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## Will broadband pricing support 1Gbps services?

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## *Will broadband pricing support 1Gbps services?*

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Policymakers in many of the leading economies have identified the need for universal access to broadband services as a critical component of their Digital Agendas.<sup>3</sup> Over time, the definition of "broadband" and what ought to constitute appropriate goals in terms of service quality -- most often summarily articulated in terms of the peak speed offered downstream -- has evolved from hundreds of Kbps to tens of Mbps. While there is still no general agreement on how to define broadband nor what should constitute an appropriate speed goal, most policymakers and analysts have targeted services with speeds of 1Gbps or less to be implemented by 2020.

In this paper, we review data on retail service offerings in the United States and from around the world and tentatively conclude that prospects for 1Gbps services becoming more widely available are not implausible even at current pricing levels. The analysis and our conclusion in this paper should be regarded as preliminary and partial, but ought to provide some comfort to those who might fear that significant improvements in broadband service quality cannot be achieved without dramatic increases in broadband service pricing. Indeed, the pricing data and recent service offerings by Google in the United States and by others abroad suggest that order of magnitude improvements in broadband speeds are achievable with pricing close to today's range.

In reaching our conclusions, we rely on earlier work modeling fiber deployment costs for Europe modified to account for conditions in the United States. The focus of this earlier work was on estimating the aggregate investment costs associated with meeting Europe-wide goals of universal deployment of fiber-to-the-home. The model emphasized the significant savings to be realized if new fiber deployments are able to share the

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<sup>3</sup> Both the USA and EU have Digital Broadband Agendas: Digital Agenda for Europe by the European Commission, see EC (2010), and The National Broadband Plan for USA, see the FCC (2010.b). For a comparison of digital agendas from a number of countries, see OECD (2011). Most of those articulate a national commitment and goals to provide universal access, although none are as ambitious as the commitment by the Australian Government to provide a national broadband network to all citizens.

significant component of costs associated with conduit and/or outside structures.<sup>4</sup> Translating a techno-economic European FTTH model to the United States and using an aggregate investment model based on a stylized representation of the technical architecture provides, at best, only a noisy order-of-magnitude estimate of the likely total costs of deploying Gbps-capable infrastructure, but we believe this is sufficient for the goals of this paper, and also helpful for policymakers when framing digital agendas.<sup>5</sup> Absent some such attempt to quantify aggregate costs, there is no *a priori* reason not to anticipate a steep increase in revenue requirements from end-users or in government universal service subsidies if the goal is to achieve order-of-magnitude enhancements in last-mile infrastructure capacity.<sup>6</sup> Simply pointing to "Moore's Law" improvements in technology when much of last-mile investment includes civil-engineering and construction expenditures is of dubious value.

We compare our estimates of the aggregate investment requirements with recent tariff data for broadband services,<sup>7</sup> and make back-of-the-envelope estimates of the contribution that those retail prices imply for other elements of the broadband service in order to derive an estimate of the contribution available for investment in next-generation last-mile infrastructure. We also examine in some detail recent offerings of fast broadband from Google in the United States and by Free-Iliad and Adamo in Europe to explore how their business models, from a new entrant's point of view, exploit sharing opportunities and novel strategies to compete in today's markets. Our analysis of the potential revenue contribution available for investment under current broadband pricing and of the strategies being used by new players offering fast broadband services support our conclusion that it is feasible to extend much higher-speed offerings (up to 1Gbps) in the United States *without* requiring order-of-magnitude increases in operator revenue requirements (or public subsidization) to justify the requisite aggregate investment.

We stress that our analysis is agnostic about what may actually happen as a consequence of regulatory policies, competitive interactions, or market strategies. Addressing these factors and verifying the analysis provided herein will require further research. Clearly, there are many unknowns, including whether households generally need or will want 1Gbps services, whether mobile broadband from cellular providers or other wireless offerings will compete so as to make the transition to "FTTH"<sup>8</sup> unnecessary to realize order of magnitude performance improvements, or whether the goal will be to sustain

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<sup>4</sup> The main conclusion of that paper was that it could decrease the total investment on FTTH for Europe if sharing infrastructure was envisaged by approximately a 40%, see Domingo and Oliver (2011).

<sup>5</sup> The original model also does not attempt to address variations in regulatory and other local conditions across European markets, which we recognize are significant factors that a more complete analysis ought to include (e.g., variations in terrain that impact costs, cultural attitudes that may impact demand, or other factors).

<sup>6</sup> Throughout this paper, we will occasionally use "capacity" and "speed" as synonyms. We recognize that these are distinct concepts and equating faster data rates with higher quality infrastructure or services or with broadband capacity is only approximate.

<sup>7</sup> See the FCC (2012) where a Fixed Broadband Price Catalogue was provided.

<sup>8</sup> We put "FTTH" in quotes because what we are talking about is dense fiber deployments which may terminate close to the home, but use some other technology for the last couple of tens or hundreds of feet as the FCC has done in their analysis, see FCC (2010.a), which includes many different types of FTTx, where in addition to x being the home (FTTH), the node (FTTN), the cabinet (FTTC), etcetera.

near-universal facilities-based competition among wireline competitors.<sup>9</sup> These and other factors, as well as refined empirical analysis of broadband infrastructure economics has the potential to significantly alter our results. Nevertheless, we are encouraged that our analysis implies capacity can continue to scale without requiring commensurate scaling in end-user payments which we suspect is a dubious prospect in any case. Furthermore, we find our analysis useful in highlighting the potential benefits of infrastructure sharing, while recognizing that significant further research is needed to quantify the costs and benefits of alternative national broadband strategies and the NGAN deployments currently underway.

## Introduction

The central question this paper examines is whether order-of-magnitude improvements in broadband performance (i.e., 10-100x speed improvements) are achievable without significant increases in pricing (i.e., on the order of 20% or higher increases in per-subscriber revenues). We provisionally conclude that the answer is "Yes". Our conclusion is provisional because the analysis is acknowledged to be partial, and based on a number of broad assumptions. The key elements of our analysis are an earlier-developed model of investment requirements for Europe to achieve FTTx universal service; and data on retail broadband speed-tiered pricing in the US and around the world. The first was a European model developed by Albert Domingo to provide a ball-park estimate of potential investment savings that might be realized if the universal service goal were approached with an architecture that emphasized shared infrastructure, avoiding the duplication implicit in facilities-based competition (even duopoly).<sup>10</sup> The second element relies on recently published data on broadband pricing from the OECD and the FCC.<sup>11</sup>

The focal question of this paper is interesting to market and telecommunications policymakers for multiple reasons. First, broadband is widely recognized as basic and essential infrastructure;<sup>12</sup> and as such, ensuring universal access at affordable prices to all citizens is an important policy goal today and in the future.

Achieving this goal will require Next Generation Access Network (NGAN) infrastructure. One obvious contender for the NGAN involves the deployment of optical fiber cables in last-mile networks.<sup>13</sup> Herein, we collectively refer to Fiber-to-the-home (FTTH), Fiber-

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<sup>9</sup> That is, the analysis undertaken here addresses the challenge of achieving (near) universal service rather than (near) universal duopoly service by wired competitors, which is a much more expensive proposition.

<sup>10</sup> See Domingo and Oliver, 2011.

<sup>11</sup> See the FCC (2012) where a Fixed Broadband Price Catalogue was provided, and the OECD (2013)

<sup>12</sup> Motivations for viewing broadband as essential infrastructure and for adopting public policies to promote widespread availability and adoption are multiple, including general recognition that broadband contributes to economic development goals and growth (employment, productivity). For further discussion, see Lehr, Clark, and Bauer (2013). Appendix I provides pointers to additional digital agendas that include discussions of motivations. From a review of these, there is significant mirroring of policy frameworks and text.

