FUTURE TELECOMS INFRASTRUCTURE REVIEW: ANNEX A

A report for DCMS

13 July 2018

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EXECUTIVE SUMMARY

A comparison with other developed economies indicates that the UK is performing well with regards to availability of superfast broadband services, with 95% of premises having access to broadband download speeds of at least 24Mbps.[1] This is primarily achieved by BT investing in the Fibre-to-the-Cabinet technology[2] (an upgrade of BT's existing copper network).

However, the UK's investment in full fibre - Fibre To The Premises (FTTP)[3] - lags behind many other countries. For example, the UK ranked eighteenth out of the 19 comparator countries[4] considered in Ofcom's 2017 International Communications Market Report, in terms of the proportion of homes that could receive FTTP and nineteenth in terms of the proportion of FTTP connections.[5]

In May 2018, in his CBI speech, the Chancellor set a target "*to see full-fibre connections being available to 15 million premises … by 2025*" and 'nationwide' coverage by 2033.[6] As part of its Future Telecoms Infrastructure Review (FTIR), the Government is considering "*additional policy interventions*" that could be used to facilitate the deployment of FTTP and help the Government to achieve these Government targets.

To assist the Government's work in this area, DCMS has asked Frontier Economics to assess how investment in FTTP infrastructure will evolve over the next 25 years under:

1. **A 'baseline' scenario** in which the current market model and regulatory framework remains broadly unchanged; and
2. **A range of alternative market models** that could be underpinned by a range of policy interventions.

Our assessment of the merits of these alternative models has been undertaken based on six main criteria specified by DCMS:

1 Ofcom (2018), Connected Nations Update

2 FTTC refers to a network architecture in which optical fibres connect the exchange to the street cabinet, and copper cables connect the street cabinet to the premises. Speeds can vary but Openreach's FTTC network is capable of offering download speeds of up to 80Mbps.

3 Fibre to the Premises (FTTP) refers to a network architecture in which optical fibres run all the way between the exchange and the premises. Capable of offering download speeds in excess of 300Mbps.

4 These include Australia, New Zealand, the USA, South Korea, Japan, The Netherlands, Sweden, Spain, France, Portugal, Italy, and Germany

5 Ofcom (2017), International Communications Market Report 2017

6 https://www.gov.uk/government/speeches/chancellor-speech-cbi-annual-dinner-2018

Figure 1 Future Telecoms Infrastructure Review – Key Criteria

Criterion	Description
Pace	In what stages, and how quickly, the network is deployed
Coverage	Total coverage achieved and distribution of coverage throughout deployment
Quality, innovation and price	The extent to which the model supports innovation over time and continuous improvement in the quality and reliability of the network, and drives down prices
Total cost	The likely total deployment cost, opex and other network-related spend during the lifetime of the infrastructure and associated risks
How costs could be recovered	The contribution to the recovery by build costs between industry, customers and government, overtime and regionally
Feasibility	Practical implementation issues

This report summarises our findings, drawing on the evidence from a range of sources, including theoretical and empirical literature review, case studies of FTTP deployment in other countries, interviews with the investor community, responses to DCMS' call for evidence for the FTIR and our own modelling.

Key drivers of FTTP investment

Based on our review of the economic literature and the evidence presented to us, we have identified the following key drivers of investment in FTTP:

- **Reducing costs/ other barriers** to FTTP deployment and **increasing demand** for fibre products is expected to increase profitability of fibre investment projects and therefore increase FTTP coverage;
- **Reducing the risk/ uncertainty** involved in FTTP investment should lead to a lower cost of capital thereby making investment more likely;
- **The level of competition** in the market can also have an impact on the expected returns on investment, and therefore affect the operators' decision to invest. There is a body of evidence to demonstrate that network competition has a positive impact on investment in FTTP. In particular, investment by alternative operators provides a stimulus to the incumbent to invest by reducing the option value of delaying investment; and
- **Reducing profitability of alternative options** is also expected to increase the relative attractiveness of investment in fibre. For the incumbent, alternative options would be to continue to rely on copper-based products (ADSL, FTTC and G.fast). For alternative operators, it would be investing in their own fibre networks vs. getting access to the incumbent's network (i.e. 'build' vs. 'buy' decision).

In our report, we consider how investment in new technologies, in particular in FTTP, has been encouraged in other countries and what could be learnt from these examples.

Modelling the baseline (or 'do nothing') scenario

We assume that in the baseline, the current regulatory framework remains broadly unchanged. We then model the decision-making process of telecoms operators considering whether to invest in new fibre infrastructure in a given area. More specifically, we estimate the returns for different operators (Openreach and alternative providers) from investing in FTTP and compare those against the returns they could earn if they invest in a different technology (or not invest at all). The analysis of the individual operators' decisions then allows us to project total fibre coverage over time and to assess potential overlaps between different networks (i.e. to estimate the extent of network competition).[7]

We estimate that in the long run, fibre coverage in the UK is likely to reach c.75% of premises in 20 years. Overall, we find that in the baseline, the projected fibre coverage falls short of the Government 2025 target (reaching 12m premises instead of 15m) and the 2033 target for national coverage (at c. 60% coverage).[8]

Overall, it appears that high deployment costs (especially for new entrants/ alternative operators), high barriers to fibre deployment (such as complex processes for obtaining wayleaves and street-work permits) and demand uncertainty are among the key factors affecting the overall fibre coverage and the speed of roll out. Moreover, uncertainties around future regulation of access to FTTP networks might also have a dampening effect on incentives to invest both for Openreach and for alternative operators.

Alternative market models

As the baseline scenario is unlikely to deliver the desired outcomes, we consider three alternative models and explore whether they could deliver a better outcome in terms of overall fibre coverage and in terms of other evaluation criteria (discussed above).

Model 1: Enhanced competition

This model relies mainly on stronger network competition to deliver more wide-spread fibre roll out. While stronger competition is likely to increase the risk of overbuild, lower deployment costs (and other barriers), more regulatory certainty and other pro-investment policies are expected to make the business case for investing in FTTP stronger.

Similar market models were implemented in Spain and Portugal, with both countries achieving high levels of FTTP deployment (63% and 86% respectively)

[7] Understanding the degree of network competition is important as competition is considered to be an important driver of future investment and innovation (so called 'dynamic efficiencies').

[8] We also estimate the cost of deployment (capex) under the baseline scenario is c £22bn to cover c.75% of the country, and c.£7.6billion to cover the remaining c. 25%. This is used as a benchmark for our evaluation of the alternative models.

and high levels of network competition. Indeed, in Spain, 35% of customers can choose from three or more networks.

Regulators in both countries imposed a suite of pro-investment policies, for example:

- An obligation on the incumbent to provide access to its passive infrastructure networks (ducts and poles) to reduce the cost of deployment for alternative operators; and
- No obligation to provide access to high-speed fibre networks for a period of time (e.g. in Spain the obligation was to provide access to services under 30Mbps). This has further incentivised alternative operators to invest in their own fibre networks.

We consider a variant of this model, but also adapt it to the UK context. In particular, in our modelling, we include a range of UK-specific policies to reduce barriers to fibre deployment.

Our modelling shows that this model achieves a steady state level of commercial fibre coverage of over 80%. It also brings investment forward achieving over c. 80% gigabit capable commercial coverage by 2033. The remaining areas could also be covered within the same timeframe, with some form of government intervention.

This model also delivers higher levels of network competition, with 3-player areas potentially increasing from 30% to up to 60% of the country. High levels of competition are expected to bring additional benefits in the form of faster innovation and efficiency savings. It is likely that at least some of these productivity gains would be passed on to consumers in the form of lower prices, with other benefits materialising in the form of faster innovation.

Model 2: National monopoly

This model relies on a single wholesale regulated provider to roll out fibre infrastructure and to provide regulated access to retail operators. This model reduces uncertainty by awarding an exclusive licence to roll out fibre to one provider (i.e. removes the risk of overbuild). This is a market model associated with utilities markets, where network competition is generally not achievable due to high fixed costs. Variants of this model have been implemented in Australia and Singapore.

In principle, this model could be expected to deliver a nationwide fibre network coverage, as the monopolist can cross-subsidise between profitable and unprofitable areas. The monopolist can also be expected to roll out at a relatively fast pace (assuming there are sufficient contractual incentives in place) and to deliver coverage at a lower total cost than in the Enhanced Competition scenario (as there is no network duplication).

However, this model is likely to involve a lengthy implementation period (as it is incompatible with the existing legal framework) and might also face several other

implementation challenges[9]. Moreover, this model would result in a significant reduction in competition (compared to the baseline and the Enhanced Competition model), with a potentially negative effect on future investment and innovation.

Model 3: **Franchising of regional licences**

Under this model, regional franchises are awarded with exclusivity for a period of time, to cover the whole of the UK, in a competitive tendering process. The level of coverage and speed of rollout, as well as the amount of any government support required, would be the criteria for the franchise award. A variant of this model has been implemented in New Zealand.

The key difference between the franchising model and the national monopoly model is that we would expect to see more competition for regional franchises than for the national monopoly. A yardstick competition regulatory approach could also be used going forward to ensure that regional franchisees continue to invest and innovate. This would, at least in part, compensate for a loss of genuine network competition.

Our evaluation of the three models

Our findings are summarised in Figure 2 below. Overall, we find that each model has strengths and limitations:

- **Enhanced Competition model** scores well across all the criteria, except 'the total cost of deployment' (due to network duplication). However, that is before taking into account the potential for dynamic efficiencies to deliver faster roll out rates and lower rollout costs due to innovation in roll out approaches/costs. The key benefits associated with this model are (a) its ability to deliver dynamic efficiencies in the long run, i.e. competing providers are expected to innovate, delivering more choice, better quality and lower prices for consumers, and (b) it can also be implemented without delay (unlike the other models, which could take 3-5 years to implement).

  Given that this model is not projected to deliver 100% coverage (as some areas remain uneconomic), external funding may be required. Ubiquitous coverage could be achieved by using 'competition for the market' mechanisms, such as awarding exclusive licences to roll out in uncovered areas to minimise the amount of subsidy required.

- **National monopoly model** – this model could, in principle, deliver 100% coverage, support nationally uniform prices and result in lower deployment costs (as there is no FTTP network duplication). However, this model also has drawbacks:

  - It greatly reduces network competition, both now and in the future, which is likely to have a negative impact on quality, choice and innovation. While dynamic efficiencies associated with innovation may be less pronounced in other utilities (such as energy and water), the telecoms

[9] For example, there is likely to be a need to compensate the existing fibre providers if their assets are acquired by the national monopolist.

sector is strongly driven by technological innovation. Reducing network competition could be detrimental for quality and choice in the future;

- The model involves a significant departure from the current approach, raising a number of issues related to implementation: it will require a new legal/regulatory framework, may require compensation mechanisms for acquiring existing FTTP assets from other operators, and is therefore highly likely to require a lengthy implementation phase; and
- Competitive tendering is unlikely to work effectively in this case, as it is not clear at this stage that there are credible contenders, apart from Openreach, to deliver this model. In the absence of an effectively competitive award process and ongoing benchmarking of the monopolist's performance, it may be difficult to incentivise the monopolist to deploy FTTP networks rapidly and efficiently. The evidence from Australia, where a similar model has been implemented, is very mixed on the merits of such a model.

- **Franchising of regional licences** – this model creates incentives to rollout FTTP networks by providing exclusivity for a period of time. It has the drawbacks of the National Monopoly model set out above, though allows in principle the re-introduction of network competition at a later stage (after the exclusivity period has ended). Yardstick competition could also be used to incentivise franchisees to improve efficiency and deliver quality.

Figure 2 A summary of our evaluation

	Baseline	Enhanced competition	National monopoly	Franchising
FTTP coverage after 15 years	60% coverage in 15 years, c. 75% coverage in 20 years	Over 80% competitive deployment and remaining c.20% 'competition for the market' in 15 years	Up to 100% In 15 years	Up to 100% In 15 years
Pace of deployment	2m industry roll out rate	3m industry roll out rate	3m for monopolist	3m in total for franchisees
Initial delay due to implementation	No	No	Yes, c.3-5 years	Yes, similar or somewhat less than NM
Government 2025 target	No	Yes	No	No
Degree of competition	c.30% - 3 players c.40% - duopoly	30-60% - 3 players	60% - monopoly 40% - 2 players (FTTP and DOCSIS).	60% - regional monopolies 40% - 2 players (FTTP and DOCSIS) Potentially more competition after end of exclusivity
Quality/ innovation	Dynamic efficiencies	Greater degree of entry and faster pace and lower cost of rollout should increase dynamic efficiencies	Monopolist has less incentive to innovate than in a competitive market	Lower dynamic efficiencies than in the enhanced competition model, but potentially higher than in the NM
Capital cost of deployment (undiscounted)[10]	£22bn (75% coverage)	£32.3bn (100% coverage)	£20.3bn (100% coverage)	£20.3bn (100% coverage)
Areas with no coverage	15% - 'hold up' 10% - uneconomic	10% - potential 'hold up' 10% - uneconomic	In principle, none In practice, deployment in some areas may be delayed	Possibly if some regional franchises fail to attract bidders
Can coverage be extended to 100%?	Yes, through government intervention (including subsidy and franchising of the remaining areas)	Yes, through government intervention (including subsidy and franchising of the remaining areas)	Through price cross-funding	Possibly through price cross-funding
Pricing	National pricing	National pricing likely, with some price variation, especially for very high speeds	National pricing	Some regional price variation – depends on design
Compensation for FTTP assets	Not needed	Not needed	Yes	Likely

[10] We present capex as it allows a comparison with previous studies (e.g. the NIC/ PRISM study). However, in our analysis in the main report, we calculate both capital expenditure and operating expenditure.

1 PURPOSE OF THE REPORT

A comparison with other developed economies indicates that the UK is performing well with regards to availability of superfast broadband services, with 95% of premises having access to broadband download speeds of at least 24Mbps.[11] This is primarily achieved by BT/ Openreach investing in the Fibre-to-the-Cabinet technology[12] (an upgrade of BT's existing copper network).

However, the UK's investment in full fibre - Fibre To The Premises (FTTP)[13] - lags behind many other countries. For example, the UK ranked eighteenth out of the 19 comparator countries[14] considered in Ofcom's 2017 International Communications Market Report, in terms of the proportion of homes that could receive FTTP and nineteenth in terms of the proportion of FTTP connections.[15] As of May 2018, FTTP coverage in the UK stood at just 4%.[16]

The Government is considering "*additional policy interventions*" that could be used to facilitate the deployment of FTTP, as part of its Future Telecoms Infrastructure Review (FTIR):

"The cross-government Review, led by DCMS, will assess whether any additional policy interventions are needed to create the conditions for long term investment in world-class digital connectivity that is seamless, reliable, long-lasting and widely available".[17]

To assist the Government's work in this area, DCMS has asked Frontier to assess how investment in FTTP (and 5G) infrastructure will evolve over the next 25 years under:

1. A 'baseline' scenario in which the current market model and regulatory framework remains broadly unchanged; and
2. A range of alternative market models that could be underpinned by a range of policy interventions.

Our assessment of the merits of these alternative models has been undertaken based on six main criteria specified by DCMS:

11 Ofcom (2018), Connected Nations Update

12 FTTC refers to a network architecture in which optical fibres connect the exchange to the street cabinet, and copper cables connect the street cabinet to the premises. Speeds can vary but Openreach's FTTC network is capable of offering download speeds of up to 80Mbps.

13 Fibre to the Premises (FTTP) refers to a network architecture in which optical fibres run all the way between the exchange and the premises. Capable of offering download speeds in excess of 300Mbps.

14 These include Australia, New Zealand, the USA, South Korea, Japan, The Netherlands, Sweden, Spain, France, Portugal, Italy, and Germany

15 Ofcom (2017), International Communications Market Report 2017

16 OECD broadband portal statistics (June 2017)

17 FTIR, Call for Evidence, https://www.gov.uk/government/consultations/future-telecoms-infrastructure-review-call-for-evidence

Figure 3 Future Telecoms Infrastructure Review – Key Criteria

Criterion	Description
Pace	In what stages, and how quickly, the network is deployed
Coverage	Total coverage achieved and distribution of coverage throughout deployment
Quality, innovation and price	The extent to which the model supports innovation over time and continuous improvement in the quality and reliability of the network, and drives down prices
Total cost	The likely total deployment cost, opex and other network-related spend during the lifetime of the infrastructure and associated risks The contribution to the recovery by build costs between industry, customers and government, overtime and regionally
Feasibility	Practical implementation issues

This report summarises our findings, drawing on the evidence from a range of sources including:

- **Theoretical and empirical literature**: we have reviewed existing theoretical and empirical evidence relating to the factors that influence telecoms infrastructure investment (with a particular focus on FTTP).
- **International experience:** we have considered evidence relating to experience from other countries. In particular, we draw upon the findings of another study, commissioned by DCMS as part of the FTIR [18], which compares the deployment of FTTP broadband infrastructure in six countries: Australia, France, Germany, New Zealand, Spain and Sweden.
- **Interviews with the investor community:** we have conducted interviews with members of the investment community including:
  - sovereign wealth funds;
  - investment banks;
  - infrastructure investment funds;
  - investment analysts; and
  - financial advisory firms.
- **Responses to DCMS call for evidence for the FTIR:** we have reviewed responses to a 6-week call for evidence, that DCMS launched in December 2017, to better understand stakeholders' views on possible market or policy interventions might support long term investment in the next generation of telecoms infrastructure.
- **Frontier modelling:** we have conducted our own modelling work, based on detailed cost data provided by Prism, produced as part of a study commissioned by the National Infrastructure Commission, updated and

[18] 'Telecommunications Infrastructure International Comparisons', NERA Economic Consulting (the 'NERA Study')

complemented with information from other sources, to project the roll-out of fibre in the UK over the next 25 years, undertaking a range of sensitivities.

In the rest of this report, we:

- review evidence relating to the key drivers of investment in FTTP infrastructure;
- consider the likely evolution of the market under the 'baseline' scenario, in which existing regulatory and policy framework are broadly maintained and initiatives that are already underway are implemented;
- consider potential alternative market models that could be used to help facilitate investment in FTTP;
- present evidence relating to these alternative market models, including the results from our own market scenario modelling; and
- assess the performance of the different models, based on DCMS's main criteria set out above.

2 THE UK'S APPROACH TO THE FIXED BROADBAND MARKET

In this section, we first describe the current structure of the UK fixed broadband market and then discuss Ofcom's approach to its regulation.

2.1 Current structure of the UK fixed broadband market

The UK's fixed broadband market is served primarily by BT's network, which has evolved from the national copper telephony network, and Virgin Media's cable network, that is available to 45% of households.[19] Regulatory reforms introduced by Ofcom in the early-to-mid-2000s – in particular, the 'functional separation' of BT's (access) network infrastructure business (called 'Openreach') from its retail operations and a set of provisions to allow alternative operators to rent access to certain parts of Openreach's network – have enabled a significant degree of competition to emerge in the retail market.

There are currently four main players in the retail fixed broadband market: BT, Sky, Virgin Media and TalkTalk. BT has a market share of 37%, Sky – 23%, Virgin Media – 20%, TalkTalk – 16%, and the remaining players (e.g. KCOM, Vodafone) represent around 4%[20]. Sky and TalkTalk rely on regulated wholesale access to Openreach's network, and offer services primarily based on copper and copper-fibre hybrid (as opposed to 'full fibre') technologies (see below for more detail). Virgin Media, on the other hand, offers services over its own cable network.

In recent years, alternative providers have started to deploy their own fibre networks in certain parts of the country. These include vertically integrated fibre providers Gigaclear and Hyperoptic, and the wholesale-only operator CityFibre. These alternative providers currently account for a small portion of the broadband market but have ambitions to expand significantly over the next few years.[21] For example, the infrastructure investment fund, Infracapital, has announced plans to invest jointly with TalkTalk to deliver fibre to around 3 million homes (see Section 3.1 for more detail).

Below, we provide a summary of the main broadband providers and technologies they use.

[19] Ofcom (2017), Connected Nations Report 2017: Data Analysis, page 15

[20] Based on total broadband subscribers from TeleGeography, December 2017

[21] According to a report for the Independent Networks Cooperative Association (INCA), as of April 2018, there were 207,000 connections to alternative fibre networks, which represents less than 1% of all broadband connections (Point Topic (2018), Metrics for the UK altnet sector: Scale, coverage, ambitions, concerns (a report for INCA))

BT/ Openreach

BT is the market leader with a reported 9.3 million broadband subscribers (c. 37% of the total broadband market).[22] It offers standard broadband services (with speeds of up to 24Mbps) over its copper network as well as faster services over its fibre to the cabinet (FTTC) network and, to a very limited extent, FTTP. BT offers regulated wholesale access to both its copper, network and FTTC and FTTP networks (where available).[23]

Openreach's standard broadband coverage is essentially universal – 99.9% of the UK population (reflecting its ubiquitous copper network), whilst superfast broadband coverage (primarily delivered using FTTC) amounted to 95% of premises passed by early 2018.[24] However, Openreach's investment in FTTP has been limited to date – by Q4 2017/18, Openreach had only passed around 555,000 (c. 2% of all UK premises) with FTTP[25]. Openreach is also deploying a more advanced form of copper-fibre hybrid technology, known as G.Fast, which is currently capable of providing speeds of up to 330Mbps.[26] However, as with the existing FTTC technology, the speed achievable declines with distance, and the highest speeds may only be available to customers within 300-400m of their cabinet.[27] As of the end of March 2018, 1 million premises had been passed by G.Fast.[28]

BT has made significant investments in premium TV content (sport rights), which is now also a part of BT/EE's offering to their mobile customers.[29] BT/EE also launched recently new converged fixed-mobile commercial offers.[30]

In February 2018, Openreach announced plans to deploy FTTP to 3 million premises by the end of 2020[31], with a target of this rising to 10 million by the mid-

22 BT's market share is lower than the market share of incumbents (i.e. operators that enjoyed a de facto monopoly before market liberalisation) in most other markets in Western Europe – according to the European Commission's 2017 Digital Progress Report, incumbents have an average share of 41% across Europe.

23 Openreach is obliged to provide wholesale access to its copper fibre networks (including FTTC and FTTP) services. As described in more detail below, access to BT's copper network and to 'up to 40Mbit/s' FTTC services is price regulated, whilst the price of higher bandwidth FTTC and FTTP services is unregulated. In addition, for those premises served with FTTP where there is no FTTC connection available, Openreach is required to offer 40Mbit/s FTTP rentals at the same price as the equivalent charge-controlled FTTC service.

24 Ofcom (2018), Connected Nations Update

25 https://www.btplc.com/Sharesandperformance/Quarterlyresults/

26 Ofcom (2017), Connected Nations, page 30

27 Ofcom (2017), WLA Market Review: Volume I, footnote 22

28 https://www.btplc.com/Sharesandperformance/Quarterlyresults/

29 In February 2018, BT retained rights to screen 32 live UK Premier League matches per season for three years (2019 – 2021), at a cost of £885m, having secured the rights to all UK broadcasts of the Champions League, at a cost of £1.18bn over the same period (https://www.theguardian.com/football/2018/feb/13/sky-bt-sport-premier-league-tv-rights; https://www.telegraph.co.uk/business/2017/03/06/bt-sees-sky-12bn-deal-champions-league-football-rights/)

30 http://newsroom.ee.co.uk/new-consumer-business-unit-of-bt-group-unveils-plan-to-deliver-uks-first-converged-products-and-provide-uks-best-customer-service/

31 http://news.openreach.co.uk/pressreleases/london-leads-the-uk-in-major-new-drive-for-ultrafast-broadband-as-openreach-launches-fibre-first-programme-2400491

2020s, and had previously announced plans to deploy G.fast to 10 million premises over the same period.[32]

Virgin Media

Virgin Media (VM) is the third largest broadband provider, with around 5.1 million broadband subscribers in 2017.[33] It offers high-speed broadband via its Hybrid-Fibre-Coaxial (HFC) network[34], which has recently been upgraded and is offering speeds of up to 300Mbps. Virgin Media is in the process of investing £3 billion to increase its footprint from 13 million to 17 million premises (c. 60% of UK premises) by 2020 (referred to as 'Project Lightning').[35] Virgin Media is expected to upgrade its cable technology (from DOCSIS 3.0 to DOCSIS 3.1), with the latter being capable of speeds of 1 Gbps or more[36].

Sky

Sky is the second largest broadband provider in the UK, with a reported 5.7 million broadband subscribers (primarily copper, but also FTTC) in 2017.[37] Sky delivers services based on wholesale access to BT/Openreach's network and has made significant investment in unbundling[38] BT's local copper loops (between local exchanges and customer premises). By November 2017, it had unbundled equipment in nearly 2,800 exchanges, serving more than 24.1 million premises (90%+ coverage).[39]

Jointly with TalkTalk, Sky has also been trialling FTTP services in York, offering speeds in excess of 900Mbps. Sky initially invested in the network as a joint venture partner but towards the end of 2016, announced that TalkTalk was to buy out its stake. As a result, Sky is set to revert to being a wholesale customer on the network.[40]

Sky has largely built its market share organically, though in 2013 it acquired the fixed line business of Telefonica's subsidiary O2 UK (for up to £200 million), which at the time had c. 500,000 fixed broadband customers.[41]

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32 https://www.btplc.com/UKDigitalFuture/Independent/Openreachone-pager.pdf

33 Ofcom (2017), Telecommunications Market Data Update, Table 16

34 HFC is a broadband technology that combines fibre with coaxial cable. Broadband services are delivered along the fibre cable to a cabinet and are then carried to the home via a co-axial copper connection which can support higher speeds than the copper pairs used in Openreach's copper network.

