Broadband in Scotland: broader, faster, poorer, remoter

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Abstract

The provision of universal broadband Internet access in Scotland has been the subject of political promises, to support economic growth and reduce social divides. The market supplying broadband is subject to complex, multi-tiered governance. Until the UK leaves the EU, it is subject to EU aspirations, directives and regulations, which are implemented in London by the UK government and regulatory authority. There are strong path dependencies, arising from the Openreach agreement on wholesale access, between the regulator and BT, which affects both the residential and business markets. Competition in fixed broadband is primarily service-based and dependent on regulation. Mobile broadband has limited infrastructure-based competition, with incentives from UK government to extend coverage. State aid has been provided by complex means to support increased rural provision, but has not been ended, in favour of cross-subsidies. Those disinclined to use the Internet are being encouraged to do so, by local initiatives, partly to ease the digital by default strategy for government services. Brexit brings the possibility of change, by leaving the EU governance system, while the possibility of Scottish independence would require an entirely new system of market governance.

Keywords: Broadband, Governance, Internet, State Aid, Telecommunications

I Introduction

The challenges in delivering universal broadband have increased significantly.[1] The goalposts have been moved by imperfectly predictable technological advances and unexpected changes to the politico-regulatory landscape, with Brexit removing the United Kingdom from the single European regulatory space, and with the possibility of a second Scottish independence referendum that might or might not return it there. The capacity of Scottish Ministers to influence broadband markets and to improve the availability of services has been overstated, with consequences for economic growth and productivity.

Despite telecommunications and Internet access being reserved matters, on which the Scottish Parliament cannot legislate, the Scottish National Party (SNP) has promised world class infrastructure, services accessible “any time, any place, anywhere”,[2] and superfast broadband to 100 per cent of premises by 2021.[3] For the most part delivery relies on policies and regulatory frameworks developed in Brussels and implemented in Westminster and Whitehall, to which Scottish Ministers add little, if any, value and over which they have

[1] *For an earlier review see Sutherland (2012).*
[2] *This is taken from a 1980s advert for Martini see https://www.youtube.com/watch?v=bF1IUGpQO-o*
[3] *Superfast is a download speed of up to 24 Megabits per second (Mbps).*

uncertain influence. For example, the Scottish Parliament recently inquired into spending of £136 million on broadband for remote areas, when the Chancellor of the Exchequer was announcing £1 billion for ultrafast broadband and related infrastructure (HM Treasury, 2016; REC, 2016). At the same time, the UK Digital Economy Bill will remove Scottish Ministers from the support for rural superfast broadband, presently delivered with state aid from HM Treasury and the European Union (EU), switching to a system of cross-subsidies, in which urban residents will pay towards the higher costs of those living in rural areas, managed by OFCOM.[4] The single United Kingdom market is constrained by the path dependencies arising from successive EU and UK legislation, policies and regulatory decisions, especially the Openreach Agreement between BT and OFCOM.

The Internet has almost become ubiquitous, with invitations to follow 'celebrities' on Instagram, to 'like' Police Scotland on Facebook, to exercise with your personal trainer on Snapchat, and to watch programmes on the BBC TV iPlayer, while courses are taught and jobs are advertised on-line. The Internet of Things (IoT) extends networks beyond people to encompass 'smart' cars, domestic appliances, factories, homes, meters, and wearables, including clothing, connected directly or via sensors (HMG, 2014a; RAND Europe, 2014; OFCOM, 2015a; PAC, 2014; BEREC, 2016). Cisco (2016) reports massive growth in Internet traffic and forecasts yet more, the annual total for global Internet Protocol (IP) traffic exceeded one Zettabyte (ZB) in 2016, and is forecast to reach 2.3 ZB by 2020.[5] These developments are built on a global market, with network and scale economies, which could be threatened by any disruption to globalisation, such as the imposition of trade barriers.

A major consideration for governments has been the link between broadband and economic growth, justifying interventions in national markets, the creation of national plans, and the provision of state aid (Czernich, Falck, Kretschmer, & Woessmann, 2011; OECD, 2011; Arvin & Pradhan, 2014). The Internet is considered a general purpose technology (GPT), one that can be used across the full range of the economy for innovation that can disrupt, eliminate or transform established activities and businesses (Clarke, Qiang, & Xu, 2015; Liao, Wang, Lic, & Weyman-Jones, 2016). Skills are central to those innovations and their adoption, raising questions about the availability of a skilled workforce and training for citizens (Ekos Ltd, 2014; Select Committee on Digital Skills, 2015; Science and Technology Committee, 2016). The importance of Internet access has been stressed by the World Economic Forum (WEF), both for growth and economic competitiveness (Baller, Dutta, & Lanvin, 2016), though since rival nations are similarly engaged in deploying networks and improving skills,

[4] *The report stage in the House of Lords began on 22 February 2017. http://services.parliament.uk/bills/2016-17/digitaleconomy.html*
[5] *1 ZB = 10^{21} bytes or 1billion Terabytes.*

it is a strategic or unavoidable necessity, something all nations must have. Like the *Tour de France*, it is a long and gruelling race, in which careful planning, strenuous training and physical exertion are required, merely to maintain a position in the broadband *peloton*.[6]

The next section outlines the complex pre-Brexit system of multi-tiered governance of telecommunication markets. This is followed by analyses of the markets for retail and business broadband, then mobile broadband. The provision and use of state aid is then reviewed. The next sections review adoption of broadband in general and specifically in Glasgow. Finally, conclusions are drawn and issues identified for further research.

II Multi-tiered governance

The EU has set an ambitious goal for economic growth from completion of its digital single market (DSM), to add €415 billion annually to its gross domestic product (GDP) (EC, 2015). As a form of European nation building, it expects fixed and mobile broadband networks to become very widely accessible (see Table 1), including making €500 million available in loans from the European Investment Bank (EIB, 2016). It is also promoting a collaborative economy, in which businesses use platforms to create marketplaces for individuals to offer the temporary use of goods and services (EC, 2016a).

Until the completion of Brexit, the governance of telecommunications markets in the United Kingdom remains part of the multi-tiered EU system, with ministers, regulators and civil servants engaged in European regulatory networks (ERNs) (Maggetti, 2014), and bound by the EU acquis (i.e., legislation, policies and treaties) (Sutherland, 2017a). Domestically, the asymmetric, quasi-federal system of government saw the creation of devolved legislatures in Belfast, Cardiff and Edinburgh, each with different and evolving powers, but unable to legislate on telecommunications or Internet access.[7] Nonetheless, successive Scottish Ministers adopted policies, setting objectives for improving availability of services in rural areas (see Table 3), channelling state aid to operators, coordinating public procurement, supporting community action to improve digital skills, and transposing some minor planning legislation. However, the targets and state aid schemes came from HMG (see Table 2).

[6] *The yellow jersey for broadband is presently held by South Korea.*
[7] See, for example, Schedule 5 of the Scotland Act 1999, section c3 of which excludes competition policy, while section c10 excludes telecommunications and wireless telegraphy.

Table 1: European Union broadband targets

Year	*Target*
2013	Basic broadband for all citizens
2020	Speeds of 30 Mbps for all homes. 50% of homes having 100 Mbps or faster. (EC, 2010a)
2025	All schools, transport hubs, main providers of public services and digitally intensive enterprises to have 1 Gbps (EC, 2016b). All urban areas as well as major roads and railways to have uninterrupted 5G wireless broadband coverage (EC, 2016g).

Table 2: Broadband targets set by Her Majesty's Government

Title	*Target*
Digital Britain (HMG, 2009)	100% coverage by 2012, with minimum speed of 2 Mbps. 90% coverage of Next Generation broadband (up to 40 Mbps) for homes and businesses by 2017.
Britain's superfast broadband future (BIS & DCMS, 2010)	At least 2 Mbps for all. Superfast broadband (at least 24Mbps) to 90% of homes and businesses
Queen's Speech (HMG, 2016c)	10 Mbps universal service obligation (USO).
Superfast Broadband Programme (BDUK, 2016)	Basic broadband (2 Mbps) for all from December 2015. Superfast broadband (24 Mbps) to 90% by early 2016 and 95% by December 2017.

The failure of its first independence referendum left the SNP unable to seize the 'economic levers', so that in the governance of telecommunications markets it was left with few mechanisms:

- Procurement (e.g., Scottish Wide Area Network (SWAN, 2017));
- State aid; and
- Persuasion of the British and European Union (EU) institutions.

It is not clear that the, admittedly secretive, Joint Ministerial Committee (JMC), has ever met to discuss telecommunications and Internet access, though Scottish Ministers have written to their UK counterparts.

