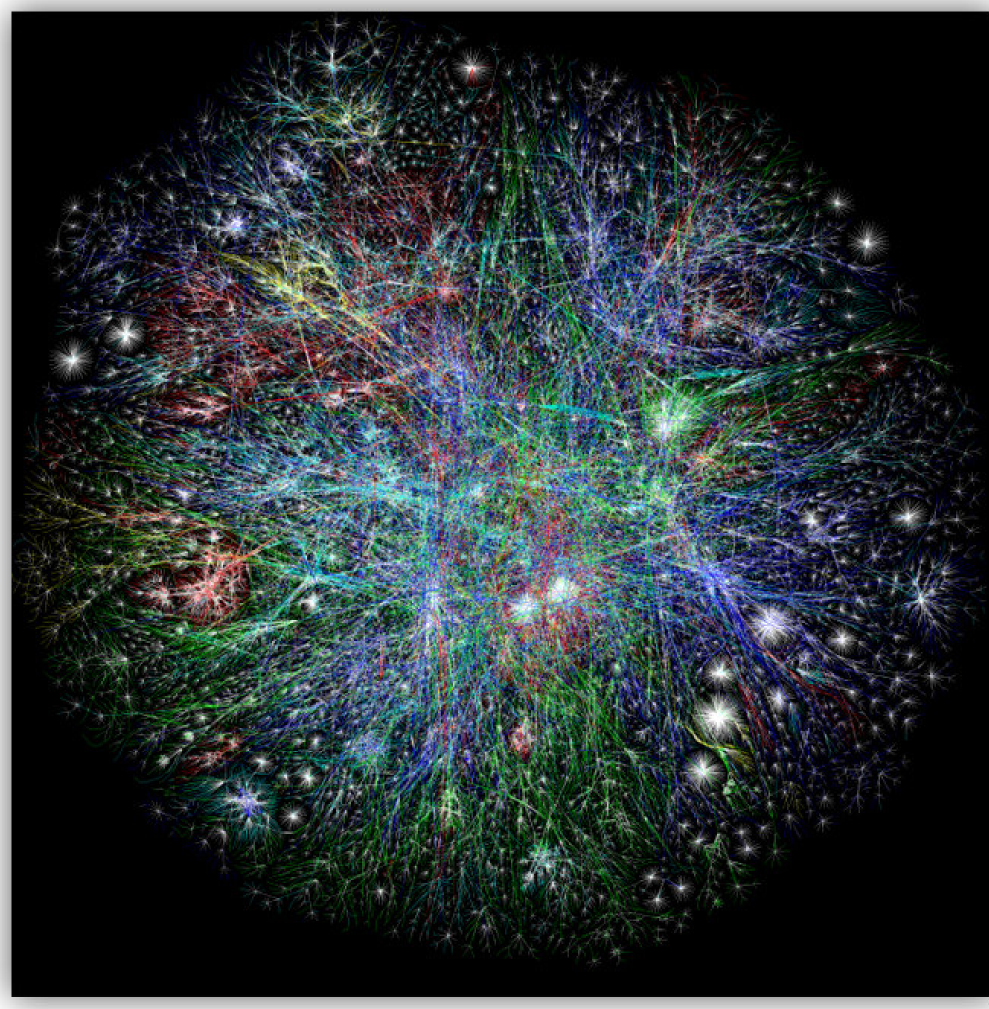
Optimal Investment in Broadband:



The Trade-Off Between Coverage & Network Capability

April 2010

INGENIΘUS CONSULTING NETWORK

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Executive summary

Governments around the world are announcing and implementing substantial plans to support high speed broadband roll-out. However, in many countries there is little evidence that these plans are based on a thoughtful consideration of the pros and cons of different potential market interventions, and certainly the plans are widely divergent in their scale and objectives.

Given the multi-billion Euro sums being spent on these projects, we believe an analytical framework to support decision making in this area could be highly valuable. This paper seeks to provide such a framework.

The decisions are undoubtedly complex. While costs can be relatively accurately assessed, consumer demand for higher speed is far less certain, and the associated externalities are even harder to quantify (though many government investment plans are based on the idea that they will be significant[1]). Moreover, given that most countries now have relatively wide availability of standard broadband, any rationale for high speed investment must consider the incremental benefits and costs, not the absolute benefits and costs.

Nonetheless, we believe these decisions can be usefully supported by quantitative analysis. Core to our work is a flexible model allowing for assessment of the incremental benefits of broadband investment, by technology, country and region[2].

Our analysis focuses on three types of broadband technology: standard (up to 15 Mbps download), fast (up to 50 Mbps download) and superfast (over 50 Mbps download)[3]. We consider the incremental costs and benefits of each, acknowledging that the trade-offs are complex. For example, there are a range of local market differences including variations in the 'counterfactual' (the likely broadband infrastructure in a given country absent intervention), uncertainties exist over consumer demand and there are severe difficulties in modelling externalities.

Our analysis allows us to consider the relative merits of a range of deployment strategies. For example, based on assumptions for the UK, we can contrast sudsidising the deployment of standard broadband to the final group of households (and achieving 100% coverage), subsidising fast broadband to areas where BT and Virgin do not already supply, and subsidising superfast broadband to the urban core. Figure 1 below illustrates the relative

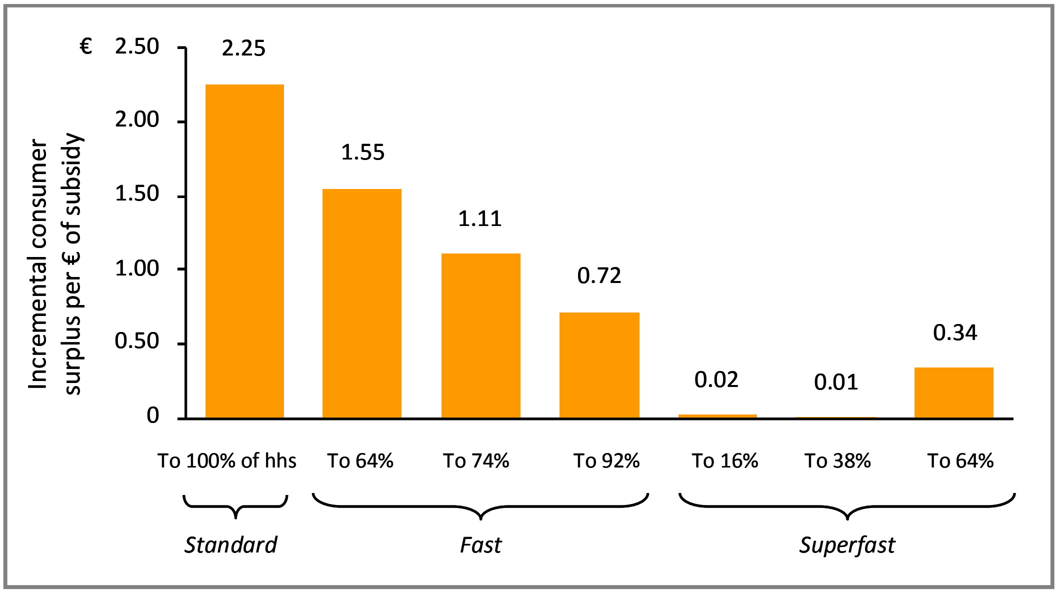
[1] Julius Genachowski, chairman of the Federal Communications Commission, stated: "broadband is essential to fostering 21st century jobs, investment and economic growth. It's also so important because of the vital role broadband must play in advancing key societal goals in areas like education, health care, energy, public safety, democracy, and small business opportunity." (February 2010)

[2] In our model, regions are proxied by 8 different geographic types ("geotypes"), split primarily by population density

[3] We note that the majority of analysis to date has been on fixed networks, and do not therefore explicitly consider any incremental benefits of mobile broadband. Given the growing importance of mobile as a complementary means of broadband delivery, we believe this is an important omission in the current body of literature.

effectiveness of each approach in terms of the value of consumer benefit realised per € of subsidy.

Figure 1: Relative effectiveness of each € of subsidy for a range of deployment options based on expected UK infrastructure[4] [5]



Based on our assumptions, the most effective approach (before considering externalities) is to extend the coverage of standard broadband to the final 3% of households. For each €1 of subsidy, €2.25 of incremental consumer value is created.

Given the existing provision of fast broadband services in the urban core, the case for investing in superfast broadband services in these regions is very weak. Competition from existing services reduces the number of customers for superfast broadband, and moreover reduces the incremental consumer value for those customers. Therefore, any remaining subsidy after supporting standard broadband in the most remote areas would be more effectively employed in encouraging deployment of fast broadband services in areas not already served (starting with the most urban, to 64% coverage).

Of course, this analysis ignores the impact of externalities. The question of which approach has the greatest overall societal benefit therefore depends on your perception of the value of externalities under each option.

Our analysis also explores the scale of the externalities required to justify current broadband deployment plans in a range of illustrative countries, ranging from Australia's commitment to 90% superfast deployment to Germany's subsidised roll-out of standard broadband to

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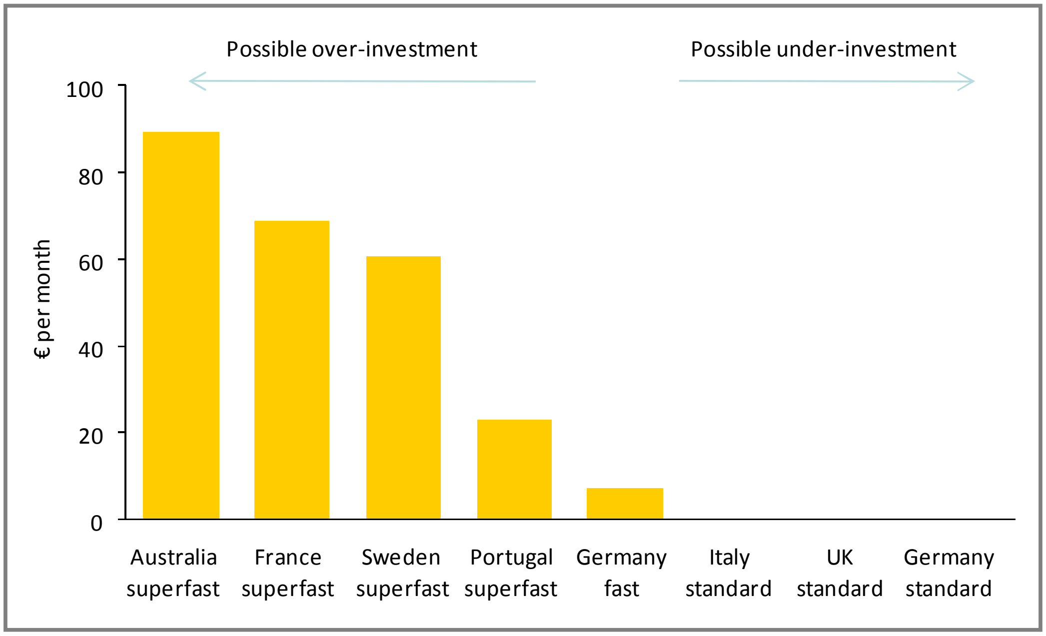
[4] Geographic areas are referred to in terms of eight 'geotypes', from geotype 1 (the most urban) to geotype 8 (the most rural)

[5] Compared to a counterfactual of standard broadband coverage to 97% of households and fast broadband to 38% of households. Assumes that subsidy is equivalent to the producer deficit associated with the infrastructure deployment.

100% coverage. We focus on the remotest region planned to be covered, since the greater expense here will require the most optimistic view of externalities. Figure 2 illustrates these results.

Figure 2: National broadband plans – incremental externalities per month per connected household required to justify proposed investment in remotest region covered



Policies for ubiquitous standard broadband in Italy, the UK and Germany can be justified based on the increased consumer surplus alone (which more than offsets the producer deficit). At the other extreme, Australia's ambitions for 90% coverage of superfast FTTH broadband means that the *incremental* externalities of superfast broadband would need to be around €90 per connected household per month to justify a roll out this extensive.

A fundamental issue when assessing broadband policy is therefore the value of the *incremental* externality resulting from network deployment.

By considering different levels of incremental externality, we can estimate the potential loss from some of the more aggressive broadband policies. For instance, if you believe the incremental externality of superfast broadband is €10 per connected household per month, then France's proposed roll-out of fibre to 70% of the population could lead to annualised loss of over €3bn, compared to a plan focused on regions where the benefits exceeded the costs[6].

Note that we are not suggesting that the policies of countries such as France are in aggregate value destructive, only that the extent of the proposed roll-out is such that in the more rural areas covered, the cost is likely to far exceed the benefits, and thus a more

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[6] The value of annualised loss falls as the assumed externality rises, but does not drop to zero until the externality rises to €70 per connected household per month for France, and around €90 for Australia

limited roll-out would be much better. In more rural areas, a government must believe in extremely high incremental externality benefits to justify current plans.

Overall, our analysis suggests that a range of general lessons can be drawn:

- There is a strong case for subsidising the roll-out of standard speed broadband to all households, and generally this should be the first priority for governments (subject to any market specific issues)
- If funds are still available thereafter, there is also a case for subsidising fast FTTC[7] or cable broadband (in those areas where the market is not already providing). However, in areas with lower population density the case becomes highly dependent on the incremental externalities of fast over standard broadband
- The case for subsidising superfast (FTTH or FTTB[8]) broadband is weaker. To believe it can create greater societal value than fast broadband requires an aggressive assumption about incremental externalities of superfast over fast broadband, but even then the societal benefits will be much less evenly distributed
- Geography is an important consideration in broadband policy. In some regions, the market is likely to deliver without intervention. In other areas, there are clear arguments for government subsidy. In many of the most rural locations, the case for subsidy of superfast broadband deployment is weak unless aggressive assumptions are made about the value of externalities. Despite this, regional targeting is, at best, peripheral in many centralised broadband policies. We suggest it should play a greater role.

We recognise that this paper is only a small first step towards a more rigorous framework for decision making, and we would welcome your comments.

We would like to thank Vodafone for their funding of this work. However, the views and opinions expressed in this study are solely those of the authors and do not necessarily reflect the views and opinions of Vodafone.

Kip Meek
Robert Kenny

February 2010

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[7] Fibre to the cabinet

[8] FTTH: Fibre to the home. FTTB: Fibre to the building

Introduction

Governments around the world have been announcing ambitious plans to support broadband investment. However, there is no consensus on the focus of these plans. Some governments have emphasised high capacity connectivity. Others are more concerned with assuring the availability of basic broadband to the greatest number. Some countries have announced twin targets of both: increasing network capability and broadband access.

The expenditure involved in deploying broadband networks is significant and therefore even the wealthiest countries must make trade-offs between depth of coverage (the proportion of the population with access) and network capabilities (access speed, technology, latency, etc.). However, to date the process by which governments have made these trade-offs might generously be described as opaque. There is often little or no discussion as to why a particular broadband plan has been chosen over the almost endless range of alternatives. Indeed in some cases policy makers have actively rejected applying cost-benefit analyses[9].

There is no question that the issues involved are complex, and that there are gaps in relevant data (for example, the incremental benefits to society of higher speed broadband). However, the sums being put at risk by broadband are far too large to be spent without rigorous consideration of the alternatives. Therefore the ambition of this report is to provide an analytical framework that policy makers can use to inform the debate.

At the heart of our analysis is a quantitative model which estimates the value created for consumers and providers of broadband services in a range of scenarios. We do not aim to provide a definitive answer as to the 'right' form of broadband subsidy and the manner in which infrastructure should be deployed. Rather, we seek to explore the trade-offs between different broadband investment approaches in a quantitative manner.

Specifically, we have sought to develop a framework which will allow us to understand:

- The trade-offs between depth of coverage and network capabilities, including speed;
- How these trade-offs are affected by country-specific variables;
- The appropriateness of current broadband policy; and
- The questions that should be asked by governments, regulators and investors when developing a coherent and socially beneficial strategy for broadband deployment.

In the report we note the importance of different geographic regions, and make reference to different 'geotypes'[10].

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[9] See for instance "Govt rejects cost-benefit analysis in NBN report", *The Age*, November 27, 2009 at http://www.theage.com.au/technology/technology-news/govt-rejects-costbenefit-analysis-in-nbn-report-20091127-jvm5.html

[10] Geotypes range from G1: 'major urban' (most dense) through to G8: 'very small exchanges with long lines' (least dense)

Broadband and government policy

Many governments have stated their intent to stimulate the provision, or directly provide, fast and superfast broadband networks. However, the details of these plans vary significantly between countries.

Types of broadband infrastructure

One question for governments is which type of broadband technology they wish to support. Governments frequently articulate this in terms of a particular speed[11]. However, given significant discrepancies between headline and actual speeds, and differences in upload and download characteristics, reference to speed alone can be ambiguous.

In practical terms, the decision is to invest in a particular technology rather than a specific speed. Therefore, in this report we refer to the type of technology, and the speed and characteristics of that technology, rather than simply the headline download speed. We consider three categories, 'standard', 'fast' and 'superfast' broadband:

- **Standard** broadband is capable of achieving access speeds of up to 15 Mbps download and 1.5 Mbps upload. It includes both wireless (e.g. 3G, 4G) and wireline technologies, the most notable fixed technology being asymmetric digital subscriber line (ADSL), currently the most widespread form of broadband. Although ADSL connections can theoretically achieve higher download speeds of up to 24Mbps, actual speeds are generally considerably lower than this[12].
- **Fast** broadband is capable of achieving download speeds of up to 50Mbps and upload speeds of up to 10Mbps. Key technologies includes fibre to the cabinet (FTTC) and cable. FTTC involves laying fibre-optic cables to street cabinets typically located within a few hundred metres of the customer premises. Households are then connected from the cabinet by copper lines. Cable networks often have a similar architecture, with fibre to the cabinet and coax cable from there to the home. FTTC and cable speeds are higher than ADSL, but are often not fully symmetric and are determined, in part, by a household's distance from the cabinet.
- **Superfast** broadband connections can achieve upload and download speed of over 50Mbps. Main technologies include fibre to the home (FTTH) and fibre to the building (FTTB), which involve laying fibre-optic cables directly to the customer premises, either through a gigabit passive optical network (GPON) or point-to-point fibre (PTP). FTTH and FTTB connections typically allow the highest speeds, lowest latency, greatest reliability and truly symmetric connections when contrasted against FTTC and ADSL.

[11] For example, Australia (100Mbps), Austria (25Mbps), Finland (1 Mbps by 2010, 100 Mbps by 2015), Germany (50 Mbps), Spain (30Mbps), UK (2Mbps, 40-50Mbps).

[12] Achieved standard ADSL speed in the UK is typically 45% of the advertised headline speed, which in turn is usually lower than the theoretical maximum; source: Ofcom (2009)

While our discussions of broadband networks primarily related to wireline networks, wireless technologies (mobile, fixed wireless and satellite) are increasingly prevalent means of broadband delivery[13]. For example, the Irish government has awarded a contract to Hutchison 3G to provide broadband to the final 10% of population through a hybrid wireless/satellite approach[14].

