Report prepared for Chorus

Estimating the Wider Socio-economic Impacts of Ultra Fast Broadband for New Zealand

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Contents

Tables

Figures

Executive summary

This report estimates in monetary values the benefits to consumers from Ultra Fast Broadband (UFB). The intent is to establish a baseline and stimulate further interest in an area that is under-researched. It is a contribution to the discussion and debate, rather than the final word.

This report complements earlier work in which we estimated the gains in business productivity and GDP of UFB. It draws from separate reports summarising relevant literature and describing in more detail our method for estimating the benefits.

We estimate the wider impacts on society from UFB, expressed in terms of the consumer surplus. Consumer surplus is a measure of the additional well-being users derive from a product after deducting the amount paid by the consumer for that product. Using publicly available data we constructed a demand curve for UFB (that is, a measure of how demand for UFB changes in response to price changes). We sourced average monthly prices for a range of technologies, including UFB.

These estimates allowed us to calculate a 'base case' value for the consumer surplus for UFB in 2016 of around $60 million per annum, given the uptake rate of UFB of 30% in that year. This relatively modest figure is due mainly to the very flat demand curve we estimated using 2015 and 2016 prices and demand. A flat demand curve signifies a high degree of responsiveness in demand to changes in price. We suspect the very flat shape of our estimated demand may reflect the limited number of data observations available to us (the literature suggests the demand curve should be steeper than our estimate). Hence our base case is likely to be conservative (that is, it probably underestimates current consumer surplus).

We extended this 'base case' to account for a rise in uptake (the % of consumers using UFB where it is available) as well as a change in the nature of demand as UFB becomes more ingrained in people's lives and as new activities able to be carried out online are discovered. We used publically available projections that UFB would reach 85% of the population by 2024 and assumed people with access to UFB would take up that offer. Increasing consumer reliance on UFB (for existing and new activities) would result in a steeper demand curve - consumers would be less responsive to price as the product becomes more important to their way of life. With a steeper demand curve the difference between the price a consumer pays and the value the consumer places on the product increases.

We estimate the consumer surplus with 100% uptake in 2024 (where UFB is available) without a price change at $1.77 billion per annum. Any reduction in the real price of UFB over time would increase the benefit to consumers.

We altered key parameters to test the sensitivity of the estimates to changes in:

- the nature of demand - that is, whether demand for UFB is more or less responsive to changes in price
- the price at which demand for UFB is zero - that is, a measure of the maximum willingness to pay for UFB per month known as a 'choke price'.

This sensitivity analysis produced a range of feasible estimates of consumer surplus when uptake is 100% (in 2024). This range was $1.29 billion to $2.3 billion. The main driver of the variation in estimates was the assumed 'choke price'. We assumed a relatively modest choke price of $175 per month, based on work done by the Commerce Commission in modelling traditional copper network services. Further work on establishing the çhoke price for UFB would be very helpful in terms of narrowing the relatively wide range of estimated consumer surplus.

An 'exploratory' undertaking such as this is subject to a range of limitations. These limitations and caveats include:

- *Guidance from literature is limited*- the wider social impacts of UFB technology have not been widely studied. Hence, the evidence base on which to rely for guidance on estimation techniques, models or relevant and clear results was thin.
- *Potential uses not fully understood* – there is a lack of an established description and understanding of some of the potentially important uses and applications that could result from greater UFB uptake. For instance, primary research on the role of UFB in the development and growth of Smart Cities, marae-based connectivity initiatives as well as other digital inclusion dimensions under the broad banner of social cohesion and inclusion would contribute greatly to the understanding of the value to consumers from the facilitation channels UFB provides.
- *Data availability*- we relied on publicly available information. Such information is patchy, lacks specificity and is not especially timely. The dearth of data means that key factors such as the shape of the demand curve, the relevant population of households and users for different connection types and migration' across technology types either have to be assumed or are omitted from the analysis.

While the sensitivity analysis identified the impacts of changing some parameters that contribute to potential over or under-estimation, the range of final estimates is unavoidably wide.

Introduction

1. Following earlier work estimating the economic value to businesses and industries of Ultra Fast Broadband (UFB) we now consider the wider (that is, non-business/productivity-related) economic value of UFB.

2. Given the relative novelty associated with estimating such wider socio-economic effects of technology, we proceeded in a staged manner. The three stages were:

- scanning and summarising relevant literature
- describing the methodology and the data sources needed to quantify (where feasible) socio-economic benefits or qualitative assessment of the magnitudes of wider benefits
- completing the quantitative estimates and qualitative assessments and writing up the results.

3. This report summarises the combined findings from the three stages. It starts by describing in general terms the various impacts likely to be associated with UFB and a conceptual framework for organising the analysis of impacts. We then summarise the key insights from relevant literature, and highlight the available techniques that could be used to derive impact estimates.

4. The concluding section presents our estimates of the wider (that is, non-GDP-related) impacts on society from UFB. We express the wider impacts in terms of the consumer surplus available from UFB. A consumer surplus arises where an end user receives goods or services at a price that is below what they are willing to pay for the service. The consumer surplus is the difference between the price the consumer pays for the good or service and the value to the consumer of the good or service. Individual consumer surpluses can be summed to obtain the aggregate benefit to consumers from a good or service. Consumer surplus has been used in similar studies calculating the benefits of broadband and other technology.

How UFB gives rise to wider impacts

5. UFB has been posited to have the following attributes:[1]

- much greater consistency of bandwidth across users and over time
- higher download and particularly upload speeds
- greater reliability of service (i.e. reduction in faults)
- other improvements in quality of service including lower latency (lags in responding), lower error rates (which can disrupt streamed video), and freedom from radio frequency interference (which raises the quality of video applications).

6. While appearing to state the obvious, any additional value that UFB provides comes from the uses that UFB is put to, not just from being connected. The characteristics shown above have no intrinsic value *per sé* but they do greatly improve the user experience and service capability of broadband.