Figure 1: Outline of multi-level governance for telecommunications

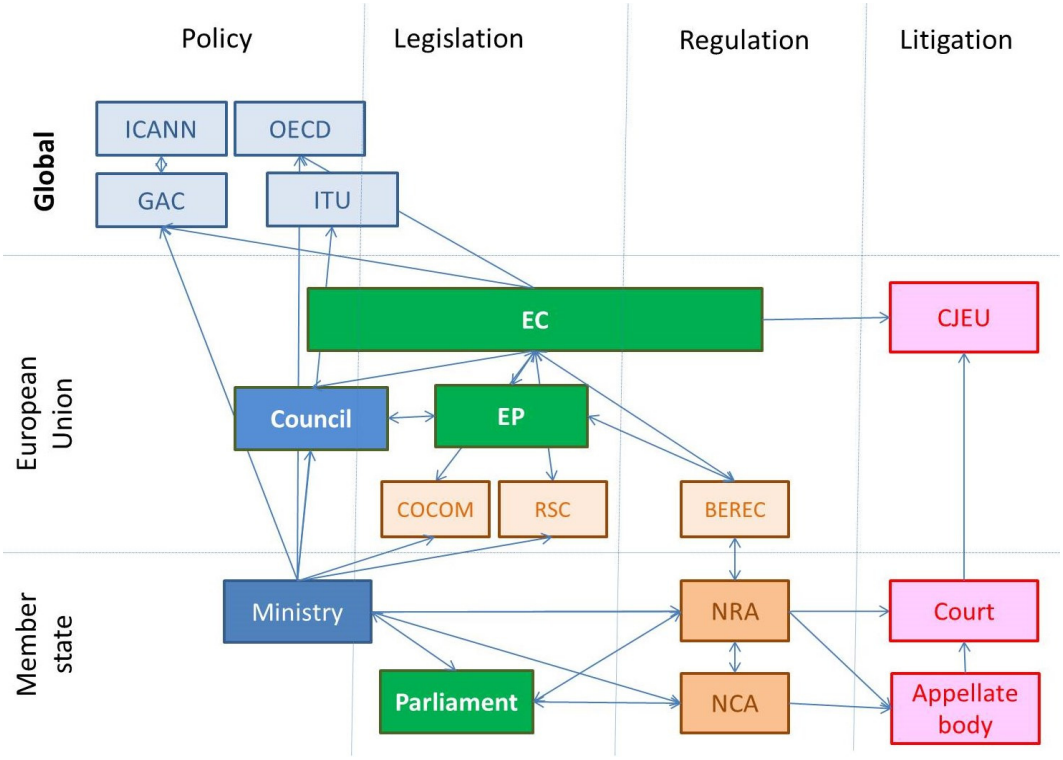


Table 3: Broadband policies of Scottish Ministers

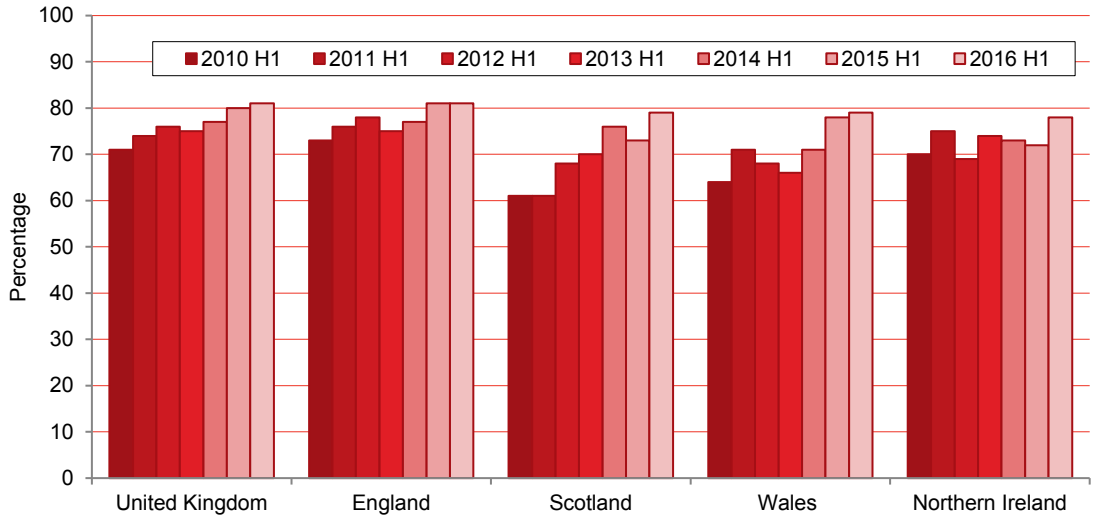
Title	*Target*	*Actions*
Connecting Scotland (SE, 2001a)	• To make affordable and pervasive broadband connections available to citizens and businesses • To ensure that every school has access to a rich online world in which it will be possible to communicate with others by text, voice or video; • To ensure that all parts of the health service can transfer data and use telemedicine as necessary.	Demand aggregation and procurement in: • Highlands & Islands and • South of Scotland
Digital inclusion strategy (SE, 2001b)	• HMG and SE committed to achieving universal access to the Internet by 2005 • As part of its Social Justice Strategy, to accelerate the number of households in disadvantaged areas with access to the Internet; • As part of its National Grid for Learning Programme (NGfL), to secure the benefits of advanced networked information technologies for education and lifelong learning.	• A major campaign with HMG to raise the awareness of the benefits of getting online; • Increasing awareness of existing public access facilities; • increasing public access facilities; • Developing 2 pilot digital communities in disadvantaged areas
Ambitions for the enterprise networks (SE, 2001c)	• We want widespread digital connections to speed information flow around Scotland and back and forth between Scotland and the world.	• Enterprise Networks to promote online business models; • Help ensure that all Scots benefit from emerging digital technologies.
Digital inclusion in partnership (SE, 2006a)	This renewed approach to tackling the digital divide will contribute to ensuring appropriate and effective support to partners delivering services, or providing access, and training to excluded groups	Promoting and raising awareness of good practice, obligations and responsibilities within a range of practitioner networks
Digital inclusion: Connecting Scotland's people (SE, 2006b)	A digitally-inclusive Scotland will ensure more equal, effective and beneficial access for all people to the digital technologies and Web facilities that benefit them in their day-to-day lives. In a digitally-inclusive Scotland, the public, private, and voluntary sectors will make positive use of digital technologies and the Web to improve quality of life and deliver new opportunities for disadvantaged individuals and communities.	• Major campaign to raise awareness of the benefits of getting online; • Mapping and publishing the locations of all public access facilities; • Significantly increasing the number of venues offering public access; • Two pilot digital communities in disadvantaged areas.
Digital Ambition for Scotland (SG, 2010a)	• Next generation broadband will be available to all by 2020, and significant progress will be made by 2015; • Rate of broadband uptake should be at or above UK average by 2013, and should be highest of the UK nations by 2015.	n/a
Scotland's digital future (SG, 2011b)	n/a	• Various coordination and planning activities.
Scotland's digital future (SG, 2012a)	To deliver world-class, future proofed digital infrastructure across all of Scotland by 2020, with an interim milestone of delivering a step change by 2015	By 2015 speeds of 40-80 Mbps for between 85-90% of premises; By 2020 world-class broadband;
Programme for government (SG, 2016a)	We are also investing in the digital infrastructure necessary to deliver next generation broadband to 100% of premises – business and residential – across Scotland.	• Launch delivery plan to reach 100%; • Invest £90 million to deliver access to fibre optic broadband to 95% of premises by end 2017; • A mobile programme to address gaps in 4G mobile coverage.

The complexity of governance of the United Kingdom broadband market and the reservation of legislative powers to Westminster limit the capacity of Scottish Ministers to intervene. However, this has not stopped them making promises of greater and universal access, even where they do not have the powers or resources to deliver, only partially sheltered by the undefinable term "world class" (Sutherland, 2017b).

III Retail broadband services

Broadband services, often bundled with broadcast and on-demand television programmes, have been welcomed by households. At the beginning of the decade Scotland had the lowest level of household adoption of the four 'nations' and, while it has caught up with Northern Ireland and Wales, it has yet to overtake England (see Figure 2). Take-up of superfast broadband in Scotland is also lagging at 27%, compared to 31% for the UK.

Figure 2: Broadband take-up at home (OFCOM, 2016a, p. 4)



There are two major providers of terrestrial broadband infrastructure, the UK-wide Openreach network, owned by BT, and the largely urban Virgin Media cable television network, owned by Liberty Global, plus a few smaller players with local footprints (e.g., B4RN (2016) and KCOM (2016)). In addition to this infrastructure-based competition, there is service-based competition amongst providers of retail broadband, using the BT Openreach local access network (see Table 4). The market is the United Kingdom, because providers mostly resell the wholesale Openreach offer and because they bundle it with video content that is licensed for the UK. Thus network and scale economies combine to make market entry difficult for local or infrastructure players. Arguably, this is a policy or regulatory failure, since it would have been possible to encourage and facilitate local infrastructure-based

competitors, for example, by ensuring the availability of backhaul from a number of local interconnection points.

