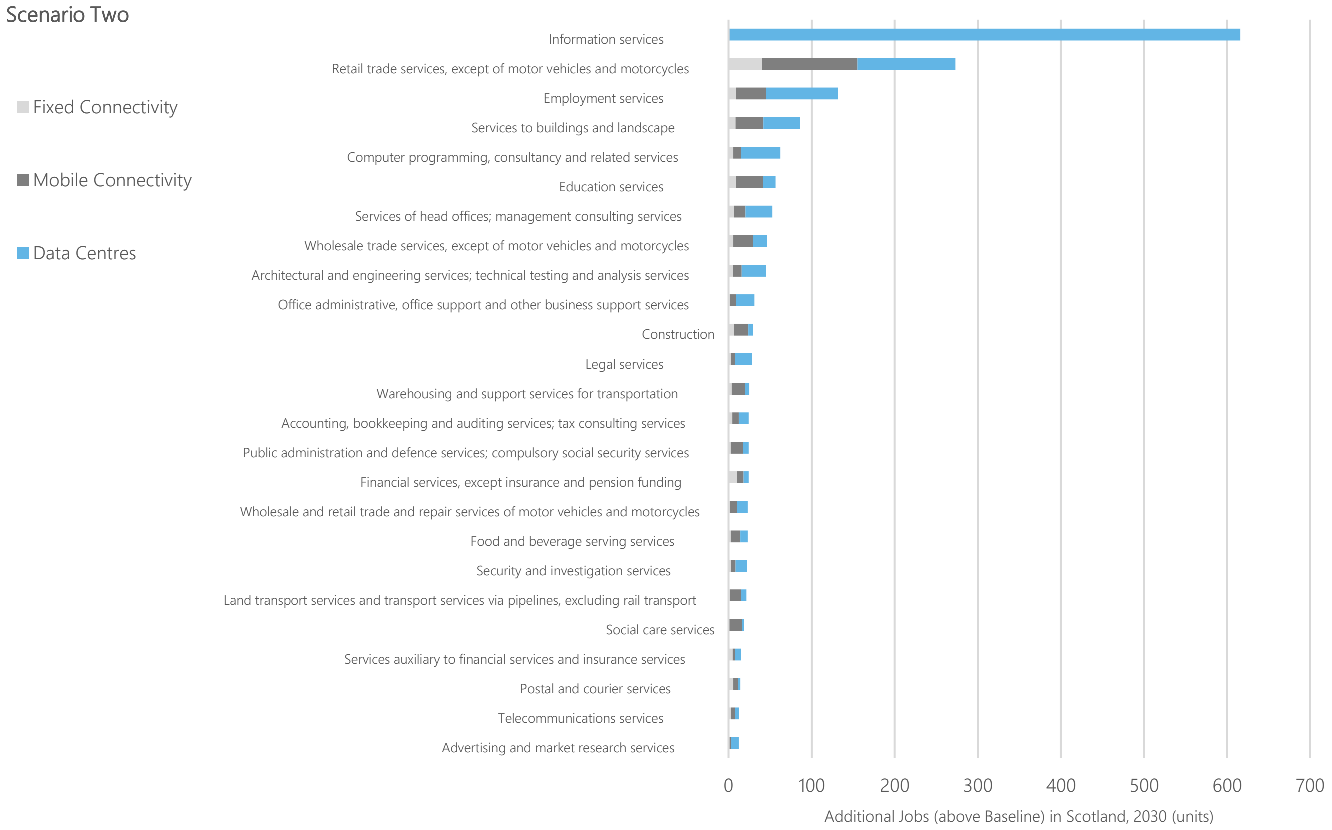
Drawing on published methodologies[9], the rate of new business growth in Scotland is expected to be permanently 1.6% higher from 2021 (with no adjustment to the business death rate) due to enhanced connectivity. Similarly, we estimate that at least 13% of the GVA and job benefits could be attributable to innovation via market growth and new products and services.

With respect to productivity changes, these jobs and GVA occur in high-productivity sectors of the Scottish economy and will result in more high-productivity jobs being created. Average productivity per worker is as much as £145,000 in the long-term in the relevant technology and communications sectors compared to an economy-wide Scottish estimate of £55,000. In those sectors most affected by improved mobile connectivity, productivity is, on average, 3.7% higher than the baseline of no enhanced international connectivity.

The split in jobs across sectors due to the fixed, mobile and data centre impacts are shown below for Scenario Two – the medium case - as an example (full results in main report text).

[9] See Chapter 5 and appendices for a full list of references and methodological details.

Figure 1.4: Job impact by sector, Scenario Two, 2030



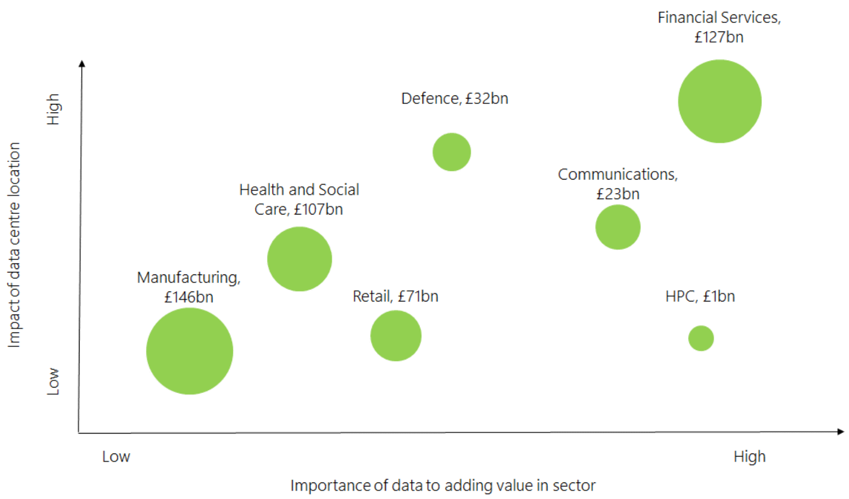
Source: Deloitte

The largest job impacts come from data centres, particularly in the information services sector of the economy which will contain many of the wider eco-system industries supporting data centres and cloud computing. Across other Scottish sectors, the benefits arising from enhanced connectivity causing greater digitalisation via more fixed and mobile subscribers is more widely distributed across, reflecting how the wider economy can benefit from better quality of service, access to markets and access to new services. The retail sector, in particular, benefits from enhanced mobile connectivity, as does the education sector that, in turn, can catalyse spillover effects around skills, social inclusivity and connectivity. In 2030 (the long-term), the impact on the telecommunications service sector is relatively smaller given that the major CAPEX has occurred earlier in the period hence the investment is already in place.

While not modelled explicitly, one might expect to see agglomeration benefits occur as data centres and supporting industries cluster in the same areas. These might include economies of scales and higher productivity levels. As set out in Chapter 3, KTN[10] reports that clustering is particularly important for data centres. Data centre clusters are shown to support the growth of allied industries of financial services and communications.

[10] See *The Big UK Data Centre Equipment Opportunity*, KTN, available at: https://admin.ktn-uk.co.uk/app/uploads/2016/12/KTN_A4_Big-Data_v9.pdf

Figure 1.5: Data centres clustering in the UK



Source: adapted from KTN

While the above clustering impacts refer to the UK, the structure of the Scottish economy is similar enough to infer a similar level of data clustering could occur.

However, as Glaeser (2010) points out, the extent of any agglomeration benefits in Scotland will also be contingent on transport networks, human capital and other urban development policies.[11]

The growth in the data centres sector also stimulates job creation in other high productivity sectors such as computer programming (including data science) and professional services.

1.3 Competitiveness and other benefits

The benefits to Scottish competitiveness are similar to those previously outlined in the enhanced digitalisation report.[12] These include:

- Improved resilience and latency rates that can complement other competitive strengths around renewable energy and skills to grow technology-dependent sectors; and
- Opportunities to extend marketplaces via online platforms to create new routes to Scottish and other markets for all businesses.

More specifically, enhanced international competitiveness could contribute to Michael Porter's 'diamond of national advantage' which measures the competitiveness of nations.[13] It could:

- Enhance Scotland's 'factor conditions' including telecommunications and skills infrastructure, providing the requisite factors for businesses to be able to compete and attract investment;
- Contribute to 'demand conditions' with the new connectivity stimulating demand for data services to take advantage of improved quality of service;
- Support the growth of 'related and supporting industries' that can support agglomeration (see below); and
- Improve domestic competition by removing barriers to entry, lowering costs to compete and stimulating opportunities to both collaborate and compete.

There are also likely to be spill over economic benefits to the rest of the UK in the form of supply-chain and consumer spending impacts, greater internet resilience and increased competition.

Enhanced international connectivity also has the potential to bring a number of other economic benefits beyond GVA, jobs and productivity in Scotland. These include:

- An improved quality of service for large-scale users through improved latency, which can help build a competitive edge in sectors such medical technologies and financial services;
- Cost savings from greater digital resilience (reducing the probability of outage by increased redundancy);

[11] Source: Agglomeration Economics, 2010, introduction available at: http://www.nber.org/chapters/c7977.pdf
[12] See https://www.scottishfuturestrust.org.uk/storage/uploads/impact_of_digitalisation_in_scotlandcompressed.pdf for more details.
[13] See https://hbr.org/1990/03/the-competitive-advantage-of-nations

- Costs savings from greater digital connectivity supporting efficiencies such as time savings and reduced distribution costs;
- Attracting FDI to take advantage of the improved digital infrastructure;
- Fiscal benefits from tax raised from new businesses;
- Positioning Scotland to test and pilot new IoT and 5G technologies that require low levels of latency; and
- Supporting key strategic industries evolve, such as the oil and gas sector, which can use connectivity to support decommissioning and the transition to other services.

1.4 Wider benefits from enhanced international connectivity across the UK

Enhancing international connectivity will have wider benefits for the rest of the UK. These will include:

- Improved resilience to the whole UK from Scotland having enhanced international connectivity, providing redundancy if all links to other parts of the UK were damaged or suffered from an outage;
- Supply chain and consumer spending impacts that occur outside of Scotland due to enhanced international connectivity;
- Increased competition in the data centre industry, stimulating lower prices and better customer services; and
- Wider FDI flows that benefit UK plc.

It should be stressed that the benefits to the Scottish (and UK) economy will come from international connectivity catalysing, supporting and reinforcing improvements in domestic connectivity. Simply investing in international connectivity alone will not yield the above benefits. As reported by a number of stakeholders, investments in domestic connectivity, such as supporting digital skills and building new local telecoms infrastructure could, on their own, also improve overall digital connectivity when compared to investments in international connectivity. Importantly, facilitating investment in enhanced international connectivity is only one part of the puzzle in improving overall digital connectivity.

Indeed, this is well recognised, with the £412m Digital Scotland Superfast Broadband (DSSB) programme investing in rolling out fibre technology across the entirety of Scotland. The DSSB programme is being delivered through two regional projects: the Highlands and Islands project and the Rest of Scotland project. The Reaching 100% Programme (R100) builds on DSSB and seeks to extend the availability of superfast broadband infrastructure across the nation. This is a unique commitment across the UK in that its objective is to deliver 100% superfast broadband coverage across Scotland by 2021. Any home or business that cannot have superfast broadband delivered commercially – or through programmes such as DSSB or Community Broadband Scotland ("CBS") – will be eligible for investment through the R100 programme. With respect to mobile connectivity. SFT played a leading role in the development of the Scottish 4G Infill programme (S4GI) that will facilitate the deployment of mobile infrastructure across rural Scotland to facilitate the extension of 4G coverages in mobile 'not spots'. A strong datacentre sector, with a number of international subsea connections is an integral element that underpins the development of a 5G strategy for Scotland where latency and edge computing are required to support the success and adoption of new use cases, especially as this is made more difficult due to the "long" transit times currently encountered via either Manchester or London.

Thus, there is a risk that without the continued enabling investment and focus on domestic connectivity, the value of enhanced connectivity could flow out of Scotland.

1.5 The impact of not enhancing international connectivity in Scotland

Over the period considered (2018-2030, with 2021 being when enhanced connectivity is assumed to be achieved), *not* enhancing international connectivity could result in between £1.6bn-£4.4bn in foregone GVA in Scotland (not NPV adjusted) over these twelve years.[14] Over the period, not enhancing international connectivity could result in up to 3,100 fewer jobs in 2030.

In addition to lower GVA and fewer jobs, Scotland could also miss the following benefits that arise from the virtuous circle between international and domestic connectivity:

- Increased internet resilience with respect to international connectivity;
- More data centres locating to Scotland to take advantage of lower latency and other comparative advantages Scotland has;
- The opportunity to be a test-bed for new technologies that require lower latency;

[14] Net Present Values have not been calculated as this is not cost-benefit analysis and costs have not been estimated or considered.

- Attracting financial services, med-tech and other sectors that require low latency levels to locate in Scotland to take advantage of enhanced international connectivity; and
- The opportunity to use enhanced international connectivity to catalyse other domestic connectivity targets and other domestic policy goals.

The loss of internet services caused by disruption in international connectivity can be highly disruptive to modern economies. Based on estimates of costs of internet outage, a rough estimate of the loss of internet activities across the UK caused by no international connectivity could be in the order of £3.2bn per day.[15] Having an additional cable to Scotland could provide further mitigation against such a risk.

1.6 The role of government in enhancing international connectivity

Typically, investments in international submarine cables are made by private consortia rather than the public sector, driven by expected commercial returns achievable from their capital expenditure.[16] Stakeholders report that currently this is unlikely to occur in Scotland due to the relatively small market and that overall the UK has substantial international cable connectivity via England. However, if this investment does not occur, Scotland risks losing the economic benefits of enhanced connectivity within its borders and relying on external providers of data centres, creating a vicious circle whereby there will never be a case for international connectivity investment.

This suggests there may be a role for a public sector-led intervention with respect to international connectivity in order to 'crowd-in' investment to improve international connectivity and stimulate demand for data centres, which require faster connectivity. This investment does not necessarily have to be via a brand new trans-Atlantic submarine cable; other European-based cabling solutions might offer enhanced international connectivity to Scotland, albeit at different levels.

Policy interventions to support enhanced international connectivity could take a number of forms, including:

- Partnering with the private sector to invest in a new submarine cable and acting as a Market Economic Operator ("MEO");
- Offering, or providing access to, competitive financing to the private sector to invest in enhanced international connectivity using initiatives such as the Building Scotland Fund ("BSF") and/or the forthcoming Scottish National Investment Bank ("SNIB");
- Creating the 'right' commercial environment for private sector investment in international connectivity through incentives and/or regulation for the public and private sector to use Scottish data centres;
- Develop 'use cases' and demand analysis for the private sector to demonstrate the business case for investment in international connectivity; and
- Running innovation competitions to test, pilot and rollout new solutions for international connectivity and widen understanding of drivers for the datacentre market.

The precise mix of policy interventions would need to be explored more thoroughly and analysed to understand which provides the best value for money for Scottish taxpayers whilst enhancing digital connectivity, the user experience and driving the economy. The next step is therefore a more detailed options analysis, the associated cost-benefit appraisal and consideration of the different public sector support mechanisms. Such an appraisal should also consider different funding and financing options, the appropriate mix of public and private investment and any policy and legal constraints.

1.7 Concluding thoughts

The Scottish Futures Trust has identified a potential strategic benefit from enhancing international connectivity. Deloitte has considered whether there is evidence that this strategic case could result in economic benefits for Scotland. The evidence and analysis suggests that the benefits from enhanced international connectivity supporting greater digitalisation could be significant.

The size of economic benefit to Scotland and the contribution to digitalisation from a relatively modest investment of around £45m for a Scottish submarine spur to improve international connectivity are significant and long-lasting.[17] Enhancing international connectivity can arguably serve to accelerate digital connectivity nationally, help kick-start particular industries and the use of technologies, and align with wider strategic objectives to build Scottish resilience and promote economic development more equally

[15] Based on a scaling up using GDP ratios of the $10m daily loss of internet citied publicly for countries that lost connectivity.
[16] See https://subtelforum.com/ for different examples.
[17] Source: SFT estimate of capital cost provided by industry. Although, to fully capture the benefits of enhanced international connectivity, investment is required in domestic connectivity and the local ecosystem of skills and other relevant factors.

across the UK economy. As noted by one stakeholder consulted for this report, investing in submarine cables is a way of sustainably maximising the value of seabed and other marine assets.

Scotland has an opportunity to enhance its international connectivity and use this in a way to complement its existing Digital Strategy, creating a mutually reinforcing circle of connectivity that allows it to deliver greater levels of prosperity quicker and across a wider area of the country.

2 Introduction

2.1 Scope and purpose of this report

The Scottish Government aims to create a more sustainable and successful Scotland through promoting inclusive economic growth. One of the key enablers of this ambition is investing in digital and telecommunications infrastructure. The government's digital strategy sets out a number of actions that collectively seek to harness the benefits of digital to deliver a step-change in productivity.[18] In particular, it targets achieving high-quality digital connectivity levels across the entirety of Scotland of at least 30 megabits per second (Mbps) by 2021, having 4G connectivity along the length of all A and B roads and major rail routes, and providing all cities with internationally competitive levels of digital connectivity.

To date, the Digital Scotland Superfast Broadband programme (DSSB) has delivered access to fibre broadband to 85% of Scottish premises and provided £7.5m in funding and support for Community Broadband Scotland through a series of programmes. The Mobile Action Plan is working to improve mobile connectivity across the country.[19] Scotland is also taking part in a 5G testbed trials for the next generation of wireless networks.[20]

The Scottish Futures Trust (SFT), an infrastructure delivery company wholly owned by the Scottish Government, plays a key role in developing the roadmap that will support the government's digital strategy. It played a leading role in the development of the Scottish 4G Infill programme (S4GI) that will facilitate the deployment of mobile infrastructure across rural Scotland to facilitate the extension of 4G coverages in mobile 'not spots'. The SFT also works with industry to promote innovation in the sector, develop the right mechanisms, incentives and commercial models for the roll-out of new services and infrastructure, and invests in pilot programmes. As part of its role and focus, SFT seeks to understand and disseminate how money can be best spent on interventions to meet the government's digital aims in a way that represents value for money, appropriate commercial returns and driving inclusive economic growth.

The SFT has commissioned Deloitte to undertake an independent analysis to understand and quantify the wider economic benefits of improved international connectivity to Scotland. In particular, the analysis will cover:

- Identifying and quantifying the economic benefits of enhanced connectivity in Scotland compared to the status quo;
- Exploring how enhanced connectivity can support and/or complement the expansion of the data centre industry in Scotland and the what the resultant economic benefits would be; and
- Exploring how, together, enhanced connectivity and a larger data centre industry in Scotland could benefit the rest of the UK.

A key part of the context to this study is to understand the economic case for enabling and investing in opportunities to land international submarine cables to Scotland that will bring direct connectivity with the East Coast of America and parts of Europe. Such direct international connectivity could provide greater resilience, lower latency (fewer delays), a better quality of service, lower costs and also accelerate growth in data centres, complementing and enhancing other policy interventions aimed at improving domestic connectivity.

Of course, securing a new submarine cable is not the only route to improving international connectivity for Scotland (i.e. undersea cabling over shorter distances such as the North and Irish seas), and domestic fixed and mobile broadband speeds can be improved independently through 'onshore' investments in fibre optic cabling and other infrastructure. Further, international connectivity is only one of a number of factors that can help grow the domestic data centre industry. However, as this report identifies, improved international connectivity via a new submarine cable could have a number of positive economic (and wider) impacts that can serve to *catalyse*, *complement* and *accelerate* domestic connectivity and the data centre industry, and is an important part of solving the wider connectivity challenge for Scotland.

[18] See *Realising Scotland's Full Potential in a Digital World: A Digital Strategy for Scotland*, available at: http://www.gov.scot/Resource/0051/00515583.pdf
[19] See https://beta.gov.scot/policies/digital/broadband-and-mobile/ for more details.
[20] See https://www.scotsman.com/regions/inverness-highlands-islands/scottish-testbed-announced-ahead-of-the-5g-mobile-broadband-revolution-1-4703351

2.2 Approach taken

The analysis presented in this report has been completed over eight weeks between July and September 2018. The broad approach taken by Deloitte has been as follows:

- A literature review to define key terms such as 'connectivity', 'data centres' and inform the benefits framework tracing changes to levels in connectivity to changes in wider economic outcomes such as jobs, GVA and productivity;
- Primary research in the form of stakeholder discussions across industry, government and with Deloitte subject matter experts to test hypotheses on how connectivity can be achieved practically;
- Secondary data collection from a range of sources including the Scottish Government, Ofcom, the Department for Digital, Culture, Media and Sport (DCMS), private sector research providers and international statistical agencies;
- The development of an analytical model quantifying the economic impact of changes to connectivity in Scotland, and the complementary impact on the data centre industry; and
- Understanding and identifying the 'counterfactual' of what will happen if there are no improvements to international connectivity.