7. Greater speed saves time and provides more realistic scope for users to share content and interact online. However, that is not the sole factor driving demand for UFB (and its uses). Reliability and 'barrier-free' access to the internet is an important factor in allowing more people to participate in activities which enhance their well-being (that is, it is not just the same people being able to do more things faster). In addition, consistency of accessibility (that is, being 'on all the time') would allow services currently performed via local area networks to be performed via the core network.[2]

8. The general mechanisms through which UFB translates to impacts include people's time, convenience, finances and way of life. The main areas where impacts (benefits and costs) arise are summarised as follows:[3]

- *education* – distance learning, pooling teaching resources/budgets via virtual learning, development of "digital schools"
- *health* – remote diagnosis, medications management, data-heavy imaging
- *entertainment* – online movies, TV, games and general content consumption
- *environmental* – reductions in travel from telework, and other government services such as e-health and e-learning
- *social well-being* – social inclusion, community and democratic participation, social capital, trust and resilience.

9. Note that the areas mentioned above include both *uses* and *applications* of UFB. For instance, education/e-learning and e-health are uses that can be delivered using a range of electronic media. Such media could be web sites, interactive television,

1 Plum Consulting (2008)

2 Ibid, p.21.

3 Castalia (2008), Deloitte (2014a),Ovum (2009), Rampersad, G. and I. Troshani (2013).

video and video conferencing. The main point is that different users and uses demand different applications and it may be that not all applications necessarily require ultra-fast speeds, reliability or other quality of service attributes.

A conceptual framework

10. The conceptual framework for this work is based on more general insights from the impacts of ICTs on economic and other outcomes (see Figure 1).[4] At the highest level are three categories of benefit relevant to the assessment of UFB relative to 'the existing method of delivery in use, which is 'standard' broadband in this case:

- doing what people do now more productively (*productive*)
- doing more with existing applications (*allocative*)
- doing new things and transformations/innovations (*dynamic*).

11. While the three general categories of benefit above are presented as distinct, in reality the boundaries are likely to be reasonably porous. That is, by doing more of what they currently do, but more productively, people are likely to develop an idea of things that they would like to do but had not thought of doing previously.

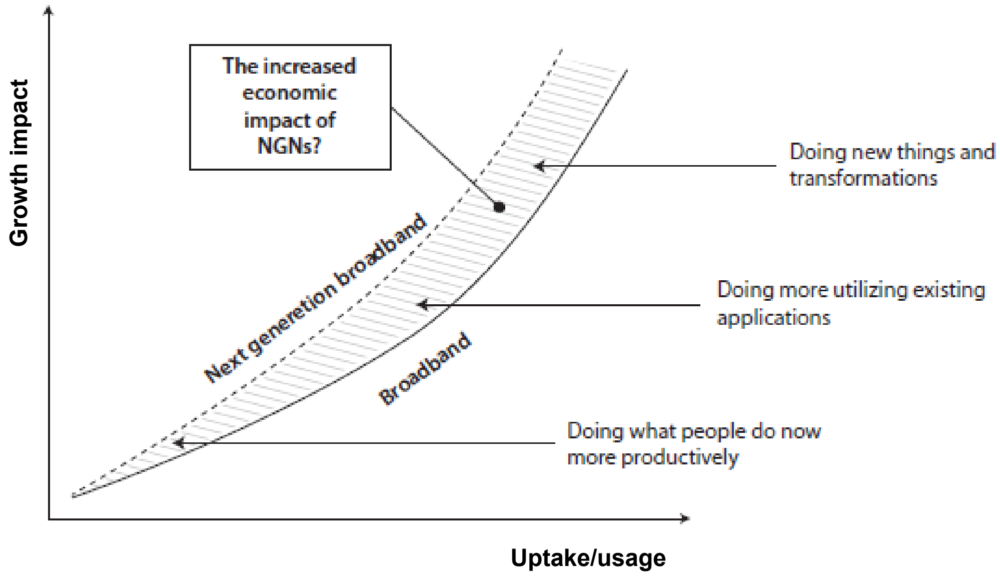
12. Furthermore, the framework starts from the perspective that existing users have 'standard' broadband, which is not always be the case. In New Zealand there are still users on dial-up connections. We understand that some work in central government is focussed on this group of users under the broad rubric of digital inclusion.

13. While not explicitly mentioned in the framework depiction, the general principles and relevant categories of benefit that apply to the shift from 'standard broadband' to UFB apply to dial-up users as well. Indeed, the potential magnitude of benefits to users who from a move away from dial-up to a UFB connection are likely to exceed those relating to a shift from 'standard broadband' to UFB at an individual level.

14. This basic framework highlights the additionality component inherent in measuring effects. The shaded area in figure 1 is much smaller than the area under the (standard) 'Broadband' curve, highlighting the need to distinguish where possible, impacts associated with the essential features of UFB (e.g. speed, latency) from those associated with 'broadband' in general.

[4] Hatonen, J (2011)