Table 4: Broadband service providers

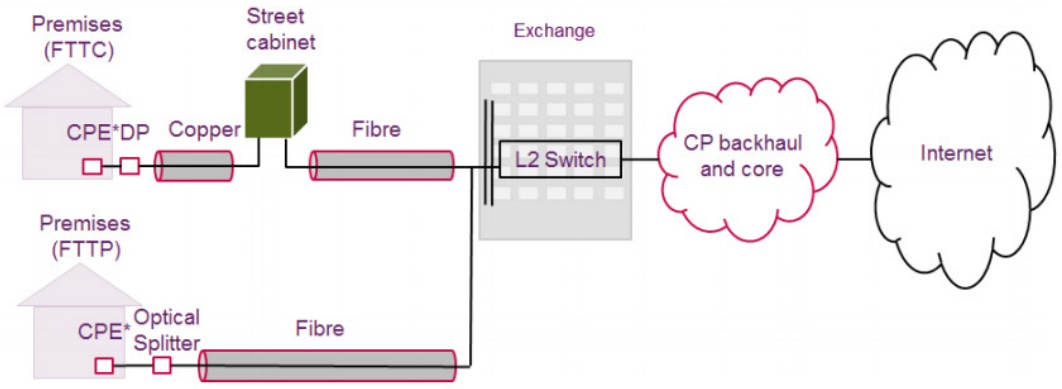
Brand	*Ownership*	*Comments*
BT	BT Group plc	Reselling Openreach offers, bundled with video content, including a significant sports selection. Also offers a bundle with its own mobile service.
EE	BT Group plc	Primarily a mobile operator of 2, 3 and 4G wireless services, reselling Openreach DSL. Acquired by BT for £12.5 billion in 2015.
Plusnet	BT Group plc	Founded in 1997 in Sheffield, floated on the Alternative Investment Market in July 2004, then acquired by BT in January 2007
Sky[8]	Listed on LSE	A satellite broadcasting, on-demand Internet streaming media, broadband and telephone services provider, with operations in the UK, Ireland, Germany, Austria and Italy. Formed by the merger of Sky TV and British Sky Broadcasting, plus a various satellite TV firms in the EU. Recently became an MVNO in the UK.
Talk Talk	Listed on LSE	Founded in 2003 as a fixed telephony provider within the Carphone Warehouse group, then spun-off in March 2010. Suffered a severe cybersecurity failure, when hacked by a teenager, being fined for inadequate safety measures (BBC, 2016a; BBC, 2016b).
Virgin Media	Liberty Global	Acquired by Liberty Global for USD 24 billion in 2013, the largest global cable company, with interests in a dozen countries. The result of mergers of a number of local cable television companies.
Vodafone	Listed on LSE	Vodafone Group plc is a global mobile phone group, with interests in many countries, operating with 2, 3 and 4G technologies. Bundles mobile with fixed broadband in UK.
Zen Internet	Privately held	Founded in 1995 in Rochdale, where it began offering services. Both retail and business services.

By relying on regulated service-based competition, using real and virtual local loop unbundling (see Figure 3), BT has been allowed a significant say in the availability of new services and technologies, and of the pace of their deployment. For example, Vodafone challenged the rollout of services using the G.Fast standard, which delivers 'up to' 330 Mbps

[8] *Presently under offer from News Corp.*

download on existing copper cables, seeking to have OFCOM control the Openreach technology migration path (Daws, 2016; FT, 2016). For more rural areas, where homes are further from exchanges, BT is conducting trials of 'long reach' VDSL in North Tolsta on the Long Isle (Fiveash, 2016). InNovember 2016, the Chancellor of the Exchequer announced business rates relief for increased deployment of fibre into networks (HM Treasury, 2016).

Figure 3: Virtual unbundled local access (VULA) (Source: OFCOM)



In more remote locations an alternative is satellite broadband (see Table 5). HMG offers a subsidy of at least £350 towards the installation costs in locations where the available terrestrial speed is less than 2 Mbps (Satellite Internet, 2016). These offer speeds close to superfast broadband, but remain unpopular.

Table 5: Ka-band satellite services

Firm	*Satellite*	*Position*
Eutelsat (Tooway brand)[9]	Eutelsat	10.0° E
Avanti Communications	Hylas 1	33.5°W
	Hylas 2	31.0°E
SES Techcom	Astra 2F	28.2°E
	Astra 3	23.5°E

The decisions of HMG and the EU to pursue local loop unbundling and of OFCOM to strike the Openreach Agreement with BT created strong path dependencies in the governance and

[9] *http://www.broadbandwherever.net/support-schemes/free-broadband-for-scotland/*

structure of the retail market. Competition relies in large measure on the Openreach Agreement, which has been the subject of considerable lobbying and litigation, an enduring tussle between service providers and BT. OFCOM has strengthened its legal separation of Openreach, but rejected calls for it to require BT to spin it off (OFCOM, 2016d). In addition to OFCOM, the Advertising Standards Authority has been a vital regulator of advertised speeds, endeavouring to restrain misleading claims about prices and speeds (Futuresight, 2015; ASA, 2016; GfK, 2016).

IV Business connectivity

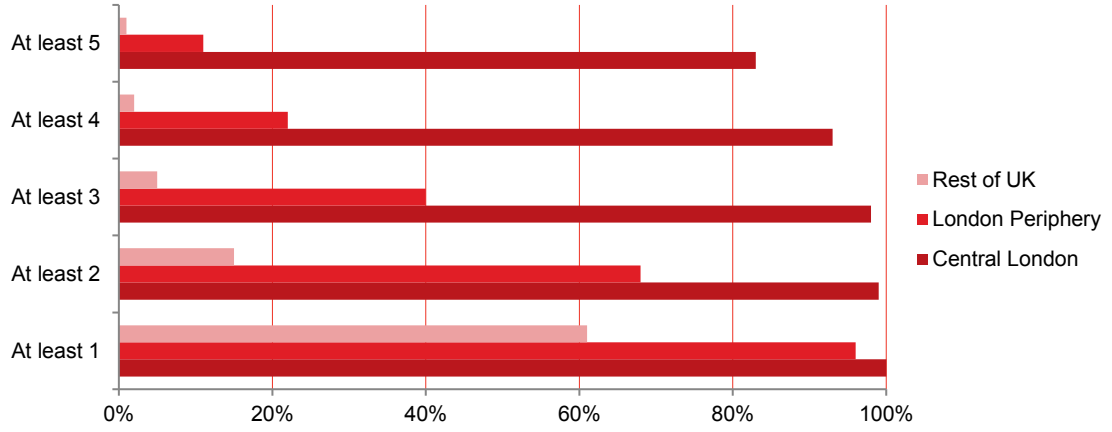
While the bulk of broadband is retail, there is another market for the provision of connections to business premises, previously known as leased lines or partial private circuits (PPCs), now termed 'business connectivity'. Providers connect commercial and government sites to virtual private networks (VPNs), Unified Communications as a Service (UCaaS), cloud services, and to the Internet. Multinational enterprises (MNEs) purchase these services on the European or global market, from a small group of network service providers (NSPs), which then build or lease any necessary local infrastructure (e.g., from BT or Colt) to reach the various premises of their customers.[10] Mobile network operators are another major group of customers, connecting masts to base stations and then interconnecting them with exchanges, constructing their own infrastructure or leasing capacity from NSPs, notably:

- BT
- CityFibre
- Colt
- Level 3
- Virgin Media
- Vodafone
- Verizon, and
- Zayo

The technologies used include dark or unlit fibre, wavelength-division multiplex (WDM), and Ethernet, plus some very old analogue services. Business connectivity is distinguished from household broadband by the provision of service level agreements (SLAs) that permit only very limited loss of connection and require the payment of penalties, necessitating backup facilities in anticipation of losses of any network components.

[10] *See, for example, the Gartner (2014) magic quadrant.*

Figure 4: Suppliers within 100 metres of business premises (OFCOM, 2016b, pp. 4, vol.1)



In regulating business connectivity, OFCOM (2016b) distinguished four geographic markets, two for London and two for the rest of country (one being the city of Hull), in each of which it measured competition in terms of the number of operators close to business premises and thus able to compete (see Figure 4). In central, but not peripheral, London it found sufficient competition to lift regulation, covering the provision of more than 30,000 leased lines. Elsewhere, the numbers of close competitors were much lower, so that it maintained regulation. OFCOM found the quality of the provision and repair of wholesale leased lines to be unacceptable, imposing minimum lead times on BT. It also created a voluntary code of practice for business broadband, clarifying the speeds offered by seven NSPs (OFCOM, 2016c). OFCOM (2015c) addressed the needs of small- and medium-sized enterprises (SMEs), including the minority that was dissatisfied with the status quo (Jigsaw, 2014). One problem SMEs faced was the lack of superfast broadband, where there was concern that supply by BT had been constrained to avoid cannibalisation of leased lines revenues.