Throughout this engagement, Deloitte has been supported by the team at SFT and would like to record its thanks.

2.3 Limitations

The analysis presented in this report is based on the available data and eight weeks resourcing. To reflect data gaps and uncertainties, a number of assumptions and scenarios have been used, and are documented in this report, especially with respect to any quantitative estimates. As improved data becomes available and policy positions are confirmed, the analysis may need to be refined and updated.

The analysis has focused only on economic impacts; other benefits from enhanced connectivity and a more mature data centre industry in Scotland such as social and community benefits have not been considered. The strategic case for enhanced connectivity has been taken as given from SFT. Equally, the costs of enhanced connectivity and associated policy interventions have not been considered, nor have any constraints or conditions such as State aid.

2.4 Structure of this report

This report is structured as follows:

- Chapter 3 provides definitions and considers the growing demand for connectivity and its resultant benefits;
- Chapter 4 considers the current state of connectivity in Scotland and future plans to improve it;
- Chapter 5 quantifies the benefits of enhanced international connectivity in Scotland (and the rest of the UK) across different scenarios. This chapter also considers the associated benefits for the data centre industry in Scotland;
- Chapter 6 presents the 'counterfactual' or what could happen if international connectivity in Scotland is not enhanced; and
- Chapter 7 explores the role the Scottish Government could play in addressing connectivity gaps.

Technical details of the modelling approach are set out in annexes.

3 Digital Connectivity and Data Centres

3.1 Digital Connectivity

The importance of connectivity to a modern economy is well known. Whether it refers to the ease and speed with which one can travel, being part of social, commercial and academic networks or the ability to access power, water or telecommunications, connectivity is a key contributor to productivity and economic prosperity. Particularly important for the 21st century, is the role of *digital connectivity*, defined as access to a fast and reliable (fixed or mobile) internet connection that allows individuals and businesses to benefit from smart and digital services (i.e. not just traditional voice and broadband access services). The Scottish Government's March 2017 Digital Strategy confirms the importance of digital connectivity in its supporting wider objectives around promoting economic growth and enabling citizens' access to online public services.[21]

For the purposes of this report, digital connectivity (or 'connectivity' for short as we will refer to it) is defined as being agnostic as to how citizens and businesses connect to the internet (i.e. through fixed lines or mobile, via a range of IoT devices). It is also agnostic to how the information and data required to power the internet is delivered to these devices (i.e. via ADSL copper telephone lines, fibre-optic cabling, wireless networks or another technology).

There is no single definition of what 'fast' internet refers to when it comes to internet speeds and initially the UK Government used a definition of 24Mbps as the standard measure. This speed was initially adopted by the Scottish Government, but subsequently raised to at least 30Mbps as a part of the Digital Scotland –Reaching 100% Programme, which is also consistent with Ofcom's definition of 'superfast' broadband.[22] We will use this definition. Reliability in this context refers to minimised outages, with access referring to geographic coverage of connectivity (within and outside premises).

A strong datacentre sector, with a number of international subsea connections is an integral element that underpins the development of a 5G strategy for Scotland where latency and edge computing are required to support the success and adoption of new use cases, especially as this is made more difficult due to the "long" transit times currently encountered via either Manchester or London.

3.1.1 The benefits of digital connectivity

The benefits of digital connectivity and digitalisation are well known. These benefits go beyond the first-wave adopters and those in the ICT supply chain. Indeed, the ICT industry is no longer an isolated industry or a supporting industry to other sectors. It is an essential success factor and irreplaceable part of the value chain of almost *every* industry in the modern economy. Most of the business activities of international companies (no matter from which industry) rely heavily on being connected internally and externally via internet. The Scottish Digital Strategy's Evidence Paper highlights a study for the OECD across 25 countries between 1996 and 2007 found a 10% increase in broadband penetration increased GDP per capita growth between 0.9 and 1.5 percentage points.[23] A World Bank study similarly found that across 66 developed countries, an equivalent rise in broadband penetration could lift GDP growth rates by 1.2 percentage points.[24] Previous research by Deloitte (on behalf of SFT) has estimated that if Scotland became a 'world leader in digitalisation' it could enjoy an increase of £13bn in GDP by 2030.[25] These benefits could grow further with the advent of new technologies such as 5G that facilitate faster speeds and higher quality of service.

Indeed, the previous Deloitte analysis for SFT highlighted the different dimensions of economic impact brought about by digitalisation, which in turn was powered by digital connectivity.

[21] Available at: https://www.gov.scot/Publications/2017/03/7843

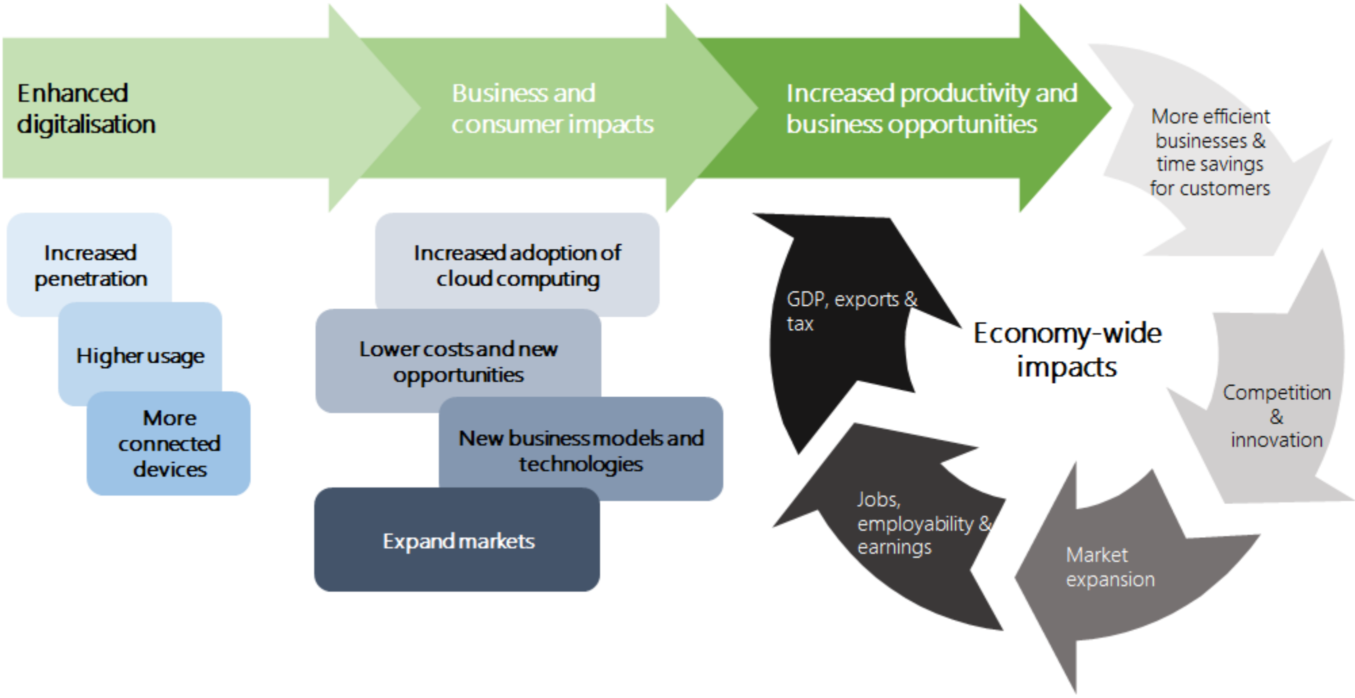
[22] See *Connected Nations 2017*, Ofcom reference, available at https://www.ofcom.org.uk/__data/assets/pdf_file/0024/108843/summary-report-connected-nations-2017.pdf. It should be noted that the UK Government (guided by the European Commission) is now targeting faster rates of at least 100 Mbps.

[23] Available at: https://www.gov.scot/Publications/2017/03/6814

[24] See *Exploring the Relationship between Broadband and Economic Growth* (WDC) by Michael Minges for the World Bank, available at: http://documents.worldbank.org/curated/en/178701467988875888/Exploring-the-relationship-between-broadband-and-economic-growth

[25] See *The economic and social impacts of enhanced digitalisation in Scotland*, available at: https://www.scottishfuturestrust.org.uk/storage/uploads/impact_of_digitalisation_in_scotlandcompressed.pdf

Figure 3.1: Benefits of digitalisation



Source: Deloitte, SFT

Access to reliable and fast connectivity to the internet can also allow businesses to take advantage of new technologies that offer cost savings, exploit opportunities to bring new products and services to market and consider new routes to reaching end customers. As a driver of productivity, digital connectivity can also help reduce barriers to entry/expansion in markets, increasing competition, and creating incentives to innovate.

Other benefits from digital connectivity include reducing the need to travel to work, which provides greater convenience and flexibility, and ultimately reduces individuals' and businesses' carbon footprints. Improved digital connectivity can also increase access to public and commercial services, addressing issues of social exclusion and social mobility.

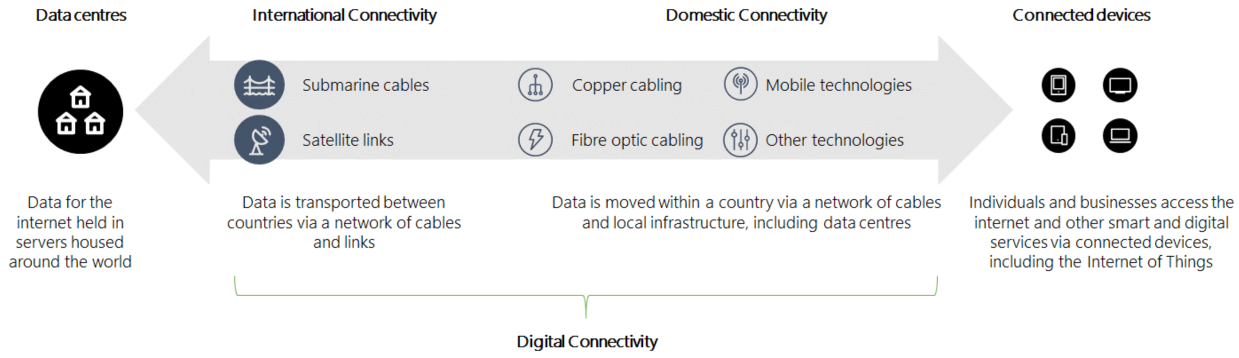
Finally, having a strong digital connectivity backbone in Scotland will also position it to take advantage of the promise of 5G and exploit the ongoing rise of the IoT, in particular transformative technologies such as connected and autonomous vehicles and artificial intelligence, and robotics that rely on strong levels of digital connectivity which will be powered by initiatives such as R100.[26]

3.1.2 International and domestic connectivity

Two key infrastructure elements underpin a country's digital connectivity: the international connectivity network and the domestic connectivity network. The data required by the internet is not held in a single place or country; it is held in data centres distributed globally (see below), with the highest concentration in the USA. This means countries must connect to one another to access the data held in these data centres. Once this data and information lands 'onshore' inside a country's territory, it then needs to be distributed to end users. The interactions between the two elements of connectivity are shown below, ultimately supporting digitalisation via more connected devices.

[26] See *The Impacts of mobile broadband and 5G: a literature review for DCMS* for more details of different 5G scenarios, available at: http://www.mobileuk.org/cms-assets/The%20Impacts%20of%20Mobile%20Broadband%20&%205G.pdf

Figure 3.2: International and domestic connectivity



Source: Deloitte analysis

While the focus of this report is on the impact of enhanced international connectivity in Scotland, its link to domestic connectivity, as shown in Figure 3.2, is critical for promoting wider digital connectivity outcomes. Focusing solely on international connectivity without considering the domestic infrastructure risks losing the benefits of both. Stakeholders spoken to as part of this study agreed that improved international connectivity could, all things being equal, likely lead to a rise in domestic connectivity via improved consumer services offerings caused by lower latency, better resilience and lower costs, taking Digital Scotland R100 Programme, 5G Testbed Initiative and 4G Infill Initiatives into account. One stakeholder further suggested that a new submarine cable landing in Scotland could catalyse investments in fibre cabling in and around the landing point, which could also improve domestic connectivity.

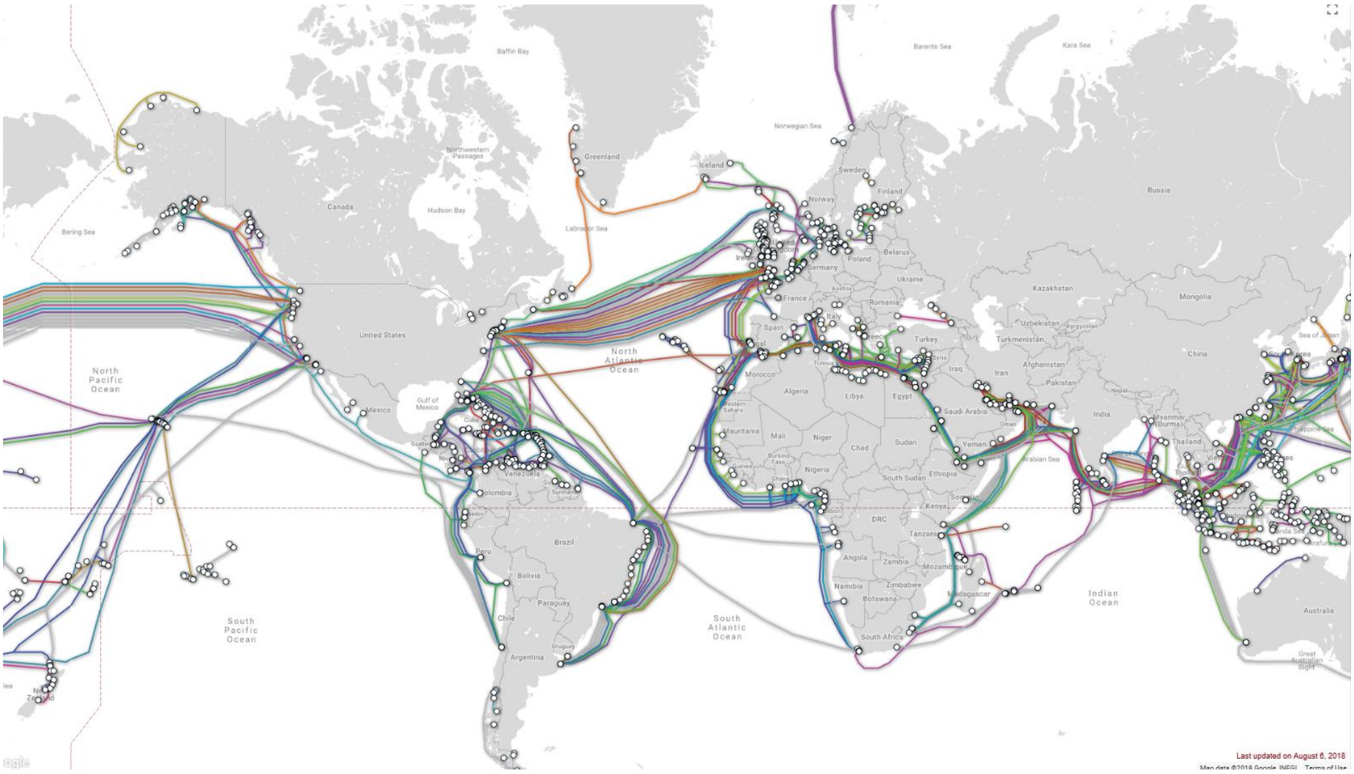
The following sub-sections describe international and domestic connectivity in more detail.

3.1.2.1 International connectivity

There are two main ways in which international connectivity can be provided into a country: via submarine cables or through satellite links. Currently, submarine cables are the preferred technological solution as, on average, they can transfer IP packets over long distances at least five times faster than satellites and at much lower costs.[27] As noted in Scotland's National Marine Plan, around 95% of all international telecommunications traffic is carried via submarine cables. Globally, there are over 400 submarine cable systems with over a million kilometres of fibre optic cables.[28] The length of cables varies considerably, with the UK-Ireland CeltixConnect cable being less than 150km, compared to the Asia America Gateway cable being over 20,000km.

[27] See *Undersea cables, indispensable, insecure* by Policy Exchange, available at: http://www.mobileuk.org/cms-assets/The%20Impacts%20of%20Mobile%20Broadband%20&%205G.pdf
[28] Source: TeleGeography, https://www2.telegeography.com/submarine-cable-faqs-frequently-asked-questions

Figure 3.3: Global telecommunications submarine cables map



Source: TeleGeography, https://www.submarinecablemap.com/

Low levels of latency (the amount of time a data packet takes to reach its recipient) is a key advantage of submarine cables. Whereas a satellite can take around 650 microseconds (msec) to deliver an IP packet between Japan and the USA, a submarine cable takes around 120 msec. Such differences in latency are particularly noticeable for businesses in sectors that depend on low levels of latency for comparative competitive advantage such as high frequency traders; but also sectors where a delay could be critical for operational reasons such as tele-medicine that relies on high-quality video links. Cable capacities vary between cables, with newer cables able to carry much more data than previous generations. As an example, the new MAREA cable between the USA and Spain is capable of carrying 160 Tbps.

Submarine cables are typically installed by private telecommunications carriers, often in consortia.[29] A trend in recent years has been the much greater involvement of content providers as investors in new cables; their investment in and use of submarine cables has outpaced those of traditional internet backbone companies. They have a particular focus in linking their data centres between different countries and streaming content on low latency and high capacity links between where the data is located and the end customer. Often the business case to invest in a submarine cable is far more compelling than relying on traditional telecommunications providers to move data. Between 2012 and 2016, the amount of international capacity deployed by content providers rose 14-fold to 170 Tbps compared to only a three-fold increase for internet backbone companies to 273 Tbps.[30] Stakeholders were divided over whether the public sector could take the lead in installing submarine cables. Some expressed the view that this could 'crowd-in' further investment, whereas other believed that if there is sufficient demand in a country for the cable, the private sector will invest.

The benefits of international connectivity (and domestic connectivity) have been shown to be significant, with higher levels of economic growth being associated with improved domestic connectivity bandwidth, reliability and affordability caused by international connectivity. The University of Huddersfield has estimated the wider benefits of UK telecommunications subsea cables to the digital economy at £62.8bn per annum.[31] McKinsey Global Institute (MGI) has found a linear relationship between the connectedness of countries and their GDP per capita.[32] Further, individual sectors' economic success are highly dependent on these cables – the US Federal Reserve has noted that cables carry in excess of US$10 trillion in daily transactions underpinning the financial services industry.

[29] See https://subtelforum.com/ for different examples.

[30] Source: Telegeography, https://blog.telegeography.com/shaping-the-global-wholesale-bandwidth-market

[31] See *An Economic and Social Evaluation of the UK Subsea Cables Industry,* by Elliott, C et al (2016), University of Huddersfield for ESCA, available at: http://eprints.hud.ac.uk/id/eprint/31526/

[32] See *Global flows in a digital age: how trade, finance, people and data connect the world economy,* (2014) McKinsey Global Institute, available at: https://www.mckinsey.com/~/media/mckinsey/featured%20insights/Globalization/Global%20flows%20in%20a%20digital%20age/MGI%20Global%20flows%20in%20a%20digial%20age%20Executive%20summary.ashx

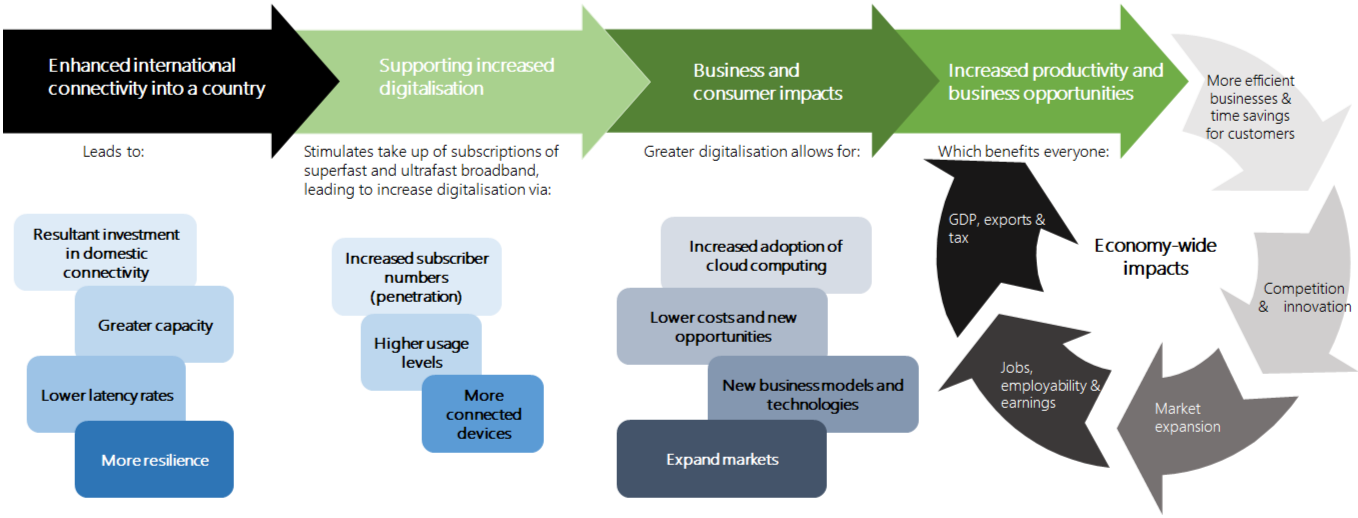
As noted by one stakeholder consulted for this report, investing in submarine cables is a way of sustainably maximising the value of seabed and other marine assets.

