COMMERCIAL IN CONFIDENCE

FINAL REPORT

Mobile and fixed line convergence

Current and future usage of fixed and mobile broadband services and economic and policy implications

Prepared for
Vodafone Hutchison Australia (VHA)

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THE CENTRE FOR INTERNATIONAL ECONOMICS
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Executive summary

Convergence of mobile and fixed broadband services refers to the increasing similarity of these services for suppliers and customers. Over the next two years, telecommunications in Australia will be transformed with the early deployment of 5G mobile networks and the completion of the National Broadband Network (NBN). These transformations have the potential to increase substitutability between fixed and mobile broadband. This has implications not only for the future business models of telecommunications service providers, but also policymakers and regulators, who will need to adopt a more technology neutral approach.

To date, much of the attention given to mobile services has been due to its role in providing connectivity when people are away from their homes and businesses. However, a significant number of households use mobile networks as their only means of accessing the internet at home.

The CIE has been commissioned by Vodafone Hutchison Australia (VHA) to model the impacts of the rapid changes in mobile and fixed technologies and demand for broadband in the home. This report presents the results of a survey of households about internet use at home and provides a range of interesting findings with respect to internet usage patterns, consumer choice and technological advancement. These findings demonstrate that improvements in mobile networks have the potential to disrupt the future of broadband services in Australia, leading to a range of emerging policy and regulatory issues. Addressing these issues in a way which enhances rather than restricts competition will be critical to reaping the benefits of these changes.

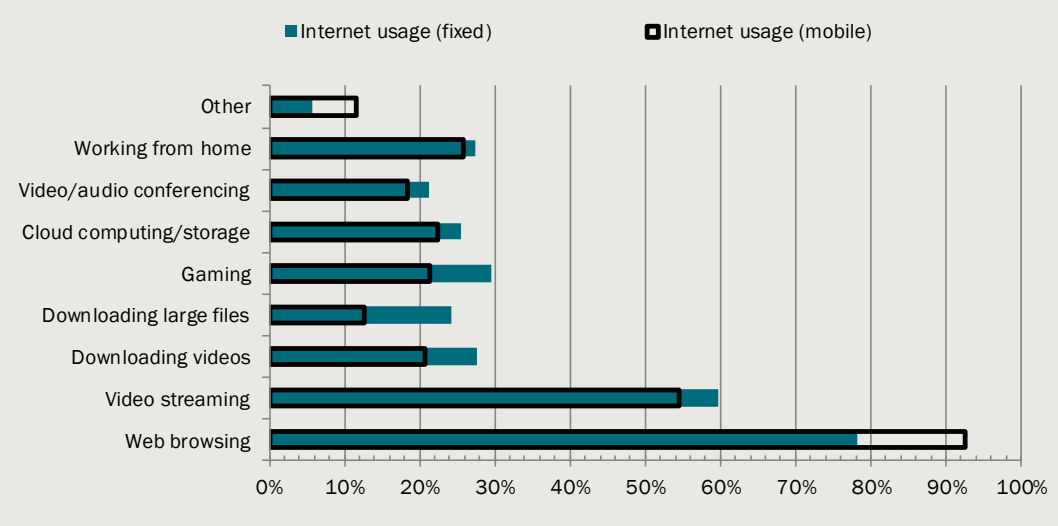
Similarly, understanding the way technology is changing will help policymakers maximise the benefits of the NBN by ensuring it plays an important role in enabling both fixed and mobile broadband services. To date the fixed and mobile investment debate has largely been focused on the relative importance of one technology over the other. The fact is both technologies are vitally important and are constantly changing and converging. This reality must continue to be incorporated into the strategic direction of Australia's telecommunications policy settings.

Usage patterns for fixed line and mobile-only connections

The types of activities performed online over fixed line and mobile-only connections are very similar, with differences observed for only a few use cases (chart 1.1).

The capabilities of mobile networks are growing, which is providing customers with new ways to access the internet and perform activities that they could previously only do on a fixed connection.

1.1 Internet usage by type of connection



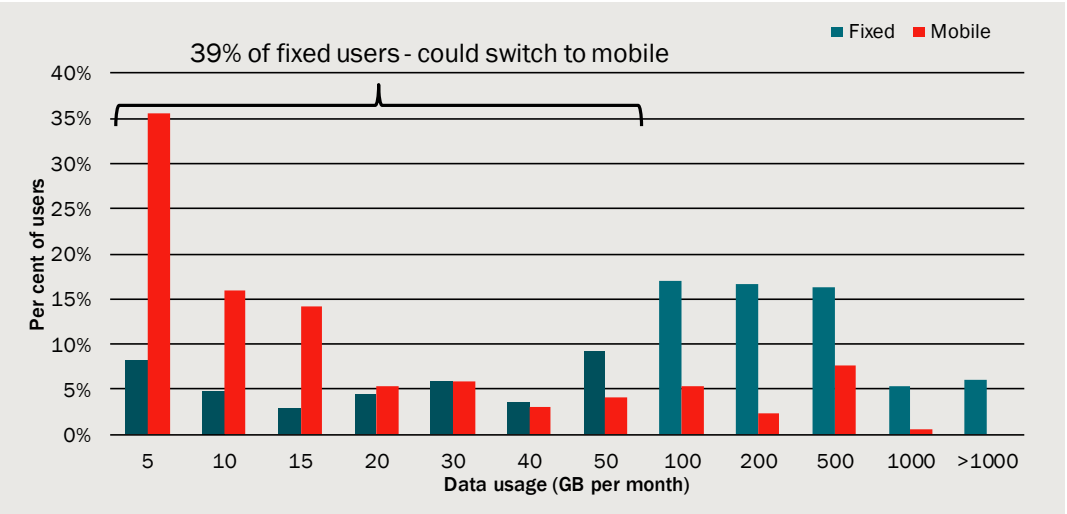
Data source: Survey data from Woolcott Research (commissioned by the CIE) (n=1000).

With respect to data usage patterns, a significant 39 per cent of fixed line users reported using up to 50GB per month, well below the survey median of 100 GB per month and the 145 GB per month ABS internet activity survey median[1]. Most striking is the overlap of fixed usage in this band with mobile data usage (chart 1.2).

Very similar proportions of users of both fixed and mobile only connections use between 20 and 50 GB per month. These patterns lend support to the fact that based on data usage alone, many fixed users could meet their needs by mobile-only.

- **We estimate that almost 40 per cent of current fixed users could have their data needs met by a mobile-only service.**

1.2 Distribution of data usage – fixed line connection



Note: Higher data usage reported on mobile is more likely to refer to portable modems or other wireless broadband rather than mobile handsets.

Data source: Survey data from Woolcott Research (commissioned by the CIE) (n=1000).

1 ABS Internet Activity, Australia December 2017, cat 8153.0

Mobile and fixed line services compared

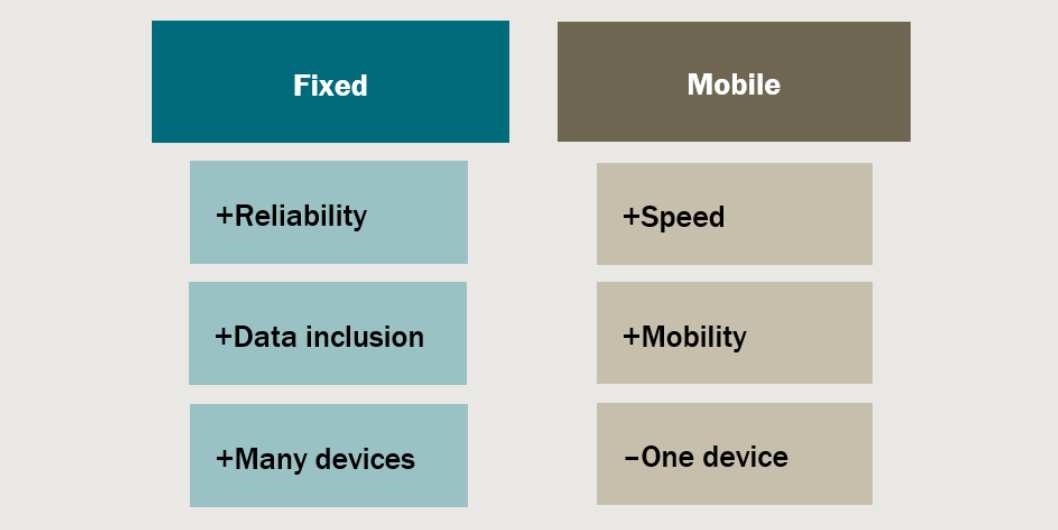
Data usage alone is not sufficient to determine whether mobile broadband is a substitute for fixed line connections. There are a range of qualitative characteristics which differentiate fixed and mobile connections for consumers.

Our research has shown that the key separating qualities of fixed and mobile internet relate to (chart 1.3):

- *Reliability* — minimal dropouts and variation in speed.
- *Data inclusion* — download limits in GB per month.
- *Speed* — the rate at which data can be downloaded and uploaded over a connection.
- *Compatibility* — whether a connection can be used with many household devices.
- *Mobility* — the ease of use associated with portability outside of the home.

Importantly, the offerings of mobile and fixed line networks are not the same in different locations. In some cases, people choose fixed line networks because they are more reliable, while in others they choose mobile networks for the same reason. This indicates that people's choices will reflect their direct experiences.

1.3 Perception of current strengths of fixed line compared to mobile services



Note: The speed of mobile is higher than fixed based on current average speeds experienced by users, rather than technical capabilities. Speed test data (see chart 3.4) suggests that mobile users experience average download speeds more than double those of fixed users. However, fixed line connections provide technical capability for significant greater capacity, particular in terms of reliable speeds in high-use hours of the day.

Source: CIE.

The decision to use a fixed line or mobile only connection in the home involves trade-offs. The advantages of fixed line connections primarily lie in being perceived to provide a reliable connection and a high volume of data download at a low cost per GB. Fixed line connections are also seen as advantageous due to their ability to pair with Wi-Fi to connect many household devices simultaneously. This is an important consideration

given the average household is expected to comprise 10 devices by 2021[2], up from 6 devices in 2017[3].

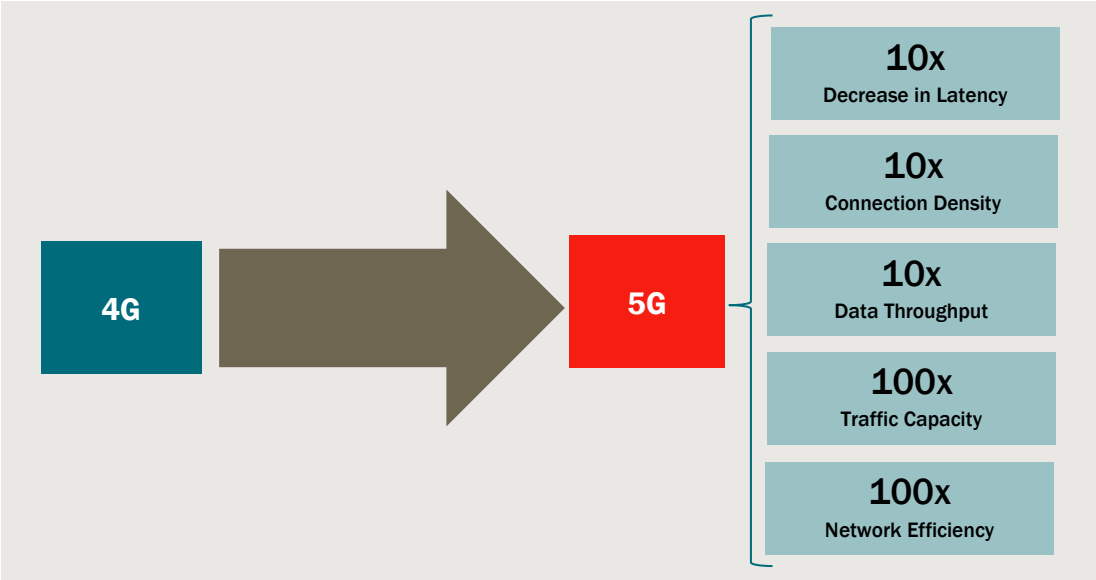
Mobile, by contrast, currently provides more modest data inclusions for a typically faster connection (depending on the number of users) and portability outside of the home. This comes at the cost of a higher price per GB and being limited to one device at a time.

- **Consumers face trade-offs between the perceived strengths of fixed line and mobile in choosing their home broadband service.**

Technological disruption – 5G and the 'mobile first' trend

5G is the next generation of cellular networks which is expected to begin rolling out in Australia in 2019. As with previous leaps in generations, 5G will involve a step-change in terms of capability. It will utilise a powerful combination of superfast speeds and ultra-low latency to unlock new uses and pave the way for accelerated digitisation through the Internet of Things (IoT) (chart 1.4).

1.4 Advanced capabilities of 5G compared to 4G



Data source: 5G and beyond: Where does 5G stand today in 2017? Cradlepoint.

5G applications in fixed-wireless

5G is showing early signs of being able to compete with the current packages offered on the NBN both in terms of speed and latency[4]. Early deployments of 5G technology are

2 Cisco Visual Networking Index Forecast – accessible through: https://www.cisco.com/c/m/en_us/solutions/service-provider/vni-forecast-highlights.html#

3 Australian Bureau of Statistics – Internet Activity, Australia June 2017 cat 8153.0

4 Telstra just launched a mobile network 10 times faster than the NBN, Business Insider 31 January 2017

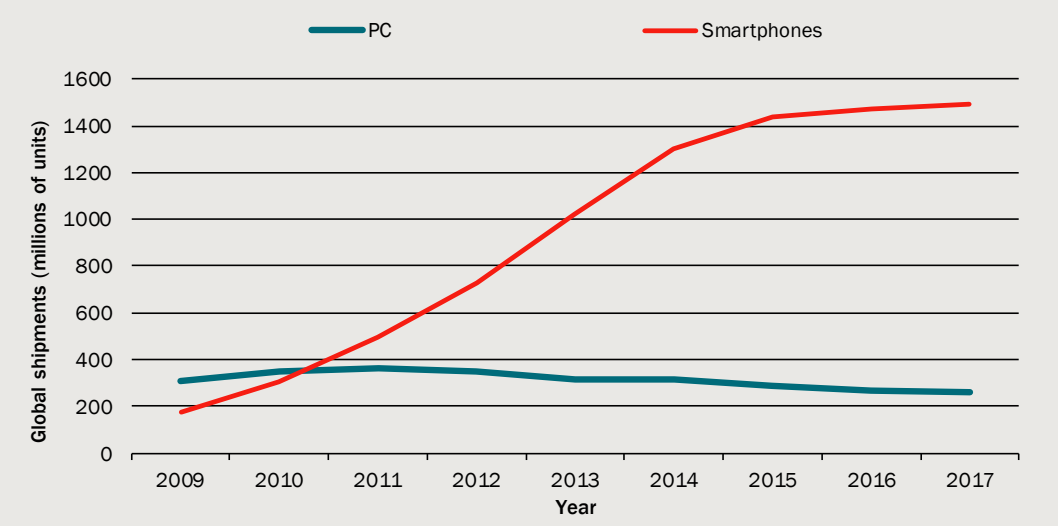
expected to be highly effective in fixed-wireless applications. Current fixed-wireless deployments using 4G wireless technology, although fast, are limited in scale due to capacity constraints. It is expected that 5G fixed-wireless will offer such a large increase in capacity that it will be viable to rollout in urban areas and compete in the fixed line market[5].

The trend towards 'mobile-first'

Underlying technological advancement in broadband delivery are fundamental changes in the way consumers are interacting with digital content. Mobile is increasingly the first and preferred means of connecting to the internet. This is reflected in the fact that mobile sales, as indicated by global shipments, have consistently exceeded the sale of PCs since 2010 (chart 1.5). The high market penetration of smartphones is reflected in the fact that people are using mobile exclusively for certain activities such as social media and web browsing, and over half of the average user's online time is now spent on mobile[6]. As the role and capabilities of mobile devices grows, there is greater potential for consumer-led substitution towards mobile-only internet.

- **We estimate that 17 per cent of households are currently 'mobile-only', using only mobile services for their internet access.**

1.5 PC and Smartphone global shipments 2009-2017



Data source: Statistica.

5 Qualcomm OEM Netcom Wireless sees tipping point for urban fixed wireless substitution, Communications Day Issue 5554, 9 February 2018

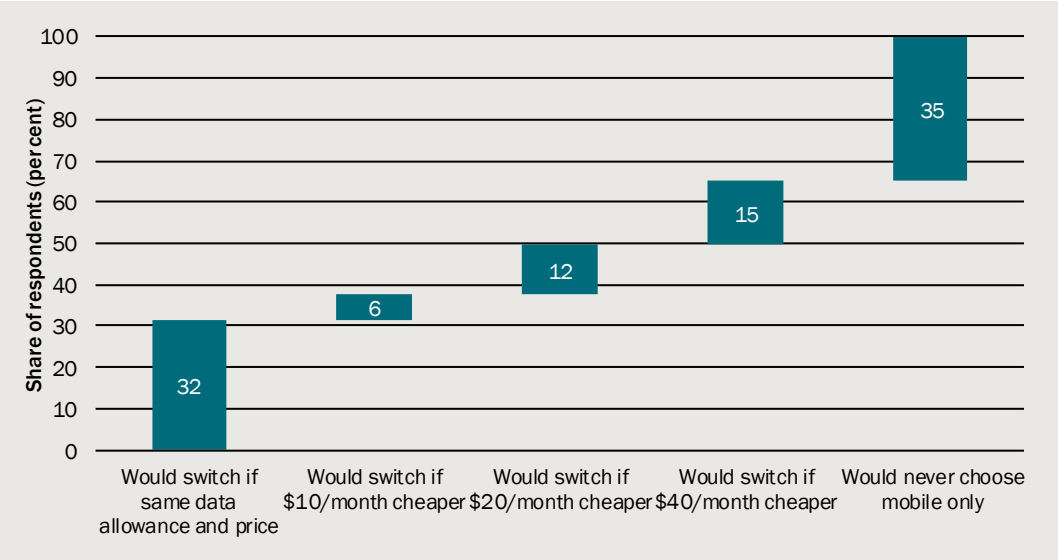
6 Communications Chambers - Mobile first, fibre as required: The case for 'fibre to the 5G (FT5G)", January 2017

Predicting future levels of substitution

By exploring patterns of data usage, we have observed that fixed line users within the 1-50GB per month data usage band were likely candidates to perceive mobile as substitutable for fixed connections. This is because their underlying demand for data could be met by the data inclusions offered on mobile plans today. Mobile broadband is currently more expensive per GB than on a fixed connection. As such, we have sought to identify at what price point broadband consumers would find it optimal to switch to a mobile network today (chart 1.6):

- 32 per cent of subscribers would switch to a mobile plan if offered the same data allowance and price.
- 6 per cent would switch if the mobile plan were $10 cheaper per month than fixed line plans.
- 12 per cent would switch if the mobile plan were $20 cheaper per month.
- 15 per cent would switch if the mobile plan were $40 cheaper per month.
- 35 per cent reported that they would never chose mobile only.

1.6 Fixed line customers with <50GB usage who might switch to mobile-only



Data source: CIE and Woolcott Research and Engagement survey.

The fact that 35 per cent of subscribers would not switch to mobile-only highlights the perceived quality differences between mobile and fixed line broadband. Among the main reasons for those that cited that they would never switch were concerns around reliability, compatibility and speed. Although mobile is generally reported as faster than fixed, some users in regional areas experience poor connectivity, highlighting the variability of experience of both fixed and mobile connections across geographic locations.

Future pathways for substitution

Ongoing technology developments are bridging the gap between the capabilities of fixed and mobile connections. As these services become more alike, some consumers will find them to be directly substitutable. Additionally, service providers may also find it favourable to employ a mix of technologies in providing connectivity solutions to their customers.

As such, we have identified two main types of substitution between fixed line and mobile services:

- *Supplier-led substitution* — where service providers may be able to substitute between fixed and mobile technologies to provide connectivity solutions for their customers.
- *Customer-driven substitution* — where customers decide between access technologies according to their preferences over price and quality characteristics.

Future scenarios for substitution

The future level of mobile-only customers reflects two offsetting factors:

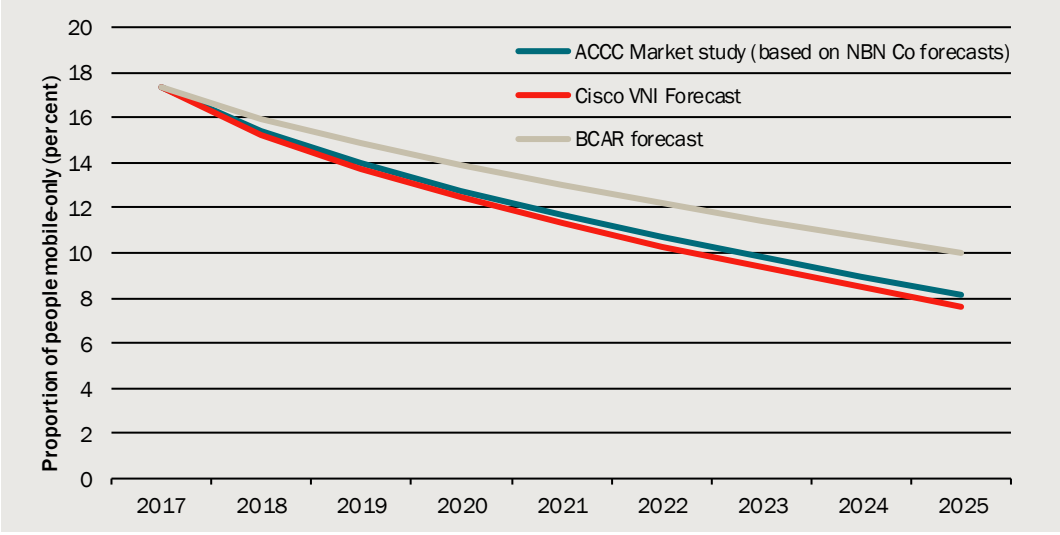
1 *Increasing demand for data* — higher demand for data will, in the absence of technological change, push people to favour fixed line technologies, as data is currently cheaper over fixed line connections.