35 http://www.virginmedia.com/corporate/media-centre/press-releases/virgin-media-announces-largest-uk-fibre-broadband-rollout.html

36 https://www.ispreview.co.uk/index.php/2018/02/update-virgin-medias-uk-ipv6-docsis-3-1-plans.html

37 TeleGeography

38 As set out in more detail below, local loop unbundling is a form of access that allows the access seeker to take physical control of the copper line between the local exchange and customer premises. This provides the access seeker greater control over customer experience and greater scope for differentiation compared to other forms of access, such as bitstream and resale, which involve lower levels of investment.

39 TeleGeography

40 https://www.talktalkgroup.com/articles/talktalkgroup/2016/October/Ultra-Fibre-Optic-Trial-set-to-cover-the-whole-of-York

41 Ibid

TalkTalk

By the end of 2017, TalkTalk was reported to have just under 4 million customers. TalkTalk has historically acquired a number of competitors (AOL UK, Tiscali, Tesco).[42] Similarly to Sky, TalkTalk invested significantly in unbundling BT/ Openreach exchanges – as of November 2017, it had invested in 3,035 unbundled exchanges, representing more than 95% of all UK premises.[43] It offers services over BT's FTTC network as well as its copper network.

As mentioned above, TalkTalk also recently announced plans for a larger scale fibre roll-out (reaching around 3 million homes, although the exact timeframe is not clear at this stage) as part of a joint venture with Infracapital, an investment fund.

2.2 Ofcom's approach to regulation of the fixed broadband market

In this section, we discuss the evolution of Ofcom's approach to the regulation of the fixed broadband market regulation in the UK.

Ofcom's approach to broadband regulation has sought to promote retail competition through regulated access to BT's network

Since the establishment of Ofcom in 2003 and its subsequent strategic review of the UK telecoms market, UK telecoms policy in relation to broadband has relied on liberalisation to support competition in the downstream retail market for broadband services. This focussed on the development of ADSL technology, that enabled the delivery of broadband services up to 24Mbps over the legacy copper network, and was based on providing regulated access to the (unbundled) BT local access copper network.

The UK has also benefited from the presence of the cable operator (Virgin Media). The development of DOCSIS[44] technologies has allowed Virgin Media to upgrade its network in order to provide higher speed broadband services to its customers, generally in competition with copper-based alternatives delivered over BT's network. However, Virgin Media had not, until recently, extended its network footprint beyond the coverage reached by the late 1990s.

Ofcom allowed Openreach a period of pricing freedom for wholesale access to its FTTC access products in order to facilitate investment

In 2010, BT/ Openreach began deploying Fibre to the Cabinet (FTTC) in the UK. This represented a further development of existing technology, allowing for the provision of superfast broadband services at speeds in excess of the 24Mbps

42 TeleGeography

43 Ibid

44 Data Over Cable Service Interface Specification (DOCSIS) is an international technology standard that allows the delivery of broadband services over cable networks. There have been a number of iterations of DOCSIS, which have brought significant improvements in network performance (in particular, higher bandwidths).

which BT/ Openreach had been achieving with its ADSL technologies. FTTC required BT to make significant investments in upgrading its local access infrastructure.[45]

Ofcom's primary means of encouraging BT's FTTC deployment involved allowing BT itself to determine the prices for access to wholesale FTTC services rather than regulating prices by reference to the relevant costs. This policy was first adopted in the 2010 Fixed Access Market Review (FAMR) and reaffirmed in the 2014 FAMR. In addition, Ofcom introduced an ex-ante margin squeeze test in 2014, which required BT to ensure that there is a sufficient margin between the price of wholesale access to FTTC services (referred to as VULA) and its own retail prices to allow its downstream rivals to compete. The introduction of an ex ante test (rather than relying on competition law) reflects the fact that, Ofcom came to the view that where the price of an access product is unregulated, Openreach's ability and incentive to impose a price squeeze on BT's downstream rivals (in particular, by raising wholesale prices) will be stronger.

The aim of Ofcom's policy of adopting pricing freedom together with an ex ante margin squeeze test, was to allow BT greater flexibility (than would be the case under regulation of wholesale access prices based on costs) to set both wholesale and retail prices for different superfast broadband products which relied upon FTTC technology, whilst at the same time protecting downstream competition.

Ofcom recognised that BT/Openreach was investing in FTTC at a time when demand for superfast broadband services (given the widespread availability of existing ADSL services) was uncertain. Therefore, in line with its 'fair bet' principle (discussed in more detail in Section 3), Ofcom allowed BT the opportunity to earn a return on its FTTC investments which might exceed those normally assumed in a regulated cost model, to bring returns in line with those expected for similar projects that carry a similar level of risk to that BT faced of sustaining a loss on its investment if demand failed to materialise. During the period of pricing flexibility for VULA, Ofcom continued to regulate copper-based access products based on their costs, which Ofcom considered would act as a competitive constraint on the VULA price.[46] This allowed Ofcom to balance the incentives to invest in FTTC with protecting consumers from high prices of superfast broadband services.

Ofcom's approach, together with Government funding in rural areas has supported widespread availability of superfast broadband

BT/Openreach invested to deploy progressively FTTC nearly nationwide, leading to widespread adoption of superfast broadband services in the UK.[47]

[45] In particular, it involved installing fibre between local exchanges and street cabinets.

[46] Competitive constraint refers to the downward pressure on prices, exerted by competing alternative products. In this context, copper-based broadband serves as a potential substitute for higher-speed FTTC services and therefore exerts a constraint on the price that can be charged for FTTC-based products.

[47] BT commenced the roll-out of FTTC in 2008/9 and passed around 13 million homes (45% of premises) by 2012/13 (Source: Ofcom 2017 WLA Market Review Consultation, Annex 8). At the end of 2016, the service was available to 85% of the country (Source: Ofcom 2017 Connected Nations Report)

However, the Government was concerned about ensuring that superfast broadband was extended to the vast majority of UK households, including those in areas which were not otherwise economic for commercial operators to serve. In 2010 the Government announced the initial allocation of £530 million of central funding, and then a further £250m, matched by a combination local authority funding and European funding, to support the deployment of superfast broadband services in these areas.[48] By 2017, this programme supported broadband coverage for 95% of premises in the UK[49]. The majority is provided by BT, who have used public funds to extend their existing FTTC deployments into areas which they might not otherwise have served, or served in the same timeframe, on a commercial basis.

UK's existing framework has not supported large-scale full fibre investment to date

BT's primary focus on FTTC deployment (and on subsequent evolutions of copper-fibre hybrid technologies such as G.fast) meant that 95% of households could achieve speeds in excess of 24Mbps, but less attention had been paid in the UK (compared to some other European and non-European economies) to the prospects for FTTP deployment.

As stated previously, some deployment of FTTP had been undertaken in the UK by alternative network operators such as Gigaclear, Hyperoptic and Cityfibre, whilst Virgin Media's 'Project Lightning' is set to extend the coverage of its network to a further 4 million households, 2 million of which would be served by FTTP technology.[50] None of the companies had proposed to deploy FTTP on a national basis. BT had itself planned back in 2009 to provide 2.5 million FTTP connections by 2012, but had achieved a fraction by that date.[51] This reflects the fact that BT ultimately chose to deploy almost exclusively FTTC technology for its national NGA roll-out, whereas they had initially envisaged that a substantive proportion of the roll-out (around 25%) would be delivered by FTTP.[52]

The Government and Ofcom have taken steps towards stronger promotion for deployment and adoption of FTTP

In view of the UK's performance in relation to FTTP deployment, the Government and Ofcom have taken steps towards re-orientating UK policies to better promote the deployment and adoption of FTTP technologies for broadband services:[53]

- During 2016, Ofcom undertook the first review of its strategy since 2005 – the Digital Communications Review (DCR). They announced '*a strategic*

[48] https://www.gov.uk/government/publications/2010-to-2015-government-policy-broadband-investment/2010-to-2015-government-policy-broadband-investment

[49] https://www.gov.uk/guidance/broadband-delivery-uk

[50] http://www.libertyglobal.com/pdf/press-release/Virgin-Media-Fixed-Income-Q3-2016-FINAL.pdf

[51] https://www.ispreview.co.uk/index.php/2013/04/bt-abandons-native-uk-fttp-broadband-rollout-for-fttpod-and-fttc.html

[52] Ofcom (2017), WLA Market Review Consultation, para. 8.11, Annex 8

[53] In addition, the Government adopted a 'broadband USO' in the 2017 Digital Economy Act under which all UK households would be assured affordable access to services of at least 10Mbps

shift to encourage large-scale deployment of new ultrafast networks, including fibre direct to homes and businesses, as an alternative to the copper-based technologies currently being planned by BT'.

- In November 2016, the Chancellor announced plans to establish a Digital Infrastructure Investment Fund (with a contribution of £400 million from public funds) specifically to support new FTTP networks, together with 100% business rate relief (for 5 years) for FTTP infrastructure[54]. The Government also undertook a call for evidence on FTTP in late 2016, published a Digital Strategy in March 2017 which advocated FTTP and provided a further £200 million of public funds to promote local FTTP deployment and adoption in the 2017 Spring Budget.
- A number of fibre funding initiatives have been launched through the Government's broadband delivery UK (BDUK) programme.[55] These include the Local Full Fibre Networks (LFFN) Challenge Fund, to help locally led projects across the UK leverage local and commercial investment in FTTP. The Challenge Fund will periodically announce waves of funding available for local bodies to bid into, and bids will be selected on a competitive basis. BDUK is also delivering the LFFN Gigabit Voucher Scheme, which will provide small businesses and local communities with vouchers to contribute towards the costs of installing FTTP.
- In May 2018, in his CBI speech, the Chancellor set a target *'… to see full-fibre to the premises connections being available to 15 million premises, that's the majority of homes and businesses, by 2025*' and committed to *'deliver a nationwide full-fibre to the premises network by 2033*'. [56]

Ofcom has introduced a number of measures to improve access to Openreach's duct and pole infrastructure for fibre deployment

Ofcom's 'strategic shift' in its approach to regulation of the fixed sector has resulted in the adoption of certain policies which are intended to promote the deployment of FTTP technologies in the UK. The most significant of these has been the decision by Ofcom to require BT to develop a more robust set of 'passive infrastructure access' products which could allow alternative network operators to significantly reduce their FTTP deployment costs by sharing BT's ducts and poles.[57] This requires BT to make investments to improve the provisioning and availability of these services, the removal of previous restrictions which Ofcom had imposed on the uses of these products, and significant reductions in the rental costs payable by other operators.

[54] Gigaclear also won BDUK contracts in mid-2015 to use public funds to support the deployment of FTTP networks in rural areas.

[55] https://www.gov.uk/guidance/broadband-delivery-uk

[56] https://www.gov.uk/government/speeches/chancellor-speech-cbi-annual-dinner-2018

[57] Ofcom (2018), Wholesale Local Access Market Review Statement, Volume 3

Ofcom has introduced price regulation for wholesale access to Openreach's 'up to 40Mbps' superfast products but will continue to allow pricing flexibility for wholesale access to higher speed services

Ofcom also indicated that it would continue to regulate BT's broadband services in a manner which promoted further investment, particularly in FTTP. Following Ofcom's DCR, Ofcom has undertaken a detailed market review of BT's local access services and decided in 2018 to apply a regulated price cap to BT's 'up to 40Mbps' VULA services for the first time.[58] As such, Ofcom argues that BT has now earned a return on its FTTC investments consistent with the 'fair bet' principle. At the same time, Ofcom is continuing to allow BT the freedom to set wholesale prices for higher bandwidths, including those delivered over FTTP, and is removing the ex-ante margin squeeze test (indicating that a price cap on 'up to 40Mbps' services should significantly mitigate margin squeeze concerns).[59] Ofcom recognised that there may be a greater risk of margin squeeze on higher bandwidths, that are not subject to a price control. However, it considered that retail services based on the 40Mbps VULA product were "*still likely to be a reasonable option for a large proportion of retail superfast subscribers*"[60] and that not having cost-based access to higher bandwidths would not seriously undermine the ability of BT's downstream rivals to compete. Further, it noted that "*to the extent that increasing demand for faster services makes these services more important for retail competition in future, this is likely to strengthen incentives for investment by competing providers, and with that the prospect of greater network competition*."[61]

Operators' views regarding the prospects of widescale roll-out of FTTP

A wide range of views were expressed regarding the prospects for the wide-scale roll-out of FTTP in the UK, assuming it continues on its current path.

CityFibre considered that the current market structure will deliver an FTTP footprint of around 10 million premises in predominantly urban areas, delivered primarily by BT but that this was contingent on the "*complexity of BT's customer migration from copper-based infrastructure to FTTP"* being overcome. Similarly, Gigaclear considered that BT's proposals to deliver FTTP to 10m homes by 2025 were optimistic as they rely on "*the forced migration of consumers from its copper network – which raises financial concerns for ISPs operating over the BT Openreach network, as well as requiring substantial changes in current regulatory controls.*" Sky noted that even if Openreach adopted an "*ambitious roll-out*", this would "*still only see full fibre coverage in the UK reaching perhaps 13m homes by 2025*", representing less than 50% of the population

On the other hand, Hyperoptic and Virgin were more optimistic. Hyperoptic considered that competition will intensify which will incentivise further roll out beyond the current commitments. Virgin Media considered it likely that "gigabit-

58 Ofcom (2018), WLA Market Review Statement

59 Ofcom (2018), WLA Market Review Statement, para. 9.94, page 194

60 Ibid, para. 9.113

61 Ibid, para. 9.116

ready infrastructure" (including cable as well as FTTH) "*can be deployed to nearly 80% of UK premises in the near-term,*" though this estimate relied on a number of "aspirations" which were yet not worked up plans.[62]

In the next section, we discuss the main drivers of investment in fibre networks, based on the evidence from our literature review, interviews with investors and operators' and investors' responses to DCMS's Call for Evidence.

[62] For example, it included in its assessments a statement from Former CEO of TalkTalk Dido Harding that TalkTalk could extend FTTP to 10 million premises. Since then TalkTalk's aspirations have been scaled back to 'over 3 million' (https://www.ispreview.co.uk/index.php/2018/02/isp-talktalk-propose-full-fibre-broadband-3-million-uk-premises.html)

3 TELECOMS INVESTMENT DRIVERS

This section reviews evidence relating to the key drivers of investment in telecoms infrastructure. The section is structured as follows:

- We first provide an overview of how telecoms infrastructure projects are financed and the availability of capital for fibre investment; and
- We then identify the key drivers of fibre investment and discuss evidence on measures to stimulate fibre investment, under each of these drivers.

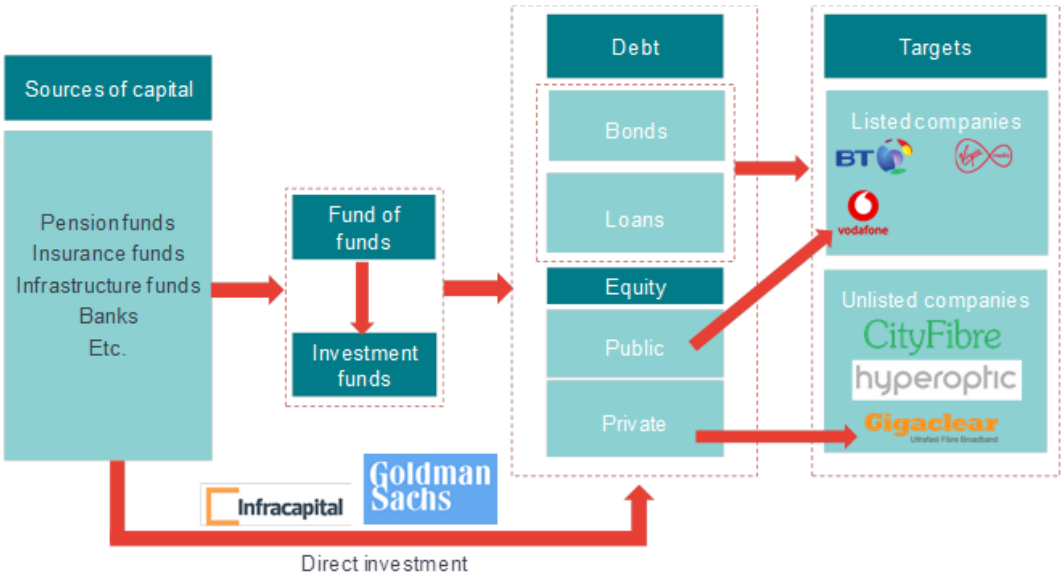
3.1 Financing telecoms infrastructure projects

3.1.1 Sources of finance for infrastructure

Most investment in telecoms infrastructure in the UK is delivered by the private sector.

As **Figure 4** shows, actual/potential investors in telecoms infrastructure in the UK include both listed (e.g. BT, TalkTalk, Vodafone) and unlisted firms (e.g. Gigaclear and Hyperoptic). Financial markets provide funding in the form of equity and debt financing, and hybrid solutions (such as mezzanine finance) are also becoming more common.

Figure 4 Flow of private capital through the infrastructure investment ecosystem



Investors may invest directly in projects/firms or indirectly through funds that manage money on behalf of others, for which they charge management fees and typically take a share of the profits.

There are number of recent high-profile examples of investors making/ committing to significant investments in fibre broadband projects or companies. These include:

- **Infracapital**, the infrastructure investment arm of M&G Investment, announced earlier this year a joint venture with TalkTalk to deploy fibre to 3 million homes.[63] Infracapital also subsequently made an offer to acquire fibre provider Gigaclear.[64]
- CityFibre agreed a $750 million takeover by a **Goldman Sachs**-backed consortium [65]

Different categories of investor typically target different risk/ returns profiles and hence the potential sources of finance will vary with the type of project and its stage of development: banks, investment funds and private equity investors may invest in the early stages and may look for an exit between 3 and 7 years once the business is established. Infrastructure funds, pension funds and other institutional investors tend to invest in more established infrastructure and seek longer term investments.

We understand from our discussions with the investor community that the scale of the project is another important factor affecting the type of investment that it attracts. In particular, the larger infrastructure funds and institutional investors tend to gravitate towards larger projects.

Government-backed institutions are also an important source of finance for major infrastructure projects

Alongside private investors, government-backed institutions have also been an important source of finance for infrastructure projects:

- The European Investment Bank (EIB) invested £35 billion in UK infrastructure (across all sectors) between 2011 and 2015, generally at cheaper rates than could be obtained by infrastructure operators from other sources of finance.[66] The EIB has provided finance for a number of fibre projects in the UK, including deployments by altnets such as Hyperoptic and Gigaclear[67]
- The European Commission and European Investment Bank recently launched the Connecting Europe Broadband Fund (CEBF), which serves as an investment platform for broadband projects that combines public with private commitment and aims to invest in some 7 to 12 broadband projects each year up to 2021 (unlocking additional investments between €1 billion and €1.7 billion in broadband deployment in underserved areas across the EU as a whole).[68]

63 https://www.ft.com/content/ad719ed2-0ca1-11e8-8eb7-42f857ea9f09

64 https://www.telegeography.com/products/commsupdate/articles/2018/03/12/infracapital-makes-gbp207m-bid-for-gigaclear/

65 https://www.reuters.com/article/us-cityfibre-infra-m-a-antin/cityfibre-agrees-750-million-takeover-by-new-consortium-idUSKBN1HV0H3

66 NIC (2017), Consultation on a National Infrastructure Assessment

67 Altnet is a term used to describe operators investing in FTTP roll-out other than the incumbent operator – this would include VM in the UK case.

68 http://europa.eu/rapid/press-release_IP-16-4351_en.htm

- In the UK, the Government has launched the Digital Infrastructure Investment Fund, which will invest on arm's length commercial terms in broadband infrastructure. HMT is to provide £400 million of funding, which will be supplemented by capital from the private sector.[69]

Many projects have also received direct government support in the form of public grants, often in combination with financing from private sources (see Section 2 for recent examples in the UK). Public funding is also available at the European Union level through European Structural and Investment Funds including the European Regional Development Fund (ERDF). We look at the role of public subsidy/ support in funding broadband investment in more detail Section 3.2.

3.1.2 Availability of finance for telecoms infrastructure in the UK

There was a view amongst investors we interviewed that investments in telecoms have historically been regarded as substantively riskier than investments in "core" infrastructure[70] (such as utilities and transport) primarily due to demand risk. In particular, one investor noted that new fixed deployments will face competition from copper and, in many areas, also cable. It was noted that future technological developments (e.g. in mobile) could result in investments becoming obsolete. The higher risk associated with telecoms, relative to other types of infrastructure, was therefore identified as a factor which could constrain the availability of capital, particularly from infrastructure funds.

However, most of the people we spoke to suggested that they had observed a change in attitude towards investments in telecoms infrastructure (particularly fibre networks) in the UK in recent years, as investors are starting to become more comfortable with the risks. One of the key factors cited as driving this shift was evidence that early investments in fibre in the UK appear to have generated the required rate of return. New models which mitigate demand risk, including the anchor tenant model used by CityFibre and Gigaclear's demand aggregation approach, were also cited as important factors behind changing attitudes.

This change in attitude appears to have resulted in an increased willingness to invest in fibre projects - one investor noted that there are a number of banks/funds that are interested in putting money into these projects and that telecoms is becoming a key part of the strategy of some infrastructure funds.

Overall, evidence gathered from our interviews with investors suggests that the higher risks associated with major investments in new telecoms infrastructure has meant that availability of finance for fibre projects has historically been more limited compared to other types of infrastructure. However, there is evidence that the availability of capital has improved in recent years, as the sector has become better understood and evidence demonstrating the viability of privately funded fibre projects has started to emerge. This is borne out by a number of examples of

[69] https://www.gov.uk/government/news/billion-pound-connectivity-boost-to-make-buffering-a-thing-of-the-past

[70] "Core" infrastructure is defined as low-risk/ low-return projects. Utilities represent classic examples of core infrastructure

private investors committing significant funds to fibre projects. Thus capital constraints per se do not currently appear to be a significant bottleneck.

3.2 Investment in fibre networks

Before looking in detail at the range of factors that influence the investment in fibre, it is helpful first to consider at a high-level the key economic principles that guide decisions to invest.

3.2.1 Net present value provides a theoretical basis for investment decisions

A core principle of standard investment theory is that an investment should be made in a particular "project" if the expected returns from the project exceed the opportunity cost of that investment (the "hurdle rate"). Equivalently, investments will be made if the net present value ("NPV") of the cash flows generated (i.e. revenues minus costs) over the life of the project is positive, where the NPV is estimated using a discount rate equal to the relevant hurdle rate.

The hurdle rate is typically the return that could be earned if that investment was made in a different project with a similar risk profile. The weighted average cost of capital (WACC) – that is the weighted average of the cost of debt and equity invested in a particular project or firm – is the standard measure for this rate of return. Broadly speaking, higher risk projects will face a higher WACC[71] (and hence hurdle rate), since investors require a higher rate of return to compensate for the additional risk. Therefore, the greater the risk associated with the project, the greater the expected rate of return will need to be to incentivise investment.

3.2.2 Investors will assess potential investments against alternative options

The decision to invest in a particular project (at a particular point in time) will rarely be made in isolation, but will typically be made alongside a range of alternative options. In the context of investment in FTTP, these options include:

- **Sweating legacy assets:** existing infrastructure owners (e.g. BT) may continue to rely on or "sweat" their legacy infrastructure assets (i.e. copper networks).
- **Renting access to the incumbent's network:** existing "access-seekers" (or potential new entrants) (e.g. Sky and Talk Talk) may choose to (continue to) rely on renting access to the incumbents' network infrastructure rather than invest in their own infrastructure.

[71] The Capital Asset Pricing Model (CAPM) is typically used to determine the rate of return that one could expect to receive from a project with a given risk profile. CAPM estimates the "risk premium" – that is the expected returns on the project over and above the risk-free rate (usually captured by investment in the safest available assets, such as government bonds) – which reflects the non-diversifiable (or "systematic") risk associated with the project.

- **Delaying investment:** operators may have the option of delaying the investment until a later date, when demand and costs will be better understood; this is sometimes referred to as the "option value" associated with delaying an investment.[72] "Option value" is especially relevant in the context of investments in new technologies, for which costs and demand are highly uncertain. In particular, firms may prefer to wait until the market conditions (demand, costs) become more certain before exercising the option to invest.

Thus, in some circumstances, firms may choose not to invest in projects that, when considered in isolation, are NPV-positive (or have an expected return that is above the cost of capital), on the basis that an alternative option (including deferring the investment to a later date) is more profitable. On the other hand, if returns on investment are expected to be high and relatively predictable, the benefits of deferring the investment are limited and the investment is more likely to be made at an earlier stage.

Competition may also erode the option value associated with delay. In particular, in dynamic competitive markets, firms will also need to consider that delaying investment in new technologies could result in a loss of market share to more innovative rivals (alternatively, investing early could allow firms to accrue/maintain market share). If this latter effect is strong, incumbents may choose to invest earlier.

[72] See, for example, Pindyck and Rubenfield (1994), *Investment under uncertainty*

4 KEY FACTORS DRIVING DECISIONS TO INVEST IN FIBRE AND EVIDENCE ON POLICY INTERVENTIONS

In this section, we consider evidence relating to key factors that drive decisions to invest in fibre. Following from the above, these factors can broadly be described as influencing the decision to invest through four channels:

- The **profitability** (or rate of return) of fibre investment projects: factors that increase the potential rate of return are:
  - **reducing the costs and other barriers** to deploying fibre and/or
  - **boosting revenues (stimulating demand)** for fibre products.
- **Reducing the risk of investment:** as noted above, investors will only undertake projects where the expected rate of return exceeds the relevant hurdle rate (typically the cost of capital). Factors which reduce risk/uncertainty should lead to a lower cost of capital (and hence hurdle rate) thereby making investment more likely.
- **Reducing profitability of alternative options:** factors that make alternative options less/ more profitable (including delaying investment) will increase/ decrease the relative attractiveness of investment in fibre. For the incumbent alternative options would be to continue to rely on copper-based products (ADSL, FTTC and G.fast). For alternative operators, it would be investing in their own fibre networks vs. getting access to the incumbent's network (i.e. 'build' vs. 'buy' decision).
- **The level of competition** in the market can also have an impact on the expected returns on investment, and therefore affect the operators' decision to invest. On the one hand, strong competition could reduce the potential profitability of investment due to competitive pressure from rival operators. On the other hand, competition from 'alternative' (to the incumbent) network operators ('altnets'), by reducing the option value of delaying investment provides a stimulus to the incumbent to invest.