There was only one response from Scotland to the consultation on business connectivity, in which the Scottish Futures Trust (SFT), a QUANGO, suggested that OFCOM investigate the "Scottish market" supplying rural SMEs. However, there are neither distinct markets for Scotland nor for rural SMEs, and SFT failed to produce any evidence to suggest that such markets exist. The creation of geographic markets for leased lines is a difficult task, with the risk of ending up in the impossible position of each premise in its own individual market (GAO, 2007). Since the whole of Scotland and all the rural areas of the United Kingdom fall into a regulated zone, no purpose could be served in defining such markets. SFT did not explain what might be found amongst rural SMEs in Scotland. To argue for lower prices, SFT would have to produce data to show the costs had been incorrectly calculated by OFCOM, while to

argue for faster provisioning or repairs, it would have to show that BT was being unjustifiably dilatory. In both cases SFT would need to produce at least preliminary data to justify OFCOM taking action, which cannot be expected to engage in ill-defined 'fishing expeditions'. Another possibility is that rural SMEs cannot afford the regulated price, in which case they would have to look to HMG or to Scottish Ministers for subsidies, similar to the voucher scheme for Superconnected Cities.

In May 2016, the then Department for Business, Innovation and Skills (BIS) and DCMS launched a joint inquiry into business broadband, in particular for SMEs and business parks (BIS & DCMS, 2016). The results of the consultation are apparently still being analysed (HMG, 2016a), in terms of the productivity plan of HM Treasury. The Autumn Statement indicated funds were being provided to support fibre networks to business parks, while OFCOM is improving access to ducts to support fibre deployments by NSPs (HM Treasury, 2016; OFCOM, 2016e).

The EC collects data on the use by businesses of ICTs. Figure 5 shows the level of adoption of fast broadband by businesses, with the United Kingdom scoring poorly. Figure 6 shows a breakdown by sector and by size of firms, where the United Kingdom is close to the EU average, further broken down in Figure 7 for the UK and EU, using NACE codes. Taken together, these suggest a poor level of adoption of fast Internet connections for businesses, both in general and in nearly all sectors. Comparable data for Scotland would be very useful, in order to assess the level of use of fast broadband and the pace of progress. It stands in strange contrast to the position of the United Kingdom as a leading digital economy (BMWi, 2016), albeit at 17 per cent of its potential (McKinsey & Co, 2016).

While much less prominent than the residential market, business connectivity is important for existing and future businesses. Although the Scottish Government may want it regulated differently, SFT failed to understand the process and thus did not provide the evidence that Scotland, rural Scotland or Scottish SMEs are different or to justify different regulatory remedies. The comparatively low levels of adoption of fast broadband in UK businesses, presumably including Scotland, are a cause for concern, though it is not obviously related to lack to availability.

Figure 5: Enterprises with fast broadband connections in the EU and EEA (EC, 2016h)

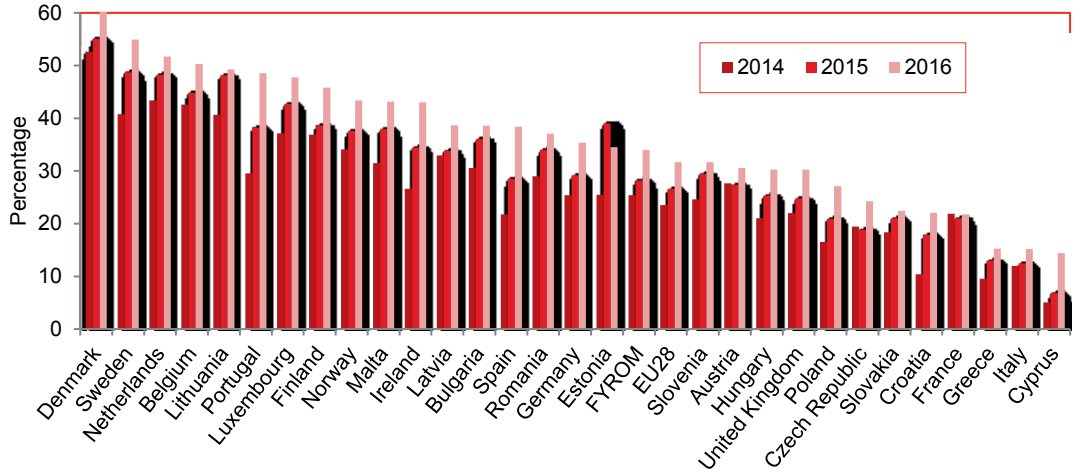


Figure 6: Enterprises with fast fixed broadband connections by economic sector (EC, 2016i)

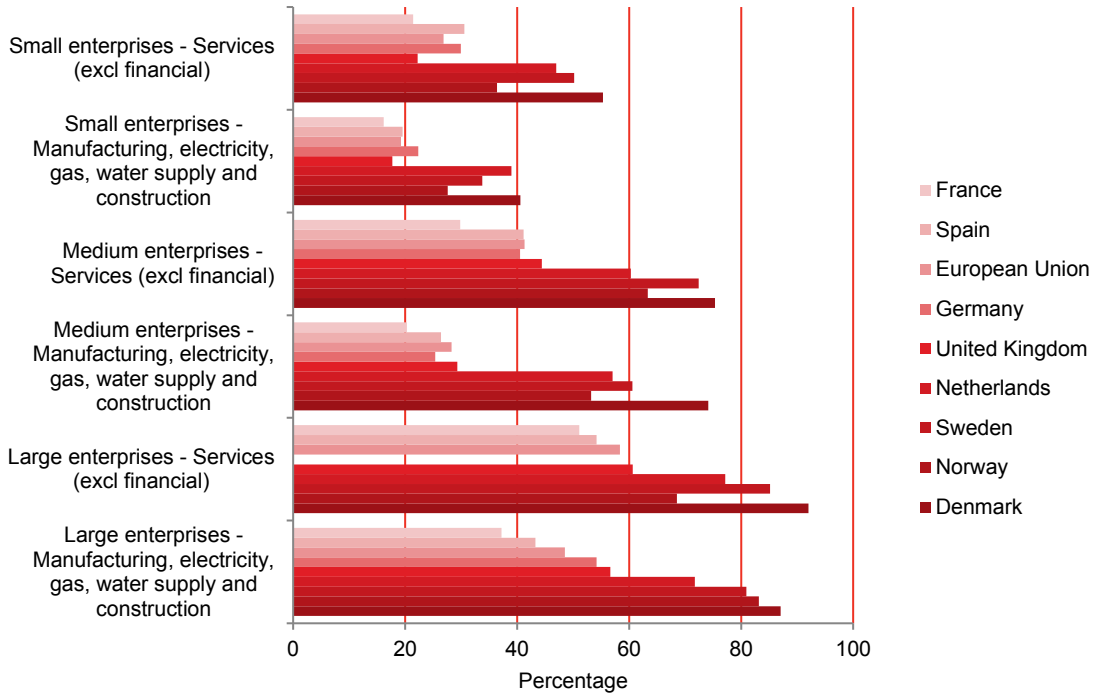
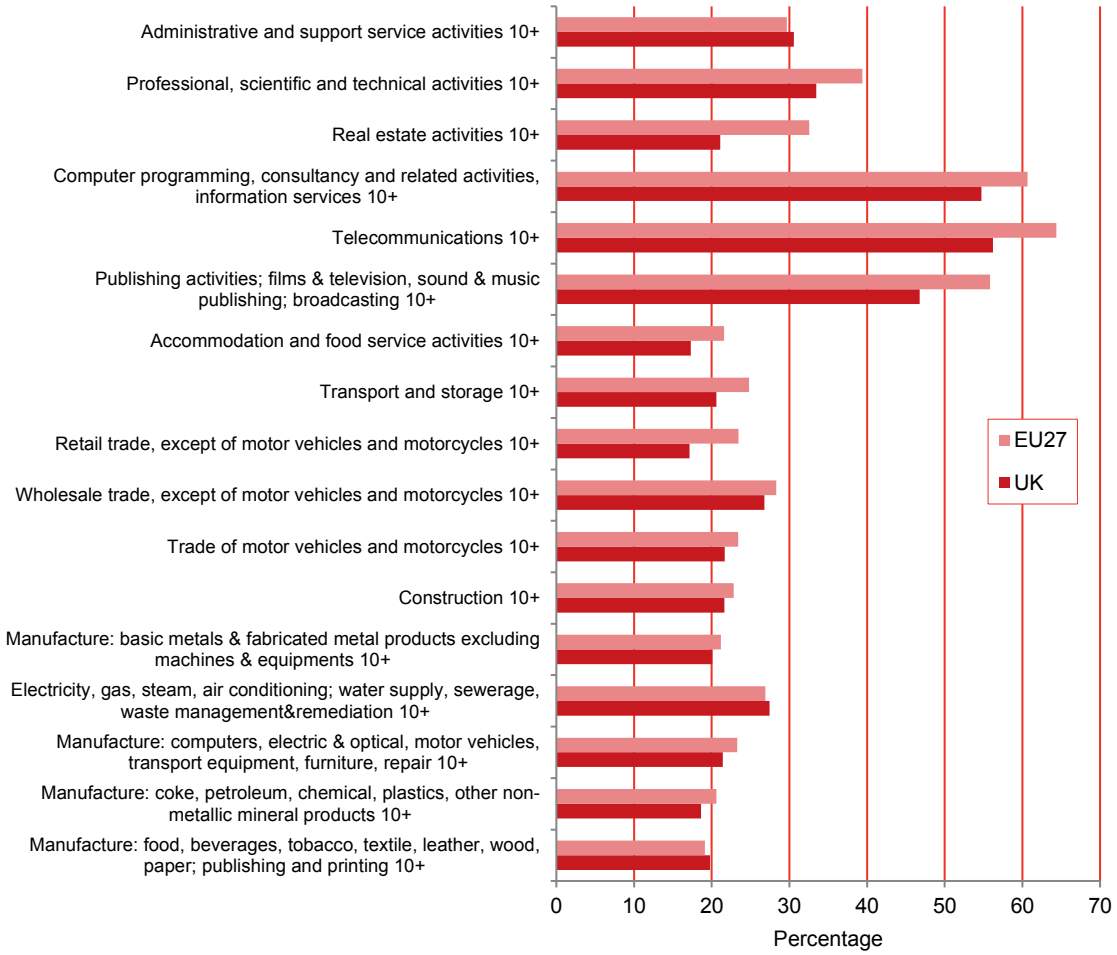