2 *Technology improvements* — ongoing increases in capacity and lower costs for mobile will tend to push people towards mobile connections.

Using a range of projections of data demand, chart 1.7 shows the first effect above.

- **Higher demand for data will, in the absence of other changes, push the proportion of mobile-only users to below 10 per cent by the mid-2020s.**

1.7 Predicted substitution assuming current mobile technology level is maintained



Data source: CIE.

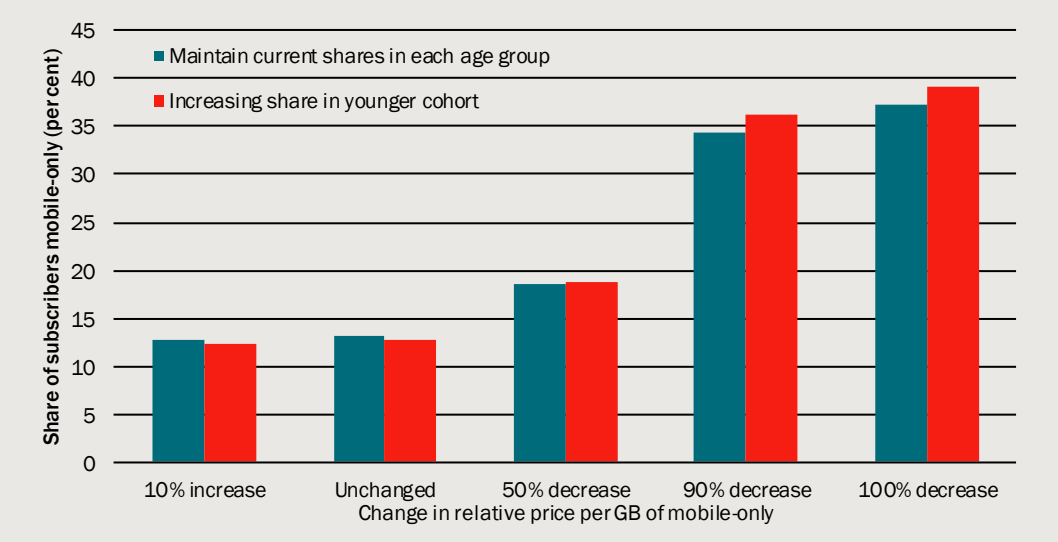
However, we find that the expected technological changes in mobile networks will likely more than offset the impact of increased demand for data. Under plausible assumptions

of how prices of data on mobile networks is likely to evolve, a greater proportion of households adopt a mobile-only connection (chart 1.8).

To increase the robustness of our analysis we have also tested the impact of a changing composition of age cohorts. This is to account for the fact that different age cohorts, such as 18-25, are more responsive to changes in mobile prices and will have a greater representation in the population in 2020.

- **If the price of mobile data decreases to a similar price of fixed, then we project that the share of mobile-only households will increase to almost 40 per cent in 2020.**

1.8 Estimated mobile-only share in 2020 under mobile price scenarios



Note: These results assume that data usage grows at 25 per cent CAGR (the ACCC Market study scenario).

Data source: CIE.

Past price trends suggest that the price of mobile data has been consistently falling and the data allowances available on mobile plans have been increasing. We have used hedonic models of mobile and fixed line plans to estimate the price of data. The price of mobile data is around $1/GB while the price of data on fixed line networks is near zero. These trends and technological developments such as 5G suggest that mobile services will increasingly able to satisfy demand for high usage, and the range of users who can substitute between fixed line and mobile will grow.

How policy and regulatory settings will need to adapt

Convergence between mobile and fixed line technologies will need technology neutral policy and regulatory settings.

Policymakers should take advantage of the opportunities presented by the ongoing development of mobile networks and seek to enable mobile even if this exposes the NBN to greater competition. Indeed, the NBN should no longer be seen as solely a fixed broadband enabler, instead playing an important role in enabling both technologies.

The following are the critical policy areas relevant to the convergence of fixed line and mobile:

- **Spectrum allocation:** The NBN currently has large holdings of spectrum that is needed for the deployment of 5G services. Spectrum policy will need to become technology-neutral so that allocations are made based on the highest value use.
- **Competitive neutrality:** The NBN pricing model and Regional Broadband Scheme (RBS) levy raise potential competitive neutrality issues.
  - Depending on the costs and revenues that NBN will generate, the 'commercial' services could be a loss-making enterprise, meaning that both arms of the NBN business model would be making a return below that required by a commercial entity. Issues of competitive neutrality would be exacerbated if industry is required to contribute to non-commercial service losses through the RBS.
  - The lack of a commercial return from NBN's commercial business is also a competitive neutrality issue. However, it is not clear that this can be solved, as there may not be a way to price NBN to make it commercial.
- **Subsidy arrangements:** Policymakers should examine the competition implications of subsidy mechanisms for regional services such as the Universal Service Obligation (USO) and the Mobile Black Spot Program and the RBS. Given the proposed reforms to the USO, these arrangements should be consolidated into a broader technology-neutral framework and be contestable to promote competition.
- **NBN pricing:** The value of services on the NBN is reduced because of artificial restrictions in service quality. This is largely because NBN's pricing has not incentivised retailers to sell higher speed services at prices that consumers are willing to pay. This has provided a trade-off between maximising revenue and maximising usage of, and the value from, the NBN. Inefficient NBN pricing structures may lead to a greater level of usage of mobile networks in the home than is efficient. The recent price changes announced by NBN are helpful to incentivise retailers to sell the 50 Mbps service but as 5G is introduced, faster speed services than 50 Mbps will need to be offered at competitive wholesale prices.
- **Access to NBN infrastructure:** Technology changes such as 5G will likely alter the importance of different parts of the NBN network, both commercially and for regulators and access seekers. Policymakers should not seek to protect the NBN from competition, instead embracing the opportunity for the NBN to be an enabler of all broadband services. Regulation of NBN pricing to the premises may become less important and regulation of access to NBN infrastructure at other points further from the premises, such as by 5G mobile networks, will become more important.

Opportunities and risks as technologies converge

The optimal policy settings would see technologies competing depending on the services that they offer to consumers. Government's role would be to ensure a level playing field, and ensure regulatory barriers do not increase costs.

Policymakers should not seek to protect NBN from competition to limit the cost to government. There are opportunities by ensuring NBN infrastructure can be efficiently

utilised as part of rolling out other networks, which both benefit NBN commercially and benefit Australian households.

To the extent that government restrictions impact on competition outside of the home, the impacts will be much larger. Past evidence has shown enormous gains to Australians from the development of mobile technologies. These gains currently, and are likely to continue to, mainly relate to the use of mobile technology outside the home.

To gain an idea of the magnitude of costs that could occur from poor policy development, we have estimated the impacts from delays to a 5G roll-out or changes to the market structure for mobile communications.

- **An increase in concentration in the provision of mobile services, such as moving from three mobile networks to two for 5G services[7], could increase prices for consumers by 30 per cent.**
- **A two-year 5G rollout delay could, if benefits from 5G match past benefits from mobile broadband, reduce future Australian economic activity by around $10 billion each year, and reduce economic growth by 0.3 per cent for each year of delay.**

These impacts are far in excess of the commercial impacts for NBN. Just as has been found for spectrum allocations, in making policy decisions, governments should focus on the welfare of the Australian people, rather than the commercial outcomes for government and the NBN.

7 We allow for a third network to compete in 4G services, and that this would enable it to retain half its current market share.

1 Introduction

Internet access within the home can be provided by:

- fixed line services, which can involve
  - a physical connection to the premises such as DSL, fibre or cable, or
  - fixed wireless,[8] and
- mobile services, which use mobile networks to carry data.

Ongoing developments in broadband technology are expected to bridge the gap between the capabilities of fixed and mobile connections. As the services become more alike they become closer substitutes for one another. There are two main types of substitution between fixed line and mobile services:

1 **Supplier-led substitution** – where service providers may be able to substitute between fixed and mobile technologies to provide connectivity solutions for their customers. Service providers may find it favourable to employ a mix of technologies and this is currently possible to a limited extent with mixed access methods such as:
   - fixed-wireless, which uses the same wireless technology used in mobile 4G networks to wirelessly connect the household premises to the fixed network;
   - hybrid routers, such as the Vodafone Wi-Fi Hub, which allow fixed line routers to switch to the mobile cellular network, and
   - hybrid cellular, which involves mixed connections between mobile cellular networks and Wi-Fi hotspots to reduce contention and metered data usage.
2 **Customer-driven substitution** – where customers decide between access technologies based on:
   - price of data;
   - characteristics such as speed, reliability and compatibility with existing devices; and
   - changing consumer trends such as a greater preference for using mobile for more online activities.

The focus of this report is on customer-driven substitution. However, the underlying capabilities and costs of the networks will be the critical factors for both types of substitution.

Although fixed line connections are currently the dominant type of access for broadband within the home in Australia, 17 per cent of households are 'mobile-only', using only

8 Fixed wireless is considered to be a fixed line technology. Fixed wireless services provided by NBN co require an antenna to be connected to the roof of the premises, and are therefore not 'mobile'. See: https://www.NBNco.com.au/learn-about-the-NBN/network-technology/fixed-wireless-explained.html

mobile services for their home internet access. Other recent data suggest that mobile services are becoming increasingly important and responsible for a large share of internet access:

- Annual global mobile sales are six times larger than PC sales[9]
- There are four times more mobile connections than fixed connections in Australia[10]
- Over half of average online time is spent on mobile devices[11]

History of mobile as a disruptor

The role of mobile displacing fixed line networks is not uncharted territory for the telecommunications sector. The introduction of mobile networks and devices had profound implications on telecommunications worldwide, including Australia. Mobile networks largely displaced incumbent public-switched telephone network (PSTN) operators for provision of voice services, with the share of originating voice minutes being performed on mobile increasing every year to the point where in 2016 almost 80 per cent of all voice minutes were performed on mobile (chart 1.1).

Prior to reaching this point, the previous policy stance concerning competition between the technologies regarded fixed line and mobile calls as not sufficiently close substitutes, thereby 'limiting the extent to which the pricing of fixed services constrained the price of mobile services'[12]. The ACCC regarded the price premium paid for mobility and the timed feature of most mobile call charging, relative to untimed fixed line charging, differentiated the services. Advancement in mobile technology has since made it increasingly cheaper to access such services, with most plans providing unlimited voice calls and SMS. As such, the capability and ubiquity of mobile networks today is increasingly rendering fixed line networks redundant for voice.

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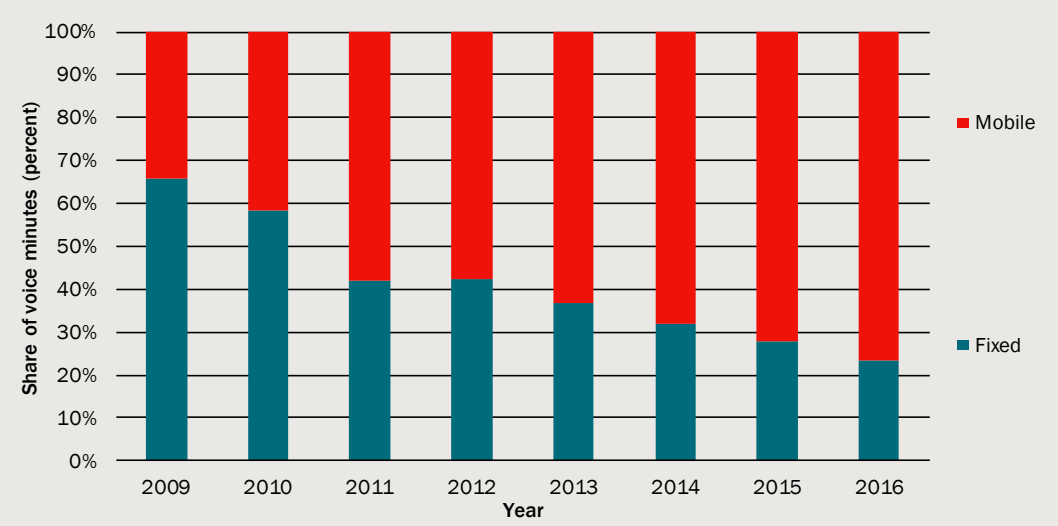
9 Statistica, Total unit shipments of PCs worldwide from 2006-2017 https://www.statista.com/statistics/273495/global-shipments-of-personal-computers-since-2006/

10 There were 32 million mobile connections (via handsets, routers and dongles) in June 2017 compared to approximately 8 million non-mobile connections: ABS Internet Activity, Australia June 2017, ACCC Competition in the Australian telecommunications sector: price changes for telecommunications services in Australia February 2017

11 Communications Chambers - Mobile first, fibre as required: The case for 'fibre to the 5G (FT5G)", January 2017

12 ACCC, Competition for long distance mobile telecommunication services, January 2000

1.1 Share of voice minutes over mobile and fixed – 2009-2016



Data source: ACCC Telecommunications report 2013-14 & 2015-16.

With respect to mobile broadband services, mobile networks are becoming increasingly capable of delivering a high-quality service. In 2018, mobile broadband mainly excels at providing superior speeds and mobility via 4G LTE networks at the cost of smaller data inclusions and a higher price per gigabyte. Fixed line connections maintain the advantage when it comes to providing high download inclusions at a cheaper price per gigabyte. It may therefore be tempting adopt a similar line of thinking to the past and assume that mobile and fixed line broadband services are, and will remain, very different, with mobile maintaining a price premium over fixed. History has shown however that technological advancement is unrelenting and that in just a short amount of time, mobile broadband services could in fact overtake fixed as the preferred means of access, just as it did for voice.

The substantial past role of mobile in driving efficiency and economic outcomes for Australia has been widely recognised.

- The CIE and Analysys Mason in 2014 found that mobile broadband had increased Australia's Gross Domestic Product (GSP) by $33.8 billion by 2013, comprising gains from a more efficient sector, and productivity gains for businesses using mobile networks.[13] These gains will only have increased since then.
- Deloitte Access Economics in 2016 found that the Australian economy was 2 per cent ($34 billion) larger than it otherwise would have been due to the long-term productivity benefits of mobile technologies[14].

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13 The CIE and Analysys Mason 2014, *The economic impacts of mobile broadband on the Australian economy, from 2006 to 2013,* prepared for the Australian Communications and Media Authority, https://www.acma.gov.au/~/media/Numbering%20and%20Projects/Report/pdf/Economic%20impacts%20of%20mobile%20broadband_Final%20pdf.pdf.

14 Deloitte Access Economics, Mobile Nation: Driving workforce participation and productivity, 2016

Nature of the project

The CIE has been commissioned by Vodafone Hutchison Australia (VHA) to provide an understanding of the current level of substitution between mobile and fixed line services, the drivers of this and how this could change.

This report:

- presents the results of a survey of households about internet use at home, and uses this to assess current and future internet usage in Australia;
- compares the characteristics of fixed line and mobile services;
- analyses the current and potential future levels of substitution using an economic model based on survey data;
- explores the technology changes in fixed line and mobile services and how these may affect substitution; and
- examines how policy and regulatory settings will need to adapt to these changes.

2 Current and future internet usage in Australia

Key points:

- **Internet access in Australia is high and data usage across both fixed line and mobile connections has grown by around 50 per cent each year over the past 5 years.**
- **Activities performed online over fixed and mobile connections are very similar. Fixed and mobile-only broadband connections have the capabilities to meet most users' day to day needs.**
- **17 per cent of households are currently mobile-only in Australia. Smaller households with 1-2 people, as well as users between the ages of 18-24 and over 55 are more likely to be mobile-only.**
- **Perceptions of the relative cost and quality of experience on fixed and mobile broadband are major drivers of the decision to use either fixed line or mobile as the primary internet connection within the home.**
- **Around 40 per cent of fixed line users use 50 GB or less each month. There is considerable overlap in these usage patterns with mobile internet, suggesting that the data needs of these users could be currently met by mobile.**
- **Data usage and demand for higher speeds are forecast to grow as more sophisticated applications, devices and IoT emerge.**

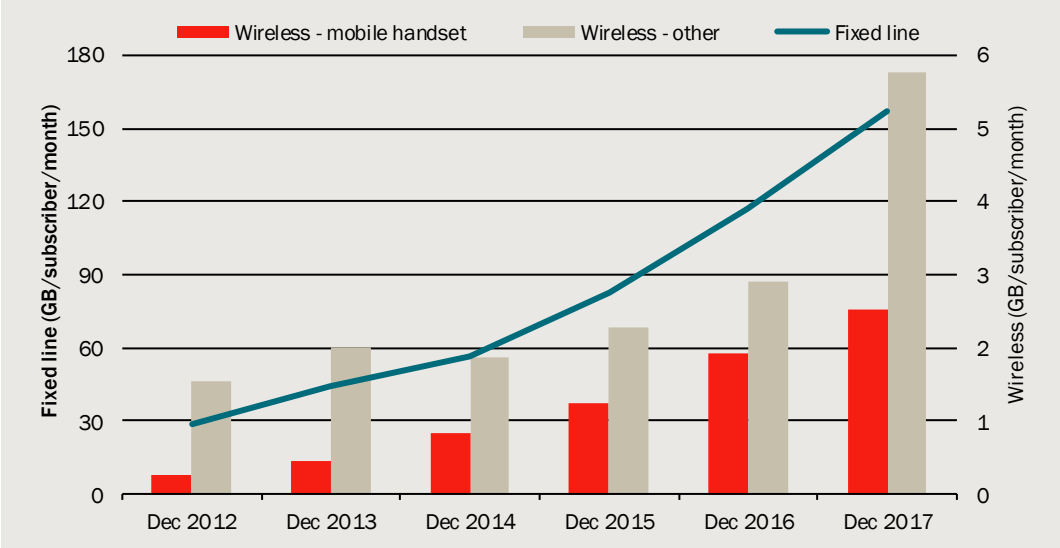
Current internet usage

Internet usage in Australia is high, with over 14 million internet subscribers reported at the end of December 2017.[15] To put this into perspective, 86 per cent of households in Australia have access to the internet as of 2016-17, up from 67 per cent in 2007-08[16], reflecting a marked increase in household internet connectivity. In addition to this trend of greater internet connectivity, the intensity of internet usage (as measured by data usage) has increased even more so. There has been a trend increase in data usage for both fixed line and mobile internet (whether through a handset or other form of mobile device) (chart 2.1). Data usage across both types has increased by around 50 per cent per year, highlighting the relevance of the internet as a major platform for an increasing number of activities.

15 Australian Bureau of Statistics – Internet Activity, Australia December 2017 cat 8153.0

16 Australian Bureau of Statistics – Household use of information technology, Australia 2014-15 and 2016-17 cat 8146.0

2.1 Median monthly data use per subscriber



Data source: ABS 2017, Internet Activity, Australia.

Whilst both fixed line and mobile data usage have achieved similar rates of growth, the levels of data usage on fixed line connections is substantially higher. Average monthly fixed line data usage is over 150GB whereas monthly mobile data usage is closer to 2GB (for mobile handsets) and 4GB for other devices using the mobile network. The driver of the difference here is mainly technological as it is more expensive to provide a comparable level of capacity over mobile networks than fixed-line infrastructure. As such, consumers must pay a premium for larger data quotas on a mobile network, leading to typically less usage compared to fixed-line.

Patterns of internet usage for fixed and mobile

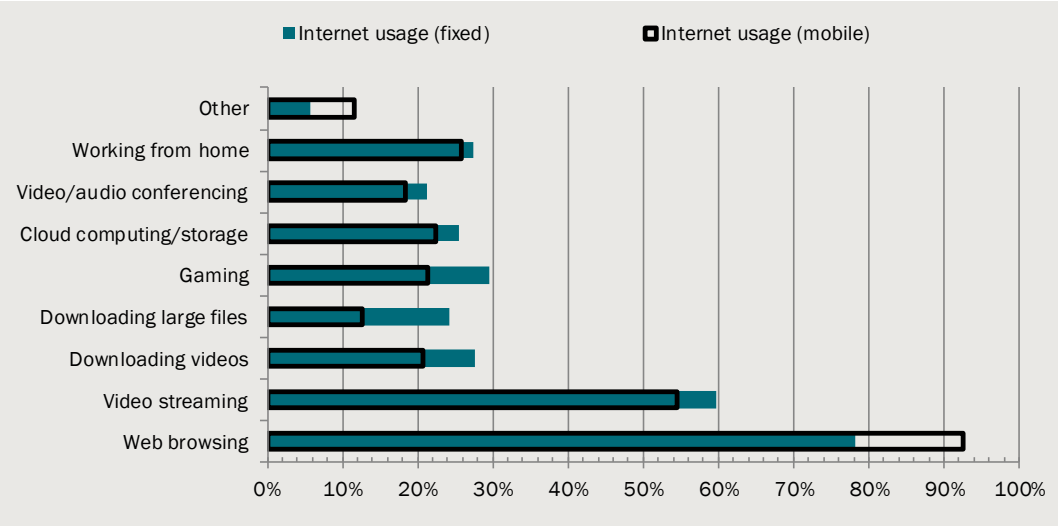
To better understand household internet usage patterns, The CIE in partnership with Woolcott Research and Engagement, conducted a survey of 1000 households across Australia. This survey asked respondents to report on the nature of their internet usage, including whether their primary access method in the home was fixed or mobile, what activities they used the internet for, as well as their data usage and allowance levels. Demographic information such as age and household size, composition and geographic location were also collected to provide a robust and well represented sample (see attachment A for the survey questionnaire).