A recent study for DCMS also confirmed how superfast broadband, which is supported by international and domestic connectivity, can increase productivity and job creation. For postcode areas where broadband infrastructure was improved, there was an increase in local economy activity of 0.32% and firms in these areas contributed to £9 billion in turnover. The overall impact of wellbeing (via access to educational materials) was estimated at £222 per annum per upgraded premise. Overall, it was shown that the benefit to cost ratio of the investment in infrastructure was nearly 2:1.[33]

Based on the academic literature, stakeholder discussions and examples from analogous sectors, the benefits of international connectivity have been representatively modelled as contributing to an increase in the proportion of people and businesses in Scotland subscribing to fixed and mobile broadband services. Improvements in international connectivity can lead to fewer delays in transferring data (latency) between countries, improve internet resilience by having more cables serving a country and feed through into lower wholesale prices for service providers. These changes can ultimately contribute to lower retail prices for broadband services that, in turn, can improve digital connectivity (measured in the number of mobile and fixed broadband subscriber numbers) and can support the development of 5G technologies and rollout. This in turn supports increased digitalisation (via increased subscriber numbers using more broadband services and there being more connected devices generating and sharing data), which ultimately drives improvements in economic outcomes such as GVA and employment and further investment in digital infrastructure to support use, with the effect becoming circular.[34]

This effect flow is shown in figure 3.4 below.

Figure 3.4: Theory of change – impact framework for international connectivity



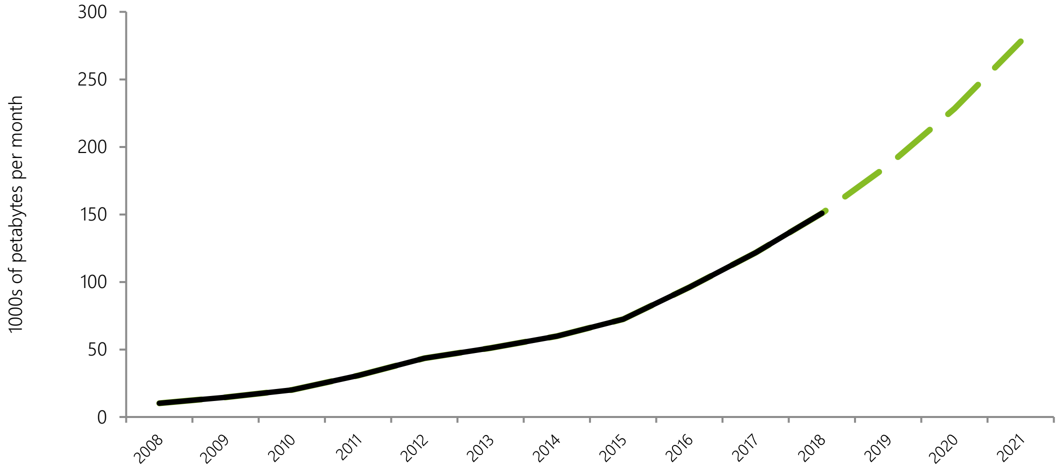
Source: Deloitte

Further follow-on benefits of international connectivity include supporting accelerated growth in the local data centre industry where businesses can take advantage of reduced barriers to entry and growth enabled by lower latency rates for data transfer. This can, in turn, promote greater uptake of cloud computing.

The benefits of international connectivity are likely to be continuous (albeit not linear), as demand for connectivity to power modern economies continues to grow, as shown below.

[33] See *Evaluation of the Economic Impact and Public Value of the Superfast Broadband programme*, DCMS, available at: https://www.gov.uk/government/publications/evaluation-of-the-economic-impact-and-public-value-of-the-superfast-broadband-programme
[34] Given data availability, the impact of enhanced international connectivity has been modelled as a change in the number of broadband subscribers. This is a representative approach to how international connectivity has a tangible impact on metrics – alternatives might include the quality and speed of connection or the volume of data usage (not used due data limitations).

Figure 3.5: Ongoing demand for international connectivity, as measured by global internet traffic



Source: Cisco systems

The importance of submarine cables has steadily risen up the agenda. A recent report by Policy Exchange highlighted the importance of securing and maintaining submarine cables on both economic and national security grounds.[35] Disruptions in submarine cables caused by natural factors, marine traffic and terrorism can be significant. Somalia suffered three weeks of internet outage at a cost of $10m a day following its single international cable being severed by an anchor in 2017. Earlier, the 2006 Taiwanese earthquake resulted in 4,000m of undersea cabling being disrupted affecting 98% of communications in Japan, Singapore, Malaysia and Korea, which took 40% of the world's global cabling fleet seven weeks to repair.

3.1.2.2 Domestic connectivity

As discussed, when international connectivity lands on a country's shores, it needs to be distributed to local citizens and businesses via domestic connectivity. A recent report for DCMS sets out how domestic connectivity has historically been achieved in the UK:

- Mass data connections were first introduced in the mid-1990s with the availability of the internet and introduction of narrowband fixed and mobile data services over existing voice networks at speeds below 100 kbps;
- Subsequent broadband services followed using packet switching technologies designed for data services such as ADSL lines using copper wiring;
- Fibre-optic cabling then following allowing for faster broadband speeds and greater capacities;
- At the same time, mobile technologies such as 3G and 4G emerged allowing digital connectivity on the move with speeds starting at 200 bps growing to 25 Mbps; and
- Next Generation Access Networks (NGAN) are now being implemented that deliver must faster domestic digital connectivity. These include Fibre to the Premise (FTTP), very high bit-rate digital subscriber lines (VDSL) and coaxial cable technologies using DOCSIS 3.0 and 3.1 standards. These technologies have the potential to deliver broadband at gigabit speeds. At the same time, work is being undertaken to design and roll-out 5G mobile networks.

The practical implications of improved digital connectivity enabled by better domestic connectivity are summarised below in terms of download speeds for consumers and businesses.

Figure 3.6: Different download speeds

Download speed	For a typical film – 1.5GB	For a very large PowerPoint file – 25MB
2 Mbps	01:47:22	00:01:44
10 Mbps	00:21:28	00:00:20
24 Mbps	00:08:56	00:00:08
4G (80 Mbps)	00:02:41	00:00:02

[35]See *Undersea cables, indispensable, insecure* by Policy Exchange, available at: http://www.mobileuk.org/cms-assets/The%20Impacts%20of%20Mobile%20Broadband%20&%205G.pdf

Download speed	For a typical film – 1.5GB	For a very large PowerPoint file – 25MB
100 Mbps	00:02:08	00:00:02
1 Gigabit	00:00:12	Virtually 00:00:00

Source: download-time.com, quoted by London Assembly

Investments in domestic connectivity will also improve geographic coverage (particularly to rural or isolated communities) and accessibility (in terms of lower costs and diversity of devices that can access the internet). The next chapter sets out the Scottish Government's current planned programme of investment in domestic connectivity.

3.2 Data Centres

The internet's physical presence can be described as a global network of international and domestic cables that connect servers hosting content for distribution to user devices such as mobile phones, tablets and laptops. Data centres have been described as the nodes that connect the digital economy to the physical space – housing the servers in racks. TechUK uses the analogy that data centres enable and power service economies in the way that heavy industry used to power manufacturing economies.[36]

Data centres can be defined as buildings or part of buildings that house the servers that store, manage and disseminate data and information systems. They comprise servers and storage equipment, run application software and process data and content. They are connected to the internet via high bandwidth connectivity (domestically or internationally).

Data centres can be in-house, located in a company's own facility, or outsourced to third-parties under a variety of models. They can be categorised in a number of ways from size, energy consumption, reliability and their use/business model. These categories are not mutually exclusive, and data centres have traditionally come in many shapes and sizes.

Figure 3.7: Data centres categories

Reliability	Physical size	Energy Use, Power Usage Effectiveness (PUE)*	Use / business model
Tier 1: with non-redundant capacity components meaning an outage will make systems unavailable, providing 99.671% availability	Server room or small data centre, less than 0.3 MW	PUE Category 0	In-house: the data centre is owned and run by the company using the servers
Tier 2: all capacity components are fully redundant, providing 99.741% availability	Mid-sized data centre, 0.3-1 MW	PUE Category 1	Co-located: data centres run by third parties hosting multiple companies' servers
Tier 3: availability around 99.982% with minimal downtime and with dual-powered equipment and multiple uplinks	Large data centre, 1-10 MW	PUE Category 2	Cloud-computing: where data is stored, processed and access off-premise
Tier 4: fully-fault resistant with physical copies of all essential equipment, providing 99.995% availability	Hyper-scale data centre, over 10MW	PUE Category 3	Edge/Micro: high speed links to numerous micro-sized data centres that cache data to end users and connected devices sending and creating it

Source: Deloitte analysis, Coreix, Swedish Data Center Initiative, Colt, Data Center Journal, 365 datacenters, CCG facilities

* PUE = Total Data Centre Facility Energy / IT Energy

As Figure 3.7 suggests, there are clear correlations between characteristics– cloud computing data centres will typically be large or hyper-scale sized, whereas edge data centres will be much smaller. Whereas hyper-scale cloud data centres are run by large multinational technology companies, co-location facilities are typically offered by local providers.[37]

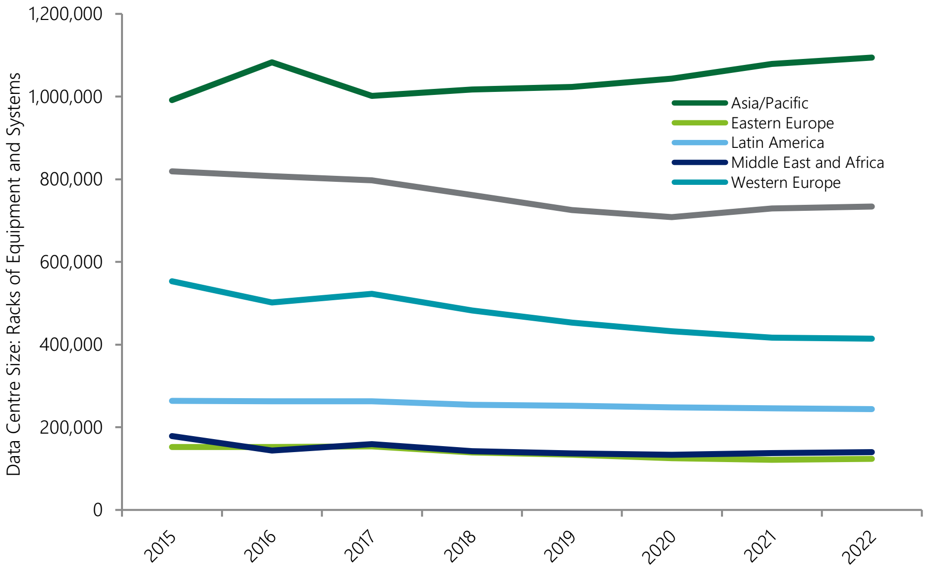
Gartner suggests that many traditional in-house data centres will close down by 2025 (around 80% of such facilities) and there will be a continued trend towards cloud data centres and decentralised edge data centres for IoT.[38] Indeed, Gartner estimates that the shift to the cloud will cannibalise other non-premise data infrastructure services such as co-location centres, leading to a five year compound annual growth rate (CAGR) decrease of 5%. The attractiveness of Pay-As-You-Go models rather than expensive CAPEX

[36] See *So What have data centres ever done for us, (2013)*, TechUK available at: https://www.techuk.org/images/programmes/DataCentres/So_what_have_data_centres_ever_done_for_us_FINAL_2013.PDF
[37] See *Data Centres UK, May 2018*, Mintel
[38] See *Forecast: Data Centers, Worldwide, 2015-2022, 2018 Update*, Gartner

models for in-house data centres are particularly compelling for many companies seeking to make cost efficiencies. End user spending for new server installation in the UK is forecast to fall by 2.7% between 2018 and 2021. Simultaneously, the industry will see more consolidation, with the total number of data centres falling in the UK by 7% in the next 3-4 years.[39]

Nonetheless, while the structure of the data centre may be evolving, overall demand for data centre services (whether they be cloud or edge) continues to grow.

Figure 3.8: Data centres demand, as measured by racks



Source: Gartner – above refers to racks which are expected to improve in efficiency meaning even if there are fewer racks, there can provide more supply

Further, a recent report by CBRE forecasts that 2018 in particular will be an exceptional year for data centres with the supply rising by nearly 5% in Europe and co-location take-up increasing by 42.5% compared to the previous quarter.[40] Focusing on Frankfurt, London, Amsterdam and Paris, total supply of data centres reached 1,256MW at end of Q2 2018; an increase of 55 MW in the quarter and 95MW since start of the year. The overall vacancy rates remained between 19-20% - in line with equilibrium levels.

The above trend is corroborated by stakeholders spoken to in the sector who saw growing demand for their own data centre offerings.

The drivers for market growth identified include:

- Existing data centres coming to the end of their 10-15 year life needing to be replaced or outsourced;
- Cost drivers – with companies seeking to move more and more services into the cloud to realise cost efficiencies; and
- Particular sectors of the economy requiring more and faster data capacity, e.g. banks have seen a 50-100% increase in data requirements.[41]

Stakeholders reported that rapidly evolving sectors such as transport, which will require much more local connectivity such as the digital railway and autonomous vehicles, will need more local data centres where information is cached locally (which may reduce the demand for international connectivity for some services). Public sector organisations seeking to make further efficiency savings and reduce their carbon footprint are also considering moving to cloud computing data centres. In the Scottish context, data centres can also support major industries such as oil and gas. International connectivity can provide real-time information with data flowing directly from Aberdeen to Houston to underpin real-time logistics. Furthermore, a strong edge/micro datacentre presence can support 5G rollout across the country.

The benefits of data centres to a country's economy go beyond the direct employment and turnover benefits. The data centre value chain has been identified as traversing a range of sectors from equipment manufacturers to construction firms to security providers to facility management and installation companies, each of which will contribute to indirect supply-chain benefits. TechUK notes that the construction part of the supply chain alone involves three separate supply chains: the supply chain involved in the physical building,

[39] Ibid.

[40] Source: *CBRE Data Centre MarketView, Quarter Two 2018*

[41] See *The data centre market in two years*, Broad Group available at: https://www.iomart.com/pdf/steve_wallage_broadgroup.pdf

the supply chain involved in implementing the communications infrastructure (sometimes known as 'holes and poles') and the supply chain involved in the provision, management and maintenance of the ICT equipment that is housed in the data centre.[42]

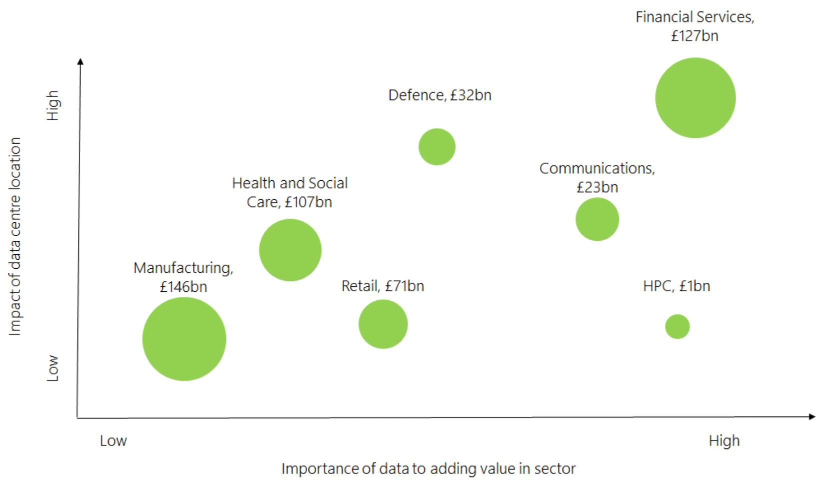
More widely, data centres have been shown to generate enabling and 'ripple' effects across the economy, supporting digital transformation and low latency digital services, IoT, big data and artificial intelligence and virtual reality.[43] A single hyper-scale data centre in Finland has been estimated to generate over €660m in economic benefits over a period of six years (2009-2015) and support 1,600 jobs annually. Many of these jobs are in high-productivity sectors such as data science, the legal and professional services sectors and energy, engineering and telecommunications more widely.

These benefits are significant. This makes hosting a large and growing data centre industry attractive to countries. The key factors influencing the location of a data centre include:

- Connectivity: particularly for customers and/or services that require data to be transferred with the smallest-possible delay (low latency), a country's international and domestic connectivity infrastructure is as critical to the proximity to key markets;
- Cost: electricity has long been recognised as the main operating cost for data centres (to power cooling systems) – around 25%.[44] Other elements affecting cost include a country's regulatory and fiscal regime and labour costs;
- Proximity to key markets and other data centres; and
- Skills base: particular digital and data science skills to take advantage of the opportunities afforded by the data centre ecosystem.

KTN reports that clustering is particularly important for data centres [45]. Whilst international cables can carry large volumes of data at capacity with low latency, it will always be cheaper and faster to move data smaller distances. Even when less data volume is concerned, distance can still be an issue. It takes 6 msec for light to travel from London to Edinburgh and back, 55 msec for the round trip to New York. While this may appear very fast, stock prices can change in this time, meaning that if a businesses' data transfer is even fractionally slower than its competitors, it can lose a competitive advantage. Thus, businesses are incentivised to cluster their data centres to minimise any differences in latency between them and their competitors.

Figure 3.9: Data centres clustering



Source: adapted from KTN

3.3 The interaction of international connectivity and data centres

It should be clear, that there is a virtuous circle between international connectivity, domestic connectivity and data centres.

Focusing on international connectivity, having direct connectivity to a submarine cable, has the potential to significantly improve latency and provide a competitive advantage for data centres, or those businesses that rely upon them. For example, latency directly influences the interaction time between a trader and the market. Lower latency means faster interactions and the ability to act upon new market information. With the rise of trading-based technology (trading algorithms), latency management is increasingly more important for gaining a competitive advantage for trading and financial institutions as well as greater efficiency and automation. Similarly, Google and Amazon's traffic revenues are heavily connected to latency. Any increase in time it takes Google to return a

[42] See *So What have data centres ever done for us, (2013)*, TechUK available at: https://www.techuk.org/images/programmes/DataCentres/So_what_have_data_centres_ever_done_for_us_FINAL_2013.PDF

[43] See *Finland's economic opportunities from data centre investments,* (2017) Copenhagen economics

[44] See *Data Centres UK, May 2018*, Mintel

[45] See *The Big UK Data Centre Equipment Opportunity,* KTN, available at: https://admin.ktn-uk.co.uk/app/uploads/2016/12/KTN_A4_Big-Data_v9.pdf

search result causes a number of search queries to fall, adversely affecting traffic and advertisement revenues. Google found that an extra 0.5 seconds in search page generation time reduced traffic by as much as 20%. Experiments at Amazon confirm the same issue, a loss of revenue of 1% was experienced for every 100ms increase in load time. The same is likely to hold for smaller search engines and online retailers, where impatient customers demand instant search results to stay active on the sites.[46] Lower latency can open up the possibility for cloud gaming (such as Fortnite) – streaming of games in a similar fashion to video streaming on Netflix. Cloud gaming opens the market to competitors that don't have to develop console hardware and high performance graphics cards, whilst also enabling incumbent firms such as Sony, to grow their existing cloud streaming services.

If the data centres are situated at the landing site of the cable this further increases customer value as data centre providers are constantly striving for incremental performance improvements in connectivity. The consequent ripple effect can attract further domestic connectivity investments and adjacent industries.

Indeed, one stakeholder has suggested that if Scotland were to simply invest in international connectivity without attracting more data centres, all the benefits of connectivity would simply flow outside its borders to data centres located elsewhere.