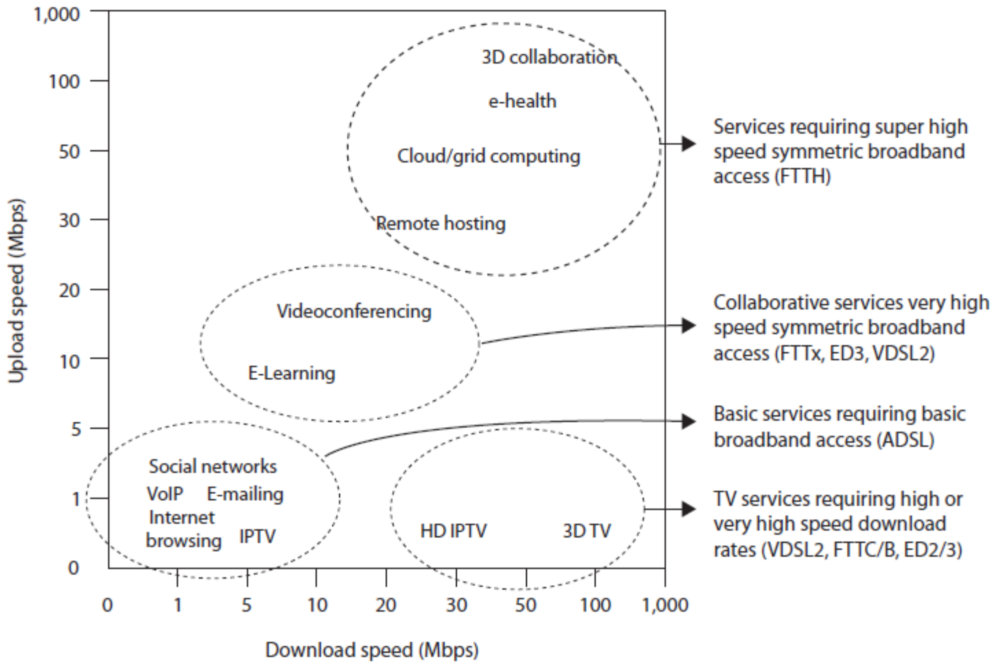
Figure 1 Beneficial impact categories schematic[5]



15. Some services such as browsing social networking are easily accessible with standard broadband connections (see Figure 2). Advanced TV services require very high speed download connectivity. The services which need faster speeds and eventually next generation fibre infrastructures include multi-location collaboration (video-conferencing), cloud computing services and industry-specific applications (for example, e-health) – all involving two-way traffic and therefore imposing high requirements both on upload and download speeds.

5 Ibid, p.49

Figure 2 Speed requirements of different applications



Notes: The figure illustrates the upload and download speeds required for different services (loosely based on El-Darwiche *et al.* 2009). How the services are defined has a great impact on the required speeds.

Source: Hatonen (2011)

16. At a wider societal level (that is, beyond the individual and organisational level) a number of factors are important in determining the existence and magnitude of benefits. These include:

- timing- the extent to which things happen at the same time or in rapid succession
- complementarity or substitutability of delivery mode- for instance in e-learning online delivery is increasingly seen as a complement to (rather than a substitute for) more traditional learning
- location- are services targeted to populations where benefits might be greatest (for example, rural delivery of telemedicine)
- participation- any benefits from availability of UFB rely on opportunities for users to participate.

Guidance from the literature

17. Our search of relevant published material identified over 60 articles of interest, from which 41 were selected for review. A summary of the findings from the review are set out below.

Social impacts less widely studied than business/GDP impacts

18. There is a clear focus from academics and policymakers on estimating productivity and GDP impacts as opposed to wider/social effects. Moreover, the specific impacts of high-speed broadband (as opposed to lower speeds) have not been widely studied. The literature acknowledges social impacts as being overlooked previously, but of potential import for future enquiries.

19. One of the major reasons identified for the relative dearth of studies on social impacts is the difficulty defining the impacts/benefits of interest and subsequently measuring and monetising such effects. The key messages from a review of the literature are:

- *The evidence base is still developing*- there is a reliance on claims and extrapolations rather than clear evidence.
- *Not all impacts/benefits are known*- what is able to be observed and measured is in essence "the tip of the iceberg" as the abilities of users often lags the capacity provided by UFB.
- *Stronger evidence requires extensive undertakings*- the most robust evidence involves significant effort, mostly from government agencies and/or academic undertakings that are multi-year projects.
- *Scepticism of claimed benefits*- a small minority of papers criticises the claims supporting UFB investment. The criticism has two strands; firstly, that many of the uses/applications (and consequently benefits) claimed from UFB can be achieved at lower speeds; secondly, that there may be "off-setting" negative impacts from UFB that have been ignored, potentially overstating benefits as a result.
- *A small but widely spread array of quantitative estimates exists*- despite the relatively small number of studies, there is a wide range of values and measures reported, including employment impacts, travel time savings, consumer welfare (that is, well-being) and general efficiency-related cost savings.

Of available options consumer surplus measure preferred

20. A variety of techniques have been, and may be, employed to estimate the impact/value of UFB. The techniques include:

- input-output analysis to derive multipliers for broadband deployment
- econometric (regression-based) analysis to measure externalities of broadband
- measurement of consumer surplus of broadband
- cost-benefit analysis of the broadband investment decision
- qualitative/descriptive reviews and surveys (including logic chains).

21. Our assessment is that measurement of consumer surplus is the technique which is both feasible and useful. Our preference is based on the following factors:

- *familiarity*- the consumer surplus method has intuitive appeal and is based on well understood concepts used in various contexts elsewhere (e.g. in cost-benefit analyses)
- *tractability*- the method is relatively flexible (as opposed to some of the more rigid approaches above)
- *simplicity*- it provides unambiguous/easy to interpret results and does not require detailed models or significant (and costly) amounts of data.

22. As discussed earlier, consumer surplus is the benefit that the user derives in excess of the price they would willingly have paid for the good or service. Consumer surplus is often used to measure changes in societal well-being from proposed changes to policy and regulatory settings in industries such as electricity, aviation (particularly airports), and more generally in competition matters.

23. Consumer surplus from UFB can be measured in a variety of ways ranging from direct estimation using demand curves and prices through to preference-based techniques that elicit consumers' willingness to pay for UFB using surveys. An intermediate option is to separately measure UFB benefits in terms of cost savings brought about by UFB and summing these to get a total.

24. Two studies provided guidance on the use of consumer surplus in measuring benefits from broadband technology. The first was a reasonably influential paper from the United States that used a direct approach to come up with an estimate of additional value to consumers (over and above their expenditures on the service) of between $234 billion and $351 billion per annum if broadband services were to become truly ubiquitous (that is, achieve 94% take-up).[6]

25. The second was a New Zealand study that estimated separate impacts from UFB for four sectors (health, education, business and dairy) to calculate a total consumer surplus of $32.8 billion over a 20 year period. Impacts related to health and education total $9.5 billion over 20 years.[7]

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[6] Crandall, R. W., Jackson, C. L. & Singer, H. J., (2003). The Effect of Ubiquitous Broadband Adoption on Investment, Jobs, and the U.S. Economy, s.l.: s.n. Available at: http://www.itu.int/net/wsis/stocktaking/docs/activities/1288356543/bbstudyreport_cryterion.pdf

[7] Alcatel Lucent, 2012. Building the Benefits of Broadband. How New Zealand can increase the social & economic impacts of high-speed broadband. [Online].