Figure 7: Enterprises with fast fixed broadband connections by economic sector (EC, 2016e)



V Mobile broadband

Having introduced competition in 2G or GSM technology with two operators and then two more, HMG pursued an n+1 strategy for its 3G auctions in 2000, successfully introducing a fifth network operator, confusingly named Three, owned by Hutchison Whampoa (Hong Kong). The £22 billion raised in the auction for licences was dismissed as "water under the bridge" by Klemperer (2002), but gradually the costs of spectrum and of network construction, plus the lack of enthusiasm from consumers, pushed the operators towards consolidation (Curwen & Whalley, 2016a; 2016b). What had been five networks were reduced when:

- Orange and Deutsche Telekom merged to form EE (EC, 2010b); and
- BT acquired EE (CMA, 2016); though
- Three was blocked from acquiring O2 (Telefónica) (EC, 2016c).

In advance of the auctions for spectrum for 4G networks, there was political pressure for improved rural coverage, including debates in the House of Commons. In response, OFCOM created one licence in the 800 MHz band with obligations to cover 98 per cent of the United Kingdom population, and 95 per cent of each of England, Northern Ireland, Scotland and Wales, potentially disadvantaging rural England (Sutherland, 2016). BT having demerged its mobile operations as O2 in 2001, re-entered the market first by buying spectrum in the 4G auctions and then acquiring EE. Some of the auctioned spectrum had been recovered through digital migration by the broadcasters, part of a complex battle over the respective claims of broadcasting and broadband (Harvey & Ala-Fossi, 2016).

HMG intervened on rural coverage, firstly with the Mobile Infrastructure Project (MIP) and secondly with a public consultation on further measures. The MIP recognised the need to fund mobile network expansion in selected areas or 'not spots' (e.g., the A9 in Scotland), through a state aid scheme (EC, 2013a). It was to be built by Arqiva, a firm that constructs and manages infrastructure for a number of networks, but used by all operators (Stonadge, 2015; Rathbone & Hirst, 2016). However, the minister later acknowledged the project had failed (Scroxton, 2016):

We had not anticipated just how difficult some of the planning issues are, particularly when we were dragging four operators with us, metaphorically kicking and screaming. Although we were paying for the mast, we were asking them to meet the operating costs going forward, which includes the land rental as well as the transmission costs for what is, by definition, an uneconomic area. (Hansard, 2016)

Of the £150 million budget, at the end of November 2015, the only spending had been (Hansard, 2015):

- Site builds £0.9 million;
- Site searches and acquisitions (including planning permission) £5.1 million;
- Supplier management and programme management costs and one-off supplier deliverables £3 million.

Some of the masts had to be 20-30 metres high, essential to provide sufficient coverage, to which the local communities they would serve had often objected. Additionally, some were in national parks or areas of outstanding national beauty, generating yet more objections.

HMG consulted on means to improve coverage, identifying four options (DCMS, 2014a):

- National roaming: phones would be able to use another network when their own was not available;

- Infrastructure sharing: networks would be able to use each other's masts;
- Reforming MVNOs: they would be enabled to offer services on all networks; and
- Coverage obligations: operators would be obliged to cover a certain percentage of the country, but leaving them to select the means to do so.

Before publication of the analysis of the responses, HMG struck a deal in which EE, O_2, Three and Vodafone agreed they would (DCMS, 2014b; OFCOM, 2015b):

- Invest £5 billion to improve infrastructure by 2017;
- Provide voice and text coverage from each operator across 90 per cent of the UK geographic area by 2017, halving partial not-spots;[11]
- Increase full coverage from 69 to 85 per cent of geographic areas by 2017; and
- Provide reliable signal strength for voice for 2, 3 and 4G services.

EE (now BT) won a contract for the Emergency Services Mobile Communications Programme (ESMCP), requiring it to build the emergency services network (ESN), by extending its mobile network to support 'universal networking' for the 'blue light' services (Home Office, 2015a; 2015b). This was intended to aid the delivery of wider public access to the EE mobile network and wholesale arrangements with rival networks, but has encountered delays and difficulties (Committee of Public Accounts, 2017).

OFCOM reports regularly on the expanding coverage and use of the various generations of mobile telecommunications. With the transition to 4G and improved coverage, customers have been making much greater use of smartphones (see Figure 8 and Figure 9). It has launched an 'app' to allow individuals to collect anonymous data on network availability and performance. The UK National Infrastructure Commission (2016) has suggested the need for significant work to prepare for 5G, accepted in part by the Chancellor.

The mobile network operators are consolidating down to a smaller number, a process that may not be finished. The economics of network construction in rural areas remain unattractive, a combination of low population density, high backhaul costs and the limited availability of lower frequency spectrum. The operators are reluctant to build networks covering the most remote parts of the United Kingdom without support from HMG.

[11] *These are locations where one or two networks are available and was to be resolved by sharing of masts, towers and other infrastructure by the operators not yet present at a site.*

Figure 8: Use of a mobile phone to access the web (OFCOM, 2016a)

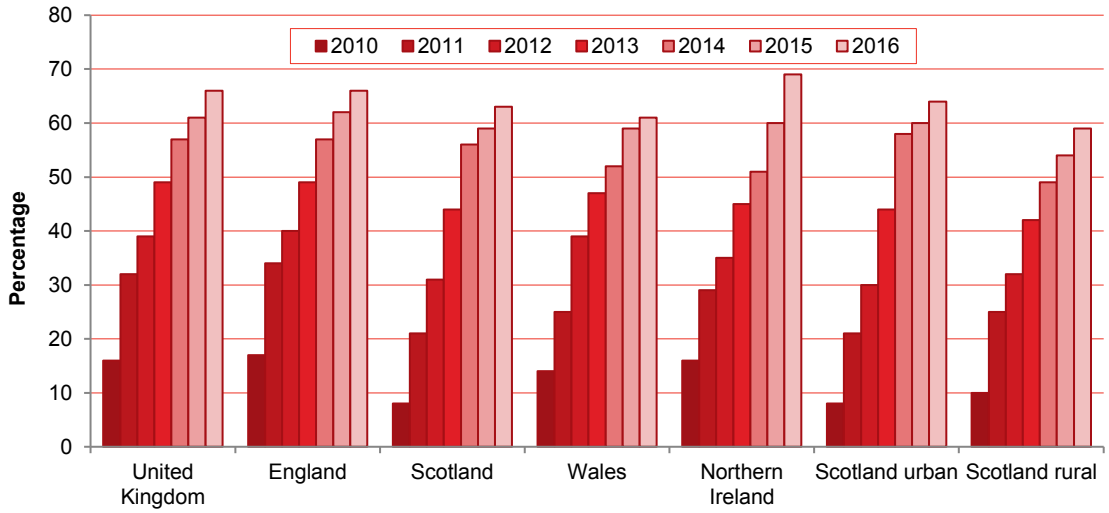
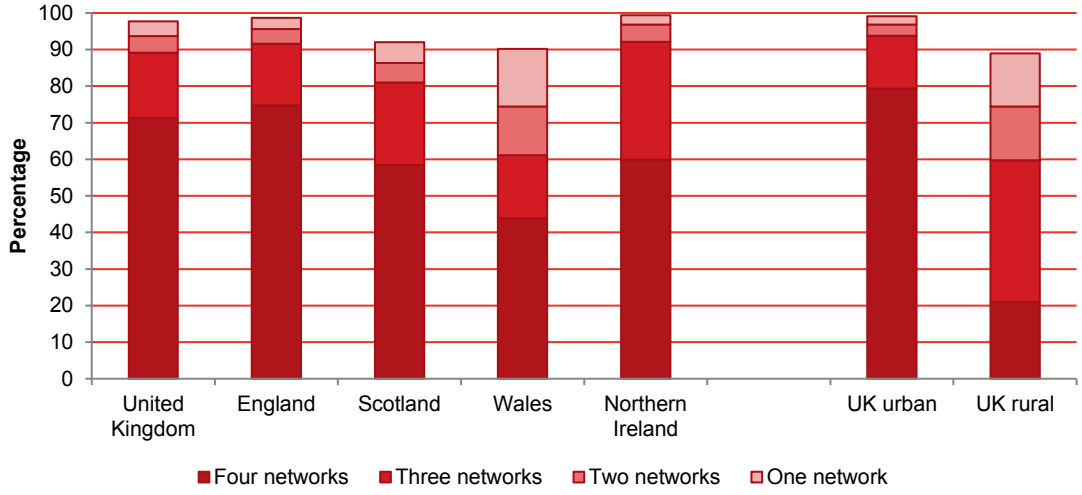