[46] Source: Giggaspace

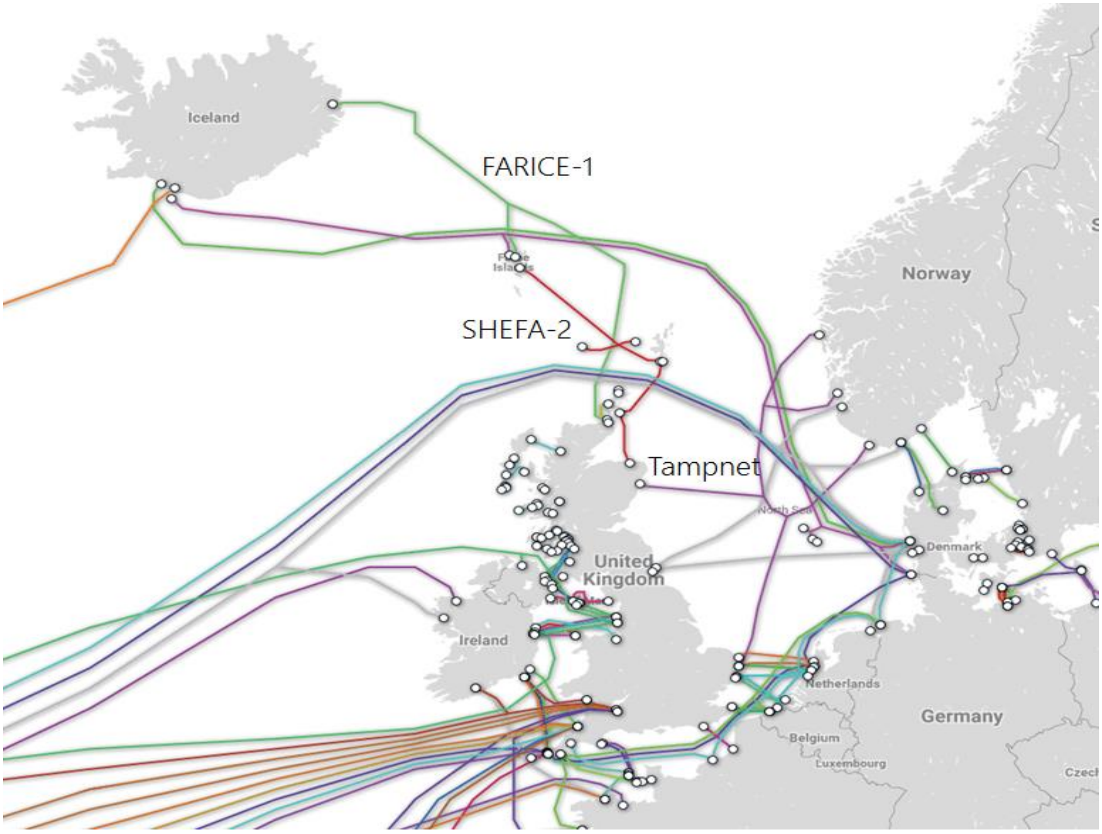
4 Digital Connectivity and Data Centres in Scotland

4.1 The current situation in Scotland – international and domestic connectivity

4.1.1 International connectivity

As noted in the previous chapter, Scotland's National Marine Plan reports that around 95% of all international telecommunications traffic is carried via submarine cables, with approximately 40% of all the UK's active international cables (also including electricity) found on the Scottish seabed.[47] However, while there are currently three direct submarine cables landings into Scotland, only one provides direct international connectivity.

Figure 4.1: International cables to Scotland



Source: TeleGeography Submarine Cable Map

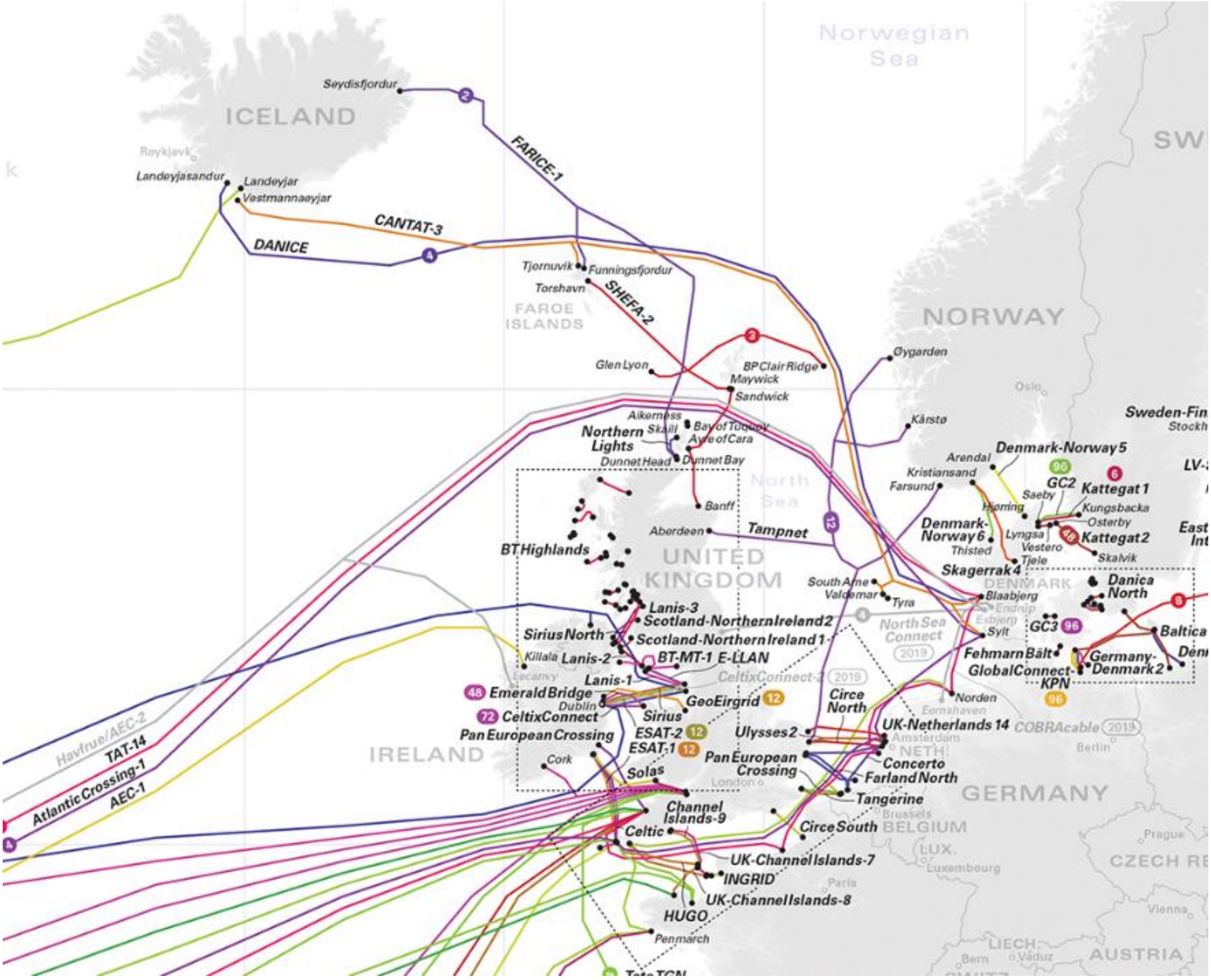
FARICE-1 and SHEFA-2, whilst landing in Scotland, are connected to London, meaning the data must complete a round-trip to London before coming to Scotland. This reflects where demand has been concentrated historically. The Tampnet cable from Norway does land data directly to Scotland but is ageing and unlikely to provide the required future capacity and latency without new investment in the route.[48]

There are a number of smaller (and older) domestic subsea cables joining the Scottish Islands to the mainland and Scotland to Northern Ireland. These cables tend to be utilised/owned by private operators and are used for their own purposes.

The situation of Scotland contrasts unfavourably to the rest of the UK and Ireland, as well as Nordic competitors, as shown below. Figure 4.2 also shows how many submarine cables travel north of Scotland, but do not land there.

[47] Available at: https://www.gov.scot/Topics/marine/seamanagement/national
[48] Source: SFT discussions

Figure 4.2: International cables to UK and northern Europe



Source: Telegeography

Stakeholders noted that a number of international submarine cables across the Atlantic are being planned or are in the construction phase beyond the traditional landing points in the UK and Ireland (such as France and Spain). None are currently planned to connect directly to Scotland.

Of course, it should be noted that the improved digital resilience brought about by increased international connectivity can be achieved through local interconnectors between neighbouring countries (such as Ireland or the Nordics) and the rest of the UK rather than trans-Atlantic cables. Gartner also note that as the price of satellite communication services fall, this may be an option for international connectivity when low latency is not a requirement.[49] However, this may not bring about the associated latency benefits of a trans-Atlantic submarine cable and may only be a short-term solution, thereby meaning potential larger economic benefits are lost.

4.1.2 Domestic connectivity

To date, much of the focus in Scotland has been on improving domestic connectivity, often led by the Scottish Government. The Digital Scotland Superfast Broadband (DSSB) programme is a £412m investment to rollout fibre technology across the entirety of Scotland. The DSSB programme is being delivered through two regional projects: the Highlands and Islands project and the Rest of Scotland project. The government's targets, as set out in a response to an oral question on 23 March 2016, confirms a target to have superfast broadband to all premises by April 2021 (with 95% coverage by the end of 2017).[50]

The Reaching 100% Programme (R100) builds on DSSB and seeks to extend the availability of superfast broadband infrastructure across the nation. It is a unique commitment across the UK in that its objective is to deliver 100% superfast broadband coverage across

[49] See *Scottish Data Centre Demand Review*, 2018 Gartner for SFT

[50] Reported in https://www.ispreview.co.uk/index.php/2018/05/scotlands-rural-minister-to-quit-if-r100-broadband-target-missed.html

Scotland by 2021. Any home or business that cannot have superfast broadband delivered commercially – or through programmes such as DSSB or Community Broadband Scotland ("CBS") – will be eligible for investment through the R100 programme.

With respect to mobile connectivity. SFT played a leading role in the development of the Scottish 4G Infill programme (S4GI) that will facilitate the deployment of mobile infrastructure across rural Scotland to facilitate the extension of 4G coverages in mobile 'not spots'. In July 2018, contracts were awarded for an initial 16 sites, with more to be added. Delivery of the overall programme will take place over four years from 2018 to 2019.

As the Digital Strategy highlights, these programmes have all contributed to steady progress on improving the numbers of premises that have access to next generation broadband services and mobile uptake, with recent Ofcom figures confirming this for both fixed and mobile access

Figure 4.3: Broadband coverage in Scotland and the UK

Measure	May 2017	January 2018
Access to a download speed of 10Mbit/s or higher	95% (Scotland) 97% (UK)	95% (Scotland) 97% (UK)
Access to a download speed of 30Mbit/s or higher (superfast)	87% (Scotland) 91% (UK)	91% (Scotland) 93% (UK)
Access to a download speed of 300Mbit/s or higher (ultrafast)	30% (Scotland) 36% (UK)	41% (Scotland) 45% (UK)
Access to full fibre services	0.7% (Scotland) 3% (UK)	2% (Scotland) 4% (UK)
4G – premises (indoor) covered by all operators	53% (Scotland) 58% (UK)	67% (Scotland) 68% (UK)
4G geographic area covered by all operators	17% (Scotland) 43% (UK)	30% (Scotland) 57% (UK)
4G coverage of A and B roads by all operators	18% (Scotland) 33% (UK)	32% (Scotland) 45% (UK)

Source: Ofcom

While broadband speeds and access have improved, Scotland continues to lag the rest of the UK, although the pace of growth is faster in some categories (such as full fibre or the road network mobile coverage). Some of this is demand rather than supply-driven. For example, Ofcom notes that a significant number of consumers could be enjoying faster speeds by upgrading their broadband service; while 87% of Scottish premises can have superfast broadband, only 39% actually take up the service.[51]

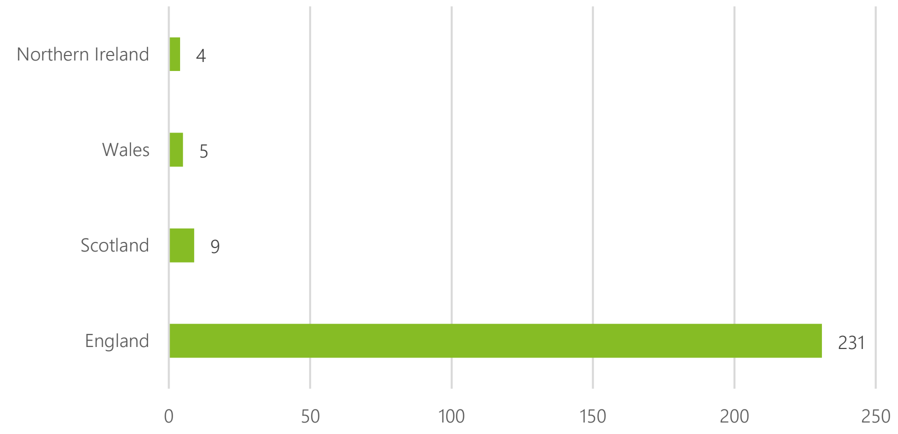
In terms of usage levels, Ofcom reports that average monthly total data usage for fixed broadband was 195 gigabytes in Scotland in 2017, higher than the UK average of 190 gigabytes.[52] Ofcom notes that Scotland has seen the fastest and largest increase in data usage of any UK nation.

4.2 The current situation in Scotland – data centres

Mintel reports that there are nearly 250 colocation data centres in the UK; with just over half being used by large companies and the public sector. These data centres are clustered in towns, close to the markets they service. Mintel reports that most data centres are in England (76 in London alone, and 20 in Manchester), followed by Scotland, Wales and Northern Ireland

[51] See Scotland – Connected Nations 2017, Ofcom, available at: https://www.ofcom.org.uk/__data/assets/pdf_file/0022/108814/scotland-connected-nations-2017.pdf
[52] Ibid.

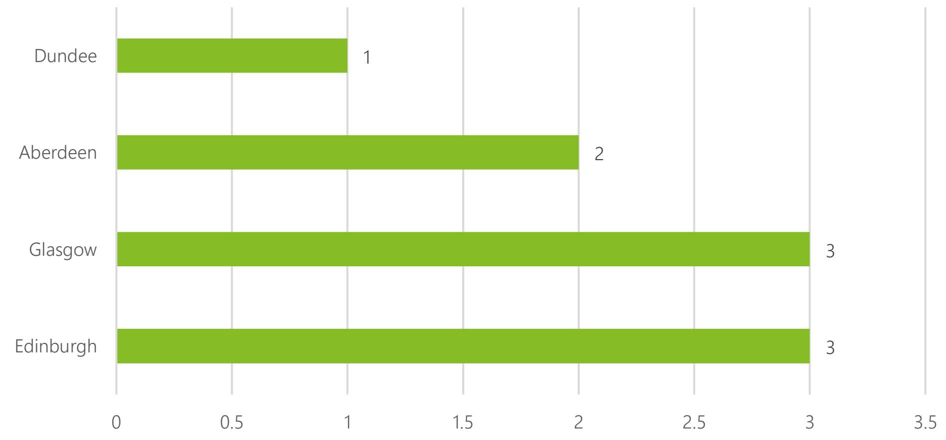
Figure 4.4: Colocation data centres in the UK, 2018



Source: Mintel

Within Scotland, Edinburgh and Glasgow have the most data centres.

Figure 4.5: Colocation data centres in the UK, 2018



Source: Mintel

Gartner reports that most of Scotland's large private sector organisations (RBS, Aberdeen Standard) currently choose providers in London due to its proximity to wider markets. There are three new planned/built data centres in Scotland – including the 44,000 sq. foot Fortis facility in Lanarkshire but take up has been slow to date.[53] In June 2018, Microsoft launched a pilot underwater data centre trial in Scotland.[54]

However, the above notwithstanding, a number of recent reports recognise the potential for Scotland to grow its data centre industry. Atos, a technology company, also recently set out digital vision for Scotland, stating that Scotland can create a competitive advantage in digital technologies and data centres, potentially becoming a cloud data centre hub.[55] The limited direct demand for data centres in Scotland is not seen a handicap, given the example of Ireland which grew its wholesale data centre industry through having strong economic incentives and direct international connectivity to the US.[56] An earlier report by Datacenter Scotland suggested the country had the potential to significantly grow its data centre industry to 40,000 sq. m and 46MW of power by 2019.[57]

More recent research by Gartner for SFT notes that while, all things being equal, Scotland might only expect incremental growth in the sector taking advantage of the availability of land and renewable energy sources[58], more radical interventions to invest in skills development and take advantage of trends in hyper-scale capabilities could help grow the industry and attract investment at a much faster rate. One particular recommendation is recognising the potential for an international or intercontinental submarine cable to

[53] See *Scottish Data Centre Demand Review*, 2018 Gartner for SFT
[54] Source: https://www.bbc.co.uk/news/technology-44368813
[55] Quoted in *Atos sets out vision for a digital Scotland*, ComputeWeekly, 10 August 2018, available at: https://www.computerweekly.com/news/252446682/Atos-sets-out-vision-for-a-digital-Scotland
[56] Source: https://digit.fyi/largest-scottish-data-centre-launched/
[57] Source: https://www.researchandmarkets.com/research/fbk7kq/data_centre
[58] The report notes that given power costs can be as much as nearly 50% of total data centre costs, Scottish clean energy is well positioned to provide data centre solutions to customers with sustainable energy and motivate some firms to relocate to Scotland from London.

improve latency and enhance the attractiveness of Scotland for data centres. Digital innovation initiatives such as Smart Cities and the R100 programme are also likely to generate more data and in turn drive domestic demand and data centre need.

CBRE, on behalf of SFT, have further noted that there are number of optimal sites across Scotland for a data centre eco-system to emerge, mirroring the data centre 'corridors' as seen in Ireland.[59] They also recommend additional investigation to understand the latency ratings to and from major connectivity hubs, again hinting at the importance of international connectivity to data centres. CBRE conclude that what is currently lacking is a major international connectivity strategy and a clear data centre strategy from the Scottish Government.

[59] Source: *Scottish DataCentre Location Review, 2018* CBRE for SFT

5 The benefits of improving International Connectivity for Scotland

5.1 The scope of benefits considered

The previous chapters have discussed the different types of benefit arising from enhanced international connectivity and a more mature, larger data centres sector, and the specific Scottish context. This chapter considers the monetary and economic value of these benefits in Scotland. In particular, the following expected benefits from enhanced international connectivity are quantitatively and qualitatively discussed:

- Gross Value Add (GVA) to the Scottish economy and individual sectors;
- Labour force participation in the form of jobs created in Scotland;
- Changes to the level of productivity in Scotland;
- Changes to business start-up rates in Scotland;
- Changes to levels of innovation in Scotland;
- Changes to the level of Scotland's competitiveness;
- Agglomeration and clustering impacts; and
- Second and tertiary sectors directly benefiting.

In describing these benefits, links will be made to existing digital and connectivity programmes such as R100.

5.2 Quantitative modelling

Quantitative modelling has been used to estimate the size of GVA and job impacts and productivity, business start-up and innovation rate changes.

5.2.1 GVA and job impacts

With respect to GVA and job impacts, the modelling begins from the premise that Scotland enjoys enhanced international connectivity due to a trans-Atlantic telecommunications submarine cable landing in Scotland. Drawing on the earlier theory of change, improvements in international connectivity can lead to fewer delays in transferring data (latency), improve internet resilience and result in lower wholesale prices and better quality of service, which ultimately could flow into lower retail prices and more demand helping support growth in mobile and fixed broadband subscriber numbers.[60] Thus, because of this cable landing in Scotland, there are subsequent changes in the level of domestic connectivity, as measured by fixed and mobile broadband subscription levels, which in turn can stimulate greater usage and more connected devices being used. This is a representative approach using the available data and subscriber numbers as a proxy for wider digitalisation impacts. Alternatives might include assessments that address the quality, usage, resilience and speed of connection (metrics not available during the drafting of this report). This approach draws on the previous benefits framework, the availability literature, discussions with stakeholders and Deloitte empirical analysis.

As a result of enhanced international connectivity, drawing on the research by Gartner and CBRE, and informed by discussions with SFT, there is resultant investment in the data centre industry in Scotland. Existing evidence on the empirical link between enhanced international connectivity and the number of data centres is not currently available, so the change in data centre investment has been assumed. This assumption is based on historic growth rates, the current size of the industry and different projections for the future. The additional data centres are over and above those announced in the press. The nature of data centre investment is taken from the

[60] According to Ofcom (2017), Scotland has an 87% coverage rate for superfast broadband (more than 30Mbps), although this is lower in rural areas. There remain around 5% of premises without broadband of at least 10Mpbs. Earlier research by Ofcom (2016) found around six in ten adults owned a smartphone with access to mobile internet services.

Gartner report implications on where the best opportunities lie for Scotland (micro/Edge data centres and hyper-scale data centres), and the modelling has been informed by their 'new submarine cable connectivity; low-latency led expansion' scenario developed for SFT.