Our estimation approach

26. In this section we discuss the conceptual underpinning of our estimation approach, outline how that relates to UFB and summarise the specific data and assumptions used to estimate the beneficial impact (consumer surplus) of UFB.

Conceptual basis

27. The key to estimating the gain in value to users from consumption of particular services is determining their willingness to pay. In general, this willingness to pay can be approximated by a demand curve that relates the price of a certain commodity (that is, good or service) and the amount of that commodity consumers are willing and able to purchase at that price.

28. Consider the following simple example (which will be further extended and applied to UFB below). John likes beer but not at any price. He uses the following equation to determine his demand for beer (which relates quantity demanded to the price of a unit of beer):

$$Q = 10 - 2p$$

where $Q$is the quantity demanded and p is the price paid. Assume the market price for a unit of beer is \$2.50. We can now determine John's consumer surplus from consuming beer.

29. John's demand equation implies that at a price of \$5 per unit of beer John would not consume any beer (that is, by setting the quantity demanded to zero and solving the equation we can see the price where John is not willing to consume any beer). This is John's maximum willingness to pay for a unit (the first) of beer. This point is often referred to as the 'choke price' (that is, the lowest price at which the quantity demanded of the good or service is equal to zero).

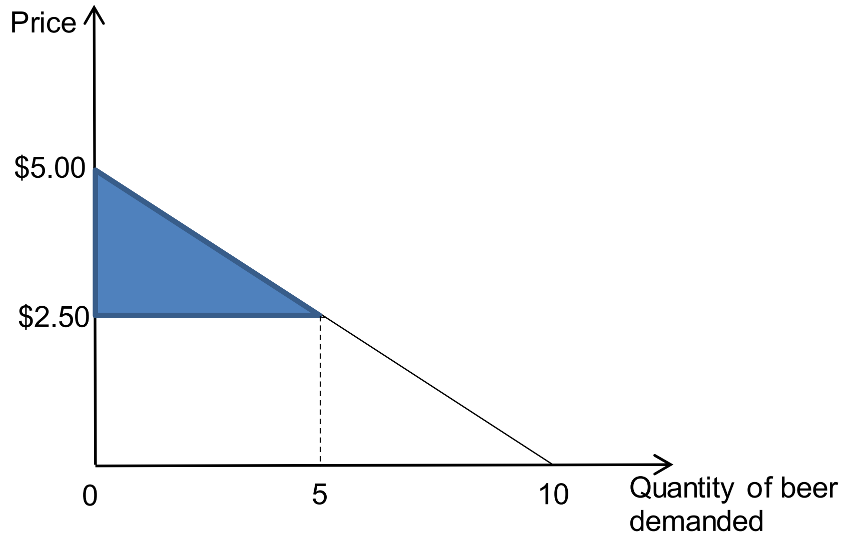
30. The function also implies that the maximum quantity of beer that John would consume (that is, when the price is zero) is 10 units.

31. Putting all of these factors into a diagram we can see from Figure 3 that at the market price of \$2.50 per unit of beer John would buy five units of beer (that is, quantity demanded equals 10 minus two times the price of \$2.50, which equals five).[8] We can also see John's consumer surplus, represented by the shaded triangle. The triangle has a base of five and a height of 2.5; thus the area of the triangle (which gives the consumer surplus) is \$6.25 (using the formula for the area of a triangle of half the base times the height, gives \$2.5 times 2.5 = \$6.25). This is the measure of value (benefit) that John gets from consuming the five units of beer at \$2.50 each, in addition to the price paid.

[8] We have not included the supply curve in the diagram as it is not necessary for our illustration, but the market price is determined by the intersection of supply and demand curves.

32. By aggregating all of the individual demand functions we are able to determine market demand (total willingness to pay) and hence, the aggregate consumer surplus. We would also be able to determine the point at which market demand for the good or service is zero (that is, the 'choke price').

Figure 3 Simple illustration of consumer surplus



A modification for the UFB case

33. We apply a modified variant of this basic apparatus to the case of UFB. The key variables required to derive an estimate of consumer surplus are a market demand curve and a market price. For simplicity, we assume linear demand as shown in the diagram. We used publicly available subscription and price data for UFB (and other technologies) for 2015 and 2016 to derive the initial linear demand curve for UFB.

34. We also utilised projections on likely uptake of UFB uptake to allow us to estimate the demand curve and consumer surplus in the future, when UFB uptake reaches 100% (that is, UFB is taken up by all of those for whom it is available).[9]

35. It is common for increases in uptake (and hence demand) to be represented by a parallel outward shift of the demand curve. That is, at all price levels the demand for UFB expands in a uniform fashion. In the case of a linear demand curve that means the slope of the initial demand curve and the new demand curve are the same.