Policy objectives

Some governments focus on supplying high capacity superfast broadband for a proportion of the population, whereas others stress the importance of ubiquitous broadband at lower speeds. For example, Germany intends to reach its entire territory with a 1Mbps service and 75% coverage of the country with a 50Mbps service. The United Kingdom has set a target of 2Mbps for ubiquitous access and expects a 50Mbps services to be deployed to around 40% of the country. Australia has stated its ambition to provide high speed 100Mbps services to 90% of the country.

As might be expected given the different objectives, the level of planned government spend also varies significantly. At one extreme, the government of Australia has announced plans for a superfast broadband network costing A$43bn/€28bn (with the government to provide at least A$4.7bn), estimated to take more than eight years to build and requiring roughly 25,000 full-time workers. Conversely Germany, with a population roughly four times as large as Australia’s, is planning to spend €150m, or roughly 5% of Australia’s minimum subsidy.

Table 1 below illustrates the disparity in policy objectives (and plans of commercial operators). Further detail on broadband policy by country (and sources) is provided in appendix A.

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[13] The FCC estimates that satellite, mobile and fixed wireless accounted for 36% of “high speed lines” in 2008 and 69% of *new* lines created between June 2006 and June 2007; source: Ehrlich (2008)

[14] Despite this, we note that the majority of analysis of broadband investment has been on wireline rather than wireless networks. We believe this is an important omission in the literature and should be considered a priority for further research, in order to support the investment debate.

Table 1: Summary of planned investment in broadband infrastructure by country

Country	Investment plan
Australia	Superfast FTTH broadband to cover 90% of the country over the next eight years
Austria	Universal coverage of 25Mbits by 2013
Belgium	Cover 80% of the population by 2011 with a fast FTTC (VDSL2) broadband network
Brazil	As of Aug 2009, the telephony carriers stated that they aim to deploy broadband to 150m people (75% of the population) by 2014 if the Brazilian government updates regulation in their favor
Canada	Broadband of at least 1.5Mbits to as many of the currently unserved and underserved households as possible
Denmark	Universal broadband access (of at least 2Mbits) by the end of 2010
Finland	Universal coverage for all permanent residences, businesses and government bodies with an average download rate of 1Mbits by 2010, and superfast networks permitting 100Mbits connection to 99% by 2015
France	Ambitions for 100Mbps superfast broadband to cover 70% of households by 2020 Universal broadband access by 2010, with minimum broadband speed has been designated at 0.5Mbps
Germany	The government's Broadband Strategy adopts a two-step strategic goal, with universal availability of at least 1Mbits by the end of 2010 (based on a mix of technologies), and availability of 50Mbits to 75% of households by 2014 (50% of households with fast FTTC (VDSL) service and 25% with superfast FTTH)
Greece	Over the next seven years the network is intended to reach 2m (c. 52% of all households) homes with a superfast FTTH 100Mbits service
Hong Kong	Superfast FTTH has already reached virtually 100% of residential buildings
Japan	The 2008 "Strategy on the Digital Divide" seeks to provide universal broadband coverage based on a mix of technologies The incumbent, NTT has pledged to provide superfast FTTH service to 30m users (24% of the total population) by 2010
Netherlands	Currently has close to 100% coverage Aims to achieve the highest broadband penetration rates in the world by 2010
New Zealand	The government's goal is to accelerate the roll-out of superfast FTTH broadband (50-100Mbits) to 75% of households 97% percent of households and enterprises should be able to access fast broadband of 5Mbits or better
Poland	Goal is to ensure that 100% of households and businesses are within the coverage of broadband infrastructure by 2013 or 2014
Portugal	Aim of the latest programme is for 1.5m homes and businesses to be connected to new fibre networks
South Korea	KT is required to provide broadband access of 1 Mbps or higher to all homes in villages (presumably allowing for near universal coverage) The Korea Communications Commission has committed to a national superfast FTTH broadband network offering speeds of around 1Gbits by 2012 on the fixed-line network and 10Mbits on wireless broadband
Slovak Republic	Goal is to achieve the level of coverage available to developed European countries by 2014 Broadband speed target of 2Mbits (symmetrical)
Sweden	40% and 90% of households and businesses to have access to broadband at minimum speeds of 100Mbits by 2015 and 2020 respectively
Switzerland	Currently has near universal standard (ADSL) broadband coverage In 2008, Swisscom announced plans to bring FTTH to 100,000 homes by the end of 2009
United Kingdom	Universal 2Mbits broadband to all citizens by 2012 based on a mix of technologies BT announced plans to build a fast broadband network covering 40% of UK households by 2012 In March 2010 the UK Government announced plans for "super-fast broadband" to 90% of homes by 2017
United States	FCC's national broadband plan includes an initiative to equip 100m households (c. 85% of all households) with 100Mbits service by 2020 FCC also aims to improve broadband coverage in unserved and underserved areas

Manner of intervention

The manner of government intervention also varies. In some countries, governments are providing direct financial assistance. In others, intervention focuses on encouraging consumer demand. Elsewhere, more market led approaches have been adopted, facilitated by a regulatory framework which seeks to develop competition, encourage efficient investment in infrastructure and ultimately let market dynamics decide.

In Europe EU restrictions on state aid (put in place originally to prevent national governments from using their funds to aid local industries in contravention of the single market) has constrained intervention. There has been an emphasis either on underserved populations or on company- and technology-neutral public tenders.

Pricing regulation is another important aspect of intervention. While examples of geographically de-averaged prices are rare, in Finland regulation around price discrimination has been relaxed as a method of stimulating roll-out.

The lack of a clear decision making framework

There are a number of reasons why we would expect government broadband policy to vary: local market considerations including the existing fixed infrastructure, the likelihood of commercial provision, consumer demand for fast and superfast broadband technologies, topography, laissez-faire or interventionist government philosophy and so on.

However, the wide variation in policies suggests that there may a further reason: a lack of a structured approach for making policy decisions. In the remainder of this report, we introduce such an approach and assess various national policies through this prism.

A framework for assessing broadband policy

Investment trade-offs

Broadband investment covers a number of dimensions and even the most affluent of nations are likely to need to make trade-offs between them. These dimensions include:

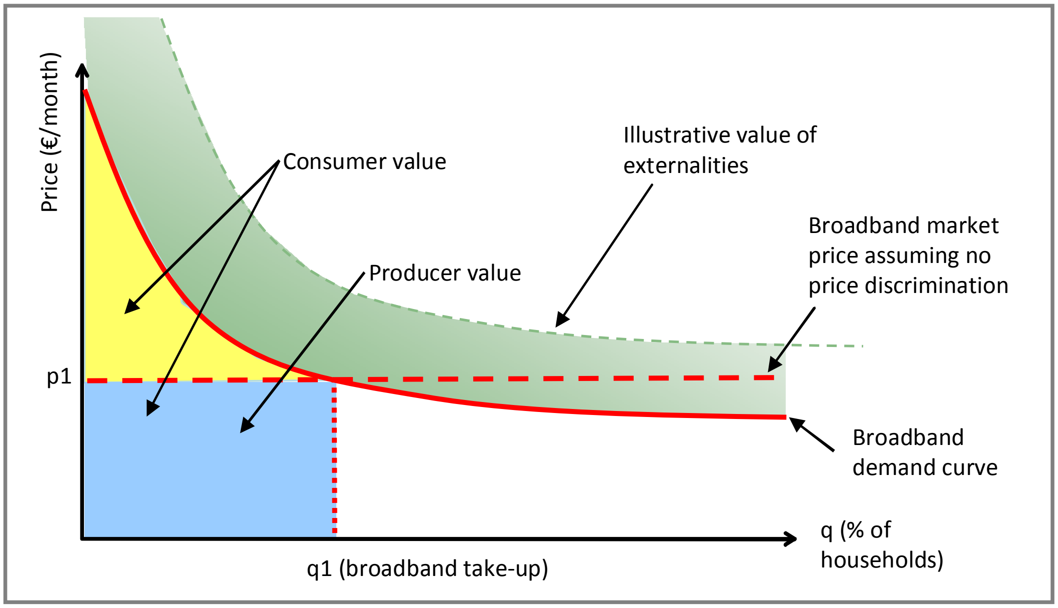
- **Coverage**, with costs per household passed generally increasing with roll-out
- **Speed**, driven by both the underlying technology (standard, fast, superfast) and network characteristics (network architecture, distance from the exchange, etc.)
- **Take-up**, often achieved through demand side stimuli (training, awareness, pricing subsidies, etc.)
- **Mobility**, with wireless networks increasingly viable as a means of broadband delivery

There is little evidence that broadband policy is being based on a thoughtful consideration of the trade-offs between these investment alternatives. Given the multi-billion Euro sums being spent by governments on broadband projects, we believe an analytical framework is needed to support decision making in this area. We have therefore developed a quantitative model which focuses, in particular, on the first two of the above dimensions: coverage and speed (proxied by network type).

Overview of the modelling approach

To develop a practical framework for assessing broadband trade-offs, we have considered the value of broadband against the classical economic concepts of consumer value, producer value and externalities. These are illustrated below.

Figure 3: Illustrative value created by broadband



Consumer and producer value are the most direct measures of economic benefit from the consumption of broadband. The (limited) set of literature exists which measures these types of value[15] forms the basis of our analysis of consumer and producer value.

It is generally believed that broadband has significant positive externalities, and indeed this is a critical underpinning assumption for the consensus that government intervention to support broadband may be justified. Positive externalities are represented (illustratively) by the green shaded area above the broadband demand curve. Positive externalities brought about by different types of broadband may include the following:

[15] Discussion of the *incremental* consumer and producer value associated with fast and superfast broadband is particularly limited, though see Plum for BSG (2008)

Figure 4: Sample externalities

Societal value	• Improvements to education such as greater collaboration • Improvements to health services such as remote diagnostics • High definition video communication and collaboration • More effective energy usage, reduced travel and lower power consumption • Improving economic participation among the elderly and disenfranchised
Productivity improvements and efficiencies	• Cloud computing and efficiencies not reflected in private demand curves • Freeing of resources (e.g. IT support staff) which can be employed elsewhere in the economy • eGovernment and migrating administrative functions online • Improved business connectivity
Innovation	• New services enabled by high speed BB critical mass

However, it is worth noting that not all externalities associated with high speed broadband are necessarily positive. Some have pointed to the increased carbon emissions likely to result from deployment, and others have posited that high speed networks will increase digital content piracy. Plum for BSG (2008) also note negative externalities associated with intervention itself: "*if public funds rather than voluntary user payments are used to fund next generation broadband, then an additional cost is incurred in terms of the economic cost of raising taxes*".

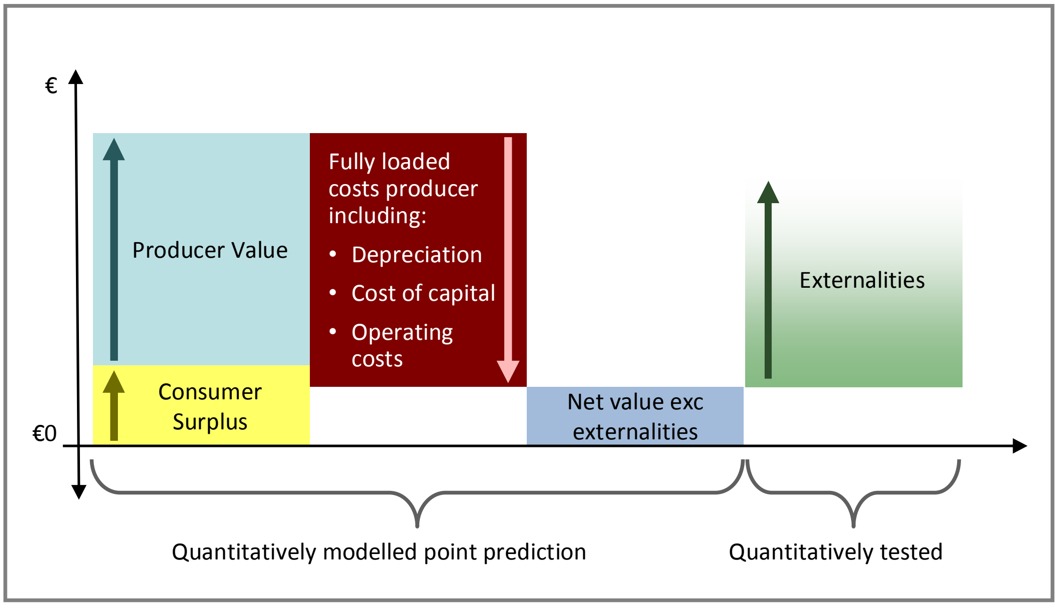
Externalities associated with broadband are hard to measure and there is no quantitatively rigorous, comprehensive estimation of the value of the externalities from broadband, particularly when considering the *incremental* value of externalities relating to fast and superfast broadband. Thus any point-prediction of the value of externalities associated with particular broadband coverage and network capability will be subject to a large degree of uncertainty.

Our modelling approach is therefore to:

- Quantitatively focus on estimating consumer and producer value / surplus, where a more consistent body of quantitative literature exists
- Discuss the scale of externalities that would be required to materially change the conclusions, drawing on existing research to assess the likelihood of this outcome

This approach is illustrated in Figure 5 below.

Figure 5: Overview of modelling approach adopted



The model performs the above calculation for each of 8 geographic regions (geotypes) in the country in question. Broadly speaking, if for a given geotype the producer value is greater than the costs (that is, the producer surplus is positive), then that geotype will be served by commercial players without the need for intervention.

If however the producer surplus is negative (i.e. producer value is less than costs) but the net value is positive, then a subsidy may be needed to support roll-out, but that subsidy can be justified purely on the basis of private value. This is the case illustrated above, where total value is greater than costs, but producer costs are greater than producer value.

Note that we do not imply that as a general rule governments should intervene purely to create consumer surpluses; rather, we believe that the risk of intervention is much less when its cost is exceeded by such surpluses, before bringing into account externalities.

If the net value is negative, a subsidy may still be justified, but a government would need to believe firmly in the value of sufficient externalities to offset the negative net value.

Scope of the modelling approach

We do not seek to provide a definitive answer to the value of broadband and the manner in which infrastructure should be deployed; rather, we aim to provide a framework to inform policy debate. A full discussion of the approach is provided in the appendices to this report.

The model estimates the incremental value created for consumers and providers of broadband services under a range of scenarios relating to coverage and technology. The model also allows us to explore the relationships between other variables, in particular country-specific factors such as pricing, penetration and geographic profile. The costs and benefits of broadband roll-out in a country will depend on such variables, and our model takes these into account where possible.

Analysis and findings

In this section we explore the case for any government intervention, how intervention should be targetted (particularly in terms of higher speeds vs wider coverage) and how our analysis compares to actual government plans.

The case for government intervention

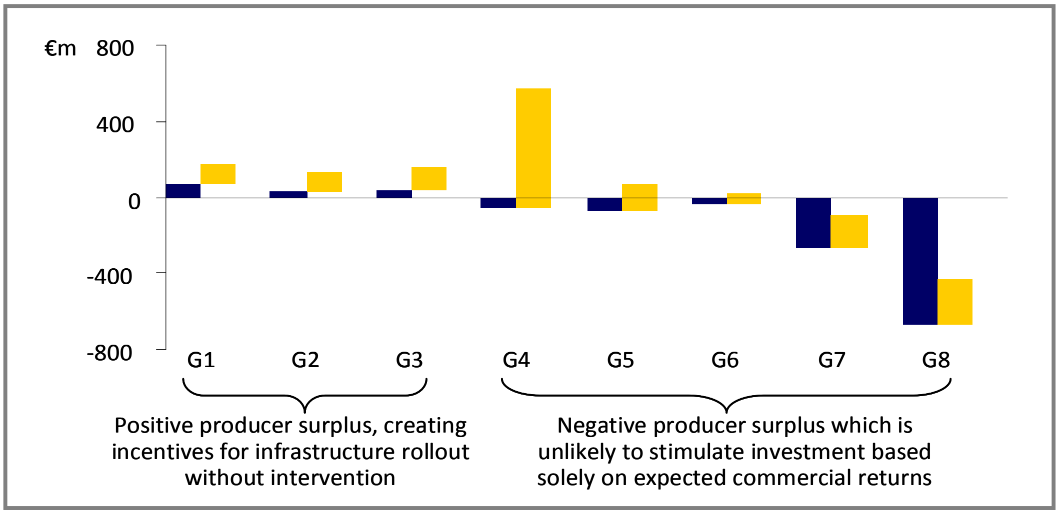
Much of the discussion of the value of higher speed broadband compares *total* costs and benefits. However, the critical question for a given government intervention is whether the *incremental* gains from the investment (the value derived from the upgrade to the base case network in the 'counterfactual') exceed the associated incremental costs. Put another way, even if the total benefits (as measured by aggregate consumer and producer value) exceed total costs, this says nothing about whether society gains, as the project's incremental benefits (over the counterfactual) might be less than its incremental costs. This therefore requires us to develop a robust understanding of what the market will deliver by itself.

A new infrastructure provider is unlikely to deliver widespread high speed broadband without intervention

The cost of deploying broadband varies significantly within a country. More remote and less dense areas will be more expensive to serve than urban, highly populated regions. Given that broadband prices are generally flat nationwide, this means that returns for higher speed broadband investment fall rapidly outside urban areas.

For instance, based on an Australian profile of household mix by geography, there is unlikely to be a significant commercial motivation for a *new* infrastructure provider to invest in widespread roll-out of fast or superfast broadband (note that we discuss the comparative incentive for an incumbent provider in the following section). This is illustrated below.

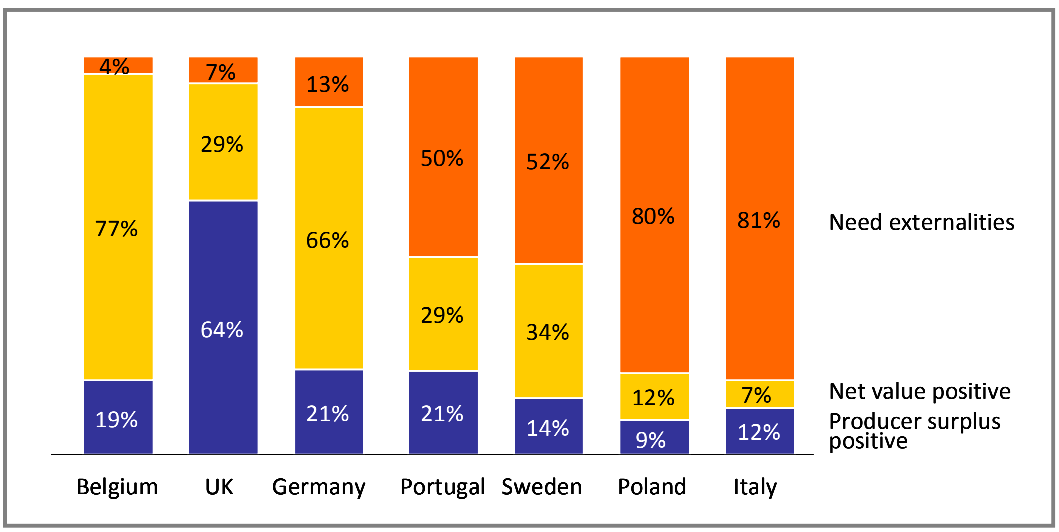
Figure 6: Market incentives to provide high speed broadband for a new monopolist infrastructure provider in Australia (2020)[16]



A positive producer surplus (expected revenue from the sale of broadband access services less costs) exists only in first three geographic areas (or, geotypes 1-3), which represent approximately 20% of households. For the remaining 80% of households (geotypes 4-8), the producer surplus is negative.