<sup>13</sup> See Vergara et al. (2010) for a comparison of alternative technical solutions and FTTH Council Europe (2012) for a discussion of different types of deployments.

to-the-Premises (FTTP), and hybrid fiber solutions such as Fiber-to-the-building (FTTB), Fiber-to-the-curb/cabinet (FTTC), or Fiber-to-the-neighborhood node (FTTN), as "FTTx." Moreover, while our focus here is on fixed broadband offerings, realization of a future with FTTx last-mile infrastructures will also provide support for much higher-speed mobile broadband services. That is, FTTx can support denser deployments of 4G LTE and other wireless broadband technologies, and we expect that mobile and fixed services will be much more seamlessly integrated in the future.

Second, it is important to recognize that broadband technologies and markets are not static and they have continued to evolve toward improved performance and higher speeds.<sup>14</sup> The growth of mobile broadband and the transition to increasingly rich and interactive media puts pressure on broadband capacity and helps drive the need for ever-greater speeds. Precisely how much capacity (speed) is needed on a per-subscriber basis is uncertain. A key advantage of FTTx is that it is the best future-proof option for meeting long term demand growth.

Third, meeting long-term investment goals to support universal service will require significant investment in additional capacity. While it is unclear whether an appropriate NGAN requires fiber optic transport all the way to the home, or whether one of the many hybrid solutions is viable, it is certainly true that we will need a lot more infrastructure investment in last-mile facilities, and much of this will include provisioning for dense neighborhood fiber. Furthermore, it should be remembered that improvements in the NGAN will enable significant increases in traffic (data usage) which will imply the need to increase capacity (investment) in backbone facilities as well. These backbone investments are not addressed herein.

Thus, a better understanding of the investment cost requirements for one of the candidate architectures (FTTx) for meeting national universal service goals for the NGAN and what those costs imply for operator revenue requirements should be helpful in framing broadband policies. The latter include (a) investments in public infrastructure (e.g., like in Australia); (b) universal service fund program design; and (c) broadband service regulation which may include open access/interconnection, price or service quality aspects.

## **NGANs and Digital Agendas**

Countries around the world have adopted national digital agendas to promote increased (universal service) access to broadband services, although there is wide heterogeneity in the ambitiousness of these goals with respect to the quality (speed), coverage targets, and timing for those goals. The motivations for adopting such plans are several, including growing recognition among economists and policymakers that broadband contributes to economic development and job and GDP growth.<sup>15</sup> For example, economic stimulus

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<sup>14</sup> See Bauer, Clark, and Lehr (2010).

<sup>15</sup> The available studies are regional, as they need inputs to create the models, and also depict a fix point of time. Katz et al. estimated on 2008 how it has a positive effect on Switzerland the deployment of a new Broadband network on the

plans in the US<sup>16</sup> and EU<sup>17</sup> included significant investments in broadband infrastructure, which included funding to support expanded coverage which is a special challenge for higher cost/less-dense rural areas.

Figure 1 summarizes a number of these plans, using data culled from country-specific digital agendas and the OECD (2011).<sup>18</sup> On a grid mapping the target broadband speed (Mbps, Y-axis) versus the coverage target (% of homes), national plans are plotted and identified by country name and the target date for achieving this goal. Fig 1 highlights a number of points:

- Widespread adoption of goals implying target speeds of 100Mbps or higher (representing an order of magnitude improvement) for NGANs. Even many of the plans with lower targets may be focused on establishing minimum performance standards for the highest cost customers or defining near-term goals.
- Dispersion in aggressiveness of NGAN coverage goals. The "leading" countries (those with ambitious goals with respect to speeds, coverage and timing) have targeted near universal availability; whereas some other countries (including the US), have less ambitious coverage goals. Part of this is due likely to the greater costs implicit in serving less-dense communities ("rural gap").

Among the leading countries, there are several that are already well-advanced in deploying FTTx NGANs. This includes a number of Asian countries like Japan, Hong Kong, Taiwan, and South Korea which already have wide spread availability and adoption of broadband services offering 100Mbps and higher access speeds.<sup>19</sup>

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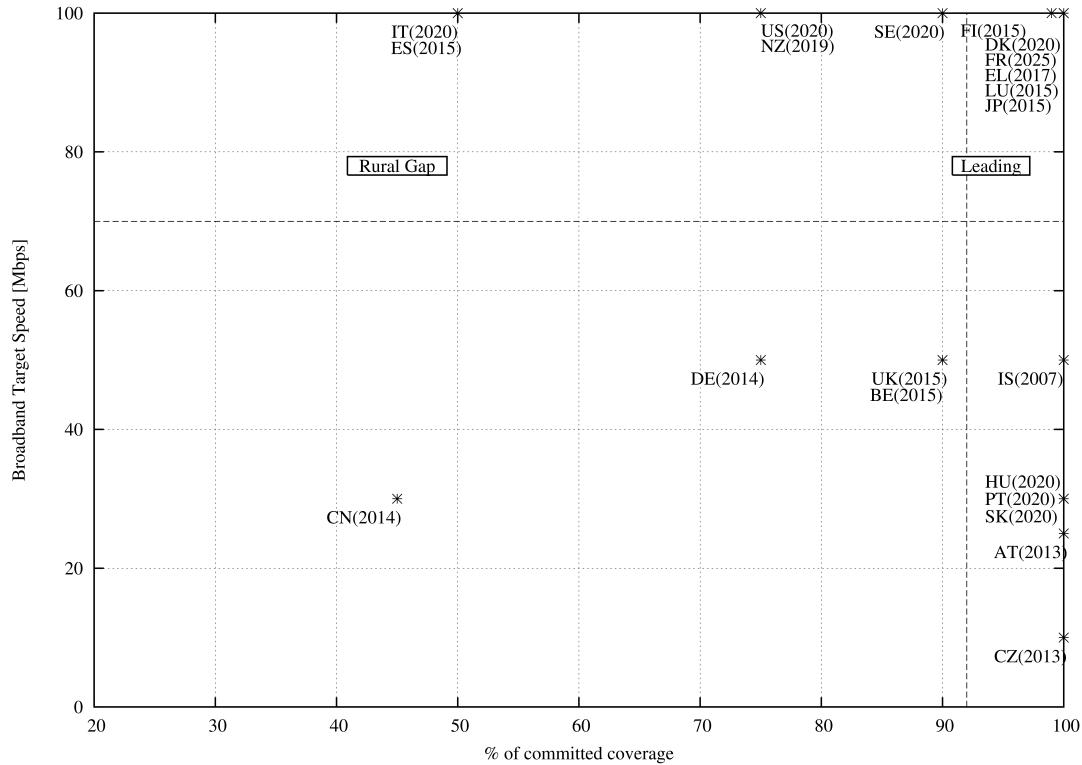
number of jobs creation, see Katz. R., L. et al. (2008). Also Koutroumpis analyzed the impact of broadband on GDP growth and determined that the effect was higher on countries where the penetration level was higher, see Koutroumpis, P. (2009) Also Katz and Suter (2009) have estimated the economic impact of the Stimulus plan.

<sup>16</sup> In the USA, just after the 2009 economic crisis was in place, it was released a plan to create new jobs, spur economic activity and transparency with a total amount of \$787 Billion, risen to \$840 Billion in 2012. Among all the actions to accomplish the goals American Recovery and Reinvestment Act of 2009

<sup>17</sup> Initially in 2012, from €50Billion, a €9.2 Billion gross was allocated to broadband development, and from those in 2013, it has been decreased to €29.3 Billion, that has lead to a reduction in broadband development to a total of €1 Billion. Now, the vice-president Neelie Kroes says "this funding will have to be exclusively for digital services: because such a smaller sum does not leave room for investing in broadband networks". See their comments on her personal blog <http://blogs.ec.europa.eu/neelie-kroes/eu-budget-innovation-cef/>

<sup>18</sup> Note, the creation of this exhibit aggregates data from multiple sources. Further details explaining how the exhibits were created is included Appendix 1.