The patterns of internet usage across both fixed and mobile internet obtained from the survey are revealing (chart 2.2). The most popular online activities include web browsing (e.g. news, online shopping, and social media), performed by nearly 80 per cent and 90 per cent of all fixed and mobile only internet users respectively and video streaming (e.g. YouTube, Netflix, Stan or iView), performed by 60 per cent and 55 per cent of all fixed line and mobile users respectively.

With the exception of use cases such as downloading large files and web browsing, the patterns of internet usage across fixed and mobile access types are not very different. Fixed internet users are more likely to perform data intensive activities such as

downloading large files and gaming compared to mobile only users. Likewise, less data intensive activities such as web browsing (and in particular web based activities such as email and online banking) are performed more on mobile. These differences in usage patterns are explained by the fact that a mobile internet connection currently typically provides a lower data allowance than a fixed-line internet connection.

2.2 Internet usage by type of connection

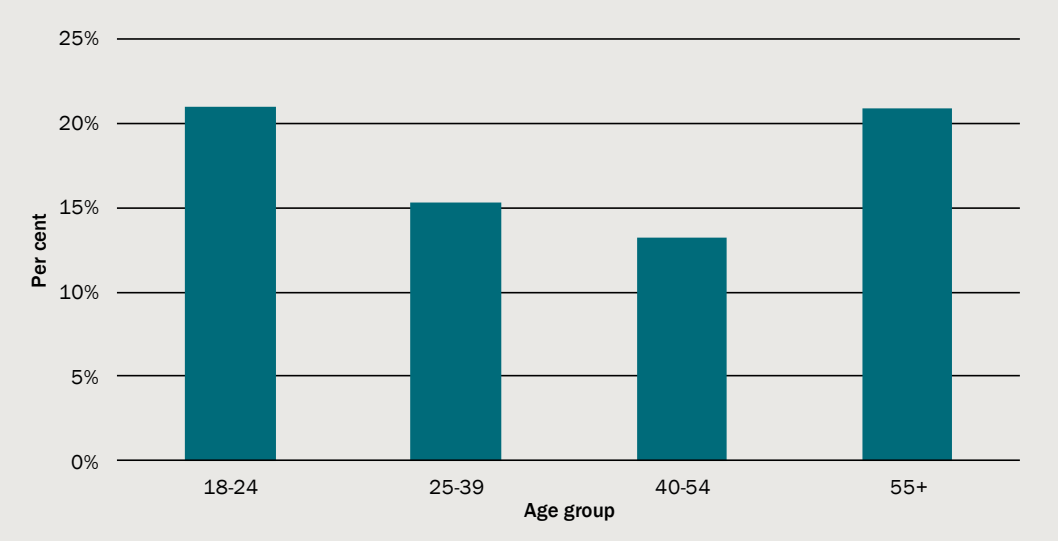


Data source: Survey data from Woolcott Research (commissioned by the CIE) (n=1000).

This could indicate that for a subset of users, either fixed line or mobile only internet could fulfil their needs and be perceived as substitutes. Indeed, this is the case for the 17 per cent of the population who have opted to only use mobile internet. The likelihood of mobile only internet usage further varies by age (chart 2.3):

- A higher proportion of mobile-only users are found in the 18-24 and over 55 age groups.
- Age groups 25-29 and 40-54 were less likely to be mobile only users, which makes sense especially if this age group are more likely to comprise larger households and families with greater data needs.

2.3 Proportion of mobile only users by age group



Data source: Survey data from Woolcott Research (commissioned by the CIE) (n=1000).

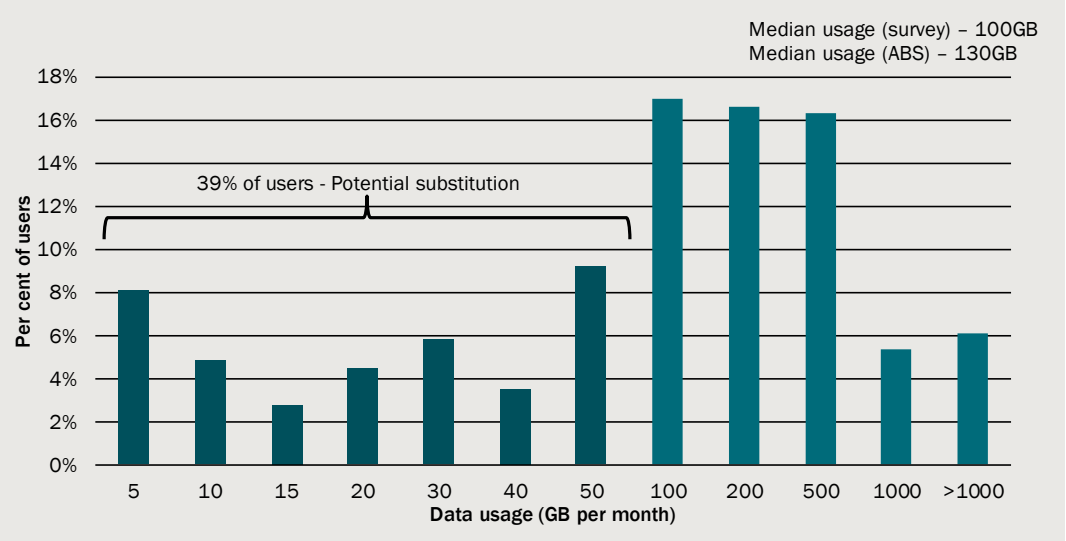
The prevalence of mobile devices has thus far not marginalised fixed line internet, with most households maintaining both a fixed line and a number of mobile internet plans. This indicates that many users perceive some level of product differentiation between the two access types.

Distribution of data usage for fixed and mobile

Although headline ABS medians suggest that data usage is 145 GB per month for fixed line connections and between 2 GB and 4 GB per month for mobile connections, a finer breakdown of the distribution of data usage suggests that there is variability in data usage across the population (chart 2.4).

Of interest is the fact that almost 40 per cent of households with a fixed line connection use 50 GB or less per month. Approximately 50 per cent of households currently use 100 to 1000 GB a month and almost 10 per cent are using over 1000 GB a month (typically via an unlimited allowance subscription).

2.4 Distribution of data usage – fixed line connection



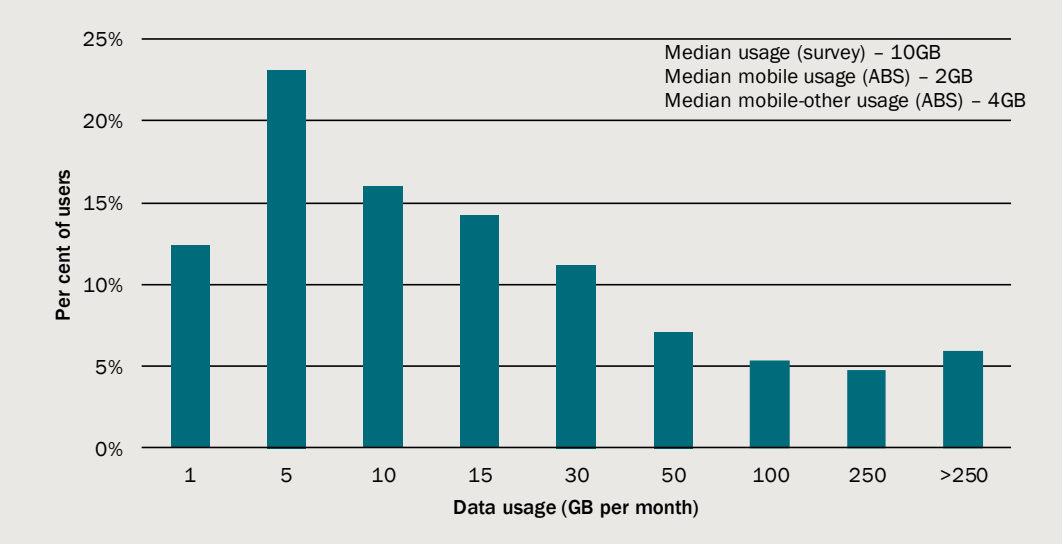
Data source: Survey data from Woolcott Research (commissioned by the CIE) (n=1000).

Compared to the ABS median fixed data usage of 145 GB per month, the survey data yields a median fixed data usage of 100 GB a month. Data usage within the 1 to 50 GB per month band is fairly evenly distributed, with 5, 10, 15, 20 and 30 GB usage levels occurring at similar rates. Most relevant is the fact that mobile plans currently exist that offer data allowances at these levels, highlighting the fact that for this subset of fixed internet users, mobile could be a viable option on the basis of data demand (all else being equal).

Compared to the ABS median mobile data usage of 2 GB (for handsets) and 4 GB (for other mobile), the survey reports a median mobile data usage of 10 GB. This higher usage level is expected since our survey measures the data usage levels of mobile-only households. The ABS internet activity survey in contrast measures mobile data usage for all households, including those who primarily use fixed internet in the home. Those who use mobile as their primary in-home internet service should therefore use more data on average on mobile compared to those who use fixed-line broadband in the home as well as mobile.

The distribution of data usage for mobile internet connections is also quite varied (chart 2.5). Whilst the most common monthly data usage level is 5 GB a month, a significant proportion of users also reported using up to 10, 15 and 30 GB of data per month. Median data usage overall for mobile-only (10 GB/month) is much smaller than what is used for a fixed line connection (100 GB/month) with up to 85 per cent of mobile only users using between 1 and 50 GB of data compared with 39 per cent of fixed users (reflecting the fact that mobile internet is more expensive).

2.5 Distribution of data usage – mobile connection

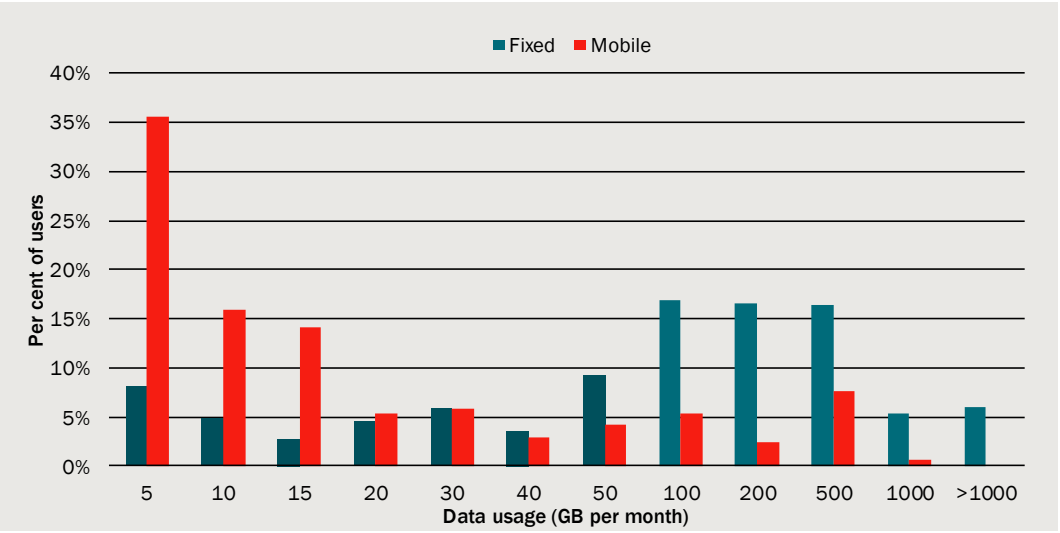


Note: Higher data usage on mobile is more likely to refer to portable modems or other wireless broadband offerings rather than mobile handsets.

Data source: Survey data from Woolcott Research (commissioned by the CIE) (n=1000).

There appears to be an overlap in the distribution of data usage up to 50 GB/month, and especially within the 20-50 GB/month usage bands for both fixed and mobile internet (chart 2.6). This lends support to the fact that based on data usage alone, mobile internet could currently act as a substitute for fixed line for almost 40 per cent of current fixed line users. As will be seen however, there are other factors in addition to underlying data demand that determine preferences for fixed and mobile internet, such as price and service quality.

2.6 Overlap in data usage for fixed line and mobile-only



Note: Higher data usage on mobile is more likely to refer to portable modems or other wireless broadband rather than mobile handsets.

Data source: Survey data from Woolcott Research (commissioned by the CIE) (n=1000).

Preferences for fixed and mobile internet connection

Internet subscribers have cited various reasons for preferring a fixed line connection over a mobile only connection (chart 2.7). Chief among these reasons were fixed line internet services providing a more reliable and faster connection compared to mobile. Fixed line internet is currently best suited to meet demand for many activities, especially during peak periods. In addition, users found fixed line connections to be compatible with current devices due to Wi-Fi capability, offering the freedom and flexibility of being mobile within the home.

2.7 Reasons cited for preferring fixed over mobile

Main reasons for preferring fixed	Per cent of respondents
More reliable connection	64
Faster connection speed	50
Compatible with current devices	43
Other	13

Source: Survey data from Woolcott Research (commissioned by the CIE) (n=1000).

Other reasons cited for preferring fixed to mobile internet include:

- lower cost per GB of data and greater download capacity
- fixed line plus Wi-Fi is more accessible to larger households
- fixed line offerings include over-the-top (OTT) services (e.g. access to Netflix/Stan) and bundle offerings
- perceptions of greater security compared to mobile.

Similarly, internet subscribers have also cited reasons as to why they prefer mobile to a fixed line connection (chart 2.8). For those that maintain a mobile only connection, the expense of subscribing through a fixed line is cited as a major reason amongst respondents. This is particularly true for lower income households. In addition to cost, a third of mobile only internet users found the comparatively smaller mobile download allowance to be sufficient for most activities such as browsing and email. This is consistent with the higher proportion of the over 55 age bracket, who use internet for less data intensive activities.

2.8 Reasons cited for preferring mobile over fixed

Main reasons for preferring mobile only	Per cent of respondents
Fixed line is too expensive	39
Mobile download allowance is sufficient for most activities (browsing and email)	32
Fixed line connection not available in region/dwelling	28
Other	14

Source: Survey data from Woolcott Research (commissioned by the CIE) (n=1000).

Other reasons noted for preferring mobile over fixed include:

- mobile internet is more convenient as most activities can be performed on a mobile device (especially where the household primary device is a mobile device such as a handset or tablet).
- mobile internet is perceived to be more reliable and faster, particularly among those fixed line users who have cited dissatisfactory experiences with their current fixed line connection.

Importantly, reliability and speed is cited both for mobile and against mobile. This indicates that the local service quality is critical in household's decisions.

Data usage across different households and age groups

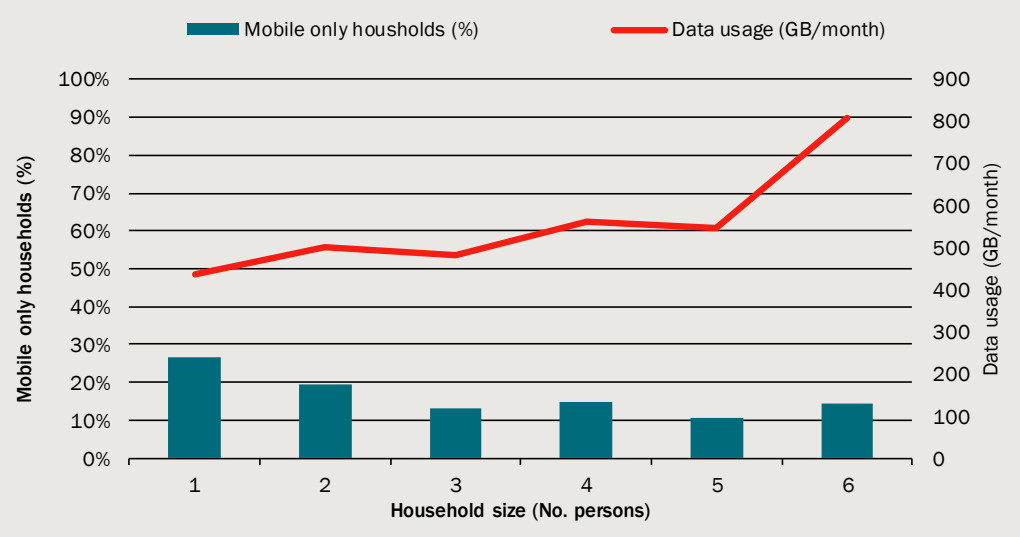
The nature of internet usage also varies with demographics. In particular, the size and composition of households can determine the extent of internet usage.

Data usage by household size

Data usage and type of internet access varies with the size of households (chart 2.9):

- larger households are more likely to have a fixed line connection compared to smaller households – households with 3 or 4 people are 5 per cent more likely to have a fixed line connection compared to households with 2 people, and 13 per cent more likely to have a fixed line connection than households with1 person.
- larger households have larger fixed download allowances and are more likely than smaller households to have an unlimited download allowances – an increase in the household size of 1 person is associated with a 5 per cent higher likelihood of having an unlimited download allowance if on a fixed line connection.
- larger households also use more data – an increase in the household size of 1 person is associated with 60 GB per month of additional data usage.

2.9 Data usage and type of access by household size



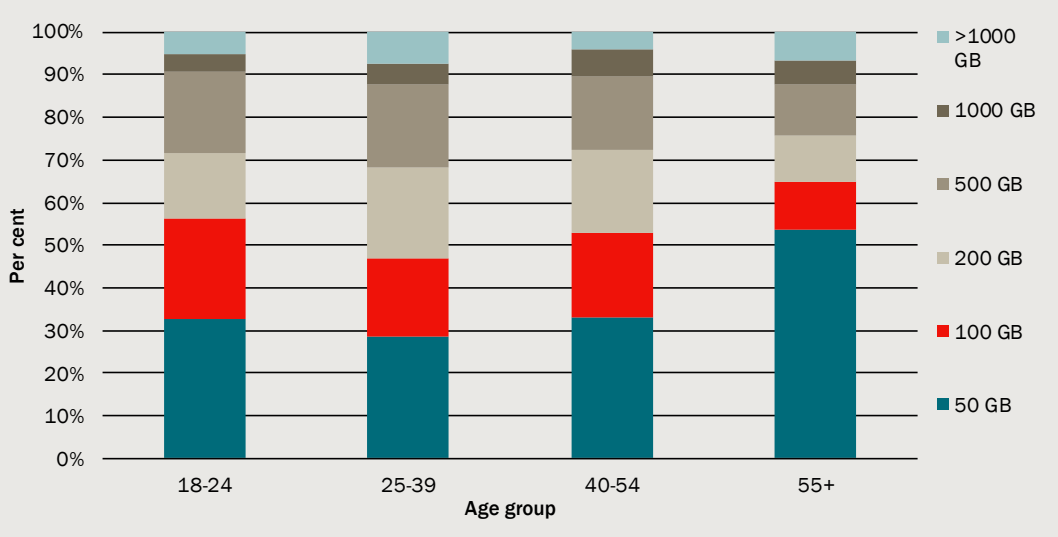
Data source: Survey data from Woolcott Research (commissioned by the CIE) (n=1000).

Data usage by age group

In addition to household size, the age of internet users also explains variation in data usage (chart 2.10).

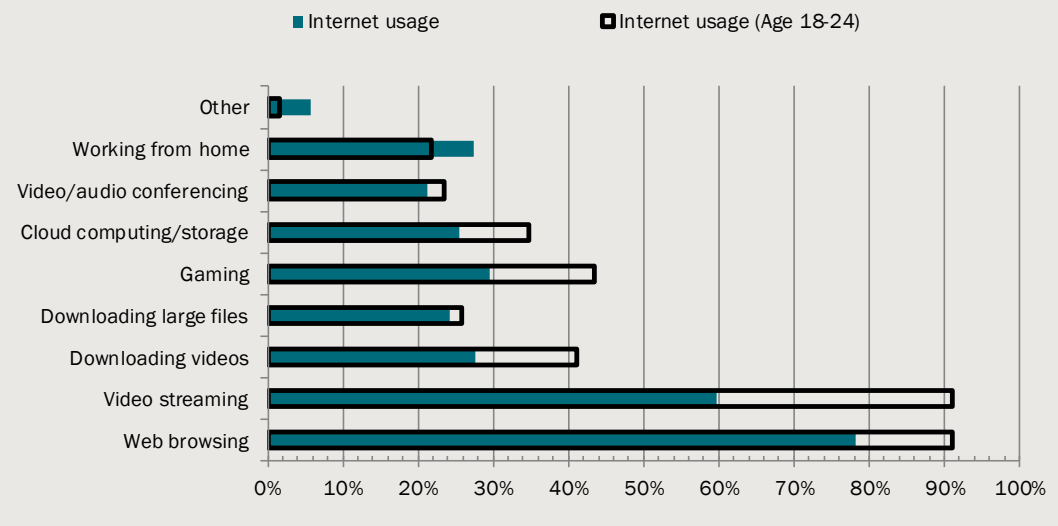
- Internet users aged 18-24 and 24-39 use more data compared to older generations.
- Almost 60 per cent of internet users over the age of 55 use less than 50 GB of data on a fixed line connection per month compared with almost 30 per cent of users between the ages 18-24 and 24-39.
- Internet users between the ages of 25-39 and 40-54 were more likely to report monthly data usage over 1000 GB. Respondents in this age group were also more likely to be part of a larger household with dependents under the age of 18 who also use the internet, resulting in greater monthly usage.
- Younger internet users generally use more data due to more intensive internet usage patterns. Users in the age group 18-24 for example, are more engaged with social media, gaming and video streaming compared to the rest of the population (chart 2.11).