Below, we present the evidence from our literature review, case studies, interviews with investors and responses to the Call for Evidence to illustrate the impact of these key drivers on operators' decisions to invest in fibre.

4.1 Reducing costs of infrastructure deployment

In this section, we first discuss the evidence on cost reduction initiatives that apply to all telecoms operators – both incumbents and altnets. We then proceed to discuss the role of access to ducts and poles in reducing the costs of fibre deployment for altnets.

The re-use of existing civil works infrastructure can reduce deployment costs

The high costs associated with civil infrastructure, including ducts and poles, can represent up to 80% of the up-front cost of deployment, and therefore represent a major barrier to investment in fibre.[73] Recognising this, regulators and policymakers have implemented a number of measures that attempt to reduce the costs of FTTP deployment.

In particular, the EU has issued a directive that aims to reduce the costs of civil works. The directive applies to network operators across all sectors and obliges them to provide access to their physical network for the deployment of high-speed networks. The key measures contained within the directive include access to existing physical infrastructure, coordination and transparency of planned civil works and installing in-building infrastructure in all new buildings and major renovations. [74]

There is also evidence of utilities' passive infrastructure being re-used for fibre deployment in other markets.

[73] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/534619/2016_07_04_Government_Response_FINAL.pdf

[74] Member States were required to transpose the EU Directive into national legislation and apply the above measures from July 2016. In the UK, these were transposed into law by the Communications Access to Infrastructure (ATI) Regulations 2016 and operators are entitled to refer issues to Ofcom where the rights or terms under which the rights are to be granted cannot be realised through commercial agreement - Ofcom (2016), Statement following consultation on Guidance under the Communications (Access to Infrastructure) Regulations 2016

EXAMPLE INFRASTRUCTURE ASSETS FROM OTHER SECTORS USED TO DEPLOY FTTP

There are also examples of infrastructure assets from other sectors being used to deploy fibre on a commercial basis:

- In Germany, most of the regional FTTP operators belong to local utilities that deployed networks using existing passive infrastructure just after market liberalisation in 1998[75];
- Spanish operator Adamo is working with a local electricity company to cover 100% of the Cantabria province with FTTP. It foresees the use of electricity rights of way and passive infrastructure in exchange for helping the electricity company to modernise its network[76];
- In 2014, the Irish national electricity company ESB launched SIRO, a 50:50 joint venture with Vodafone to deploy FTTP using ESB's overhead and underground electricity distribution network infrastructure.[77] Phase 1 of the project is intended to cover 500,000 premises at a cost of €900 per home passed.[78] In terms of the business structure, SIRO pays ESB annually for the use of its network and offers wholesale open access, with Vodafone as a retail partner anchor tenant. At the same time, SIRO offers ESB access to fibre for its operational needs, at below market rates;
- Enel, Italy's major power utility, plans to roll-out fibre using its electricity network to 9.5 million premises, at an estimated cost of €390 per home passed.[79] Based on a technical field study conducted by Analysys Mason, Enel expects to be able to reuse around 60% of its existing network assets (e.g. towers, cabinets, ducts and poles). The scope for reuse of underground ducts is, however, expected to be significantly more limited than for overhead infrastructure;
- SSE recently announced a partnership, enabling the distribution of SSE Enterprise Telecoms' fibre optic cables throughout Thames Water's waste water network. SSE estimates that, by using Thames Waters existing infrastructure, it will be able to reduce network deployment costs by 60% and roll-out up to 10 times faster than traditional digs;
- In France, the electricity company ERDF's physical distribution network infrastructure has been used extensively to support the deployment of fibre – as of 2014, around 37% of fibre in France has been deployed using ERDF's low and medium voltage poles.*; and*

In New Zealand, the electricity companies Northpower and Waikato Networks Limited are two of four providers awarded concessions to deploy fibre as part of the government's national broadband plan. Northpower is connecting most of its fibre to households using overhead lines installed on its electricity poles.[80]

Whilst the above examples suggest that there is significant scope for the sharing of utilities' infrastructure to reduce fibre deployment costs, collaboration between telecoms operators and infrastructure owners from other sectors has been relatively limited in the UK to date. The introduction of general access obligations

[75] NERA study, page 29

[76] NERA study, page 51

[77] https://siro.ie/more-about-siro/esb-and-vodafone/

[78] http://www.teleco.com.br/huawei/releases/Power-Companies%20-Deploying-Fibre-Networks.pdf

[79] Ibid

[80] https://northpower.com/fibre/one-tree-point

within the Access to Infrastructure (ATI) regulations, which apply to infrastructure operators across all sectors (including gas, electricity, water and sewage and drainage systems, heating and transport services) may help to encourage greater infrastructure-sharing in future.

Access to passive infrastructure (ducts and poles) can reduce the cost of fibre deployment for altnets

Costs of fibre deployment tend to vary between incumbents and altnets. Incumbents rely on their existing passive infrastructure (ducts and poles), which allows them to deploy FTTP cheaper and faster compared to new entrants who have no access to ducts and poles. Recognising this, some countries (including notably Portugal and Spain) have focussed regulation in recent years on access to physical infrastructure. As a result of this measure (and other favourable factors), both Spain and Portugal are considered to have seen significant deployment of FTTP, including by alternative operators.[81]

Duct and pole access has also been combined in some cases with a symmetric obligation (i.e. applying to all operators) for the first operator to roll-out to a multiple dwelling unit (MDU) to provide passive access to in-building wiring.[82]

Historically take-up of passive infrastructure access has been limited in the UK

Whilst Ofcom introduced a duct and pole access remedy (referred to as PIA) as part of its 2010 WLA market review, take-up has thus far been limited in the UK. Duct quality and availability is one of the factors behind variations in the relative success of passive access measures.[83]

Since PIA has not yet been widely used, it is difficult to compare the quality of the incumbent's existing infrastructure in UK with other countries'.

Restrictions on usage are another factor affecting the take-up of passive infrastructure remedies. A recent study by WIK looking at best practice for passive infrastructure access found that there are few restrictions on use in countries where duct access is commonly used.[84] Ofcom also noted in a recent review of duct and pole access in the UK that stakeholders had argued that relaxing usage restrictions was important to supporting the investment case and that economies of scope from delivering all types of services over the same network can support a PIA based business case.[85]

[81] Shortall and Cave (2015) Is symmetric access regulation a policy choice?

[82] See BEREC (2016) Challenges and drivers of NGA rollout and infrastructure competition, page 36 for more details

[83] BEREC (2016), Challenges and drivers of NGA rollout and infrastructure competition, page 21

[84] WIK-Consult (2017), Best practice for passive infrastructure access

[85] Ofcom (2017), WLA Market Review: Consultation on duct and pole access., page 34

Ofcom has recently introduced a raft of measures to improve the effectiveness of its duct and pole access remedy

Ofcom's recent review into its duct and pole access remedy identified a number of issues that it hopes to address through the raft of reforms introduced as part of its 2017 WLA market review (published in early 2018). The key changes include:[86]

- introducing cost-oriented charges;
- imposing non-discrimination obligations to ensure that Openreach does not discriminate unfairly against alternative operators in the provision of passive access;
- improving the processes that BT uses to deliver PIA (in particular, requiring it to provide detailed digital maps of its ducts and poles);
- broadening the scope of the remedy to allow mixed usage (where residential fixed broadband is the main usage); and
- introducing requirements for Openreach to make adjustments to its infrastructure where necessary (e.g. increase capacity) to accommodate requests for access.

Ofcom expects that PIA could reduce the cost of building a full-fibre network *"in some cases by up to 50%."*[87] [88]

It is difficult to predict the extent to which these reforms will prove to be effective in practice. However, the experience from the implementation of measures to open up access to BT's copper network in the UK is consistent with policy measures taken to improve the effectiveness of access regulations being able to have a significant impact.[89]

Investors and operators have highlighted the importance of having effective duct access regimes

There was a broad consensus amongst the investors we interviewed and operators responding to the Call for Evidence that improving access to civil infrastructure – in particular ducts and poles – could help the business case for fibre significantly and that builders are generally keen to use BT's ducts where feasible. Some interviewees also considered that policy makers should also seek to encourage the use of utilities' infrastructure, including electricity poles. It was also noted that the attractiveness of using existing ducts will vary depending on location and the quality of the ducts.[90]

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[86] Ofcom (2018), WLA Market Review Statement

[87] Ofcom (2018), WLA Market Review Statement, Volume 3, para. 2.9

[88] This estimate of 50% is based on the assumption that i) civils costs scale according to the proportion of PIA used, and ii) this proportion could be "as high as 75%". It is also worth noting that this estimate does not take into account the cost of installing the final drop.

[89] ULL was introduced in Europe through regulation in 2000. However, take-up in the UK was initially low and lagged well behind other EU5 countries. Take-up increased rapidly after Ofcom introduced two policy changes in 2004/2005 to encourage investment in ULL – a significant price reduction and functional separation of Openreach from the rest of BT.

[90] In particular, one interviewee argued that in cities, operators would use existing duct wherever possible in order to avoid having to replace paving slabs whereas in suburban areas, where tarmac is the primary

Overall, the costs of fibre deployment are among the key drivers of the operators' decision to invest. The evidence on reduction of these costs for altnets by providing access to passive infrastructure (ducts and poles) and for all operators by encouraging access to passive infrastructure across other sectors is consistent with such measures having a positive effect on fibre deployment.

4.2 Reducing other barriers to fibre deployment

In addition to the costs of the works themselves, difficulties associated with securing planning rights and wayleaves to be allowed to undertake civil works have also been identified as important barriers to roll-out. For example, a recent report by Analysys Mason for the Broadband Stakeholder Group found 19 specific issues with planning legislation that it considered are likely to have a negative impact on the deployment of telecommunications infrastructure.[91] The report also noted that permit schemes are implemented regionally, whilst many telecoms operators operate at a national level and that within these schemes there were inconsistencies in the way guidance is interpreted.

Operators in their responses to the Call for Evidence also set out a number of other measures that would reduce deployment costs and other barriers, including:

- improvements to wayleave processes[92];
- changes to building regulations to facilitate fibre deployment for new builds;
- several proposals to reduce barriers related to street-works, including the introduction of a standard permit scheme, and establishing a single point of approval for Local Authorities for different types of traffic management;
- battery back-up, Ofcom has confirmed that fibre providers are only required to provide a battery back up to vulnerable customers, while other customers can choose to purchase the service if needed; and
- use of 'narrow trenching' and other innovative trenching techniques - although these methods have been approved for fibre deployment (in the Specification for the Reinstatement of Openings in Highways 2010), highway authorities often restrict the use of these techniques, designating roads as 'unfit' for these techniques, without any supporting evidence.

Barrier busting initiatives

As a direct response to the 2017 BSG report on barriers to telecoms deployment in the UK, the Government has set up a cross-government 'Barrier Busting Taskforce'. The taskforce is seeking to reduce the costs of street-works, liberalise planning, simplify and shorten the process for wayleave agreements, ensure that all new builds have fibre and tackle other barriers to roll-out. The taskforce is

surface, it may be more effective for them to dig their own, noting the difficulties that Virgin has with using BT's ducts in Wrexham.

91 Analysys Mason (2017), Lowering barrier to telecoms infrastructure deployment

92 Wayleaves are required to allow access to private land/ premises to lay cables/ carry out maintenance work. The new Electronic Communication Code aims to speed the time to get wayleaves and to reduce costs.

working with local bodies to identify solutions or implement best practice and may make changes to regulations on planning, transport, and wayleave if necessary[93].

For example, the Government has already approved a five year business rate tax relief on new fibre investment. Other examples of Barrier Busting initiatives include:

- **Wayleaves**: mediating between operators and local authorities (LAs) on live issues, exploring solutions to improve understanding and considering potential ways to instigate lasting change, including changes to legislation if necessary;
- **Streetworks**: examining quality standards of operators and their subcontractors, cross-utility collaboration, narrow/micro trenching and works classifications; and
- **New build and retrofit**: assessing the efficiency of the Memorandum of Understanding (MOU) between the House Builders Federation, Openreach, GTC (utilities provider) and Virgin Media and ways to assist new developments with poor connectivity, and to improve connectivity in all new builds[94].

4.3 Stimulating demand for higher bandwidths

Lack of demand for higher bandwidths may undermine the investment case for fibre

Due to the high up-front investment costs associated with network deployment, the ability of operators to charge a premium relative to legacy services whilst achieving sufficient scale is a vital part of the business case for FTTP. Demand and consumer willingness to pay for higher bandwidths are therefore potentially important drivers of investment in FTTP. Indeed, a recent study by BEREC found that fibre roll-out is typically more widespread in countries where end-users have a higher willingness to pay a premium for high capacity broadband connections.[95]

A study by the Communications Chamber (for Liberty Global) found that "*with the exception of Belgium, no [EU] country has achieved more than a 20% share [of 100+ Mbps connections] if their price premium was greater than €10 per month. This suggests that the pool of customers who place a material value on the incremental benefits of 100 Mbps broadband is low*."[96]

Available data for the UK broadband market indicates that consumers have been prepared to pay a premium for higher speed, more reliable services. For example, Virgin Media charges £33 a month for 50Mbps products and £48 a month for

[93] https://www.gov.uk/government/speeches/building-a-full-fibre-britain

[94] DCMS presentation, https://democracy.walthamforest.gov.uk/documents/s59954/Appendix%201%20-%20DCMS%20LFFN%20Presentation%20Workshops%20Slides%201.pdf

[95] BEREC (2016), The Challenges and drivers of NGA rollout and infrastructure competition

[96] "Connectivity for the Gigabit Society" (2016) Communications Chambers

350Mbps[97]. Whilst unlikely to be sustainable with wider take-up, it is evidence of a higher willingness to pay in a segment of the market.

Demand-side subsidies, such as voucher schemes, have been used to bridge the gap between the returns which an FTTP network investor would require and the current willingness of households to pay for these services. In principle, improved connectivity may be associated with 'positive externalities' – that is, benefits to wider society that are not reflected in individuals' (or businesses') willingness to pay for higher bandwidths. Indeed, part of the rationale for the UK Government's Broadband Connection Voucher Scheme[98] was that it would help to capture "*value that is not accounted for in an individual SME's assessment of the benefits of the investment, such as the value of improved industry collaboration and spill-over effects in the supply chain*."[99]

In some other European markets, similar schemes have been adopted to allow households to overcome the initial cost to connect which they may face when switching from an existing copper-based network to an FTTP network. In other cases, operators or third party financial institutions are being encouraged to amortise connection costs over a much longer period than normal.[100]

Indirect subsidy via tax relief is an alternative form of demand stimulation that has been adopted, for example, in Denmark. In January 2016, Danish authorities decided to introduce a tax deduction for private households upgrading or establishing broadband access, up to a maximum of DKK 12.000 (€1,600) per household.[101]

4.4 Reducing uncertainty and encouraging risk-sharing

Operators deploying fibre infrastructure face a number of risks:

1. demand for their high-speed products/ consumers' willingness to pay could be lower than projected;
2. other operators could overbuild their network and undermine their business case; and
3. regulatory decisions could also affect profitability of their investment, especially if these decisions are unexpected and therefore had not been factored into the original business plans.

[97] http://www.virginmedia.com/shop/broadband/broadband-only.html. Gigaclear's and Hyperoptic's offers also include a premium for higher speed products – see https://www.gigaclear.com/our-broadband-products/for-home/home-broadband-packages/#product-1G , and https://hyperoptic.com/price-plans/

[98] The Broadband Connection Voucher Scheme ran from March 2014 to March 2016, with an aim to help businesses meet the capital costs of the infrastructure upgrade required for an improved broadband connection to their premises. According to an impact study, 42,500 small firms benefited from the scheme, although only 9,000 of those took FTTP. In March 2018, the Chancellor announced that £67 million of the £200 million of funding for FTTP announced in the Spring 2017 budget will be allocated to vouchers which will allow households and SMEs to purchase FTTP connections (from any FTTP network operator).

[99] DCMS (2017), Broadband Connection Voucher Scheme Impact and Benefits Study

[100] Feasey, Bourreau et al, CERRE Demand Side Measures

[101] https://ec.europa.eu/digital-single-market/en/country-information-denmark

These uncertainties contribute to higher option value, i.e. operators' postponing large scale investment until these uncertainties are resolved/minimised, even in areas that are likely to be profitable.

Below, we discuss evidence on steps taken by operators and policy makers to reduce these risks in more detail.

Risk due to uncertainty around demand (and to a lesser extent costs), has been identified as a key barrier to investment in fibre. Indeed, Ofcom has noted that where investments involve a step change in quality: "*This can lead to significant uncertainty on network deployment costs, consumer demand, and the prices that consumers will pay".*[102]

Some FTTP operators have sought to mitigate the risks around demand by requiring households to commit to purchase FTTP services before they actually deploy the network. Reggefiber adopted this approach in the Netherlands, where it would deploy fibre to a given area once it had reached a certain pre-subscription level (ranging between 30 – 40%).[103] This model was replicated by other operators in the Netherlands, and resulted in some successful local co-operative FTTP networks.[104] In the UK, a number of local and regional authorities ran such 'demand aggregation' schemes in the early 2000s in order to encourage BT to introduce ADSL services in particular localities. More recently, a number of national and local network operators in the UK (including Gigaclear and Hyperoptic) have set up demand registration schemes, to help gauge the level of demand within an area before committing to invest.[105]

Aggregation of demand from the public sector itself – a major consumer of communications services – can also help to support the business case for fibre investment. For example, in the UK, Peterborough City Council agreed a strategic partnership with CityFibre, for which they created a local fibre network.[106] In Sweden, political initiatives have been adopted to harness demand for high-speed internet from public services. In particular, fibre networks have been initiated as part of broader IT-strategies about connecting schools, hospitals and municipal buildings to fibre broadband.[107] DCMS has consulted on how to facilitate more widespread use of demand aggregation in the public sector and is looking at how best to encourage and coordinate public sector bodies to work together to aggregate demand.[108]

[102] Ofcom 2016, Initial conclusions from the DCR, page 42

[103] https://www.belegger.nl/Forum/Upload/2012/6570899.pdf

[104] OECD (2015), Development of high speed networks and the role of municipal networks, page 41

[105] DCMS (2018), Guidance for community-led broadband options (https://www.gov.uk/government/publications/community-led-broadband-schemes/introduction-to-community-led-schemes)

[106] https://www.peterborough.gov.uk/council/campaigns/cityfibre/

[107] BEREC (2016) Challenges and drivers of NGA rollout and infrastructure competition, page 126

[108] DCMS 2017, Extending Local Full Fibre Networks

Co-investment as a strategy to lower risk

Co-investment can help to mitigate the impact of uncertainty by spreading the costs and therefore the risk of the large-scale investments required for fibre networks across multiple parties.

There are a number of examples of commercial co-investment projects in Europe:

- In Germany, EWE and Deutsche Telekom have recently announced the creation of joint venture to invest up to €2 billion over 10 years to build an FTTP network and connect over a million private households, mainly in rural areas.[109]
- In Portugal, Vodafone and NOS recently signed an agreement to deploy and share an FTTP network covering 2.6 million homes based on reciprocal access.[110] Similar deals have been struck between operators in Spain (Telefonica/Jazztel[111] and Orange/Vodafone Spain[112]).
- In the UK, Vodafone and CityFibre recently announced a strategic partnership to deploy FTTP to 1 million homes in the UK (with the option to increase to 5 million), starting in 2018, based on a long-term access model.[113] CityFibre will build and operate the network, providing wholesale access to Vodafone and other providers, whilst Vodafone made a volume-based commitment for 10 years in return for exclusive access during the build phase.

Recognising the potential benefits of co-investment, particularly in areas where multiple parallel networks may not be viable, regulators have sought to incentivise alternative operators to jointly invest and share network assets rather than rely on regulated access. France provides the most prominent example of regulated co-investment in Europe. In the French model, all operators deploying fibre networks offer to other operators the opportunity to enter into a co-investment arrangement to build the last section of fibre (referred to as the terminating segment), based on a long-term access arrangement.[114]

The European Commission has proposed to introduce new provisions to the European Electronic Communications Code to incentivise joint commercial investment in new infrastructure by incumbents and alternative operators. Under the proposals, regulated access would not be imposed on SMP network owners that co-invest, subject to certain conditions including: the network deployed must be a very high capacity network and access seekers that do not invest can continue

[109] https://www.telekom.com/en/media/media-information/archive/ewe-and-dt-cooperate-on-fiber-expansion-510644

[110] http://www.vodafone.com/content/index/media/vodafone-group-releases/2017/vodafone-portugal-and-nos-fibre-network-share-agreement-in-portugal.html

[111] https://www.telegeography.com/products/commsupdate/articles/2012/10/10/jazztel-inks-FTTP-deal-with-telefonica-for-shared-deployment/

[112] http://www.vodafone.com/content/index/about/policy/news/public-policy-news-releases/2014/vodafone-spain-orange-spain-fibre-sharing-agreement.html

[113] https://www.cityfibre.com/news/vodafone-cityfibre-bring-gigabit-speed-fibre-uk/

[114] See NERA study for more detail

to enjoy the same quality of access that they had prior to the investment.[115] [116] The EC's rationale for this approach is that it would enable "*all co-investors to benefit from a first-mover advantage, compared to other undertakings.*"[117]

Whilst co-investment may help to encourage the deployment of FTTP, the impact on competition is less clear-cut, particularly where the incumbent operator is involved. For example:

- BEREC has noted in response to the above proposals from the EC that there is a risk that co-investment could reinforce or extend the market power of SMP operators.[118] In particular, it argues that there is a risk of the market foreclosing smaller players if access to the new network is restricted.[119]
- Similarly, a theoretical study by Cambini and Silvestri (2013) considers the impact of co-investment with the incumbent under a range of conditions and finds that whilst co-investment may be beneficial in terms of competition and investment, there might be a concern with the potential exclusion of outsiders from the network agreement under a joint venture model.[120]

Thus, when considering the best approach to the regulation of co-investment there appears to be a trade-off between protecting/encouraging competition in the downstream market whilst at the same time ensuring that the co-investing parties have sufficient incentives to invest.

Regulatory uncertainty

Regulatory uncertainty is a source of risk for investors in broadband infrastructure. In particular, as set out above, access and access price regulation can have a significant impact on operator revenues and any uncertainty in this area is therefore likely to dampen investment incentives.

A number of operators and investors highlighted the importance of regulatory stability and certainty in facilitating investment in their Call for Evidence responses.

- Virgin Media considered that "*regulatory stability and confidence that [it] will be able to make a return on our risky, high-upfront (sunk) cost investment is critical*";
- Similarly, Hyperoptic noted that "*Investors prefer consistency and predictability in the policy and regulatory environments*" and that "*significant and dramatic changes or the fear of such, can exaggerate the normal risk*" of investments in new infrastructure;

[115] European Commission (2016), Review of the Electronic Communications Regulatory Framework, Executive Summary 1: Access Networks, page 4

[116] Other conditions identified include i) the co-investment offer is transparent with reasonable and non-discriminatory terms offered to potential co-investors and ii) co-investors have the possibility to contribute for the amount and at the time that they deem best

[117] Ibid, page 5

[118] BEREC 2017, views on Article 74 of the draft Code Co-investment and "very high-capacity (VHC) networks"

[119] The EC proposals appear to allow for access to the new network restricted for access-seekers that do not co-invest, as long as these access-seekers can continue to enjoy the same quality of access that they had prior to the investment.

[120] Cambini and Silvestri (2013), Investment sharing in broadband networks

- Telefonica also highlighted the importance of a *"stable, predictable regulatory regime*"; and
- Investment firm, Invesco, considered that "*There needs to be a clear regulatory environment which gives investors certainty over a long period."*

BT argued, in particular, that greater clarity was needed on the framework that Ofcom uses when applying the "fair bet" principle to access regulation and that uncertainty in this area would mean that "*once an investment has been made*, *regulatory actions may be taken subsequently which potentially deny investors the opportunity to earn a fair return given the risks taken*."

4.5 Impact of infrastructure competition

Infrastructure competition within the fixed sector has historically been limited due to the high fixed costs (or, 'natural monopoly' characteristics) associated with deploying a fixed access network. As such, ex-ante regulation has primarily focussed on mitigating competition concerns stemming from the dominant position held by a vertically integrated incumbent operator. In particular, where the incumbent is found to have significant market power (SMP) regulators in the EU have sought to encourage competition in the downstream market and protect against the risk of excessive pricing, by imposing wholesale access obligations on the incumbent network.[121]

However, with the transition to Next Generation Access (NGA) technologies, regulators have increasingly sought to encourage operators that have rented copper loops in the past to deploy their own networks.[122] The European Commission has also made the promotion of infrastructure competition and network deployment by all operators as one of the key objectives of its review of the European Electronic Communications Code.[123]

Ofcom's Strategic Review of Digital Communications in 2015 led to a strategic shift towards encouraging large-scale investment in competing full fibre networks, and away from reliance on BT's existing copper-based network. Ofcom's current regulatory approach can be characterised as seeking to promote efficient infrastructure and retail competition through passive and active access regulation.[124]

This can help to boost fibre coverage via two channels:

[121] In 2000, the EC introduced regulation which required incumbent operators to meet reasonable requests for unbundled access to local copper loops to address lack of competition in the local network (Regulation (2887/2000/EC) on unbundled access to the local loop). Following this, unbundling regulation was absorbed into NRAs' broadband market analysis procedures, with a range of access remedies being imposed on dominant operators (see Sutherland (2007), Unbundling local loops: global experiences.