Figure 5.1: Gartner new submarine cable connectivity; low-latency led expansion scenario for data centres

Scenario overview
• There is an exponential increase in data flowing through new cables meaning that data centre providers whose facilities are close to or at where cables land benefit hugely. • A success factor for Ireland as a data centre market has been that many submarine cables that link Europe, the UK and USA for internet and communications connectivity, pass in and around Ireland.
Scenario implications
• Data centres with access to more cable landing sites are far more attractive than those that don't as they have better connectivity with the rest of the world. • There is always demand by data centres for locations near landing sites. • Currently, the lack of intercontinental submarine cable landing in Scotland means latency and connectivity is poorer than other geographies. • Many of the other conditions for success for data centres (e.g. sustainable power) are already present in Scotland.
Scenario benefits
• Not only will a new cable bring all Scottish traffic directly into the country, but it could also attract data processing from other countries. • There will be a very high to exponential increase in traffic and data volumes leading to more data centres locating to Scotland.

Source: Gartner analysis

Full details of the modelling approach are placed in Annex 1, below are the key steps for the international connectivity module:

1. Source baseline forecasts for the growth of the Scottish economy (by sector) for the period 2018 – 2030 covering metrics such as GVA, employment and productivity. These provide the baseline of what could be reasonably expected to happen to the Scottish economy without any additional investment or enhancement in international connectivity and against which all benefits could be measured.
2. An indicative 'rule of thumb' relationship determined between international connectivity, domestic connectivity and the chosen connectivity metrics, to show how a change (increase) in international connectivity flows through into outcomes in Scotland.
3. An indicative 'rule of thumb' relationship determined between the change in connectivity metrics and wider economic impacts in Scotland such as GVA, jobs and productivity for those sectors directly impacts by increased connectivity.
4. The individual sectoral impact of increased connectivity is modelled in a fixed-coefficient Input-Output model to generate economy-wide impacts across Scotland.

Subscription forecasts from Oxford Economics have been used for the baseline forecasts for GVA, employment and productivity (defined as the amount of output per worker in Scotland). A combination of indicative correlation and regression analyses have been used to create a 'rule of thumb' for the expected level of change in fixed and mobile subscribers per 100 people following the addition of an extra submarine cable. In the case of fixed subscribers, the 'rule of thumb' approach suggests that one additional submarine cable could be expected, alongside other important contributory factors, to stimulate an increase of between in 2.5% and 6% of fixed line broadband subscribers per 100 people through lower prices and higher levels of resilience – many of these subscribers could be taking advantage of lower latency rates. In the case of mobile broadband subscribers, a new international cable is associated with, alongside other important contributory factors, an increase of between 3% and 7.7% increase in subscribers per 100 for similar reasons. Drawing on the academic literature (specifically a paper by Crandall, Lehr and Litan, 2007) and other literature (Deloitte, 2012) the expected change in the number of fixed and mobile broadband subscribers are used to determine the potential change in GVA in those sectors where the impact of greater connectivity has statistical significance. The changes in economic outcomes in these sectors are then inputted into Deloitte's standard Input-Output model, calibrated for Scotland and 2030, to generate economy wide impacts on both GVA and jobs.

With respect to the impact of data centres, the following approach has been followed (with full details in the annex):

1. Data has been collected on the number of data centres in Scotland, average revenue per data centre (where possible by data centre type/size);

2. A high-level assumption based on the available evidence has been made according to each modelling scenario (see below) on the relationship between data centres and international connectivity, and how the latter can stimulate the former to growth;
3. The additional expected revenue generated by data centres due to international growth by 2030 is then fed through the Deloitte Input-Output model to estimate economic outcomes on both GVA and jobs.

Given time and data limitations, a number of simplifying assumptions have had been made that, if changed, will significantly alter the overall results. These include:

- The results are presented for the year 2030 only, as the representative 'steady state' year when the impacts of connectivity and more subscribers will have become the norm;
- It is assumed enhanced international connectivity is achieved in 2021 via a new cable and attracts new data centres in two waves (2021 and 2025);
- Zero displacement is assumed for data centres between Scotland and the rest of the UK, i.e. the new data centres established in Scotland are genuinely new and not relocated centres from elsewhere in the UK;
- Current Scottish Government policy initiatives to improve *accessibility* to broadband continue as planned, but do not necessarily raise the number of subscribers as the same pace as would be the case if there was enhanced international connectivity;
- The baseline forecasts are assumed to already account for (publicly known) baseline rate of change investments in domestic connectivity and new data centres; and
- The Scottish Government and others take the necessary steps to support the economy in investing in skills and other infrastructure to complement enhanced international connectivity to attract data centres.

5.2.2 Productivity, Business Start-Up and Innovation

The changes in productivity due to enhanced connectivity are estimated as the change in the ratio of GVA to jobs (where productivity is calculated as GVA per unit of input, in this case jobs). In the case of productivity led growth, all growth stems from productivity changes on a fixed employment base.

The change in business-start numbers is calculated using an approach similar to that of calculating the impact of high-speed broadband for communities for Openreach.[61] This approach, in turn, builds on research by Etro (2013)[62] on the economic impact of cloud computing on business creation, employment and output in Europe which estimates that improvements in cloud computing (an imperfect proxy for international connectivity) can increase business creation by up 1.7% per annum.

We have conservatively adjusted this increase rate of business creation down and applied a compounded annual growth rate (CAGR) over a five year period to reflect business growth reaches a peak five years after the initial enhanced connectivity investment. Data from the ONS and Scottish Government (including business survival rates) are then used to estimate the number of new businesses due to enhanced connectivity. GVA and employees for these new businesses are not estimated separately to avoid double-counting.

A similar approach is used for innovation from the same Openreach report. That is to say, the benefits of innovating, extending market shares and entering new markets could be at least as large as the core GVA benefits. We have conservatively adjusted this down by a factor of 0.5.

5.3 Qualitative modelling

Qualitative modelling has been used to discuss the expected impact on competitiveness, agglomeration and the impact on secondary and tertiary sectors.

5.4 Scenarios

To reflect uncertainty in the data and the impact different policy interventions can have, three distinct scenarios have been modelled relative to the baseline of no enhanced international connectivity. These scenarios have been co-developed with SFT. The three scenarios are summarised below.[63]

[61] For further details see *The Impact of High-Speed Broadband for Communities* (2018) by Regeneris Consulting for Openreach, available at: https://communityfibre.openreach.co.uk/assets/uploads/resources/1520803822_CFP%20Regeneris%20Report%20Jan%202018.pdf
[62] See Etro, F (2009), *The Economic Impact of Cloud Computing on Business Creation, Employment and Output in Europe,* KU Leuven, Faculty of Economics and Business, Review of Business and Economic Literature, vol. 0(2), pages 179-208.
[63] We do not provide a view which scenario is most likely as this will depend on the nature of the investment.

Figure 5.2: International connectivity and data centres scenarios

Scenario One (low subscriber growth, one-off connectivity improvement and incremental data centre growth) – *low case*	Scenario Two (high subscriber growth, persistent connectivity improvement and accelerated data centre growth) – *medium case*	Scenario Three (high subscriber growth, persistent connectivity improvement and very significant growth in data centres) – *high case*
• The positive 'shock' to the economy from enhanced international connectivity to fixed line subscribers occurs in the year the cable becomes operational (2021) increasing the relevant growth indicators for a single year, but future years' growth indicators revert to the baseline rate (although the absolute level in year one has increased with knock-on impacts for future years) reflecting already high levels of subscriber numbers. A lower growth rate is used (lower rule of thumb). • A lower estimated growth rate is used for mobile subscribers, and the increase in growth indicators has a similar profile to fixed subscribers. • Over the period 2021-2030, Scotland attracts one new colocation data centre and three new edge/micro data centres.	• The positive 'shock' to the economy from enhanced international connectivity to fixed line subscribers occurs in the year the cable becomes operational (2021) increasing the relevant growth indicators for a period of five years before reverting to a new 'steady state', i.e. subscriber numbers grow for some time. A higher estimate growth is used (higher rule of thumb). • A higher estimated growth rate is also used for mobile subscribers, and the increase in growth indicators has a similar profile to fixed subscribers. • Over the period 2021-2030, Scotland attracts two new colocation data centres, five new edge/micro data centres, plus a new hyper-scale data centre.	• Same as the 'medium' scenario except that over the period four new colocation data centres, ten new edge/micro data centres and two hyper-sale data centres are established.

As better data and evidence become available, the above assumptions may require refinement and the subsequent model results will differ.

5.5 Impact for Scotland of enhanced international connectivity

5.5.1 Scenario one – low subscriber growth, one-off connectivity improvement and incremental data centre growth

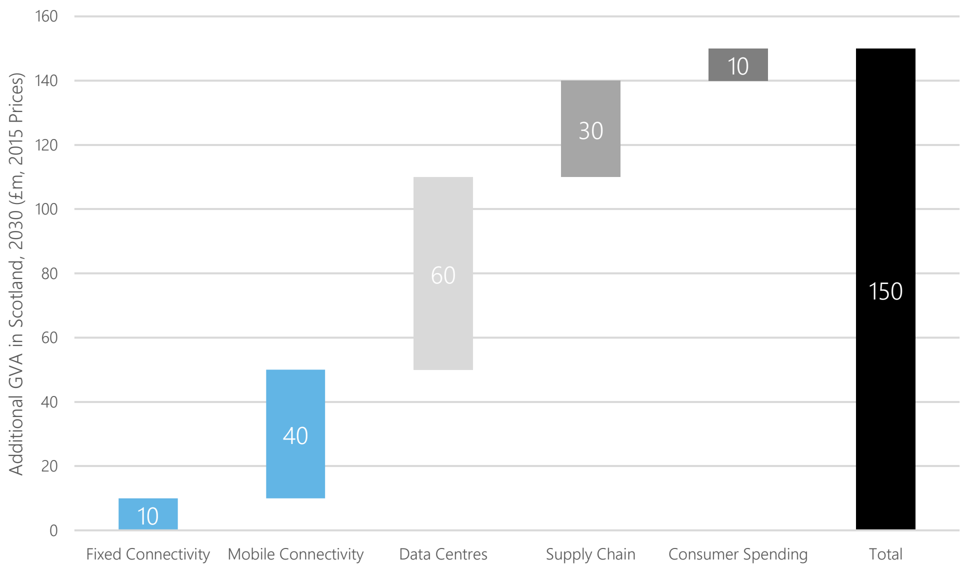
5.5.1.1 GVA, jobs and productivity

Under this scenario, the modelling analysis estimates that in the long-term (2030), Scottish GVA will likely be around £0.15 billion higher annually due to enhanced international connectivity compared to the baseline, with over 1,200 additional jobs in that year relative to the baseline of no new international connectivity and only incremental increases in the number of additional data centres.

These benefits will come from more fixed broadband subscribers, more mobile subscribers contributing to greater digitalisation and a larger data centre industry in Scotland, as shown below.[64]

[64] Greater digitalisation will help increase demand for cloud computing, which will increase demand for data centres – hence a positive feedback loop.

Figure 5.3: Annual long-term GVA impacts: scenario one, relative to the baseline



Source: Deloitte analysis

As Figure 5.3 shows, less than 10% of GVA benefits come from fixed connectivity, reflecting the relatively high fixed-line subscriber numbers. Around £40m in GVA is generated via greater mobility connectivity, which helps raise Scottish productivity allowing for more agile and flexible working, and greater usage/consumption of data. The most direct GVA generated comes from data centres, reflecting the relatively larger impact enhanced connectivity has on this sector.

The indirect (supply chain) and induced (consumer spending) are smaller, at around a quarter of all GVA benefits.

The increased GVA and associated increase in jobs can be decomposed into direct impacts due to enhanced international connectivity affecting fixed and mobile subscriptions and more jobs due to more data centres and related activity. As Figure 5.4 shows, there is no direct employment created in 2030 from fixed and mobile connectivity as the construction and installation of the cables will have already occurred earlier in the period (and will have been capital rather than labour intensive). However, there will be jobs directly created to run and maintain data centres. There are, nonetheless, supply chain or indirect impacts from both connectivity and data centres through sectors that benefit from enhanced connectivity, as well as induced impacts from more consumer spending. The full results, including employment, are shown below.

Figure 5.4: Detailed annual long-term GVA and employment impacts: scenario one

		Fixed Connectivity	Mobile Connectivity	Data Centres	Total
Direct	Employment	-	-	500	500
	Value Added (£m)	10	40	60	120
	Expenditure (£m)	20	80	100	200
Indirect (total)	Employment	20	170	330	520
	Value Added (£m)	-	10	20	30
	Expenditure (£m)	-	20	30	50
Induced (total)	Employment	10	90	130	260
	Value Added (£m)	-	-	10	10
	Expenditure (£m)	-	10	10	20
Total	Employment	30	260	980	1,270
	Value Added (£m)	10	60	90	160
	Expenditure (£m)	20	110	150	280

Source: Deloitte analysis. Note numbers do not sum precisely due to rounding. Value added here refers to profits and wages; expenditure also includes intermediate consumption.

With respect to productivity changes, these jobs and GVA occur in high-productivity sectors of the Scottish economy (such as information services, see below) and will result in more high-productivity jobs being created. Average productivity per worker is £124,000 in 2030 in the affected sectors compared to the overall Scottish figure of £55,000. In the sectors most affected by improved mobile connectivity, productivity is, on average, 3.5% higher than the baseline of no enhanced international connectivity.

The rule of thumb Type I expenditure multiplier (capturing direct and indirect effects) is approximately 1.3; with the Type II expenditure multiplier (including induced effects) estimated at 1.5. This means £1 spent will generate a further £0.5.[65] The equivalent rule of thumb Type I and II multipliers for employment are 1.7 and 2.0 respectively. According to Scottish Enterprise Economic Impact Guidance, Type I multiplier, also referred to as Supplier Linkage effects, arise as beneficiaries increase their demands for goods and services from supplier businesses based within Scotland. These businesses in turn increase their demands for goods and services and so on down the supply chain. Type II multiplier, also referred to as Income multiplier effect, arises from the additional spending by those employed through Type I multiplier effects, on goods and services from suppliers based in Scotland.

5.5.1.2 Business start-up rates, innovation and competitiveness

The jobs and GVA discussed above will be achieved through a combination of mechanisms, including the formation of new businesses to take advantage of enhanced connectivity, expansion of existing businesses into new markets or offering new products, improved domestic competition stimulating economic activity and Scotland becoming a more attractive place to invest.

Given the structure of the data centre sector (and requirements for CAPEX), it is reasonable to assume the majority of new business created will be due to improved fixed and mobile connectivity. Using the aforementioned methodology, suggests compared to the baseline around 55% of the new jobs created due to fixed and mobile connectivity impacts are achieved via new business creation; this is equivalent to 13% of all the additional jobs.[66] Drawing on the Etro methodology and taking a conservative approach, the rate of new business growth is expected to be permanently 1.5% higher from 2021 (with no adjustment to the business death rate). Similarly, conservatively we estimate that at least 13% of the GVA (c.£20m) and job benefits (c.200) could be attributable to innovation via market growth and new products and services.

The benefits to Scottish competitiveness are similar to those previously outlined in the enhanced digitalisation report.[67] These include:

- Improved resilience and latency rates that can complement other competitive strengths around renewable energy and skills; and
- Opportunities to extend marketplaces via online platforms to create new routes to Scottish and other markets.

More specifically, enhanced international competitiveness could contribute to Michael Porter's 'diamond of national advantage' which measures the competitiveness of nations.[68] It could:

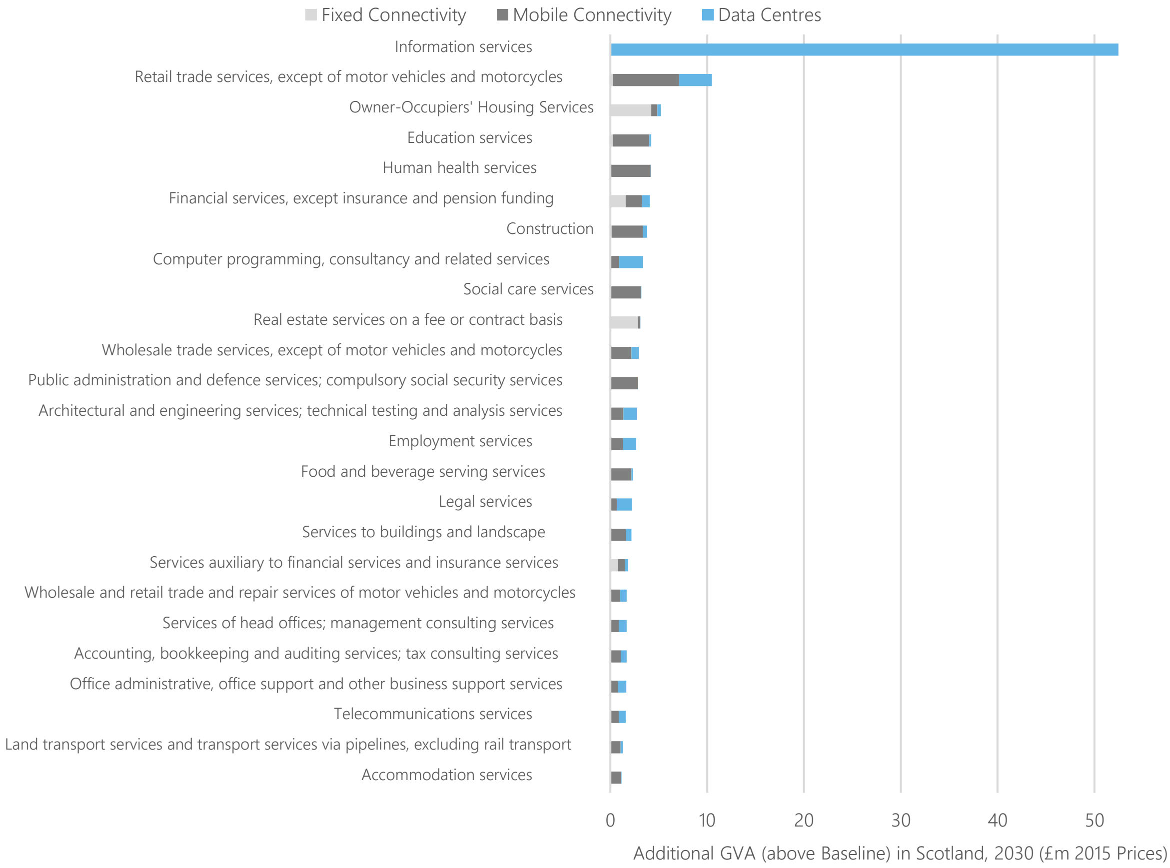
- Enhance Scotland's 'factor conditions' including telecommunications and skills infrastructure, providing the requisite factors for businesses to be able to compete and attract investment;
- Contribute to 'demand conditions' with the new connectivity stimulating demand for data services to take advantage of improved quality of service;
- Support the growth of 'related and supporting industries' that can support agglomeration (see below); and
- Improve domestic competition by removing barriers to entry, lowering costs to compete and stimulating opportunities to both collaborate and compete.