In European countries with less population living in dense urban areas, such as Sweden and France, the case for extended roll-out is similarly weak. In these countries, a direct commercial incentive exists for less than 20% of households.

Figure 7: Market incentives to provide superfast broadband for a new monopolist infrastructure provider in various EU countries – percent of population (2020)[17]



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[16] Assumes aggressive pricing such that the retail price of superfast broadband reflects only a small premium over standard ADSL broadband in 2020. ADSL assumed to be universally available

[17] Assumptions as for Figure 6

We note that in Sweden and France the availability of fast and superfast broadband is already higher than that predicted to be delivered by the model in 2020 (currently 21% and 16% respectively). However, this has been driven by a combination of government intervention, historical artifact and non-financial drivers, rather than the existence of direct commercial incentives. In France, for example, superfast (FTTH) roll-out by non-incumbent operators such as Iliad and NeufCegetel has been fuelled by the bundling of higher value IPTV services with broadband access in urban areas. In Sweden, innovative municipality-sponsored roll-out schemes have subsidised open access superfast networks in towns such as Västerås.

We should note that this result is dependent on certain assumptions that may be optimistic:

- That the new entrant has a broadly similar cost base to the incumbent, and in particular has access to ducts on favourable terms
- That the new entrant can rely on no competitive response from the incumbent (duplicated high speed networks would significantly reduce the new entrant's returns in geotypes 2 to 3)
- That the moderately positive returns available are sufficient to justify the capital put at risk (though note that a cost of capital has been included[18]).

Thus overall it seems unlikely that, without intervention, roll-out would go beyond the first three geotypes, and indeed could be appreciably narrower. A new infrastructure provider is unlikely to deliver widespread roll-out of fast or superfast broadband based purely on commercial incentives.

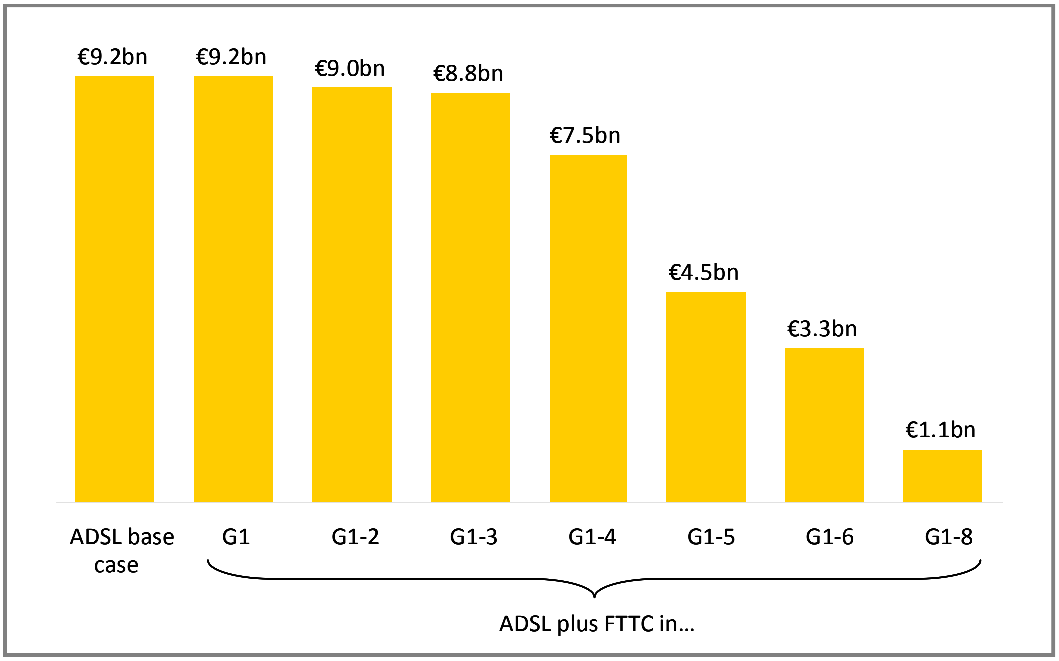
Incentives for investment are extremely weak for incumbents

The incentives for widespread deployment of high speed broadband are weak for new infrastructure providers, but are even weaker for incumbents who already operate standard speed broadband networks. For these incumbents, roll-out of high speed broadband services to areas already served by standard speed broadband will result in cannibalisation of revenues, further eroding incentives to invest (unless, of course, a third party is already threatening those standard broadband revenues by building its own fibre network).

This is illustrated in Figure 8 below. Based on a German geographic profile and infrastructure, an incumbent will realise a producer surplus of around €9.2bn per annum through its standard broadband network. Given costs of deployment and cannibalisation of revenues (either wholesale or retail), providing a fast broadband network will erode this surplus, even at a price premium.

[18] In our model we have assumed a cost of capital of 12% for all broadband deployment. We have not adjusted the cost of capital to reflect higher risk premiums for fast and superfast broadband networks

Figure 8: Producer surplus from fast FTTC broadband deployment, versus base case in Germany[19]



For example, if the incumbent were to deploy a fast FTTC network in geotype 1, producer surplus would fall by around €10m per annum. If an incumbent deployed fast broadband to the whole country, the model suggests that producer surplus would fall by €8bn per annum, or 88%.

Contrast this to the results in Figure 7, where a market incentive for a *new entrant* exists to provide *superfast* broadband to 21% of households (assuming duct access). The incentives for a new entrant are greater than for an incumbent as they will not be concerned with cannibalisation of standard broadband revenues.

Indeed, the very presence of incentives for a new entrant may result in deployment of competitive high speed broadband networks for the most urban regions. This has certainly been the case in countries such as the UK, where Virgin Media have deployed fast cable networks in the first two geotypes, in part to cannibalise revenues from the incumbent BT. BT has attempted to counter the threat by announcing its own plans to deploy a fibre network (to a broadly similar geographic footprint).

The benefits of copper switch off will help the deployment of broadband, but initially only in urban areas

Commentators have pointed to the benefits of copper switch off (CSO) as an incentive for upgrading broadband networks. Migrating all consumers to a high speed (fibre) network and

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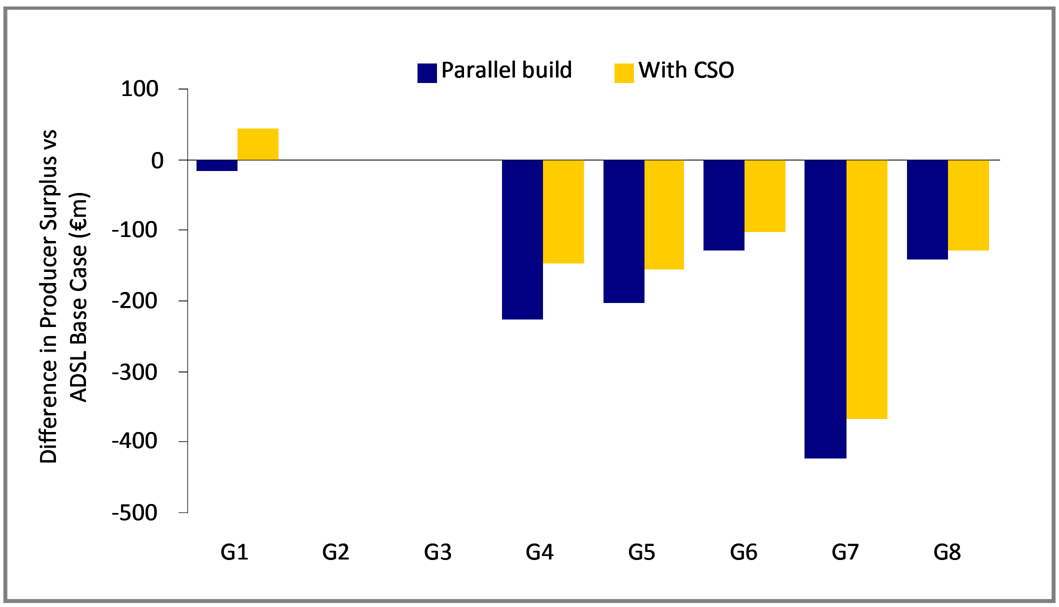
[19] Based on German geotype profile and infrastructure in 2020. Base case assumes 100% coverage from one standard ADSL broadband network.

switching off the standard copper network would allow an incumbent to enjoy reduced operating costs and release value from the copper itself, land and buildings.

Based on our analysis, a monopolistic incumbent in a country with, say, a Portuguese topography will have no direct commercial incentives to invest in *parallel build* of a superfast broadband network. This is illustrated in Figure 9 below, where the incremental producer surplus for parallel build is negative for all geotypes.

If the benefits of CSO are taken into account, and consumers are migrated to the new high speed network on a geotype by geotype basis, the commercial incentives for the incumbent improve. However, the improvement is sufficient to flip the producer surplus positive only for geotype 1 (21% of households in Portugal). In this most dense region an incumbent may be incentivised to roll-out superfast broadband and to transition customers onto a superfast network, but elsewhere the prospect of CSO is insufficient to turn the fibre business case positive.

Figure 9: Change in producer surplus with and without the benefits of CSO (Portugal)[20]

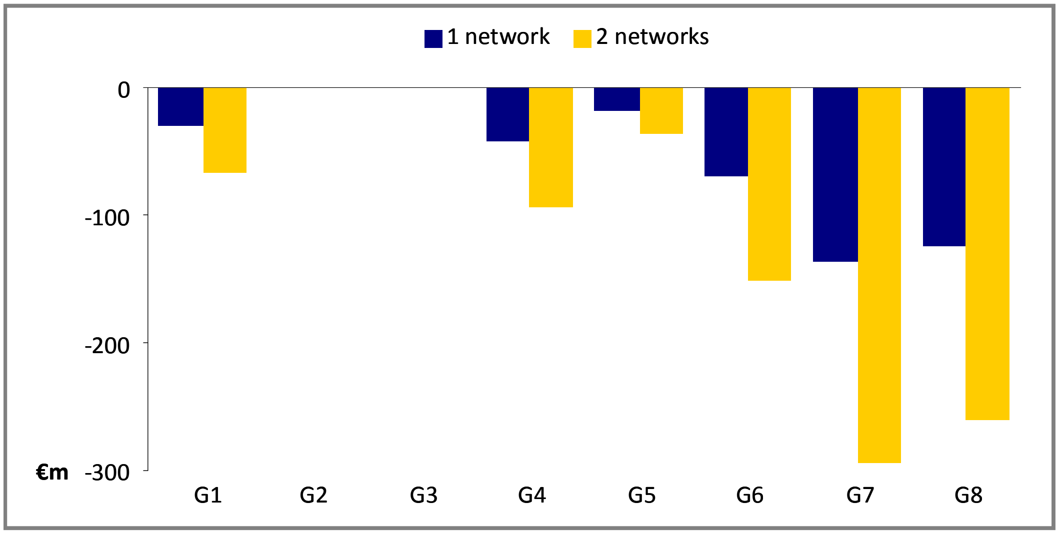


Competition from multiple networks is likely to adversely impact on total value

Multiple providers within a geographic region are likely to erode aggregate producer surplus, since network duplication provides additional cost without direct additional value for the providers. (Note that we have not sought to quantify the impact of competition leading to greater adoption through, for instance, greater marketing). This is illustrated in Figure 10 below, based on Sweden's geographic profile.

[20] Based on geotype profile of Portugal and deployment of superfast FTTH in 2020

Figure 10: Incremental producer surplus over standard broadband only, one or two fast broadband networks, based on Swedish household geotype mix[21]



Fast broadband roll-out generates a negative producer surplus for all geotypes even if there is only a single fibre network, but that loss increases significantly if a second network is added. Put another way, the necessary subsidy to incentivise fast broadband roll-out would be much larger.

Of course, in most circumstances it is axiomatic that more competition will ultimately lead to a better outcome for consumers. However, if the effect of competition is to create or increase a negative producer surplus, then in this context it simply increases the subsidy necessary to enable roll-out. Moreover, regulators with an eye to the long term should be seeking to maximise consumer *and* producer surplus, not just the former.

In different ways, Australia and Singapore's broadband plans recognise the impact of competition on potential fibre roll-out, essentially by creating (to a greater or lesser extent) de-facto monopoly providers of infrastructure, with retail providers riding on top.

Given the lack of clear market incentives, government subsidy may be required to stimulate deployment

Government policies broadly fall into the two main categories: supply side and demand side policies. Our focus in this report is on the supply side - where governments invest in infrastructure or tailor their regulatory action so as to improve provision[22].

Given that in most geotypes deployment of higher speed broadband infrastructure results in a producer deficit, particularly for the incumbent, a supply side subsidy may be required to offset the net loss.

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[21] Based on fast broadband retail prices and take-up in 2020, in a country with Swedish geotype profile and deployed alongside one ubiquitous standard ADSL broadband network.

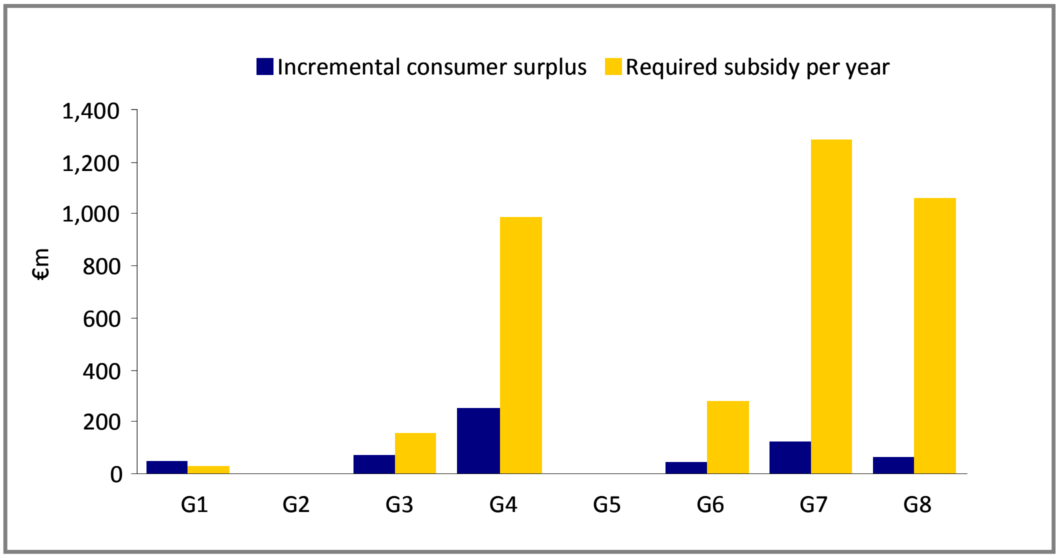
[22] We note, however a range of demand side options also exist (for example, improving skills or awareness, subsidising equipment and so on). See Plum (2010) for a more detailed discussion

The case for subsidy varies by region

In many geotypes, deployment of high speed broadband results in a net producer deficit. To provide a commercial stimulus to infrastructure providers for these regions, a subsidy may be required to offset these deficits. The per-household subsidy requirement will increase for less dense populations.

This is illustrated in Figure 11 below, where the annual subsidy required to offset the producer deficit increases, relative to the producer surplus, as coverage of superfast broadband increases.

Figure 11: Consumer surplus and subsidy requirement for superfast broadband, Polish geotype profile[23]



Given that the case for subsidy varies by region, government intervention through subsidy should therefore, at the very least, be targeted to those regions where the case is strongest:

- In regions where the consumer surplus exceeds the producer deficit, there is a case for subsidy based on consumer surplus alone. In other words, if only private value (consumer and producer surplus) is considered, society would still benefit from government subsidy. In the example above (based on a Polish geotype profile in 2020) this private value subsidy case applies for the first geotype only. Thereafter the required subsidy is greater than the consumer value.
- Beyond this point, consumer surplus alone does not justify the subsidy investment. To justify further subsidy to stimulate wider roll-out, a government must believe there are additional benefits which are not captured in the private transaction – externalities. From an aggregate societal perspective, the wider the deployment is, the greater the externality value that is required to justify the subsidy in each region.

[23] Based on Polish geotype profile and infrastructure. Subsidy requirement equivalent to producer deficit for superfast FTTH broadband deployment within each geotype in 2020.

In the example above, externalities per connected households in the final, most remote area would have to be around €105 per month to justify subsidising roll-out.

Overall, our analysis illustrates the importance of geography in broadband policy. Despite this, regional targeting is, at best, peripheral the broadband policies of most central governments. The European Commission refers to "white", "black" and "grey" zones based on the number of existing broadband providers, but we believe a more geographically targeted approach should play a much greater role.

De-averaged prices may provide further investment incentives

Once a decision has been made to roll out to a particular area (either with or without subsidy), societal value will be maximised by signing up all households for whom externalities plus consumer value is greater than the marginal cost to serve. Given the low variable costs of telecoms, this may be virtually all customers. However, to persuade the tail of customers (those with low consumer value) to sign up would require aggressive pricing, which, if applied on a flat rate basis, would likely severely damage the producer surplus. This points to the importance of pricing flexibility or targeted consumer subsidies as tools for maximising societal value[24].

In our model we assume a flat national price for broadband. This assumption is consistent with actual practice in most countries, with price discrimination very rarely permitted by regulators. However, our analysis implies that in rural areas where the market is unlikely to provide on its own, it may be possible to offset negative producer surplus through higher prices. In other words, allowing higher retail prices in less densely populated areas could act as a partial alternative to government subsidy. This is supported by evidence from Finland, where broadband providers will be expected to fund ubiquitous roll-out without government assistance, but will not be subject to the prohibition of geographic price de-averaging that is prevalent elsewhere.

Whether or not geographic de-averaging is likely to improve market incentives to deploy broadband networks will depend, in part, on the consumer demand curve and whether rural users have higher valuations of broadband. We believe that further research in this area would be beneficial.