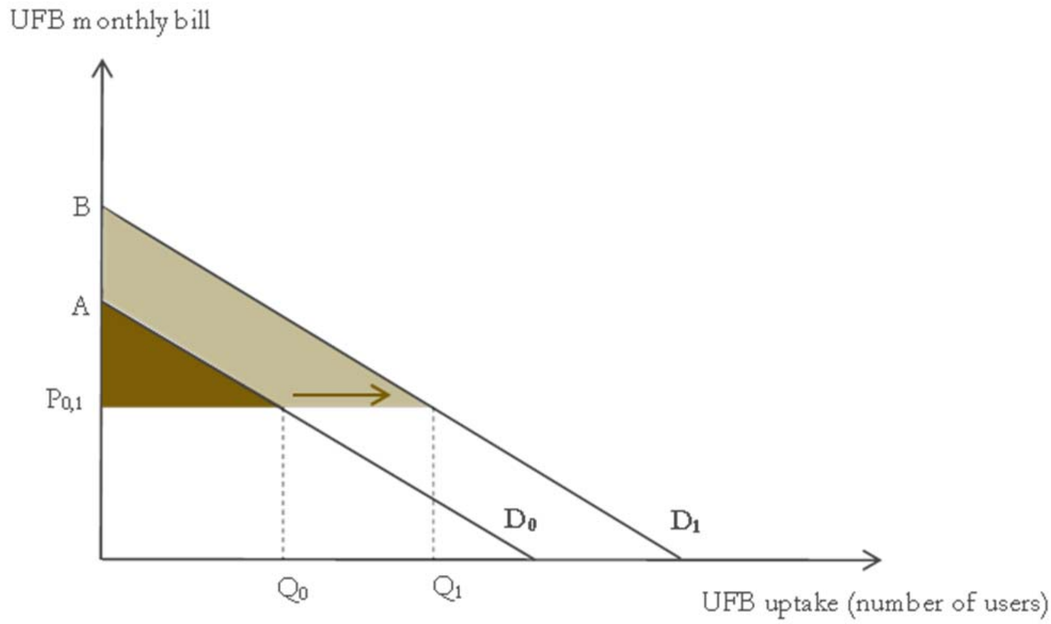
36. Figure 4 represents the original demand for UFB at Q_0 (determined by the point at which the original price, P_0, intersects the initial demand curve D_0). The consumer surplus is represented by the dark triangle (A P_0 Q_0). As UFB demand increases, demand is now represented by the new demand curve D_1 and uptake increases to Q_1.

[9] Estimating the gain in value/consumer surplus from 100% UFB take-up is the objective of this research.

With no change in price ($P_0=P_1$) the consumer surplus grows and is now the area of the triangle B P_1 Q_1.

37. For the purposes of our analysis we are interested in the initial consumer surplus and the consumer surplus measured using the new demand curve D1 representing 100% uptake of UFB. Points A and B represent the maximum monthly willingness to pay for UFB initially and following the change in demand.

Figure 4 Consumer surplus from parallel shift in demand



38. We believe that a modification of this approach is necessary to capture the changes we are looking to model. That is, a parallel outward shift of the demand curve would not adequately capture the essence of the conceptual framework outlined above (see paragraph 10).

39. In our view, the ability to undertake current activities faster and to do more with existing applications would be consistent with a future shift of the demand curve in a parallel fashion. However, the ability that UFB gives to users to do new things and make transformations to their usage is not represented by such a shift. As these innovations are discovered and bedded down, the gains in value of UFB to the user rise, in ways that are not likely to have been represented in the shape of the initial demand curve. With greater value in use, demand for UFB becomes less sensitive to price changes. Hence, the future demand curve in the figure would be steeper than the initial demand curve to reflect these possibilities.

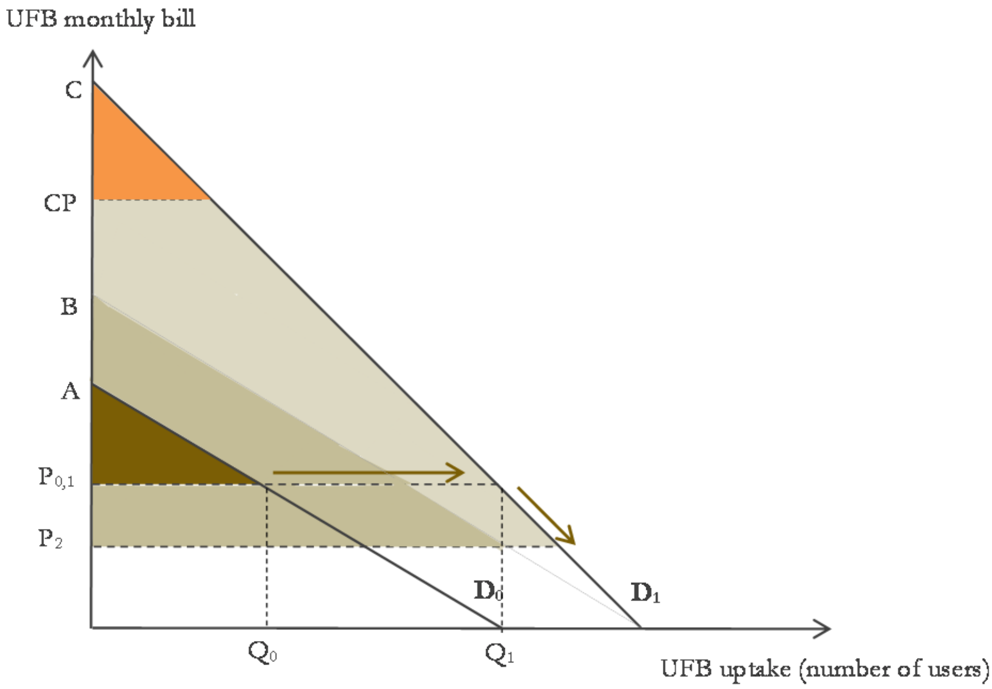
40. In addition, it is reasonably well accepted that as a technology becomes more of a necessity (that is, commonplace and routinely utilised as part of day-today living), the sensitivity of demand to changes in price reduces. In other words, the demand curve becomes steeper.

41. To reflect the greater value from innovative uses and the 'entrenchment' of UFB technology in future, we alter the steepness of the future demand curve by pivoting it

around a point on the horizontal axis where the parallel shift would have intersected the axis (see Figure 5). The new demand curve, D_1, is now steeper and the consumer surplus is given by the area of triangle C P_1 Q_1 (where (P_0=P_1). The area of this curve is clearly larger than the corresponding triangle in Figure 4.