5.5.1.3 Agglomeration and secondary and tertiary sectors benefiting

The estimated splits between different sectors across Scotland are shown below for the long-term by 2030 in terms of GVA and jobs.[69]

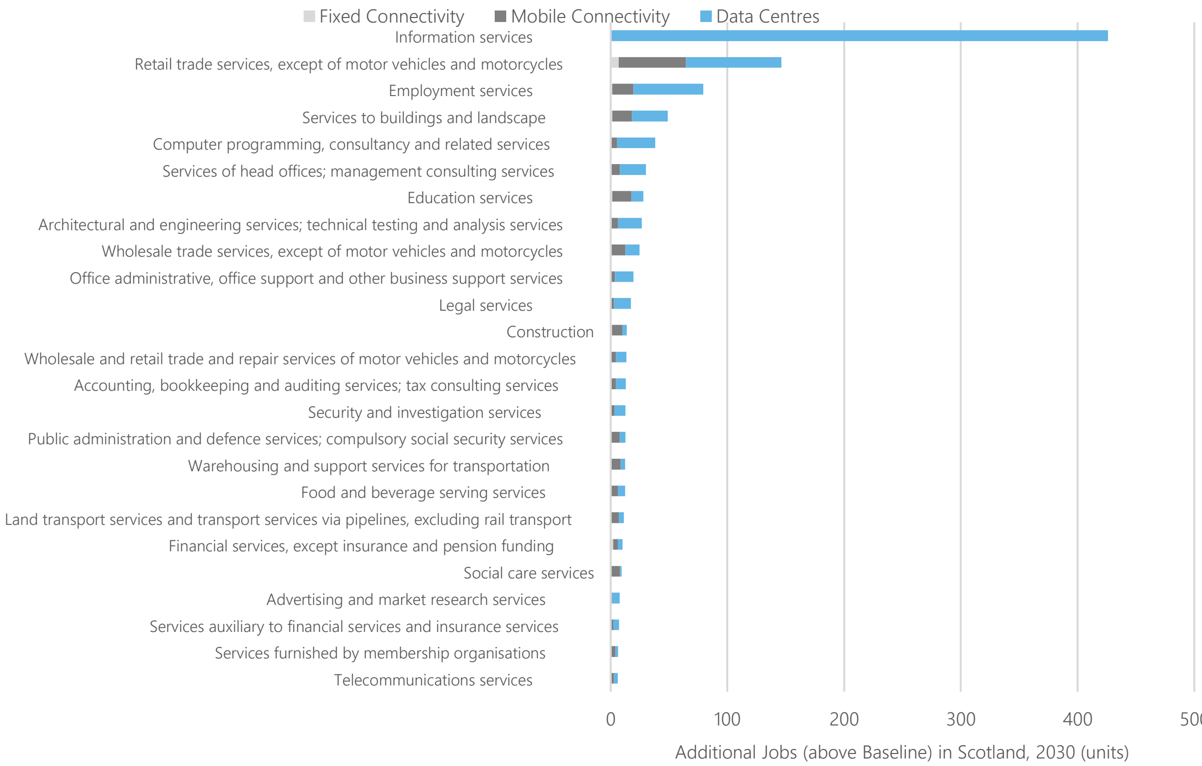
[65] The GVA ratio to expenditure is 0.8.
[66] On this scenario, the size of the majority of new businesses is assumed to remain at the 'micro' level (reflecting historic Scottish) trends, with a proportion graduating to medium size enterprises by the end of the period.
[67] See https://www.scottishfuturestrust.org.uk/storage/uploads/impact_of_digitalisation_in_scotlandcompressed.pdf for more details.
[68] See https://hbr.org/1990/03/the-competitive-advantage-of-nations
[69] The regional split for the GVA and jobs has not been modelled, but would be likely to reflect existing economic activity in Scotland, save for a relative increase in the area where the new submarine cable landed (to be determined).

Figure 5.5: Detailed annual long-term GVA impacts by sector: scenario one



Source: Deloitte analysis

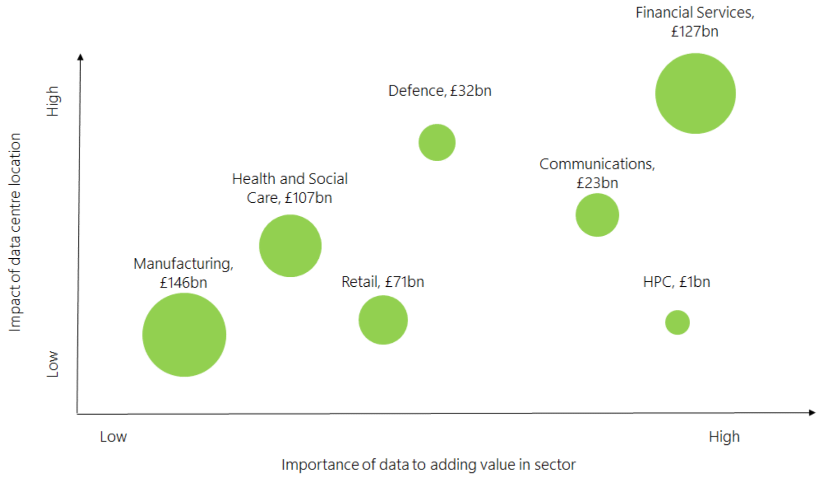
Figure 5.6: Detailed annual long-term employment impacts by sector: scenario one



Source: Deloitte analysis

As the model depicts, the key sector benefiting from the growth in data centres is information services. While not modelled explicitly, one might expect to see agglomeration benefits occur as data centres and supporting industries cluster in the same areas. These might include economies of scales and higher productivity levels (which were confirmed above for data centres). However, as Glaeser (2010) points out the extent of any agglomeration benefits will also be contingent on transport networks, human capital and other urban development policies.[70] As set out in Chapter 3, KTN reports that clustering is particularly important for data centres. Data centre clusters are shown to support the growth of allied industries of financial services and communications.

Figure 5.7: Data centres clustering



Source: adapted from KTN

While the above clustering impacts refer to the UK, the structure of the Scottish economy is similar enough to infer a similar level of data clustering could occur.

The growth in the data centres sector also stimulates job creation in other high productivity sectors such as computer programming (including data science) and professional services.

The benefits arising from enhanced connectivity causing greater digitalisation via more fixed and mobile subscribers is more widely distributed across other sectors of the Scottish economy, reflecting how these sectors can better from better quality of service, access to markets and access to new services. The retail sector, in particular, benefits from enhanced mobile connectivity, as does the education sector which, in turn, can further spill over effects around social inclusivity and connectivity. In 2030 (the long-term), the impact on the telecommunications service sector is relatively smaller given the major CAPEX has occurred earlier.

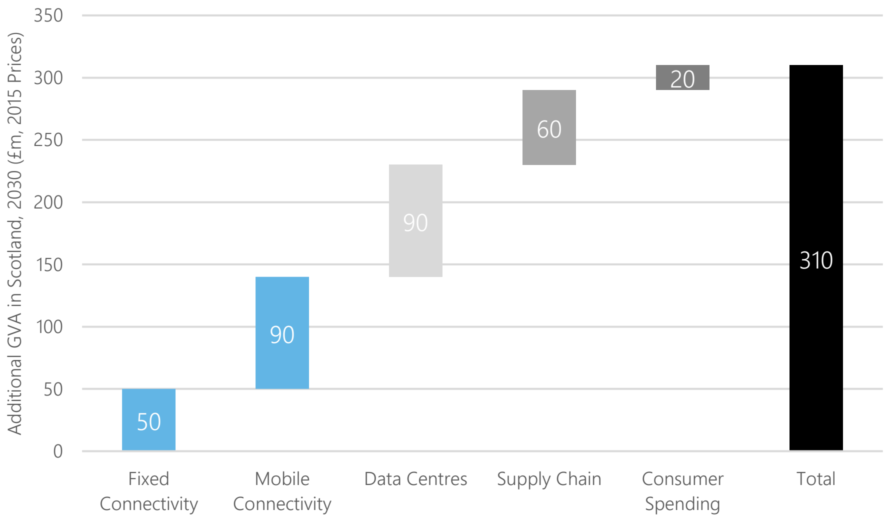
5.5.2 Scenario two - high subscriber growth, persistent connectivity improvement and accelerated data centre growth

5.5.2.1 GVA, jobs and productivity

The modelling analysis estimates that in the long-term (2030), Scottish GVA will likely be over £0.3 billion higher due to enhanced international connectivity compared to the baseline, with over 2,100 additional jobs in that year. These benefits will come from more fixed broadband subscribers, mobile subscribers contributing to greater digitalisation and a larger data centre industry in Scotland.

[70] Source: Agglomeration Economics, 2010, introduction available at: http://www.nber.org/chapters/c7977.pdf

Figure 5.8: Annual long-term GVA impacts: scenario two



Source: Deloitte analysis

Figure 5.8 shows the different components of the overall GVA uplift in 2030 from enhanced connectivity, including the establishment of a new hyper-scale data centre in Scotland. Given a more persistent impact of fixed and mobile connectivity, having a longer-term impact on growth rates, their relative contributions to the overall GVA uplift are higher than in scenario one. The detailed breakdown of GVA and employment by direct, indirect (supply chain) and induced (consumer spending) impacts are shown below.

Figure 5.9: Detailed annual long-term GVA and employment impacts: scenario two

		Fixed Connectivity	Mobile Connectivity	Data Centres	Total
Direct	Employment			720	720
	Value Added (£m)	50	90	90	230
	Expenditure (£m)	80	170	150	400
Indirect (total)	Employment	100	340	490	920
	Value Added (£m)	10	20	30	50
	Expenditure (£m)	10	40	50	100
Induced (total)	Employment	60	180	220	470
	Value Added (£m)	-	10	10	20

		Fixed Connectivity	Mobile Connectivity	Data Centres	Total
	Expenditure (£m)	10	20	20	50
Total	Employment	170	530	1,420	2,120
	Value Added (£m)	60	120	130	310
	Expenditure (£m)	100	220	210	540

Source: Deloitte analysis. Note numbers do not sum precisely due to rounding.

With respect to productivity changes, these jobs and GVA occur in high-productivity sectors of the Scottish economy (such as information services, see below) and will result in more high-productivity jobs being created. Average productivity per worker is higher than the previous scenario at £145,000 in 2030 in the affected sectors compared to the overall Scottish figure of £55,000. In the sectors most affected by improved mobile connectivity, productivity is, on average, 3.7% higher than the baseline of no enhanced international connectivity.

The multipliers remain the same as the previous scenario. That is to say, the rule of thumb Type I expenditure multiplier (capturing direct and indirect effects) is approximately 1.3; with the Type II expenditure multiplier (including induced effects) estimated at 1.5. This means £1 spent will generate a further £0.5. [71] The equivalent rule of thumb Type I and II multipliers for employment are 1.7 and 2.0 respectively.

5.5.2.2 Business start-up rates, innovation and competitiveness

The jobs and GVA discussed above will be achieved through a combination of mechanisms, including the formation of new businesses to take advantage of enhanced connectivity, expansion of existing businesses into new markets or offering new products, improved domestic competition stimulating economic activity and Scotland becoming a more attractive place to invest.

Given the structure of the data centre sector (and requirements for CAPEX), it is reasonable to assume the majority of new business created will be due to improved fixed and mobile connectivity. Using the aforementioned methodology, suggests compared to the baseline around 56% of the new jobs created due to fixed and mobile connectivity impacts are achieved via new business creation; this is equivalent to 13% of all the additional jobs.[72] This is the similar as scenario one, albeit the absolute number of businesses and jobs created is larger.

Drawing on the Etro methodology and taking a conservative approach, the rate of new business growth is expected to be permanently 1.6% higher from 2021 (with no adjustment to the business death rate). Similarly, conservatively we estimate that at least 13% of the GVA (c.£40m) and job benefits (c.300) could be attributable to innovation via market growth and new products and services.

The benefits to Scottish competitiveness are similar to those previously outlined in the enhanced digitalisation report and in scenario one, albeit they are likely to be larger. These include:

- Improved resilience and latency rates that can complement other competitive strengths around renewable energy and skills; and
- Opportunities to extend marketplaces via online platforms to create new routes to Scottish and other markets.

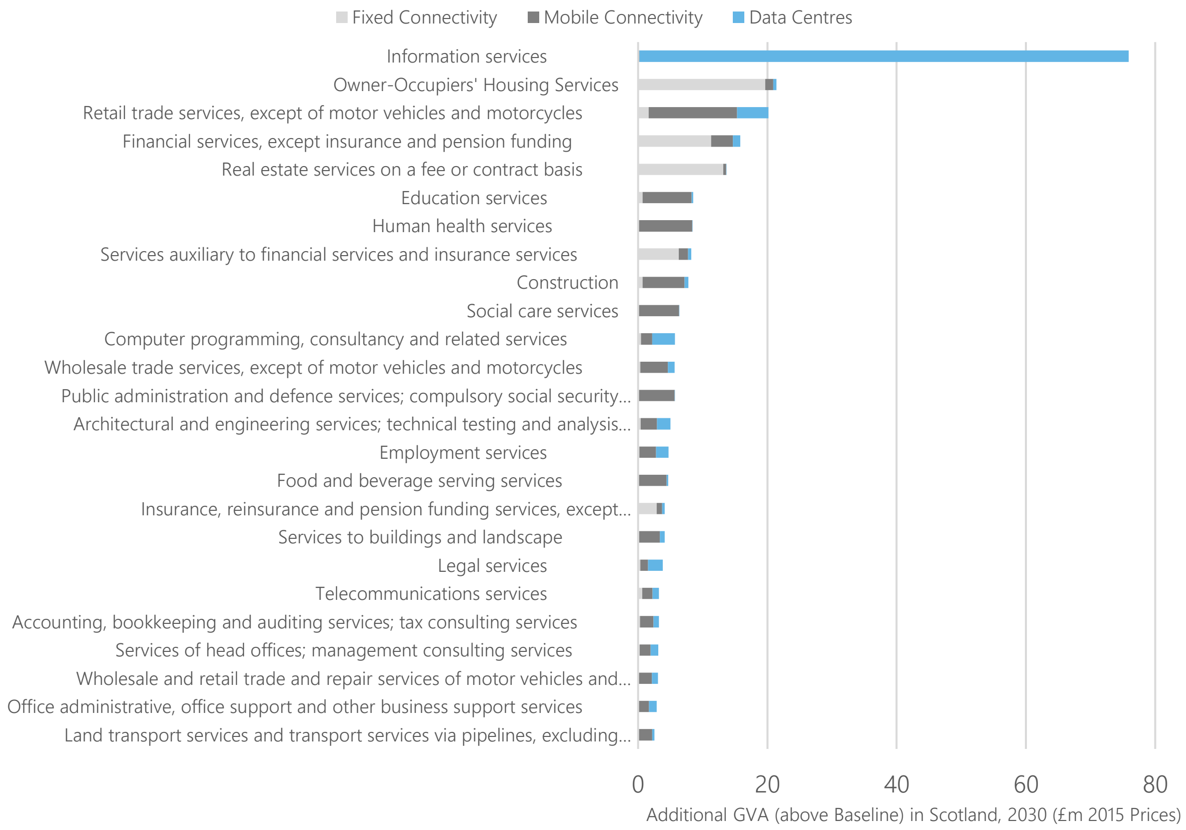
Again, more specifically, enhanced international competitiveness could contribute to Michael Porter's 'diamond of national advantage' in similar way to scenario one.

5.5.2.3 Agglomeration and secondary and tertiary sectors benefiting

The estimated splits between different sectors across Scotland are shown below for the long-term by 2030 in terms of GVA and jobs.[73]

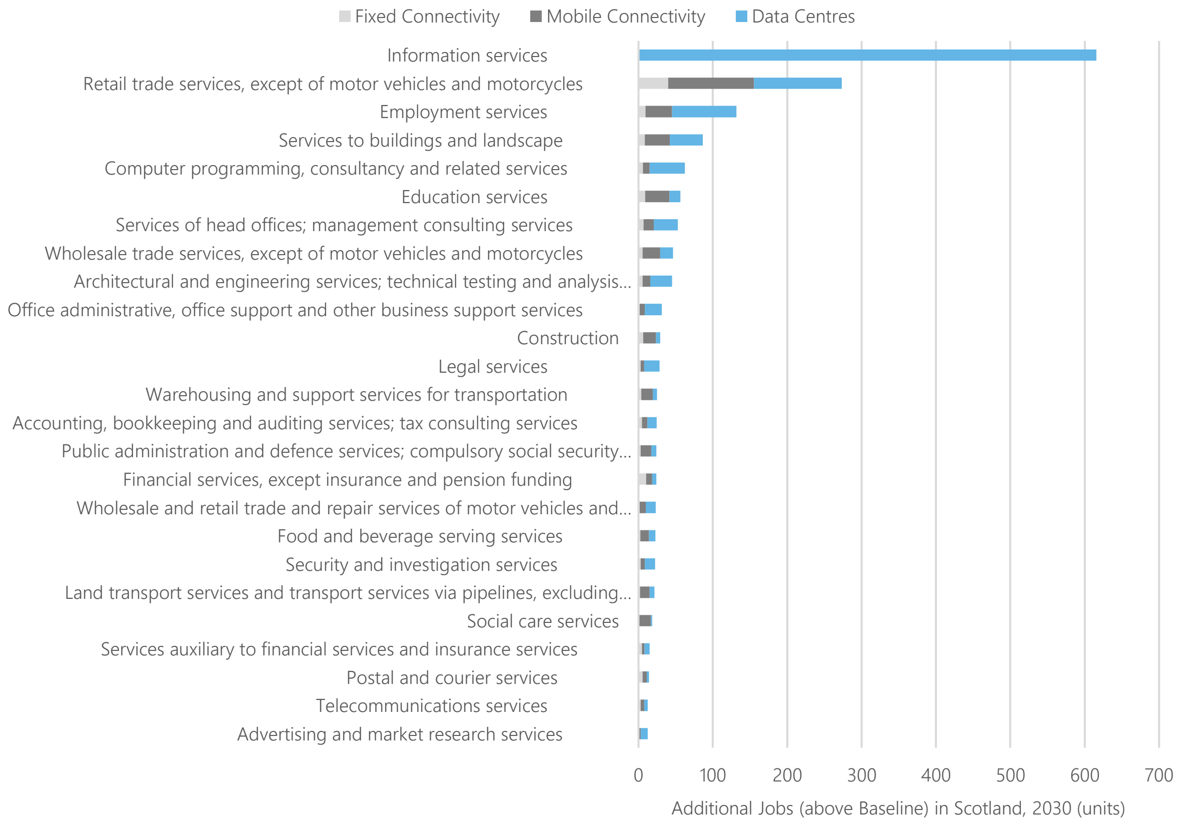
Figure 5.10: Detailed annual long-term GVA impacts by sector: scenario two

[71] The GVA ratio to expenditure is 0.8.
[72] On this scenario, the size of the majority of new businesses is assumed to remain at the 'micro' level (reflecting historic Scottish) trends, with a proportion graduating to medium size enterprises by the end of the period.
[73] The regional split for the GVA and jobs has not been modelled, but would be likely to reflect existing economic activity in Scotland, save for a relative increase in the area where the new submarine cable landed (to be determined).



Source: Deloitte analysis

Figure 5.11: Detailed annual long-term employment impacts by sector: scenario two



Source: Deloitte analysis

The impact of the hyper-scale data centre can be clearly seen, with the increased number of jobs in the information services sector. This reflects how more data sectors allow Scotland to retain more of the benefits of internationally connectivity domestically, rather than the new cable simply being used to service other markets.

A similar impact on agglomeration is expected as described in scenario one.

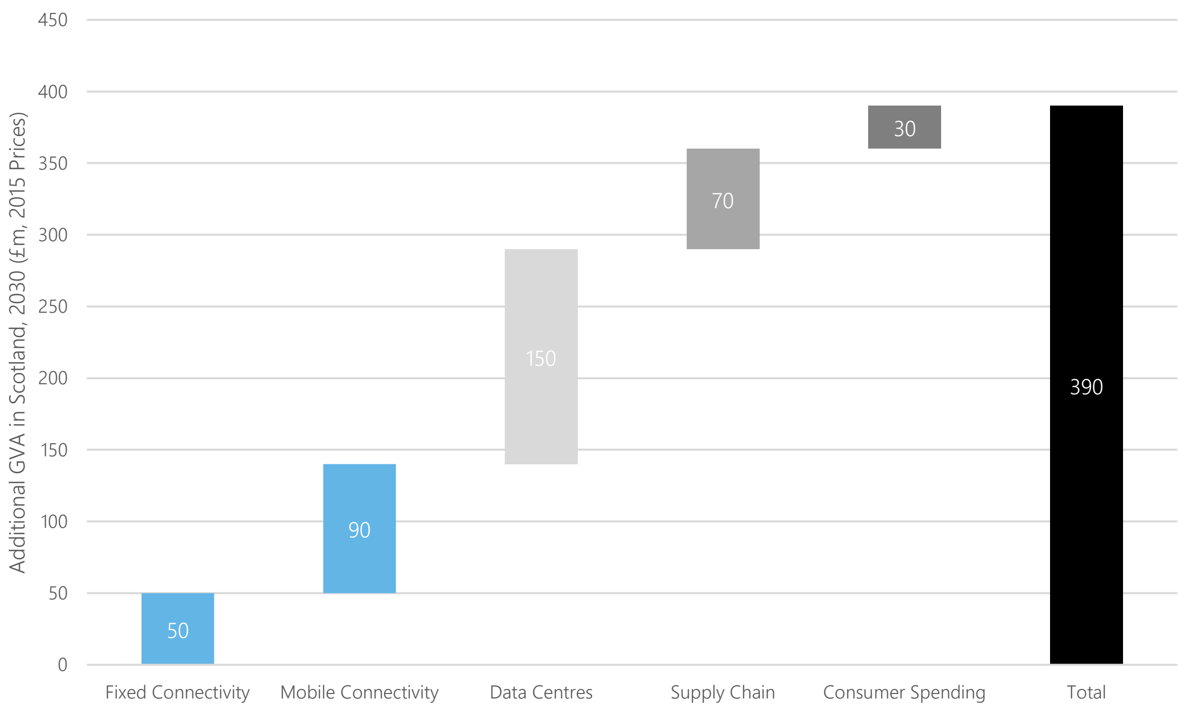
5.5.3 Scenario three – (high subscriber growth, persistent connectivity improvement and very significant growth in data centres

5.5.3.1 GVA, jobs and productivity

The modelling analysis estimates that in the long-term (2030), Scottish GVA will likely be around £0.4 billion higher annually due to enhanced international connectivity compared to the baseline, with over 3,000 additional jobs in that year relative to the baseline of no new international connectivity and only incremental increases in the number of additional data centres.