Trade-offs between coverage and network capability

Given the costs of deploying broadband infrastructure, trade-offs between breadth of coverage and network capability typically need to be made. From a government's perspective, an important question is therefore what combination of roll-out and network capability maximises value.

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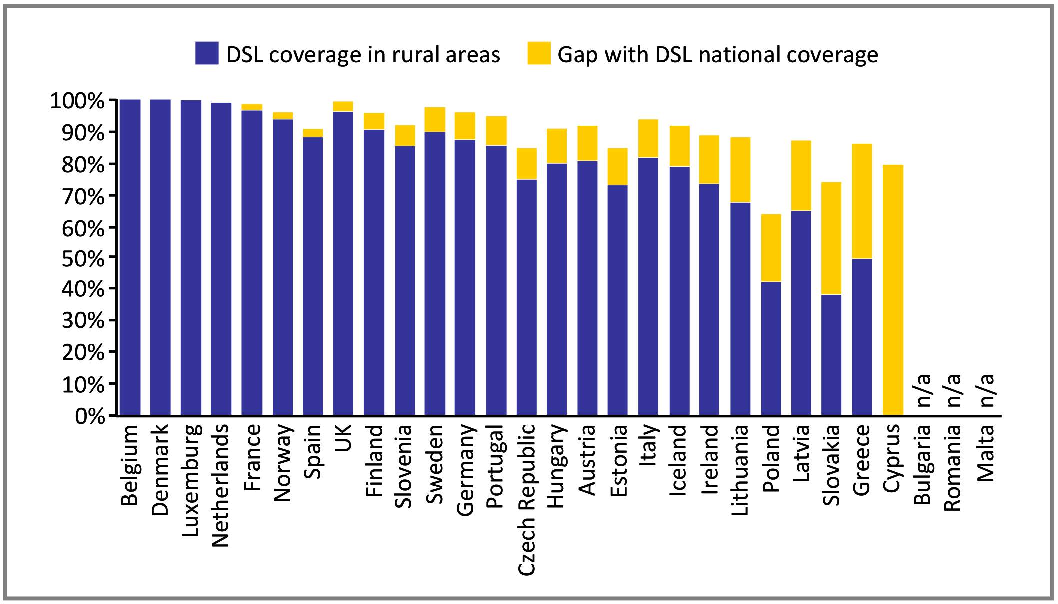
[24] There is an argument that broadband can be viewed as a public utility like street lighting, where low variable costs and high externalities argue for it to be funded directly from tax revenues.

There are benefits to ubiquitous rollout of standard broadband, but the case for investment without intervention is unclear

In most EU countries there has been widespread deployment of standard (typically ADSL) broadband. However, there remains a material number of households who do not have broadband coverage of any speed, particularly in rural areas (those above the blue shaded areas) but even in some urban areas (those above the yellow shaded areas).

Figure 12: Standard broadband coverage in rural areas by European country, 2008[25]



Policy makers frequently stress the importance of universality of broadband access. Germany intends to reach its entire territory with a 1Mbps service. The United Kingdom has set a target of 2Mbps for ubiquitous access. Last year, Finland passed a law making access to broadband a legal right for its citizens, guaranteeing every person access to a 1Mbps broadband connection[26]. The question this raises is what the relative cost and benefits of fulfilling such universal service ambitions are.

Based on a UK infrastructure where broadband is available for 97% of households, we consider the consumer and producer benefits of ubiquitous (100%) deployment of standard broadband. This is illustrated in Figure 13 below.

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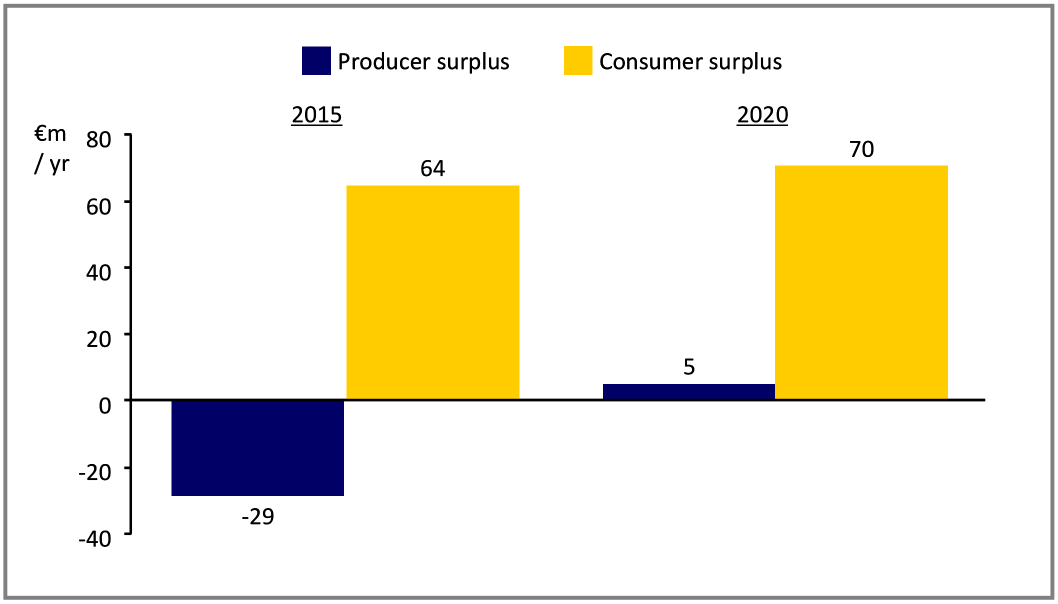
[25] Source: IDATE, Broadband Coverage in Europe 2008. Note that DSL coverage refers of the percentage of households dependent on an exchange which is equipped with a DSLAM. This figure therefore over-counts broadband availability (some of these homes may be too far from the exchange to obtain a standard ADSL broadband connection)

[26] The Finnish example is unusual in that no public funds have been allocated to subsidise the USO roll-out. Instead, Finnish operators are not required to geographically average their retail prices, as is the case in the rest of Europe. As a result, providers such as Sonera, the incumbent, may vary their fees in rural areas in order to charge the value-maximising price that best offsets the costs of roll-out to the final 4% of households

Figure 13: Producer and consumer surplus per year from deployment of standard broadband to the final genotype, UK[27]



Our analysis shows that considerable consumer surplus is realised by roll-out to the final 3% of households (before considering externalities). The incremental consumer value also increases over time, driven by falling access prices, crystallisation of demand and increased take-up. Between 2015 and 2020 the total consumer surplus accruing from the final geotype increases from €64m to €70m.

However, whether universal standard speed broadband deployment will be delivered by the market without intervention is less clear.

In 2015, providing standard broadband to the final tranche of the most remote households results in a net loss of €29m per year for a monopolistic supplier. By 2020, producer value increases to a nominal €5m per year thanks to decreased costs and increased demand, but given the certain roll-out costs required (around €435m in total capital expenditure to serve the final 3%[28] under a fixed infrastructure) and uncertain demand, it is questionable whether such an approach would be seen as viable by an infrastructure provider.

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[27] Based on a UK geotype profile and infrastructure in 2015 and 2020. Assumes no fast or superfast broadband is available to the final 3% of households.

[28] Source: Ingenious Consulting Network estimate based on Analysys Mason (2008) cost forecasts. Our analysis assumes costs that are equivalent to FTTC broadband since these locations are typically too far from exchanges to receive standard ADSL services. The 2009 Digital Britain report states that “to address these remaining homes [those without 2Mbps connections] will require a mix of professionally assisted consumer home solutions, professional home engineered solutions, fixed network engineered solutions, and wireless network engineered solutions (including satellite)” and that approximately 420k UK homes could be connected by “long telephone line resolved by FTTC upgrade”.

There is a subsidy case for universal roll-out of standard speed broadband, irrespective of the perceived value of externalities

Given that the producer loss in 2015 is more than offset by the increase in consumer surplus, there is a case for government subsidy in the final 3% based on private value alone. Naturally the case would be even stronger if externalities were factored in, and there may be felt to be particular societal value from enabling universal availability of broadband (e.g. increased social inclusion).

If the combination of consumer benefit and externality value made a compelling case for government intervention to support universality, there remains the question of how it would be most effectively achieved.

Given the significant costs in connecting the most remote households to a fixed broadband infrastructure, alternative wireless technologies may be a more viable mechanism for reaching universality. The Irish government, for example, has awarded a contract to Hutchison 3G to provide broadband to the final 10% of population. 3 are adopting a hybrid wireless/satellite approach, rolling out HSDPA services to the majority of this 10% and partnering with satellite provider Avanti Communications for the remainder.

Based on the UK infrastructure, providing broadband to the final 3% will yield a higher return than extending fast and superfast broadband coverage

Although the benefits of rolling-out standard broadband to the final group of households outweigh the costs, this does not necessarily mean that subsidising basic broadband universality is the value maximizing approach. To test this, it needs to be considered against a range of alternative policies, including further deployment of fast and superfast services.

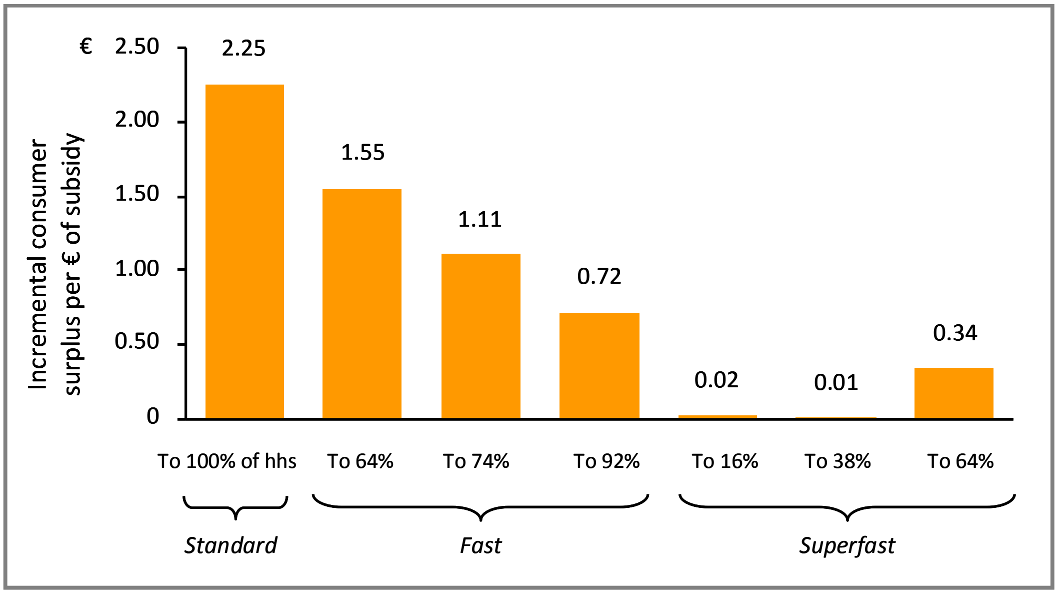
We compare the required level of subsidy and the corresponding incremental consumer surplus for a range of deployment options, based on a UK infrastructure profile in 2015. We assume the market has already provided fast broadband to the first 38% of households (geotypes 1 and 2)[29].

The results are illustrated in Figure 14 below for the following subsidy options:

- Standard broadband to the final 3%
- Fast broadband to the areas where it is not already available, namely geotypes 3, 4 or 5 (where we assume that existing infrastructure providers BT and Virgin Media will not deploy fast broadband services)
- Superfast broadband to the three most urban geotypes (1, 2 or 3)

[29] This broadly represents the expected broadband infrastructure in the UK in 2015 given BT and Virgin Media deployment plans for higher speed broadband services

Figure 14: Relative effectiveness of each € of subsidy for a range of deployment options based on expected UK infrastructure[30] [31]



Based on the analysis, we find that:

- The most effective approach is to extend the coverage of standard broadband to the final 3% of households. For each €1 of subsidy, €2.25 of incremental consumer value is created.
- Given the existing provision of fast broadband services in the most urban areas (geotypes 1 and 2), the case for investing in superfast broadband services in these regions is very weak. Competition from fast broadband reduces the number of customers for superfast, and moreover reduces the incremental consumer value for those customers (who would otherwise receive the benefits of fast broadband).
- Any remaining subsidy after support for universal standard broadband deployment would be most effectively employed in encouraging deployment of fast broadband services to the most densely populated areas in which it is not already available.

Of course, this analysis ignores the impact of externalities. The question of which approach has the greatest overall societal benefit therefore depends on your perception of the value of externalities under each option. Taking an arbitrary assumption that the externalities created by basic broadband are €10 per connected household per month, a government

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[30] Based on a UK geotype profile in 2015. Compared to a counterfactual of standard broadband coverage to geotype 7 (available to 97% of households) and fast broadband to geotype 2 (available to 38% of households). Assumes that subsidy is equivalent to the producer deficit associated with the infrastructure deployment.

[31] For any broadband policy where the incremental consumer surplus per € of subsidy is greater than one, there is a case for subsidy without the need to consider the value of externalities. Where the value is less than one, you need to believe in the presence of externalities to justify the subsidy investment.

would need to believe that the externalities resulting from fast broadband are approximately €23 higher in order to prefer fast broadband to G3 rather than basic to G8. This figure seems very high relative to the €10 for basic broadband, suggesting that even once externalities are taken into account, extending basic broadband is likely to be preferable to fast broadband roll-out.

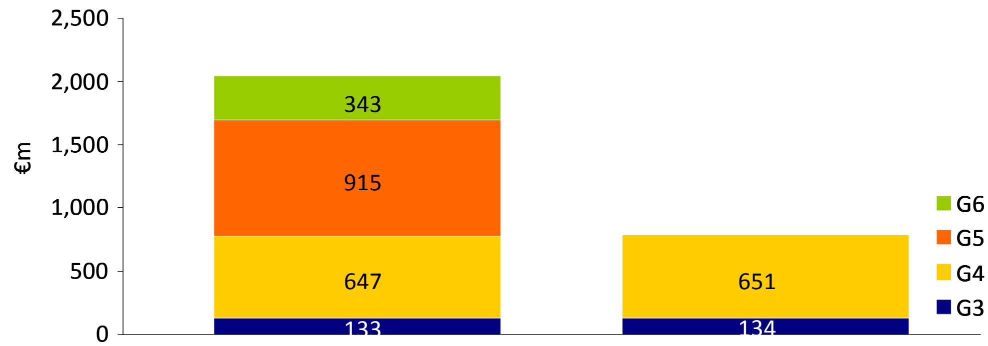
Any analysis should also take into account the longer term benefits (and costs) of intervention. For example, it is argued that superfast broadband provides a more 'future proofed' solution than other options. However, this, in itself, is not an argument for deployment of superfast networks. Rather, the assumed future benefits need to analysed and considered in reference to a cost-benefit framework such as that previously discussed.

Distribution of value varies based on the technology adopted

In the example above, subsidising the deployment of superfast broadband to the first geotype releases less consumer surplus, € for €, than deploying fast broadband to the next underserved regions. However, in addition to considering the absolute value of the consumer surplus, governments may well be interested in how evenly and fairly a given consumer surplus is distributed.

For example, Figure 15 illustrates the choice for the German government facing the choice between spending approximately €1.5bn per year on either superfast or fast broadband. For the purposes of this comparison, we have assumed that the market will provide fast or superfast broadband in urban areas (geotypes 1-2, around 17% of the population), and that a government would only consider subsidy outside these areas.

Figure 15: Comparison of consumer surplus generated by government subsidy towards fast and superfast broadband infrastructures in Germany, outside urban areas[32]



Infrastructure	Fast broadband in geotypes 3-6	Superfast broadband in geotypes 3-4
Required subsidy per year	€1,569m	€1,479m
Estimated take-up of all hhs	Fast bb: 16.1m (40%)	Superfast bb: 4.8m (12%)

A government investing a subsidy of €1.6bn per year in fast broadband would generate over €2bn of incremental consumer benefit, whereas investing €1.5bn per year in a superfast network generates less (c. €1.3bn) additional consumer surplus. Ignoring any discussion of externalities, this suggests that if this government is considering subsidising a single technology, investment in fast broadband, rather than superfast broadband, is most cost effective.

However, what makes the case for fast rather than superfast broadband even stronger is that the benefits are much more evenly distributed:

- The subsidy of fast broadband supports roll-out in geotypes 3-6.
- The superfast broadband subsidy only reaches geotypes 3 and 4.
- Moreover, superfast broadband is used by a smaller group within covered areas – those with the highest willingness-to-pay.
- The net result is that the benefit of the fast broadband subsidy is shared by 16.1m users, as opposed to superfast broadband, which is confined to 4.8m users.

Thus in order to prefer a superfast investment, our hypothetical German policy maker would have to believe that the externalities per superfast line were sufficiently greater than the fast externalities to compensate for:

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[32] Based on a German geotype profile in 2020. Compared to a counterfactual of standard broadband only (i.e. assumes that there is no existing fast or superfast broadband available). Assumes that subsidy is equivalent to the producer deficit associated with infrastructure deployment.

- The fact that those externalities will be received from only 4.8m superfast lines, as opposed to the potential 16.1m fast lines
- The €1.3bn greater consumer surplus created by fast broadband
- The greater equity in distribution of the fast broadband benefits

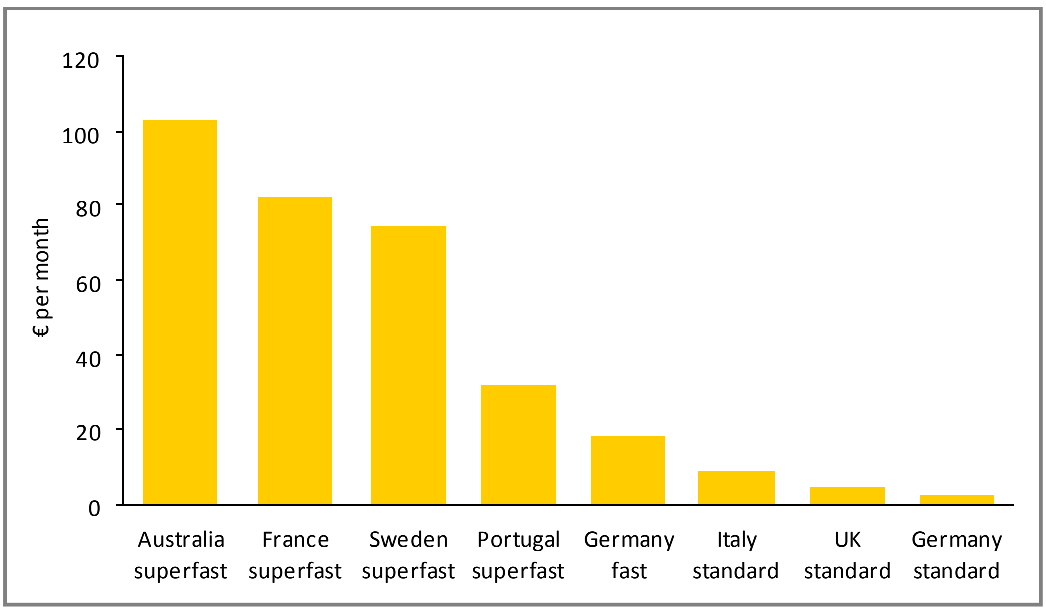
Assessment of current broadband policy in selected countries

In this section of the report, we compare and contrast actual broadband policy from a selected range of countries with outputs (admittedly indicative) from the model, considering countries with ambitions for superfast, fast and standard broadband deployment in turn.