[122] Feasey and Cave (2017), Policy towards competition in high-speed broadband in Europe, in an age of vertical and horizontal integration and oligopolies

[123] European Commission (2016), Proposal for a directive of the European Parliament and of the Council establishing the European Electronic Communications Code

[124] See Wholesale Line Access Statement, (2017)

- Firstly, since new entrants also do not have a legacy network to defend, all else being equal, we would expect them to have stronger incentives to invest in FTTP infrastructure; and
- Secondly, the direct (or potential) competitive pressure from alternative fibre networks should increase the incumbent's incentives to invest in fibre in order to protect its market share (so called *'defensive effect'*).

Below we consider the evidence relating to the role of infrastructure competition in driving fibre deployment. We begin with a brief summary of the theoretical literature on the relationship between competition and investment before reviewing the evidence relating to the impact of infrastructure competition on fibre roll-out.

Economic theory suggests that the relationship between competition and investment depends on the nature of the market and investment

Increasing the extent of competition in oligopolistic markets may incentivise firms to invest in order to forestall potential entry or to better differentiate themselves from rivals. It has also been proposed that there may be an inverted U-shape relationship between competition and innovation – at low levels of competition, more competition encourages investment/innovation because there is more incentive to "escape competition" and win share by differentiating, whilst at higher levels of competition the "Schumpeterian effect" (an ability to earn sufficient returns on investment) dominates and the incentive to invest declines.[125] Thus, in theory at least, the relationship between the degree of competition, and the level of innovation investment in a market may not be straightforward.

The economic literature also suggests that the impact of competition on investment will vary according to both the nature of the investment and the firm investing. In particular, Dasgupta & Stiglitz (1980) present a model of competitive investment which explains the circumstances under which (i) an incumbent is more likely to invest or (ii) new entrants are more likely to invest. They find that, where an investment leads to a 'drastic' change in technology (i.e. replacing existing technology), the incumbent would be less likely to invest as it would merely replace its existing assets and the associated revenue streams. The entrant, on the other hand, would be more likely to invest as it could enable it to replace (or steal market share from) the incumbent. For "non-drastic innovation", the monopolist has a greater incentive to invest, since doing so would not cannibalise existing profits to the same degree and could also stop the entrant from breaking into the market.[126] This could explain why empirical evidence indicates that some fixed incumbents are more likely to undertake incremental upgrades to their existing copper networks (in particular, by deploying FTTC) than invest in FTTP (which represents a more 'drastic' change), unless strongly pushed by new entrants investing in fibre.

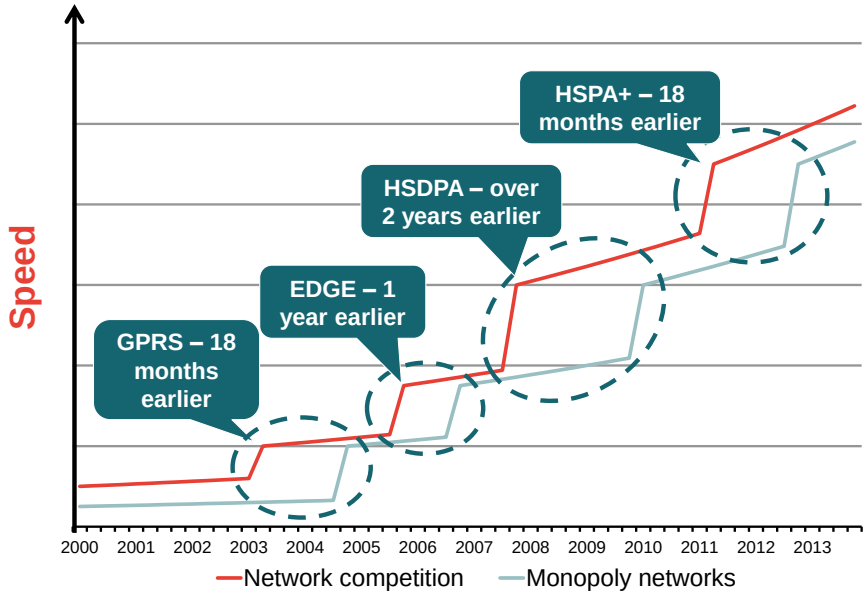
[125] Aghion, Bloom, Blundell, Griffith, Howitt (2005) Competition and Innovation: an Inverted-U Relationship

[126] Dasgupta & Stiglitz (1980)

Empirical evidence indicates that competition can drive investment

Empirical evidence is consistent with network competition having a positive effect on investment relative to a monopolistic market structure. In particular, evidence from the mobile market indicates that competitive markets have been faster than uncompetitive markets to transition to new technologies – this is illustrated by the chart below, which compares the median year in which successive mobile technologies were first launched across countries with single networks compared to competitive markets. As the chart shows, monopoly networks have tended to be much slower at introducing new technologies.

Figure 5. Diagram showing timing of technology upgrades



Source: Frontier analysis based on TeleGeography data

A recent study by WIK Consult found that where cable exists and has a significant presence, it has usually played a strong role in stimulating NGA deployment (albeit primarily FTTC rather than FTTP).[127] This is supported by Telefonica's (the incumbent network in Spain) statement that "*competition from cable operators has stimulated Telefónica to invest in NGA in order to provide equivalent services in terms of quality, download speed, availability of PayTV services that couldn't be provided on the cooper legacy network*."[128]

WIK's study also found that the stimulus to move straight to FTTP in several countries was provided by alternative fibre investors and/or municipalities investing in fibre networks. These findings are reinforced by a similar study by BEREC.[129]

[127] WIK Consult (2015) Competition and investment: an analysis of the drivers of superfast broadband; BEREC (2016) Challenges and drivers of NGA rollout and infrastructure competition

[128] NERA Study, page 9

[129] BEREC (2016) Challenges and drivers of NGA rollout and infrastructure competition

In addition to incentivising the deployment of fibre, there is also a significant body of evidence that increased infrastructure competition would bring further dynamic benefits, in the form of ongoing network innovations and increased productivity. We discuss this in detail in the textbox below.

BENEFITS OF COMPETITION (DYNAMIC EFFICIENCIES)

There is a body of research supporting the hypothesis that competition is associated with improved consumer outcomes in the communication sector, through incentives to innovate and to introduce technological improvements faster to achieve efficiencies and/or introduce superior services and products.

An example is the evidence relating to the impact that local loop unbundling has had in driving developments in the broadband market in the UK. There has been a lot of innovation in the fixed broadband sector, which has progressed from dial-up to DSL/ ADSL, then FTTC/ vectoring, G.fast and DOCSIS[130].

A study by Valletti et al. (2015) found that investments in LLU by alternative operators led to a substantial increase in quality of service, and in particular, speed.[131] This appears to be due to alternative operators investing in higher-speed technologies (particularly ADSL2+) in order to attract customers with a higher willingness to pay. Another study by Ovington et al. (2017) also found evidence that the introduction of LLU competition has had a positive impact on broadband adoption, whilst bitstream or resale access products, which offer more limited scope for differentiation, were found to have limited impact.[132]

In the mobile sector, 5th generation technology (5G) is expected to be introduced in the next one to two years, less than 40 years since the very first mobile technology (1G) was launched. As indicated above, there is also evidence of the benefits of competition for the transition to the successive generations of mobile technologies.

The social costs arising from delays to the introduction of technological improvements can be substantial.[133] Dynamic efficiencies are likely to translate into improved consumer outcomes. In particular:

- marginal cost reductions will be passed on to consumers to some degree in the form of lower prices, and
- innovation can also mean that consumers will have access to better products (i.e. faster/ better quality networks) sooner.

A recent analysis published by the GSMA[134] found that the evidence supported the view that dynamic efficiencies are likely to lead to a significant reduction in unit costs each year: "*Innovation determines the speed of adoption of new technologies and technology upgrades in mobile networks. This in turn has a major effect on the unit costs of services for consumers*"

We would expect the scope for innovation to be greater where several operators deploy their own FTTP networks. For example, Ofcom has noted that one of the benefits of duct and pole access over fibre unbundling is that it would "*allow access-seekers to assemble fibre networks in cities in the form of rings rather than in BT's "tree-and-branch" architecture*."[135]

[130] Not all technologies were successful (e.g. WiMAX), which shows also that there are risks involved in the telecoms sector.

[131] Valletti et al. (2015), Unbundling the incumbent: evidence from UK broadband

[132] Ovington T. et al. (2017), The impact of intra-platform competition on broadband penetration

[133] Hausman (1997), "Valuing the Effect of Regulation on New Services in Telecommunications", Brookings Papers on Economic Activity: Microeconomics, 1-38 has found that the cost related to delays in the introduction of new telecoms services, such as voice messaging in the USA in the period from the 1970s to 1990s, were close to $100 billion.

Whilst infrastructure competition can spur investment in parts of the country where there is scope for multiple overlapping networks, in areas where the business case for fibre is more challenging and high penetration rates are required to make investment viable, there is a risk that competition (either from existing or new services) could in fact undermine investment incentives by diluting demand (this point was discussed above, in Section 4.4, in the context of reducing risks). This risk is likely to be particularly acute for a new entrant that needs to grow its customer base and is competing against an incumbent that may enjoy certain cost advantages.

Some altnets expressed concern to Ofcom during its 2017 WLA market review that BT would respond to FTTP investment, or the threat of investment, by a rival operator by strategically targeting overbuild at areas of early roll-out by rivals. However, Ofcom did not consider it proportionate to impose an ex-ante restrictions on BT rolling-out FTTP or G.fast in order to address this risk. Instead it considered that ex-post competition powers would be the most appropriate means for addressing the potential harm from strategic overbuild.[136] This approach implies that Ofcom intends to restrict overbuild by BT where it can be shown that it is behaving anti-competitively.

Overall, there is evidence to demonstrate that network competition is associated with investment in NGA. However, there is also a positive relationship between competition and risk, i.e. more competition could make investment in less profitable areas more uncertain. In an extreme case, it could lead to a deadlock, when no operator invests in an area because of the fear of being overbuilt by the incumbent.

4.6 Reducing profitability of alternative options/ making investment in fibre more profitable

For new entrants/ access seekers, the choice is between deploying their own fibre networks ('build' decision) and seeking access to the incumbent's network ('buy' decision). Ofcom noted that "*competing providers will only invest in building their own networks if this is more attractive than buying wholesale services from BT, as many do at present.*"[137] In this context, it is important to understand how the regulation of access to the incumbent's network affects these incentives. This is discussed below.

Regulated access to an incumbent's fibre network and investment

As noted above, regulators in Europe have typically imposed obligations on fixed operators with significant market power to allow alternative operators to rent

[134] https://www.gsma.com/publicpolicy/wp-content/uploads/2014/09/Assessing_the_case_for_Single_Wholesale_Networks_in_mobile_communications.pdf

[135] Ofcom (2016), BCMR Statement

[136] Ofcom (2018), WLA Market Review Statement, para. 11.111, page 252

[137] Ofcom (2018), WLA Market Review Statement, para. 1.8, page 5

access to their copper and/or fibre (and in rare cases, cable) networks[138]. This form of regulation has encouraged competition at the retail level - by the end of 2014 in the UK, 95% of premises were connected to an unbundled exchange (i.e. an exchange where an alternative operator was providing broadband services based on renting access BT's copper loops) and 29% of UK lines were provided by alternative providers using ULL.[139]

On the other hand, it has been argued that this form of access regulation may be ineffective at fostering network investment. Ofcom noted that:[140]

"Whilst these approaches have delivered continued retail competition, a strategy based on LLU and VULA has limitations. It provides limited incentives for Openreach to upgrade the underlying fixed network, and limited opportunities and incentives for others to invest in their own networks."

A number of authors have suggested that there could be a negative relationship between access-regulation and investment in fixed telecoms infrastructure (e.g. Cambini and Jiang (2009)[141], Grajek and Roller (2009)[142], Briglauer et al. (2013)[143]) – although these generally predate the roll out of NGA. Feasey and Cave (2016) also note that those with existing investments in DSL technologies may be reluctant to deploy fibre due to the "replacement effect", whilst other firms that are not currently active in the broadband market but with a cost advantage (e.g. utilities that can exploit economies of scope) may be more likely to enter.[144] As set out in Section 2.2, following a period of no direct price regulation of access to BT's FTTC network, Ofcom recently decided to introduce a price cap for Openreach's "up to 40Mbps" FTTC service, and continue to allow pricing freedom on higher bandwidth services. Ofcom argued that this would "*achieve a reasonable balance"* between retaining incentives to invest in new networks and protecting consumers from the risk of high pricing.[145] Views of the decision were mixed, with some operators suggesting that this may be overly focussed on shorter term consumer interests rather than investment; while others arguing that BT had earned sufficient returns on FTTC to maintain investment incentives.

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138 This access takes three primary forms: (i) Bitstream: this involves limited investment on the part of the alternative operator but also offers little scope for differentiation; (ii) Unbundled local loop (ULL): alternative operators physically take control of (or 'unbundle') the incumbent's local access (i.e. last mile) copper or fibre loops. This involves more material investment by the alternative operator and brings greater scope for innovation and differentiation than bitstream access. Ofcom refers to its ULL remedy as LLU (local loop unbundling); and (iii) Virtually unbundled local access (VULA): this form of access does not allow the alternative operator to physically take control of the incumbent's infrastructure but offers some (not all) of the innovation and differentiation benefits of ULL.

139 Ofcom (2016), Digital Communications Review – Initial Conclusions

140 Ibid

141 Cambini, C., & Jiang, Y. (2009). Broadband Investment and Regulation: A Literature Review; Grajek, M., Röller, L.H., Regulation and Investment in Network Industries: Evidence from European Telecoms; Briglauer, W. & K. Gugler (2013), The Deployment and Penetration of High-Speed Fibre Networks and Services: Why are European Member States Lagging Behind?

142 Grajek, M., Röller, L.H., Regulation and Investment in Network Industries: Evidence from European Telecoms

143 Briglauer, W. & K. Gugler (2013), The Deployment and Penetration of High-Speed Fibre Networks and Services: Why are European Member States Lagging Behind?

144 Feasey and Cave (2017), Policy towards competition in high-speed broadband in Europe, in an age of vertical and horizontal integration and oligopolies

145 Ofcom (2018), WLA Market Review Statement, para. 1.10, page 5

Countries that adopted lighter touch regulation (in combination with passive infrastructure access) have benefited from FTTP deployment

Spain and Portugal (countries that have seen amongst the most significant deployment of FTTP) refrained from regulation of FTTP access products. For example, in Spain, until very recently, access obligations had been limited to bandwidths up to 30Mbps.[146] Similarly, the Portuguese regulator has not yet imposed any wholesale access obligations on the incumbent's fibre network.[147]

However, restricting access could lead to higher prices for consumers (at least in the short term, while network competition is still emerging). It is worth noting that in the European countries that have adopted an approach of more limited requirements for access to fibre, this has been within the context of ongoing regulation of copper-based services, which acted as a constraint on the price of higher speed products.

Regulation of prices for access to existing infrastructure also affects incentives to invest

To the extent that an incumbent can choose to upgrade its copper-based products (e.g. to deploy G.fast) rather than invest in full fibre (FTTP), one also needs to assess whether the rate of return on investment in fibre is higher (or lower) that the return it can earn on copper-based products (LLU, VULA and G.fast).

In this respect, the regulation of legacy copper access products, based on LLU and VULA, is likely to be an important factor influencing the decision to invest in fibre. The relationship between LLU/ VULA pricing and FTTP investment is not clear cut.

- On the one hand, by acting as a constraint on the price of FTTP services (both at the wholesale and retail level) tighter LLU / VULA regulation could reduce the potential revenues earned from fibre investments and hence dampen the incentive to invest (this has been referred to in the literature as the 'business migration effect').[148] Further, all else being equal, lower access prices for copper will make it more attractive for access seekers to continue renting the incumbent's legacy infrastructure rather than building their own fibre network. Hence, it could be argued that more relaxed regulation of LLU/ VULA prices could help to incentivise investment in FTTP, both by the incumbent and new entrants.
- On the other hand, a higher copper access price increases the incumbent's return on copper relative to the return on investment in fibre. Since fibre services are a substitute for copper services, and will therefore result in the cannibalisation of the incumbent's copper sales, more relaxed LLU/ VULA

[146] In 2016, the regulated conducted a market review and deregulated areas with 3 or more networks - 66 cities (35% population). In other areas, it imposed an obligation on Telefonica to provide access to its FTTP network. NERA study, page 8

[147] We note that the Commission expressed reservations about this approach, following a recent market review https://www.anacom.pt/render.jsp?contentId=1392433

[148] For example, see CRA 2012, Costing methodologies and incentives to invest in fibre

regulation could therefore actually disincentivise investment in fibre by the incumbent, due to the so-called 'replacement effect'.

Some stakeholders have proposed to implement a "copper tax wedge", whereby the price charged to access seekers for LLU is higher than the price received by the infrastructure owner.[149] Under this approach, the returns which BT Openreach would expect to earn from services provided by means of its existing copper network would be reduced over a given time period (with the magnitude of the reductions being known by BT well in advance). However, the wholesale prices payable by BT's existing wholesale customers for copper-based services could be kept fixed (or even raised), with a result that a 'wedge' would gradually arise between the wholesale prices payable to BT Openreach (and therefore the price paid by retail consumers) and the income which BT Openreach would actually obtain from such sales. In effect, a tax would be imposed on copper products which BT Openreach sold. This measure would have a number of effects:

- By decoupling the price charged to access-seekers from the price received by Openreach, the policy would address concerns that lower copper prices would deter retail customers from switching to FTTP networks.
- The future returns which BT Openreach might otherwise expect to obtain from continuing to invest in its existing copper infrastructure could be reduced relative to the returns that could be earned from investing instead in FTTP infrastructure.
- The 'wedge' would generate a pool of funds, which could then be applied to strengthen incentives to invest in FTTP. For example, FTTP investors might be allowed to recover a proportion of these foregone revenues each time a FTTP household was connected.

In principle, the approach is expected to support the right incentives. The policy would raise a number of practical implementation issues, which we discuss below, in Section 7.1.

Copper switch off

At some point after the fibre to the premises network is rolled out in a given area, the previous copper based access network can be decommissioned. There is limited international experience to draw upon regarding the likely effectiveness of copper switch-off or how such a measure could be implemented. Australia provides an example of copper switch-off being imposed to facilitate the roll-out and take-up of FTTP. The process is still ongoing and should provide valuable lessons for other countries.

A 2014 trial conducted by the French incumbent, Orange, in the municipality of Palaiseau is a useful case study.[150] The trial was encouraged by the French government and the regulator and Orange cooperated with the municipality to inform inhabitants and businesses about the project by organising information

[149] Vodafone (2015), Response to Ofcom's Consultation: Strategic Review of Digital Communications discussion document, page 51

[150] EC (2016), Regulatory, in particular access, regimes for network investment models in Europe, page 133

meetings and supplying information through municipal publications. The trial appears to have been relatively successful – Orange had migrated 90% of its residential subscriber base to FTTP by early 2015. However, the project has also faced a number of challenges. In particular:

- Orange failed to negotiate early closure of MDFs where alternative operators had installed their own equipment;
- While the vast majority of users have already migrated to FTTP, a low number of subscribers have opted to maintain a traditional access line; and
- There are certain legacy non-voice services, for which no substitute exists on NGA network, including a number of applications in the energy sector.

In light of the possible technical and financial challenges associated with copper switch-off (in particular the potential need for compensation), a report conducted by a former president of ARCEP, on behalf of the French Government, has advocated a gradual transition rather than a hard deadline for switch off.[151]

BT has also recently announced the switching off the analogue phone services (PSTN) in 2025 – implying that there will be no longer any provision of analogue based voice services in the whole of the UK by that date. This could affect a significant number of customers and also raises a number of practical issues related to the use of PSTN technology to support a range of non-voice applications (alarms, traffic lights, etc). While this is not equivalent to a complete copper switch off, many of the issues raised are similar. In particular, BT is envisaging a long transition period (up to 7 years) before PSTN lines can be fully switched off.

4.7 Government support

Governments in many countries have supported the deployment of fibre infrastructure, particularly in areas where rollout is unlikely to be viable on a purely commercial basis.

Whilst government support can be an effective means of facilitating network deployment, it also brings the risk of crowding out private investment and thereby distorting competition. However, government support could be justified on the basis that NGA broadband is associated with positive externalities that will not be taken into account by private investors, resulting in a market failure in the form of underinvestment.[152]

Another possible objective of government intervention is to correct social or regional inequalities. For example, rural communities may be underserved by commercial deployments due to the higher cost of rolling out to more remote and sparsely populated parts of the country. Reflecting this, the Government has sought to define the universal service obligation (USO) for broadband in the UK such that it 'allows full and effective social and economic participation.'[153]

[151] https://www.economie.gouv.fr/files/files/PDF/rapport-final-paul-champsaur_2014.pdf

[152] EC Commission (2013), EU Guidelines for the application of State aid rules in relation to the rapid deployment of broadband networks

[153] Ofcom (2016), Achieving decent broadband connectivity for everyone

Government support can take different forms, including funding or provision of financial support in the form of 'State Aid'. In order to minimise the potential distortive impact of State aid on the broadband market, the European Commission has developed detailed guidelines for the application of State aid to NGA broadband networks (see text box below).

NGA BROADBAND GUIDELINES

The guidelines are based on a classification of areas according to its existing or expected future broadband infrastructure:[154]

- **White areas:** no NGA network at present exists and is not likely to be built within the next three years by private investors. In this case the area is in principle eligible for State aid for NGA;
- **Grey areas:** only one NGA network is in place or planned within the next three years. In this case the EC will conduct a more detailed analysis to verify whether State aid is needed.
- **Black areas:** there are multiple existing or planned NGA networks. In this case State aid applications are unlikely to be successful unless they would bring a step change in quality (e.g. moving from superfast to ultrafast speeds).

The guidelines also set out a number of conditions that must be met, including basing funding decisions on a competitive process, making use of existing infrastructure, and to meet certain requirements as to wholesale access.

More ambitious State funding/support programmes have been adopted outside the EU

Outside the EU, there have been more extensive state-funded network deployments, most notably in New Zealand, Australia and Singapore – partly reflecting less stringent State aid rules. This has allowed governments to pursue more ambitious programmes and given greater control over the implementation of national broadband plans, by reducing reliance on the private sector. This approach has been reported to have resulted in FTTP coverage in New Zealand that is above levels typically seen in the EU.[155] However, the deployment of a national broadband network in Australia has thus far been less successful, with FTTP coverage relatively modest by international standards. Further, as noted above, the potential benefits of state intervention to be weighed against the potential negative impact of crowding out private investment and distorting (or potentially eliminating) infrastructure competition where it could be feasible.

There was a broad consensus amongst those we interviewed that direct government support in the form of State aid can be helpful, particularly in areas where deployment is more economically challenging.

In summary, where market-based interventions alone have been deemed not to be sufficient, Governments have supported roll-out directly in the form of a State

[154] WIK Consult, The broadband state aid rules explained

[155] See evidence from NERA case studies.

support. However, there is a risk that such support may crowd-out private investment and distort competition. Recognising this, the EU has specified fairly strict guidelines for the provision of State Aid, which allow State grants to be provided where there does not appear to be any material prospect of commercial roll-out without any support.

4.8 Conclusion

We have identified above the key drivers underpinning the investment case for fibre broadband infrastructure and summarised the evidence on measures taken in other markets. In some cases, the policy implications are relatively straight-forward - in particular, measures to **reduce costs and other barriers** have been shown to be an effective means of facilitating efficient infrastructure investment. Both Ofcom and the Government have already taken a number of steps in this direction. There is also a broad consensus that **more regulatory certainty and predictability** and **measures to stimulate demand** are generally positive for investment.

In other cases, however, the relationship between potential investment drivers and market outcomes may involve trade-offs:

- Where it is economically viable to have multiple overlapping networks, **infrastructure competition** has proven to be a driver of fibre deployment, most notably in Spain and Portugal. Competition could also result in a 'hold up' situation where demand and deployment costs were such that a single fibre network would be economically viable, but operators are unwilling to invest for fear of being overbuilt.
- **Profitability of fibre investment is typically assessed against the alternatives** of continuing to 'sweat' copper-based networks (for incumbents) or to get access to the incumbent's network (for alternative operators).

5 MODELLING THE BASELINE SCENARIO

In this section, we set out our approach and assumptions underlying our modelling of fibre rollout, assuming that policy broadly continues as currently. This is referred to as 'baseline' scenario or 'status quo'. The modelling results are referred to as 'baseline results'.

- We first present the modelling approach and main assumptions used to generate the baseline results.
- We then present and discuss the modelling results and the sensitivities we carried out to test the stability of the baseline results.

In our modelling, we aim to capture the key drivers of fibre investment, such as:

- **costs of fibre deployment** for the incumbent and altnets;
- **evolving demand** for higher speeds;
- **uncertainties involved** (reflected in different hurdle rates for the incumbent and new entrants); and
- **demand for fibre vs other products/ fibre price premia,** which are driven by consumers' willingness to pay for faster products, and potentially by access regulation.

Our model has been constructed to provide a tool that can support informed comparisons between different scenarios/ market models (discussed in Section 7 below). Hence it involves a degree of aggregation (for example, we group premises into a number of geotypes) and assumptions (for example, changes in the assumed hurdle rates under different market models) that aim to capture the main features of the UK market and impact of investment drivers. The results should therefore be interpreted in this context: they are not aiming to be accurate estimates of the commercial case of overall FTTP coverage by region/city/area and/or degree of competition, but to inform an assessment of alternative options (compared against the 'baseline' scenario and against each other).