These benefits will come from more fixed broadband subscribers, more mobile subscribers contributing to greater digitalisation and a larger data centre industry in Scotland, as shown below.[74] The impact of having many more data centres (including a second hyper-scale data centre) are particular pronounced.

Figure 5.12: Scenario three: Annual long-term GVA impacts, relative to the baseline



Source: Deloitte analysis

As Figure 5.12 shows, around 40% of all GVA is directly attributable to the data centres sector, which also positively impacts the supply chain and consumer spending components. The impact of the data centres sector is larger than the direct GVA benefits from increased digitalisation attributable to more fixed and mobile subscribers, reflecting how enhanced connectivity is a major driver for this sector's growth.

The increased GVA and associated increase in jobs can be decomposed into direct impacts due to enhanced international connectivity affecting fixed and mobile subscriptions and more jobs due to more data centres and related activity. As Figure 5.13 shows, there is no direct employment created in 2030 from fixed and mobile connectivity as the construction and installation of the cables will have already occurred earlier in the period (and will have been capital rather than labour intensive). However, there will be jobs directly created to run and maintain data centres. There are, nonetheless, supply chain or indirect impacts from both connectivity and data centres through sectors that benefit from enhanced connectivity, as well as induced impacts from more consumer spending. The full results, including employment, are shown below.

Figure 5.13: Detailed annual long-term GVA and employment impacts: scenario three

		Fixed Connectivity	Mobile Connectivity	Data Centres	Total
Direct	Employment			1,220	1,220
	Value Added (£m)	50	90	150	290
	Expenditure (£m)	80	170	250	500

[74] Greater digitalisation will help increase demand for cloud computing, which will increase demand for data centres – hence a positive feedback loop.

		Fixed Connectivity	Mobile Connectivity	Data Centres	Total
Indirect (total)	Employment	100	340	810	1,250
	Value Added (£m)	10	20	40	70
	Expenditure (£m)	10	40	80	130
Induced (total)	Employment	60	180	380	620
	Value Added (£m)		10	20	30
	Expenditure (£m)	10	20	40	60
Total	Employment	170	530	2,400	3,090
	Value Added (£m)	60	120	210	390
	Expenditure (£m)	100	220	350	690

Source: Deloitte analysis. Note numbers do not sum precisely due to rounding.

With respect to productivity changes, these jobs and GVA occur in high-productivity sectors of the Scottish economy (such as information services, see below) and will result in more high-productivity jobs being created. Average productivity per worker is £127,000 in 2030 in the affected sectors[75] compared to the overall Scottish figure of £55,000. In the sectors most affected by improved mobile connectivity, productivity is, on average, 3.5% higher than the baseline of no enhanced international connectivity.

The rule of thumb Type I expenditure multiplier (capturing direct and indirect effects) is approximately 1.3; with the Type II expenditure multiplier (including induced effects) estimated at 1.5. This means £1 spent will generate a further £0.5. The equivalent rule of thumb Type I and II multipliers for employment are 1.7 and 2.0 respectively.

5.5.3.2 Business start-up rates, innovation and competitiveness

The jobs and GVA discussed above will be achieved through a combination of mechanisms, including the formation of new businesses to take advantage of enhanced connectivity, expansion of existing businesses into new markets or offering new products, improved domestic competition stimulating economic activity and Scotland becoming a more attractive place to invest.

Given the structure of the data centre sector (and requirements for CAPEX), it is reasonable to assume the majority of new business created will be due to improved fixed and mobile connectivity. Using the aforementioned methodology, suggests compared to the baseline around 58% of the new jobs created due to fixed and mobile connectivity impacts are achieved via new business creation; this is equivalent to 13% of all the additional jobs.[76] This is the similar as scenario one, albeit the absolute number of businesses and jobs created is larger.

Drawing on the Etro methodology and taking a conservative approach, the rate of new business growth is expected to be permanently 1.7% higher from 2021 (with no adjustment to the business death rate). Similarly, conservatively we estimate that at least 13% of the GVA (c.£51m) and job benefits (c.400) could be attributable to innovation via market growth and new products and services.

The benefits to Scottish competitiveness are similar to those previously outlined in the enhanced digitalisation report and in scenario one, albeit they are likely to be larger. These include:

- Improved resilience and latency rates that can complement other competitive strengths around renewable energy and skills; and
- Opportunities to extend marketplaces via online platforms to create new routes to Scottish and other markets.

Again, more specifically, enhanced international competitiveness could contribute to Michael Porter's 'diamond of national advantage' which measures the competitiveness of nations.

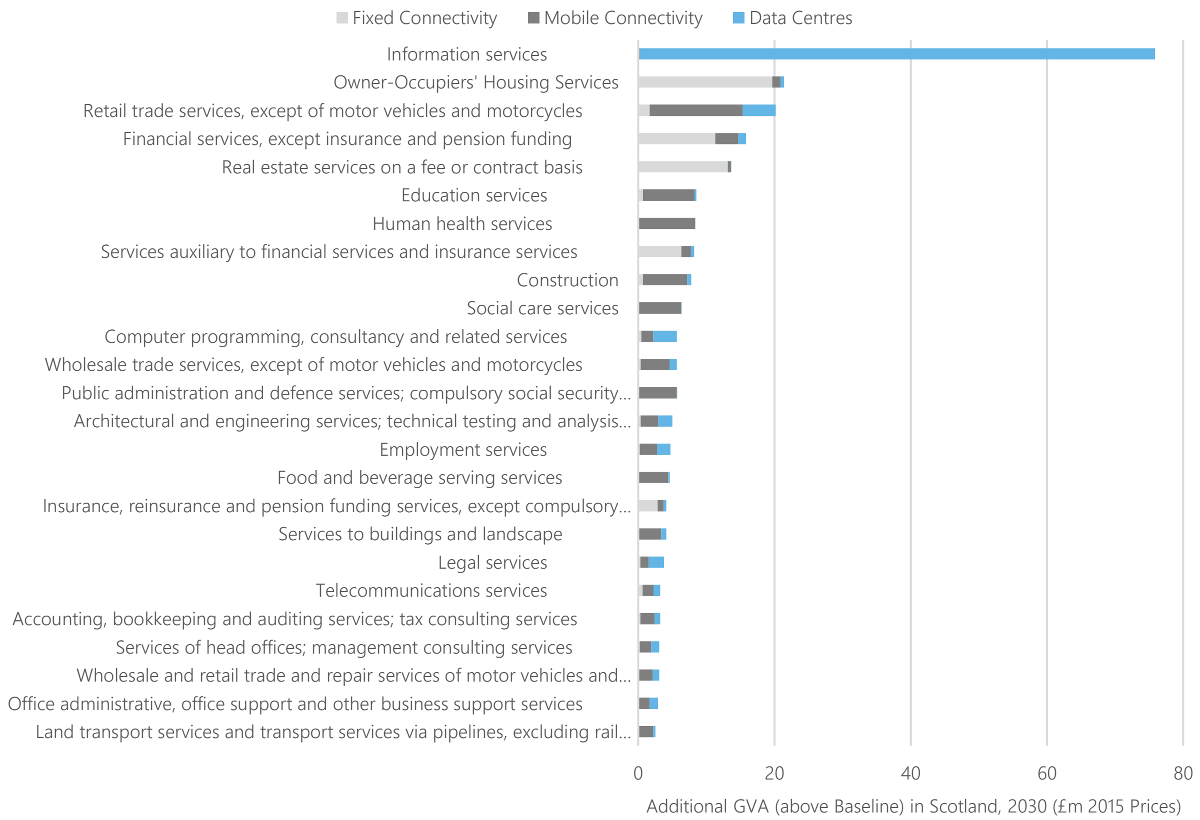
A major difference in scenario three will be more opportunities for cloud computing through more and larger data centres.

5.5.3.3 Agglomeration and secondary and tertiary sectors benefiting

The estimated splits between different sectors across Scotland are shown below for the long-term by 2030 in terms of GVA and jobs.[77]

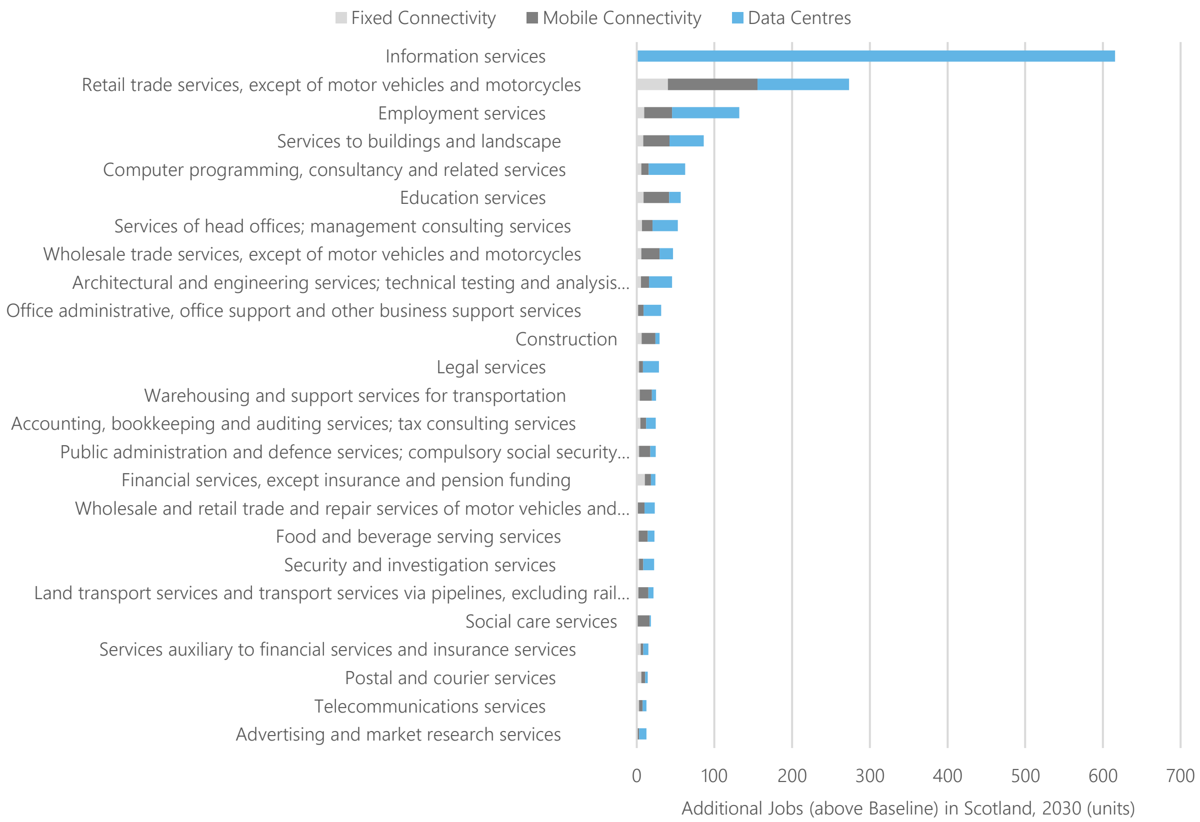
[75] This is lower than scenario two due to the larger eco-system created, including lower productivity jobs.
[76] On this scenario, the size of the majority of new businesses is assumed to remain at the 'micro' level (reflecting historic Scottish) trends, with a proportion graduating to medium size enterprises by the end of the period.
[77] The regional split for the GVA and jobs has not been modelled, but would be likely to reflect existing economic activity in Scotland, save for a relative increase in the area where the new submarine cable landed (to be determined).

Figure 5.14: Detailed annual long-term GVA impacts by sector: scenario three



Source: Deloitte analysis

Figure 5.15: Detailed annual long-term employment impacts by sector: scenario three



Source: Deloitte analysis

As with scenario two, the largest impacts occur in the data centre sector.

In terms of further scenarios, if a second or third cable were to be added, it is likely the benefits from enhanced international connectivity would largely be captured by data centres rather than more mobile and fixed subscribers (as maturity is reached). This suggests the benefits would accrue to data centres rather than more digitalisation overall. It is not possible to say, and stakeholders did not have a view, on what 'rule of thumb' might be for another submarine cable stimulating more data centre investment in Scotland as this will depend as much on demand conditions as relieving supply constraints.

However, even for data centres, the benefits would eventually taper off as the relative benefits of more connectivity would diminish. Equally, any new data centres that might locate to Scotland might no longer be additional (as in the above three scenarios), i.e. they may come from other parts of the UK to take advantage of Scotland now having more favourable conditions for data centres overall.

5.6 Other benefits common to all scenarios

As discussed in Chapter 3, enhanced connectivity is likely to bring a number of other economic benefits beyond GVA, employment and productivity. These include:

- An improved quality of service for large-scale users through improved latency, which can help build a competitive edge;
- Cost savings from greater digital resilience (reducing the probability of outage by increased redundancy);
- Costs savings from greater digital connectivity supporting efficiencies such as time savings and reduced distribution costs;
- Attracting FDI to take advantage of the improved digital infrastructure;
- Fiscal benefits from tax raised from new businesses;
- Positioning Scotland to test and pilot new IoT technologies that require low levels of latency; and
- Supporting key strategic industries evolve, such as the oil and gas sector that can use connectivity to support decommissioning and the transition to other services.

As noted above, while the scenarios do not assume any displacement to the rest of the UK, greater international connectivity could support certain industries relocate back to Scotland or establish hubs there to take advantage of closer proximity to the landing site of the submarine cable. This might be particular pertinent for financial services firms.

5.7 Impact for the rest of the UK

Independent of any displacement effects, enhancing international connectivity will have wider benefits for the rest of the UK. These will include:

- Improved resilience to the whole UK from Scotland having enhanced international connectivity, providing redundancy if all links to other parts of the UK were damaged or suffered from an outage;
- Supply chain and consumer spending impacts that occur outside of Scotland due to enhanced international connectivity;
- Increased competition in the data centre industry, stimulating lower prices and better customer services; and
- Wider FDI flows that benefit UK plc.

As discussed in Chapter 3, the loss of internet services caused by disruption in international connectivity can be highly disruptive to modern economies. Based on estimates of costs of internet outage cited by Policy Exchange and others, a rough estimate of the loss of internet activities across the UK caused by no international connectivity could be in the order of £3.2bn per day.[78] Having an additional cable to Scotland would provide further mitigation against such a risk.

5.8 Link to previous Deloitte research

Earlier work by Deloitte for SFT in 2015 found that if Scotland became a world leader in digitalisation, it could expect to see an increase in GDP (analogous to GVA) of over £13bn by 2030. The estimates cited in this chapter are both part of this figure and an addition to it. Specifically:

- The benefits from increased subscriber numbers (fixed and mobile penetration) and the resultant increase in data usage and connected devices is part of the £13bn. For example, the £140m of GVA benefits in scenario one would be part of the original research.

[78] Based on a scaling up using GDP ratios of the $10m daily loss of internet citied publicly for countries that lost connectivity.

- However, the benefits accruing from more data centres are additional and over and above previous estimates.

This reflects that fact that achieving the benefits from digitalisation is not just about enhancing international and domestic connectivity – other measures around skills and other initiatives are required (see Chapter 5).

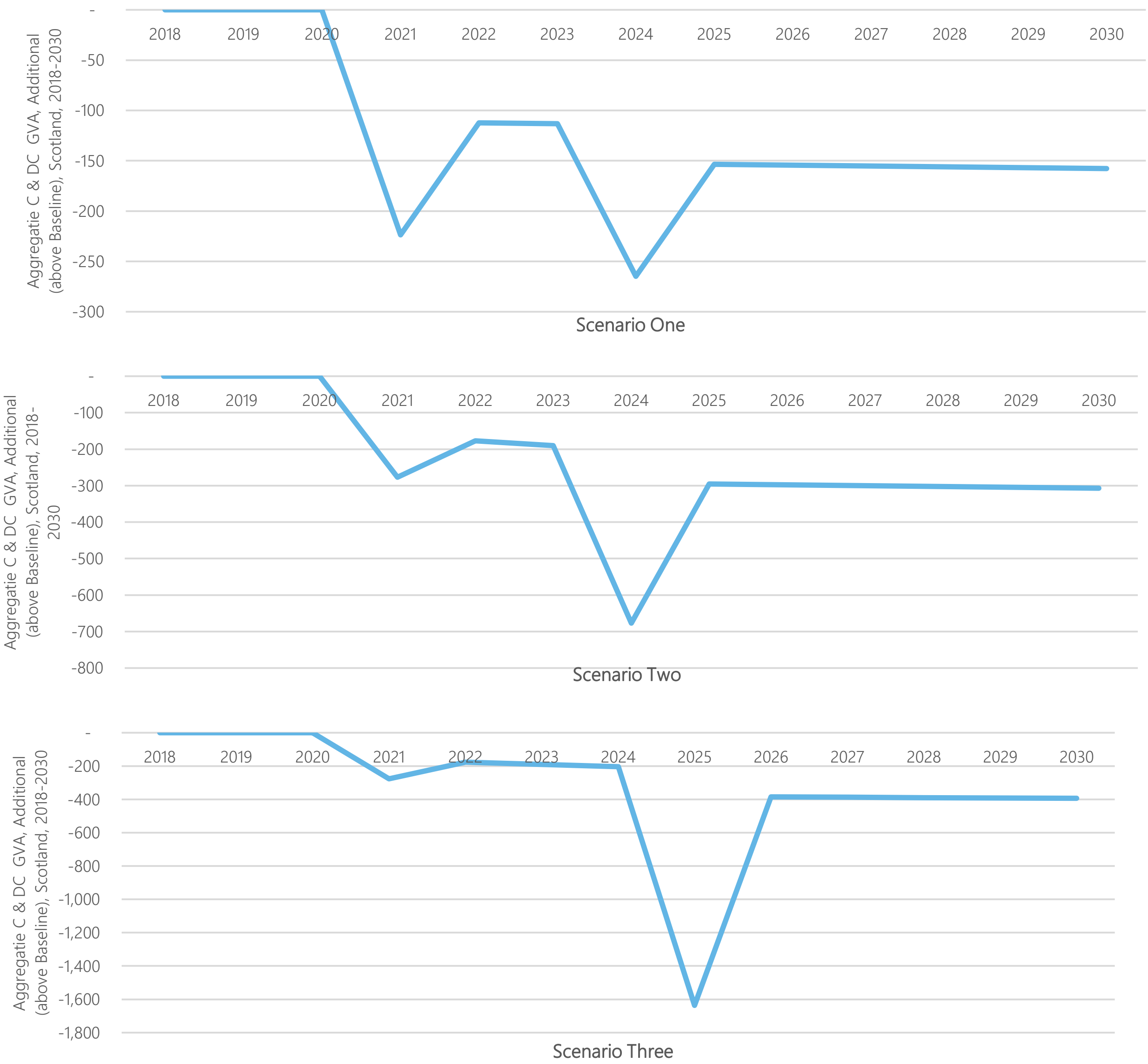
6 The risks of not improving International Connectivity

6.1 The impact of no enhanced international connectivity

The previous chapter has presented estimates of the increased GVA and employment arising from enhanced international connectivity in Scotland. In the absence of any change in international connectivity, one would still expect GVA and employment growth in Scotland as the economy develops, due to a variety of factors including planned investments in domestic connectivity. However, this growth would be slower relative to if international connectivity were increased.

The additional GVA and job growth for each scenario is show below, with the effects starting in 2021 (when enhanced connectivity occurs). The figures show the additional direct, indirect and induced benefits caused by the connectivity – this is essentially what is lost if connectivity is not improved under each scenario. The spikes occurring in 2021 and 2025 reflect the CAPEX spend for new data centres in that year stimulating one-off GVA associated with construction that year and also on-off job impacts that do not persist.