Overview of subsidy requirements, by country

Governments around the world have been addressing the question of broadband roll-out through national broadband policies, which combine coverage targets with regulatory concessions and public subsidy. Based on our model,Figure 16 illustrates the scale of subsidy required to offset the producer deficit created by national broadband plans in the final geographic region served. Countries modelled range from Australia's commitment to 90% super-fast deployment down to Germany's subsidised roll-out of standard broadband to 100% coverage.

Figure 16: National broadband plans – necessary subsidy per month per connected household in the final geotype[33]



[33] Assumed to be equivalent to the value of the producer deficit in the final connected geotype; in other words, the subsidy required to provide a commercial incentive for deployment, absent of additional motivations (competitive advantage) or a "deadweight loss" to intervention.

In some of the above countries, our model suggests that the incremental consumer surplus created offsets the producer deficit. Therefore, a societally beneficial case for subsidy can be made without recourse to externalities.

For other national broadband plans, consumer surplus alone does not justify the subsidy investment. In such cases, a government must believe there are additional benefits which are not captured in the private transaction – externalities - to justify further subsidy to stimulate wider roll-out.

Through our analysis we have estimated the minimum value of externalities required to justify subsidy investment. This is based on the differential between total value created (producer value plus all consumer value) less all producer costs, as illustrated below.

Figure 17: Overview of approach used to calculate externalities required[34]

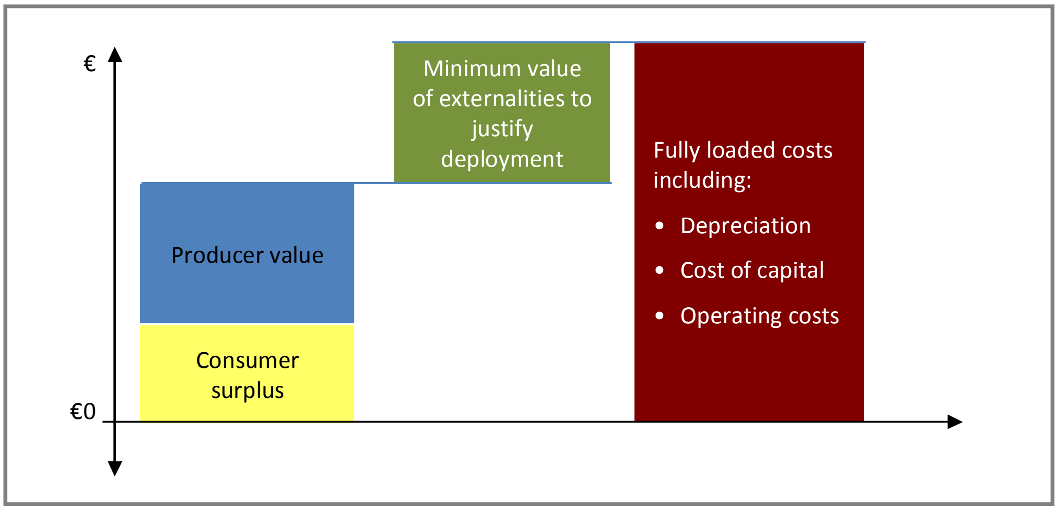


Figure 18 illustrates the value of externalities required to justify subsidy in the last connected geographic area.

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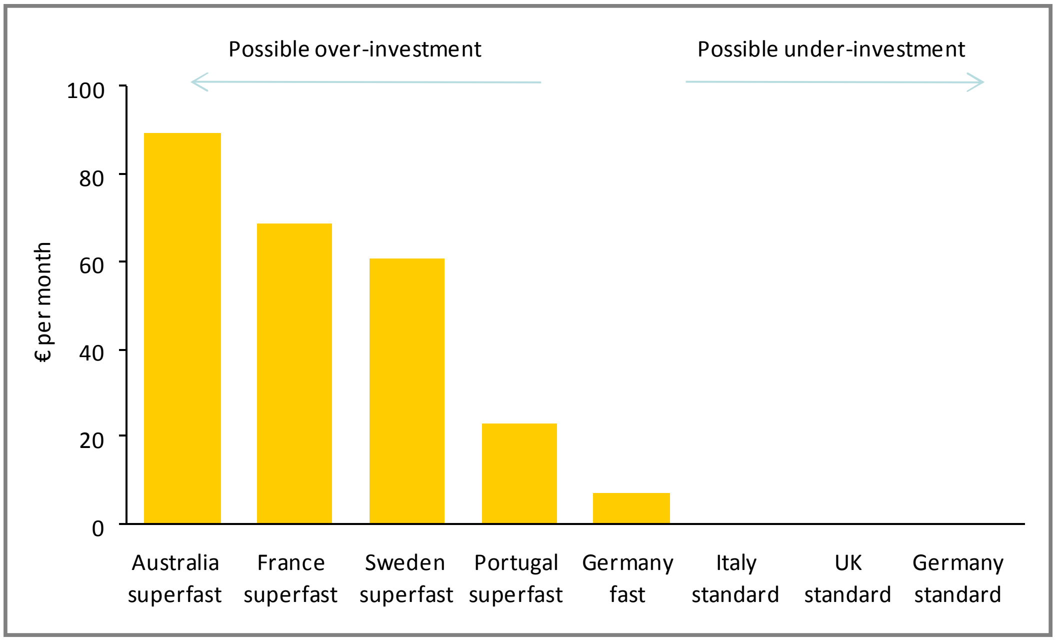
[34] Note that our analysis does not take into account non-financial consumer costs or any "deadweight" loss resulting from intervention.

Figure 18: National broadband plans – required externalities per month per connected household



At one extreme, Australia's ambitions for 90% coverage of superfast broadband mean that the *incremental* externalities of superfast broadband would need to be around €90 per connected household per month to justify a roll out this extensive[35]. Given the vast range of capabilities of a standard broadband connection, this seems a very high figure for the further value of superfast broadband.

At the other extreme, the broadband policies for ubiquitous basic broadband roll-out in Italy, the UK and Germany can be justified based on a belief of increased consumer surplus alone (which more than offsets the producer deficit). Indeed, the policies of Italy and the UK, which in the short term focus on the deployment of ubiquitous standard broadband, may be an underinvestment[36]. While the externalities are hard to quantify, there is little debate that they exist, and one would expect an optimal level of investment to be associated with an assumption of at least some externalities.

A fundamental issue when assessing broadband policy is therefore the value of the *incremental* externality resulting from network deployment.

By considering different levels of incremental externality, we can estimate the potential loss from some of the more aggressive broadband policies. For instance, if you believe the incremental externality of superfast broadband is €10 per connected household per month, then France's proposed roll-out of fibre to 70% of the population could lead to annualised

[35] The deficit includes the loss of contribution from standard broadband subscribers, resulting from their migration to the new superfast broadband network

[36] We recognise the UK's longer term policies to support fast broadband to more rural locations (the UK government's Final Third Project).

loss of over €3bn, compared to a plan focused on regions where the benefits exceeded the costs[37].

Note that we are not suggesting that the policies of countries such as France are in aggregate value destructive, only that the extent of the proposed roll-out is such that in the more rural areas covered, the cost is likely to far exceed the benefits, and thus a more limited roll-out would be much better. In more rural areas, a government must believe in extremely high incremental externality benefits to justify current plans.

Assessment of broadband policy for countries with superfast broadband plans

Several countries have committed large sums of money to extensive superfast FTTH roll-outs. As we have noted, the Australian approach requires subsidy of over €100 per month per connected household to offset producer losses in the most remote geographic area.

France, Sweden and Portugal have also committed to ambitious superfast broadband targets which will require considerable subsidy. Absent of consideration of externalities, our analysis suggests that this money might be better deployed in the short term by extending standard broadband coverage to 100% of households, before deploying fast networks to areas not already served.

That said, this does not necessarily mean that superfast networks are suboptimal from a net value perspective. Firstly, as we have noted, significant incremental externalities may make superfast FTTH rational (although we suggest the incremental externalities would need to be extremely large). Secondly, in countries with high levels of population density, superfast networks may be the optimal broadband infrastructures. For example, in Hong Kong, where the entire population is within the first geotype, our analysis suggests that the market can support four or more parallel super-fast networks without the need for subsidy.

Assessment of broadband policy for countries with fast broadband plans

A further group of countries have centered their broadband ambitions on the provision of fast FTTC or cable networks. For example, Germany has announced plans to deploy fast FTTC broadband to 75% of the population by 2015, and the UK has referred to plans to support roll-out to the "final third" through a part subsidy.

Based on our analysis, this will required subsidy of around €20 per month per connected line in the most remote geographic areas. Given the incremental consumer surplus released, this plan requires policy makers to believe in externalities worth €8 per month per connected household in the final geotype.

Existing research into next generation network externalities seems to suggest that this is not unreasonable. For example, Plum for BSG (2008) estimate £500m/year from spectrum

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[37] The value of annualised loss falls as the assumed externality rises, but does not drop to zero until the externality rises to €70 per connected household per month for France, and around €90 for Australia

efficiency (though admittedly in the long term), which equates to just over €4 per connected household per month[38] [39].

Other countries are relying on the market to deliver fast broadband networks, such as Belgium and, in part, the UK. While, evidently, such an approach does not require public subsidy, it may be overly conservative, constraining the realization of consumer surplus and positive externalities.

Assessment of broadband policy for countries with standard broadband plans

Countries aiming to reach standard speed broadband ubiquity include UK, Germany, Italy, Finland, Ireland and many others.

Based on our models, the increase in consumer surplus created by deploying standard broadband to the final underserved or unserved areas more than offsets the producer deficit. This suggests there is a clear case for subsidy, irrespective of whether policy makers believe in externalities resulting from the deployment.

Furthermore, as our previous analysis based on the UK has illustrated, investment in providing broadband to the final geotypes may actually the most effective approach to deployment.

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[38] Assuming take-up by 40% of household who have access to the superfast network

[39] Although we should note that these potential benefits of spectrum release could also be obtained through other means, and not solely broadband deployment (e.g. the growth of satellite broadcasting alongside digital terrestrial)

Conclusions

We believe there is a strong case for subsidising the roll-out of basic broadband to all households, and generally this should be the first priority for governments (subject to any market specific issues). We note that in many countries policy makers are instead focused on fibre as the prime recipient of government support.

However, if funds are still available after supporting basic broadband, there is also a case for subsidising fast broadband (whether this be FTTC, cable or even mobile) in those areas where the market is not already providing. That said, in areas with lower population density the case becomes highly dependent on the incremental externalities of fast over standard broadband.

While many countries are supporting fast broadband, frequently this does not appear to be targetted to the areas that most need support, and in certain cases the scale of support is such that it is likely pushing into areas with rapidly diminishing returns.

The case for subsidising superfast FTTH or FTTB broadband is weak. To believe it can create greater societal value than fast FTTC broadband requires an aggressive assumption about incremental externalities of superfast over fast broadband, but even then the societal benefits will be much less evenly distributed. Australia is an example of a country that is nonetheless putting massive sums to work to roll FTTH out to 90% of the country.

Based on our analysis, the *incremental* externalities of superfast over standard broadband in Australia would need to be around €90 per connected household per month to justify a roll out this extensive[40]. Given the vast range of capabilities of a standard broadband connection, this seems a very high figure for the further value of superfast broadband.

These are general conclusions that would need to be considered in more detail by individual countries, taking into account their local circumstances. However, we believe all policy makers should incorporate into their thinking:

- *Consideration of the counterfactual*. The market is likely to provide improved broadband to at least some parts of the country – these areas should not be the focus of subsidy
- *The time dimension*. Both declining costs and maturing consumer demand will expand the number of geotypes for which there is a commercial case to roll out fibre. Immediate subsidy to these areas will accelerate roll-out rather than absolutely enable it, and should be considered in that light
- *The* incremental *benefits and costs*. Basic broadband already provides substantial consumer value and externalities. Investment in overlay fibre networks needs to be justified by the *uplift* in value and externalities from better speed and performance

[40] Taking into account the loss of revenue from the migration of standard ADSL broadband households to the new network

- *Alternative uses of government funds and potential returns* – For instance, even within the broadband arena, demand side stimulus may yield greater value

We recognise that our modelling framework and the analysis provided in this report is only a small first step towards a more rigorous framework for decision making. We believe there are a range of areas where additional analysis could shed further light on broadband policy and the choices faced, some of which are outlined in the appendices to this report.

Overall, we hope that this report has illustrated the value in using a framework for exploring the trade-offs that typically need to be made when formulating broadband policy. We argue that a more structured approach, and greater transparency in setting broadband objectives, will make significant contributions to the debate on optimal broadband deployment.

About the authors

The Ingenious Consulting Network

The Ingenious Consulting Network is a London-based group of advisory businesses specialising in the telecoms, media and technology sectors. Its areas of focus include policy, regulation and strategy, and it works with blue-chip clients such as Vodafone, Microsoft, Telstra, Telecom New Zealand and the BBC in the US, Europe, Asia and Australasia.

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Kip has 27 years of experience in telecoms policy and regulation – as co-founder and MD of Spectrum, a media and telecoms strategy consulting firm, Director of Coopers & Lybrand's Media Practice, Chief Policy Partner at Ofcom (the UK regulator) and as Chairman of the Ingenious Consulting Network. He also chairs the Broadband Stakeholders Group, a UK industry-government forum, and has recently been advising the UK Government as the Spectrum Broker for the Digital Britain review – developing spectrum policy proposals to help expedite the transition to next generation mobile.

Rob Kenny

Rob has extensive telecoms experience, and has recently led projects for clients including Vodafone, Google, the GSMA, Telstra and CSL. He previously headed M&A for Level 3. Prior to this, Rob led sales, marketing, strategy and M&A for REACH (the co-investment vehicle for Telstra and Hongkong Telecom's international businesses) and strategy and M&A for Hongkong Telecom. Rob began his career in consultancy with the LEK partnership, and holds an honours degree in Mathematics and Management Studies from Cambridge University.

Tom Broughton

Tom has a number of years experience in telecommunications and media consulting and has worked with broadcasters, telecommunications companies, regulators, investors and content owners since joining in 2007. Recent clients have included the BBC, Ofcom, CSL, BT and Telstra. Previously, Tom was a senior consultant for Deloitte. He holds a first class degree in Econometrics from the University of Nottingham and is a qualified management accountant.

Richard Thanki

Richard's recent projects have including authoring a report on the current and potential economic benefits of unlicensed - or licence-exempt – spectrum for Microsoft and heavy involvement with Kip on Spectrum Broking in the UK. Previously Richard was a Senior Modelling and Economic Associate at Ofcom. Richard has a degree in Philosophy, Politics and Economics from Oxford and a Postgraduate Diploma in Competition Policy.

Ed Corn

Since joining Ingenious, Ed has worked on the development of next-generation access co-investment structures for Vodafone, a report on the limitations of international benchmarking for Telstra and an assessment of TV's case for digital dividend spectrum for the GSMA. He was also part of the Spectrum Broking team with Kip. Ed has an MA with distinction in Cultural Studies from University of London, and a first in Music from Cambridge University.

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Appendix A : Summary of planned investment in broadband infrastructure by country

Country	Coverage/ Speed	Technology	Spend/ Proposed Financing
Australia	Superfast broadband to cover 90% of the country over the next eight years	Superfast FTTH	Estimated total estimated investment of AUS$43bn (€28.4bn) Government is providing an initial investment of AUS$4.7bn (€3.1bn) although it has stated that it will remain a majority shareholder in the new holding company[41]
Austria	Universal coverage of 25Mbits by 2013[42]	Unspecified	Planned broadband investment of €125m of which €25m will come from the government[43]
Belgium	Cover 80% of the population by 2011 with a fast broadband network[44]	Fast FTTC (VDSL2)	Unspecified
Brazil	As of Aug 2009, the telephony carriers stated that they aim to deploy broadband to 150m people (75% of the population)[45] by 2014 if the Brazilian government updates regulation in their favor[46]	Unspecified	The government has emphasized that it does not want to take the place of private enterprise Although public companies are encouraged to invest, no direct public investments have been made
Canada[47]	Broadband of at least 1.5Mbits to as many of the currently unserved and underserved households as possible	Unspecified	CA$225m (€158.5m) to be provided by the government over three years to develop and implement a strategy to extend broadband coverage to all underserved communities
Denmark	Universal broadband access (of at least 2Mbits) by the end of 2010[48]	Unspecified	The government is committed to a market-based approach and has not made any substantial broadband investments However, there has public-private partnerships for fibre deployment at the regional level (e.g. Djursland.net and Aarhus Network) [49]
Finland	Universal coverage for all permanent residences, businesses and government bodies with an average download rate of 1Mbits by 2010 Superfast networks permitting a 100Mbits connection to 99% of permanent residences, businesses, and government bodies by 2015	Unspecified	Financing for the state contribution for the 2015 target proposed to come from the auction of certain radio frequencies and telecommunications network compensatory payment (in the event of shortfall) [50]

[41] Source: Budget 2009: Government makes initial investment in National Broadband Network, May 2009, Stephen Conroy, available at: http://www.minister.dbcde.gov.au/media/media_releases/2009/041
[42] Source: Progress report on the single European electronic communications market, 2008, European Commission
[43] Source: A review of broadband Internet transitions and policy from around the world, October 2009, Berkman Centre
[44] Source: Summary of the Reactions to the National Consultation on Next Generation Networks and Next Generation Access, 2008, BIPT, Belgium
[45] Note: Based on an estimated total population of 199m as of 2009
[46] Source: Cisco Broadband Barometer, Jun 2009, Cisco
[47] Broadband Programme, 2009, Canada's Economic Action Plan, available at: http://www.actionplan.gc.ca/initiatives/eng/index.asp?mode=3&initiativeID=96
[48] Source: IT and Telecommunications Policy Report 2009, March 2009, The Danish Government
[49] Source: A review of broadband Internet transitions and policy from around the world, October 2009, Berkman Centre