2.10 Fixed line data usage by age group



Data source: Survey data from Woolcott Research (commissioned by the CIE) (n=1000).

2.11 Internet usage of young Australians compared with the population



Data source: Survey data from Woolcott Research (commissioned by the CIE) (n=1000).

Drivers of future internet usage

Although internet usage levels vary across different groups and household types, internet usage growth on average has increased every year and is expected to continue as the applications of the internet for work and entertainment grow. The increase in demand for internet usage is related to a variety of factors, namely:

1 the falling price and increasing volume of data, both on fixed line and mobile;

2 the increasing proliferation of high bandwidth applications; and

3 the increasing number of internet connected devices (via IoT) being used by households and businesses.

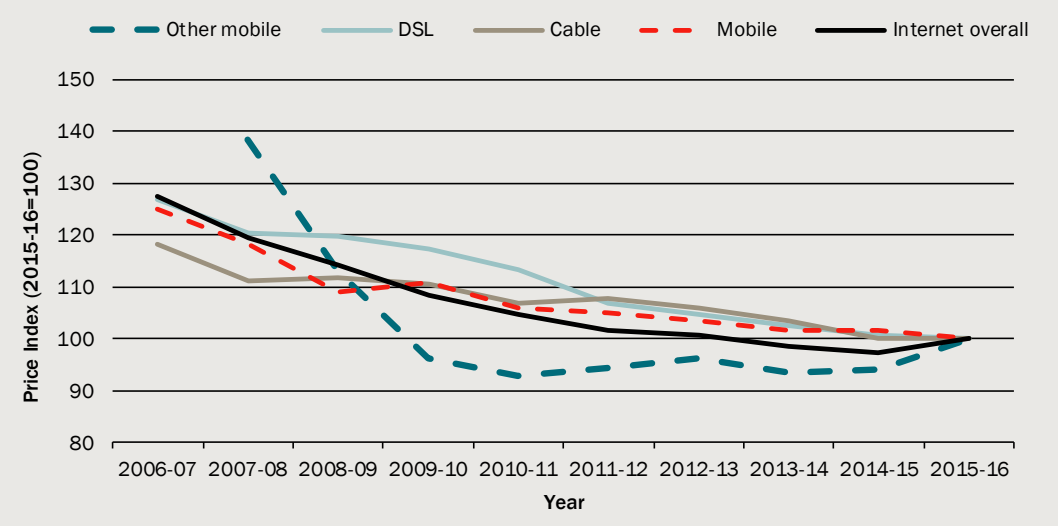
The interactions of these trends, particularly 2 and 3, means that future internet demand will manifest across two dimensions:

- quantity of data – represents higher volume of data download and upload; and
- quality of data – represents the connection speed and reliability to enable seamless use of internet connected devices and applications.

The falling price and increasing volume of data

Real prices of internet access for consumers have decreased over time, falling on average by 2.6 per cent each year across all connection types since 2006-07 (chart 2.12). Cheaper internet prices make internet access more affordable and accessible to more people. As the unit price of data falls, consumers are able to increase their data usage at a lower cost and this has been observed strongly for fixed line data, with average per subscriber monthly data usage increasing by over 100GB over the past 5 years[17]. This trend is expected to continue for mobile internet as well, as improvements in technology (such as 5G) increase capacity and reduce the price of data.

2.12 Real prices of fixed line and mobile internet 2006-07 to 2015-16

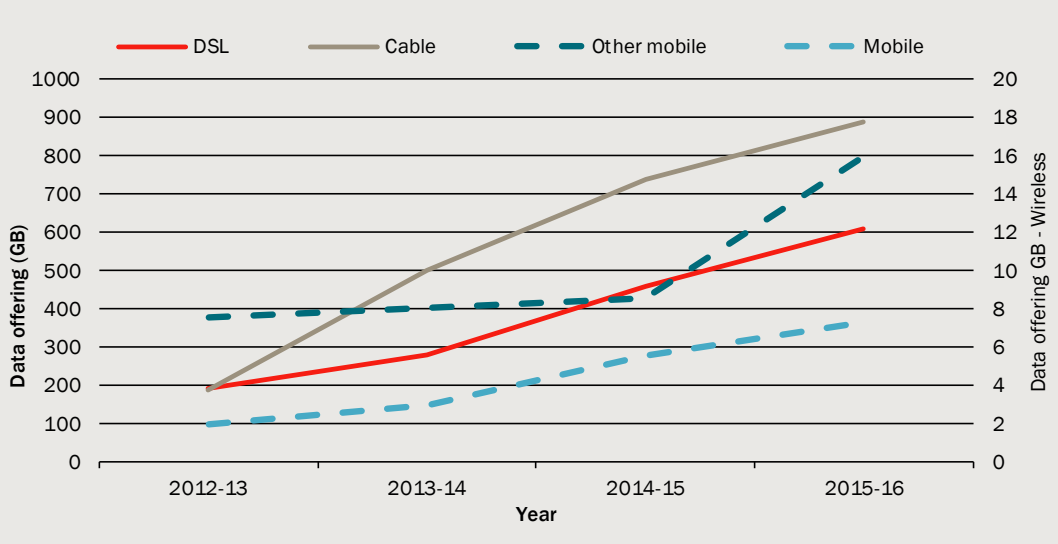


Data source: ACCC Telecommunications reports, 2015-16, CIE calculations.

The cheaper price of data is not necessarily fully reflected in the price series however. Parallel to falling prices has been strong rises in the amount of included data in internet plans (chart 2.13). Over time, network improvements have led to increases in data inclusions of 60 per cent each year for fixed line connections to the home and 45 per cent each year for mobile. Even if monthly internet subscription prices were to remain the same, an increase in data inclusions would still represent an increase in value to the consumer and a cheaper unit price of data.

17 Australian Bureau of Statistics – Internet Activity, Australia June 2017 cat 8153.0

2.13 Average monthly internet data inclusions 2012-13 to 2015-16



Data source: ACCC Telecommunications reports, 2015-16, CIE calculations.

Thinking about the price of data on a value to the consumer basis (how much data is provided for a given price) indicates a stronger downward trend in the price of data than the monthly subscription price series alone indicates. The magnitude of this trend is determined by the value premium of higher data allowances however, and this would most likely diminish as the level of included data exceeds what can reasonably be used in a given month. Given that mobile data allowances are currently lower than their fixed counterparts, it is reasonable to expect that the value-added to the consumer of increasing data allowances would be stronger for mobile than fixed line internet plans, assuming of course that consumers value mobile data allowances at a similar level to fixed line. Additionally, quality changes in service (such as speeds and reliability) also represent value to the consumer that is not necessarily well represented in the price series.

At a broad level, therefore, if increases in data inclusions for both connection types continue, then this will lead to a lower unit cost of data in the future. The Cisco Visual Networking Index forecasts that average monthly mobile internet usage in Australia will increase to just over 9 GB in 2021[18] from current levels of approximately 2 GB.

Increasing proliferation of high bandwidth applications

The proliferation of applications and web-based services is a strong driver of data usage, with different forms of content demanding different levels of network capacity and speed (chart 2.14). Speed (also known as bandwidth) is an important part of the quality dimension of internet usage, and this is metric is of particular relevance to future internet usage as the types of activities internet is used for evolves.

18 Cisco Visual Networking Index Forecast – accessible through: https://www.cisco.com/c/m/en_us/solutions/service-provider/vni-forecast-highlights.html#

2.14 Application speed requirements (on fixed-Wi-Fi and mobile network)

	Text	Audio	Video
	Mbps	Mbps	Mbps
Speed requirement (2017)	0.1	1	10

Source: Communications Chambers – Mobile first, fibre as required: the case for 'Fibre to 5G' (FT5G), January 2017.

A large proportion of consumer internet traffic is in the form of video. This is driven largely by sites such as YouTube and video streaming services such as Netflix, which are now widely used in Australia. As of 2016, 72 per cent of all consumer internet traffic was video traffic, up by 4 per cent from 2015[19]. This figure is expected to grow to 79 per cent of all internet traffic by 2021[20].

The demands of video based traffic is sensitive to different quality standards than other traffic. To date most video usage has been in the form of standard definition (SD) and more recently high definition (HD), which has become more popular[21]. Improvements in the quality standard of video have already began to filter down to everyday household use. Higher resolution displays are already prevalent in the newer generations of smartphones such as the Samsung Galaxy S9 and iPhone X. It is expected that as more Ultra HD (4K) video content is produced, and as data compression rates for this type of content improve, as many as 50 per cent of connected flat panel TV sets will be Ultra HD in Australia in 2021 (up from 10 per cent in 2016)[22]. In terms of data usage, higher video standards have higher data and speed requirements to support viewing at the correct resolution without interruption (chart 2.15).

2.15 Video standard speed requirements

	Standard definition (SD)	High definition (HD)	Ultra-high definition (4K)
	Mbps	Mbps	Mbps
Speed requirement	2	7.2	18

Source: Cisco Visual Networking Index Forecast, ARN from IDG.

As this type of technology becomes more affordable and is adopted by more consumers and visual content producers, internet usage and the demand for high speed connections will increase.

19 Cisco Visual Networking Index Forecast – accessible through: https://www.cisco.com/c/m/en_us/solutions/service-provider/vni-forecast-highlights.html#

20 Cisco Visual Networking Index Forecast – accessible through: https://www.cisco.com/c/m/en_us/solutions/service-provider/vni-forecast-highlights.html#

21 Telsyte/NBN – Internet Uninterrupted: Australian Households of the Connected Future

22 Cisco Visual Networking Index Forecast – accessible through: https://www.cisco.com/c/m/en_us/solutions/service-provider/vni-forecast-highlights.html#

Increasing number of internet connected devices used by households and businesses via IoT

IoT reflects a growing trend of the digitisation of traditionally non-digital devices. These devices are embedded with technology which enables them to connect to networks and exchange data with other devices either locally or over the internet. Key examples of this trend are smart TVs which connect to the internet to access applications and stream video. More recently, developments in wearable technology has led to traditional devices such as watches and other apparel becoming 'smart'. These devices can connect to the internet via wireless means such as Bluetooth, and in some instances, through cellular radio capabilities like those of mobile phones.

Consequently, not only are more developments in data intensive applications leading towards more demand for data, but also more devices which connect to the internet are being used as well. Currently the average number of internet connected devices per household is 6 as of 2017[23], this number is expected to grow to 10 by 2021[24]. For households, this is particularly important since this can translate to multiple applications being used at the same time, creating additional requirements for high capacity and high-speed internet connections to service all users concurrently[25].

Projections on future data and speed requirements

Future data usage

Taking into consideration the falling price of data, more data intensive applications and the increasing number of devices being used to connect to the internet simultaneously, ABS forecasts on future internet usage to 2021 show a marked increase in the level of data usage across all access types, with the strongest growth forecasted for mobile and other wireless usage (chart 2.16).

- Fixed line (including Wi-Fi) data usage is forecasted to grow to 350 GB in 2021 from 145 GB in 2017
- Mobile data usage is forecasted to grow to 10 GB in 2021, up from 2.5 GB in 2017
- Other mobile data usage (e.g. wireless modems and dongles) is forecasted to grow to 20 GB in 2021, up from 4.5 GB in 2017.

Note that the data use for households that are mobile only is substantially higher than average mobile usage. Based on our survey, this is currently 10 GB/month.

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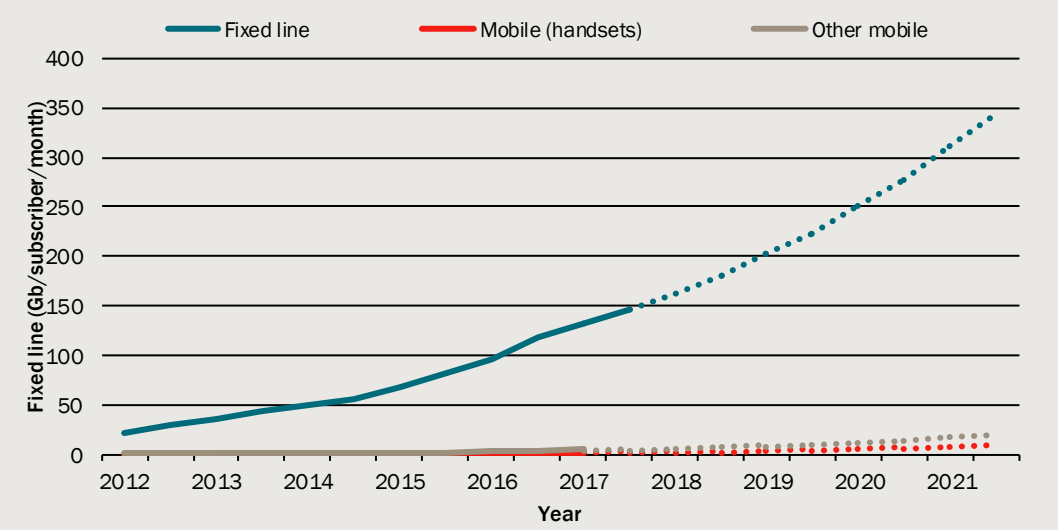
23 Australian Bureau of Statistics – Internet Activity, Australia June 2017 cat 8153.0

24 Cisco Visual Networking Index Forecast – accessible through: https://www.cisco.com/c/m/en_us/solutions/service-provider/vni-forecast-highlights.html#

25 Communications Chambers – Domestic bandwidth requirements in Australia: A forecast for the period 2013-2023, 26 May 2014

2.16 Per subscriber monthly data usage



Data source: ABS 2017, Internet Activity, Australia; Cisco Visual Networking Index Forecast; CIE calculations

Future demand for high-speed internet

Similarly, the intensity of data usage (on a Mbps basis) is expected to lead to higher speed requirements in the future. Forecasts of actual speed requirements in Australia are not as prevalent as for data demand although one detailed study by Communications Chambers in 2014[26] did make a detailed forecast on future demand for high-speed internet in Australia to 2023. A recent study by the Bureau of Communications and Arts Research (BCAR) also performed a similar analysis of speed requirements in 2016 through to 2026.

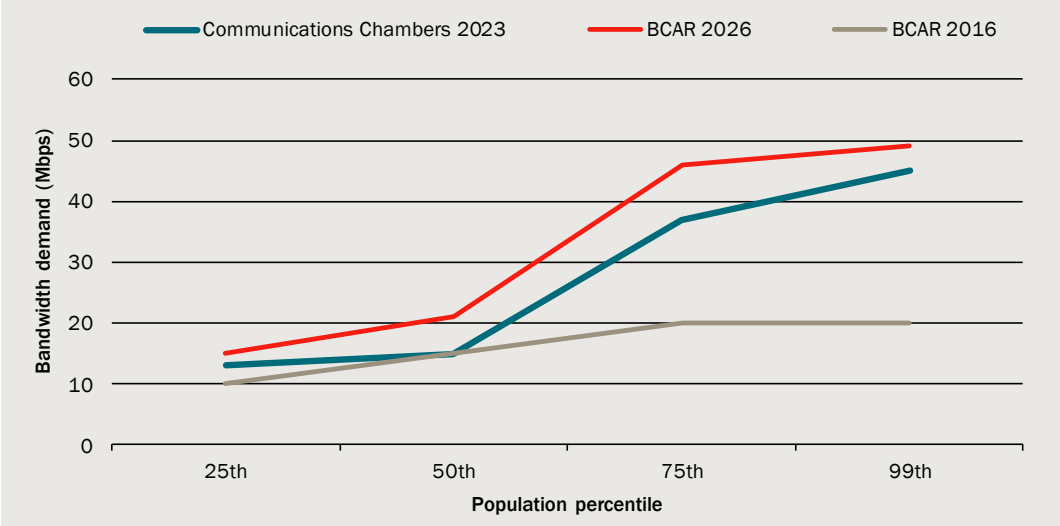
These studies analysed the broad range of applications, household types and the interactions of using different applications simultaneously to estimate a distribution of download speeds needed for the population during peak hours and the results are quite consistent (chart 2.17).

- demand for faster internet increases over time, however at different rates for different segments of the population.
- up to the 50th percentile, half of the population's needs are met with download speeds up to 15 Mbps by 2023 and 20 Mbps in 2026.
- in contrast, the second half of the population experiences stronger increase in demand for speeds up to 45 Mbps in 2023 and 49 Mbps in 2026 at the 99th percentile.

A key highlight of these studies is the variability in speed requirements across the population.

26 Data source: Communications Chambers – Domestic bandwidth requirements in Australia: A forecast for the period 2013-2023

2.17 Future speed requirements forecast to 2023 and 2026



Data source: Communications Chambers – Domestic bandwidth requirements in Australia: A forecast for the period 2013-2023; BCAR – Demand for fixed-line broadband in Australia, working paper February 2018.

3 Comparison of fixed line and mobile services

KEY POINTS

- **Data allowances for mobile are increasing and the price of data for mobile services is falling.**
- **Speed tests performed by fixed line and mobile customers suggests that average download and upload speeds are currently higher for mobile compared to fixed line connections.**
- **There is little data available comparing the reliability of current fixed line and mobile services. Surveys by Choice suggest fixed line customers experience more connection problems than mobile customers.**
- **Comparisons of these characteristics across the entire population will not account for individual differences in location and other factors that can significantly impact the speed, reliability and performance of fixed line and mobile services.**

Customer choices between fixed and mobile services will depend on the price of these services, in addition to other characteristics such as the:

- amount of included data usage per month;
- connection speed;
- reliability;
- latency; and
- compatibility with existing devices.

The level of substitution between fixed line and mobile services will depend on how they compare in terms of these characteristics. If non-price characteristics of these plans are very different, then they would be poor substitutes, while if these characteristics are similar it suggests they would be close substitutes.

The perceived relative strengths of fixed line are better reliability, higher data inclusions and easier handling of many devices,[27] while mobile services provide faster speeds (at current usage levels) and mobility (chart 3.1). In this chapter we compare the characteristics of fixed line and mobile services, and assess the magnitudes of differences between fixed line and mobile.

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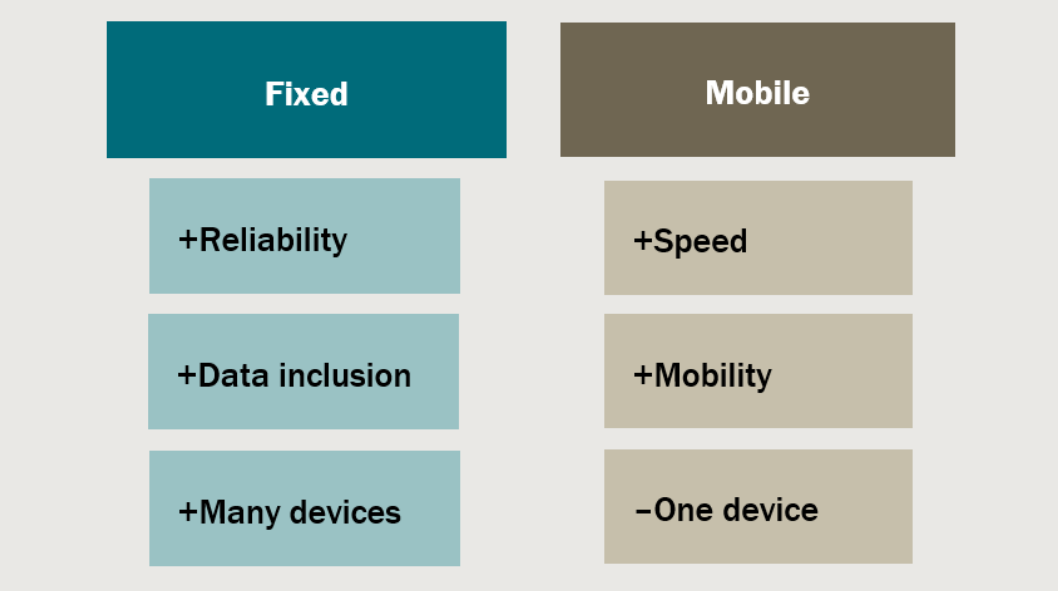
27 Mobile tethering allows mobile handsets to provide internet access to multiple devices, and mobile broadband modems are also not limited to a single device. However, the norm remains for households to have multiple mobile services, with one for each handset. The ABS Internet Activity Survey (Cat No. 8153.0) found that there were approximately 26.3 million mobile handset subscribers in Australia, which equates to over 2.5 subscriptions per household.

3.1 Perception of current strengths of fixed line compared to mobile services



Note: The speed of mobile is higher than fixed based on current average speeds experienced by users, rather than technical capabilities. Speed test data (see chart 3.4) suggests that mobile users experience average download speeds more than double those of fixed users. However, fixed line connections provide technical capability for significant greater capacity, particular in terms of reliable speeds in high-use hours of the day.

Source: CIE.

Data allowances and prices per gigabyte

Consumers are downloading increasing amounts of data, mainly associated with video streaming, cloud services and having more connected devices. This means that the download allowance of broadband internet plans is a very important characteristic to consumers.