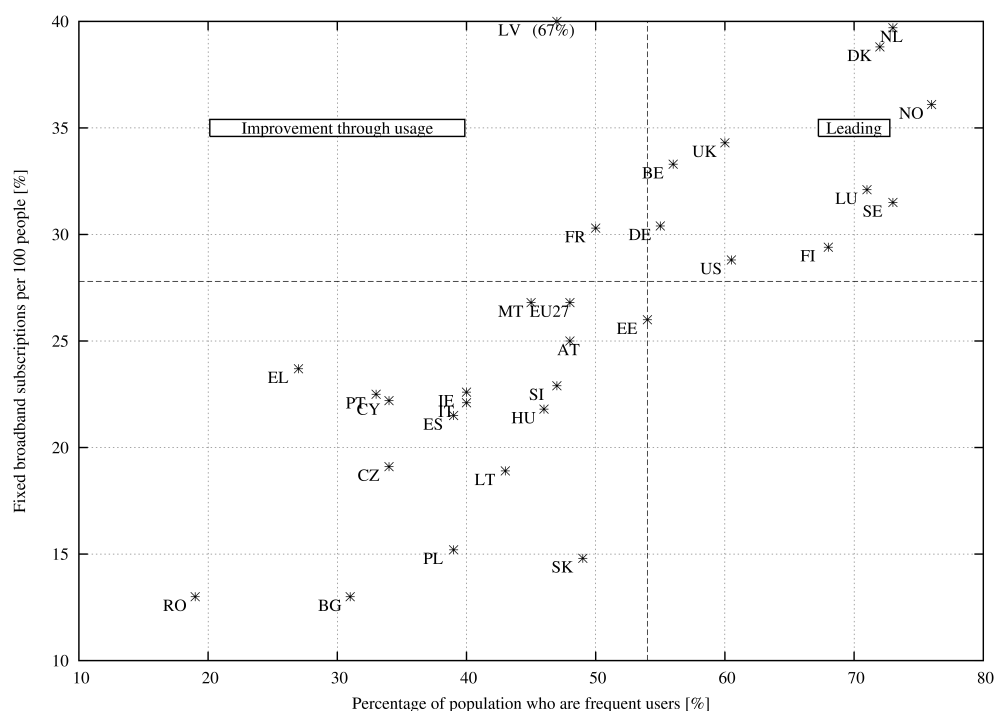
<sup>19</sup> Appendix I provides a cite to the Singapore iDA report, which represents one of the earlier digital agenda plans which was launched in the 1990s. Today, the NGAN in Singapore reaches more than 95% of homes. Hong-Kong and South Korea are two other examples of NGAN leaders. And, it is worthwhile highlighting the example of Australia which is in the midst of ambitious plans to deploy a National Broadband Network –NBN. According to the NBNco plan, it is expected that Australia will have three different wholesale NGAN offers available by the end of 2013 (<http://www.nbnco.com.au/blog/nbn-gigabit-available-december.html>), as follows (download/upload Mbps): 1,000/400 for AUD\$150/month; 500/250 for AUD\$100; and 250/100 for AUD\$70. See Voon and Mitchell (2011) for further details on the Australian NBN plans.



**Figure 1 Digital agendas constellation. Country coverage versus broadband targets, and in parenthesis, the target year for accomplishing the goal. Data extracted from OECD (2011) and country specific Digital Agendas, some of which are documented in Appendix I. Dotted axes show the average points.**

Much of the heterogeneity in digital plans/agendas is associated with differences in national market conditions. It is reasonable to expect that there is a positive correlation between the quality of broadband and Internet usage. This is obvious in Figure 2 which plots the percentage of population that are frequent Internet users (X-axis) against the percentage of population which subscribes to (fixed access) broadband services per 100 people (Y-axis). Broadband significantly enhances the quality of a subscriber's Internet experience, and thus, increased Internet usage and broadband access are mutually reinforcing. Markets with advanced, high levels of broadband access penetration and Internet usage support both the commercial and political demand for more aggressive NGAN strategies. Observation of this positive correlation helps motivate interest in improving broadband quality with the expectation that improved broadband quality enables new and improved (interactive, rich media) applications which stimulates per subscriber and aggregate demand, motivating further demand to expand aggregate capacity. This positive-feedback response is an example of the positive network externalities that the transition to universal service for an enhanced NGAN enables. That is, the value of broadband to subscribers increases with the total number of subscribers,<sup>20</sup> so long as the growth in subscribers is not offset by increased congestion costs.<sup>21</sup>

<sup>20</sup> The network externalities arise in multiple ways. A larger broadband network makes it feasible for each subscriber to communicate at broadband speeds with a greater number of broadband users and applications, obviating the alternative of defaulting to lower-speed or less-connected forms of communication. And, a larger potential market for broadband



**Figure 2 Relation between users demand and broadband implementation. Data sources are from OECD 2012, US Department of Commerce 2013. Latvia comment<sup>22</sup>. Dotted axes show the average point.**

## Current status of FTTx deployment in US/EU

We are still in the early stages of a possible transition to FTTx-based infrastructure and widespread availability/adoption of next generation ultrafast broadband services.<sup>23</sup> Most users today have broadband service (mobile or fixed) that offers speeds ranging from 1-10s of Mbps;<sup>24</sup> however, in a large number of markets, it is increasingly possible for

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users motivates increased investment in complementary goods like broadband-enabled content and applications, which adds to the quality of the broadband experience (analogous to how demand for Microsoft's Windows and Apple's iPhone benefited from the proliferation of compatible applications).

<sup>21</sup> Congestion imposes a negative externality which can make broadband less valuable as subscription grows. The expansion of the NGAN to higher speeds creates the potential for increased range of peak/average per-subscriber data rates which accentuates the capacity provisioning challenges, and the difficulties inherent in forecasting future NGAN investment requirements. As with telephone provisioning, we do not expect everyone to be using their broadband (or telephones) at the peak data rates continuously and at the same time, allowing for significant statistical traffic aggregation and resource economies for shared components.

<sup>22</sup> Latvia should be set higher in the figure, but is so high that it leaved all the others together and distorted the view and porpoise of showing correlation. In the case of Latvia, mainly Riga and some cities are covered. Riga with around 710.000 inhabitants is a high percentage of around 2.200.000 people living in Latvia. Speeds offered reach 500Mbps.

<sup>23</sup> OECD data reports that 14.88% of broadband subscribers have fiber connections as of December 2012 (see, <http://www.oecd.org/sti/broadband/11-PctFibreToTotalBroadband-2012-12.xls>). Those connections are called "ultrafast broadband" to be differentiated from current "broadband" literature, as they are provided with a medium, fiber, that will allow 10 times or more speed increases in the future.

<sup>24</sup> Akamai reported that average global connection speed was 3.1Mbps and the average global peak connection speed was 18.4Mbps in 3Q2012 (see, [http://www.akamai.com/dl/akamai/q1\\_2013\\_soti\\_infographic.pdf](http://www.akamai.com/dl/akamai/q1_2013_soti_infographic.pdf)). The comparable data for the US (average/peak Mbps) were 8.6/36.6. Ofcom reports that average broadband speeds in the UK have



users to obtain services offering 100-1,000Mbps services. Coverage (deployment measured as homes passed) and penetration (measured as share of eligible homes that subscribe) have increased significantly in recent years, exceeding 10% of homes passed and achieving high penetration rates among those households (exceeding 30-40%) even in the face of wide dispersion in retail pricing for ultrafast broadband services and uncertainty about the consumer need for such services.<sup>25</sup>

**Table 1 Current status of FTTx deployment in North America and Europe**

	North America <sup>26</sup>	Europe <sup>27</sup>
Homes/Buildings passed by FTTx (millions)	21	33.8
Percentage of homes passed%	16.4% <sup>28</sup>	15.8% <sup>29</sup>
Connected homes (buildings)	9	7.3
Penetration (% of those passed)	42%	21.5%

While the ultrafast broadband market is still in the early stages of development, we have passed the point where these can be regarded as research/pilot-test-case offerings. There exists of subset of users and communities for which ultrafast broadband is already a commercial reality, and providers are experimenting with how best to service/address this emerging market. We might reasonably expect that user behavior and demand for ultrafast broadband will change as the market matures, and that operators will change their strategies in how these services are provisioned and marketed in response.<sup>30</sup> Additionally, the expansion in market demand and learning-by-doing may be expected to have scale/scope cost saving benefits. These anticipated changes and uncertainty suggest caution in examining current retail pricing for ultrafast services.