5.1 Modelling approach

In our model, we aim to replicate as far as possible the investment decision-making process within operators when they are determining whether to make investments in new fibre infrastructure, i.e. whether the expected return from making the investment is sufficient to adequately compensate investors.

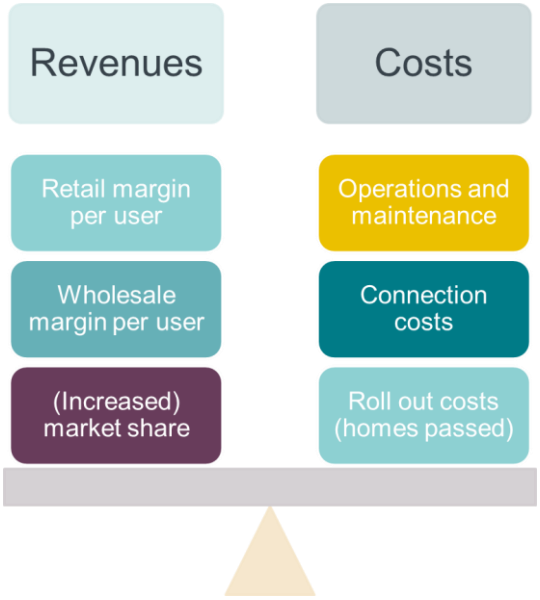
Our modelling consists of two stages:

1. A **cashflow analysis of the incremental return** for operators making investments in a given area; and
2. An **analysis of the evolution of fibre coverage** as operators roll out fibre given supply-side constraints (the number of premises that can be covered in any given year), and the investment returns identified in the first stage of analysis (i.e. we expect that the most profitable areas are likely to be covered first).

5.1.1 The cashflow analysis – incentives to invest

In our model, we consider separately BT, Virgin Media with their existing infrastructure and new entrants (or 'altnets'). We model different investment decisions for BT and the new entrant(s)[156] and the resulting customer switching between available services over time. We use the costs of deploying and operating the infrastructure and the margins (wholesale margins and, if the provider operates in the retail market, retail margins) earned by each provider to calculate the operators' cashflows in each scenario.

Figure 6 Building blocks of the cashflow analysis



Source: Frontier Economics

Definition of geotypes

As discussed above, there is significant evidence that investors' decisions as to whether they should invest in fibre rollout will differ between geographies reflecting two key factors:

- The **cost of rolling out fibre** infrastructure in the area; and
- The **existence or otherwise of competing broadband infrastructure** in the area.[157]

[156] In areas where Virgin is currently not present, we model it as a new entrant. In areas, where Virgin is present, we assume that there will always be a business case for incremental upgrades to its existing infrastructure to DOCSIS 3.1 to provide Gigabit speeds. As our focus is on assessing the degree of 'new/additional' FTTP roll-out, we have assumed that the areas where Virgin upgrades to DOCSIS3.1 correspond to 40% of UK households.

[157] Other factors, such as the socio-economic makeup of potential customers and split of business and residential customers in the area which may also play a role, are not modelled explicitly.

We have therefore segmented the UK geography according to these two dimensions. We have defined three categories of competitive conditions:

- areas where the only wholesale provider present is Openreach and it only provides ADSL;
- areas where the only wholesale provider present is Openreach and it provides FTTC; and
- areas where Virgin Media is present in addition to Openreach, and is then assumed to offer very high speed (up to 1Gbps) broadband (equivalent to speeds that are achievable with FTTP).

We have split each of these three groups into five different geotypes, according to the estimated cost of rollout.[158] The two lowest cost areas are relatively large, comprising 60% of UK premises. The medium/low cost areas represent c. 20% of premises, while the remaining 20% are areas with medium, high and very high costs.

Modelling customer flows and revenues

We calculate revenues by applying average revenues per user (ARPUs) to projected customer numbers on fibre networks and on Openreach's existing copper based networks (ADSL, FTTC and G.fast).

We assume that, over time, demand for higher broadband speed increases (driven by new applications and other factors) and customers are more likely to switch to higher-speed products if their current services are too slow (assuming that higher-speed products are available in their area).

We have also made certain simplifying assumptions in relation to the transition to higher speed broadband offers:

- Consumers change providers as a result of natural churn (e.g. because their contract ends or because they move homes) or because they want to upgrade to higher speed products or both;
- We assume that customers have a speed requirement which rises over time. When they are consuming a service that does not meet this speed requirement they churn at a faster rate, reflecting a desire to upgrade their service; and
- We assume that customers are equally likely to select any network provider that meets the required speed at that point in time.[159]

These assumptions lead to a gradual migration away from legacy technologies towards higher speed fibre networks (where available) over time in a similar way

[158] Proxied by average road length per premise. This was calculated at the Output Area (OA) level using MapInfo, a mapping tool.

[159] Our aim is to seek to assess the longer term outcomes in terms of the incentives of the different types of investors to invest in FTTP. Our approach does have the flexibility to assume that consumers may have a stronger (or weaker) preference to select an incumbent v a new entrant network.

to previous service migrations (e.g. dial-up to ADSL (or Standard Broadband – SBB); and from ADSL/SBB to FTTC (Superfast Broadband - SFBB)).

ARPUs

To model the evolution of ARPUs for different technologies over time, we looked at current ARPU premia (for FTTP vs FTTC) and trends for FTTC over time, and used these to derive ARPUs for G.fast and FTTP. We assumed that ARPUs remain constant in real terms throughout the period modelled. We do, however, conduct a sensitivity to assess the potential impact of convergence in the ARPUs of different technologies over time.

We consider this to be conservative, as it assumes relatively modest premia on very high speed broadband relative to FTTC based broadband speeds. As set out above, there is evidence of higher willingness to pay for faster more reliable broadband particularly in parts of the market. The rollout of ultrafast broadband could also open up a market of business customers willing to pay a higher price for reliable high capacity broadband services. Their choice to date has been limited between often relatively expensive leased lines, and cheaper lower quality/speed superfast broadband.

Cost assumptions

The main costs associated with rolling out FTTP networks are the capital costs relating to deployment, i.e. the costs of rolling out the distribution network, but not including the costs of connecting customers, which depend on take-up. We differentiate between ***brownfield costs***, which rely on infrastructure reuse[160] and are an estimate of the costs faced by BT/Openreach, and ***greenfield costs***, which in our base case, reflect the costs that will be faced by a new entrant. Greenfield costs are higher than brownfield as they assume that the new entrant would not be able to reuse, more cheaply, the existing BT/Openreach infrastructure.

The cost data is largely based on a report commissioned by the National Infrastructure Commission and conducted by PRISM and Tactis[161] ('the PRISM report').

The PRISM report suggests an estimate of the average cost of roll-out in our two lowest-cost geotypes of £555 for brownfield roll-out, and £744 for greenfield. The Prism report discusses a number of cost reduction measures and technological innovations that could lower costs, although those measures are not taken into account in PRISM's base case on which our initial estimates above are based.[162] Since the report has been published, more information on the cost of roll-out has become available. Notably, BT/Openreach announced recently that it expected the cost of rollout (capex per premise excluding connection) over the next three years,

[160] Brownfield costs reflect less than 100% infrastructure re-use due to the suitability of existing infrastructure. For example, some ducts might have no spare capacity. The re-use assumptions underlying the brownfield cost assumptions are explained in Appendix B of the PRISM report: https://www.nic.org.uk/wp-content/uploads/Cost-analysis.pdf

[161] https://www.nic.org.uk/wp-content/uploads/Cost-analysis.pdf

[162] Section 5.2, PRISM report.

covering around 3 million premises, or around 10% of the country, to be "around £300-£400 per premise passed".[163] We have therefore considered that it would be reasonable to revise the Prism estimates to take into account this information. As the lowest cost geotypes in our modelling account for around 60% of UK premises, we have used the upper end of the range provided by BT/Openreach: we have assumed that the cost of brownfield rollout in the lowest-cost areas is £400 per premise passed. We also assume that the same reduction in costs can also be achieved by alternative operators in these areas, i.e. we assume that greenfield costs can be reduced to £589 per premise passed.

Since the PRISM report, Ofcom has also introduced more effective measures for passive infrastructure access which, according to Ofcom, could reduce "the average cost per home passed in some cases by up to 50%".[164] Ofcom further assumes that the use of passive infrastructure access could be as high as 75%.

Based on these observations we consider that alternative operators are likely to face an average of greenfield and brownfield (plus the cost of wholesale infrastructure rental to reflect passive infrastructure re-use). We therefore consider a further reduction of 'greenfield' costs to £524 per premise passed to reflect infrastructure reuse in around 30% of areas. Again, we cautiously assume that the adjustments apply to the lowest cost geotypes only.

As well as the 'cost per home' of rolling out network in a given geotype, we model the ongoing costs of operating the network, connecting customers to the network and serving customers (customer service costs, etc.).

Output of cash flow modelling

The model produces forecasts of (incremental) cash flows over a 25-year period for each operator and then calculates the net present value (NPV) of the cash flows based on an assumed real hurdle rate for the operator, along with an internal rate of return (IRR).

We estimated hurdle rates for BT and new entrants. by looking at:

- the cost of capital Ofcom currently applies to BT Openreach, adding an NGA premium to reflect the additional risk associated with FTTP; and
- a range of hurdle rates used by BT and Ofcom to assess the risks of FTTC when it was a technology at a comparable stage to FTTP today.

The new entrant's hurdle rate is assumed to be higher than BT's consistent with statements from stakeholders made during interviews conducted by DCMS as part of this study.

Strategic issues

There are three effects that drive the incentives of the providers to roll out FTTP:

[163] http://news.openreach.co.uk/pressreleases/openreach-launches-fibre-first-programme-to-make-fibre-to-the-premises-broadband-available-to-three-million-uk-homes-and-businesses-by-the-end-dot-dot-dot-2399074

[164] 2017 WLA market review, Volume 3, para 2.9

- *Profit effect*: FTTP provides a higher variable margin than lower speed products for BT (and a positive variable margin for the new entrant). – This effect is driven by a combination of **Demand** and **Costs**. The profit effect is greater when costs are lower;
- *Defensive effect*: BT will lose market share if other operators offer ultrafast speeds and BT does not. Therefore, where BT faces competition it has a stronger incentive to offer higher speeds in order to defend existing revenues. This effect is driven by **Competition**; and
- *Deterrence effect*: The incentive of a provider (either BT or the new entrant) to invest in FTTP may be stronger if it will not have to share the market. A provider's anticipation of potential entry in an area by others may therefore deter a provider from rolling out. This effect is driven by the **Risk of Overbuild**.

To determine the entry behaviour of BT and the new entrant (or entrants) we estimate the return for a potential investment in FTTP, which depends on the number of competing networks (i.e. on the behaviour of other operators). To capture this dynamic, we calculate an operator's incremental returns[165] on investing in FTTP under a scenario where they enter alone, or where there is additional entry. This is then used to derive the optimum strategy for each operator, i.e. whether to deploy FTTP in a particular area or not. We find that, depending on the geotype area characteristics:

- two or more operators might find it profitable to invest (more likely to be the case in the lowest cost areas);
- some areas might be unprofitable even for one operator (most likely in the very high cost areas); and
- some areas might experience a so called 'hold up' problem. For example, a new entrant might find it profitable to invest if BT does not invest in a given area. However, BT would only invest if there is competition from another fibre provider – as this would lead to a high defensive value for BT (i.e. loss of market share and revenues). This undermines the business case for the new entrant and, as a result, no one invests (this can typically be the case in some of the 'medium cost' areas).

5.1.2 Estimating total FTTP coverage

Once we have derived the optimal strategy for each operator in each of the geotypes, the second stage considers how each operator will roll out fibre consistent with these strategies. We model this as follows:

- We assume that BT can deploy fibre to up to 1 million premises per year, and that new entrants can roll out up to 1 million premises per year in total (i.e. 1 million premises where only one entrant rolls out and 500,000 premises each where two entrants roll out simultaneously). This reflects

[165] We note that for BT, this is based on the NPV of incremental cashflows compared to business as usual, i.e. the cost of maintaining its copper network.

historic experience from other countries, announcements made[166], and the fact that Ofcom's latest DPA policies and existing DCMS/Government initiatives, such as the 5 year exemption from business rates[167] would also be expected to support faster roll out in the future compared to the past.;

- We identify the most profitable geotypes (those with the highest expected rate of return) and assume that the operators would deploy fibre networks in these geotypes first. When those areas are fully covered, the operators move to the next most profitable area, etc; and
- We assume that any areas where G.fast is deployed are covered at a faster rate.

The second assumption above is critical in determining the speed with which competition between networks emerges, in areas where the model projects that it is profitable for more than one operator to enter. This approach seems reasonable, and consistent with the feedback received. It implies however that even if there are relatively small differences in the profitability of different geotype areas, new entrants will prioritise entry in the (marginally) more profitable geotype areas, and will not enter the other, less profitable, geotype areas until they have completed their roll out in the more profitable area. In practice, entrants may well consider prioritising entry in the more profitable cities/towns within the different geotypes, implying that the rate at which multiple entry is observed in practice may be sooner than predicted by the model.

Given the individual rollout plans of each operator, we then construct the profile of competitive conditions – the proportion of premises that are passed by zero, one, two or three networks over time.

5.2 Baseline results

5.2.1 Central estimates

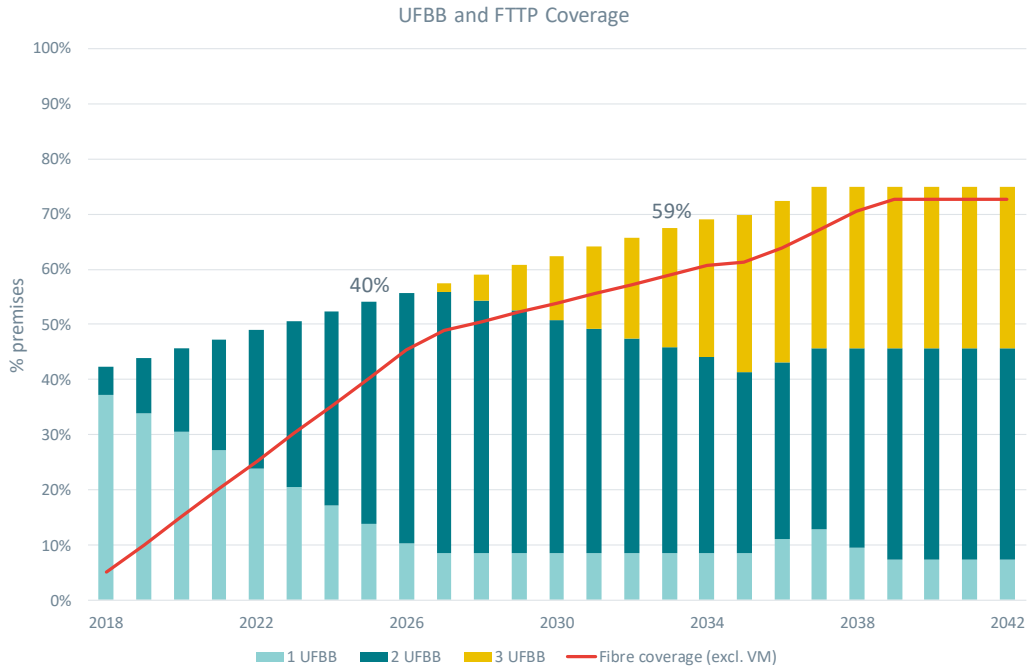
In this section, we provide the high level results of the baseline modelling. The chart below shows how new fibre (FTTP) will be rolled out (represented by the red line) and how the level of Ultrafast competition (total of stacked bars) will change over time[168]. Since providers have a limit to the pace at which they can roll out FTTP to new homes, we estimate the order in which providers will choose to roll out to areas with different costs and initial competitive conditions, and the implications for the development of coverage and competitive conditions over time.

[166] See more details on the operators' plans to roll out FTTP in Section 6.

[167] These policies are discussed in Section 4.

[168] The reason we are considering Ultrafast competition rather than FTTP competition is because we have assumed that Virgin Media's existing DOCSIS footprint (40%) would qualify as Ultrafast coverage (as DOCSIS3.0 will be upgraded to DOCSIS3.1 which can deliver 1Gbps+), but not as FTTP coverage.

Figure 7 New fibre coverage and degree of competition over time



Source: Frontier Economics

Note: The % figures above the bars show the overall level of unique fibre coverage in 2025 and 2033

The chart shows a number of results about the expected availability of FTTP in the baseline:

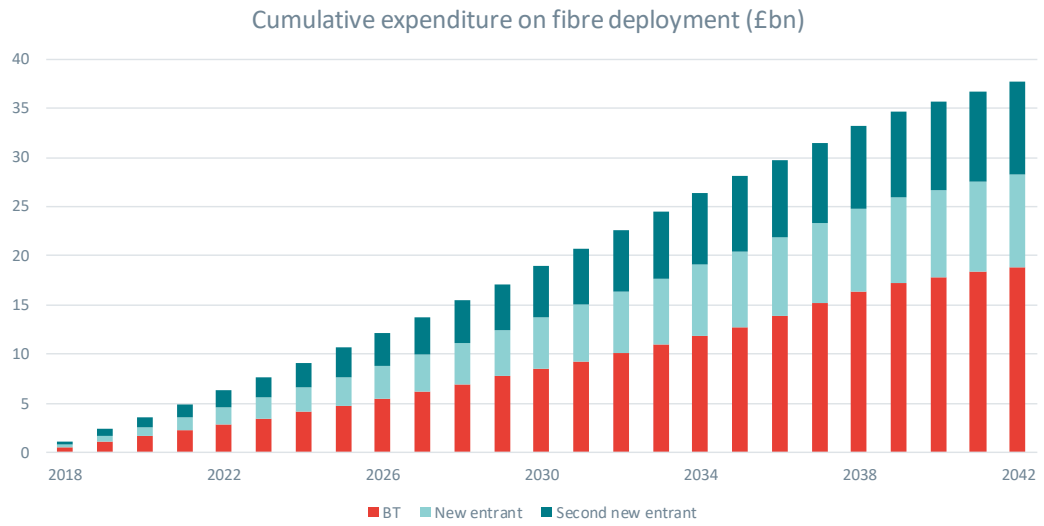
- **Fibre coverage** of new fibre (i.e. excluding existing DOCSIS coverage by Virgin Media) rises to c. 60% in 15 years, with the level of c. 75% being reached after around 20 years;
- **Fibre coverage in 2025** is likely to be c. 40% (or 12 million premises) – below the Government target of 15m;
- **Fibre coverage in 2033** is likely to be c. 60% (or 18 million premises), also below the Government target of 'nationwide' coverage;
- In almost all periods there is an increase in the overall level of competition, whether this is a third provider entering a duopoly area or new entrants rolling out in an area with only one incumbent provider; and
- Three-player competition may take time to materialise, depending on the regional focus of BT's FTTP roll-out. However, the model predictions may differ from the evolution of competition in practice – we explain this below.

We observe the following:

- Under our baseline assumptions, FTTP is sufficiently profitable that, absent any further policy intervention, FTTP coverage eventually becomes available to c. 75% of premises.
- As prospective customers are assumed to have similar preferences for speed irrespective of the geotype where they are located, it is more profitable to rollout to areas with lower costs. Areas with the lowest cost are also the most likely to develop higher levels of competition, and we find that three-player competition arises in the lowest cost geotype that does not currently have a Virgin Media presence, which covers 30% of premises in the country (note that Virgin Media may be one of the entrants in these areas).
- Our modelling suggests that only BT enters in areas where Virgin Media is already present, reflecting defensive value, whereas new entrants prefer to avoid Virgin Media areas and enter mainly in areas where there is little current competition for ultrafast services, for example where BT only offers lower speed products (FTTC or ADSL).
- Under the assumptions made, there are c. 10% of premises for which rolling out FTTP is unprofitable for any provider, regardless of other operators' rollout decisions.
- In an additional c. 15% of premises, there would be a risk of no FTTP build due to the "hold up" issue, whereby new entrants would like to invest if no other operators were present, but do not do so because it would be unprofitable for them if BT were to deploy FTTP (which BT would do if there was new entry).
- The gradual emergence of three player competition reflects BT placing a higher weight to the defensive value of rolling out in Virgin Media areas first; and the constraint in the rate of build (of 1m premises/per year for BT). Three player competition could emerge more quickly if it was possible to achieve higher rates of roll-out without a material impact on costs, as BT would then find it attractive to enter in areas outside the current Virgin Media footprint sooner.
- Although BT's defensive strategy is to roll out to areas with an existing Virgin Media presence first, it is predicted that it will also roll out FTTP in areas also covered by new entrants, i.e. the model predicts that eventually, there will be no/very limited areas without BT being present.

In Figure 8 below, we set out the costs associated with the rollout that is achieved above. This includes both capital and operating costs involved with deployment of the network, representing the **total costs** that would be incurred regardless of the level of take-up on the networks, i.e. excluding connection costs.

Figure 8 FTTP deployment costs incurred in the baseline (undiscounted)



Source: Frontier Economics

A summary of **deployment costs** is presented in Figure 9 below.

Figure 9 Costs of deployment under the baseline (c.75% coverage)

Total cost, £bn	Undiscounted	Social discount rate (3.5%)[169]
Deployment capex	22.0	16.1
Deployment fixed opex[170]	16.0	9.5
Total deployment cost	38.0	25.7

Source: Frontier Economics

Uncovered areas

As described earlier in this section c. 10% of premises are unprofitable for either BT or a new entrant to roll out to using FTTP and c. 15% of areas could experience a hold-up situation in which no operator invests given the anticipated decisions of others. The deployment costs of covering these areas, which we do not expect to be covered under our baseline assumptions, would be in the region of £3.7bn (of which £3.5bn capex and £0.2bn opex) for unprofitable geotypes and £4.7bn (of which £4.1bn capex and £0.6bn opex) for the hold-up geotypes[171].

[169] This is the Treasury "Green Book" rate used to assess "social time preference" i.e. reflecting the value society places on the present vs future periods. See p.7, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

[170] By 'fixed' opex we refer to operating costs that are independent of the number of subscribers, i.e. do not vary according to the level of take-up on the network.

[171] All costs are undiscounted

Sensitivity analysis

We tested the sensitivity of results on key metrics including total fibre rollout, the prevalence of competition in different areas, and the speed at which coverage and competition is achieved, to the input assumptions. These confirmed that the key drivers of fibre investment are likely to be deployment costs, hurdle rates (i.e. the levels of uncertainty and risk faced by investors) and the capacity of networks to roll out networks.

5.2.2 Conclusions

To summarise, our modelling of the baseline shows that:

- FTTP coverage in the long run is expected to be c. 75%. Under the assumptions made about feasible speed of roll-out, this will be achieved in around 20 years;
- The Government targets of 50% coverage by 2025 and nationwide coverage by 2033 are not achieved (the baseline is estimated to deliver c. 60% fibre coverage by 2033);
- It is projected that c 30% of consumers will have access to 3 networks, c. 40% will have a choice of 2 networks (likely an FTTP network and a cable network), and c. 5% will only be served by one provider;
- c. 25% of consumers may have no FTTP coverage, absent some additional intervention, because they live in uneconomic areas (c. 10%) or in 'hold up' areas (c. 15%);
- The total capex (excluding connection) under the baseline scenario is estimated to be c. £22 billion (undiscounted) to cover c. 75% of the country, and c. £7.6bn to cover the remaining c. 25% that is not covered due to hold-up issues or being commercially unviable.

In the following section, we discuss these modelling results in the context of key investment drivers (cost of deployment, uncertainty, degree of competition, etc.).

6 FACTORS THAT MAY BE HOLDING BACK FIBRE INVESTMENT IN THE UK

Our modelling of the baseline suggests that, although significant fibre deployment is likely to take place in the next 25 years (up to 60% commercial deployment by 2033), there are a number of uncertainties involved, especially around the pace of rollout. We estimate that FTTP networks will be rolled out to c. 12m unique premises by 2025 [172] (and c. 18m/23m premises by 2033/2039 respectively). Our projection of coverage by 2025 is broadly consistent with the announcements made by the operators about planned rollout:

- BT has announced that it plans to roll out FTTP to 3 million premises by 2020[173] and has ambitions to reach 10 million by 2025[174];
- Vodafone and CityFibre announced a long-term strategic partnership that will bring "*ultrafast Gigabit-capable full fibre broadband to up to five million UK homes and businesses by 2025*"[175];
- Hyperoptic stated an ambition "*to pass two million homes and businesses by 2022*"[176]; and
- TalkTalk and InfraCapital announced the creation of a separate company that will aim to provide FTTP broadband to more than 3 million premises in mid-sized UK towns and cities[177].

Whilst the aggregation of all the 'targets' set out above would exceed the projections from our modelling exercise, the 'firm' commitments are hard to gauge. Indeed, a number of these announcements are referred to as 'ambitions' or plans rather than 'commitments'. Even when the announcements are closer to commitments, there is still a risk that they may not materialise (for example, in 2011, BT announced plans to roll out FTTP to 2.5 million premises by the end of 2012[178], and 5 years later, it has rolled out to c. 20% of those plans). The announcements need to be treated with caution, especially when they refer to the longer term.

In this section, we draw on the evidence presented in Section 4 to help understand what drives this outcome. In the remainder of the report we then assess options to incentivise more fibre deployment in the UK.

[172] We estimate that FTTP networks will be deployed to 16m premises in aggregate, but some premises will be passed by two or more operators, resulting in 10m unique premises passed.