Country	Coverage/ Speed	Technology	Spend/ Proposed Financing
France	Ambitions for 100Mbps superfast broadband to cover 70% of households by 2020 Universal broadband access by 2010 with minimum broadband speed designated at 0.5Mbps	Superfast FTTH	Government will provide €2bn to accelerate superfast FTTH deployment in less densely populated areas, part of a €4.5bn funding initiative dedicated to the digital economy Government announced designation of "universal broadband providers" that would ensure broadband at an affordable price of c. €35/ month[51] (has currently been postponed because of economic slowdown)
Germany	The government's Broadband Strategy adopts a two-step strategic goal, with universal availability of at least 1Mbits by the end of 2010, and availability of 50Mbits to 75% of households by 2014[52]	50% of households with fast FTTC (VDSL) service and 25% with superfast FTTH Mix of technologies for universal 1Mbits[53]	€150m will be provided to local authorities in underserved regions[54]
Greece	Over the next seven years the network is intended to reach 2m (c. 52% of all households)[55] homes with a 100Mbits service	Superfast FTTH	Government announced development of a €2.1bn superfast broadband network in late 2008 (currently delayed due to the economic crisis) One third of this investment (€700m) is to come from the government
Hong Kong	Broadband coverage is to virtually 100% of residential buildings and penetration to ¾ of households	Superfast FTTH	Given high superfast FTTH coverage and universal ADSL coverage, government policies are now focused more ensuring equity of penetration - about €4.0bn was earmarked for general IT spending in the 2007-08 financial year
Japan	The 2008 "Strategy on the Digital Divide" seeks to provide universal broadband coverage[56] The incumbent, NTT has pledged to provide superfast service to 30m (24% of the total population)[57] users by 2010[58]	Mix for the universal broadband target FTTH for NTT's superfast broadband	Japan has committed ¥185bn (€15.0bn) as part of its strategy for "eliminating the digital divide, promoting the development of wireless broadband and fostering digital terrestrial broadcasting"[59]

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[50] Source: Making broadband available to everyone: The national plan of action to improve the infrastructure of the information society, 2008, The Ministry of Transport and Communications, Finland
[51] Source: Progress report on the single European electronic communications market, 2008, European Commission
[52] The Federal Government's Broadband Strategy, Feb 2009, Federal Ministry of Economics and Technology, Germany
[53] Source: The Impact of Broadband on Jobs and the German Economy, 2008 (Katz)
[54] Source: The Federal Government's Broadband Strategy, Feb 2009, Federal Ministry of Economics and Technology, Germany
[55] Note: Based on an estimated total population of 10.7m in 2009 and estimated average household size of 2.8
[56] Source: A review of broadband Internet transitions and policy from around the world, October 2009, Berkman Centre
[57] Note: Based on an estimated total population 127m in 2009
[58] Source: Explaining International Broadband Leadership, 2008, ITIF
[59] Source: A review of broadband Internet transitions and policy from around the world, October 2009, Berkman Centre

Country	Coverage/ Speed	Technology	Spend/ Proposed Financing
Netherlands	Currently has close to 100% coverage Aims to achieve the highest broadband penetration rates in the world by 2010[60]	Unspecified	Unspecified
New Zealand[61]	The government's goal is to accelerate the roll-out of ultra-fast broadband (50-100Mbits) to 75% of households 97% percent of households and enterprises should be able to access fast broadband of 5Mbits or better	Superfast FTTH	Progressive network upgrades will take place over ten years from 2009 and will include government investment of up to NZ$1.5bn (€0.77bn) alongside private sector investment The government also intends to spend up to NZ$300m (€155m) to improve rural broadband
Poland	Goal is to ensure that 100% of households and businesses are within the coverage of broadband infrastructure by 2013 or 2014	Unspecified	Poland will invest €300m under its "Broadband network for Eastern Poland" program (of which €225m is expected to come from the EU's European Regional Development Funds)[62]
Portugal[63]	Aim of the latest programme is for 1.5m homes and businesses to be connected to new fibre networks	Unspecified	The government has announced a €800m credit line for the roll-out of next-generation broadband networks in 2009
South Korea	KT is required to provide broadband access of 1 Mbps or higher to all homes in villages (presumably allowing for near universal coverage)[64] The Korea Communications Commission has committed to a national broadband network offering speeds of around 1Gbits by 2012 on the fixed-line network and 10Mbits on the wireless broadband network	Superfast FTTH	Current South Korean plan calls for an additional US$27bn (€19.9bn) to be spent between 2008-2012 Only US$1bn (€736m) of this amount will be spent directly by the government[65]
Slovak Republic[66]	Goal is to achieve the level of coverage available to developed European countries by 2014 Broadband speed target of 2Mbits (symmetrical)	Unspecified	The government announced a programme to increase the use of high-speed internet across the country by deploying SK240m (€6.4m) in direct subsidies to users in 2006
Sweden[67]	40% and 90% of households and businesses to have access to broadband at minimum speeds of 100Mbits by 2015 and 2020 respectively	Unspecified	The government announced support for broadband initiatives under the Rural Development Programme worth SEK250m (€25.5m) over 2010-2012
Switzerland	Currently has near universal standard (ADSL) broadband coverage In 2008, Swisscom announced plans to bring fibre to 100,000 homes by the end of 2009[68]	Superfast FTTH	In late 2008, Swisscom announced that it would invest CHF8bn (€5.5bn) in FTTH over 6 years[69]

[60] Source: Explaining International Broadband Leadership, 2008, ITIF
[61] Source: Broadband in New Zealand, Ministry of Economic Development, New Zealand, available at: http://www.med.govt.nz/templates/StandardSummary____40551.aspx
[62] Source: A Report on the Condition of the Telecommunications Infrastructure in Poland, 2008, CCIFP
[63] Portuguese Government Approves €800m Credit Line for NGNs, PwC, available: https://www.communicationsdirectnews.com/do.php/140/33928?199)
[64] Source: Explaining International Broadband Leadership, 2008, ITIF
[65] Source: A review of broadband Internet transitions and policy from around the world, October 2009, Berkman Centre
[66] Development of Broadband in the Slovak Republic, Murín & Ščehovič, Research Institute of Posts and Telecommunications, Slovak Republic
[67] Source: Broadband strategy for Sweden, 2009, Government Offices of Sweden

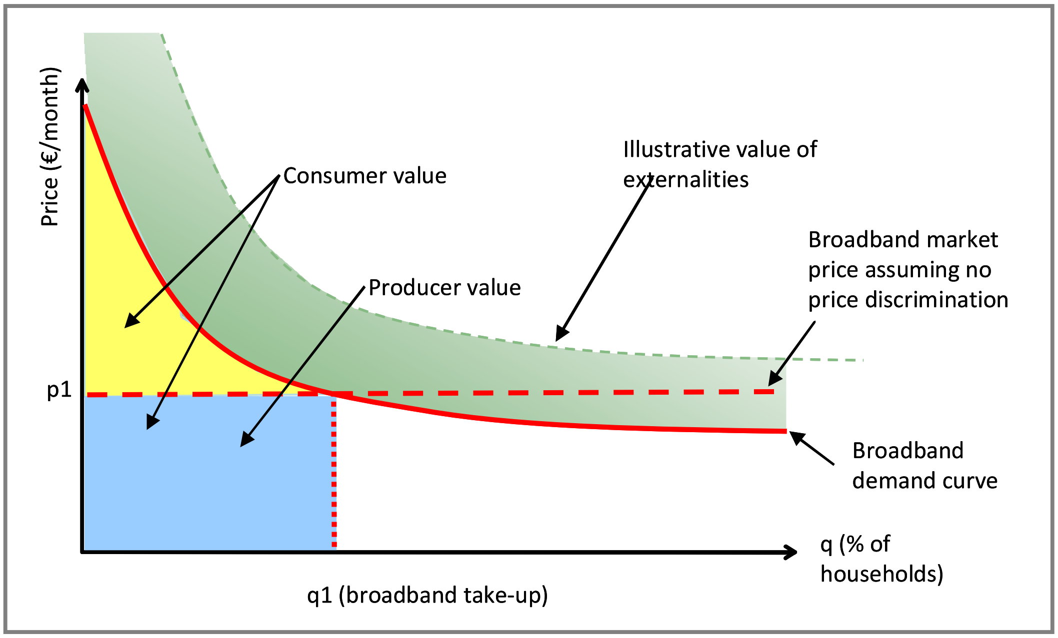
Country	Coverage/ Speed	Technology	Spend/ Proposed Financing
United Kingdom	Universal 2Mbits broadband to all citizens by 2012[70] BT announced plans to build a fast broadband network covering 40% of UK households by 2012	Mix including standard ADSL, fast FTTC, wireless and satellite	Universal 2Mbits broadband will be funded via £200m (€230m) of direct public funding and supplemented by other sources[71] BT's fast broadband network is expected to cost £1.5bn (€1.7bn)
United States	FCC's national broadband plan includes an initiative to equip 100m households (c. 85% of all households) with 100Mbits service by 2020 FCC also aims to improve broadband coverage in unserved and underserved areas	Unspecified	Recovery Act provides US$7.2bn (€5.3bn) to improve the national broadband infrastructure of which US$4.8bn (€3.5bn) will be dedicated to connecting unserved and underserved areas

[68] Source: A review of broadband Internet transitions and policy from around the world, October 2009, Berkman Centre
[69] Source: Swisscom has announced a €5 billion investment in an FTTH rollout, 2008, FTTH Council
[70] Source: Digital Britain Final Report, Jun 2009, available at: http://www.culture.gov.uk/images/publications/digitalbritain-finalreport-jun09.pdf
[71] Source: Digital Britain Final Report, Jun 2009, available at: http://www.culture.gov.uk/images/publications/digitalbritain-finalreport-jun09.pdf

Appendix B : Analytical framework

We consider the value of broadband against the classical economic framework of consumer value, producer value and externalities. These are graphically illustrated below.

Figure 19: Illustrative value created by broadband



Consumer value relates to the sum of the yellow and blue shaded areas (all value from those households who subscribe to the service), consumer surplus is the yellow area, and producer value corresponds to the blue area only (the sum of all revenue generated by provision of the service). Consumer and producer value are the most direct measures of economic benefit from the consumption of a particular good or service.

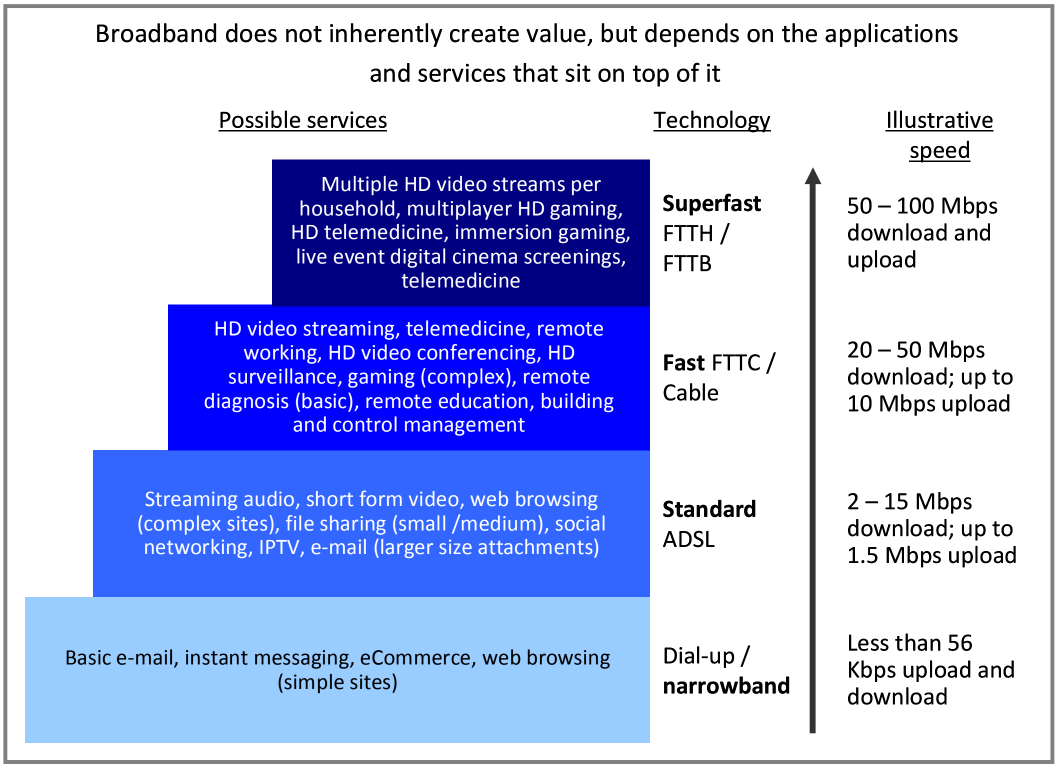
Externalities are represented by the green shaded area above the broadband demand curve as they are not captured in the private transaction between consumer and producer.

Estimating consumer value

Consumer value reflects the benefit to consumers of subscribing to broadband services. This could include the value derived from obtaining access to new content and services, increased household entrepreneurship, time savings etc.

However, in assessing consumer value, it is important to recognise that broadband is a service that is utilised, not in its own right, but as a means of accessing and using applications and services which can directly impact and enrich the diverse range of consumer and business experiences. Broadband services must therefore be viewed as an enabler, and not as an end in themselves. In particular, in assessing the benefits of upgrading the network from standard to fast or superfast broadband, the relevant consumer value created is primarily that associated with the *incremental* services enabled.

Figure 20: Example services enabled by broadband technology



A limit to the incremental benefits of fast and superfast broadband is the continuing improvement of services possible using standard broadband. For instance, Hulu (US), iPlayer (UK), SVTPlay (Sweden), etc. have demonstrated that acceptable IPTV can be provided over standard broadband.

However, fast and superfast broadband have significant advantages in consistency, low latency and upload speeds, which greatly improves the potential for applications such as software-as-service, telemedicine, surveillance and so on. Higher download speeds will enable HD video, and multiple heavy bandwidth users per household.

Offsetting the increased consumer value will be greater consumer costs. These are both financial (monthly subscription charges) and non-financial (time and inconvenience from the set-up, etc.).

In our model, to assess the consumer value associated with different broadband infrastructures, we estimate the willingness to pay curves for standard, fast and superfast broadband. This is based on research by Dutz, Orsag and Willig (2009), who employed two methods to measure household consumer value attributed to standard ADSL broadband in the US: empirical data and consumer research. We then:

- Proxy the consumer demand curve for standard ADSL broadband by a mathematical function (power series functions provide the best fit to the empirical data)
- Estimate the demand curves for fast and superfast broadband services by
    - Assuming these curves could be modelled using the same power series

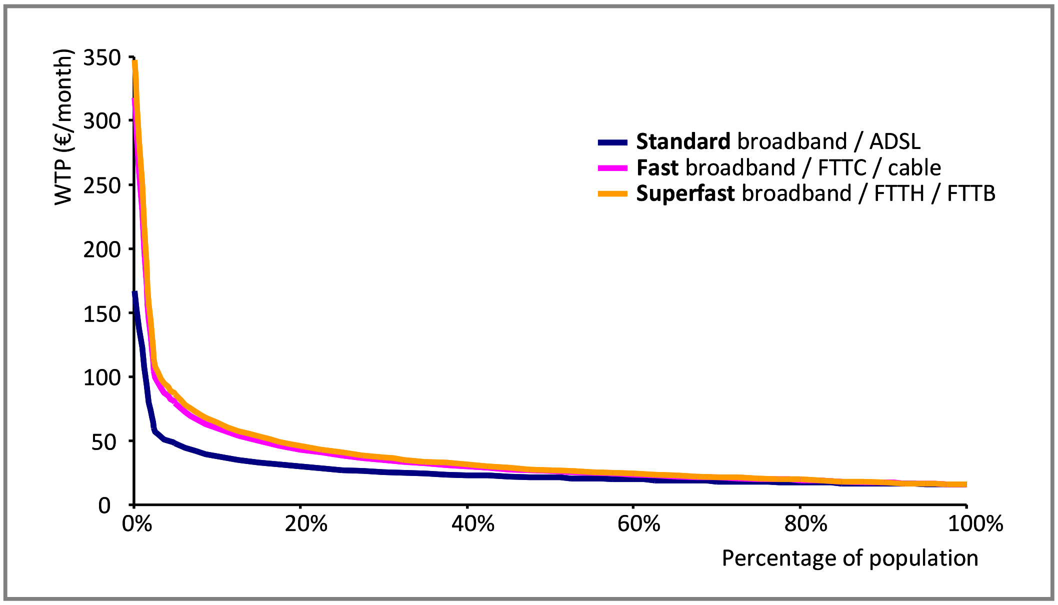
functions; and

- Anchoring these curves using data points on the prices and take-up of fast and superfast broadband services in enabled areas, in particular Hong Kong and Sweden (for which reliable datasets are available).

This provides us with a set of demand curves for standard, fast and superfast broadband.

When using empirical data on current take-up of fast and superfast broadband, significant care needs to be taken. For example, we excluded data from markets where fast and superfast broadband providers are throttling broadband upload speeds (presumably to allow greater segmentation of retail and business customers) as this distorts demand and take-up for a given price level.

Figure 21: Willingness to pay curves for broadband services (2010 forecast)



We have assumed that those who value superfast broadband highest, will also value fast and standard broadband highest. This is consistent with the finding in Dutz, Orszag and Willig (2009) that:

> *"The monthly net additional willingness to pay per household for a speed of 1,000 times dial-up speed for existing broadband users is $31.40, while it is just $21.93, or roughly 43 percent less, for those who currently have a dial-up Internet connection."*

We then estimate take-up of broadband services, based on these demand curves, the market prices of different broadband services[72] and availability of broadband services within each of eight geotypes.