Figure 9: Outdoor 4G premises mobile coverage by operators (OFCOM, 2016a)



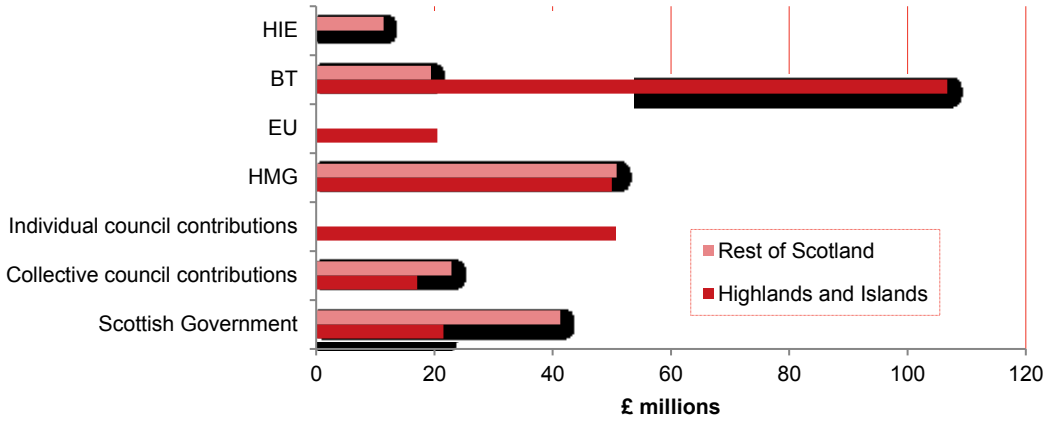
VI State aid

The upgrading of the Openreach network, laying more optical fibres to exchanges, street cabinets and into buildings, is constrained by population densities, adoption levels and rates of return. In the EU framework, a government wanting to accelerate deployment or to extend it into remoter areas can provide subsidies, provided it complies with specific state aid rules (EC, 2013b). These allow support in 'white areas', where there is no competitive provision of broadband, but not in 'black areas' where there are competitive networks (EC, 2016d). A

further complication has been the need to upgrade networks, where there may already be infrastructure, but offering only the slower speeds of a previous technological generation.

HMG has struggled with the broadband state aid rules. The rural scheme was delayed and had to be renegotiated, while the Superconnected Cities project had to be converted from network construction to vouchers for businesses, following a complaint it was overbuilding an existing network in Birmingham.

Figure 10: Funding for BDUK projects in Scotland (McGrath, 2016)



The rural state aid scheme was developed by Broadband United Kingdom (BDUK), part of the Department of Culture, Media and Sport (DCMS).[12] In England the money was channelled to 'local bodies' (i.e. groups of local authorities), which added EU money, before tendering for contracts, won by BT. Elsewhere it was to devolved administrations, with Scottish Ministers creating two projects (see Figure 10). The first routed through Highlands and Islands Enterprise (HIE) and the second managed by the Scottish Government. In order to reach some of the remoter locations, it was necessary to lay 19 undersea cables. The scheme was calculated on a rate of adoption that was frequently exceeded, triggering a clawback clause, allowing further extensions to the network.

Scottish Ministers also found £2.5million for experimental projects under the Community Broadband Scotland (CBS, 2016) scheme (see Table 6).

[12] *It had been part of the BIS Department, but transferred following remarks by the then BIS Secretary about a merger case he had to adjudicate.*

Table 6: Community broadband Scotland schemes (CBS, 2016)

Location	*Project*
Ewes Valley (Dumfries & Galloway)	A small rural community not able to receive standard broadband service due to distance from the serving BT exchange.
Tomintoul & Glenlivet (Moray)	Remote, inland mountain communities in the Cairngorm National Park, too remote from many services.
Elvanfoot (South Lanarkshire)	A community at an advanced stage in their broadband plans and with scope to provide a service to a neighbouring community. Community has combined with nine other area villages and formed B4GAL - broadband for Glencaple and Lowther. Potential access to funding from area renewable energy projects.
Colonsay (Argyll & Bute)	An island with a small population. Local group has identified improved broadband provision as a key component for supporting development and retaining population.
Corgarff & Glenbuchat (Aberdeenshire)	Small dispersed settlements within glens at the edge of the Cairngorms, remote from BT exchanges, with many residents relying on satellite broadband.
Applecross (Highland)	A remote coastal community with a small population, heavily dependent on tourism. Users were unable to exceed 0.5Mbps on conventional broadband, with no service on the north coast.

The state aid activities in Scotland were conducted under a BDUK umbrella approval from the EC, with money from HM Treasury, both direct and via Barnett consequential funds, plus EU funds. While these projects are in Scotland, it is far from clear that they can otherwise be called Scottish. Indeed, the proposals presently being prepared by the Scottish Government for its Reaching 100% (R100) project appear to be the funds clawed back from BT and matched with EU funds.

VII Adoption

In May 2010 the then Coalition Government took the unusual step of retaining the services of the UK Digital Champion, appointed by Gordon Brown the previous June. The digital inclusion tsar and the associated charity (Race Online 2012, later rebranded Go On UK) were to encourage those not yet using the Internet to do so, both to boost economic growth and to assist the government save money by preparing citizens for online transactions. Such was her success that she was made Baroness Lane-Fox of Soho, while the European Commission encouraged other EU member states to make similar appointments (EC, 2016f). The UK government launched a Digital Inclusion Charter in April 2014, aiming to reduce by one quarter the number of people offline by 2016 and that by 2020 everyone who “can be

digitally capable" would be. This involved public and private sectors, with voluntary, community and social enterprise (VCSE) organisations, notably the Tinder Foundation (now Good Things Foundation) and Go On UK, overseen by a Digital Inclusion Delivery Board (HMG, 2014b). This work supported the initiative for 'digital by default' services across government.

The Scottish Government opted out of this voluntary and unfunded initiative, waiting until 2011 to adopt a charter signed together with leading technology firms to boost digital adoption, though with little, if any, apparent effect (SG, 2011a). In parallel, public libraries were offering free, if limited, access and training (SLIC, 2015). The policy changed in 2014, with work subcontracted to the Scottish Council for Voluntary Organisations (SCVO, 2016), and the creation of a Digital Participation Programme. To date, no report or statistics have been published.

Scottish Ministers distanced themselves from the initiatives of HMG and Lane-Fox, though without any explanation or provision of an obviously superior alternative. Their delays appear to have contributed to the lower adoption rates and thus to the failure to deliver the goal of higher adoption rates than other parts of the United Kingdom. The aspiration of Scottish Ministers to be world class requires nearly universal adoption, yet the scope of those still excluded or refusing to participate has been poorly surveyed. Consequently, there cannot be evidence-based policy, forcing Scottish Ministers to fall back on ideology and copying others.