[173] https://www.btplc.com/Thegroup/BTUKandWorldwide/BTRegions/Wales/InTouch/Wales/Spring2018/FibreFirst/index.htm

[174] https://www.ft.com/content/e1a0d21a-0da8-11e8-8eb7-42f857ea9f09

[175] https://www.cityfibre.com/news/vodafone-cityfibre-bring-gigabit-speed-fibre-uk/

[176] https://www.hyperoptic.com/press/posts/hyperoptic-secures-100million-to-accelerate-full-fibre-rollout/

[177] https://www.ispreview.co.uk/index.php/2018/02/isp-talktalk-propose-full-fibre-broadband-3-million-uk-premises.html

[178] 25% of 10m homes FTTP, p.7: http://www.bcs.org/upload/pdf/sfisher-090311.pdf

6.1 Drivers of the 'baseline' outcome

Based on the general drivers of fibre investment discussed in Section 4, the feedback from the interviews, and international experience, we identify the following main drivers of our modelling results:

- **High deployment costs, especially for alternative operators:** There are high barriers to entry associated with the fixed infrastructure market, and operators have highlighted the high costs associated with civil works as a key factor which can undermine the business case for investing in their own FTTP infrastructure.

  This has been recognised by Ofcom, which has recently introduced a number of policy measures to reduce deployment costs for new entrants (introduced as part of its 2017 WLA market review). It is yet too early to tell whether these measures will be as effective as envisaged by Ofcom. Therefore, in our modelling of the baseline, we take a cautious view and assume that alternative operators, whilst facing lower costs than assumed by Prism in their analysis which predates the Ofcom proposals, will continue to face higher deployment costs than Openreach.
- **High barriers to fibre deployment:** Section 4.2 highlights a number of planning and legislative issues that have been identified as potential barriers to fibre deployment in the UK. These barriers primarily affect the speed of roll out. If these barriers are addressed successfully, we would expect to see faster FTTP deployment both for Openreach and for other operators (all else being the same).
- **Demand uncertainty**: A number of stakeholders have highlighted significant uncertainty around the inherent demand for fibre – in particular, the premium people would be willing to pay for FTTP over-and-above the services that can be delivered using legacy infrastructure. To reflect this uncertainty, we model a sensitivity, where fibre price 'premium' is assumed to disappear over time (so called ARPU convergence). We find that this would have a limited impact on overall fibre coverage, but might have an impact on the number of competitors rolling out fibre networks in different areas.
- **Risk of overbuild**: an actual or perceived risk of overbuild (in some combination with other risks and uncertainties) has been identified by the operators and investors as a barrier to FTTP deployment, which could lead to higher hurdle rates, slower deployment and, ultimately, lower coverage. In the model, this issue manifests itself in 'hold up' areas - 15% of premises with no FTTP coverage, despite being commercially viable for one network (but not for two). Our modelling (sensitivity analysis) shows that if deployment costs fall (for all operators or for alternative operators), these areas become viable for two networks and the risk of hold-up diminishes.
- **Insufficient network competition:** although competition from cable has been a driver of investment in FTTC[179], it was not sufficient to stimulate significant FTTP roll-out in the UK. Measures to reduce costs/ barrier for alternative

[179] Ofcom (2018), WLA Market Review Statement, para. 5.14, page 90

operators are likely to strengthen their business case to invest in fibre and, consequently, strengthen Openreach's business case to invest.

- **Profitability/ relative attractiveness of investing in FTTP vs. alternatives:** as we set out in Section 2, regulation of the UK's fixed telecoms market has historically been focused on encouraging and protecting competition at the retail level, through requiring access to BT's network. However, some stakeholders have argued that Ofcom's approach to the introduction of cost-oriented access regulation on FTTC dampens BT's incentives to invest in FTTP by reducing its expected risk adjusted returns from such investment. In terms of investment by alternative operators, it has been argued that access regulation might undermine FTTP investment by increasing the attractiveness of a 'buy' verses a 'build' option for alternative operators (i.e. seeking access to BT's networks rather than investing/ co-investing in their own networks). As discussed in Section 4, some countries with high levels of FTTP deployment (notably Spain and Portugal) applied lighter touch access regulation to incentivise FTTP roll out.

Below, we discuss alternative market models which would address some of these issues and therefore encourage more-widespread fibre investment.

7 ALTERNATIVE MARKET MODELS

In light of our findings in Sections 5 and 6, we now consider alternative market models[180] in order to understand whether these models could deliver a better outcome than the 'baseline' scenario in terms of overall fibre coverage and in terms of other evaluation criteria. These models, at a high level, are as follows:

- **Model 1: Enhanced competition** – This model relies mainly on stronger network competition to deliver more wide-spread fibre roll out. While stronger competition is likely to increase the risk of overbuild, lower deployment costs (and other barriers), more regulatory certainty and other pro-investment policies are expected to make the business case for investing in FTTP stronger.
- **Model 2: National monopoly** – This model relies on a single wholesale regulated provider (which may also be involved in the retail market) to roll out fibre infrastructure and to provide regulated access to retail operators. This model removes the risk of overbuild by awarding an exclusive licence to roll out fibre to one provider. This is a market model associated with utilities markets, where network competition is generally not achievable due to high fixed costs. Variants of this model have been implemented in Australia and Singapore.
- **Model 3**: **Regional franchising model** – Under this model, regional franchises are awarded with exclusivity for a period of time, to cover the whole of the UK, in a competitive tendering process. The level of coverage and speed of rollout, as well as the amount of any government support required, would be the criteria for the franchise award. A variant of this model has been implemented in New Zealand.

The table below shows the main drivers of fibre deployment (as set out in Section 4) and identify those that are expected to improve incentives to roll out fibre, relative to the baseline, under each model.

[180] These include options based on significant changes in market structure, as well as a series of other policy options, some of which may be common across the different market models.

Figure 10 Drivers of investment under each alternative model

Drivers of investment	Enhanced Competition	National Monopoly	Regional Franchising
Lower deployment costs and barriers	✓	✓	✓
Stronger demand	✓	✓	✓
Stronger competition	✓		
Reduced risk of overbuild		✓	✓
Reduced regulatory uncertainty	✓	✓	✓
Making alternatives less attractive	✓	✓	✓

Source: Frontier

While some drivers can be strengthened under all three models (e.g. to reduce costs, to stimulate demand, to increase regulatory certainty), other drivers are model-specific and may present a trade-off. Indeed, facilitating competition likely increases the risk of overbuild, while providing exclusivity limits the potential of competition as a driver of investment.

Below, we describe each model and supporting evidence from case studies, Call for Evidence responses and stakeholder interviews in more detail.

Note that some policies could be implemented under all three models, for example, incentivising accelerated switch off of the copper network after fibre networks are rolled out in an area. We discuss copper switch-off after the presentation of the three models.

7.1 Enhanced competition model

We first describe in this section the model and explain its effect on key investment drivers. We then present policies that can be part of this model, building on the experience from other countries.

7.1.1 Description of the model

The 'enhanced competition model' puts a strong emphasis on interventions that are designed to encourage infrastructure competition. A key objective of the model is to maximise efficient competitive fibre roll out, both by new entrants and by the incumbent.

The potential for the competitive market model[181] to foster deployment of FTTP is illustrated most strikingly by Spain, where over the period between 2011 – 2016, FTTP coverage grew from 10% to 63% of Spanish households/premises[182]. Stronger competition can be supported by policies related to several investment drivers. More specifically:

[181] In combination with regulated access to passive infrastructure and a degree of regulatory forbearance.

[182] NERA Study, pages 7 - 8

- **Lowering costs of fibre deployment, especially for altnets** –more emphasis on ensuring effective provision of access to Openreach's passive infrastructure (ducts) and other utilities' infrastructure.
- **Removing barriers to fibre deployment,** which would increase the speed of deployment – measures adopted tend to be country-specific, and in the case of the UK would include measures such as supporting the process of obtaining wayleaves and street work permits, identified among key bottlenecks. In addition, measures to expand and re-allocate 'industry deployment capacity' could also increase the speed of rollout**;**
- **Raising profitability of fibre investment (relative to alternatives**) achieved by 'regulatory forbearance', i.e. adopting a more flexible regulatory approach in relation to access obligations on FTTP broadband products for a period of time;
- **Greater regulatory certainty/lower risk** – consider measures to reduce/mitigate uncertainty related to the regulatory environment; and
- **Increasing demand for fibre-based products** using targeted government interventions and by encouraging/ supporting copper network switchover[183].

In addition to its impact on incentives to invest in FTTP network, stronger competition is also expected to have an impact on the operators' incentives to compete, invest and innovate in the long term ('dynamic efficiencies' – discussed in Section 4.5).

7.1.2 Measures to support enhanced infrastructure competition

Lowering deployment costs for alternative operators

As illustrated by the earlier modelling results, the cost of rolling out FTTP for new entrants is a key driver of the profitability of entry in different geotypes – both the level of costs itself, and more certainty around it. The success of the Enhanced Competition model is therefore likely to depend on the extent to which operators are able to use existing passive infrastructure to deploy their own networks, and do so under conditions of reduced/minimal uncertainty. This is illustrated by the finding from NERA's study that few (if any) operators rolling out FTTP in the six countries (Spain, Portugal, Sweden, France, Australia and New Zealand) relied on passive greenfield infrastructure of their own.

In markets that have seen a rapid expansion of FTTP in recent years based on infrastructure competition (Spain and Portugal), alternative operators have relied extensively on regulated access to the incumbents' existing duct networks.[184]

Ofcom has recently implemented a package of measures to improve access to BT's ducts and poles. It is however early to assess whether these measures are effective in terms of reducing the gap between deployment costs faced by Openreach and by new entrants.

Ofcom is putting in place a monitoring programme to ensure that the new DPA measures are effective. In particular, Ofcom will be working with the Office of the

[183] We note that copper network switchover may be implemented under all three market models. Therefore, we consider it separately in Section 7.4.

[184] BEREC (2016), Challenges and drivers of NGA rollout and infrastructure competition, page 35

Telecoms Adjudicator (OTA) and with access seekers, in order to evaluate their experience of the PIA product[185]. It is not clear from the statement what measures will be used if the DPA proves to be less effective than anticipated (i.e. if alternative operators continue to build their own passive infrastructure rather than re-use the existing one). More clarity on these measures could strengthen Openreach's incentive to comply.

Ofcom has also historically not imposed any significant sanctions/ fines in relation to regulatory breaches – under the presumption that such breaches are likely to have a relatively limited impact[186] In view of the significance of DPA in supporting competitive FTTP roll-out, there is a case for considering a more stringent approach to non-compliance, under the existing regime, or arguably, a case for considering the possibility of introducing specific sanctions related to non-compliance with DPA obligations, where such non-compliance is not objectively justified.

It is expected that effective DPA could play the same role in relation to competitive FTTP roll-out, as the introduction of functional separation and reduction in DSL access prices played in the roll-out of ULL based competition in the provision of retail broadband services. Access based competition increased from 2% of retail broadband lines in 2005 to around 70% in 2010[187]. It should therefore be possible for Ofcom to develop a set of targets for FTTP roll-out, which would be consistent with previous experience, taking into account also the latest available information. These targets could be both based on overall FTTP roll-out and also the share of such roll-out that is competitive.

The overall FTTP deployment progress relative to these targets could be reviewed in the next 2-3 years and, if the progress is slow because DPA is not effective, additional interventions could be considered[188]. Moreover, this review could consider if there are any other issues preventing or delaying FTTP roll-out under this model, beyond passive infrastructure access. For example, an important issue to achieve fast roll-out is the supply side ability to deploy sufficient civil works capacity, at low cost, to undertake the necessary construction at large scale (we return to this in the next subsection).

Our analysis has indicated that there could be competitive roll out in a significant part of the UK, in line with experience from some other European countries. Nevertheless, uncertainties still remain, as there has not been a similar level of telecoms infrastructure roll out in the UK since the roll out of cable in the 1990s. As operators roll-out FTTP networks in different parts of the country, there will be more certainty in relation to the cost of deployment in different types of areas, and more clarity on the types, and size of areas where competitive roll out is unlikely to be achieved. As part of a review in two to three years, the possibility of using the 'competition for the market' model in order to achieve comprehensive FTTP roll-out by 2033 could also be considered.

[185] Ofcom, Wholesale Local Access Market Review: Statement - Physical infrastructure access remedy (Volume 3)

[186] See Equality of Access Board Annual Reports for more details

[187] Richard Cadman (2012), Invention, Innovation and Diffusion of Local Loop Unbundling in the UK

[188] For example, further measures to ensure a level playing field for access to Openreach's passive infrastructure such as a complete structural separation of Openreach's passive infrastructure. .

Expanding or re-allocating 'industry deployment capacity'

The rate of deployment in the baseline is constrained by assumptions that BT/Openreach can deploy to a maximum of 1 million premises and other operators to a maximum of 500k each, giving a total industry 'deployment capacity' of 2 million households a year. As noted above, the assumptions in the baseline model determine the timing and manner of deployment by BT (and as a consequence by each of the other operators). Policy could influence this, and hence alter the rate of deployment in a number of ways:

- Measures could be taken to increase the overall 'deployment capacity' of the industry as a whole. This might involve, for example, addressing issues related to labour market constraints or planning constraints (to the extent that existing/planned measures are not already doing so).
- It may also be appropriate to focus on measures to ensure that available building capacity is fully exhausted. This might involve, for example, measures which seek to ensure that all operators are deploying to their maximum capacity in each and every year (e.g. through the agreement of construction milestones or by ensuring that BT/Openreach or other operators cannot take strategic actions which might otherwise serve to restrict the capacity of others to build). Measures to accelerate the rate of deployment by individual operators are, by definition, also likely to ensure that deployment capacity is more fully utilised.
- Alternatively, or in addition, policymakers might consider measures intended to expand the deployment capacity of individual operators. This might involve facilitating smaller operators to 'procure' deployment capacity jointly, and/or for longer periods of time, so as to allow for the realisation of economies of scale.[189]

In addition, an expected benefit of the further measures set out below aimed at reducing deployment costs, eliminating barriers to deployment and reducing uncertainty would be a faster rate of deployment.

Lowering deployment costs/ eliminating barriers to FTTP deployment for all operators

DCMS is considering additional measures related to reducing the costs and facilitating the roll out of FTTP. These include streamlining/ standardising the process of granting permits for street-works, mandating all new buildings to have FTTP connectivity and simplification/shortening of the process for wayleave agreements.

In addition, steps could be taken to upgrade in-building wiring in the existing housing stock (particularly, in multi-dwelling units - MDUs). 'Symmetric access' to in-building wiring (i.e. applying to all operators) is part of the regulatory approach adopted in Spain. This requires an operator that upgrades in-building wiring in any given MDU to provide access to this wiring to other operators. While MDUs

[189] Our baseline modelling makes no assumptions on this, although as noted above we do assume that non-BT operators have a more limited capacity to deploy than BT

represent a smaller part of the housing stock in the UK, similar measures could also be considered in the UK.

More flexible approach to the regulation of access to FTTP investments

The approach adopted by the Portuguese and Spanish regulators, was to refrain from imposing any access obligations on high-speed broadband products for a certain period of time. Ofcom has not adopted such an approach historically, as there are both benefits and costs, related to the risk of undermining competition in the retail market which may result in higher prices for consumers (at least for a period of time).

There is evidence that these risks to competition may be less significant in the transition to FTTP compared to the transition to FTTC. In particular:

- there are plans for alternative operators to roll out FTTP in the next few years, with investment already taking place;
- there have been announcements for significant funds being committed for FTTP roll out in the UK, beyond the Openreach/VM announcements. This should provide access seekers with alternatives to relying on BT, which were not available when BT rolled out FTTC;
- there has been successful and significant FTTP roll out by altnets in other countries;
- business models are emerging where 'bilateral' access arrangements are implemented between broadband providers that have rolled out FTTP networks in different parts of a country;
- BT has consulted on its proposal to roll out FTTP to 50% of premises with the industry, including the access based operators[190]; and
- Ofcom decided to regulate wholesale access to Openreach's 'up to 40 Mbit/s' FTTC product based on costs, providing protection for consumers.

On balance, there seems to be a stronger case for considering the Spanish/ Portuguese regulatory approach (i.e. refraining from imposing any access on high-speed products for a period of time) in relation to FTTP, subject to the provision of safeguards to minimise risks of foreclosure of access based rivals[191], compared to FTTC.

More regulatory certainty

Regulatory certainty and predictability is an important factor influencing investment in fibre networks. More stable regulatory environment (e.g. longer regulatory cycles) could, in principle, reduce uncertainty, both for BT and for new entrants, and reduce their respective cost of capital.

Our modelling shows however that different forms of competition may emerge in different areas (3-player competition in some areas, duopoly and monopoly in other

[190] See Openreach, February 2018, http://news.openreach.co.uk/pressreleases/openreach-launches-fibre-first-programme-to-make-fibre-to-the-premises-broadband-available-to-three-million-uk-homes-and-businesses-by-the-end-dot-dot-dot-2399074

[191] For example, our modelling has indicated that there is a significant share of UK premises, where it would not be economical to have more than one (or two) FTTP networks rolling out – the approach to the regulation of FTTP access could therefore be geographically differentiated, we return to this below.

areas). Moreover, the degree of competition in some areas may change (e.g. from 2 to 3 players). Furthermore, based on our projections, significant parts of the UK may face different competitive conditions without the prevalence of a specific market structure (monopoly, duopoly and three player competition could all have a significant presence). As there are limited precedents for such a market structure, greater regulatory certainty could be provided by Ofcom offering more clarity in terms of the expected relation between regulation/deregulation and the emergence of different geographic competitive conditions.

Geographically differentiated regulation

One additional way of increasing regulatory certainty is to consider committing to adopting an *ex ante* geographically differentiated regulatory approach, which will reflect variations in competitive conditions.

Ofcom has indicated that, going forward, it would consider adopting lighter-touch regulation in parts of the country where there is evidence of competitive pressure emerging:

> *Our strategy anticipates that different regulation is likely to be needed in different geographic areas. In places where there is evidence of competitive pressure emerging, we would expect to deregulate.*[192]

We note that recent examples of European regulators adopting geographically differentiated approaches (in Portugal and Spain) have been based on assessment of areas in which competition has *already* emerged (although access regulations applied to fibre were limited to up to 30 Mbps services). However, the Commission recently indicated – in response to a recent regulatory decision by the Portuguese regulator – that it would be open to a *"more dynamic assessment of likely infrastructure competition*"[193] that takes into account evidence relating to prospective as well as existing competition.

In Spain, prior to the most recent review (in 2015), the regulator had only imposed access obligations on fibre for speeds up to 30Mbps (but not on higher-speed products). In the 2015 review, the regulator identified two separate geographic markets for Wholesale Broadband Access (WBA), corresponding to competitive and non-competitive areas. The regulator introduced access obligations on the incumbent to provide access to its FTTP network in non-competitive areas.[194]

Stimulating demand for fibre

Limited demand/ willingness to pay for high-speed broadband has been identified as a barrier to FTTP deployment. Government schemes to date have been used successfully to stimulate demand for high-speed broadband (e.g. the Broadband Connection Voucher Scheme) and could continue playing a role going forward.

[192] Ofcom, WLA Market Review: Draft Statement – Volume 1, para 5.68-5.69

[193] https://ec.europa.eu/digital-single-market/en/news/european-commission-requires-portuguese-regulator-grant-regulated-access-fibre-rural-and-remote

[194] Market 3a (WLA), was found to be national in scope (as per the previous review), existing LLU and passive remedies were kept in place.

The public sector as an 'anchor tenant' can also play a role to further stimulate demand for fibre broadband.

Making investment in alternative technologies less attractive

Copper tax wedge has been proposed as a policy lever to influence demand for fibre products (and to reduce profitability of alternative options). While, in principle, it could sharpen incentives to invest in FTTP by Openreach, this policy also has some implementation issues, which need to be considered carefully and weighed against potential benefits. More specifically:

- Deriving the appropriate level of the price paid and received for legacy copper services is not straightforward and could potentially lead to Openreach under-recovering some costs;
- If the funds collected as a result of introducing a copper tax wedge are to be recycled to promote FTTP investment, it is not clear what mechanism could be used to hypothecate this tax and how to split the funds between different operators rolling out FTTP.

As there is limited precedent of actual implementation of such a policy at 'scale', there is merit in considering the practical/legal aspects of this policy option in more detail, to establish whether its benefits are likely to outweigh potential costs/ implementation issues.

7.2 National FTTP Monopoly

7.2.1 Model description

An alternative model to network competition would be to seek to establish a single national monopoly fibre network that provides wholesale access to downstream retail providers, with coverage targets to ensure that national coverage is achieved.

There are different ways in which this could be done. A relevant example is the National Broadband Network (NBN) in Australia, which was established in 2009 as a state-owned enterprise to build a FTTP network in Australia. Key features of the Australia model are[195]:

- The NBN is a wholesale-only access network that provides access to its network on equivalent terms to all retail providers;
- It is also required to charge nationally uniform prices, which are to be funded through cross-subsidies, including across geographic areas and across all technologies;
- A special access undertaking ('SAU') sets out price and non-price terms that NBN offers;
- Since the network is national, and therefore overlaps with legacy copper and cable networks, the government negotiated with the existing network

[195] This description is based on the NERA's study

operators, Telstra and Optus, to acquire their networks and to 'switch off' the copper network once the NBN was deployed; and

- While it was initially envisaged as a FTTP-only model, NBN is now a multi-technology model, that also uses cable, FTTC, FWA and other technologies.

An alternative approach would be to adopt a "utility-like" framework in which the network is owned and operated by a private entity that offers wholesale access at regulated prices. This is the standard model of regulation adopted for privately owned utilities' networks in the UK and elsewhere (referred to sometimes as a 'RAB' model), whereby efficiently incurred capital expenditure is added to a "regulatory asset base" and prices are set such that the network owner earns a rate of return that is equal to its cost of capital[196].

Whilst in theory, operators could bid for the right to build and operate such a network (as was the case in Singapore), in practice, as the only existing national network owner, it is likely that BT/Openreach would be the most credible bidder[197]. Therefore, the scope for competition 'for' the market may be limited under this model.

There are a number of ways in which the boundaries of the monopoly network could be defined.

- In the case of Australia, the NBN encompasses the entirety of the broadband access network and alternative retail operators purchase a bitstream access product[198];
- Alternatively, the monopoly could apply just to the "last mile" section of the network, with the monopoly operator offering unbundled (or virtually unbundled) fibre access to other operators with their own 'core' networks – this is analogous to the regulatory model currently adopted for Openreach in the UK; and
- Singapore's national monopoly network has a three-tiered structure – a 'passive' (civil engineering) network operator ('NetCo'), an 'active' network operator ('OpCo') and retail service providers.[199] Retail providers can choose to either buy active products from the OpCo or deliver services based on passive access using their own active equipment.

We assume that under a 'baseline' national monopoly market model in the UK, any existing FTTP assets would be acquired by the National Monopolist (if they were deployed by other operators), but, unlike in Australia, this would not include non-FTTP assets. Hence, although the FTTP network will be exposed to less demand risk than in the baseline scenario, the risk will not be completely eliminated.[200]

[196] See for example Stern J. (2013) "The role of The Regulatory Asset Base as an instrument of regulatory commitment ", Centre for Competition and Regulatory Policy, Working Paper N22

[197] For example, BT/OR has been the successful tenderer for most of the BDUK tenders to roll-out FTTC in commercially unprofitable areas. BT has also delivered some FTTP in unprofitable areas. We also note that BDUK procurement process is technology neutral.

[198] https://www.nbnco.com.au/sell-nbn-services/products-services-pricing/nbn-co-ethernet-bitstream-service.html

[199] Analysys Mason (2015), International case studies

[200] We are assuming that Virgin Media would not be the national monopolist – we are not aware of a similar precedent, and VM has not provided any indication of interest for such a model in the UK.

However, if the chosen policy was similar to the Australian approach, it could involve an 'amalgamation' of cable assets into the monopoly licence, which would require an additional compensation.

7.2.2 Evidence relating to the merits of national monopoly model

International experience of monopoly fibre deployments is mixed and limited

There is little to draw on in the way of international experience of monopoly FTTP network deployments. We note, however, that the performance of the monopoly network in Australia is rather mixed:[201]

- A strategic review of the NBN in 2013 by an expert panel found that the NBN would require an extra ASD 73 billion of funding and take an extra three years to complete compared to the original plan;
- As a result of this review (and a change of government), the NBN is now transitioning to a multi-technology mix ('MTM') model, which focuses on upgrading existing networks (cable and copper) instead of building a new 100%-FTTP network; and
- It is expected that only 20% of a total 11.9 million premises will be served by FTTP by 2020, with the remainder of connections made up primarily by FTTC or cable. It does not appear that the NBN will deliver a national FTTP network, as envisaged originally.
    - The original arrangement (in 2011) envisaged spending ASD 11.8bn for Telstra and Optus to decommission their copper and cable networks in order to avoid NBN's fibre network competing with the copper and cable-based services provided by those networks. This deal was modified in 2014 to transfer these assets to NBN rather than to decommission them.

Outcomes in Singapore, however, have been better. In particular:[202]

- As of 2016, the state-commissioned FTTP roll-out had achieved its objective of virtually 100% coverage; and
- Take-up of FTTP is high – at the end of 2014, it had reached 48%.

Singapore is however a much smaller country than the UK, with a population of 5.6 million living predominantly in dense urban areas. Further, as with the NBN in Australia, the network deployment was supported by significant public funding, amounting to around £241 per premise passed.[203]

A national monopoly model is likely to be challenging to implement, which may lead to delays in deployment

The limited international experience relating to the establishment of national single networks in the fixed and mobile sectors suggests that it is likely to be a challenging process which could delay the deployment of fibre:

[201] NERA Study

[202] Analysys Mason (2015), International case studies

[203] Ibid

- The NBN in Australia faced significant delays – by June 2016, the NBN had connected 2.9 million customers, 3.6 million fewer than 2011 expectations.[204] Key factors in this appear to be:
  - **Complex negotiations with the incumbent:** Before roll-out could begin, NBN had to agree key terms with Telstra. [205] This was a complex process taking over a year[206]; and
  - **Shift in deployment strategy:** In April 2014, three years into the deployment phase, the project was switched from FTTP to a multi-technology mix (including FTTN and hybrid fibre-coaxial), in order to contain costs. The transition to a mixed strategy, which requires access to Telstra's copper network, meant agreement with Telstra had to be renegotiated – this led to a further delay of a year.
- The Mexican Government announced plans to deploy a national, wholesale-only wireless network in December 2012 (using all of the 700 MHz spectrum band). [207] The plan was for the roll-out to begin in 2014 and for the wholesale network to be operational by 2018. Completion is expected in 2024.