42. A consequence of using a steeper future demand curve for UFB (the line D_1 in the diagram) is that the price at which there is no demand for UFB is higher than would otherwise have been in the parallel shift case. This is shown as point C. While there is some intuitive support for such a notion, we introduce a 'choke' price that is lower than point C (shown as CP in the diagram). Recall that this point represents the price point past which nobody would be willing to consume UFB (that is, the maximum willingness to pay for UFB). This introduces more realism into the modelling. The consequence of introducing this maximum monthly willingness to pay is to reduce the estimated consumer surplus. In the diagram the consumer surplus is reduced by the area of the orange triangle.

Figure 5 Modified consumer surplus measure



Source: Sapere

43. Our results assume there is no price change in future. That is, the sole reason for consumer surplus increases over time is a rise in UFB uptake. For exposition purposes only Figure 5 shows how a change (in this example a reduction) in price (represented as P_2), would increase the estimated consumer surplus, subject to the constraint that demand cannot exceed Q_1.

Data and outputs

Prices

44. We use the monthly average broadband bill measure from the Commerce Commission's 2016 Annual Telecommunications Monitoring Report.[10] This data is based on a recent pricing study which looked at 77,900 invoices for residential broadband services. This is a useful measure as it better reflects what consumers actually pay (for example, retailers often provide discounts on their packages). We also sourced 2015 and 2016 data for ADSL, VDSL and UFB.

45. Slight tweaks were made to the average VDSL monthly bill to introduce sufficient variation to derive consumer surplus estimates for that technology, as the reported average monthly prices were the same in 2015 and 2016. The tweak was immaterial to the prices for 2015 and 2016 (representing less than half a per cent change on an average monthly bill of $116).

46. Data on dial-up bills is not readily available. For 2016, we used the price for Vodafone's Home 150 package[11] and for 2015 we assumed that the price was 3% lower.

Uptake rates

47. Uptake rates of UFB are mostly published in terms of total connection lines. Given our focus on residential UFB use we assume that a connection represents a household. We obtained data on connections for 2015, 2016 and 2019 from the Ministry of Business Innovation and Employment's quarterly broadband deployment update reports.[12] We estimated likely UFB connections in 2024 using the 2024 target population coverage published by Crown Fibre Holdings[13] and assumed that the ratio of connections to users remains the same as in 2019.

48. Residential uptake rates were derived from this starting information by assuming:

- For each technology, the proportion of residential connections reflects the 2011-2016 average of the share of residential internet connections out of total internet connections. The data on residential and business/government internet connections was sourced from the ISP Survey published by Statistics New Zealand.
- The number of people who benefit per connection/household is the number of adults in a household.[14] The number of adults per household was derived based

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10 http://www.comcom.govt.nz/dmsdocument/15435.

11 https://customerzone.vodafone.co.nz/residential/homeplan/internet/dial-up.cfm

12 http://www.mbie.govt.nz/info-services/sectors-industries/technology-communications/fast-broadband-2/deployment-progress/?searchterm=broadband%20deployment%20update%2A

13 https://www.crownfibre.govt.nz/wp-content/uploads/2017/01/UFB2-Media-Pack-Population-Coverage_25.01.17.docx.pdf

14 The assumption is that the adults would be able to pay for the service if they were to live separately.

on 2013 Census data. While the focus on adults might tend to understate the consumer surplus (by excluding user benefits to children) this simplifying assumption was used to reflect users' ability to pay. All adults in a household were included on the assumption that they would be able (and willing) to pay for the service if they were to live separately (that is, it captures the essence of UFB being 'on all the time for all who want to use it').

49. Data on VDSL connections was sourced from a report on fixed-line pass-through undertaken for the Commerce Commission.[15] ADSL connection numbers were derived from Statistics New Zealand ISP survey data (by subtracting VDSL connections from total digital subscriber line connections). The ISP survey was also the source for dial-up connection numbers.

50. In terms of the outputs from the modelling, we derived estimates of the annual consumer surplus:

- in a 'base case' using 2015 and 2016 average monthly prices where UFB uptake is 30%
- for a rate of UFB uptake 100% (projected to occur in 2024) with no price change
- alternative scenarios relating to the shape of the demand curves and the 'choke price' used.

15 http://www.comcom.govt.nz/dmsdocument/15545

Findings

51. Our objective was to estimate the wider benefits to society (that is, an expression of the value to consumers) uptake from 100% uptake of UFB by those for whom UFB is available. Based on available data and current projections this level of uptake is thought to take place in 2024, though timing is not necessarily important to this analysis. We start from a 'base case' in 2016 when UFB uptake is around 30%, before estimating the consumer surplus at 100% uptake.

Base case

52. We estimate the annual consumer surplus in the 'base case' to be around $60 million. Table 1 shows the starting parameters for the 'base case.'

Table 1 Base case parameters

Parameter	Value
2015 Average monthly UFB bill	$107
2016 Average monthly UFB bill	$96
2015 Fibre users	227,349
2016 Fibre users	457,543
Assumed 'choke price'	$175 per month[16]

53. These parameters allow a linear demand curve to be derived, which has a slope of -0.00004779 and intersects the vertical axis at price $117.86. That is, based on the available data for 2015 and 2016, at an average monthly price of $117.86, there would cease to be demand for UFB services. In terms of the previous illustrations of consumer surplus, this demand curve is obviously much flatter. A flat demand curve may reflect the sensitivity of demand to price of newer technology.