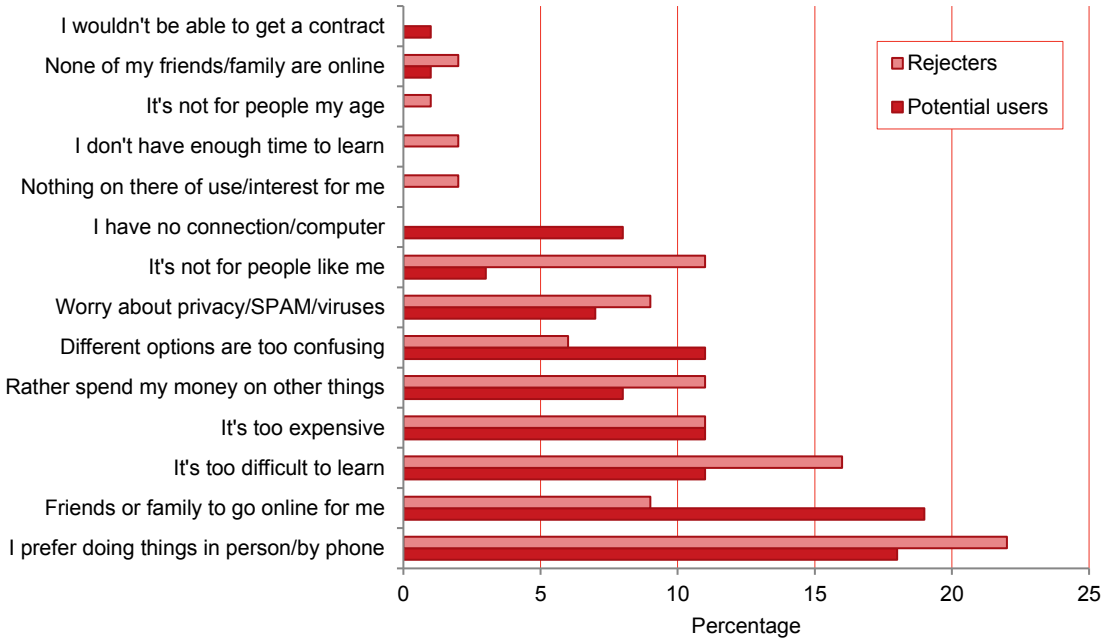
VIII Urban case study: Glasgow

In 2010, OFCOM reported that only half the homes in the Glasgow, Clyde and Lanarkshire 'region' had installed broadband, compared to 76 per cent for the United Kingdom; a level substantially below a range of British cities. Since Greater Glasgow accounts for more than ten per cent of the population, this significantly depressed the overall adoption rate for Scotland, presenting a challenge to achieving the highest level of the four nations (SG, 2010b). There was no immediate explanation of the poor performance, nor why it was seen across all socio-economic and age groups (OFCOM, 2012, p. 16). While the level has since risen, recent progress has been by an atypically heavy dependence on and sharp upturn in access to mobile broadband, surprisingly amongst the over 65s.

The Carnegie Trust commissioned 200 face-to-face interviews (White, 2013), finding two offline groups (see Figure 11), requiring different strategies; those interested in going online in the future and those who expressed no interest. Amongst the barriers to digital participation were the attractions of the offline world, fear of certain aspects of trying to go online, low

levels of trust in technology, the cost, illiteracy and vicarious use, through family and friends. Low adoption rates were also thought to exist in Inverclyde and Ayrshire.

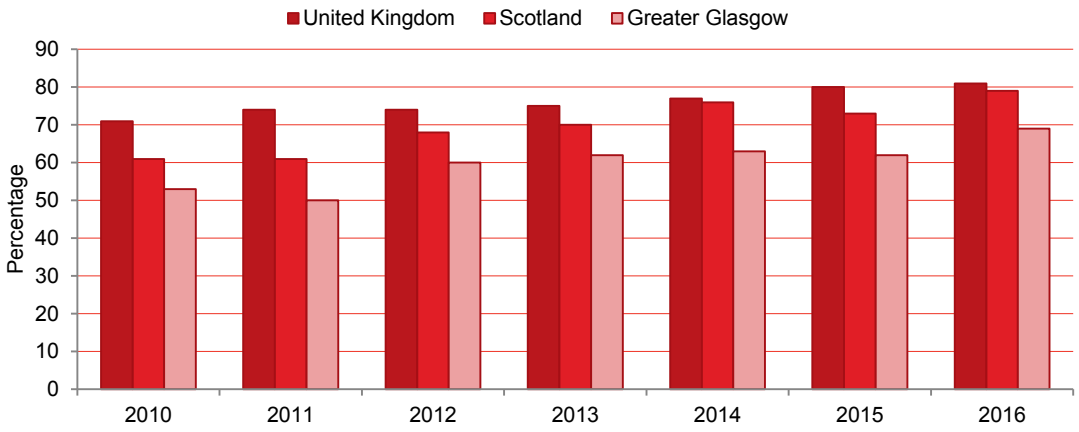
Figure 11: Barriers to Internet access, by potential users and rejecters (White, 2013, p. 19)



One solution to the lack of residential access has been public facilities, primarily the 33 libraries, the result of historical work by the Carnegie Foundation and the former Glasgow Corporation. Today, these are operated by Culture and Sport Glasgow, an arm's length external organisation (ALEO), under the brand 'Glasgow Life' (2015). The installation of computers for Internet and Wi-Fi access was supported by the United Kingdom National Lottery, though there were continuing challenges in maintaining staff skills and equipment, in line with advances in technology. A survey of those using libraries for Internet access found a strong geographic effect, tending to be those living nearby, suggesting the need for more libraries or comparable facilities, and also for greater capacity in the libraries (Anderson & Whalley, 2015). Glasgow Life had taken a "passive approach" to meeting demands that were growing in sophistication and volume, rather than seeking to understand the motivations of their users. There were two key activities, driven by the HMG (2016b) 'digital by default' strategy, requiring Internet access to:

- Apply for Universal Credit; and
- Generate evidence of having searched for jobs.

Figure 12: Fixed broadband adoption levels in Glasgow[13]



This led providers of social housing to consider installing broadband access. For example, the Wheatley Group (2016) undertook pilot projects to develop a model for low cost broadband for its tenants, but switched to a partnership with Glasgow Kelvin College to create thirty 'Click & Connect' computer learning centres for tenants. Coordination is performed by the Glasgow Digital Participation Group, including the City Council and Glasgow Housing Association (GHA).

The new Glasgow Economic Strategy aims to make it "the most productive major city in the UK", requiring it to overcome significant underperformance, especially with respect to continental European cities. Additionally, the ICT sector is a major economic sector, generating £480 million gross value added (GVA) and employing 26,350 in 2014, which:

We will expand on our position as the number one digital city in Scotland by increasing the number of people with digital skills, growing our business base and more effectively marketing our digital success (Glasgow City Council, 2016, p. 6).

It had previously set out the objective that:

Glasgow will be a world leading digital city by 2017 securing and growing the competitive advantage of the city and providing opportunities for residents and businesses to embrace the benefits of the digital age (Glasgow City Council, 2014).

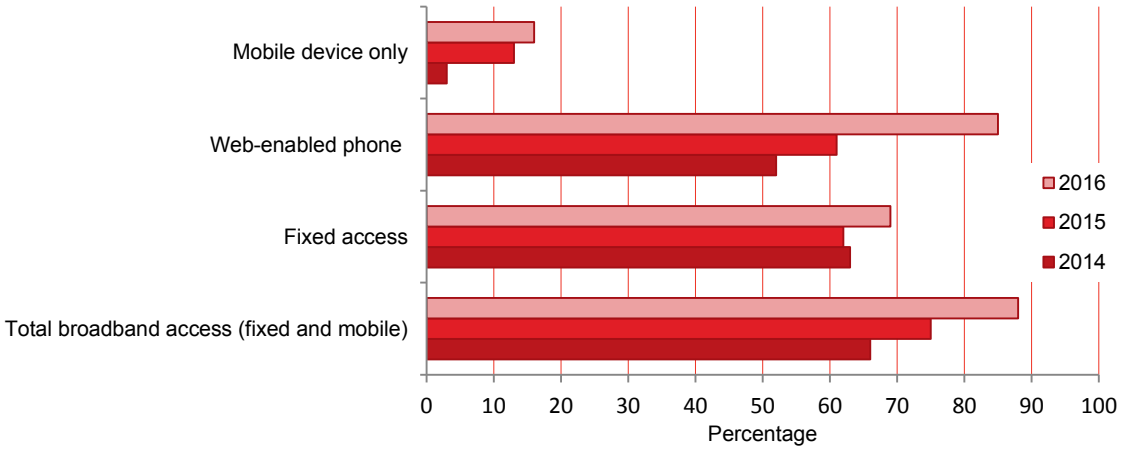
In January 2013 Glasgow City Council won £24 million from the UK Technology Strategy Board, for a Future Cities Demonstrator project. Then the City Deal with HMG and

[13] *The original source is the British Population Survey, reported by OFCOM in its annual Communications Market Reports.*

surrounding local authorities provided funding for infrastructure, including digital infrastructure and part of the Smart City project (Glasgow City Region, 2016). The City Council and BT offered a 'free' Wi-Fi service in public places, initially for the 2014 Commonwealth Games,[14] with a similar service on many buses, railway stations and trains.[15] In parallel, railway and travel apps were made available for smartphones, while some operators sell electronic tickets.

Recently, there has been an improvement in broadband adoption rates in Glasgow, with a sharp rise in the number of smartphones (see Figure 13), even more remarkably this appears to be generated by the over 65s, though this may be ownership rather than use (see Figure 14). If this increase is repeated in 2017 it will be truly unusual.