On the other hand, the deployment of Singapore's national fibre network was quicker:

- The request for proposals to build and operate the network was issued in December 2007 and closed on 5 May 2008 with proposals from two consortia, with the contract being awarded to OpenNet shortly afterwards[208];
- Roll-out commenced in 2009 and by 2012, coverage had exceeded 90%; and
- By 2014, 100% FTTP coverage had been achieved.[209]

However, as we note above, the fact that Singapore is highly densely populated is likely to be a key factor behind the more rapid deployment rate.

A national monopoly model may benefit from a lower cost of capital than operators in a competitive market

One of the arguments in favour of a national monopoly model is that this model would result in more predictable demand and hence a lower hurdle rate required by investors. It is argued that the type of regulation applied in regulated utilities, but also the nature of the services themselves contribute to the lower levels of the cost of capital (WACC), i.e. not only does the regulation ensure recovery of the allowed revenues, but also the exclusive provision of the service ensures that

[204] Sorensen L. and Medina A. (June 2016) , The End of Australia's National Broadband Network

[205] https://blog.telegeography.com/the-politics-of-broadband-in-australia

[206] Terms of engagement for negotiations were agreed in December 2009 (https://www.telstra.com.au/content/dam/tcom/about-us/investors/pdf%20C/prospectus_supplement_10.pdf)

[207] http://www.cullen-international.com/asset/?location=/content/assets/regulatory-intelligence/regulatory-news/cullen-international---a-reflection-on-the-mexican-telecoms-and-audiovisual-reform.pdf/cullen-international---a-reflection-on-the-mexican-telecoms-and-audiovisual-reform.pdf

[208] https://www.imda.gov.sg/infocomm-and-media-news/buzz-central/2008/10/next-generation-national-broadband-network-to-be-rolled-out-nationwide-by-2012

[209] Analysys Mason (2015), International case studies

demand uncertainties are kept to a minimum. This allows the structure of financing of these regulated utility companies to be more geared towards debt.

Quality and innovation are likely to be lower, with regulation being an imperfect substitute for competition

In Section 4.5 above, we discussed evidence on the positive relationship between competition and quality and innovation. By implication, if the degree of competition is limited, one would expect to see less innovation and investment in quality.

Generally, regulation can help to alleviate some of the concerns that stem from the significant market power held by network monopolies. In particular, utilities regulators typically apply price controls to parts of the supply chain that are regarded as natural monopolies in order to address concerns around excessive pricing.

They have also considered regulatory mechanisms to incentivise improvements in quality of service.

- Ofwat has added a "K factor" in the price control to incentivise water companies to invest to improve quality[210];
- Ofcom is regulating the quality of Openreach's wholesale services that are used by other telecommunications providers to provide retail broadband and telephone services to customers and businesses[211]; and
- Ofgem recently introduced two annual Network Innovation Competitions (NICs) one for electricity transmission companies and one for gas network companies.[212] However, competition is still a feature of such funds.

However, it is highly challenging to replicate the benefits of competition in other areas through regulation – in particular, innovation. For example, the chairman of the Regulatory Policy Institute, George Yarrow has noted that:[213]

> *"…discovery and innovation are the areas where the performances of competitive markets and protected monopolies (including governmental monopoly) can be expected to show the greatest divergence. Regulation might perform not too badly in static conditions, but its weaknesses are more exposed when dealing with innovation."*

Similarly, the UK regulators' network (UKRN) has noted that "*longer term, risky and uncertain investment in innovation may be harder to achieve with structured price control periods*". [214]

Indeed, maximising dynamic efficiency through innovation is one of the key reasons why regulators have sought to encourage competition where possible. For example, UKRN has noted that: "*In competitive markets, innovation is necessary because if firms do not innovate, they will often lose market share and become*

[210] https://www.ofwat.gov.uk/wp-content/uploads/2017/06/IN-17-04-The-process-for-determining-the-application-of-in-period-outcome-delivery-incentives-%E2%80%93-updated-for-2016-17-.pdf

[211] Ofcom, Statement: Quality of service for WLR, MPF and GEA, 2017

[212] UKRN (2015), Innovation in regulated infrastructure sectors, page 19

[213] George Yarrow (2010), Where next for utility regulation?, page 12

[214] UKRN (2015), Innovation in regulated infrastructure sectors, para 3.7 page 8

less profitable. In a range of different ways regulators have therefore sought to promote competition in order to encourage innovation driven by industry." [215]

7.3 Franchising of regional licences

7.3.1 Model description

An alternative to the national monopoly model, which would address the actual/perceived risk of overbuild and reduce asset duplication, is a regional franchising model which would award a number of exclusive (for a period) regional licences to cover the whole of the UK. This is similar to the national monopoly model, in that each premise would be served by a single FTTP network that offers wholesale access to competing retail providers.

Regional franchising would involve first dividing the country into several geographically distinct regions, with operators competing for exclusive rights to serve premises within a given region, i.e. firms will bid for exclusive licences to build, fund and operate an FTTP network within a particular geography. Competitive tendering of this sort was used in the 1980s and 1990s to facilitate the deployment of cable in the UK.

A variant of this model was implemented in New Zealand (see the box below for a detailed description).

[215] UKRN (2015), Innovation in regulated infrastructure sectors, para 3.12, page 11

NEW ZEALAND'S ULTRAFAST BROADBAND PROGRAMME[216]

Under New Zealand's Ultrafast (UFB) Broadband Programme, the government split the country into different regions and allowed bids for individual regions and also national bids. This resulted in four different regional UFB providers that have partnered with the government to deliver FTTP to 87% of the population by 2022, on a wholesale-only open-access basis. The government is supporting these partnerships with equity investment (up to NZD1.35 billion for the first phase, which covers 75% of the country).

Because network providers are prohibited from providing retail services, to participate in the UFB program the formerly vertically integrated Telecom New Zealand voluntarily demerged into a wholesale fixed network business (Chorus) and a retail fixed line business that also owns a mobile network (Spark). The other partners are electricity lines companies (Northpower and WNL) and an existing broadband network owned by the Christchurch City Council.

The key features of the New Zealand franchising model, implemented in 2011/12, are:

- Ambitious targets for FTTP coverage of 75%/87% by 2019/22, motivated partly by economic advantage NZ could gain from pioneering FTTP roll out. Coverage in 2017 was c. 65%;
- The approach was based on a national, competitive franchising model to cover (near) exclusively a number of different regions/areas, with government support; and
- Franchisees were not allowed to offer retail services. Franchisees other than Chorus account for c. 30% of UFBB coverage and Chorus for remaining 70%.
- Government support has been designed quite innovatively: it takes the form of funding (rather than subsidy) for franchisees other than Chorus; and 50:50 debt/ equity investment in Chorus.
- Dark fibre unbundling has been deferred until 2020.
- There is (indirect) regulation of w/s access prices for two products: 30Mbps and 100Mbps
- We understand that wholesale prices are uniform within each franchise, but there are some small differences between the franchises

National franchises are regulated during the period of exclusivity. After the period ends, there is potential for other operators to enter the region and compete with existing players.

[216] NERA study

7.3.2 Evidence on the merits of a franchising model

Evidence from New Zealand supports the potential for franchising to support rapid FTTP deployment, with significant government support

As noted above, New Zealand has adopted a regional franchising model. New Zealand's national broadband programme appears to have been successful in facilitating relatively fast deployment of fibre and strengthening competition at the retail level:

- Roll-out commenced in late 2011[217], three years after it was announced, and between 2012 and 2017 FTTP coverage increased from around 6% to 65%;
- In August 2017, the programme was on track to reach its initial coverage target of 75% by the end of 2019, with a plan to extend this to around 87% by the end of 2024[218] ; and
- The open access nature of the Ultra-Fast Broadband (UFB) programme and disaggregation of the incumbent has arguably led to a less concentrated market structure at retail, with Spark's market share now 43% compared to 65% in 2005.

The NERA Study identifies a number of factors that explain the success of the New Zealand model:

- The competitive tender process helped efficient new entrants to enter the market and prompted the incumbent to invest in FTTP;
- The targeted nature of the UFB initiative (75% of the population for UFB1 and then 87% for UFB2) did not include the least urban/most expensive customers and therefore kept costs down;
- The government bearing some of the demand risk resulted in lower bid prices than would have occurred if the private sector bore all of that risk;
- Flexible regulatory conditions[219] allowed operators to run their businesses in the most efficient way while meeting the Government's objectives; and
- Innovative funding mechanisms allowed the government to 'recycle' its funds, thus reducing the upfront funding obligation on the government.

Evidence from the deployment of cable in the UK in the 1990s also illustrates the potential for franchising to support significant infrastructure investment. Cable franchises were issued from 1984 onwards as regional monopolies in order to promote investment and by 1991 a total of 135 franchises covering 70 per cent of the population had been issued.[220] The industry saw significant investment in the 1990s, which primarily went into building cable infrastructure. Investment came primarily from US-based telecommunications companies, attracted by the fact that cable was largely unregulated (due to lack of market dominance) in contrast to the

[217] https://blog.chorus.co.nz/nz-fibre-connections-experience-fastest-growth-in-oecd/

[218] https://company.chorus.co.nz/file/80026/Annual-Report-2017.pdf

[219] I.e. a contractual compensation mechanism whereby the Government would compensate the operators if regulation was introduced that reduced prices below the contractual cap and dark fibre remedy deferral until 2020.

[220] Lax (2008), Media and Communications Technologies: A Critical Introduction

US where operators were subject to rate of return regulation.[221] By the end of the decade 50% of homes were covered, concentrated in urban areas.

7.4 Copper switch off

At some point after the fibre to the premises network is rolled out in a given area, the previous copper based access network can be decommissioned. Providing clarity on the conditions under which the copper network can or will be switched off could increase investment incentives:

- For Openreach, the ability to switch off segments of the copper network will enable it to avoid the fixed costs of operating that segment; and
- For other potential investors, migration away from the copper network can provide an opportunity to capture increased market share, reducing demand risk.

We understand that Openreach is considering the prospect of switching off its copper network at some point in the future (after its FTTP network has been rolled out) and has consulted with the industry on proposals for Openreach to roll out FTTP to 10m UK premises, and the conditions it considers necessary to support this[222].

At this stage, there are few examples of copper switch off on a large scale. In Spain, Telefonica has recently announced its plans to switch off one copper exchange per day over the next three years, mentioning energy savings and smaller footprint among the main benefits.[223]

We note that copper switch off can only be implemented after all properties in a given exchange area are covered by an FTTP network. Otherwise, copper switch off will result in some customers being disconnected from the fixed network. Given that exchange areas typically represent a mix of different geotypes (with low and high deployment costs), achieving 100% coverage of any given exchange area is likely to take time (which is consistent with Telefonica's announcement that the process might take three years in Spain despite the fact that FTTP deployment in Spain has already reached 63% of premises).

We also note that, while the greater capability of FTTP networks would be expected to lead to the majority of customers migrating from copper networks to fibre networks relatively quickly, there may be a subset of customers who for practical reasons, lack of demand for enhanced services or lack of engagement, remain on the copper network. The copper network in an area cannot be decommissioned until a point where remaining customers have migrated to other networks. After the majority of customers have migrated to the fibre network, this raises the question of the appropriate approach to the remaining customers, some of who may be vulnerable customers. To the extent that some customers may not be willing to pay more for broadband and/or not interested in faster speeds, a 'basic FTTP tariff'

[221] Deshpande and Jones (2014), From denationalisation to wholesale broadband access: a retrospective of regulatory policies in the UK for the communications industry.

[222] https://www.ispreview.co.uk/index.php/2017/07/openreach-start-consultation-plan-large-scale-fttp-full-fibre-rollout.html

[223] https://www.mobileeurope.co.uk/press-wire/telefonica-closes-copper-exchanges-in-fibre-push

may be needed that would effectively allow those users to subscribe to equivalent packages (albeit delivered on an FTTP (or equivalent) network).

Overall, it appears that if the process is industry-led, most benefits and costs of copper switch off are likely to be internalised[224], with a possible exception of the impact on vulnerable customers (which may require a regulatory intervention).

[224] i.e. the operators will try and accelerate the process if the benefits of doing so outweigh the costs

8 MARKET SCENARIO MODELLING

In this section, we extend our model to consider the three alternative models, i.e.:

1. Enhanced competition model;
2. National monopoly; and
3. Franchising of regional licences.

For each model, we first present our modelling assumptions, followed by the results of the models. These results inform the subsequent evaluation of the different models against the six evaluation criteria listed in the terms of reference. This evaluation is presented in Section 8.

8.1 Enhanced competition model

8.1.1 Assumptions

We use the same cash flow model as in the baseline (discussed in detail in Section 5). However, we modify the inputs to reflect the different characteristics of the model compared to the baseline scenario. More specifically, we assume that the group of measures discussed under the enhanced competition model, would lead to the following effects:

- Lower deployment costs for new entrants (i.e. new entrants incur lower cost of civil works in areas that are economically viable in the baseline).[225] This is likely to include mechanisms that make it easier/cheaper for operators to make use of existing infrastructure, both telecommunications and otherwise, and facilitate a more efficient rollout through flexible planning and other administrative requirements. We assume that this would result in a reduction of costs faced by new entrants, in particular reducing the gap between the rollout costs of BT/ Openreach and new entrants by half.[226] This would make more areas profitable for new entrants to enter and deploy their networks and/or increase their profitability in areas that are already profitable.
- Higher pace of deployment - up to 3m premises per annum between new entrants and BT (compared with 2m in the baseline). This assumption is based on evidence of speed of deployment from markets that adopted similar market models (notably Spain and Portugal, where the passive infrastructure access was particularly effective) [227] and the pace of deployment was in the range of 10% - 20% premises per annum (in aggregate). This is expected to be supported through the implementation of the overall policy package which seeks to reduce costs and uncertainty for all players, thus reducing the option value of postponing FTTP investment; and

[225] We assume that deployment costs in uneconomic areas will not change as these are unlikely to have ducts that could be reused and therefore applying Greenfield costs in those areas appears to be appropriate.

[226] Although to the extent that this then implies greater use of DPA, the operating costs of an entrant will increase reflecting corresponding wholesale access (PIA) charges.

[227] Additionally, in France, FTTP networks were rolled out to 2.7m premises in the last 12 months (https://www.mobileeurope.co.uk/press-wire/french-operators-lay-fibre-but-regulator-wants-more)

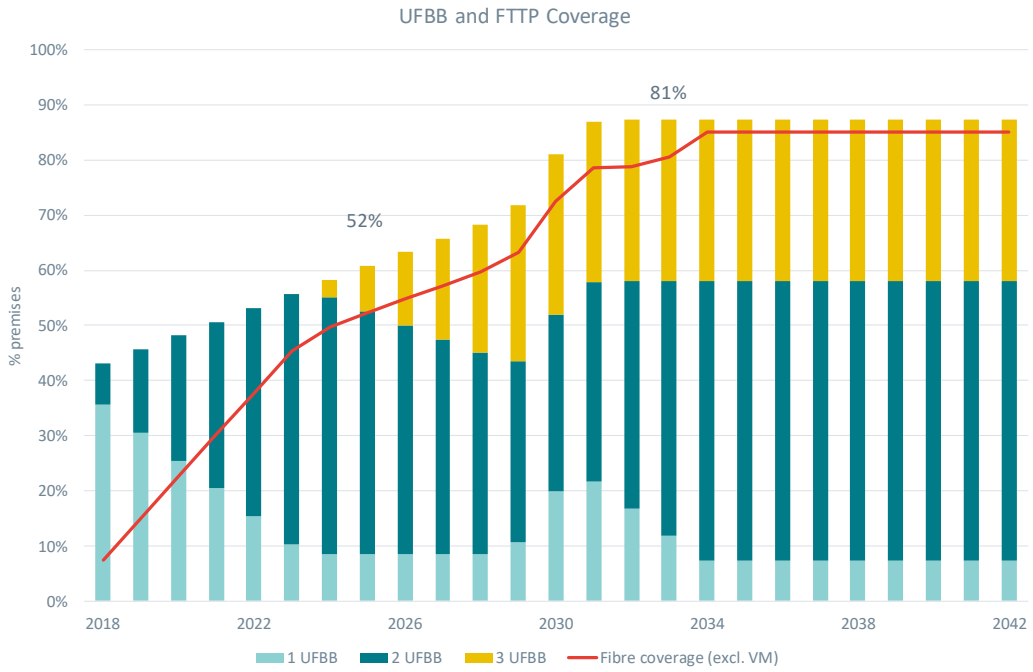
- Real hurdle rates that are 1% point lower than in the baseline scenario, both for BT and for new entrants reflecting also lower perceived risks due to the policy measures proposed.

8.1.2 Modelling the Enhanced Competition model

The impact of these assumptions is to support the achievement of a higher level of overall commercial network coverage in the long term, which increases from c. 75% to over 80%.

Figure 11 illustrates the evolution of ultrafast coverage under the Enhanced Competition model.

Figure 11 Competitive conditions over time



Source: Frontier Economics

Note: The % figures above the bars show the overall level of unique fibre coverage in 2025 and 2033

Figure 12 below shows the resultant market structure. It shows that the hold-up areas are reduced - from c. 15% in the baseline scenario to c.10%. That is, c.5% of premises in the medium-low cost areas (where Openreach currently offers superfast broadband) now become profitable for two operators to enter (both Openreach and another operator).

Figure 12 Market structure under the enhanced competition model

Level of competition	% premises
3 players	30%
2 players	50%
Potential hold-up areas	10%
Unprofitable	10%

In terms of the level of competition, we estimate that:

- c.50% of premises will have a choice of two competing networks, an increase from c. 40% in the baseline scenario; and
- A share of areas with three competing networks remains the same as in the baseline scenario – c.30%. We note however that under a more 'optimistic' set of assumptions about BT's duct re-use and new entrants' hurdle rates, this share can increase to up to 60%.[228]

In Figure 13, below we present the costs of coverage under this scenario, on the basis of the >80% commercial coverage being delivered competitively, and the remaining being covered by a single provider (e.g. as a result of franchising).[229]

Figure 13 Costs of 100% deployment under Enhanced Competition

Total cost, £bn	Undiscounted	Social discount rate (3.5%)
Deployment capex	32.3	23.7
Deployment fixed opex	23.7	14.1
Total deployment cost	**56.0**	**37.8**

Source: Frontier Economics

8.2 National Monopoly

8.2.1 Assumptions

In this model, we assume that a National Monopolist can be directed to roll out FTTP to achieve 100% coverage at a national regulated price, i.e. FTTP deployment in unprofitable areas is funded from profits earned in the lower cost areas[230].

One of the potential advantages of this model is that the national monopolist may be able to roll out FTTP at a faster rate, as it will be the only company rolling out FTTP - so the pace of deployment could, in principle, be faster than in the baseline scenario.

For example, in the baseline, two operators may each be deploying to 0.5m premises per year in the same area (if this area is sufficiently profitable to sustain two or more networks). If these premises completely overlap, the overall FTTP coverage would only increase by 0.5m premises. In the national monopoly case, under a similar assumption of roll out capability, such a duplication would not happen, as the monopolist would cover premises only once. Assuming that the national monopolist has access to the same labour pool as the competitive

[228] We have conducted a sensitivity to estimate the impact of even greater infrastructure re-use. We assume new entrants choose to rent infrastructure in 100% of areas that are economic in the baseline, i.e. they face brownfield costs when rolling out their network and incur additional duct rental charges in all of these areas. In this case c. 60% of premises benefit from 3-player competition.

[229] We assume that this single provider has the same costs as Openreach and a roll out at rate of 3 million premises per year.

[230] We model the national monopolist as a vertically integrated operator that provides regulated wholesale access to its FTTP network to downstream competitors, and we model BT as the national monopolist. We assume that its retail market share remains at the same overall level. This is a conservative assumption as BT has the lowest deployment costs.

industry, it could be assumed to be able to deploy FTTP to 3 million premises per year.

However, separately from the theoretical pace of deployment, we note that the process of awarding the national monopoly and agreeing all contractual details would take time. In Australia, where a similar model was used, no deployment took place between 2009 (when the NBN was set up) and 2011. Even by 2016, FTTP coverage in Australia was only 14%. And, by design, a national monopolist would not face a competitive threat from altnet FTTP roll-out, other than Virgin Media.

Moreover, the current (and proposed) EU framework precludes granting exclusivity to telecommunications providers. Whilst it is possible that the legal framework might change after the UK's withdrawal from the EU, the process of establishing a new legal/regulatory framework is likely to take considerable time.

To reflect both of these aspects (an initial delay followed by an increased pace afterwards), we assume that:

1. There will be a delay of three to five years before the monopolist will start rolling out its fibre network;
2. After this initial delay, the pace of deployment is projected to be higher, at 3 million premises per annum; and
3. We expect a freezing effect on any material FTTP deployment from altnets during the design/implementation period due to uncertainties involved, especially around changes to the legal framework and valuing and transferring existing FTTP assets. BT/Openreach could be expected to engage in some FTTP roll-out - to the extent that it would form the view that it would be the most likely national monopoly operator, but lower than its recent announcement of 3m by 2020).

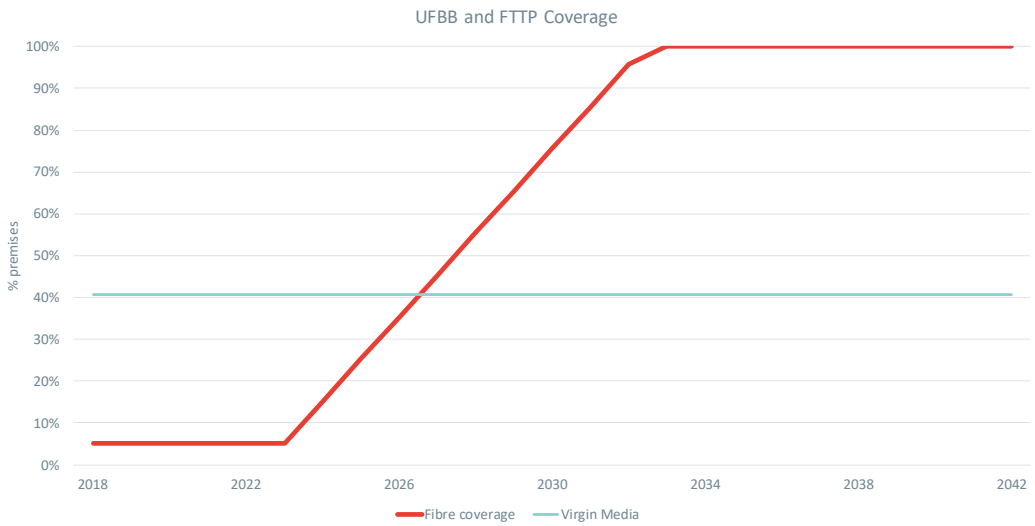
Unlike in Australia, we assume that cable assets will not be decommissioned/ acquired by the national monopolist. Hence, we assumed that Virgin Media will continue to compete in the market, but that any FTTP-based extension of coverage beyond its 'current' footprint would be acquired by the national monopolist. However, if the chosen policy required an 'amalgamation' of cable assets into the monopoly licence, an additional compensation would be needed.

8.2.2 Modelling results

Based on the assumptions above, our modelling results for this scenario are as follows:

- The monopolist is projected to achieve 100% coverage by 2033 (assuming that large scale rollout does not start before 2024); and
- Due to the initial delay, there would be 7.5 million FTTP deployment by 2025.

Figure 14 Timing of fibre coverage under national monopoly



Source: Frontier

As indicated above, there will be **a reduction in the level of network competition**. In particular, there will be no areas with 3-player competition, and fewer areas with 2-player competition.

The deployment capex under this model is expected to be £20.3 billion (undiscounted), compared to £32.3 billion (undiscounted) to cover 100% of the country in the Enhanced Competition scenario. The national monopolist incurs lower costs of deployment than those incurred in the baseline scenario due to lower network duplication. These comparisons are before any compensation payments made to FTTP operators under the monopoly model.

These estimates reflect the assumption of using the brownfield costs for FTTP roll-out, as BT/Openreach is assumed to be the national monopoly operator. Were this not to be the case, then deployment costs would be higher.

Figure 15 Costs of deployment

Total cost, £bn	Undiscounted	Social discount rate (3.5%)
Deployment capex	20.3	17.1
Deployment opex	22.8	14.1
Total deployment cost	43.1	31.1

Source: Frontier Economics

8.3 Franchising of regional licences

8.3.1 Assumptions

The third scenario we consider involves franchising of regional licences. Under this scenario, we assume that the country is divided into several geographically distinct

regions, with operators competing for exclusive rights to serve premises within a given region.

It is assumed that franchisees will be required to deliver up to 100% coverage in their exclusive areas (potentially with minimum rollout commitments per year) and provide wholesale access to their networks at a regulated price[231].

The regions can in principle be defined in such a way that profitable and unprofitable areas are combined and each region can be covered without a subsidy. That is, for each franchisee, profits earned in profitable areas are assumed to be sufficient to subsidise FTTP deployment in unprofitable areas. However, in practice, this would be a complex franchise design, and it may well not be feasible to delineate franchise regions in this way. As a result, there could be less commercial interest in bidding for some of these franchises, resulting in delays in roll-out (consistent with the experience from New Zealand). It is, therefore, likely that some government subsidy would be required to secure 100% coverage under this model.