## Retail Pricing for Ultrafast Broadband Services

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continued to increase, rising to 14.7Mbps as of May 2013 (see, <http://media.ofcom.org.uk/2013/08/07/average-uk-broadband-speed-continues-to-rise/>).

<sup>25</sup> We do not address arguments here about how much speed is enough, and note that speed is not the only nor necessarily best predictor of improved performance. Obviously, there are other factors that matter for performance assessment (e.g., latency, reliability), but speed is often positively correlated with these other performance metrics, and speed often remains the best single metric available to assess the capacity and performance capabilities of the access service. Also, a higher speed NGAN opens additional technical and regulatory options for enabling competition and can compensate for resource bottlenecks at other points in the system. Thus, a 1Gbps NGAN might be shared to support multiple lower-speed last-mile providers (enabling greater competition); or to reduce the need to invest in optimizing application performance or content delivery strategies. Conversely, additional resources elsewhere in the system (caching, CPU-cycles for compression, channel-bonding, etc.) can offset deficits in access capacity. We highlight these complexities here to suggest that even if one doubts whether household consumers want or need ultrafast broadband, that focusing on speeds and investment remains a useful exercise.

<sup>26</sup> See Fiber To The Home council (2013)

<sup>27</sup> Data extracted from Director of Studies, Telecoms Business Unit. It can be consulted the public news on Digiworld by IDATE, February 2013 <http://blog.idate.fr/tag/ftth/>

<sup>28</sup> the number of households in USA, see United States Census Bureau (2012), and Canada, See Gouvernement du Canada (2011), 114,761,359 and 13,320,615 respectively, therefore the optical fiber coverage is set around the 16.4% among the US and Canadian households together

<sup>29</sup> 213,572,400 according to Eurostats (2012)

<sup>30</sup> For example, ultrafast broadband may be sold as a luxury good when its availability and capacity to support widespread adoption are issues; but, we generally expect very different pricing economics when yesterday's luxury good becomes today's mass market median good.

Earlier we described ultrafast broadband as offering an order of magnitude or more increase in data rates, which with today's typical speeds implies speeds of 100Mbps to 1Gbps. An examination of retail pricing data demonstrates that such services are available from a wide range of operators, but few subscribers are choosing such plans. This may be because subscribers do not need such high data rates or because the price for such plans is perceived to be too high. While it is interesting to look at existing offers of 100Mbps – 1Gbps service, these appear to be priced today by some operators as luxury goods, and so do not seem likely to bear any obvious connection to the underlying costs of providing such service.<sup>31</sup> In this paper, we define ultrafast broadband services as those offers with speeds of 30Mbps or greater for several reasons.

First, it is likely that an operator who wishes to offer 30Mbps or higher speeds is relying on an NGAN based on an HFC or a FTTx architecture (or one with similar investment cost implications) that could support 100Mbps to 1Gbps services.

Second, 30Mbps provides a natural break point in today's markets. Figure 3 plots the same OECD data from Figure 2 with the Y-axis replaced by the percentage of subscribers with broadband access service in excess of 30Mbps per 100 people. This shows the same sort of positive correlation as in Figure 2 but is shifted downward because lower speed broadband customers are excluded. Government policymakers have used a similar 30Mbps threshold to distinguish ultrafast broadband and may have different regulatory policies for ultrafast services, recognizing that these are still emerging and that the need for a public commitment to ensure universal access to ultrafast services is still controversial. For example, in European wholesale markets, policymakers price regulate wholesale offers below 30Mbps, but do not require operators to offer wholesale services at higher speeds nor regulate the pricing of such services when offered. Also, policymakers may (reasonably) adopt multipart broadband policies that promote ultrafast broadband to a subset of households while simultaneously promoting at least a minimum level to all households.

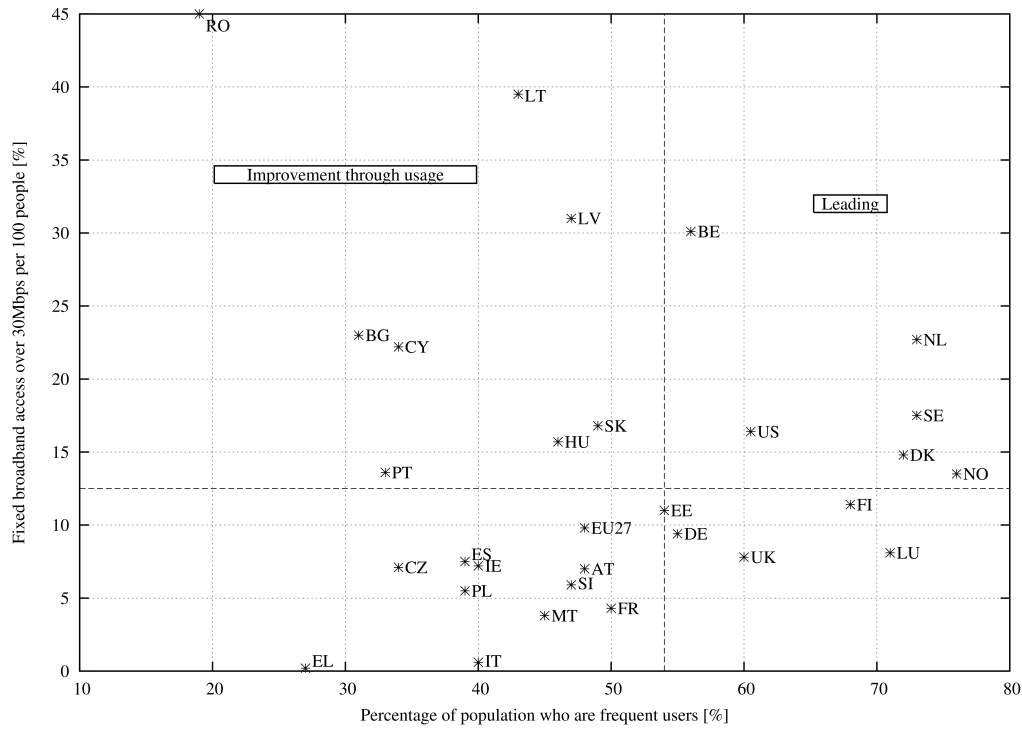
Third, the connection between NGAN speed and the user experience is not linear and the optimal provisioning of access speeds and backbone capacity depends on traffic usage patterns. Today, few customers might be able to see much of a performance difference between 30Mbps and 1Gbps NGAN service, but this may change over time as per subscriber and aggregate usage changes over time.<sup>32</sup> Thus, for many of today's consumers, the 30Mbps and 1Gbps services might be considered as substitutes; and service providers

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<sup>31</sup> Indeed, we might expect that operators would consider consumer demand responses and the need to recover fixed/shared/common costs in setting service tier prices, and so such services would not strictly mirror differences in incremental costs.

<sup>32</sup> Consider how the benefits of faster PCs was often offset by more resource-hogging software applications over time. Folks used to say "Andy Grove giveth, and Bill Gates taketh away," to explain why ever faster Intel-processors were needed to support more bloated PC software. Because economizing on bandwidth capacity is costly (via caching, compression, and other methods), less economizing may occur when bandwidth is more abundant. For example, content providers like Netflix and YouTube may make higher-resolution video available, increasing the size of data files substantially.

may further control usage-related costs by employing data volume caps or other non-linear usage-based pricing.



**Figure 3 Relation between users demand and broadband implementation. Data extracted from BEREC 2012, US Department of Commerce 2013, EU 2012. Dotted axes show the average point.**

## Worldwide Retail Offers

To examine retail broadband pricing offers, we use the data published by the FCC<sup>33</sup> on broadband pricing offers in 38 countries available during August 2011 to February 2012, reported both in \$USD and Purchasing Power Parity (PPP) deflated \$USD (PPP deflators are commonly used for international price comparisons).<sup>34</sup> The FCC data includes 569 plans offering speeds above 28Mbps. The average price for these plans was \$USD 55.20, or when PPP deflated, \$USD-PPP 71.83. Table 2 presents the data broken out by speed tiers.