The price of data under fixed line and mobile plans

The data allowance of mobile and fixed line plans is one of the most important characteristics in determining the price of the plan. The cost of data can be measured by decomposing the price of broadband plans into separate components related to their included features. Appendix A describes the hedonic modelling approach we have used to break down the price of plans into the value of included data, the premium for different providers, and value of other characteristics. The relationship between price and data inclusions in broadband plans can be measured in terms of the price per gigabyte of download allowance.

Fixed line price of data

It is difficult to estimate the price per gigabyte for fixed line plans, given that these plans often have unlimited download allowances. Where the data allowance is unlimited, the price of data (in $ per GB) is not defined. This suggests that the price per gigabyte has fallen

to almost zero, given that customers are not generally charged higher prices per month for higher data allowances.[28]

Some providers do have plans with limited data allowances (such as 10GB, 100GB or 1000GB allowances). However, all providers now offer plans with unlimited data allowances, and some providers only offer unlimited allowances.

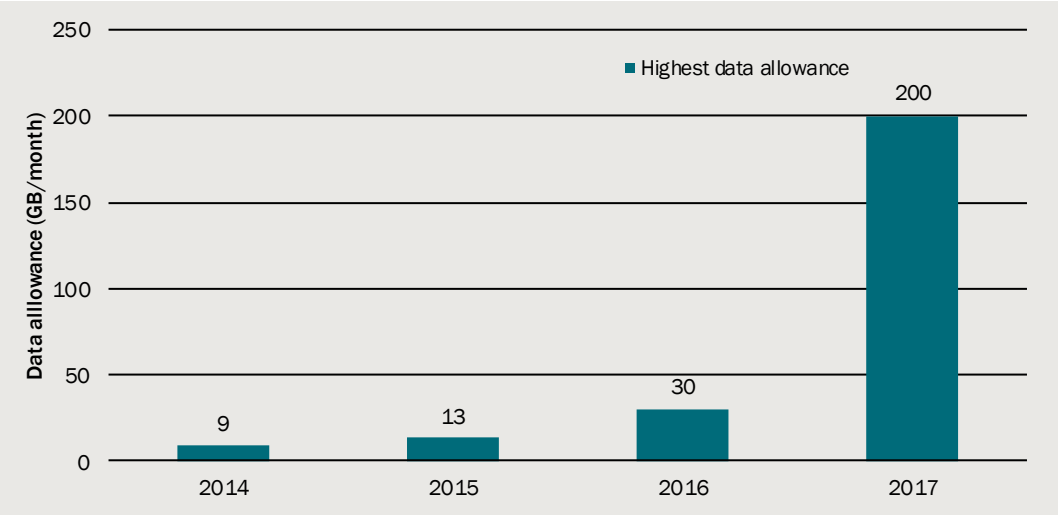
Mobile price of data

In contrast to fixed line plans, mobile plans often have limited data allowances. The price per gigabyte for mobile plans can therefore be estimated using the hedonic modelling. The price of data is not constant with respect to the amount of data included, with the price per gigabyte of plans with low allowances being lower than the price per gigabyte for plans with high allowances.

As part of this current project and in previous work, The CIE has collected a database of mobile plans each year from 2014-2017. Over time the upper limit of data allowances available has been increasing significantly, up to 200GB in 2017 (chart 3.2). This does not include the unlimited data allowance mobile broadband plan available from Vivid Wireless (which was acquired by Optus) since at least 2014, which has slow speeds and may not deliver significantly higher data inclusions in practice.

The increase in maximum data allowances available under mobile plans means that mobile is increasingly able to meet consumer demand for higher downloads. That is, the difference between data allowances of fixed line and mobile plans is getting smaller.

3.2 Highest mobile data allowances available over time



Note: This does not include the Vivid Wireless (now owned by Optus) unlimited data plans for wireless in the home. These plans have been available since at least 2014, but speeds are low meaning that high data usage may not be possible.

Data source: CIE databases of mobile plans 2014-2017.

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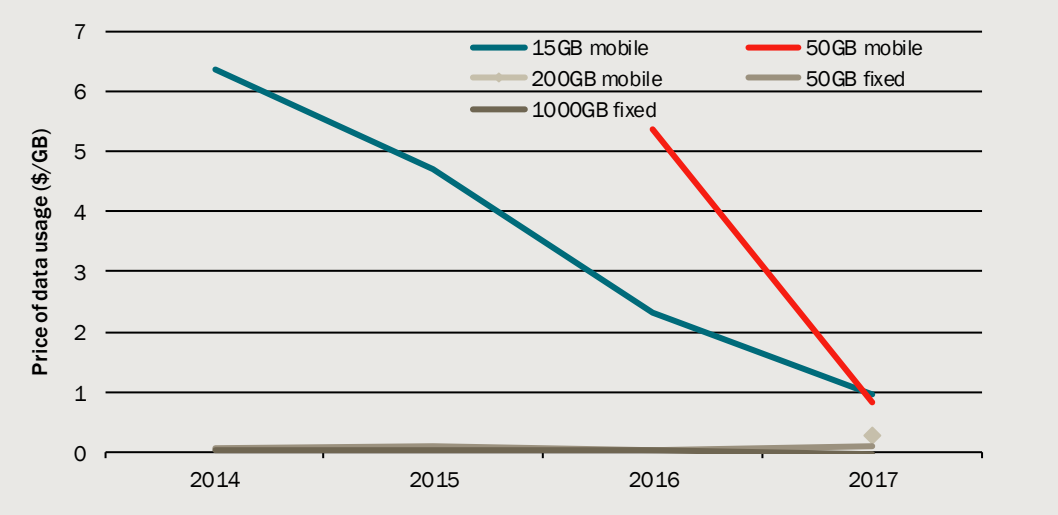
28 Instead of charging users based on their usage, providers may recover the costs of providing more usage capacity through fixed costs charged to all users. If this were the case, it would suggest that the cost of data is low. If the price of data was high this would be an unsustainable equilibrium, because competitors would be able to supply the same service to low-usage customers at lower prices than to high-usage customers.

Comparing the price of data between fixed line and mobile

It is apparent from chart 3.2 that data allowances for mobile are increasing at a much faster rate than prices, suggesting that the price of data is falling.

Hedonic modelling of the price of data for mobile shows that it has fallen dramatically over time (chart 3.3). For example, the price of a data allowance of 15GB (not including the base price of mobile plans without a data allowance) has fallen from over $6/GB in 2014 to around $1/GB in 2017. The price of a 50GB data allowance has likewise fallen dramatically from $5.5 in 2016 to now $1 in 2017. Only one year of data is available for mobile plans with a 200GB allowance, but the price per gigabyte in 2017 for 200GB plans is $0.30/GB. The price of data allowances for fixed line plans is hard to measure because of the prevalence of unlimited allowances, but appears to have fallen to almost $0. For example, we estimate the price of data for a 1000GB plan is around $0.10/GB.

3.3 Price of data for fixed and mobile over time



Data source: CIE hedonic modelling.

Speeds of services

Connection speed is another key characteristic of fixed line and mobile services. Consumers prefer faster connections, particularly with the proliferation of bandwidth-intensive applications such as video streaming.

Factors that affect connection speeds

The connection speed that a consumer receives is dependent on a number of factors, such as the following:

- **Network technology**: whether the service is provided via the fixed line or mobile network. If the service is provided on a fixed line network, speeds will also vary between fibre, ADSL2+, fixed wireless or other network types.

- **Geographic location**: Fixed line connection speeds are higher for households located closer to certain parts of the network infrastructure (such as exchanges or nodes). The type of fixed line connection (fibre-to-the-home, ADSL2+, etc.) available to a household depends on their location, with households outside metropolitan areas often only having access to relatively slower fixed wireless or satellite services. Mobile connection speeds depend on location and topography as well as distance from network infrastructure such as mobile towers.
- **Time-of-day and competing users**: The number of competing users of fixed line and mobile networks at a given time will affect speeds. In particular, speeds are lower during peak times in the evening, when many households are using the internet at the same time.
- **Capacity provisioning**: The difference between peak and average speeds experienced by customers can depend on capacity provisioning. Fixed line customers receiving services on the NBN will be allocated a certain amount of capacity based on the amount of Connectivity Virtual Circuit (CVC) acquired by their retailer.

Comparison of average connection speeds between fixed line and mobile

One way that speeds can be compared between fixed line and mobile networks is through comparing the average speed measured by speed tests performed by customers.

Speedtest data reflects the actual speeds that customers experience. Importantly, it does not necessarily reflect the speeds that each technology is capable of because speeds of some fixed and mobile broadband connections are deliberately throttled. For example, NBN limits customer speeds depending on the speed tier they pay for.

'Ookla Speedtest'[29] lets users measure their connection speed through their website, and this data is aggregated to produce estimates of the average download and upload speeds of fixed line and mobile connections. In Q2-Q3 2017 (April-September), the average download speed for fixed line of 24 Mbps (megabits per second) was slower than the average mobile download speed of 44 Mbps (chart 3.4). Average upload speeds were also slower for fixed line compared to mobile customers who performed the speed test.

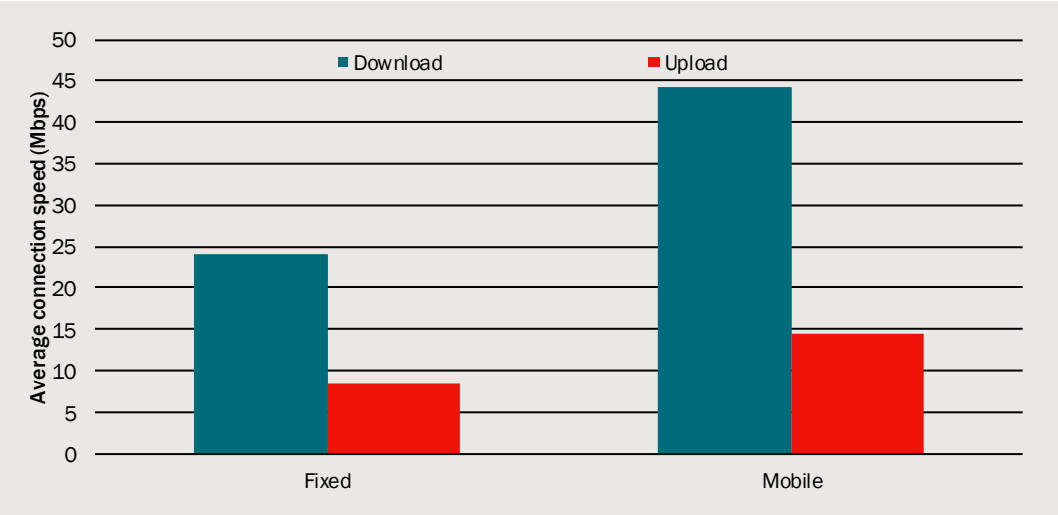
The speed test results will include customers with different network technologies, geographic locations, and amounts of capacity provisioned. Additionally, tests are conducted throughout the day, and the sample sizes are large, with 0.4 million different mobile users and 3.6 million different fixed line users performing speed tests in Q2-Q3 2017. However, the average speeds measured by this speed test may be biased estimates of average speeds across all users and times. It is likely that users perform speed tests at times when they have just started receiving a new service, or when they are experiencing connection problems and slow speeds. These and other unknown factors have an uncertain net effect on the estimates. The results of the Ookla Speedtest are the largest data sample available to assess the relative speeds of fixed line and mobile customers.

The Ookla Speedtest results for Australia are surprising in that they are a reversal of the relative average speeds at a global level. The global average download speed for mobile is

29 See http://www.speedtest.net/reports/australia/

22 Mbps and for fixed line is 42 Mbps.[30] Thus, Australia is an outlier in that average mobile speeds are higher than average fixed line speeds.

3.4 Comparison of average fixed and mobile speeds (Q2-Q3 2017)



Data source: Speedtest Q2-Q3 2017 results (available at: http://www.speedtest.net/reports/australia/ accessed on 20 February 2018), CIE.

Another source of speed testing data is available from OpenSignal, which publishes the results of connection testing of mobile devices as part of the *State of Mobile Networks: Australia (June 2016)* report.[31] This study reports the results of 7904 device tests in Australia by OpenSignal users between 1st February and 30th April 2016. This testing doesn't involve fixed line connections, but the average mobile speeds reported are almost half the average levels according to the Ookla Speedtest.

Reliability

Reliability can have two main meanings in the context of home internet services, either relating to the:

- variability of speeds, or
- frequency of service interruptions.

Customers may interpret 'reliability' to relate to speeds, and may describe a connection which experiences long loading times as being 'unreliable', even if this is attributable to low average speeds. Having already addressed average speeds, in this section we focus on the variability of speeds and the frequency of disconnections and drop-outs.

Customers value connections which have consistent speeds. Highly variable speeds can result in unexpected delays in videos while files are downloading, inability to quickly

30 Ookla Speedtest, January 2018, available at: https://www.speedtest.net/global-index accessed on 19 February 2018.

31 Available at: https://opensignal.com/reports/2016/06/australia/state-of-the-mobile-network and accessed on 20 February 2018.

access downloadable files when desired or reductions in the resolution of streaming videos when speeds fall.

The Choice *Internet Service Provider Satisfaction Survey 2017* found that 17 per cent of ADSL2+ users and 25 per cent of NBN users experienced disconnections, dropouts or variable performance of their connection.[32] In contrast, the *Mobile Provider Satisfaction Survey 2017* found that 10 per cent of SIM-only mobile customers and 13 per cent of SIM and mobile handset customers experienced problems with their internet connection, and the same proportions reported problems with very slow connection speeds. This comparison doesn't account for differences in customer expectations about the speeds they should get from fixed line and mobile connections, but suggests that fixed line reliability is worse than mobile reliability.

There is little quantitative evidence about the variability of speeds for fixed line services. The speed of fixed line services may fall during peak times when many users are trying to access the network at once.

The primary source of evidence about variation mobile speeds is the OpenSignal *State of Mobile Networks* report, which measures the proportion of the time that users have a Long-Term Evolution (LTE) connection available to them. This is a measure of how often users can access a 4G network rather than a lower speed network. The report states that depending on the mobile network the customer uses, a 4G connection is available around 75 per cent of the time. Average 4G connection speeds among users who performed the speed test is around 18-24 Mbps depending on provider. Average 3G speeds are around 4-5 Mbps depending on the provider, which may be insufficient speeds for many applications such as video-streaming.

A secondary source of evidence about variation in mobile speeds is the P3 connect Mobile Benchmark study.[33] This study examines the performance and quality of mobile networks in Australia, with a particular focus on comparing this performance across locations and providers. The study's methodology involves walking and driving around large Australian cities, regional towns and regional roads and measuring download speeds, upload speeds and other performance/quality indicators.

The P3 connect Mobile Benchmark results exhibit considerable variation in download speeds across locations. The average speed in large cities of 65 Mbps while driving is around 35 per cent higher than the average speed while driving around regional towns (chart 3.5). The speeds experienced while driving are not ideal measures for assessing the speeds likely to be experienced by mobile users at home, but this illustrates the significant difference in speeds between towns and cities.

The average speed while walking in large cities was 74 Mbps and speeds were between 14-141 Mbps 80 per cent of the time. This illustrates the wide variation in speeds

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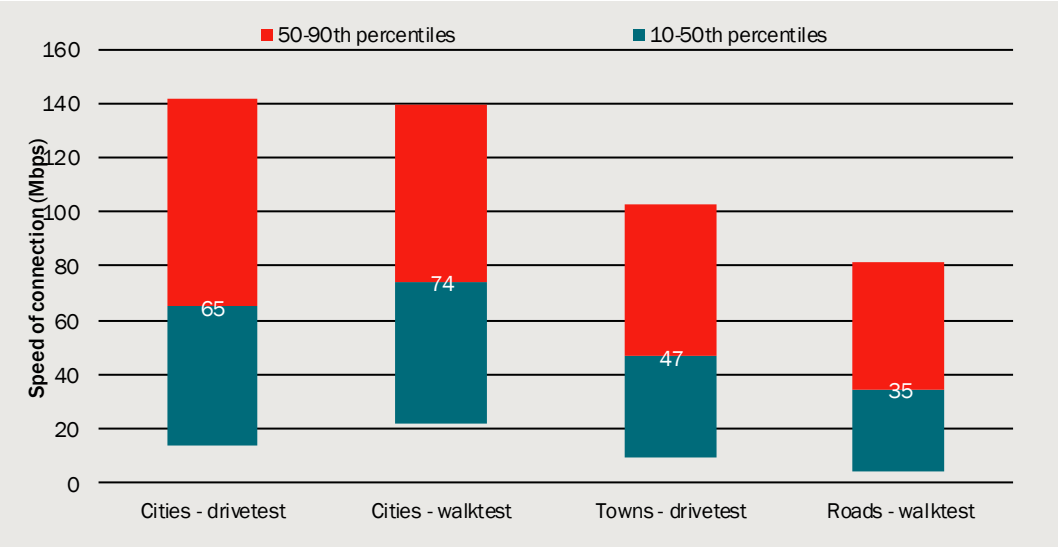
32 *Internet Service Provider Satisfaction Survey 2017*, July 2017, available at: https://www.choice.com.au/electronics-and-technology/internet/connecting-to-the-internet/articles/internet-service-provider-satisfaction-survey-2017

33 *The 2017 P3 connect Mobile Benchmark in Australia*, December 2017, available at: http://www.p3-group.com/en/wp-content/uploads/2017/12/Report_P3-connect-Mobile-Benchmark-Australia-2017.pdf

experienced on mobile networks. However, testing was conducted between 8am and 10pm, meaning that average speeds may not reflect those experienced by households using their mobile network during peak hours. Additionally, because testers were walking during the test, which means they may walk between areas of lower or higher connection strength, the amount of speed variation not be reflective of speed variation experienced during stationary use at home. Despite these qualifications, the results provide an illustration of the variability in speeds experienced by mobile network users.

3.5 P3 connect Mobile Benchmark variability in speeds by location (7 second download test)



Note: The 10th-50th percentiles and 50th-90th percentiles have been calculated using the tables on pages 6-7 of the P3 connect Mobile Benchmark in 2017. These tables report the speed (in Mbps) threshold that speeds exceed 90 per cent of the time, and that speeds exceed 10 per cent of time. These are interpreted as 10th and 90th percentiles of the distribution of speeds during testing.

Data source: The 2017 P3 connect Mobile Benchmark in Australia 2017, CIE.

Latency

Latency refers to the time taken for a signal to be sent from your computer or device to another and then a response to be received. This can be interpreted as the delay in an internet connection.

Latency can be important for certain applications such as video-conferencing, gaming and live-streaming.[34]. For example, video-calls using a connection with high latency will have a noticeable delay between when one person says something and the other person hears it, much like the delay experienced with long-distance phone calls.

Information on the actual latency experienced by Australian fixed line and/or mobile users is sparse. The OpenSignal *State of Mobile Networks* report presents metrics for latency of 3G and 4G mobile networks. Depending on provider, 3G networks had average latency of 72-95ms and 4G networks had average latency of 51-57ms. Lower scores for

34 Latency refers to the time taken for data to travel between its source and destination.

latency show that the network is more responsive, and that users will experience shorter delays as data makes a round trip through the network.

The OpenSignal data does not provide a comparison between these latency estimates and latency of fixed line connections. However, latency is highly dependent on the hardware used by the customer. For example, Wi-Fi connections experience higher latency than ethernet connections.[35] Thus, while latency may be an important factor for households considering fixed line and mobile connections, because of the individual-specific factors (such as hardware) that affect latency, there is insufficient evidence to determine whether fixed line or mobile connections offer lower latency.

Other factors that will affect preferences for mobile or fixed line

A number of other reasons may exist for customers preferring mobile or fixed line services:

- **Many devices or a single device**: there are few mobile services available that cope with multiple devices. That is, most mobile services have one SIM card associated with that service, which is inserted in one device (such as a mobile handset or tablet). While technology (such as Wi-Fi routers with a SIM card slot) is available, these may be unfamiliar to customers, thus presenting a barrier to switching from fixed line to mobile.
- **Regular changes of address or no fixed address**: these customers may prefer mobile services over fixed line services in order to avoid the longer contract durations and initial/setup costs of fixed line subscriptions, which may be prohibitively expensive for those who regularly change address.
- **Location of premises**: some premises do not have a fixed line connection available or would experience poor fixed line connection performance due to their distance from network infrastructure (such as exchanges or nodes). This may relate to more than just speed.

35 See https://www.NBNco.com.au/blog/connected-homes/wifi-vs-ethernet-cables-pros-and-cons.html

4 Technology changes in fixed line and mobile services

Key points:

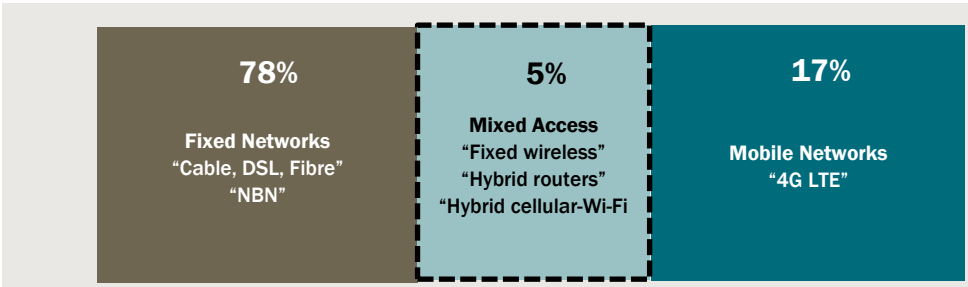
- **Technological advancement is enabling a growing number of households to access the internet without using a fixed-line connection.**
- **5G technology will continue to erode the barrier between fixed line and mobile internet, with vastly superior speeds and reliability ushering in a new era of digital connectivity through the 'Internet of Things'.**
- **5G technology is showing early signs of being able to compete with fibre based fixed line networks. The NBN may have a role to play in facilitating the deployment of 5G infrastructure.**
- **Consumers are increasingly turning to mobile devices as their first point of online access. Many digital business strategies are geared towards 'mobile-first' and consumers have grown accustomed to focusing on services rather than infrastructure, forcing telecommunications providers to adapt to remain relevant.**
- **Like mobile technology, fixed line technology will continue to evolve and improve. This will require technology-neutral policy settings.**

Evolution in broadband access

The growing capabilities of telecommunications technology is empowering customers with new ways to access the internet. Since the introduction of 4G LTE mobile networks, a subset of households has found it favourable to bypass conventional fixed line broadband and have their needs met by a mobile-only connection. In 2018, fixed line and mobile internet connections, although enabling very similar use cases, are still different with respect to a few key characteristics, bringing about a unique set of advantages and limitations for users. As has been previously explored, these differences mainly lie in the fact that fixed line connections typically provide large download allowances at a relatively lower cost per GB, whilst mobile connections provide a more modest download allowance at a higher cost per GB in exchange for faster speed and mobility.