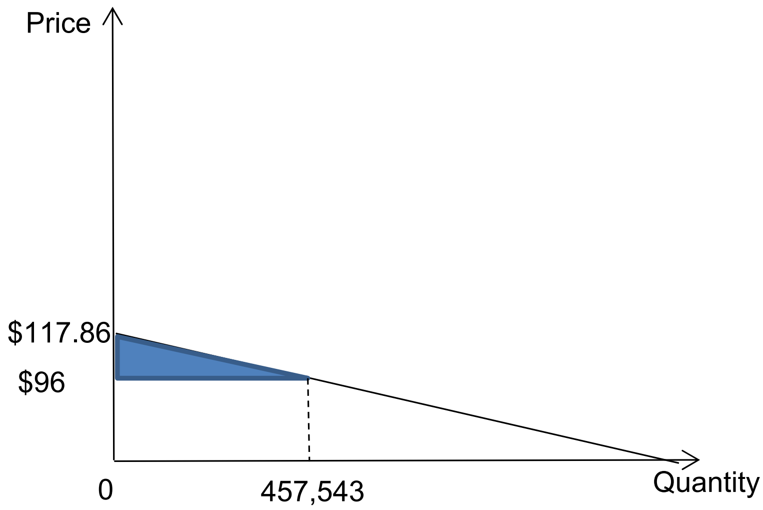
54. Figure 6 reproduces Figure 3 for the base case with the key parameters shown. The consumer surplus is calculated using the formula for finding the area of a triangle (that is, 0.5*base* height), which yields an estimated consumer surplus of around $5

16 This 'choke price' was taken from the recent price determination undertaken by the Commerce Commission for access to the copper network by internet service providers. We use this 'choke price' for convenience as we are not aware of any estimates of this price for UFB.

million. On an annualised basis this equates to just over $60 million. In terms of Figure 5, this represents the dark shaded triangle from A $P_{0,1}Q_0$.

55. The analysis highlights two points. Firstly, the point on the demand curve from which consumer surplus is calculated is highly elastic (that is, small changes in price result in relatively large changes in quantity demanded). The elasticity at this point is estimated to be -9.85 (when demand is generally classed as elastic for a value above -1). In addition, given the calculated maximum willingness to pay for UFB of $117.86, the assumed 'choke price' of $175 per month does not come into the calculations.

Figure 6 Consumer surplus in base case



56. Table 2 expresses the estimated consumer surplus in terms of households and users.

Table 2 Consumer surplus per household and user (2016)

Measure	Value
Annual consumer surplus per household	$225.24
Annual consumer surplus per user	$131.18
Monthly consumer surplus per household	$18.77
Monthly consumer surplus per household	$10.93

57. By way of comparison a relatively recent Australian study estimated household benefits from higher speed broadband could be as high as AUD$59.10 per month, with the weighted average total benefit per household being AUD$26.30 per

month.[17] We note that this estimate of total benefit includes a price premium as well as the consumer surplus, so would always exceed just the consumer surplus value.

Consumer surplus at maximum uptake

100% uptake and no price change

58. Recall that at higher uptake rates we allow the slope of the future demand curve (D_1 in Figure 5) to change, which in turn affects the extent to which demand is responsive to price changes. A steeper curve indicates less sensitivity of demand to price changes. This has the effect of increasing the estimated consumer surplus. In this section we present our estimate of the consumer surplus once uptake reaches 100%.

59. The Ministry of Business Innovation and Employment estimates uptake of UFB would reach 85% of the population in 2024.[18] Using the same 2016 price level (of $96 per month), the estimated annual consumer surplus is around $1.77 billion. The key factors giving rise to that estimate are shown in Table 3. The steeper slope of the demand curve in 2024 was derived using an assumed elasticity of -0.5.[19]

60. Given the demand curve intersects the vertical axis (that is, point C in the diagram) at a price of $321 the assumed 'choke price' of $175 comes into play. In essence, it reduces the estimated consumer surplus by $107.5 million per month, resulting in an estimated consumer surplus of $147.8 million per month.[20] On an annualised basis this equates to around $1.77 billion.

Table 3 Factors driving consumer surplus at 100% uptake (2024)

Factor	Value
2024 Fibre users	2,269,502
Slope of demand curve in 2024 (D_1)	-0.00009914

[17] Independent cost-benefit analysis of broadband and review of regulation – volume 11 costs and benefits of high speed broadband, August 2014.

[18] http://www.mbie.govt.nz/info-services/sectors-industries/technology-communications/fast-broadband/broadband-and-mobile-programmes

[19] This is the lower bound price elasticity of demand accepted by the Commerce Commission in its price determination for access to the copper network by internet service providers.

[20] The estimated consumer surplus without the 'choke price' is $255.3 million (i.e. (0.5 *2, 158,5493)* ($321-$96)). Subtracting the estimated consumer surplus at the 'choke price' of $107.5 million (i.e. (0.5*1,472,655)*($321-$175)) leaves around $147.8 million as the monthly consumer surplus.

Factor	Value
Vertical axis intercept for demand curve in 2024 (the estimated price at which demand for UFB is zero)	$321
Assumed 'choke price'	$175 per month
Estimated demand at the 'choke price'	1,472,655
Assumed elasticity (i.e. sensitivity of demand to price changes)	-0.5

61. Table 4 expresses the estimated consumer surplus at 100% uptake in terms of households and users.

Table 4 Consumer surplus per household and user 100% uptake (2024)

Measure	Value
Annual consumer surplus per household	$1,341.96
Annual consumer surplus per user	$781.57
Monthly consumer surplus per household	$111.83
Monthly consumer surplus per household	$65.13

Comparisons with other sources of consumer surplus

62. To put these impact estimates in context we examined publicly available evidence on consumer surplus benefits in other areas. Table 5 **Error! Reference source not found.**shows that the estimated annual benefit from 100% uptake is in line with an analysis looking at consumer benefits from Google services such as Gmail, Google search, Google Maps and YouTube. The estimated benefits in this study maybe twice as high as those New Zealanders are estimated to enjoy from price stability and around half the estimated annual benefit passengers get from air transport.