These pricing patterns show several interesting points. First, it is worth noting that prices increase sub-linearly with capacity. Second, the fact that the 30-50Mbps average price is higher than for the 50-75Mbps service highlights the problems of averaging across markets. Many providers offer multiple speed tiers of service with higher speed services usually priced higher, but comparing plans across operators (even within the same

<sup>33</sup> See Fixed Broadband Price Catalogue was provided by FCC (2012).

<sup>34</sup> Whether it is better to focus on USD or PPP-adjusted USD prices is open to debate; we report both here and leave it to the reader to determine which is more interesting. The source of the PPP deflators is identified in the FCC source documents.

country) is complicated by other differences (e.g., in promotional offerings, volume limits, and other service options).

**Table 2 Worldwide retail offer's prices categorized by speed type**

<b>Monthly Offer Type</b>	<b>Average PPP USD</b>	<b>Average USD</b>	<b># OBS<sup>+</sup></b>
<b>Equal or Above 1Gbps*</b>	176.02	125.47	19
<b>Between 75 Mbps to 1Gbps</b>	81.78	62.81	282
<b>Between 50 to 75 Mbps</b>	52.00	39.69	146
<b>Between 30 to 50 Mbps</b>	70.46	54.61	118
<b>All offers over 28 Mbps</b>	71.83	55.20	569

\*Excludes Slovenia, with an offer from T2 operator of 1Gbps priced at USD-PPP \$1,589 that is a clear outlier

<sup>+</sup>Number of Observations

In Table 3, we present data on broadband pricing in the US, focusing on the offers from the two largest providers of broadband services, Verizon (10 plans) and Comcast (13 plans) to highlight the range in pricing.

**Table 3 Average offers from Comcast and Verizon with granular study on the download speed**

<b>Offer Type</b>	<b>Averaged price USD</b>
Above 100 Mbps*	144.86
Above 75 Mbps	142.21
Above 50 Mbps	163.66
Above 20 Mbps	151.65
<b>Averaged</b>	<b>66.43Mbps</b>
	151.41

\*Without TV service. Offers from Verizon and Comcast above that speed exclude TV (as of February 2013).

First, it is worth noticing that the average pricing for ultrafast broadband in the US is significantly higher than the average over all countries reported in Table 2. The fact that prices are higher in the US seems relatively robust to how one defines ultrafast broadband.

Second, retail pricing for the two largest broadband providers are closely matched within speed tiers, which suggests that telephone and cable network-provided broadband are regarded as substitutes by retail customers, and either have similar costs or offer very different margins. The latter explanation seems unlikely in light of a comparison of financial performance.

Third, Table 3 highlights a further problem in comparing broadband pricing. In the U.S. and other markets, broadband is often sold as part of a bundle that includes television services. When television services are included as part of the bundle, it is difficult to infer what portion of the price is for television programming and what part is for broadband service. Increasingly, as television services shift from separate subscription services to over-the-top (OTT) delivery of television, we would expect pricing and provisioning to change. For example, cable providers may be expected to shift RF capacity from television to broadband services, and billing for programming might be unbundled from billing for data transport/delivery.

Table 4 reports data from the FCC sample for all 113 US broadband plans for all speeds that shows the difference in average pricing for broadband plans with and without TV

programming included. This shows that including television in the broadband price in US offers more than doubles the price of the service.

**Table 4 US averaged Offer speed including or not TV on it as a bundled service**

US averaged Offer Speed	Average price USD	Including TV	#OBS
12.5 Mbps	124.48	Yes	34
18.45 Mbps	59.03	No	79
16.55 Mbps	70.21	Averaged containing both	113

By way of comparison, Table 5 summarizes the FCC pricing data from Europe where the inclusion of television has only a minor impact on broadband pricing. This is due in part to systematic differences between the US and European television markets. In Europe, it is much more common to deliver television programming over-the-air via Digital Terrestrial Television or via Direct Broadcast Satellite systems. Furthermore, the costs of television programming are not recovered as part of broadband service revenues (Appendix II provides additional details on European TV regulations).

**Table 5 EU averaged Offer speed including or not TV on it as a bundled service**

EU <sup>35</sup> averaged Offer Speed	Average price USD	Including TV	#OBS
33.13 Mbps	56.50	Yes	234
37.60 Mbps	52.19	No	676
36.45 Mbps	53.28	Averaged containing both	910

In comparing the no-TV broadband services in Europe (Table 5) and the US (Table 4), it appears that the average price for broadband services are reasonably close, but the average offered speed is nearly twice as high in Europe as in the US. Thus, a simple quality-adjusted comparison of pricing would seem to suggest that the average European is getting a much better deal. Multiple explanations for these pricing differences might be hypothesized, including:

- US ISPs are earning significant monopoly profits, perhaps because US regulators have been less aggressive in controlling market power in broadband markets;
- US ISPs confront much higher costs. This might be because of higher usage in the US, because of the less dense users, or because of excessive facilities-based competition that limits the realization of infrastructure sharing costs;
- Other differences in European and US markets not addressed by this comparison of average tariffs, a number of which were noted earlier (e.g., broadband service quality differences, different regulatory or market ecosystems, etc.).

In this paper, we do not attempt to engage which of these hypotheses is most likely to explain the observed data, but note that further research is warranted on the basis of these comparisons.

<sup>35</sup> Europe countries included in this table: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Lithuania, Luxembourg, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, The Netherlands, United Kingdom.

## **Google as an example of a new FTTx entrant**

Finally, it is worth considering Google's launch of 1Gbps FTTH services in Kansas City in 2012. This is interesting because Google provides an example of a new entrant (albeit a rather unique one), and provides possible insight into how the costs and pricing of incumbents and entrants might differ, as well as providing another interesting data point to consider. There are reasons why we might expect incumbents and entrants to have asymmetric costs (which we do not consider here), so including Google here enriches the discussion.

Google's FTTH launch was originally perceived as a demonstration platform for ultrafast broadband and as a new model for rolling out FTTH infrastructure. Google announced its intention to build its network and solicited proposals from cities across the US to help Google select where to launch its deployment. Google considered 1,100 applications before finally selecting Kansas City, Kansas. Shortly afterwards, Google announced it would expand service across the river to Kansas City, Missouri, and then in April 2013, Google announced plans to deploy services in Austin, Texas and most recently to Provo, Utah. We mention these expanded service offering plans to highlight several noteworthy points about the Google plan.

First, with the expansion of the 1Gbps services to multiple cities, the Google project is moving beyond what might be characterized as a pilot/demonstration program to a full-fledged model for deploying FTTH infrastructure for the NGAN. This also illustrates an important feature of fixed infrastructure deployments: it is often possible to expand coverage virally from a network core. Thus, an urban FTTx infrastructure might be expanded to provide coverage in adjacent suburban areas or linked to provide coverage in nearby towns. Coverage gaps may be filled in over time.

Second, Google's process for soliciting bids looks to have been a smart move. The detailed proposals given to Google save Google much of the expense and pain of trying to identify which markets would offer the best prospects for the roll out of Google FTTH services. Google's collection of proposals is a valuable input for strategic planning. Furthermore, when Google commits to deploying to a city, its neighborhood roll-out plan and pricing requires a threshold level of committed buyers, thereby providing some protection for recovering costs. In both respects, Google has realized advantages that will help ease further expansion of its network services.

Third, Google has been savvy in exploiting its brand and market leverage to negotiate attractive terms for things like access to conduit and outside structures that might reasonably be expected to significantly lower its FTTH deployment costs. Whether the cost savings and other economies Google realized in Kansas City or other markets are available to other would-be FTTx entrants or incumbents is uncertain.