In some applications, advancements in telecommunications technology has also begun to blur the lines between fixed and mobile broadband, with increasing convergence leading to mixed broadband access types such as fixed wireless and hybrid SIM-routers. The rapid pace of growth in wireless technology has the potential to disrupt the future of household broadband and this is already being seen, with over 20 per cent of households accessing the internet through alternatives to conventional fixed line connections (chart 4.1).

4.1 Internet access by technology type in Australia



Note: The number of users with hybrid routers or hybrid cellular-Wi-Fi connections is not known based on our survey. Some proportion of users may have these or other mixed access service types, and the proportion of users with mixed-access services in total will be at least 5 per cent.

Data source: CIE & Woolcott Research Survey.

Convergence in broadband technologies

Convergence in telecommunications technologies leads to less emphasis on the customer choosing access types and instead allows the ISP to determine the optimal connection depending on the context. This is a form of supplier-led substitution between fixed and mobile internet connections. Convergence has the role of bridging the gap between the advantages and limitations of fixed line and mobile connections to provide a superior service to the customer and this is currently achieved by:

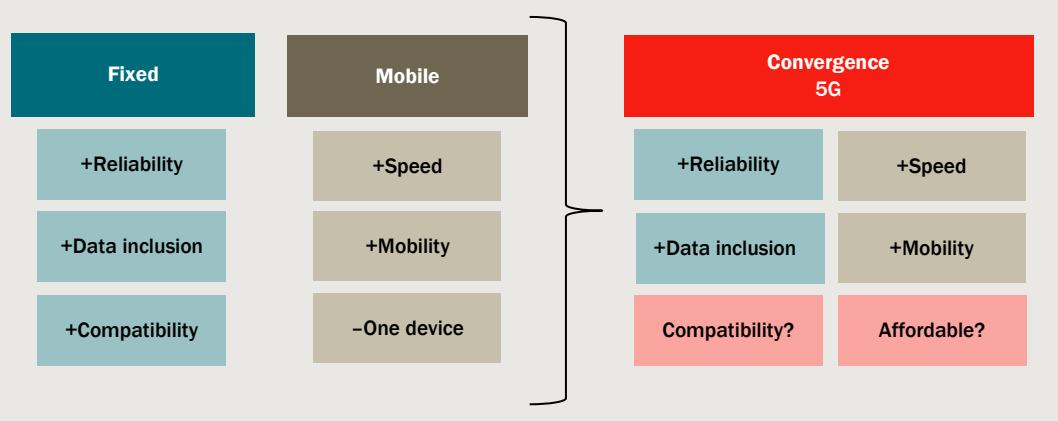
- **Enabling higher data usage on mobile** – current efforts involve the use of hybrid cellular networks which uses automatic switching between cellular connections and local Wi-Fi hotspots to reduce contention on the mobile network and enable non-metered data usage (such as Telstra Air in Australia and Google's Project Fi overseas).
- **Increasing speed and performance on fixed line** – this is possible through new hybrid routers which include an in-built sim card and antenna that enables connection to the mobile cellular network, such as the Vodafone Wi-Fi Hub. This provides customers with instant access to Vodafone's 4G mobile network while they wait for the NBN to be connected, or if there is a fault on the NBN.

New service offerings are made possible due to the rapidly accelerating pace advancement in wireless technologies. Whilst it is technically possible to 'cut the cord' entirely today and use mobile or fixed wireless connections, many internet users have so far not made the trade-offs associated with switching technologies due to either cost or limits of technological capability in servicing large volumes of customers in urban areas. This pattern is set to change however, as the capabilities of next generation cellular networks such as 5G arrive. The capabilities of 5G are described as capable of combining the best features such as ultra-fast speeds and mobility of mobile networks with the high capacity and reliability users typically experience on fixed connections[36] (chart 4.2). Whilst unknowns remain however with respect to the affordability of future 5G services and how compatible it will be with common household devices (compared to fixed/Wi-

36 GSA: 5G vision, characteristics and requirements 2016 (accessed at https://www.gsma.com/spectrum/wp-content/uploads/2016/08/GSA-5G-Spectrum-update.pdf), NGMN 5G White Paper 2015, page 9

Fi), the introduction of superfast mobile networks will certainly provide new opportunities for connectivity and enhance the user experience by unlocking new use cases.

4.2 Convergence between fixed line and mobile



Data source: CIE.

The next generation of mobile broadband – 5G

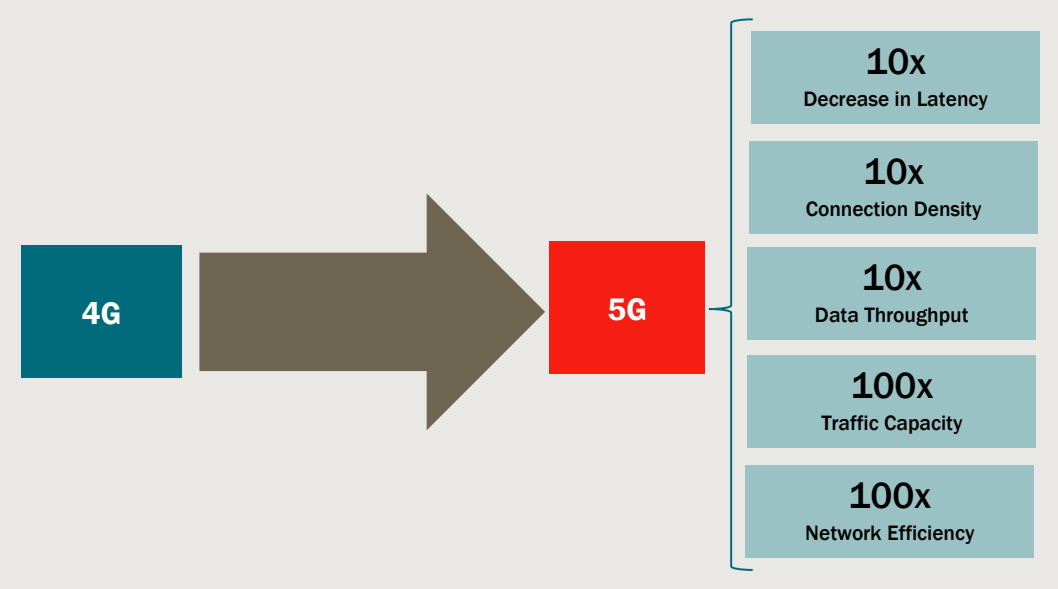
5G is the next generation of cellular networks which is expected to begin rolling out in 2019. As with previous leaps in generations, 5G will pave the way for a dramatic growth in capacity compared to 4G, allowing a much higher density of concurrent mobile users and enabling superior device-to-device and massive machine communications (chart 4.3).

5G networks are expected to incorporate extremely high frequency radio spectrum and millimetre wave spectrum, enabling superfast data transfer rates compared to 4G networks at vastly reduced latency (chart 4.4). The most notable characteristics of 5G will include[37]:

- Fast data rates of 100 Mbps for metropolitan areas
- Extremely low (<1ms) latency
- Stronger and more reliable connections when mobile

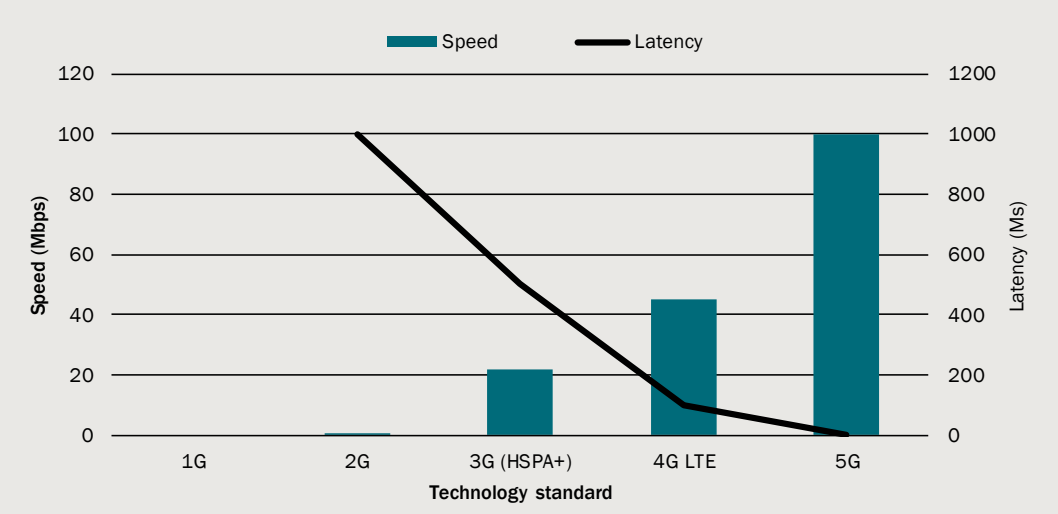
37 GSA: 5G vision, characteristics and requirements 2016 (accessed at https://www.gsma.com/spectrum/wp-content/uploads/2016/08/GSA-5G-Spectrum-update.pdf), NGMN 5G White Paper 2015, page 9

4.3 Advanced capabilities of 5G compared to 4G



Data source: 5G and beyond: Where does 5G stand today in 2017? Cradlepoint

4.4 Typical speeds and latency on mobile technologies



Data source: Qualcomm, the evolution of mobile technologies; High performance browser networking: Performance of wireless networks, chapter 7 O'Reilly.

5G infrastructure will also differ to current the current deployment of 4G LTE networks by incorporating a dense network of small cells. This is due to the fact that to achieve superfast data rates on high frequency spectrum, cellular range is reduced and must be compensated with a broader deployment of cells to achieve a comparable level of coverage. 5G infrastructure deployments will also retain the functionality of 4G networks, and will therefore be able to adapt to different usage needs dynamically. Whilst deployments of 5G networks have not yet begun, early demonstrations of the capability of 5G technology have been performed by Australian network operators.

Unlocking new use cases with 5G

The extreme growth in capacity of 5G is expected to pave the way for a new paradigm in internet usage. The combination of high speed (bandwidth) and low latency is expected to enable a variety of use cases[38]:

1 **Fast broadband access in dense areas**
   - providing access to thousands of people and devices per square kilometre
   - data rates in the hundreds of megabits per second, enabling pervasive use of always-connected applications and high-fidelity visual content, including augmented and virtual reality

2 **High user mobility and reliability**
   - enhanced connectivity for in-vehicle internet usage, including high speed transport such as trains and aircraft
   - more precise navigation capabilities
   - seamless usage whilst traveling, with no dropout when moving between cell sites

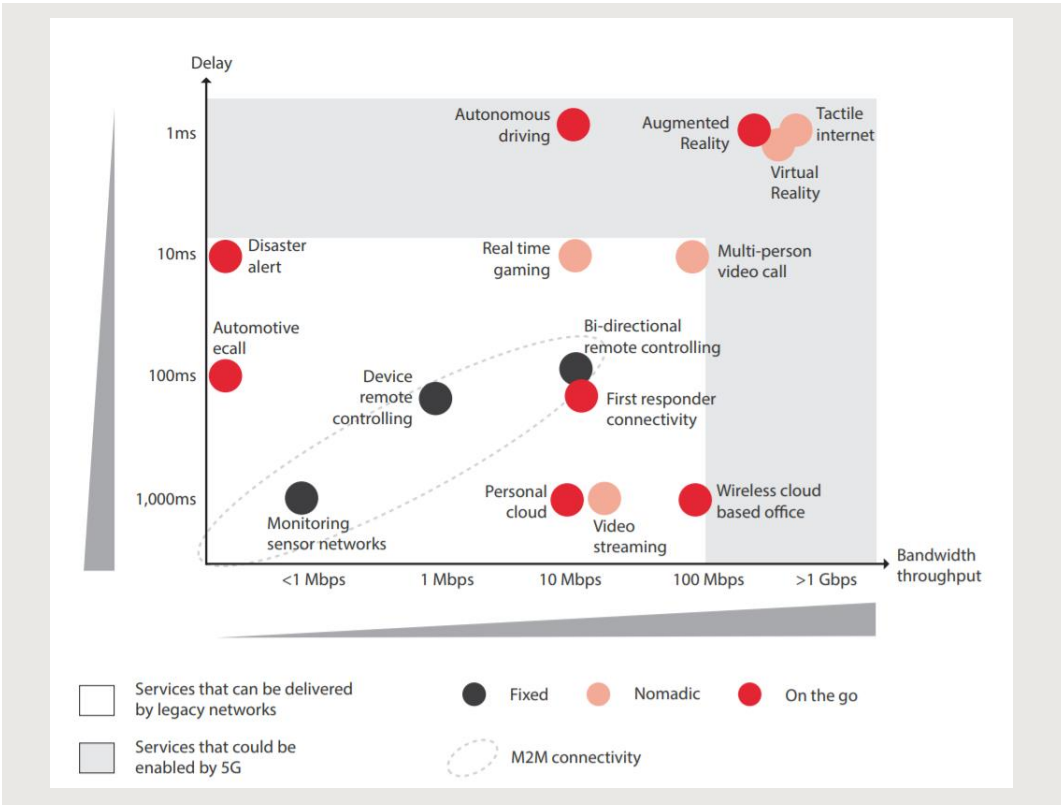
3 **Massive Internet of Things**
   - high capacity networks can facilitate many connected devices simultaneously
   - pervasive sensor networks in urban areas with applications in smart cities for dynamic traffic management, metering and surveillance

4 **Extreme real-time communications and 'tactile internet'**
   - extremely low latency will enable mobile real-time interactions including remotely controlling real and virtual objects with instant or 'tactile' feedback
   - network connected devices such as autonomous vehicles can respond to each other in real time, leading to more reliable and safer experiences.

The benefits of 5G are primarily in the form of faster speeds (higher bandwidth) and lower latency (less delay between sending and receiving signals). New applications such as autonomous driving, virtual and augmented reality as well as 'tactile' human-to-machine interactions will be made possible on 5G networks (chart 2.11).

38 NGMN White Paper, 2015

4.5 Speed and latency drive new use cases

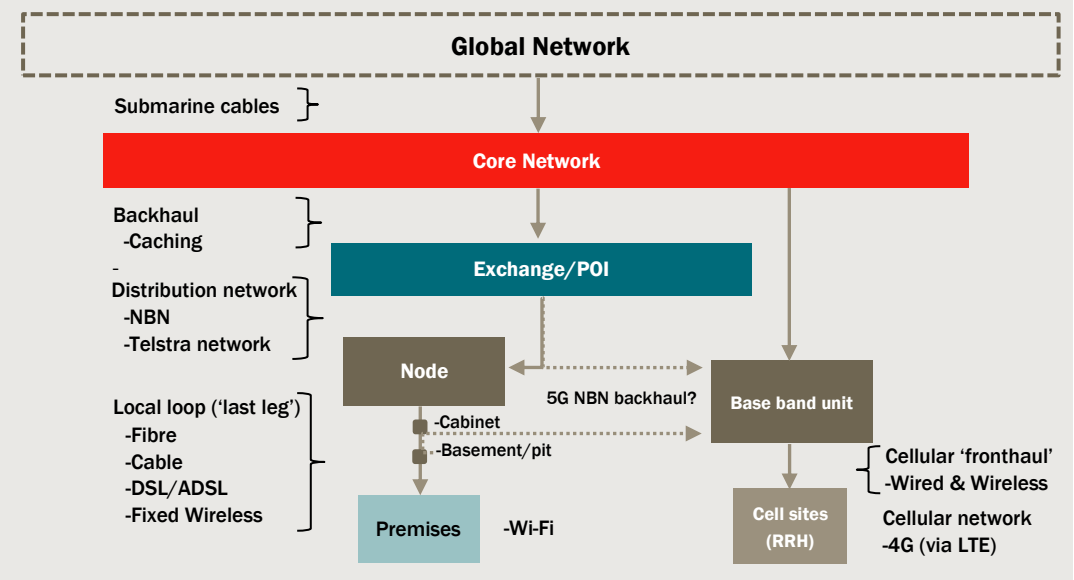


Data source: GSMA Intelligence, Understanding 5G: perspectives on future technological advancements in mobile.

Role of fibre, NBN and 5G in providing superfast broadband

Parallel to innovation in mobile networks is the rollout of the NBN. This involves replacing Telstra's legacy copper distribution network linking the point of interconnect (POI) to the node with fibre optic cabling (FTTN). A subset of households will receive fibre further than the node to points such as the cabinet, basement and to the premises (FTTP) (chart 4.6).

4.6 Telecommunications network architecture



Note: RRH refers to remote radio head.

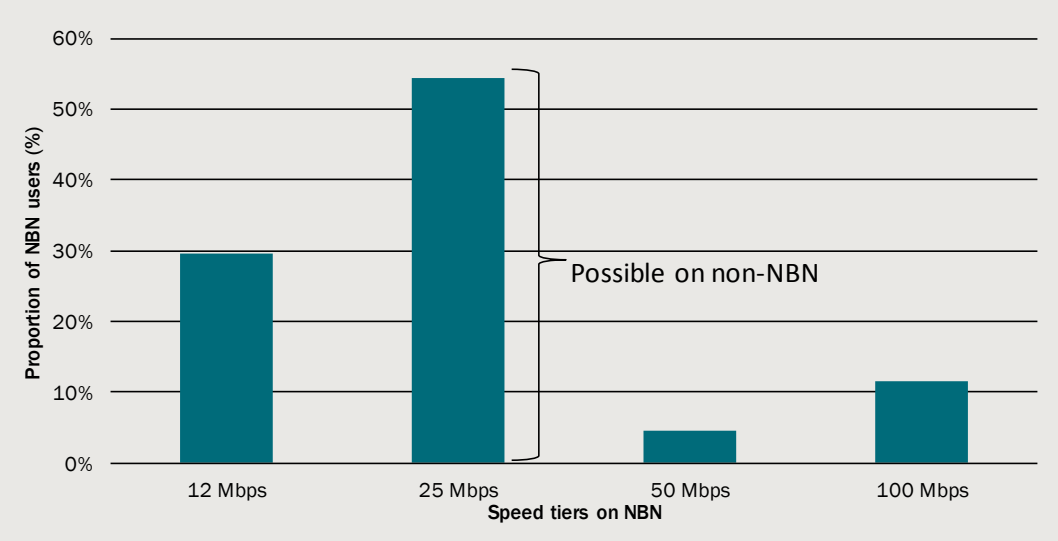
Data source: CIE.

Although there are a mix of technologies connecting the premises such as fibre, HFC and DSL, speeds on fixed line in 2018 are not necessarily limited by choice of access technology.

Retail speed offerings on fixed line are directly related to the costs retailers must pay to transfer data on the NBN (also known as connectivity virtual circuit or CVC). The prohibitive costs of providing higher speed broadband on the NBN are reflected in the low take up rate for speeds faster than 25 Mbps (which is currently available on non-NBN packages such as ADSL2+), prompting NBN to implement CVC affordability measures and increase performance on NBN.[39] As of 31 December 2017, almost 85 per cent of users on NBN have opted for speeds up to and including 25 Mbps (chart 4.7). This is expected to change as customers migrate to 50 Mbps plans, as a result of NBN pricing changes leaving 50 Mbps plans priced similarly to 25 Mbps plans.

39 ACCC Media release, NBN retailers acquired 37% more CVC, 8 February 2018

4.7 Take-up rate of speed packages on NBN – 31 December 2017



Data source: NBN Wholesale market indicators report 31 December 2017.

Fibre-based fixed line networks can offer superfast speeds, although their ability to deliver and ultimately compete with alternate technologies such as 5G depends a great deal on cost and pricing. Until these change (which for many fixed broadband technologies is technically possible), the advantages of fixed connections will lie primarily in offering large data download inclusions as opposed to speed.