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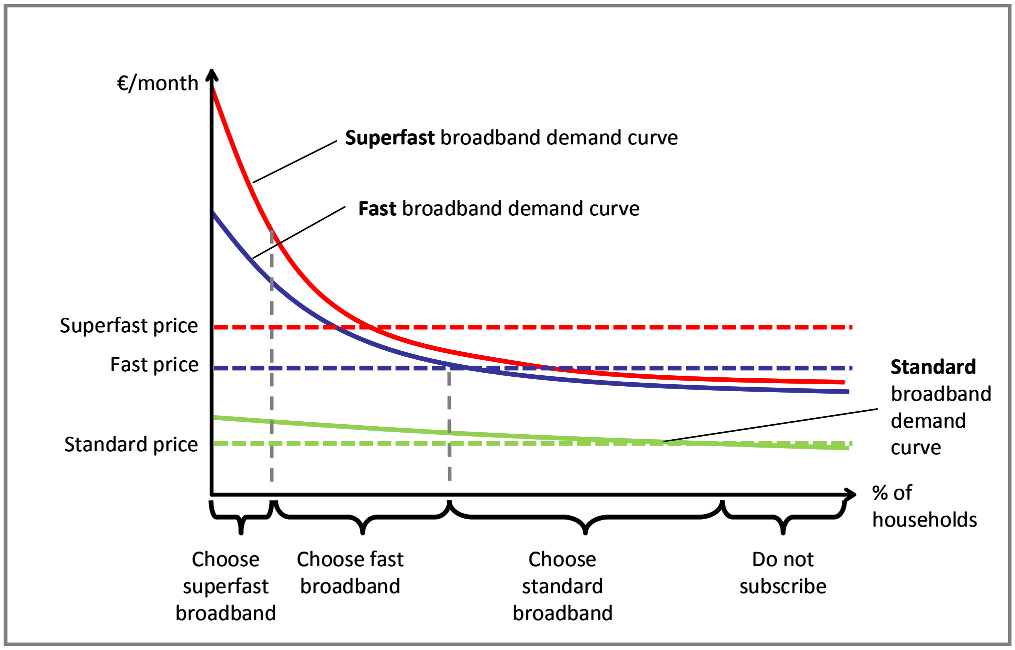
[72] Under the assumption of no price discrimination, we assumed that the retail prices for each broadband service applied to all consumers, within and across geotypes

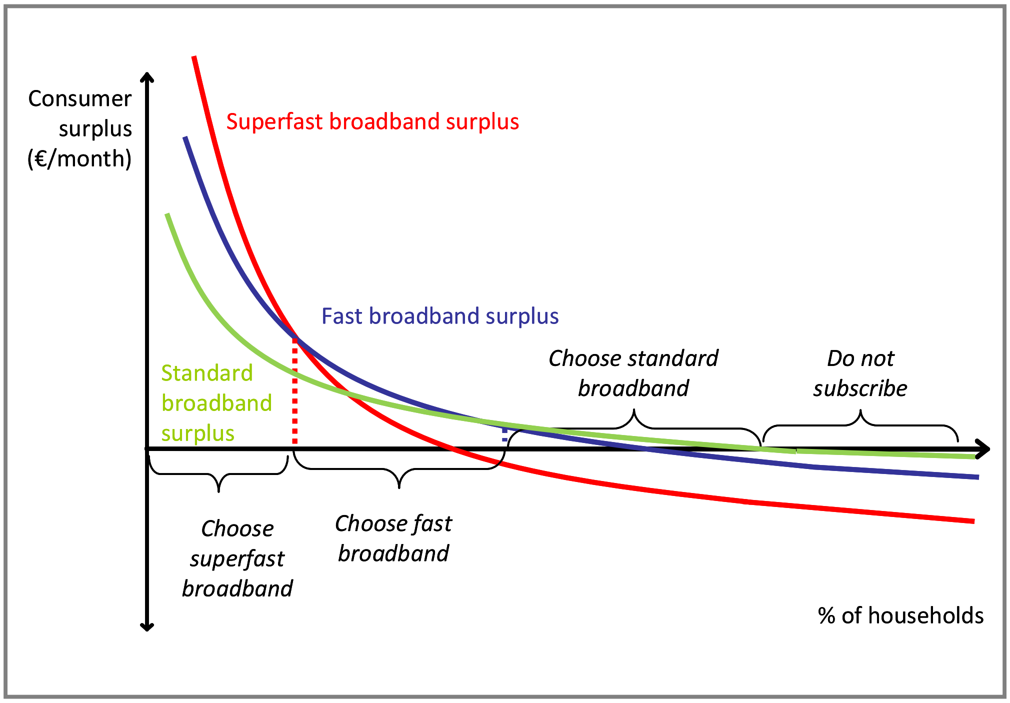
The model assumes consumers subscribe to the broadband service which maximises their consumer surplus; that is, select the technology where the difference between the willingness to pay and the retail price is the greatest. Those consumers whose willingness to pay is less than the retail price for each of the available broadband services do not subscribe to any service.

Figure 22: Illustrative consumer demand by broadband technology



Consumer surplus for each of the following options – standard broadband, fast broadband and superfast broadband – is illustrated in Figure 23 below.

Figure 23: Illustrative consumer surplus by broadband technology



The assumption that consumers rationally select the broadband service which maximises their consumer surplus is a simplifying one. In practice there are a range of financial and non-financial costs which, in reality, will affect consumers' behaviour. This includes up-front connection charges, lack of awareness or understanding, inconvenience, response sluggishness, and so on. Indeed, the fact that in countries across the world there remain households subscribing to dial-up services when broadband services are available for equivalent (or cheaper) subscription charges, supports the notion that not all consumers act in an economically rational manner. We suggest that future analysis would be well served investigating (empirically) the effect of non-financial costs in consumers' purchase decisions.

Estimating producer value

Producer value relates to the benefits to suppliers of providing broadband services, primarily increased revenue[73]. In our model, by estimating take-up of broadband services and entering assumptions for retail prices for each country, we can estimate producer value.

While we typically assume a monopoly provider of high speed broadband within each geotype, we also explore the impact of multiple infrastructure providers resulting in duplication of costs and overheads.

In estimating true producer value, we should consider the profits earned by *all* broadband-related firms including, for example, the computer equipment and software industries (increased household purchases of equipment and software), the retail and wholesale

[73] However in practice, in many markets to date fibre pricing has been close to or even lower than ADSL pricing (FiOS from Verizon in the US has been an important exception).

sectors of the economy (greater efficiency in the distribution of consumer products), content providers (greater demand for entertainment products), etc. However, predicting what these value-added services may be, or the magnitude of any producer surplus arising from them, would be speculative. We have therefore focussed on the value from the provision of broadband access only.

We have also not considered underlying wholesale arrangements in our model. While this is clearly a simplification, the net impact is unclear. It is likely that an incumbent will be required to wholesale both its copper and a prospective fibre network. It would thus lose some of the margin from retailing in both cases. However, to the extent that this loss was equivalent in the two cases, the net impact on the calculated incentives to roll out fibre would be unchanged (since the model does not address the impact of wholesaling in either case).

Estimating costs

For the purpose of our model, we have assumed that the key drivers in the cost of rolling out a broadband infrastructure are the technology adopted and the household density within each geotype. (Capital costs for superfast FTTH connections might vary from €150 per dwelling passes in the most dense urban areas to more than €4,400 in the least dense and most remote regions[74]).

Cost data for the roll-out of fast (FTTC / cable) and superfast (FTTH / FTTB) networks[75] has been taken and adapted from Analysys Mason's work for the Broadband Stakeholder Group in the UK[76] . A weakness of this data set is that it reflects UK costs which will be affected by a range of local market factors. However, we believe it is the most consistent and comprehensive work on network costs currently publicly available. It therefore forms the basis of our cost analysis.

The data has been adapted to other countries using purchasing power parity exchange rates and local geotype mix. To facilitate international comparison we have also consolidated Analysys Mason's thirteen geotypes into eight.

An analysis of costs associated with different broadband infrastructures is a significant task in its own right and we have not sought to develop a detailed cost model here. We have therefore made a number of simplifying assumptions. For example, we have assumed that the operating costs for each broadband connected household (customer care, billing, etc.) do not vary by geotype. Again, further analysis into the costs of deployment and operating the broadband network by country would be beneficial .

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[74] Source: Ingenious Consulting Network analysis of Analysys Mason (2008)

[75] We have used data for FTTH GPON rather than PTP, since this network type has been more widely adopted thus far

[76] Analysys Mason, *The costs of deploying fibre-based next-generation broadband infrastructure* (September 2008)

In the context of fibre, a cost saving and value realisation is through copper switch off ("CSO"), the opportunity to replace the copper network on an exchange by exchange basis, migrating all customers to fibre. Plum (2008) estimates that running a single fibre network could mean that:

> *"cost savings in the range 30-50 per cent of those involved in operating the copper network could be achieved relatively quickly (including allowance for the value of copper, land and buildings released)"*

Fibre migration and copper switch off would not come without costs. This will include the costs of disruption, consumer notification and migrating non-telephony services dependent on the copper network such as traffic lights. However, overall savings, including proceeds from the sale of copper and land and buildings, could potentially be greater. Given regulatory requirements for legacy copper services, CSO is unlikely to be possible without active support from governments and regulators.

Assessing externalities

As well as consumer and producer value, there are other components of the total economic benefit from a product or service like broadband. These benefits and costs are generally known as "externalities". Externalities occur where there are third party (or spill-over) effects arising from the production and/or consumption of goods and services, outside normal market changes in demand and prices. The classic example of a negative externality is pollution, generated by some productive enterprise, and affecting others who had no choice and were probably not taken into account.

In a competitive equilibrium where externalities are present, economic theory demonstrates that competitive markets alone will typically not achieve an outcome that is optimal from society's point of view. In other words, the presence of positive externalities often means that absent some public intervention, there will be less of an activity or product consumed than is economically optimal. A wide range of externalities are posited in the literature, including some of those below.

Figure 24: Sample externalities

Societal value	• Improvements to education such as greater collaboration • Improvements to health services such as remote diagnostics • High definition video communication and collaboration • More effective energy usage, reduced travel and lower power consumption • Improving economic participation among the elderly and disenfranchised
Productivity improvements and efficiencies	• Cloud computing and efficiencies not reflected in private demand curves • Freeing of resources (e.g. IT support staff) which can be employed elsewhere in the economy • eGovernment and migrating administrative functions online • Improved business connectivity
Innovation	• New services enabled by high speed BB critical mass

Some of these externalities have discontinuities – their value does not increase in direct proportion to the number of broadband users. For instance, it seems likely that once there is a critical mass of high speed broadband households, a range of advanced services will suddenly become commercially viable[77]. Furthermore, as the importance of broadband grows, some governments are seeing universal availability as becoming increasingly important for social cohesion (ensuring all citizens have access to the same services).

Beyond ubiquitous availability is ubiquitous adoption. However, this is a much more ambitious goal. The construction of a high-capacity infrastructure is not sufficient to make a population use broadband. Many people with access to broadband simply lack the skills to take advantage of the technology, or do not realise the benefits that they could obtain by properly using the internet for personal use or at work (see Plum (2010) for a full discussion).

While there is a body of literature considering the value of broadband, in general it only considers certain aspects of externalities (for instance impact on productivity) rather than seeking to be comprehensive. Moreover, the great majority of the literature is focused on the impact of basic broadband, or even ICT in general. There is very little that specifically considers the incremental impact of higher speed broadband[78]. The table below provides an overview of some sample studies into the value of broadband.

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[77] Atkinson refers to this as an indirect network externality – see The Case for a National Broadband Policy, The Information Technology and Innovation Foundation (2007)

[78] Plum (2008) is an example of a useful report that focuses purely on the incremental benefits of higher speed, but it does not claim to make an aggregate estimate of externalities, instead quantifying certain examples

Table 2: Selection of existing research on broadband value, productivity effects and externalities[79]

Study	Technology	Methodology	Result
Connected Nation 2008	Basic broadband (200Kbps)	Impact of increased broadband access and adoption in Kentucky from ConnectKentucky initiative, using self-reported health care improvements, time and travel savings, and wages from jobs created or saved. These results are applied across the USA to determine the potential gain of a national initiative	Kentucky economic impact of $1.59 billion per year; USA economic impact of $134 billion per year.
Stiroh 2002	ICT generally	Regression analysis of the US productivity revival, and analysis of whether this is linked to ICT use	Value-added productivity 1995-2000 is 1.0 percentage points higher than that of 1987-1995, study indicates that ICT is a leading candidate as a catalyst, but unable to quantify
Crandall et al 2007	Basic broadband (200Kbps)	Cross-sectional analysis of US data to estimate the productivity impacts of broadband in the medium-term. Regression analysis from the 'first 48 states' in the US	Finds an increase of 0.01 broadband lines per head of population associated with a 0.46% increase in output in the non-farm private sector
MICUS 2008	Broadband (speed unclear)	Analyses impact on productivity at company level and macro level, for the implementation of e-business practices and improvements arising from business services outsourcing over the period 2004-2006	Average annual productivity improvement of 0.27% in the EU27, higher in services (0.32%) and business services (0.58%), lower in manufacturing (0.14%)
Varian et al 2002	Internet generally	Methodology unclear, measures productivity impact of internet business solutions in the US and the three largest European economies (France, UK and Germany) over 1996-2000, with projections for 2001-2010	1996-2000 average annual gains of 0.17% in US and 0.017% in European big three, 2001-2010 forecasts of 0.43% p.a. for the US and 0.11% p.a. for the European countries
Gillett et al 2006	Basic broadband (200Kbps)	Econometric regression analyses of cross-sectional/time-series data at state level and zip-code level, based on broadband penetration in the US over 1998-2002	Those areas where mass-market broadband was available before December 1999 experienced more rapid growth in employment, business numbers, and business in IT- intensive sectors
Allen Consulting 2003	Standard - fast broadband (10Mbps)	Impact of a rollout over south-east Queensland over 2004-2008, covering 50% of Queensland dwellings, using Monash Multi-Region Forecasting (MMRF)	Increased GDP of US$4.2 billion over 15 years, 1,630 jobs additional per year
Crandall et al 2003	Ubiquitous broadband (speed unclear)	Impact of broadband at penetration similar to standard telephony services by 2021 (95.3% of population), and impact of high-speed broadband over 2003-2021, with penetration of 78.5% of households by 2021	Widespread penetration results in increased GDP of $9.5 billion per year through 2003 to 2010; high-speed broadband results in further benefits of $4.9 billion over 2003 to 2021
New Zealand Institute 2007, 2008	Standard – fast broadband (10Mbps)	Methodology unclear, benefits are estimated by improved productivity of digital media and storage and manipulation of data, health care and education savings, and remote working, with FTTP to 75% of the population by 2018	Impact of 0.26% on GDP, with gain of NZ$2.7-$4.4 billion per year
Plum 2008	Standard, fast and superfast broadband	Considers the incremental value of wide spread availability and take-up of next generation broadband against a counterfactual that includes the evolution of existing platforms with upgrades to existing copper. Assumes availability to 80 per cent of the population of the UK.	The wider economic and social value of next generation broadband "could be considerable". Incremental benefits include time savings (worth up to £900m/yr) to reduced travel time (up to £200m/yr)
Motu 2008	"Slow" and "fast" (cable) broadband	Micro-survey of firms to determine the impact that differing types of internet access have on firm productivity including high speed broadband	Productivity gains can be attributed to adoption of slow relative to no broadband, with no discernable additional effect arising from a shift from slow to fast broadband.

As noted by the European Regulators Group amongst others[80], many of the concrete externalities associated with broadband are hard to quantify. Not least this is because the value of broadband externalities is likely to vary significantly between countries, based on a wide range of local market factors. For example, externalities will depend on a country's ability to absorb the benefits of broadband. As illustrated by the Nokia Siemens Connectivity

[79] Adapted from Access Economics (2009)

[80] See, for example, the European Regulators Group, Broadband Market Competition Report (2005)

Scorecard[81] (which assesses national connectivity and socio-economic transformation across a range of countries), this ability is likely to vary widely among OECD countries.

Based on the existing research, it is impossible to appropriately model the relationship between broadband coverage, speed and the value of externalities. Given this, our approach is to discuss the scale of externalities that would be required to materially change the conclusions, based on our assessment of consumer and producer value.

Costs of intervention

Through our analysis we have considered the relative costs and benefits of different broadband deployment approaches, and the effectiveness of subsidy in each case. We have not sought to assess the manner of subsidy intervention.

As noted by Plum (2008), if public funds rather are used to fund broadband deployment, an additional cost is incurred, reducing the net benefits of any subsidy. This excess burden or "deadweight loss" of taxation is the economic loss that society suffers as the result of a tax, over and above the revenue it collects. Estimates suggest the deadweight loss from taxation could be around 30% of the public funds raised (although it could be even higher given the current economic climate and the risk of credit downgrade in some countries).

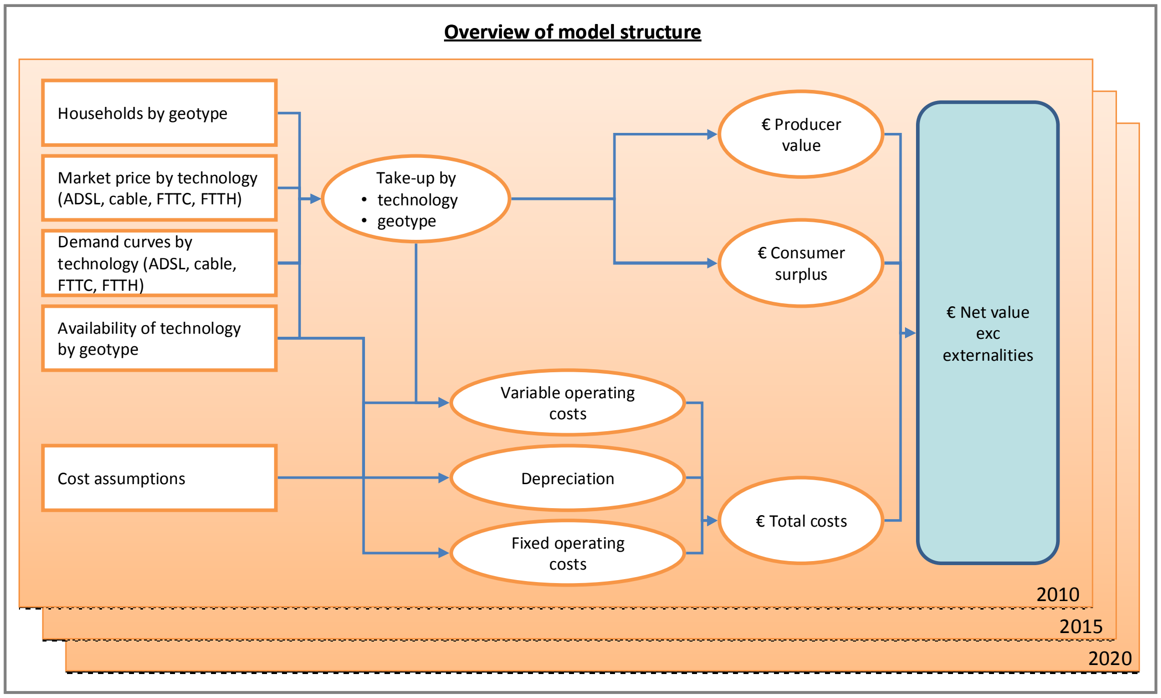
Although out of the scope of our analysis, broadband policy should consider the manner, as well as the scale and nature, of intervention.