Fourth, Google's price of \$127 per month was generally noted as among the cheapest offerings for a bundle that included television and symmetric 1Gbps service. Other innovative broadband offers from Google included 1Gbps service for \$70 per month and

an offer for free 5Mbps service for seven years if the subscriber paid for the fiber drop installation.<sup>36</sup>

## Looking at European and US Ultrafast Broadband Offers More Closely

In this section, we look at the tariffs of different US and European broadband providers more closely, breaking out offers from both incumbents and new entrants. Table 6 provides some basic statistics on the companies considered and highlights the wide range of diversity across companies.

**Table 6 Operators by Market and number of users per employee**

Operators	Market <sup>37</sup>			Employees	Users (Thousands)	Users per employee
	Wired	Wireless	Others			
<b>Free-Iliad (France, New)</b>	99%	1%	0%	5 655	5 364	948.54
<b>Verizon (US, Incumbent)</b>	37%	63%	0%	216 704	144 800	668.19
<b>Google (US, New)</b>	0%	0%	100%	16 to 115 <sup>38</sup>	21 <sup>39</sup>	181 to 1304 <sup>40</sup>
<b>Comcast (US, Incumbent)</b>	64%	0%	36	126 000	22 900	181.75
<b>Telefonica (Spain, Incumbent)</b>	NAD*	NAD	NAD	291 027	313 800	1078.25
<b>Numericable (France, New)</b>	100%	0%	0%	4000<X<5000	1 269	317.25
<b>Adamo (Spain, New)</b>	100%	0%	0%	21	6	285.71
<b>France Telecom (France, Incumbent)</b>	NAD	NAD	NAD	165 533	215 900	1304. 27

\*NAD - Non-Accurate Data

<sup>36</sup> Information site about fiber Google projects <https://fiber.google.com>

<sup>37</sup> See Thomson Financial (2012). It provides accurate data mainly for investors, but also it is a good source for research.

<sup>38</sup> Google currently has 53,861 employees. From those, scaled to the minimum and maximum employees per customers' ratios, they should devote between 16 to 115 people to the Google Fiber division.

<sup>39</sup> Kansas City has 65,000 Comcast's subscribers based on a statement made by the CEO Brian Roberts in Atlanta, information retrieved on August the 1st of 2012, Comcast launches X1 in Atlanta; reports 65% increase in Q2 cable self-installs, from the site <http://www.fiercecable.com>. Based on the take-up rate of the Google's fiber page, <https://fiber.google.com>, and accounting the minimum rate to deploy de network, is currently set between 5% and 25%, but it is getting more than that with an average of 23%, something that gives a total approximate number between 14,950 and 20,000 possible subscribers if all the city surpasses by a 5% the minimums established by Google to deploy their network in Kansas City. We should add also plans for Provo and Austin, but they seem to be clearer at fall 2013. So, a non-too optimistic approximation at the end of 2014 should be 21,000 Google Fiber subscribers.

<sup>40</sup> If Google would be accounted as the other operators they would outstand all the numbers, as they would be having 2.5 staff people to attend one customer. 0.40 would be their ratio in the table column then.

The companies in Table 6 span a range of business models. There are three firms from the US: Comcast, the largest incumbent cable broadband provider; Verizon, the largest incumbent telephone broadband provider; and Google, the preeminent Internet search company, but a new entrant into fixed broadband services. The remaining firms are European from France and Spain, with two incumbents (Telefonica in Spain and France Telecom in France),<sup>41</sup> which also have operations in a number of other national markets; and three entrants (Numericable and Free-Iliad in France and Adamo in Spain).

The incumbents (Comcast, Verizon, Telefonica, and France Telecom) are all large, established companies operating in multiple telecommunication market segments. In contrast, the entrants are much smaller and more recent participants in the broadband service markets. For example, Numericable is a new venture that was launched five years ago by a combination of rural French cable companies, that now serves 9.8 million subscribers and was one of the leading operators to deploy highspeed cable-based services using DOCSIS 3.0.<sup>42</sup> Adamo is an emerging Spanish FTTB provider that operates in the north of Spain and that is currently serving six thousand FTTx subscribers.<sup>43</sup> It is noteworthy that these entrants with new infrastructure are pushing the envelope in offering ultrasfast broadband services. Finally, Free-Iliad in France is one of the older and best known of the new broadband entrants that have built their business by leveraging regulated access to France Telecom's copper network.<sup>44</sup> Free-Iliad has disrupted the ultrafast broadband market with offers of 28Mbps service for \$39/month. In addition, they are currently serving about 300k subscribers (about 6% of their installed base) over their own fiber optic network, offering those subscribers 100Mbps service for the same low price.

Table 7 provides a comparison of the offers from incumbents, European new entrants, and Google. Creating this table requires making a number of heroic assumptions that include:

- The retail offer prices are the averages based on the tariffs advertised on the providers' websites as of March 2013. The averaged prices for incumbents and Google are for retail services that offer "Triple Plays" that bundle in TV and telephone services, whereas the entrant services exclude TV.
- TV costs are estimated at \$29.44/subscriber based on the cost reported in Comcast's annual report.<sup>45</sup>

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<sup>41</sup> Both Telefonica and France Telecom are large multinationals and extracting the national broadband market-relevant data proves to be quite difficult. For example, Telefonica (operating as Movistar or O2 depending on the country) and France Telecom (Orange) operate in multiple national markets in Europe and elsewhere.

<sup>42</sup> Numericable, consulted on March 2013, <http://www.numericable.fr>

<sup>43</sup> Adamo Telecom Iberia S.A., consulted on March 2013, <https://www.adamo.es>

<sup>44</sup> 94,2% of its 5.36 Million subscribers is unbundled from the existing copper network, mainly owned by the French incumbent France Telecom.

<sup>45</sup> We take Comcast as one of the operators that expend more on programming and TV content delivery. By selecting Comcast we guarantee that the cost one approximation to the real cost per month that we can obtain without being an operator. We have also tried to obtain it for the past years and observed that this cost is really growing. Currently we can approximate it to a monthly cost of \$29.5, but for 2010 was set around \$25. Data extracted from the Comcast 2012 Annual Review, Annual report on form 10K. The increase as \$4.5 per month was also due to the London Olympics.



- Customer management costs include sales and marketing and customer service costs and are estimated as a percentage of operating expenditures. From operator annual reports, this ranges from 19.99% to 39.95%, for an average of 21.42% for large companies and about 17% for the entrants (excluding Google, which is assumed to be a large company).
- Telephone expenses are estimated as \$4/line for legacy telephone, and \$1/line for newer VoIP-based services.
- Network operating expenses are estimated at between 5% to 10% of operating expenses, based on a review of operator accounting statements. We assume operating expenses are 9%, at the higher range based on this selection of operators.

**Table 7 Unwrapping different type of operator's retail offers (all table expressed in USD)**

	<b>Incumbent Operator 100Mbps</b>	<b>New entrant 200Mbps</b>	<b>Google Kansas 1Gbps</b>
<b>Average retail offer</b>	166.19	61.57	127.00
<b>TV programming cost</b>	29.44	0.00	29.44
<b>Customer management</b>	35.64	10.47	27.48
<b>Telephony and Voice</b>	4.00	1.00	1.00
<b>Network OpEx</b>	14.96	5.54	11.43
<b>ARPU before Taxes</b>	82.15	44.56	57.65
<b>Taxes</b>	9.41	10.69	7.19
<b>NET Money (ARPU)</b>	72.74	33.87	50.46

With these assumptions, the above analysis suggests that ultrafast broadband operators have something like \$30 to \$70<sup>46</sup> per month per subscriber to recover the costs of providing ultrafast broadband services. Moreover, if these offers are economically sustainable (i.e., recover the costs of providing ultrafast services, including earning a fair, risk-adjusted return on invested capital), then this suggests that substantial improvements in quality are achievable without implying significant increased costs (i.e., new entrants in Europe and Google can offer services that differ in speed by a factor of 5x, but differ in revenue contribution by less than 0.5x; and, that either incumbent operators confront much higher average costs or substantial price reductions or cost increases might be economically viable.<sup>47</sup>

<sup>46</sup> According to Comcast on their cable segment: "Our average monthly total revenue per video customer increased to \$149 in 2012 from \$138 in 2011 and \$127 in 2010" the monthly ARPU would be higher than the estimated one, but it would include Video On Demand, and supplementary services see Comcast 2012. According to Free (2011) would have an ARPU lower than Comcast: "Broadband ARPU was € 34.5 per month (excl. VAT) during the 4th quarter 2006, vs. € 32.2 per month in the 4th quarter 2005", see Free 2007.