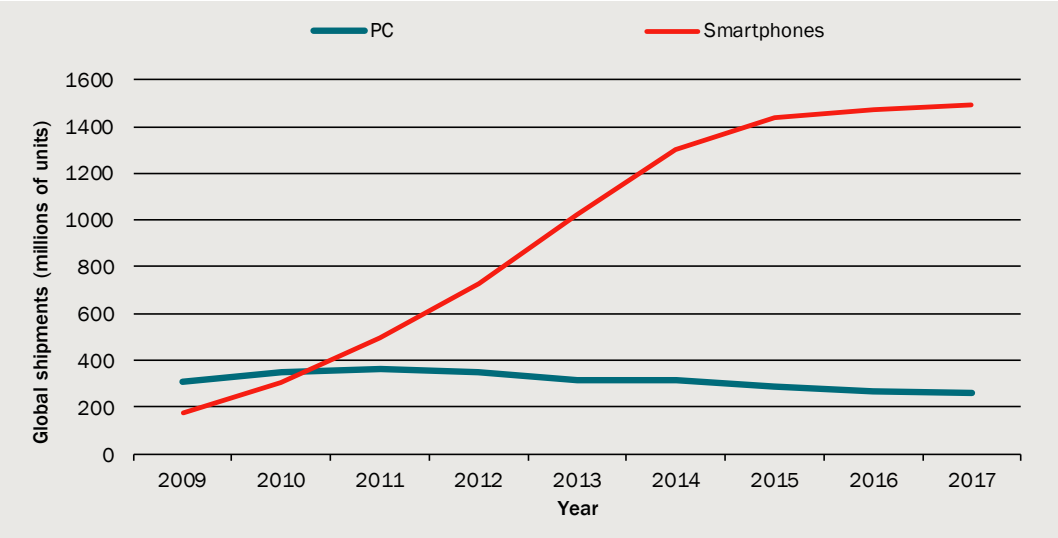
5G applications in fixed-wireless

Although 4G enabled fixed-wireless can provide fast speeds as part of the current deployment of NBN, it cannot cater for large numbers of users due to capacity limits. The use of higher frequency spectrum and new technologies such as massive multiple-input, multiple output (known as MIMO) on 5G will enable larger scale fixed-wireless deployments in urban areas with vastly reduced congestion[40]. These early deployments of 5G technology are expected to be highly effective in fixed-wireless deployments for household broadband. Point to point transmission on 5G fixed-wireless is expected to provide extremely fast speeds and ultra-low latency, competing with the current speed offerings on the NBN.

The trend towards 'mobile-first'

Underlying technological advancement in broadband technology are fundamental changes in the way consumers are interacting with digital content. Mobile is increasingly the first and preferred means of connecting to the internet. This is reflected in the fact that mobile sales (as indicated by global shipments) have consistently exceeded the sale of PCs since 2010 (chart 3.5). The high market penetration of smartphones is reflected in the fact that people are using mobile exclusively for certain activities such as social media and web browsing, and over half of the average user's online time is now spent on mobile[41]. As the role and capabilities of mobile devices grows, there is greater potential for consumer-led substitution towards mobile-only internet.

4.8 PC and Smartphone global shipments 2009-2017



Data source: Statistica.

40 Qualcomm OEM Netcom Wireless sees tipping point for urban fixed wireless substitution, Communications Day Issue 5554, 9 February 2018

41 Communications Chambers - Mobile first, fibre as required: The case for 'fibre to the 5G (FT5G)", January 2017

Customers care about services, not infrastructure

The appeal of mobile is in being able to perform any action on any device, anywhere and at any time. This ease of access has been enabled by app developers and digital businesses adopting 'mobile first' strategies as the best way to engage the customer.[42]

The ubiquity of such services is a powerful disruptor to the way in which customers perceive the role of their telecommunications provider. Increasingly, the focus of the customer is on the service being not the infrastructure delivering the service. The effects of this behaviour area already visible with the rise of OTT services such as Facebook and WhatsApp and Apple iMessage. Consumers are bypassing traditional mobile voice and SMS services in favour of OTT services, in much the same way that mobile cannibalised fixed line voice services only decades earlier.[43]

Changing consumer behaviour places greater pressure on telecommunications providers to remain relevant to the customer. In an era where the last leg of internet access to the device is wireless, telecommunications providers will have a larger role to play in utilising the mix of technologies at their disposal to provide seamless connectivity solutions for their customers.

42 Mckinsey, The economic essentials of digital strategy, July 2015

43 Mckinsey, Overwhelming OTT: Telecommunications' growth strategy in a digital world, January 2017

5 Current and future levels of substitution

KEY POINTS

- **Currently, 17 per cent of households that use the internet at home have a mobile service and no fixed line service (i.e. are 'mobile-only').**
- **There is considerable scope for an increase in the share of households that are mobile-only as mobile data allowances increase and prices drop.**
- **Households with higher data usage are more likely to choose fixed line over mobile. We modelled the household choice between fixed line and mobile-only services and find that:**
  - **If the price of mobile plans remained the same compared to fixed line plans, increasing data usage over time will result in the share of households that are mobile-only falling to 13–14 per cent in 2020.**
  - **If the price of data under mobile plans falls to near zero, the share of households that are mobile-only could rise to almost 40 per cent in 2020.**
  - **Other factors such as the speed and reliability of mobile networks are expected to improve over time, which would likely lead to a higher mobile share than under the scenarios above. However this may be countered to an extent by improvements in the speed and reliability experienced by fixed broadband consumers as the NBN is completed and pricing issues addressed.**

There are two main types of substitution between fixed line and mobile services:

- Consumers may be able to use a fixed line or a mobile service to deliver their needs
- Service providers may be able to substitute between networks to provide services

This report focusses on substitution by consumers between fixed and mobile services.

The substitutability of fixed line for mobile services is a matter of degree. A greater share of households choosing to access the internet at home only with mobile services (the 'mobile-only' share) would imply that fixed line and mobile are closer substitutes. There will likely always be some customers for which fixed line and mobile services are not substitutes, either because of their particular characteristics or their location and service availability.

In this chapter we:

- present estimates of the current share of households which are mobile-only;
- assess the scope for potential future substitution based on survey responses about what it would take for users to substitute between these services; and
- model the extent to which households substitute between fixed line and mobile services based on measurable factors such as usage preferences. This model enables

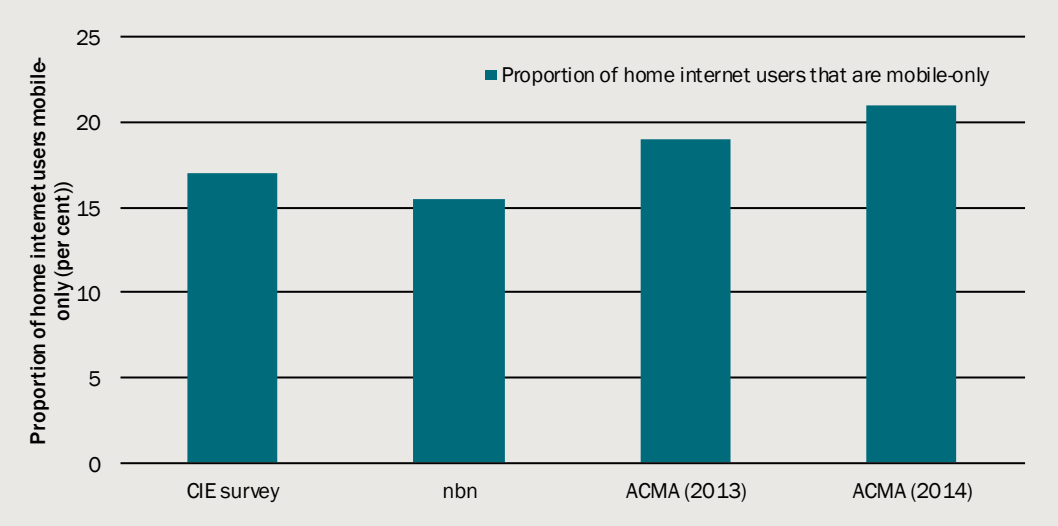
projection of the mobile-only share under different scenarios of data demand and costs of mobile relative to fixed line.

Current levels of substitution

Currently, 17 per cent of households that use the internet at home have a mobile service and no fixed line service (i.e. are 'mobile-only'). This estimate is based on the survey conducted by The CIE and Woolcott Research and Engagement. This estimate is similar to estimates by NBN (15 per cent)[44] and ACMA (19 and 21 per cent) shown in chart 5.1.[45]

The ACMA surveys in 2013 and 2014 suggest that the proportion of households that were mobile-only increased 2 per cent in one year. However, the ACMA estimates are above the NBN (2017) and CIE estimates, which are more recent. Thus, there is not conclusive evidence that the mobile-only share is increasing.

5.1 Estimates of the proportion of households that are mobile-only



Data source: NBN *Corporate Plan 2017* p.39, ACMA research ACMA snapshot, available at: https://www.acma.gov.au/theACMA/engage-blogs/engage-blogs/Research-snapshots/Australians-get-mobile, CIE and Woolcott Research and Engagement survey.

A greater share of households with lower data use are mobile-only (chart 5.2). For example, the mobile-only share of households with usage 20GB or less is 42 per cent. In contrast, only 7 per cent of households with usage between 20–1000GB and 0 per cent of households with usage over 1000GB are mobile-only.

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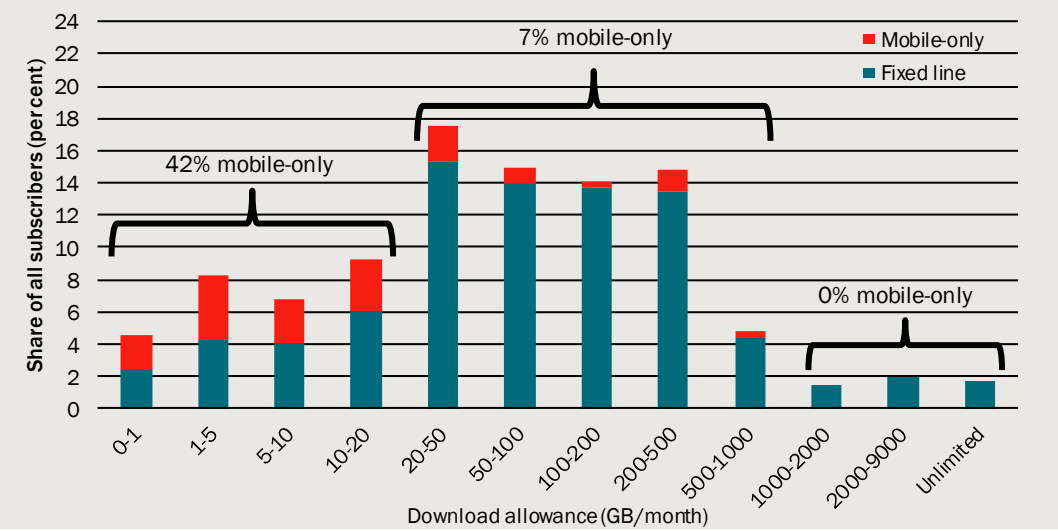
44 NBN, *Corporate Plan 2017*, p.39

45 The OECD notes that in some countries (Australia, Finland, Austria and Italy) mobile-only customers represent more than 25 per cent of all households. This conflicts with the other evidence cited above for Australia. It is not clear what data was used by the OECD to estimate this share, and because a specific point estimate is unavailable we have not included it in the comparison (chart 5.1). See: OECD 2016, "Digital Convergence and Beyond: Innovation, Investment and Competition in Communication Policy and Regulation for the 21st Century", Background report for Ministerial Panel 2.1.

The primary reason that households with higher usage are more likely to choose fixed-line is because the price of data is lower for fixed line, and mobile plans with high data allowances (such as those with more than 100GB per month) may be significantly more expensive than fixed line plans with the same data allowance.

5.2 Substitution and data allowance



Data source: CIE and Woolcott Research and Engagement survey.

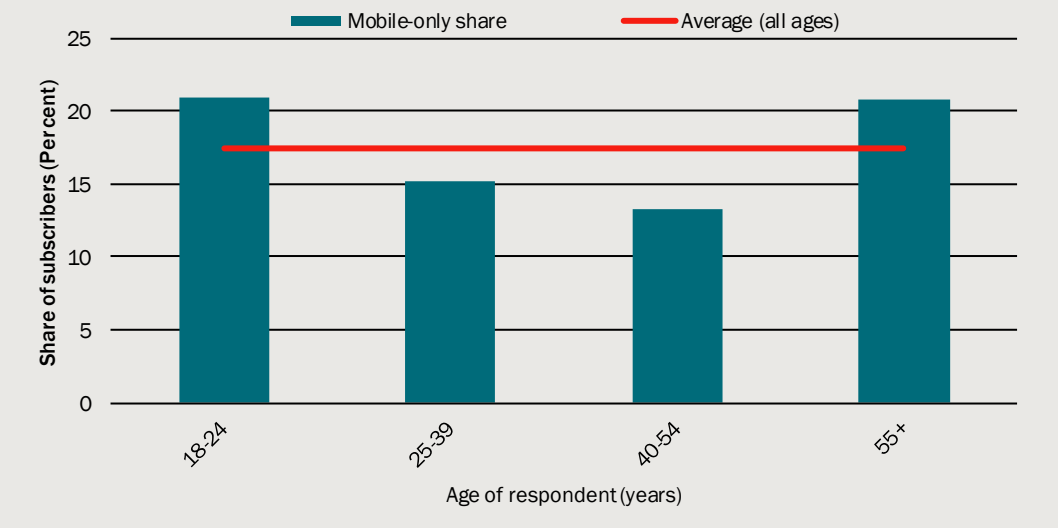
Current substitution by age group

Substitution also varies by age group. The youngest (18-24 years old) and oldest (over 55 years old) cohorts of the CIE survey have mobile-only shares over 20 per cent, while 25-39 year-old and 40-54 year-old cohorts had shares of 15 and 13 per cent respectively (chart 5.3).

There are a few potential explanations for differences in shares by age group:

- The youngest cohort consists mainly of people who grew up using the internet and mobile phones, and they may be more comfortable switching between devices.
- Low data users among this group may be more likely to choose mobile-only because they have lower incomes, and are therefore more price-sensitive.
- The older cohort may consistent of a higher share of people with low usage, and low usage is associated with a higher mobile-only share.
- The 25-39 and 40-54 cohorts may be more likely to have children living with them, and thus have a greater preference for fixed line services which can more easily handle multiple devices.

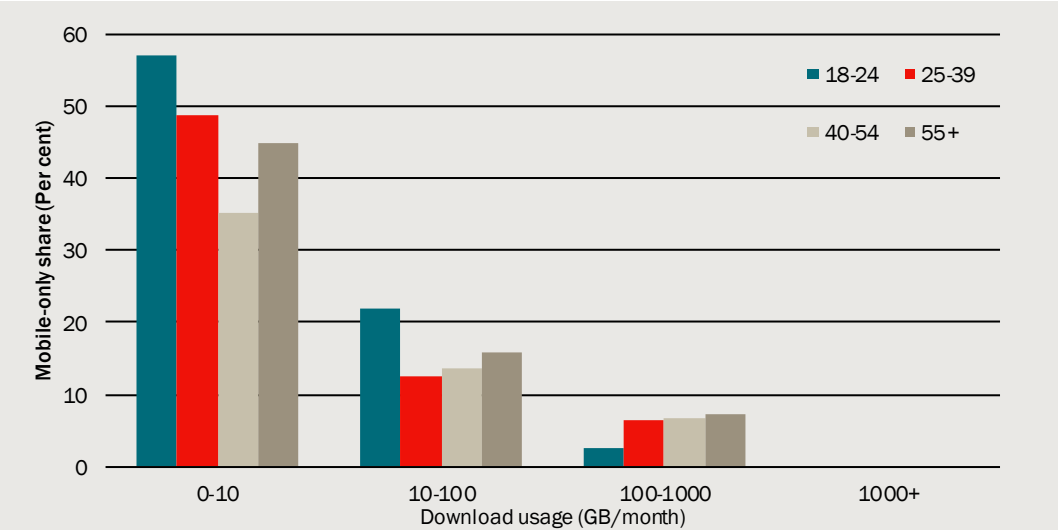
5.3 Average share of mobile-only subscribers by age



Data source: CIE and Woolcott Research and Engagement survey.

As mentioned above, a portion of the variation in the mobile-only share by age may be explained by differences in data usage. However, there are also differences in the mobile-only share of each age group within a given tier of usage (chart 5.4). For example, in the 0-10GB usage tier and 10-100GB tier, the youngest cohort still has the highest mobile-only shares, which may be due to greater price-sensitivity. The youngest cohort has the lowest mobile-only share for usage between 100-1000GB per month, which accords with the explanation that this cohort is the most price-sensitive and comfortable switching between service types. The mobile-only share among households with usage over 1000GB per month is zero per cent across all age groups.

5.4 Share of mobile-only subscribers by age and data usage



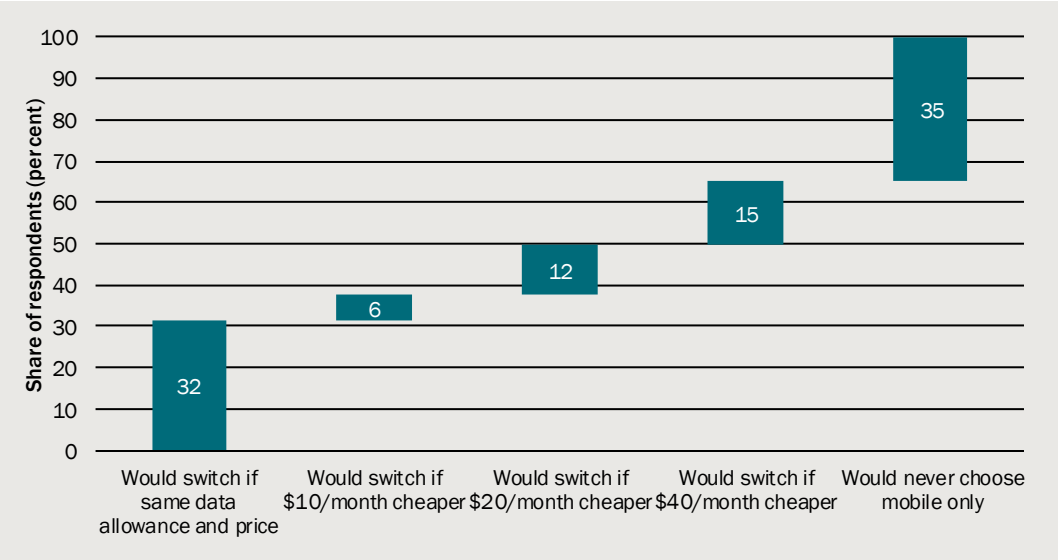
Data source: CIE and Woolcott Research and Engagement survey.

Scope for future substitution

As discussed above, there is a lack of evidence suggesting a clear trend in the share of households that are mobile-only. To assess the potential for substitution between fixed line and mobile services, we consider the opinions of households about whether they would switch between fixed line and mobile, and their reasons for why or why not.

In chapter 3 of this report we assessed that a significant proportion of households with usage below 50GB per month are mobile-only. Among households receiving fixed line services and with usage below 50GB per month, 32 per cent indicate they would switch to mobile if they were offered a plan with the same data allowance and price (chart 5.5). Additionally, a further 33 per cent indicate that they would switch if the price of mobile plans fell below fixed line plans by $10–40 for the same data allowance, which would represent a more than halving of the price of many mobile plans. The remaining 35 per cent of this group of households indicated they would never choose mobile-only even if it was as much as $40 per month cheaper and had the same data allowance as their fixed plan. These customers do not view fixed line and mobile as substitutes with their current speed, reliability and other characteristics.

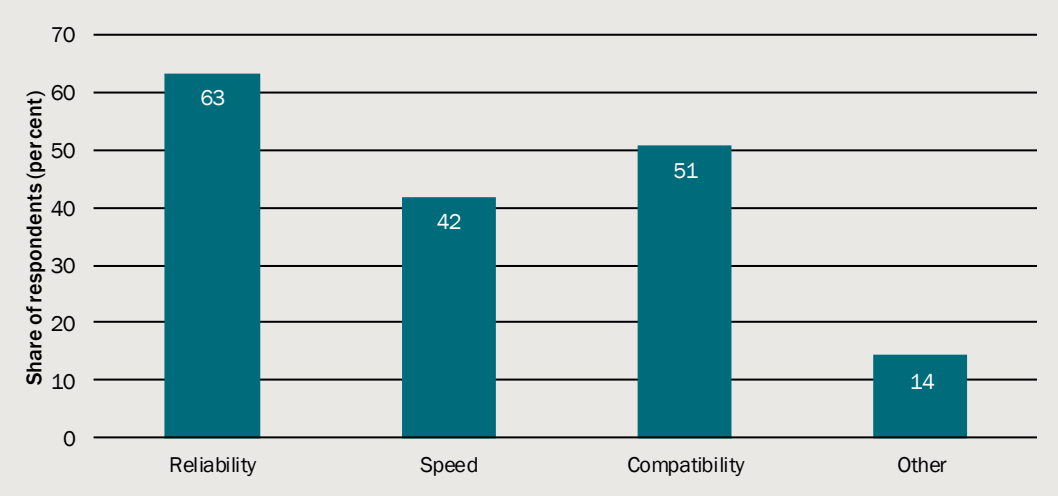
5.5 Fixed line customers with <50GB usage who might switch to mobile-only



Data source: CIE and Woolcott Research and Engagement survey.

Survey respondents that indicated they would never choose mobile-only were asked whether the reasons for this preference included reliability, speed, compatability of devices or another reason. Compatibility of devices refers to having existing devices (such as a fixed line modem/router) which would be incompatible with mobile. Chart 5.6 shows that the most common reason for being unwilling to switch to mobile-only was reliability (63 per cent of respondents), however similarly high proportions also indicated that speed (42 per cent) and reliability (51 per cent) were reasons.