Pace of FTTP deployment is assumed to be the same as the national monopoly model, i.e. 3 million per annum across all franchises. This is broadly in line (in percentage terms) with the speed of deployment in New Zealand, where fibre coverage increased from 6% in 2012 to 65% in 2017.

There are reasons to consider that moving from the current model to the franchising model could take less time than the national monopoly model. First, under the regional franchise model altnets could form part of consortia that are able to bid/win some of the regional licences, hence they could be expected to be more supportive of this model compared to the national monopoly one. The UK also has a mechanism/process to award regional licences (BDUK) and has been through a process of awarding regional exclusive licences before. Finally, the experience from New Zealand is also consistent with a period of less than five years for awarding the regional licences.

On the other hand, and as in the National Monopoly model, the implementation of this model will also need to address the changes in the legal/regulatory framework that will be required to enable the award of exclusive licences. And, even under this model, there may still be a need for a mechanism that would enable compensation for FTTP investments undertaken already. On balance, we have maintained in our modelling the same assumption in terms of period of implementation of the regional franchise model compared to the national monopoly one. We note also that shortening the period of implementation by one to two years would not affect materially the modelling results. We take into account the possibility of an earlier roll out under this model when we undertake the evaluation in the next section.

As in the national monopoly case, we assume that Virgin Media will continue to provide UFBB services using its cable network within the existing footprint, but will not expand its footprint, unless it wins one or more of the regional franchises.

[231] This could include an obligation to offer a 'basic' fast broadband service at the same price across regional franchises.

8.3.2 Modelling results

Based on the assumptions above, our modelling results for this scenario are as follows:

- The franchised operators are projected to achieve 100% coverage by 2033 (assuming that large scale roll out does not start before 2024); and
- Due to the initial delay, there would be 7.5 million FTTP deployment by 2025.

As indicated above, there will be **a reduction in the level of network competition**. In particular, there will be no areas with 3-player competition, and fewer areas with 2-player competition.

The deployment capex under this model is expected to be £ £20.3 billion (undiscounted). The franchisees incur lower costs of deployment than those incurred in the baseline scenario due to lower network duplication.

Figure 16 Costs of deployment

Total cost, £bn	Undiscounted	Social discount rate (3.5%)
Deployment capex	20.3	17.1
Deployment opex	22.8	14.1
Total deployment cost	43.1	31.1

Source: Frontier Economics

8.4 Dynamic efficiency considerations

In this subsection, we consider the potential impact of dynamic efficiencies, which are not reflected in our main cost analysis above.

As shown earlier, the cost of rolling out to 100% of the country is expected to be higher under Enhanced Competition model compared to National Monopoly/ Franchising of regional licences (c. £32.3bn vs £20.3bn undiscounted capex), as a result of the network duplication involved in the Enhanced Competition scenario.

The network competition delivered by the Enhanced Competition scenario is most likely however to produce additional benefits in the form of dynamic efficiencies (discussed in Section 4.5), including in the design and build of the networks. The latter could deliver faster roll-out and lower build costs due to innovations in deployment approach and costs.

There is significant evidence to support the relationship between competition and productivity/ efficiency gains, implying that competitive markets, such as that modelled under the Enhanced Competition model, tend to bring faster innovation and efficiency savings than markets characterised by regulated monopolies. It is likely that at least some of these productivity gains would be passed on to consumers in the form of lower prices, with other benefits materialising in the form of faster innovation.

As an illustration, based on estimated annual retail revenues of c. £14bn in 2020, growing to over £17bn by 2030, if we assumed that the potential dynamic benefits from competing networks were to deliver c. 2.5% lower prices than in the monopoly scenario during the 25-year period considered[232], we would estimate the NPV of the benefit for consumers to be around £7bn (discounted).

[232] We assume a 2.5% flat reduction in prices, i.e. competitive prices are assumed to be 2.5% lower than the monopoly prices in any given period.

9 OUR EVALUATION OF THE THREE MODELS

In Section 8 above, we presented our modelling of the three alternative scenarios. It provides quantitative information that helps us to evaluate the models against the baseline and each other, using a set of criteria. However, not all criteria can be assessed quantitively. Therefore, we assess the market models against the criteria using both quantitative and qualitative information.

This section is structured as follows:

- In Section 9.1, we discuss how we 'operationalise' the criteria;
- In Section 9.2, we evaluate each model against the criteria; and
- In Section 9.3, we summarise the overall results.

9.1 Criteria used for the evaluation

There are six broad criteria we use in our evaluation (set out in Section 1). These include coverage, pace of deployment, quality and innovation, total cost of deployment, how the cost gets recovered, and feasibility. We try as much as possible to rely on measurable outputs, which could be supported by evidence from the relevant markets (in particular, Spain, Portugal, Australia and New Zealand), economic theory and our modelling. These 'outputs' are summarised in Figure 17 below.

Figure 17 Future Telecoms Infrastructure Review – Key Criteria

Criterion	How we assess these criteria
Coverage	- Total coverage achieved - When will it be achieved - Characteristics of areas covered by FTTP and not covered by FTTP
Pace	- Average pace of deployment - 2025/2033 targets
Quality, price and innovation	- Quality, price and innovation is largely driven by network competition and the performance/quality of regulation (under the monopoly scenarios).
Total cost	- The projected total deployment cost, opex and other network-related spend during the lifetime of the infrastructure (25 years) - Whether some form of external (from the sector) funding is required to deliver any required coverage targets - Whether consumers are likely to pay nationally averaged or regional prices (reflecting differences in costs) - Average level of prices

Criterion	How we assess these criteria
Feasibility	Practical implementation issues, in particular: - whether the model can be implemented quickly or involves a delay; - whether there are likely to be stranded assets and how significant they are

9.2 Our evaluation of each model against the six criteria

9.2.1 Enhanced competition model

Based on this definition and the modelling carried out earlier, our evaluation of this model against the six criteria is as follows:

Coverage

In this model, total FTTP coverage delivered by the market is expected to reach >80%, in 15 years. For a comparison, in the 'baseline' scenario, total coverage is expected to be c. 60%, in 15 years. This increase in coverage delivered commercially is a result of the policies to strengthen competitive roll out and reduce costs, which make more geographic areas profitable and create incentives for the operators to deploy FTTP networks.

The remaining areas are either (i) uneconomic (unprofitable) – c. 10% or (ii) there is a risk of the hold-up issue – c. 10%. This model delivers a reduction in the size of hold-up areas compared to the baseline, where the hold-up areas represent c. 15%. It is possible that government intervention or efficiencies could deliver commercial investment in these areas. We have assumed that investment is secured in these remaining areas, by a single provider, (either using Government support and/or by implementing 'competition for the market' model, e.g. sub-regional franchising). This would increase coverage to 100%, i.e. to the same level as coverage in the national monopoly and regional franchise models. Roll-out in uneconomic areas could be carried out in parallel with commercial roll-out.

Pace

In this model, the industry build rate is 3 million premises per annum, with BT and new entrants building at higher rates than in the baseline. Overall, the pace is 50% higher than in the baseline.

While this could lead to up to 3 million premises passed in every year, in view of the assumptions made in our model, we project that ***unique*** coverage is lower than this, as there will be a degree of overlap. The projected level of coverage by 2025 is therefore around 16 million.

By 2033, projected commercial coverage is expected to reach 24 million premises. However, if the Government were to support FTTP roll out in uneconomic areas, nationwide gigabit coverage could be achieved by 2033.

Quality and Innovation

This model is projected to deliver higher levels of network competition, increasing 3-network coverage to up to 60% (from 30% in the baseline) under maximum passive infrastructure re-use, or under less favourable assumptions[233], increasing duopoly areas from c. 40% to c. 50%, while maintaining 3-network competition at c. 30%.

As discussed in Section 7.1 above, there is a body of evidence supporting the link between competition and efficiency gains/lower prices, quality and innovation in competitive markets compared to regulated monopoly markets. These benefits could include quicker introduction of higher speed products, introduction of new offers, more innovation around provision of content, etc.

It is also expected to perform better than the other two models (national and regional monopoly models), as the latter have very limited levels of competition and, consequently, put less pressure on the operators to invest and innovate continuously.

Total cost of deployment

As presented in Section 8.1.2 above, and shown below, deployment capex to cover 100% of premises under this model is expected to £32.3 billion (undiscounted). This cost is higher than in the monopoly scenarios (where the undiscounted capex is £20.3 billion).

Figure 18 Costs of 100% deployment under Enhanced Competition

Total cost, £bn	Undiscounted	Social discount rate (3.5%)
Deployment capex	32.3	23.7
Deployment fixed opex	23.7	14.1
Total deployment cost	**56.0**	**37.8**

Source: Frontier Economics

We expect the price for consumers in the long run to be no higher than in the 'baseline' scenario and potentially lower than in the monopoly models. As explained above, we would expect network competition to bring additional benefits in the form of faster innovation and efficiency savings, and lower prices for end consumers.

The impact on prices in the short run is more uncertain. To the extent that deregulation (removal of access obligation to BT's FTTP network) is used, prices for early FTTP adopters could be higher than in the baseline (until stronger network competition emerges).

We expect that a number of operators may continue to charge nationally uniform retail prices for most of their offers for the following reasons:

1. There are reasons operationally and on a marketing basis for national operators to prefer a nationally averaged price (similar to what BT and Virgin Media are doing now);

[233] 50% passive infrastructure re-use by altnets

2. We project that BT would cover over 80% of households with FTTP; while Virgin Media would also likely extend its current coverage; and
3. Other providers of FTTP services (Sky, TTG and Vodafone) are also likely to be national players.

Nevertheless, there is also the prospect under this model for more regional price variation to emerge for very high-speed offers, compared to the National monopoly, and possibly the Regional monopoly model. This is because competitive conditions are likely to be different in different areas. Therefore, altnets may charge lower prices in the most competitive areas.

In this model, some areas (c. 10%) remain uneconomic. These areas could be covered by using (i) a Government subsidy or (ii) by franchising these uneconomic areas together with hold up areas (which are viable for one operator) to reduce the amount of subsidy required. Alternatively, the most expensive areas could be covered with other cheaper technologies. This, however, could be done under all three models.

Feasibility

This model builds on/enhances the current model and therefore would not be expected to involve delays compared to the National monopoly/Regional monopoly model. Nevertheless, some measures, if they were included in the enhanced competition model, would require time to implement, hence its effectiveness will reflect the precise mix of measures that are implemented, and the speed with which they are implemented.

Deployment of overlapping networks could create inconvenience for local residents (in the form of prolonged civil works). Such issues could be mitigated through the precise policy package that gets implemented to facilitate rollout.

Under this model, as in the 'baseline' scenario, there would be no need to compensate providers for existing FTTP assets.

9.2.2 National Monopoly

As set out in Section 5.2, in this model it is assumed that there is just one national FTTP network provider, with access to its network regulated using a Regulatory Asset Base (RAB) model[234]. Therefore, there is competition at the retail level. There is also assumed to be continued competition from the existing cable provider.

Coverage

As discussed in Section 8.2.2 above, this model could, in principle, result in FTTP coverage of up to 100% by 2033.

In practice, there are uncertainties involved in this model, especially around the length of the implementation period and the regulator's ability to incentivise the monopolist to continue to roll out the network as required at the time of the award of the monopoly licence – this is discussed in more detail below, under the

[234] I.e. all its efficiently incurred costs are recovered via a wholesale regulated price

feasibility criterion. Indeed, in Australia, where a similar model was implemented, a 100% FTTP target has been replaced by a mixed-technology approach, with FTTP representing only 20% of the target (with cable, FTTC and FWA also being used to deliver broadband connectivity). This example highlights the uncertainties involved in this model.

Pace of deployment

After the implementation period[235], the pace of deployment is expected to be c. 3 million premises per annum. This reflects the overall deployment capacity, but also assumes that the monopolist could be incentivised to deploy FTTP quickly.

As discussed in Section 6 above, there is likely to be limited FTTP deployment during the implementation period (due to uncertainties involved).

Coverage by 2025 is expected to reach 7.5m premises, compared to 16 million under the Enhanced Competition model and 12 million in the baseline scenario.

Quality and innovation

To the extent that this model delivers more limited network competition (40% duopoly areas[236] and no 3-player competition), quality, innovation and customer choice are likely to be poorer than in the baseline (and under the Enhanced Competition model).

This is consistent with the evidence to date from Australia.[237]

Whilst regulation can alleviate these concerns to a certain extent, it cannot be expected to deliver the outcomes that would be obtained in a competitive market (see Sections 8.1 and 8.2 for more details).

Total cost of deployment

As set out in Section 8 above, the total capex is £20.3 billion undiscounted (assuming 100% coverage).

Figure 19 Costs of deployment

Total cost, £bn	Undiscounted	Social discount rate (3.5%)
Deployment capex	20.3	17.1
Deployment fixed opex	22.8	14.1
Total deployment cost	**43.1**	**31.1**

Source: Frontier Economics

The national monopolist incurs lower costs of deployment than those incurred in the baseline. The cost is also lower than in the enhanced competition scenario. This is because under the national monopoly model all properties are passed only

[235] The factors affecting the length of the implementation period are discussed under the 'feasibility' criterion.

[236] See our earlier footnote on the treatment of Virgin Media's FTTP assets

[237] https://www.theguardian.com/technology/2018/apr/17/nbn-complaints-surged-by-more-than-200-in-second-half-of-2017-report-finds

once, i.e. there is no FTTP network duplication – and this effect offsets the lower costs of competitive deployment under the enhance competition model.

If the monopolist needs to acquire the existing FTTP assets from alternative providers, it would require a compensation to be paid to the asset holders. It is not clear at this stage how this process would work, how the amount of compensation will be determined and whether the Government would have to provide this compensation (see more on this issue in the feasibility section below).

The monopolist may be required to charge a geographically-averaged wholesale regulated price. Therefore, consumers in high cost areas would get access to fibre at the same cost as consumers in urban areas, i.e. the monopolist would fund rollout to serve high-cost customers through profits earned in low-cost areas (though competition from Virgin Media could lead to more competitive offers in the areas where the networks overlap). There is also the question of early adopters paying more than later adopters, depending on the approach taken by the regulator to the setting of the access price.

Feasibility

There are a number of issues related to the implementation of this model:

- **Delayed implementation**: This model represents a significant departure from the current competitive model in telecoms. Both in Australia and New Zealand (where competition for the market models were adopted), the transition took a considerable period of time. The delay is likely to be longer if the national monopolist is required to be a wholesale-only business. In New Zealand, full vertical separation of the incumbent was required for it to be able to compete to become a wholesale fibre provider. In Australia, the NBN was set up from scratch, but was required to acquire and decommission the existing copper and cable assets, which has prolonged the implementation and resulted in no fibre rollout for at least five years. Moreover, in the UK the existing regulatory framework will need to be changed for this model to be adopted. While, in theory, this could be possible after the UK's withdrawal from the EU, the whole process is likely to take up to 5 years.
- **Compensation for existing assets**: There may also be a need to acquire/ consolidate existing FTTP assets. For example, it has been reported that up to 1 million premises have been covered by FTTP to date by operators other than BT and Virgin[238]. If these operators do not become the national monopolist, then these operators will need to be compensated (as they will not be allowed to provide services going forward). We have used a recent reported transaction to arrive at a (highly) indicative valuation estimate of these assets. Based on some simplifying assumptions, we arrived at an estimate of (up to) £4.5 billion, based on the future cashflows that these assets would could have been be expected to generate in the absence of any intervention. [239]

[238] https://www.inca.coop/sites/default/files/Altnet-report-INCA%20April-2018.pdf

[239] This is based on Gigaclear valuation. In March 2018, Infracapital bid £270m for Gigaclear, which at the time had passed around 60,000 premises with its FTTP network. Since this valuation reflects the expected future profits of the business, we grossed this figure up to arrive at an estimate of the aggregate market value of the altnets as a whole, assuming 1 million premises passed to date.

- **Continued regulatory oversight**: This model also contains some additional risks/ feasibility issues:
  - It may not be feasible to use competitive tendering to appoint a national provider (as competition is likely to be weak/ non-existent). Therefore, it may be difficult to rely on a licence award process that would support cost minimisation; and
  - There will likely be a need for a stronger regulatory oversight (compared to the ECM) to ensure that there are incentives in place to rollout the network as per the requirements set-out at the time of the award of the monopoly licence.

9.2.3 Franchising of regional licences

Our evaluation of the Franchising of regional licences model is as follows:

Coverage

Similar to the outcome in the national monopoly scenario, coverage in this model, at least in principle, could achieve 100% by 2033.

However, in practice, coverage may fall short of 100% if some regions are considered unattractive and receive no bids. For example, in New Zealand, there were areas that received no bids (despite Government support). We discuss this issue in more detail in the context of feasibility below.

Pace of deployment

The implementation period is expected to take significantly longer than the enhanced competition model, and arguably could take as long as the national monopoly model.

We expect on the other hand to see more competition for regional franchises than for a national monopoly (due to differences in scale). This could potentially result in faster/ more efficient roll out in practice (compared to the national monopoly model), as bidders can be assessed based on pace of rollout planned. As there are likely to be multiple licensees, yardstick competition[240] could also be used to compare the operators' performance and seek to incentivise those lagging behind. This model could therefore achieve a higher speed of roll out than the national monopoly case. The available evidence is consistent with this, as the implementation period in New Zealand was faster than in Australia. The process started in 2011 and by 2016, 65% of premises were covered by FTTP.

We note that in the UK, and similar to the national monopoly model, the legal/regulatory framework will also need to change before this model could be implemented.

[240] Yardstick competition has been used in the UK and internationally by regulators to incentivise companies to reveal their efficient level of costs. See, for example, https://www.ifs.org.uk/fs/articles/0041a.pdf

As a result of the required implementation period, the Government's 2025 target is likely to be missed, with c. 7.5 million premises projected to be covered by FTTP by that date.

Quality and Innovation

Quality and innovation in the long run is likely to depend on the degree of competition, while the latter would depend on the length of the exclusivity period. If the exclusivity period is indefinite, the regional monopoly will result in relatively low levels of innovation in the long run (vis-à-vis the baseline and the enhanced competition scenario). To the extent that a yardstick competition regulatory approach could be used, a regional franchise model could perform better than a national monopoly in terms of efficiency.

If the exclusivity period granted to regional monopolists is relatively short (e.g. 5-10 years), there is also a prospect of network competition emerging after the exclusivity period has ended. It is difficult to predict whether network competition will emerge afterwards, i.e. whether new entrants would find it profitable to overbuild the original licence holders at a later stage. In a scenario in which exclusivity was granted on a temporary basis, this model would be more likely to deliver better quality and innovation in the long run than the National Monopoly model - should competition emerge after the exclusivity period has ended.

Total cost of deployment

Total costs of deployment – £20.3 billion undiscounted – are the same as those incurred in the national monopoly case.

Figure 20 Costs of deployment

Total cost, £bn	Undiscounted	Social discount rate (3.5%)
Deployment capex	20.3	17.1
Deployment opex	22.8	14.1
Total deployment cost	**43.1**	**31.1**

Source: Frontier Economics

We recognise that in practice, the costs of deployment may be slightly different:

- On the one hand, there is more likely to be stronger competition for regional franchises than for a national monopoly, which may bring deployment costs down; and
- On the other hand, deploying networks on a smaller scale may result in some losses in economies of scale.

This model may be able to maintain nationally uniform prices, at least for a 'basic/anchor' product, as this could become a requirement of the franchising process.

In relation to higher speed products, achieving a national uniform price is likely to be more difficult than in the monopoly model. Indeed, different franchisees might face different deployment costs and therefore might charge different prices. It may

or may not have an impact on retail consumers, depending on whether operators downstream (at the retail level) would prefer to charge a nationally averaged price (even if they face different wholesale costs in different areas). This issue would need to be given careful consideration as uniform prices are unlikely to emerge automatically in this model.

There may be no need for government roll-out support under this model, if regions could be defined in such a way that profitable and unprofitable areas are combined: profits earned in profitable areas could be used to subsidise FTTP deployment in unprofitable areas. However, as explained above, we consider that in practice it will be difficult to implement the model in this way, meaning that some government subsidy would likely be required to secure 100% coverage.

Feasibility

As with the National Monopoly model, this model represents a significant departure from the current model:

- **Implementation**: as with the national monopoly, the implementation of the regional monopoly model is likely to be delayed by legal constraints. The existing framework will need to be changed before this model could be implemented.
- **Stranded/existing assets**: There is the issue of how to treat pre-existing fibre investments within franchise areas. In particular, if a provider has already deployed fibre within a given area but fails to win the associated franchise, this would give rise to the need for compensation. However, we consider that the level of compensation required is likely to be lower than in the National Monopoly model:
  - Given that different operators can win franchises in different areas, it would be reasonable to expect that those who have already deployed FTTP in an area are in a stronger position to win that franchise. Moreover, having existing fibre assets explicitly recognised in the award process/ increase the chances of winning that franchise; and
  - The risk would still remain in areas with duplicating fibre assets. However, these areas are likely to be small (or non-existent) given that overall level of fibre deployment in the UK is still low.
- **Ensuring 100% coverage**: While, theoretically, this model should be able to deliver 100% coverage without a subsidy (because of its ability to cross-subsidise between profitable and unprofitable areas), some areas may be considered less attractive and receive not bids. For example, in New Zealand, there were areas that received no bids (despite Government support). This issue could be minimised by delineating the areas carefully to maximise their attractiveness/ profitability. If this is not successful, a subsidy (or some form of demand stimulation) may be needed for some less attractive areas.

9.3 Overall evaluation

Our findings are summarised in Figure 21 below. Overall, we find that each model has strengths and limitations:

- **Enhanced Competition model** scores well across all the criteria, except 'the total cost of deployment' (due to network duplication). The key benefits associated with this model are (a) its ability to deliver dynamic efficiencies in the long run, i.e. competing providers are expected to innovate, delivering more choice, better quality and low prices for consumers, and (b) it can also be implemented without delay (unlike the other models, which could take 3-5 years to implement).

  Given that this model is not projected to deliver 100% coverage (as some areas remain uneconomic), external funding may be required. Ubiquitous coverage could be achieved by using 'competition for the market' mechanisms, such as awarding exclusive licences to roll out in uncovered areas.

- **National monopoly model** – this model could, in principle, deliver 100% coverage, support nationally uniform prices and result in lower deployment costs (as there is no network duplication). However, this model also has drawbacks:

  - It greatly reduces network competition, both now and in the future, which is likely to have a negative impact on quality, choice and innovation. While dynamic efficiencies associated with innovation may be less pronounced in other utilities (such as energy and water), telecoms sector is strongly driven by technological innovation. Reducing network competition could be detrimental for quality and choice in the future;

  - The model involves a significant departure from the current approach, raising a number of issues related to implementation: it will require a new legal/regulatory framework, compensation mechanisms for acquiring existing altnet FTTP assets, and is highly likely to require a lengthy implementation phase. There is also a case that the national monopolist should be restricted from offering retail services, as in the New Zealand case, which would likely further add to the implementation period;

  - Competitive tendering is unlikely to work effectively in this case, as it is not clear at this stage that there are credible contenders, apart from Openreach, to deliver this model. In the absence of an effectively competitive award process and ongoing benchmarking of the monopolist's performance, it may be difficult to incentivise BT to deploy FTTP networks rapidly and efficiently. The evidence from Australia, where a similar model, has been implemented, is very mixed on the merits of such a model;

- **Franchising of regional licences** – this model creates incentives to rollout FTTP networks quickly by providing exclusivity for a period of time. It has similar drawbacks of the National Monopoly model, though allows in principle the re-introduction of network competition at a later stage (after the

exclusivity period has ended). Yardstick competition could also be used to incentivise franchisees to improve efficiency and deliver good quality, and this model has a greater likelihood of attracting more than one credible bidders.

Figure 21 A summary of our evaluation

	Baseline	Enhanced competition	National monopoly	Franchising
FTTP coverage after 15 years	60% coverage in 15 years, c. 75% coverage in 20 years	Over 80% competitive deployment and remaining c.20% 'competition for the market' in 15 years	Up to 100% In 15 years	Up to 100% In 15 years
Pace of deployment	2m between BT and entrants	3 m between BT and entrants	3m for monopolist	3m in total for franchisees
Initial delay due to implementation	No	No	Yes, c.3-5 years	Yes, similar or somewhat less than NM
Government 2025 target	No	Yes	No	No
Degree of competition	c.30% - 3 players c.40% - duopoly	c.30-60% - 3 players	60% - monopoly 40% - 2 players (FTTP and DOCSIS).	60% - regional monopolies 40% - 2 players (FTTP and DOCSIS) Potentially more competition after end of exclusivity
Quality/ innovation	Dynamic efficiencies	Greater degree of entry and faster pace of rollout should increase dynamic efficiencies	Monopolist has less incentive to innovate than in a competitive market	Lower dynamic efficiencies than in the enhanced competition model, but potentially higher than in the NM
Capital cost of deployment (undiscounted)	£22bn (75% coverage)	£32.3bn (100% coverage)	£20.3bn (100% coverage)	£20.3bn (100% coverage)
Areas with no coverage	15% - 'hold up' 10% - uneconomic	10% - potential 'hold up' 10% - uneconomic	In principle, none In practice, deployment in some areas may be delayed	Possibly if some regional franchises fail to attract bidders
Can coverage be extended to 100%?	Yes, through government intervention including subsidy and franchising of the remaining areas	Yes, through government intervention including subsidy and franchising of the remaining areas	Through price cross-funding	Possibly through price cross-funding
Pricing	National pricing	National pricing likely, with some price variation, especially for very high speeds	National pricing	Some regional price variation – depends on design
Compensation for FTTP assets	Not needed	Not needed	Yes	Likely

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