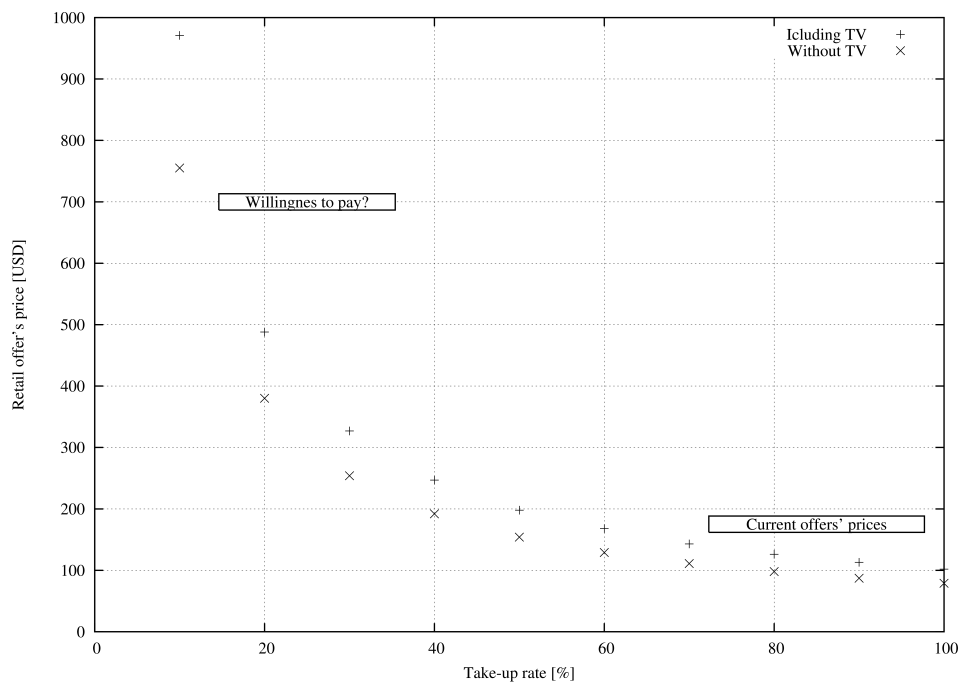
<sup>47</sup> The data in Table 6 suggests incumbent firms have an additional 50% of revenue contribution available to support broadband services and investment, and are capturing that revenue with a lower quality (in terms of speed) offering. This might be due to legacy excess margins that might be eroded by the requirement of investing in new FTTx infrastructure; or, it might be due to incumbents facing higher costs. That might be the case because entrants can cream skim the markets they choose to serve, because incumbents face asymmetric regulatory burdens (e.g., carrier of last resort) that impose additional costs, or some other reason. We might expect that operators would be reluctant to admit that high margins are the explanation for the significant differential in broadband margins and to resist forces that would compress those margins, but as long as firms can earn a competitive return, the economic investment is sustainable.

## Estimating the costs of NGAN investment

Our estimates of the required investment for an NGAN to support ultrafast broadband services is based on an earlier model developed to estimate the costs of providing universal FTTx services in Europe that relies heavily on shared infrastructure. This is in marked contrast to the current situation in the U.S., where duopoly facilities-based competition has prevailed in broadband services thus far.

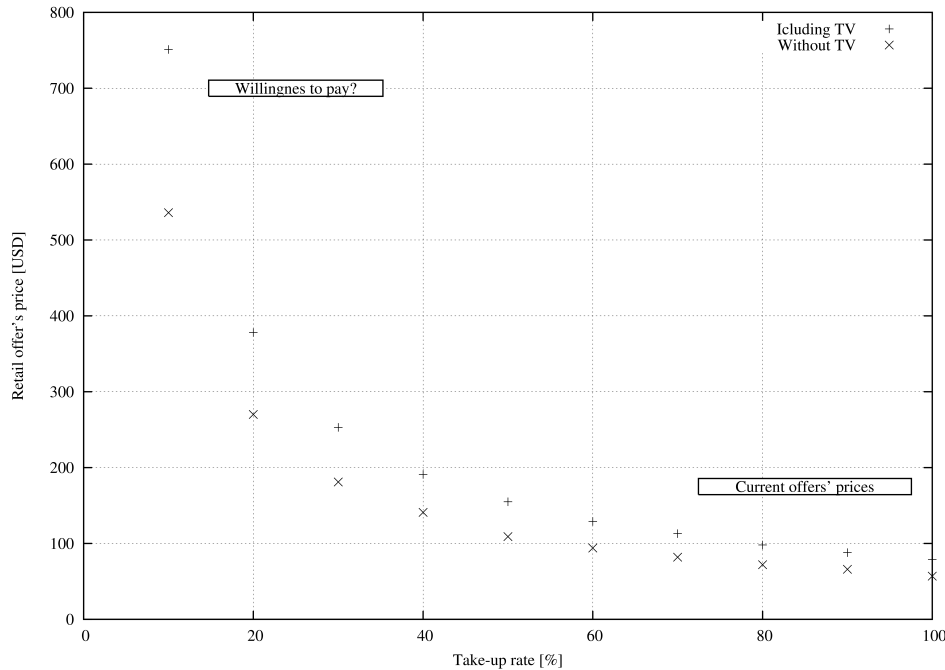
This earlier model was simplified and parameters were adjusted to reflect US market conditions, based on data provided by folks involved in rural broadband deployments in Massachusetts. The assumptions and modeling framework are described more fully in Appendix III.

The cost-model provides estimates of the investment required to deploy universal service FTTx infrastructure. To match these cost estimates to the revenue requirements, we compute the average revenue per month required to produce a positive Net Present Value (NPV) investment in five years (assuming a real return of 10%) at different take rates. At lower take rates, the revenue contribution per line has to be much higher to recover the total costs.



**Figure 4: US NPV set to an investment of 5 years. Retail offer Price set over take-up rate**

Figure 4 shows that achieving a positive NPV within 5-years requires a broadband service contribution in excess of \$100 for any NGAN that fails to capture at least 80% of the homes passed. If there is duopoly (or more) facilities-based competition, then the total market penetration needs to be shared.



**Figure 5: US investment to get a positive NPV in 10 years. Retail offer Price set over take-up rate**

Figure 5 re-computes the revenue contribution requirements if break-even after 10-years is acceptable. As we might expect, this significantly reduces the revenue requirements. It might be argued that this longer break-even horizon is reasonable in light of the fact that so much of the investment is in long-lived outside plant infrastructure, rather than electronics that might be subject to much more rapid economic depreciation. With this adjustment, prices approaching the range of today's ultra-broadband retail offers are consistent with providing service in rural areas. Because these estimates are based on providing universal service to rural markets (under the assumption that Massachusetts provides a reasonable proxy for such markets), this likely overstates the average cost of providing universal service since rural markets are more costly to serve than urban markets. These estimates also show how revenue requirements increase when take rates are lower, which occurs both when aggregate adoption saturates at a lower level and when facilities-based competition requires aggregate penetration to be shared across multiple providers.

## Conclusions

In this paper, we examine data on broadband pricing and match it with a model for shared FTTx infrastructure deployment, and conclude that it is not unreasonable to expect to be able to meet universal service goals to provide order-of-magnitude (future-proof) broadband infrastructure in rural areas in Europe and the US without necessitating dramatic increases in per-subscriber revenue contributions for broadband. We estimate that today's broadband pricing includes a revenue contribution to support broadband investment of between \$30 to \$70 per user-month, which is sufficient to recover the costs of a shared fiber NGAN network.