Table 5 Estimates of consumer surplus in other contexts

Impact area	Estimate of annual consumer surplus	Reference
Value of Auckland Regional Parks (2000)	$91 million	https://www.victoria.ac.nz/sef/research/pdf/Saunders.pdf
Benefits to New Zealand Passengers from Air Transport	$3.8 billion	https://www.iata.org/policy/Documents/Benefits-of-Aviation-New-Zealand-2011.pdf
Benefit to New Zealanders from Price Stability	$1.034 billion (0.39% of GDP, estimated to be $265 billion at present)	https://www.rbnz.govt.nz/-/media/ReserveBank/Files/Publications/Bulletins/1998/1998sep61-3bonato.pdf
Consumer benefits from access to Google Services	Around $2 billion	http://www.alphabeta.com/wp-content/uploads/2017/05/Google-Economic-and-Social-Impact_NZ_Mar2017.pdf https://initiativeblog.com/2017/04/28/tallying-googly-benefits/

Sensitivity analysis

63. In this section we alter some key input assumptions to ascertain their impact on the consumer surplus estimates derived above. The two parameters we alter are the assumed elasticity (that is, the responsiveness of demand to changes in price) of the new demand curve (D_1 in Figure 5) and the 'choke price' (that is, the price at which demand for UFB is zero) of $175 per month.

64. Table 6 shows that the 'choke price' seems to have a greater impact on the estimated consumer surplus than does the elasticity. A roughly 14% decrease in the choke price' results in a decrease in the estimated consumer surplus of about 27%, while an increase in the 'choke price' of a similar magnitude results in an increase in consumer surplus of about 23%.

65. The elasticity changes do not have such a major impact. This is understandable as the values are not as directly related to the calculation of consumer surplus in our

model as the 'choke price'.[21] The results of the sensitivity testing suggests that further work to determine the price at which UFB falls to zero would be very helpful in establishing more precise estimates of the consumer surplus associated with UFB.

Table 6 Effects on annual consumer surplus of altered parameters (2024)

	100% uptake no price change
Elasticity of -0.5 (current assumption)	*$1.77 billion*
Elasticity of -0.25	$1.96 billion
Elasticity of -1.0	$1.43 billion
'Choke price' of $175 per month (current assumption)	*$1.77 billion*
'Choke price' of $150 per month	$1.29 billion
'Choke price' of $200 per month	$2.18 billion

Limitations and caveats

66. An 'exploratory' undertaking such as this is subject to a range of limitations. We list such limitations and caveats below.

- *Guidance from literature is limited*- the wider social impacts of UFB technology have not been widely studied. Hence, the evidence base on which to rely for guidance on estimation techniques, models or relevant and clear results was thin. As a consequence, our findings are based on models constructed specifically for this purpose and a range of assumptions. The findings should be considered with this constraint on full validation in mind.

  Of more import was the lack of an established description and understanding of some of the potentially important uses and applications that could result from greater UFB uptake. For instance, primary research on the role of UFB in the development and growth of Smart Cities, marae-based connectivity initiatives as well as other digital inclusion dimensions under the broad banner of social

[21] That is, elasticity values are used largely to estimate the slope of the future demand curves. By construction the elasticity values are constrained to be below -1 as future demand curves are assumed not to be strongly responsive to changes in price (refer to the discussion in paragraphs 38-42).

cohesion and inclusion would contribute greatly to the understanding of the value to consumers from the facilitation channels UFB provides.

- *Data availability*- we relied on publicly available information. Such information is patchy, lacks specificity and is not especially timely. The dearth of data means that key factors such as the shape of the demand curve, the relevant population of households and users for different connection types and migration across technology types either have to be assumed or are omitted from the analysis. Lack of a detailed series relating to 'migration' data means that it is difficult to estimate the net/incremental consumer surplus for UFB, as well as the total consumer surplus.
- *Estimates are aggregated*- contributions to beneficial impacts from specific impact areas are not identifiable in the analysis. This is largely a consequence of the choice of method employed, which in itself was driven by data considerations.
- *Estimates are imprecise* - the analysis excludes beneficial impacts on children. In addition, the treatment of innovation and transformation (that is, the ability for users to do new things as a result of UFB) relied on parameters that were used for a different (older) technology. Finally, the assumption around the number of (bill-paying) adult users in households could be considered conservative as it remains constant over time and is estimated to be 1.7 per household when in reality the number of adults per household is best represented as an integer. These factors may mean our estimate of consumer surplus is under-stated.

  On the other hand, the assumption of linear demand and the calculation of benefits on the basis of users (rather than connections) may mean our estimate of consumer surplus is over-stated.

  While the sensitivity analysis identified the impacts of changing some parameters that contribute to potential over or under-estimation, the range of final estimates is unavoidably wide.

Conclusions/summary

67. We have estimated the wider impacts on society from UFB, expressed in terms of the consumer surplus (that is, the additional well-being users derive from UFB). Using publicly available data we constructed a demand curve for UFB, which for reasons of simplicity was linear in nature. Average monthly prices were sourced for a range of technologies, including UFB.

68. This allowed us to estimate a 'base case' value for the consumer surplus for UFB in 2016, given the uptake rate of 30% at the time. The 'base case' estimate of the consumer surplus in 2016 was around $60 million per annum. The relatively modest figure is due mainly to the very flat demand curve that was estimated using 2015 and 2016 prices and demand. A flat demand curve signifies a high degree of responsiveness in demand to changes in price.

69. Our objective was to estimate the consumer surplus from 100% uptake of UFB (that is, UFB is taken-up by all possible users where UFB is available). Such a rate of uptake was projected to arise in 2024. We extended this 'base case' to account for the rise in uptake as well as a change in the nature of demand as UFB becomes more ingrained in people's lives and new activities able to be carried out online are

discovered. This was represented as a steeper demand curve (that is, less responsiveness in demand to changes in price).

70. We estimate the consumer surplus with 100% uptake in 2024 without a price change at $1.77 billion per annum. Any reduction in the real price of UFB over time would increase the benefit to consumers.

71. We altered key parameters to test the sensitivity of the estimates to changes in the nature of demand (that is, whether demand for UFB is more or less responsive to changes in price) and the price at which demand for UFB is zero (that is, a measure of the maximum willingness to pay for UFB per month known as a 'choke price'). This produced a range of feasible estimates of consumer surplus when uptake is 100% (in 2024). This range was $1.29 billion to $2.2 billion. The main driver of the variation in estimates was the assumed 'choke price' so further work on establishing this price for UFB would be very helpful in terms of narrowing the relatively wide range.