[81] See http://www.connectivityscorecard.org/. For further discussion on the relationship between national connectivity and broadband benefits, see also LECG (2009)

Appendix C: Notes on the modelling approach

Overview of model structure

Figure 25: Modelling structure adopted to estimate producer and consumer surplus



Geotype definition

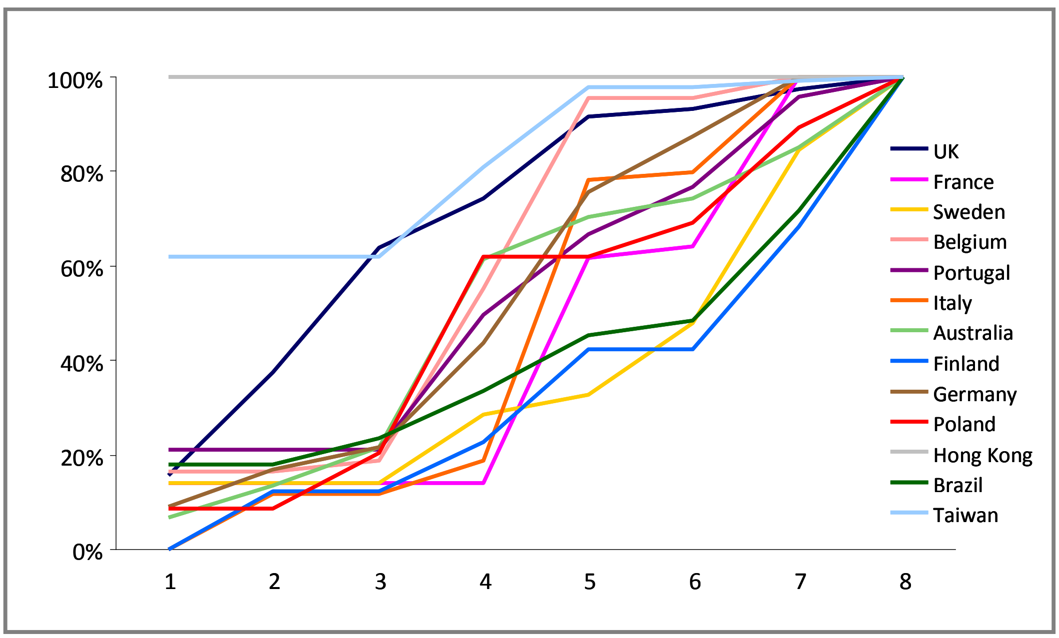
To model the cost of broadband deployment, eight geographic areas or "geotypes" have been considered. These geotypes have been derived from the thirteen geotypes modelled by Analysys Mason in their UK next generation network cost analysis, and consolidated into eight based on the population density and deployment cost per household. A brief description, using an illustrative UK geographic profile, is given below:

Table 3: Geotype descriptions, UK sizes

Geotype	Description	Households (000)	Approx premises per sq km
1	Major urban centres, large towns with short line lengths	4,300	>1,200
2	Large towns	5,959	850–1,200
3	Medium-size exchanges, short line lengths	7,115	350–850
4	Smaller exchanges, short line lengths	2,848	100–350
5	Medium-size exchanges, long line lengths	4,744	50–100
6	Very small exchanges, short line lengths	438	20–50
7	Small exchanges, long line lengths	1,150	5–20
8	Very small exchanges with long lines	703	<5

In order to obtain geographic profiles for other countries, data on population and area was used to split the countries into eight sections by population density. As a result, the different countries modelled have significantly different profiles, as shown below:

Figure 26: Cumulative population by geotype for modelled countries[82]



[82] Sources: individual country census data, most recent available; Ingenious analysis of Analysys Mason (2008)

Local market considerations

A range of local characteristics will influence the costs and benefits of infrastructure deployment, such that the value maximising solution will differ country by country. Many of these factors concern national demand for broadband services: for instance existing broadband prices and infrastructure, starting level of broadband penetration, country topography and geotype structure, and government and operator roll-out plans. In adapting our model for different countries we have attempted to accurately reflect the impact of these variables, but to optimise the model for a particular country, more granular data could be used, particularly for geotype structure.

We have noted the importance of geography and geotype mix in our analysis. In general, the economic case for broadband is weaker in rural areas than more densely populated ones. In terms of government policy, this introduces a tension. On one hand, densely populated areas will have greater incentives for the market to provide, suggesting a lower need to government subsidy. On the other, targeted subsidy in these areas is likely to achieve a higher net value per € spent.

Our model also illustrates the importance of relative country affluence. In general, it is more difficult to justify government subsidy in countries with lower GDP per capita, assuming this is reflected in lower consumer demand schedules (and lower willingness to pay).

As discussed above, the relative level of ICT adoption may also drive country difference, since the level of ICT development is likely to proxy a country's ability to absorb the positive externalities associated with broadband deployment.

As we have noted, relative costs between countries is likely to have a significant impact on the 'right' level and nature of government intervention. However, obtaining detailed data on the variation in roll-out costs by country is difficult. Our modelling framework has been designed to be applicable to any international developed broadband market, but the UK-specific nature of the input cost assumptions (for example the FTTC and FTTH capital expenditure costs sourced from Analysys Mason) will have affected the results for other countries. A number of factors may cause the cost of roll-out to vary, including: local labour and civils costs, use of alternative conduits for cable such as sewers or aerial poles, line lengths, exchange sizes, amount of duct re-use and different regulatory approaches to issues such as pricing and wholesaling. Where available, country-specific cost data taking these variables into account could be added to the model, further optimising it for an individual broadband market.

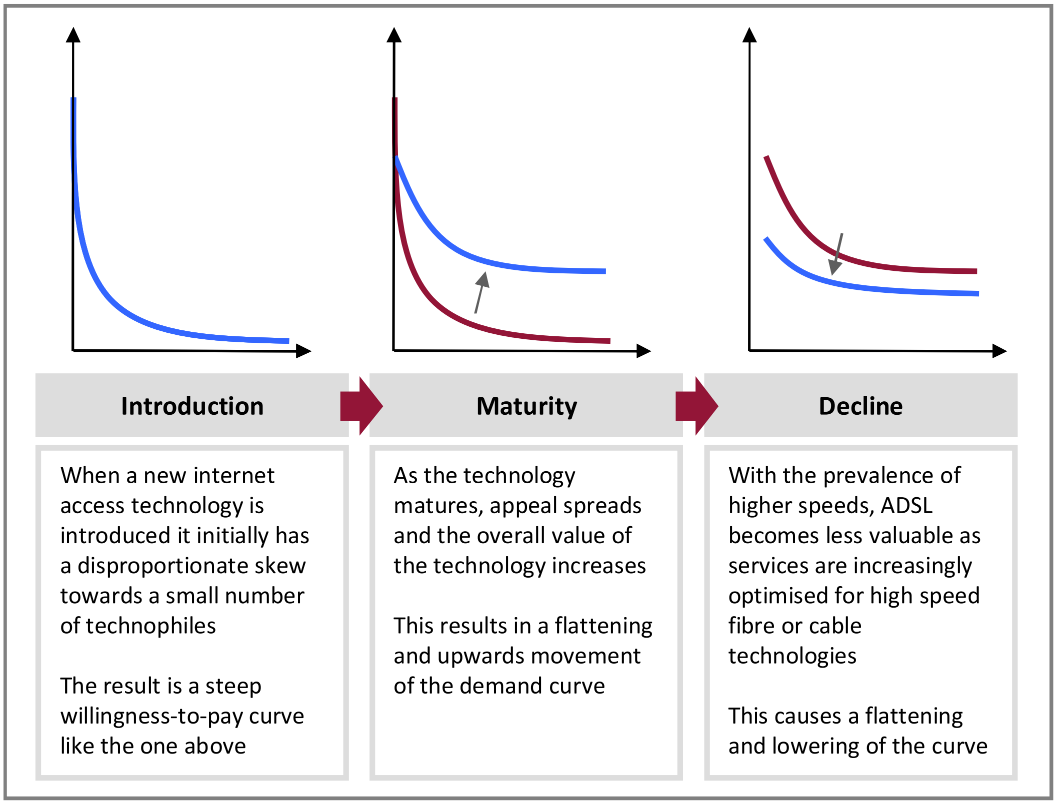
There are also a number of wider model developments which could be made, independent of the focal country. These are outlined in the next section.

Appendix D: Future model developments

We recognise that our modelling framework and the analysis provided in this report is only a small first step towards a more rigorous framework for decision making. We believe there are a range of areas where addition analysis could shed further light on broadband policy and the choices faced. These include:

- *Further demand curve research*. The model relies on research into willingness to pay for broadband conducted in the US by Orszag, Dutz and Willig. This work could be replicated in other countries through the use of bespoke consumer research. In doing this, demand for high speed services as opposed to standard broadband could also be tested.
- *Refinement of geotype data*. In our report we emphasise the importance of geographic considerations when developing broadband policy. We find that the 'right' answer for an urban area is likely to be very different to a more rural location. In our analysis we have considered 8 geographic areas, or "geotypes". In adapting international data to UK geotypes, a number of approximations have been made. More granular data and more sophisticated allocations of regions to geotypes would refine the model results.
- *Shifting demand curves over time*. We have used the same demand curves for standard, fast and super-fast broadband in each time period of our modelling. Growth in broadband penetration and consumer surplus over time therefore results directly from falling prices. However, it is likely that demand curves for new technologies shift upwards and flatten over time. This is because when a new technology is introduced, its appeal is likely to be limited to a small group of consumers, some of whom may value the technology very highly. Then as the technology matures, it often gains greater mass market appeal. With broadband services, indirect 'network' effects may also occur. For example, if higher broadband speeds become common then a variety of additional online activities taking advantage of those speeds may become economically viable. As these additional innovations arise, the valuations placed on higher speed broadband will there likely become higher. In reality, therefore, the profile of demand for different broadband services is likely to change over time, and could be modelled in order to exhaustively forecast growth future willingness to pay. The following diagram illustrates this changing demand profile:

Figure 27: Demand curve movement over time



- *Non-rational switching behaviour*. For simplicity, our model assumes that consumers will immediately switch to an alternative broadband service if it is economically rational to do so, in other words if their consumer surplus increases. In reality, however, there are a variety of financial and non-financial costs involved in switching, and the dampening effect of such costs could be incorporated into the modelling of take-up. An important corollary of this is likely to be to reveal the power of regulatory interventions to facilitate switching, since removing barriers to churn can result in increased take-up of new services and a boost in consumer surplus.
- *Wholesale effects*. The model does not take into account wholesale regulation and retail layer competition, and as a result does not allow analysis of (for instance) the impact of a 'holiday' from a wholesaling requirement on the incumbent in exchange for a specified roll-out.
- *Business usage*. Our model currently considers only consumer broadband access, but could be altered to incorporate business use separately, with alternative demand curves, pricing structures and roll-out costs.
- *Deployment costs and depreciation over time*. Deployment costs for FTTC and FTTH are currently treated as a lump sum per household passed, and decrease by a certain percentage each year. It may be the case, however, that the different elements making up this lump sum decrease at different rates, for instance the cost of electronic components may fall faster than that of civil infrastructure works. Similarly, the model currently applies a single depreciation policy to all aspects of

NGN investment, whereas a more detailed approach could take into account different policies for different asset classes.

- *The effect of differential pricing*. Currently the model calculates consumer surplus and producer value using one price point (the minimum available in a given country) for each technology. However, in reality most providers offer several broadband products, with different headline speeds, usage caps and added features. By allowing consumers to select more expensive packages, some value which will be allocated to consumer surplus in our model will be transferred to the producer. Our model could be modified to take this into account by allowing different steps in pricing for each technology. There are also some countries where geographical de-averaging of retail prices is permitted (for example Finland). The model could be modified to take this into account as well, by allowing different price points for each geotype.
- *Cost options for delivering standard broadband in the remotest regions*. We have used an FTTC-style solution in the final geotype (as advocated in the UK by the Government's "Digital Britain" report), but the geographical characteristics of particular regions may mean that alternative solutions such as fixed wireless or satellite are more suitable. Further research into household distribution in particular countries could allow the costs of remote broadband roll-out to be more closely modelled.
- *Treatment of mobile technologies*. We note that the majority of analysis to date has been on fixed networks, and do not therefore explicitly consider any *incremental* benefits of mobile broadband. Given the growing importance of mobile as a complementary means of broadband delivery, we believe this is an important omission in the current body of literature.
- *Costs of intervention*. We have not considered any costs of government intervention. However, if public funds rather are used to fund broadband deployment, an additional excess burden or "deadweight loss" is incurred, reducing the net benefits of the subsidy. Further analysis into the impact of different forms of subsidy would be beneficial.

Sensitivity analysis

The following illustrates the impact on net value of +/-10% changes for price and demand multiplier (applied to the power series function used to proxy consumer demand).

Table 4: Effect of 10% changes in price and demand multipliers on net value[83]

	Change in net value - price			Change in net value - demand		
Change in input	ADSL	FTTC	FTTH	ADSL	FTTC	FTTH
-10%	+9%	+1%	+1%	-11%	-4%	-2%
+10%	-10%	-10%	-1%	+21%	+5%	+4%

Prices used in the model have been sourced from incumbent operators in the respective countries wherever possible, and then changed over time using a compound annual growth rate derived from OECD pricing data. The above analysis demonstrates the sensitivity of price as an input, and indicates that prices and net value tend to be negatively correlated, in other words lower prices lead to higher net value and vice versa.

The demand curve for standard broadband used in the model has been derived from research undertaken in the US by Orszag, Dutz and Willig (2008). The above analysis illustrates the importance of this underlying research, since a 10% increase in the demand multiplier leads to a 21% increase in net value. To derive curves for fast and super-fast broadband we used data on penetration and price by technology from Hong Kong and Sweden to generate a scaling factor. The above analysis demonstrates that this variable is less sensitive than the standard demand curve, with 10% increases for fast and superfast broadband multipliers resulting in 5% and 4% increases in net value respectively.

The sensitivity of the results on the characteristics of the underlying demand curve further supports our belief that future work in this area would be beneficial.

[83] Sensitivity analysis undertaken on the following base case: UK geotype profile; 2020 pricing, penetration and costs; 100% ADSL coverage, 74% FTTC coverage and 38% FTTH coverage

Appendix E : Glossary of terms

ADSL – Asymmetric Digital Subscriber Line is a technology that enables fast data transmission over traditional copper telephone lines, and as a result it is the most common form of broadband connection in the world. ADSL speeds depend on the technology used (ADSL, ADSL2 or ADSL2+) and the distance from the premises to the local exchange. Typically, ADSL connections can theoretically achieve download speeds of up to 24Mbps and uploads speeds of 1Mbps with ADSL2+, but in practice generally achieve speeds that are considerably lower than this[84]. In this report we refer to ADSL as a 'standard' broadband technology.

Consumer surplus – the difference between a consumer's willingness to pay for a given service, and the retail price which they are required to pay in order to consume it. In other words if a consumer is happy to pay €30 for a product but the retail cost is €20, then their consumer surplus is €10 (assuming no additional non-financial costs).

Copper switch off (CSO) – CSO occurs where, for a given exchange or region, all copper pairs have been replaced by a next generation high speed broadband network. It is believed that CSO will result in significant operating cost savings and release further value (for example through the sale of land used for exchanges).

Cost of capital – the rate of return that capital could be expected to earn in an alternative investment of equivalent risk to that being considered

Coverage – the proportion of households for which connection to a service is technically possible.

Depreciation – describes any method of attributing the historical or purchase cost of an asset across its useful life, roughly corresponding to normal wear and tear. For the purposes of this model, we has assumed a straight line depreciation over a period of ten years with a residual value of zero.

Externalities – in an economic transaction, an externality is an impact on a party that is not directly involved in the transaction. Externalities can be either positive (external benefit) or negative (external cost). In the case of next generation broadband investment, a positive externality may be that high speed broadband enables remote working, resulting in reduced travelling and therefore lower congestion and pollution.

Fast broadband – higher speed broadband than standard broadband, and includes technologies such as fibre to the cabinet (see FTTC) or high speed cable networks using DOCSIS 3.0 technology[85]. Download speeds are likely to be between 25 and 50 Mbps, with upload speeds considerably less.

FTTC – 'fibre-to-the-cabinet' (FTTC) involves laying fibre-optic cables to street cabinets which are typically located within a few hundred metres of the customer premises. Households are

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[84] Achieved standard ADSL speed in the UK is typically 45% of the advertised headline speed; source: Ofcom (2009)

[85] We note that cable using DOCSIS 3.0 may actually be able to deliver superfast broadband

then connected from the cabinet by copper lines. Cable networks often have a similar architecture, with fibre to the cabinet and coax cable from there to the home. FTTC and cable speeds are higher than ADSL, but are often not fully symmetric and are determined, in part, by a household's distance from the cabinet. FTTC and DOCSIS 3.0 cable connections can achieve headline download speeds of up to 40-50Mbps and upload speeds of up to 10Mbps. In this report we refer to FTTC and cable services as 'fast' broadband technologies.

FTTH – 'Fibre-to-the-home' (FTTH) involves laying fibre-optic cables directly to the customer premises, either through a gigabit passive optical network (GPON) or point-to-point fibre (PTP). FTTH connections typically allow the highest speeds, lowest latency, greatest reliability and truly symmetric connections when contrasted against FTTC and ADSL. Typically FTTH connections can achieve upload and download speed of over 50Mbps. In this report we refer to FTTH services as 'superfast' broadband technologies.

FTTB – 'Fibre-to-the-building' is a broadband network architecture which deploys fibre optic cables to the boundary of the building (for example an apartment block), with the final connection to the individual home being made via copper or cable. Access speeds are similar to those achieved through FTTH networks.

Geotype – in this report a geotype is a group of premises, the situations of which share certain characteristics such as population density, exchange size, and line length. For further detail on geotypes, please refer to Appendix 0.

GPON – a PON (Passive Optical Network) is a point to multi-point network which enables a single optical fibre to serve multiple premises using optical splitters. GPON, or Gigabit PON is an advanced version which supports high rates and enhanced security, and has been adopted widely as the standard for many superfast FTTH networks around the world

Latency – a measure of the time delay between when a packet of information is sent and when it is received, Latency is more important in the usage of certain applications; for example, a time delay in an email being delivered does not generally cause problems, however, for video streaming services, time delays cause a major disruption of service.

Narrowband – refers to a dial-up internet connection delivered over a telephone line. Speeds possible via dial-up are low (typically less than 64Kbps), and access is shared with traditional voice usage so the connection is not always on.

Network capability – refers to the performance characteristics of the underlying network technology. For example, superfast FTTH technologies not only allow faster speeds, but also symmetry (equivalent upload and download speeds) and reduced latency.

PTP – point to point is an FTTH network architecture in which each premise is served by a dedicated fibre optic cable (as opposed to a GPON architecture in which one fibre connects several premises by using optical splitters).

Producer surplus – the amount of value captured by selling a product for a retail value higher than the costs incurred in producing it.

Standard broadband – refers to basic speed broadband, delivered wirelessly (e.g. through

3G) or wireline, via ADSL or low speed cable. This typically equates to headline download speeds of between 2 Mbps and 24 Mbps, and is also distinguished from narrowband dial-up by being “always on”.

Symmetry – refers to a network which allows equivalent upload and download speed. This is only possible with a full fibre network (FTTH).

Superfast broadband – refers to broadband speeds of over 50 Mbps (upload and download) which include fibre-to-the-building or to-the-home (FTTB or FTTH) technologies.

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