Figure 13: Fixed broadband and mobile adoption in Glasgow (OFCOM, 2016a, p. 19)



Glasgow was found to have slower download speeds than comparable cities in the United Kingdom, though these had risen from 7 to 15 Mbps, between September 2009 and December 2014 (Gijón, Whalley, & Anderson, 2016). Those living in more deprived areas experienced slower speeds compared to more affluent neighbourhoods, which might reflect greater investment where higher adoption rates had been expected (see Figure 9). However, there were also engineering problems, such as exchange only lines (EOLs) and some aluminium wiring.[16] A further factor could be infrastructure competition with Virgin Media, pushing Openreach to upgrade its network in specific areas.

[14] BT uses its street furniture (e.g., payphones) to allow its broadband customers to log into Wi-Fi.
[15] HMG provided subsidies under the Superconnected Cities initiative for buses and trams in Edinburgh (DCMS, 2015).
[16] *EOLs lack the street cabinets that are otherwise upgraded to fibre to provide superfast speeds.*

Figure 14: Broadband adoption in Glasgow, over 65 years (OFCOM, 2016a, p. 20; 2015d, p. 28)

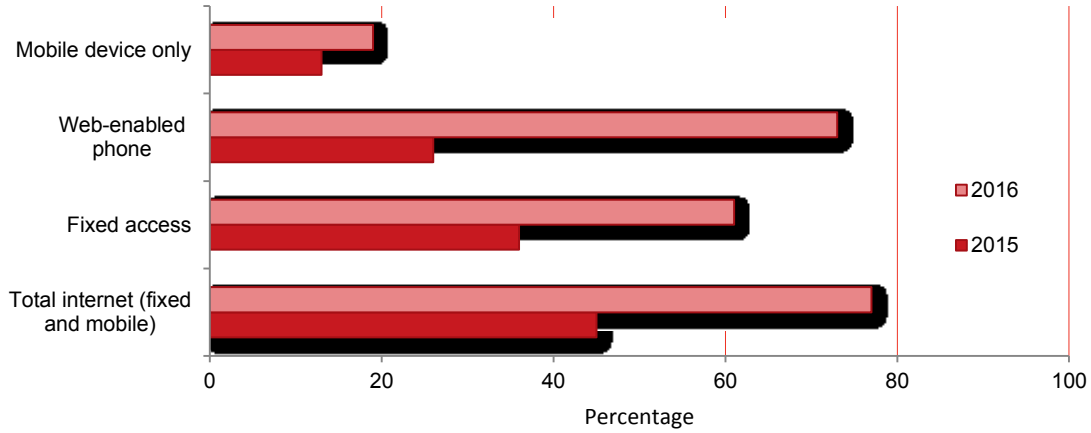
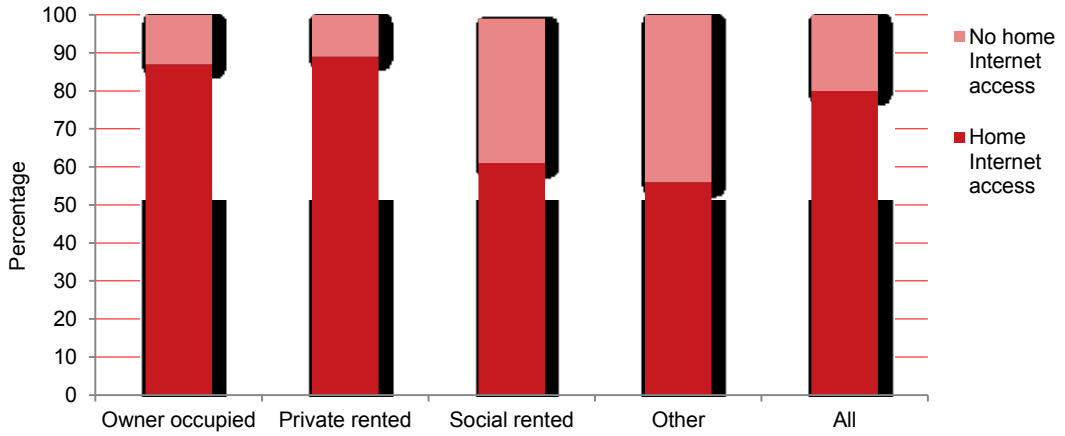


Figure 15: Broadband by home ownership and tenancy in Scotland (SG, 2016b, p. 137)



The 'Glasgow effect' of excess mortality in public health has received considerable and continuing research, with death rates having diverged noticeably from the United Kingdom average, failing to match improvements achieved elsewhere (Walsh, Bendel, Jones, & Hanlon, 2010; Reid, 2011). A further comparison is available from economic migrants and refugees, whose health has been gradually declining, as they become acculturated and as the effects of deprivation in the areas in which the live become evident (Kearns, Whitley, Egan, Tabbner, & Tannahill, 2016). Something more than "just deprivation" has been seen to be at work in Glasgow, potentially including:

- Climate;
- Culture;
- Genetics;
- Politics; and
- Socio-economic factors.

After controlling for deprivation, the mortality disadvantage has worsened, as has psychological morbidity, death from cancers and chronic liver disease, with inadequate intake of fruit and vegetables, and a lack of physical activity pervasive across socio-economic groups. There has been an insidious accumulation of relatively minor, but pervasive and persistent causes of stress that, taken together, offer the "most parsimonious explanation" for the poor health outcomes and morbidity (Cowley, Kiely, & Collins, 2016).

The work in public health points to methodologies for identifying underlying causes of broadband adoption and rejection at low levels of aggregation. However, it also identifies differences in behaviour, communications, culture, social capital and the stresses of daily life that are common to both health problems and the lower levels of broadband adoption. A somewhat disturbing possibility, from a study advocating increased physical activity to counter the effects of systemic stress, is that efforts to increase the adoption of broadband Internet access might reduce levels of physical activity, worsening morbidity, with one quarter of adults in Scotland reporting they too much time online (OFCOM, 2016a, p. 12).

IX Conclusion

Scottish Ministers have high political aspirations for broadband, but lack the means to implement them, being almost entirely reliant on Brussels (until Brexit) and London (until independence), something they have been loath to admit. The decision by HMG to switch rural network extension from state aid to cross-subsidies between users of the broadband network removes their role from the BDUK scheme, though its final phase is being rebranded Reaching 100% (R100) in Scotland, but which duplicates and clashes with the UK universal service obligation, which has its own, somewhat obscure payment mechanism, with funds moving from urban to rural consumers, under the oversight of OFCOM. Scottish Ministers should have been sending political requests to HMG and techno-economic analyses to OFCOM in support of their socio-economic policy goals, rather than rebranding commitments made in London. However, it is necessary to recognise the importance of path dependency, especially of Openreach, and the slowness with which change can be made to the regulatory system.

Scottish Ministers made their 100 per cent coverage commitment without any costing or impact assessment. Moreover, it would neither deliver "world class" infrastructure, being only 24 Mbps, nor would it be "any time, any place, anywhere", being only inside premises. The limits of their ambitions were highlighted by the Chancellor of the Exchequer, who is pushing for fibre to the home and to the business park, as well as for 5G mobile, while the EC is pushing for a Gigabit society. Aspirations to being "world class" must be judged on market structures and systems of governance (Sutherland, 2017b), rather than infrastructure, which, unlike roads or sewers, are constantly evolving, with even optical fibre undergoing significant technological advances (Lord, Soppera, & Jacquet, 2016).

The problem of poor productivity in the United Kingdom is well established. The argument by both the Chancellor and the Glasgow City Council is that broadband offers a tool to improve productivity, but requires training of individuals and an understanding of both adoption and non-adoption by businesses. Low levels of business use of fast broadband suggest significant problems.

The Brexit referendum brought uncertainty, since the legislative and policy framework for the United Kingdom telecommunications market has been deeply embedded in the European Union for decades. Ceasing to be a member state means no longer having a voice in the future regulation of the single market, indeed at the time of writing it is unclear what sort of access firms based in the United Kingdom will have to that market. HMG will, once Brexit is complete, have a free hand to review laws and to determine policies for the sector, with an obvious incentive for the established operators to lobby for an easier regime, with few organised voices to oppose them. The position in Scotland is yet more complex, with talk of a second independence referendum opening up a range of scenarios, of the possible splitting of the existing United Kingdom telecommunications networks and markets, of the need to create new institutions for their governance, which might or might not have to be in compliance with the EU *acquis*, perhaps both at different times. Existing operators would be required to carve out their Scottish operations, if only for accounting and regulatory purposes. They might also be tempted to spin off those businesses, perhaps to hedge funds or to local groups, those better able to negotiate a new set of regulations in a new country.

There are a number of areas for further research, not least in tracking events around Brexit, a second Scottish independence plebiscite and technological advances. The issue of broadband being a strategic necessity and the consequent need to track global developments should be examined. An analysis of the costs and benefits of broadband by sector, emphasising leading sectors of the Scottish economy would be beneficial.

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