Moreover, limiting facilities-competition and sharing last-mile infrastructure can significantly reduce deployment costs. This is likely to be especially relevant in providing service in rural areas where demand is more limited (and hence the excess capacity associated with provisioning more than a single FTTx NGAN) and costs are higher (because of the lower density of addressable subscribers).

Furthermore, if we consider deploying a single 1Gbps-capable FTTx NGAN, this could be shared among multiple service providers either dynamically (based on which ISP a household subscribes to) or by allocating fixed partitions of the capacity if the peak data rates are 500Mbps or less. With shared infrastructure, revenue requirements would be reduced and broadband prices could fall without threatening economic viability.

Google's entry into offering broadband services is interesting because it potentially raises the bar for launching services on newly deployed fiber networks by offering 1Gbps services at pricing that is close to what consumers are paying for much lower quality broadband in most other markets.

This analysis also begs the question of why broadband customers appear to be getting a much better deal in Europe than the US: Europeans are paying less for higher speed broadband. Possible explanations include US operators earning higher profit margins than their European counterparts; US subscribers paying for the benefit of increased choice in broadband offerings (duopoly facilities competition); or US operators confronting higher costs than European operators. Figuring out what mix of these or other possible answers poses an interesting question for broadband analysts.

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Digital Plan references are in Appendix I.

## Appendix I

This Appendix provides additional information on the sources used to construct the mapping of national digital plans/agendas included in Figure 1. Figure 1 was constructed by collecting information from a large sample of digital agenda reports and publications.

Table A.1. Country Name/Code Mappings used in Figure 1

Code	Country Name		
AU	Australia	JP	Japan
AT	Austria	LV	Latvia
BE	Belgium	LT	Lithuania
BG	Bulgaria	LU	Luxembourg
CN	China	MT	Malta
CY	Cyprus	NL	Netherlands
CZ	Czech Republic	PL	Poland
DK	Denmark	PT	Portugal
EE	Estonia	RO	Romania
FI	Finland	SK	Slovakia
FR	France	SI	Slovenia
DE	Germany	ES	Spain
EL	Greece	SE	Sweden
HU	Hungary	UK	United Kingdom
IE	Ireland	USA	United States of America
IS	Iceland	NO	Norway
IT	Italy	EU27	European Union of the 27 first added countries

The following digital plans were among those considered in preparing Figure 1:

- Argentina, El Poder Ejecutivo Nacional; “Estrategia de Agenda Digital de la República Argentina”; Spanish written, Buenos Aires, May 7<sup>th</sup>, 2009.
- Australia, Department of Broadband, Communications and the Digital Economy “National Broadband Network corporation Plan 2012-2015”; prepared for the consideration of the Shareholder Ministers, August the 6<sup>th</sup>, 2012.
- Austria, Ministry of Transport, Innovation und Technology; “Broadband-Strategy 2020”, 2012.
- Belgium, Ministre pour l’Économie et la Simplification administrative; “La Belgique – Coeur de l’Europe numérique 2010-2015”; Quickonomie.be, 2009
- Cyprus adopted the broadband targets of the Digital Agenda for Europe. By 2013 all households will have access to the Internet with at least 2Mbps, by 2020 they will accomplish the EU targets. Information extracted from European Commission, Information Society, and Implementation of the Digital Agenda. 2012.
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## Appendix II: European TV market

As this is not the main goal of the article, we have taken into account the cost of broadcasting TV offers over fixed networks, but we found it really interesting to know, we can categorize some European examples based on their TV payment fees.

Some countries have as an only income for TVs the television license taxes; those are France, Denmark, Norway and Sweden. Others have a television license tax and also allow the display of commercials on TV like Greece, Ireland, Italy, Polonia, and plenty of other European countries follow that model, a cost example for Ireland is €160 per television at home<sup>48</sup>. Then, some regulated countries with license per TV at home, commercials shown on TV and government grants are Germany and UK. For Germany you can consult the current fees for a combined TV & Radio license and obtain that a yearly fee is set at €215,76 per obtaining both at home<sup>49</sup>. Another example of this is United Kingdom. There, according to Ofcom, you must yearly pay a fee of £145 per color TV at home or £49 per a black and white TV<sup>50</sup>. This allows you to watch TV in computers or mobile, but you have to live on an address that pays this fee. Then, you have some countries with no license on TV and that are funded basically by governmental funds and may include or not commercials on their broadcasting programs. This last example occurs in Finland, Netherlands, Portugal, Spain or Turkey, although some other taxes are imposed to obtain the amounts of the public grants like Turkey obtaining them from a small percentage over light consumption or Spain with a percentage applied to telecommunication operators.

In Europe most of the TV channels have been always broadcasted in the UHF spectrum band, and not until now, some local or regional channels are debating to start broadcasting as an all IP channel. White Spaces, and the need of spectrum for 4G-LTE and future 5G connections is also lowering the number of radio broadcasted signals. See Domingo et al. (2012) that concludes that there is more availability of White Spaces in rural areas than in Urban areas, showing that radio TV broadcasting is the most common way of doing it.

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<sup>48</sup> See for more information <https://www.anpost.ie/AnPost/tvlicence250108.htm>

<sup>49</sup> See for more information <http://www.rundfunkbeitrag.de/>

<sup>50</sup> See for more information <http://www.tvlicensing.co.uk/>

## Appendix III: Further Notes on Investment Modeling

In this Appendix, we provide some further notes on the modeling approach used to develop the investment forecasts that are matched with the pricing data. As noted earlier, the basic model was originally developed to estimate the costs of meeting universal service goals in Europe for FTTH deployment (Domingo & Oliver, 2011). A European Commission sponsored study had previously estimated that meeting this goal would require €300Billion, now €202 billion according to FTTH council Europe<sup>51</sup>. By exploiting opportunities to share last-mile infrastructure more intensively, Domingo & Oliver (2011) concluded that the investment requirements could be reduced by 40%.

For this paper, this model was simplified and re-parameterized using data for Massachusetts to derive a comparable benchmark for the investment requirements to meet a FTTx universal service goal in the US. The parameters used for Massachusetts are intended to capture the challenges confronting a US operator seeking to deploy FTTx to a rural (less dense) market. Focusing on rural deployments is conservative since these are typically the higher cost and present the most difficult challenge for universal service goals. In this paper, we calculate how much revenue is needed to yield a positive NPV for a "typical" rural fiber deployment under different typical monthly revenue streams (as summarized in Figures 3 & 4).<sup>52</sup> The model uses parameter estimates derived from Massachusetts state data, including such things as current State pricing for outside structure sharing/pole attachments and other data.

Some of the key parameter inputs included:

- Inhabitants density per squared Kilometer: less than 600
- Averaged of the first tram: 3.8 Kilometers
- Averaged last tram: 150 meters
- Tax applied: 6%
- Rate of return: 10%
- Inflation: 4%
- Cost of cabinet installations
- Also applied costs of deployment per meter, aerial 90% and pavement/road 10%. Aerial deployment estimation is 42\$ in front of the 59\$ accounted for pavement/road
- Model deployed with passive technology following a GPON<sup>53</sup> model, meaning that we share over one fiber a number of users. Splitters installed are 1:8 and 1:4 models<sup>54</sup>.
  - Depreciation of active equipment: 6 years
  - Other accounted costs of installations cost of fibers from 96, 32 fibers, deploying cable, home installation, active elements (ONTs and OLT).

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<sup>51</sup> Estimated by McKinseyAnalysis to be around €250-300 billion. Estimated by FTTH council Europe to be €202 billion, See FTTH council Europe, 2012.b.

<sup>52</sup> Successful is that we get profits on it within the agreed period of time with the network investor.

<sup>53</sup> GPON: Gigabit Passive Optical Network. Following recommendation of 2010 from ITU it can be achieved a 40km deployment and it may also be achieved a 60km deployment, but the current implementations take 5 as a maximum stable window for operation between Point of Presence and User Homes. See ITU-T (2010).

<sup>54</sup> From 1 fiber it splits its data to the second written number of exiting fibers, e.g.: 2, 4, 8, 16. Noted as 1:2, 1:4, 1:8, 1:16. Those are passive elements and do not need any energy to their normal operation.