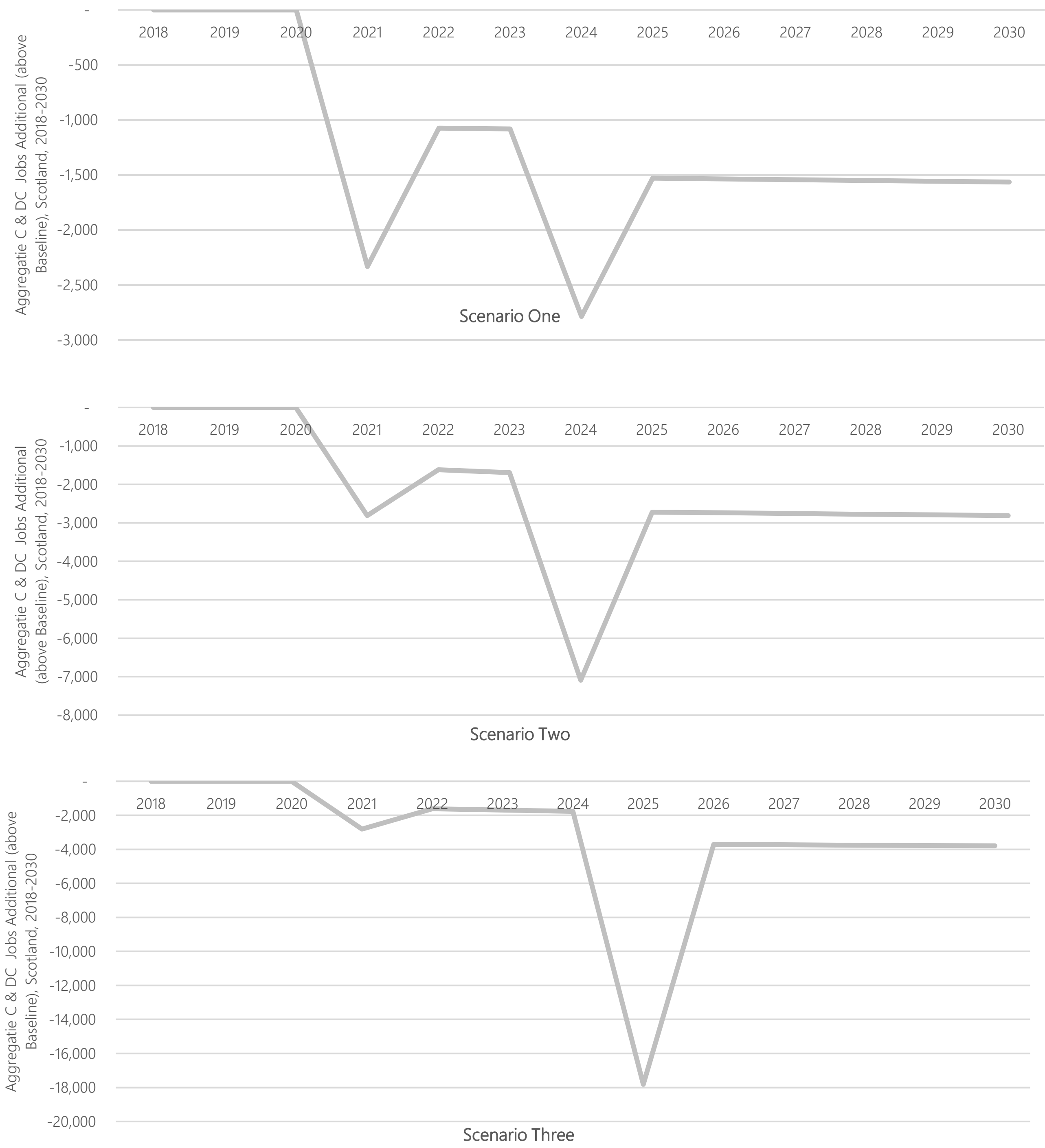
Figure 6.1: 2018-2030 GVA 'delta' between baseline and scenarios one, two and three (foregone GVA)



Source: Deloitte analysis

Over the period, not enhancing international connectivity could result in between £1.6bn-£4.4bn in non-achieved GVA in Scotland (not NPV adjusted). There are similar spikes due to construction of more data centres in 2021 and 2025.

Figure 6.2: 2018-2030 Employment 'delta' between baseline and scenarios one and two (lost employment per year)



Source: Deloitte analysis

Over the period, not enhancing international connectivity could result in between 1,500 and 3,800 few jobs by 2030.

In addition to lower GVA and fewer jobs, Scotland could also miss the following benefits that arise from the virtuous circle between international and domestic connectivity:

- Increased internet resilience with respect to international connectivity;
- More data centres locating to Scotland to take advantage of lower latency and other comparative advantages Scotland has;
- The opportunity to be a test-bed for new technologies that require lower latency;

- Attracting financial services, med-tech and other sectors that require low latency levels to locate in Scotland to take advantage of enhanced international connectivity; and
- The opportunity to use enhanced international connectivity to catalyse other domestic connectivity targets and other domestic policy goals.

7 The Role of Government

7.1 Addressing the connectivity gap

The benefits from enhanced international connectivity are clear. From improved economic outcomes to greater resilience in the case of internet outage to supporting domestic policy objectives and new technologies, a modern economy requires reliable and dedicated international connectivity. Not having this in place means continuing to rely on third parties for international connectivity and placing potential barriers to growth on local tech industries.

Scotland has an opportunity to enhance its international connectivity and use this in a way to complement its existing Digital Strategy, creating a mutually reinforcing circle of connectivity that allows it to deliver greater levels of prosperity quicker and more widely.

Typically, investments in international submarine cables are made by private consortia rather than the public sector, driven by expected returns achievable from a domestic market. Stakeholders report that currently this is unlikely to occur in Scotland due to the relatively small market. However, if this investment does not occur, Scotland risks losing the economic benefits of enhanced connectivity and falling further behind its international competitors and relying on third parties for its data centres.

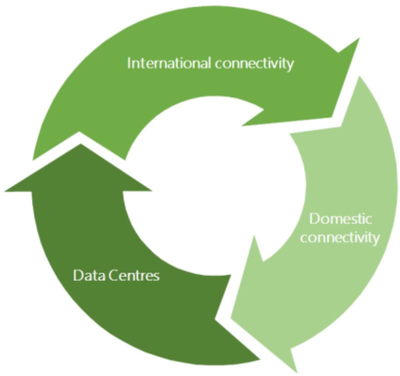
There is therefore a case for a public sector intervention with respect to international connectivity to 'crowd-in' investment to improve international connectivity and stimulate demand. This does not necessarily have to be via a brand new trans-Atlantic submarine cable; other European-based cabling solutions might offer enhanced connectivity. Policy interventions to support enhanced international connectivity could take a number of forms, including:

- Partnering with the private sector to invest in a new submarine cable and acting as a Market Economic Operator ("MEO");
- Offering, or providing access to, competitive financing to the private sector to invest in enhanced international connectivity using initiatives such as the Building Scotland Fund ("BSF") and/or the forthcoming Scottish National Investment Bank ("SNIB");
- Creating the 'right' commercial environment for private sector investment in international connectivity through incentives and/or regulation for the public and private sector to use Scottish data centres;
- Develop 'use cases' and demand analysis for the private sector to demonstrate the business case for investment in international connectivity; and
- Running innovation competitions to test, pilot and rollout new solutions for international connectivity and widen understanding of drivers for the datacentre market.

The precise mix of policy interventions would need to be explored more thoroughly and analysed to understand which provides the best value for money for Scottish taxpayers. The next step is therefore a more detailed options analysis and associate cost-benefit appraisal. Such an appraisal should also consider different funding and financing options, the appropriate mix of public and private investment and any policy and legal constraints.

Importantly, facilitating investment in enhanced international connectivity is only one part of the puzzle in improving overall digital connectivity. As show throughout this report, international connectivity works in concert with domestic connectivity to deliver economic and social outcomes.

Figure 7.1: Virtuous circle between international and domestic connectivity



Source: Deloitte analysis

Thus, policy interventions to enhance international connectivity should be complemented by measures to improve digital skills (so that Scotland can exploit the benefits of connectivity), lower cost and more sustainable energy (to attract data centres) and existing plans to improve domestic digital connectivity (e.g. the roll out of fibre to ensure everyone can connect).

Annex 1: Modelling Approach

The modelling approach has three modules: the impact of international connectivity on (i) fixed broadband subscriber numbers; (ii) mobile broadband subscriber numbers and (iii) data centres in Scotland.

Fixed Broadband Connectivity

We take a four-step approach to model the impact on GVA per sector from improved fixed broadband arising from greater international connectivity.

1. Source baseline forecasts for the growth of the Scottish economy (by sector) for the period 2018 – 2030 covering metrics such as GVA, employment and productivity. These provide the baseline of could be reasonably expected to happen to the Scottish economy without any additional investment or enhancement in international connectivity and against which all benefits could be measured.
2. An indicative 'rule of thumb' relationship determined between international connectivity, domestic connectivity and the chosen connectivity metrics, to show how a change (increase) in international connectivity flows through into outcomes in Scotland.
3. An indicative 'rule of thumb' relationship determined between the change in connectivity metrics and wider economic impacts in Scotland such as GVA, jobs and productivity for those sectors directly impacts by increased connectivity.
4. The individual sectoral impact of increased connectivity is modelled in a fixed-coefficient Input Output model to generate economy-wide impacts across Scotland.

To develop our 'rule of thumb' approach for the relationship between international connectivity and domestic connectivity we have completed a basic correlation analysis of the number of international cables with number of fixed broadband subscribers across four countries (Denmark, Ireland, Norway and Sweden) to test if there is a positive correlation. The analysis suggests a fixed broadband subscriber and international cable correlation of 0.58 suggesting if one grows the other may as well.

This is of course, not the same as causation (or even what the direction of causation is). Whilst a full detailed econometric analysis is out of scope, a very preliminary panel data regression was estimated for approximately 15 years for the above countries. The regression specification used was:

$$Domestic\ Connectivity\ Proxy_{it} = \alpha + \beta.International\ Connectivity\ Proxy_{it} + \varepsilon_{it}$$

where $Domestic\ Connectivity\ Proxy_{it}$ is fixed broadband subscriptions per 100 people; $International\ Connectivity\ Proxy_{it}$ is number of submarine cables and ε_{it} is unobserved random shocks to yearly domestic connectivity proxy. The key parameter of interest is β, which captures the impact of the international cable unit change on fixed broadband subscriptions per 100 people across four countries. The estimated β value is 12.6% significant at 5%.

However, clearly this regression misses a number of other important explanatory variables and cannot be taken as definitive. Further, given Scotland is now a more mature broadband market than many of these countries were in the early 2000s, the β value may be overstated.

For these reasons, the rule of thumb used has assumed a much smaller relationship value, reducing the β value by a factor of five in the scenario one and a factor of two in scenarios two and three. This is based on stakeholder discussions and a review of the literature suggesting there is a positive causal relationship between international and domestic connectivity. More detailed regression analysis is required to more accurately estimate this relationship.

We have then draw on a study by Crandall, Lehr & Litan (2007) (Issues in Economic Policy The Brookings Institution, The effects of Broadband Deployment on Output and Employment: A cross sectional Analysis of U.S. Data) which estimates the impact of increased take up of fixed broadband on the wide economy. We use their estimated coefficients of the relationship between subscriber numbers and economic growth to model how a unit change in international connectivity affects growth rates in four sectors. These four sectors are finance and insurance, real estate, educational services and 'other' services and are chosen as they coefficients are statistical significant.

In the scenario one, we assume the uplift to sectoral GVA growth rate is effective for one year and the estimated β value is divided by five. This is to be consistent with Crandall paper (although the absolute level in year one has increased with knock-on impacts for future years). In scenarios two and three, to be consistent with economic theory, the uplift to GVA growth rates is assumed to persist longer than one year – give years – and the β value is divided by two.

The estimated changes to year-on-year growth rates in these sectors are then converted in absolute GVA values and compared against the baseline GVA values for these sectors. The 'delta' or difference in the values for 2030 are then used in Deloitte's Input-Output (IO) model to generate economy wide impacts.

Originally developed by Leontief, the Input-Output model characterises the relationships different sectors of the economy have to each other in order to determine the impact of additional expenditure in any particular sector. The model uses sector-specific multipliers to trace through how a £1 spent in one sector has a wider impact, decomposing the direct, indirect and induced impacts. This model, which draws on published data from the Office for National Statistics, was originally developed for national economies. Our model has been updated to represent the Scottish economy.

The delta is fed into the model, and through the calculated multipliers, economy- and sector-wide impacts are estimated.

Mobile Broadband Connectivity

Similar to fixed connectivity, we take a four-step approach to model the impact on GVA per sector from improved fixed mobile arising from greater international connectivity.

1. Source baseline forecasts for the growth of the Scottish economy (by sector) for the period 2018 – 2030 covering metrics such as GVA, employment and productivity. These provide the baseline of could be reasonably expected to happen to the Scottish economy without any additional investment or enhancement in international connectivity and against which all benefits could be measured.
2. An indicative 'rule of thumb' relationship determined between international connectivity, domestic connectivity and the chosen connectivity metrics, to show how a change (increase) in international connectivity flows through into outcomes in Scotland.
3. An indicative 'rule of thumb' relationship determined between the change in connectivity metrics and wider economic impacts in Scotland such as GVA, jobs and productivity for those sectors directly impacts by increased connectivity.
4. The individual sectoral impact of increased connectivity is modelled in a fixed-coefficient Input Output model to generate economy-wide impacts across Scotland.

In this case, the estimated β value is 12.6% significant at 5%. Again, for the purposes of this study, the rule of thumb used has assumed a much smaller relationship value, reducing the β value by a factor of five in scenario one and a factor of two in scenarios two and three. This is based on stakeholder discussions and a review of the literature suggesting there is a positive causal relationship between international and domestic connectivity. More detailed regression analysis is required to more accurately estimate this relationship.

We have then draw on a previous study by Deloitte for the GSMA[79] to translate changes in mobile subscriber numbers to economic outcomes. We use the estimated coefficients of the relationship between subscriber numbers and economic growth (log mobile penetration on log GDP per capita) to model how a unit change in international connectivity affects growth rates in four sectors. These four sectors are finance and insurance, real estate, educational services and 'other' services and are chosen as they coefficients are statistical significant.

In scenario one, we assume the uplift to sectoral GVA growth rate is effective for one year and the estimated β value is divided by five. In the scenarios two and three, to be consistent with economic theory, the uplift to GVA growth rates is assumed to persist longer than one year – give years – and the β value is divided by two.

The delta between the baseline and estimated scenarios are then inputted in the IO model for economy- and sector-wide impacts.

Data Centres

With respect to the impact of data centres, the following approach has been followed (with full details in the annex):

1. Data has been collected on the number of data centres in Scotland, average revenue per data centre (where possible by data centre type/size);

[79] Available at: https://www.gsma.com/publicpolicy/wp-content/uploads/2012/11/gsma-deloitte-impact-mobile-telephony-economic-growth.pdf

2. A high-level assumption has been made according to each modelling scenario (see below) on the relationship between data centres and international connectivity, and how the latter can stimulate the former to growth based on stakeholder discussions, growth trends and industry insight;
3. The additional expected revenue generated by data centres due to international growth by 2030 is then fed through the Deloitte Input-Output model to estimate economic outcomes on both GVA and jobs.

Limitations

Given time and data limitations, a number of simplifying assumptions have had been made that, if changed, will significantly alter the overall results. These include:

- The results are presented for the year 2030 only, as the representative 'steady state' year when the impacts of connectivity and more subscribers will have become the norm;
- It is assumed enhanced international connectivity is achieved in 2021 and attracts new data centres in two waves (2021 and 2025);
- Zero displacement is assumed for data centres between Scotland and the rest of the UK, i.e. the new data centres established in Scotland are genuinely new and not relocated centres from elsewhere in the UK;
- Current Scottish Government policy initiatives to improve *accessibility* to broadband continue as planned, but do not necessarily raise the number of subscribers as the same pace;
- The baseline forecasts are assumed to already account for (publicly known) baseline rate of change investments in domestic connectivity and new data centres; and
- The Scottish Government and others take the necessary steps to support the economy in investing in skills and other infrastructure to complement enhanced international connectivity to attract data centres.

The limitations to this approach are the following:

- A direct causal relationship between international connectivity and other outcomes of interest has not been estimated.
- The focus has been on subscriber numbers rather than other indicators such as speed, resilience, coverage, etc., as these data were not readily available for Scotland.
- The direct impact of enhanced connectivity per sector has not been possible due to lack of data.
- Due to data availability, the by sector elasticity estimates are from year 2005 and focus on the US market. There are a number of sectors that were not included in the study, for example, E-commerce. This impacts our model as we are currently unable to model the direct uplift on E-commerce industry should international connectivity improves. In addition, the US market has a very different economy compared to Scotland, though the elasticities still serve as a credible source of indicator as our best alternative.
- The Crandall, Lehr & Litan (2007) paper does not include lags of the dependent variable as independent variables, so in the upper bound scenario, we have assumed the impact on t =1 would stay constant in t = 2, 3,4 and 5. This is an assumption that seeks to model the upper boundary.

Annex 2: Bibliography

365 Data Centres (2016) *Data Centre Colocation Build vs. Buy*

APEC policy Support Unit (2012) *Economic impact of Submarine Cable Disruptions*

Bell (n.d.) *Why connectivity counts for your data centre*

Broad Group (n.d.) *The data centre market in two years*

Cabinet Office (n.d.) *Cloud Business Summary*

Copenhagen Economics (2017) *Finland's Economic Opportunities from Data Centre Investments*

Copenhagen Economics (2018) *European Data Centres: How Google's digital infrastructure investment is supporting sustainable growth in Europe*

Cushman and Wakefield (2017) *Brexit Implications on the UK Data Centre Market*

DBS Asian insights (2016) *Data centres: What to Do in the Face of Public Cloud?*

Deloitte (2018) *2018 Telecommunications Industry Outlook*

Department of Commerce (2018) *State of the Data Center Industry*

Digital Scotland (2014) *Scotland's Digital Future: Report on the current landscape for Data Hosting and Data Centres in the Scottish Public Sector*

Digital Scotland (2017) *Scotland's Digital Strategy; Evidence Discussion Paper*

DLA Piper (2014) *Global Data centre Market Report*

Eliott, C., Al-tabbaar, O. Semeyutin, A., Njoya, E. (2016) *An Economic and Social Evaluation of the UK Subsea Cables Industry*

FNT (2017) *The truth about connectivity*

Frontier Economics (2018) *Future Telecoms Infrastructure Review: Annex A*

Gartner (2018) *Forecast: Data Centres, Worldwide, 2015-2022, 2018 update*

Gartner (2018) *Prepare for the death of the data centre as we know it*

Gartner (2018) *Scottish Data Centre Demand Review*

HM Government (2017) *Industrial Strategy: building a Britain Fit for the Future*

Hot Telecom (n.d.) *The future of IPX in Bahrain and the GCC*

Intellect (2017) *So what have data centres ever done for us?*

KTN (n.d.) *The Big UK Data Centre Equipment Opportunity*

Linxscotland (n.d) *An internet exchange for Scotland*

London Assembly (2017) *Digital Connectivity in London*

Marinescotland (2014) *Scotland's National Marine Plan*

Minges, M. (2016) *Exploring the Relationship Between Broadband and Economic Growth*

Mintel (2019) *Data Centres – UK, May 2018*

NERA Economic Consulting (2018) *Telecommunications Infrastructure International Comparison*

Nzier (2011) *Trade and Investment impacts of submarine cable disruptions*

OECD (2013) Measuring the Internet Economy: A Contribution to the Research Agenda. *OECD Digital Economy Papers, No. 226, OECD Publishing, Paris*. Available from: http://dx.doi.org/10.1787/5k43gjg6r8jf-en

Ofcom (2017) *Communications Market Report*

Ofcom (2017) Summary *Communications Market Report*

Ofcom (2017) *Scotland Connected Nations Update*

Ofcom (2018) *Connected Nations Update*

Policy Exchange (2017) *Undersea cables*

Qiang, C. (2017) *Broadband Infrastructure Investment in Stimulus Packages: Relevance for Developing Countries*

Regeneris for Openreach (2018), *The Impact of High-Speed Broadband for Communities*

Rickne, A. (2006) Connectivity and Performance of Science-based firms. *Small Business Economics, vol.26 no.4, pp.393-407*

SQW (2014) *UK Broadband Impact Study*

SSE Enterprise () *Telecoms Network Map Digital*

Stellium DataCentres (2018) *What it takes to be a winning City / Region in the digital age*

Subsea Cables UK (n.d.) *Written submission from Subsea Cables UK*

Terabit Consulting (n.d.) *The Global Market for Submarine Cables: Insights into Economic development*

The Boston Consulting Group (2016) *Capturing the Data Centre Opportunity*

The Brookings Institution (2017) *The Effect of Broadband Deployment on Output and Employment: A cross sectional Analysis of U.S. Data*

The Department for Culture, Media and Sport (2017) *Mobile infrastructure Project impact and Benefits report*

The Department for Digital, Culture, Media and Sport (2017) *UK Digital Strategy 2017*

The Scottish Government (2012) *Scotland's Digital Future – Infrastructure Action Plan*

The Scottish Parliament: McGrath, F. (2016) *SPICe Briefing: Digital Connectivity*

Tim Kelly, Victor Mulas, Siddhartha Raja, Christine Zhen-Wei Qiang and Mark Williams, World Bank (2009) *What role should governments play in broadband development?*