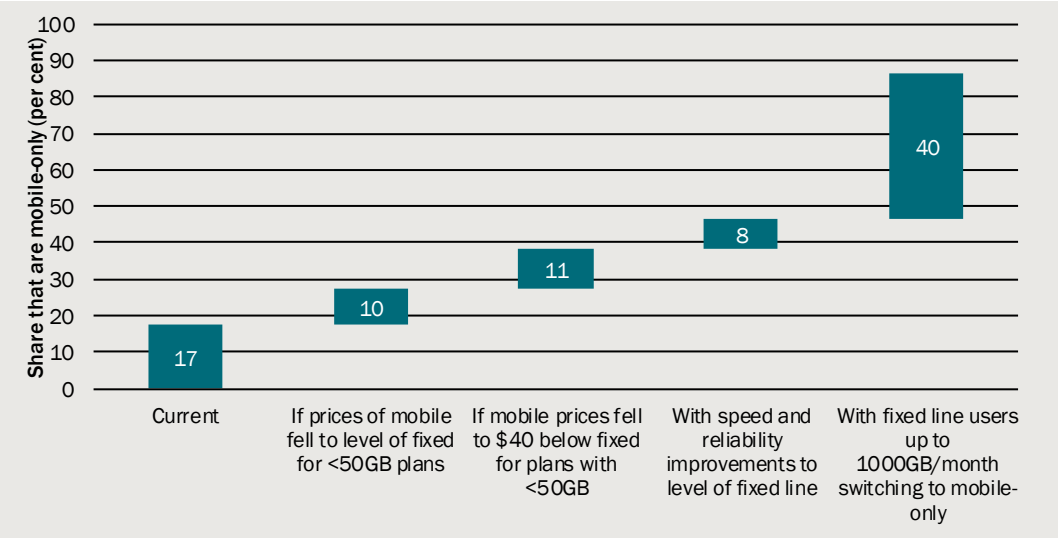
5.6 Reasons for being unwilling to switch if usage is less than 50GB per month



Data source: CIE and Woolcott Research and Engagement survey.

Chart 5.7 shows that there is considerable scope for an increase in the share of households that are mobile-only. The sum of the current mobile-only share (17 per cent) and the additional share if the price of mobile plans fell to the level of fixed plans for users with less than 50GB usage (10 per cent) implies that 27 per cent of users would choose mobile-only for only small changes in the market. Beyond this, larger changes in the price of mobile plans and speed and reliability improvements could drive a higher share of customers to be mobile-only. The chart shows that an additional 40 per cent of households indicate they would switch to mobile-only if the price of mobile plans with usage up to 1000GB fell significantly below the price of fixed plans and speeds and reliability improved. The remaining 13 per cent of users would not be willing to switch to mobile-only because their usage is above 1000GB per month or because of compatibility/other reasons.

5.7 Scope for future substitution if mobile plans improve



Data source: CIE and Woolcott Research and Engagement survey.

Estimating the future mobile-only share

In order to better understand the decision between fixed line and mobile-only, we use the survey dataset to model substitution between these two services.

We construct a model of household choices between fixed line and mobile services, which enables for prediction of the mobile-only share under different usage and cost scenarios. Note that these scenarios do not cover many other factors that will affect fixed and mobile substitution. Importantly, changes in speed and reliability cannot be modelled in this way, since we cannot incorporate speed and reliability into the model.

Methodology

We estimate a model that seeks to predict the choice of individual households between two options: fixed line or mobile-only. Consumers are assumed to purchase the option that gives them the greatest utility/benefit.[46] The model we have estimated is a logit model, which is used where the aim is to predict a choice between options.

This model accounts for the following individual and usage characteristics that affect the probability of choosing fixed line compared to mobile services:

- Data usage of an individual household (in GB/month);
- Whether the household is in a capital city or not;
- The composition of the household, including the number of adults, children under the age of 5 and children over the age of 5;
- The sex of the person responding to the survey (who is a member of the household),
- The income of the household; and
- The highest qualification level among household members (e.g. High school, Certificate level, etc).

This model allows us to estimate the share of households which are mobile-only under different scenarios for these characteristics such as usage.

Each age group is modelled separately. That is, respondents are segmented by their age group, and separate effects of these characteristics on the probability of choosing fixed line or mobile are estimated for each. This approach has been taken because different age groups are expected to have different relationships between usage and their choice of fixed or mobile. For example, younger cohorts are expected to switch between fixed and mobile more easily than older cohorts.

Other studies have modelled the choice between types of broadband services in overseas telecommunication markets. The most relevant studies are summarised in box 5.8.

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46 Cardona et al. (2007) explain how utility maximisation is the basis for these types of logit models: Cardona, M., Schwarz, A., Yurtoglu, B.B. and Zulehner, C., 2007, 'Demand estimation and market definition for broadband internet services', Working paper, available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1081261

5.8 Other studies modelling the choice between broadband services

A number of studies have estimated logit models to analyse consumer choices between broadband service options, including the following:

- Srinuan, Srinuan & Bohlin (2012) found that mobile services are a substitute to fixed line services in Sweden. This study used survey data to estimate nested choice models, whereby consumers choose between options in stages. That is, firstly, consumers choose whether to purchase internet access services, then choose whether to purchase fixed or mobile services, then choose between various fixed line technologies that are available in their geographic area. This study estimated the price of each alternative decision in each stage (e.g. the price of mobile and fixed line services), and estimated the own-price and cross-price elasticities of demand for each option.
- A previous study using similar methods is Cardona et al. (2007), which estimated nested logit models using survey data from Austria. This study likewise included price estimates for each option to estimate price elasticities. The modelling approach allowed for the authors to conclude the cable network s are likely to be in the same market as DSL connections, illustrating that substitutability of goods/services is a key component to defining separate markets.

Srinuan, Srinuan & Bohlin (2012) is particularly relevant because it presents empirical evidence from Sweden about substitution between fixed line and mobile broadband services. However, the extent of substitution between fixed line and mobile is expected to be highly dependent on the infrastructure, regulatory environment, demand prices and competition levels of each country. This suggests that their results will not necessarily hold in Australia. Additionally, the authors do not make predictions about the future path of prices or the level of substitutability between fixed and mobile broadband.

Our approach is distinct from the approach of these studies in two key ways:

- We do not estimate the price of each alternative or include this as a variable in the decision between broadband service options.
- We have data concerning usage of fixed line and mobile subscribers and use this variable as a predictor in our model. Note that using usage as a predictor variable in the model implicitly assumes that the choice between fixed line and mobile-only does not affect usage.

Maintaining current mobile technology under different demand scenarios

We use the model to predict the impacts on the mobile-only share of increasing data usage if mobile technology does not improve relative to fixed line technology. This is equivalent to assuming that the cost of data under mobile plans does not reduce relative to the cost of data under fixed plans.

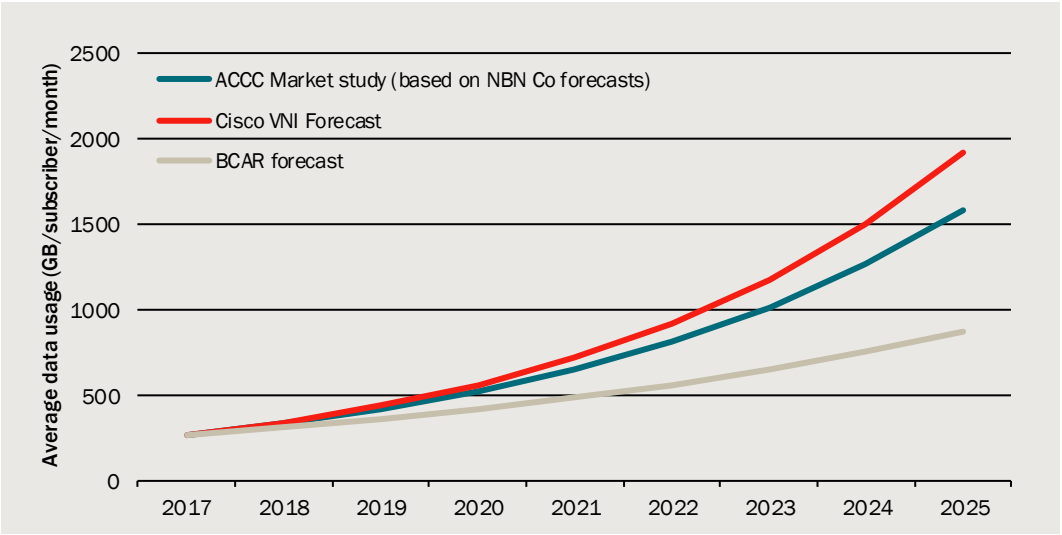
We have modelled the level of substitution under three projections of data usage/demand (chart 5.9), which are based on:

1 The ACCC Communications Sector Market Study, which uses the projections of data usage from the NBN Corporate plan 2018. NBN projects usage to increase by 20–30 per cent each year. Using the midpoint of this projection gives a Compound Annual Growth Rate (CAGR) of 25 per cent.

2 The Cisco Visual Networking Index, which forecasts a CAGR for usage (across fixed line and mobile) of 27 per cent.[47]

3 The Bureau of Communications and Arts Research (BCAR)[48] forecast that usage will increase from 95GB in 2016 to 420GB in 2026, implying a CAGR of 16 per cent.

5.9 Projections of data demand



Note: The ACCC Market study projection is based on the NBN *Corporate Plan 2018*, and assumes a Compound Annual Growth Rate (CAGR) of 25 per cent. The Cisco VNI forecast is based on a CAGR of 27 per cent. The Bureau of Communications and Arts Research project is based on a CAGR of 16 per cent. All projections use the same starting point of 266GB average usage in 2017.

Data source: ACCC Communications Market Study draft report 2017 (p.170), Cisco Visual Networking Index, CIE.

Data usage is variable across households. We have projected growth in usage that is equal in percentage terms across the distribution. This has been implemented according to the following steps, followed separately for the separate models for each age group:

1 The population of households is split into tiers of usage based on the share of survey respondents in each tier.

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47 See the 'consumer internet traffic' forecast at the bottom of table 8. We have chosen to use a constant CAGR for simplicity, and because year-to-year variation in growth rates may reflect country-specific factors. Additionally, the 'Asia Pacific' projections likely reflect factors affecting other countries in this region, moreso than factors affecting Australia, thus, we have chosen to use the global forecast: https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.html#_Toc484813985

48 Bureau of Communications and Arts Research, 2018, 'Demand for fixed-line broadband in Australia', working paper, February 2018, accessed on 28 February 2018, available at: https://www.communications.gov.au/publications/demand-fixed-line-broadband-australia

2 The average usage of each tier in 2017 is estimated based on survey data.

3 The ratio of average usage for each tier to average usage across all tiers is calculated.

4 The average usage across all tiers is projected according to the specified CAGR for each scenario.

5 Holding the ratio of average usage for each tier to average usage across all tiers constant, the usage for each tier in forecast years is estimated.

The final step makes clear that we assume the ratio of average usage in each tier remains in constant proportion to the average usage across all tiers as average usage increases. An alternative assumption is that the entire distribution of usage shifts by an amount (in GB) equal to the change in average usage. This is clearly less plausible, since an annual increase in usage of 50GB may plausible for a household using 200GB or 1000GB, but clearly not plausible for a household using 1GB in the previous year.

Table 5.10 presents the usage projections for age group as an example (the 18-24 year-old cohort). It shows that the usage of each tier increases by around 95 per cent between 2017 and 2020, which is equal to the average increase in usage projected by the ACCC Market study (CAGR of 25 per cent). This means that the usage of each tier increases by a different level in absolute terms, with usage in the bottom tier (0-1GB) increasing by 0.5GB while usage in the top tier (2000-9000GB) increases by around 5000GB.

Note that there is no usage growth for the 'unlimited usage' tier. This small (2.4 per cent of 18-24 year-old users) group consists of entirely fixed line customers, and under all scenarios we project that these household continue to receive fixed line rather than mobile services. 'Unlimited' usage is not possible, and survey respondents may have erroneously entered that they had unlimited usage because their actual usage exceeded the maximum allowed in the survey (9999GB), they could not determine their actual usage[49], or because they misunderstood the question and have an unlimited download allowance.

5.10 Usage tiers and projections of average usage to 2020 – 18-24 cohort

Usage tiers	Proportion of users	Average usage of tier in 2017	Average usage of tier in 2020
	Per cent	GB	GB
0-1	0.4	0.5	1.0
1-5	0.8	3.6	7.0
5-10	0.9	8.8	17.3
10-20	1.6	16.2	31.7
20-50	1.9	39.2	76.5
50-100	2.4	86.9	169.7
100-200	1.5	163.8	319.8
200-500	2	367.0	716.8

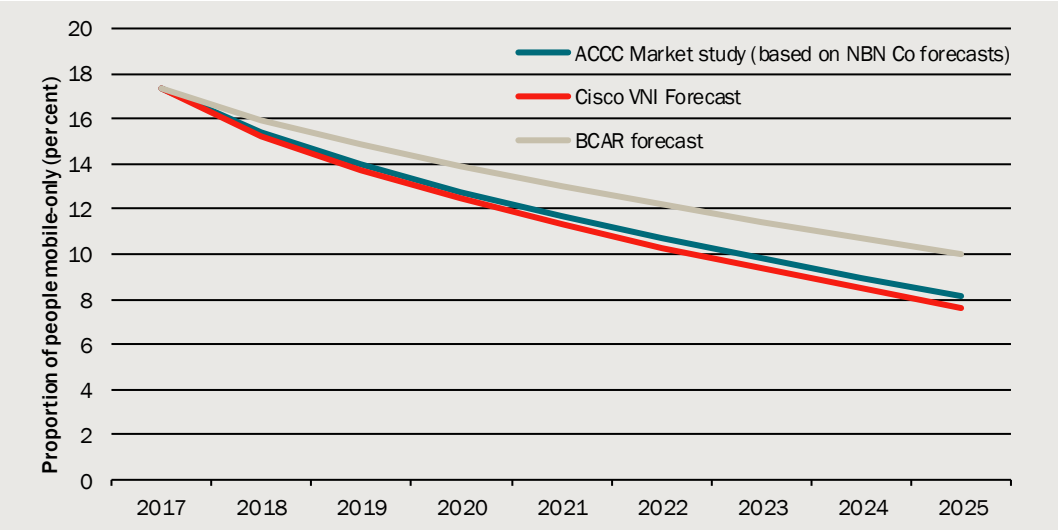
49 For example, TPG customers with unlimited download allowances cannot view their actual usage for their account. Survey respondents with such plans may have responded that they have unlimited usage because they have an unlimited download allowance.

Usage tiers	Proportion of users	Average usage of tier in 2017	Average usage of tier in 2020
	Per cent	GB	GB
500-1000	0.4	768.4	1 500.8
1000-2000	0.1	1 770.0	3 457.0
2000-9000	0.1	5 271.8	10 296.5
Unlimited	0.3		
Average across all excluding unlimited		**191.0**	**373.1**

Note: The average usage projections shown in the table assume a 25 per cent CAGR based on the ACCC Market study projections.
Source: CIE.

As usage increases and mobile technology does not improve relative to fixed line technology, we project that the mobile-only share falls to 13 per cent by 2020 and around 8 per cent by 2025 under the ACCC and Cisco usage projections (table 5.11). Under the BCAR scenario, the mobile-only share falls to 14 per cent in 2020 and 10 per cent in 2025. The fall in the mobile-only share under these scenarios is initially larger, but the rate of decrease slows down despite a constant CAGR under both scenarios. This occurs because we model different age profiles and usage segments separately, with some segments reaching saturation (zero per cent mobile-only) quickly. A declining proportional response in the dependent variable to changes in the independent variables is also a feature of logistic models.

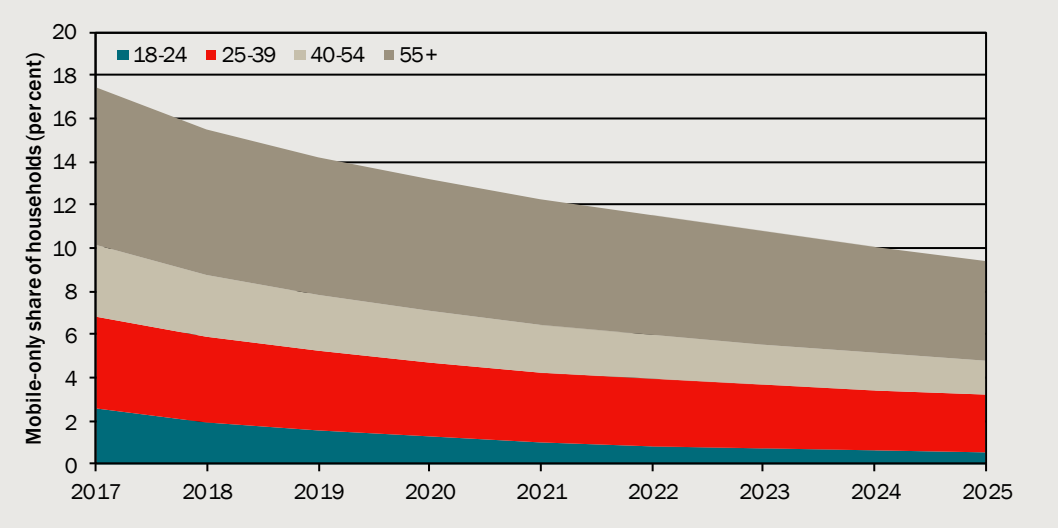
5.11 Predicted substitution assuming current mobile technology level is maintained



Data source: CIE.

The saturation of some age group/usage tier segments can be seen particularly in the 18-24 year-old cohort (table 5.12). The 18-24 cohort is the most responsive to changes in usage (in terms of their choice of fixed line or mobile), and usage tiers in this group 'saturate', entirely choosing fixed line services over mobile as their usage increases. In contrast, the other age groups experience more gradual and smooth changes in the mobile-only share as usage increases.

5.12 Mobile-only share by age group under ACCC market study usage scenario



Data source: CIE.

Falling price of mobile data scenario

One of the key changes for fixed line and mobile markets is the roll-out of 5G mobile technology. This technology will dramatically improve speeds, latency, and data capacity of mobile networks. Given that the price of data for fixed line services is already near zero, the price of data for mobile relative to fixed is likely to fall significantly.

We have modelled the impact of this fall in the price of data by adjusting the magnitude of the assumed relationship between usage and the probability of choosing fixed line rather than mobile (see Appendix B). At an extreme, if the price of mobile data fell to almost zero, data usage would no longer be expected to affect the choice between fixed and mobile.

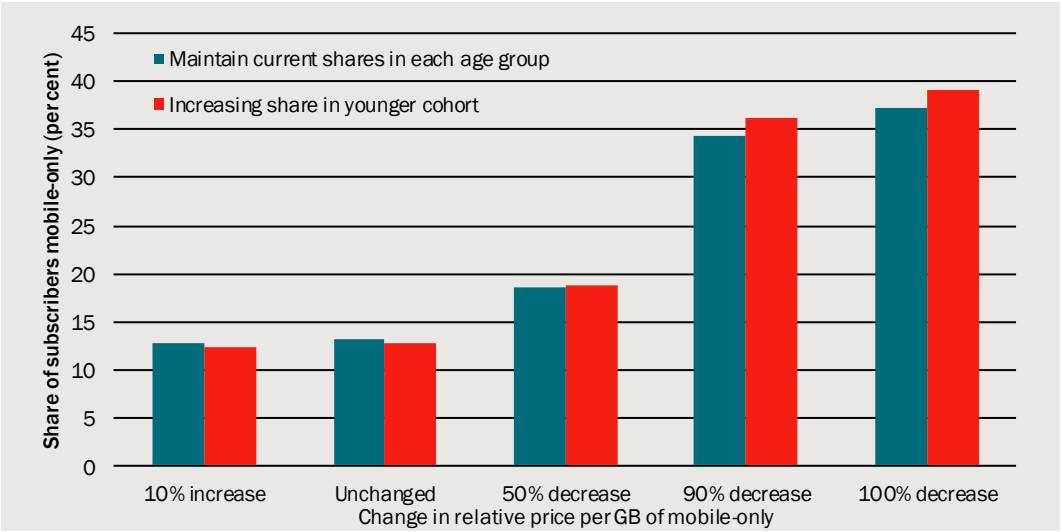
As with modelling the usage scenarios, we have modelled each tier of the usage distribution separately to account for 'saturation' of the mobile-only share among low-usage households.

An additional dimension of the modelling of this scenario is that we project an increase in the share of households which choose between mobile-only and fixed more easily. That is, we assume that 300 000 more households make choices between fixed and mobile-only according to the 18-24 cohort model, which is more responsive to changes in usage. This is equivalent to a 43 per cent increase in the 18-24 cohort by 2020. Correspondingly, 300 000 fewer people[50] make decisions according to the over 55 years-old cohort model. This feature has been incorporated to reflect a decrease in customer inertia over time, whereby each year more people become familiar with technology and able to switch between fixed and mobile more easily.

50 300 000 people is equivalent to one-seventh of the size of the 18-24 cohort in 2017. Therefore, it is roughly the amount of 17-year-old people who would enter this adult cohort.

If the price of mobile-only data were unchanged at 2020, the increase in data usage would result in a fall in the mobile-only share to around 13 per cent (chart 5.13). Maintaining the current shares of households in each age tier, if the price of mobile were to fall by 50 per cent, the mobile-only share would increase to around 18 per cent. If the price of mobile-only were to fall to almost zero, the share would increase to 37 per cent. If the share of households with choices that are modelled according to the 18-24 cohort model increases to 43 per cent by 2020, the mobile-only share would reach 39 per cent.

5.13 Estimated mobile-only share in 2020 under mobile price scenarios



Note: These results assume that data usage grows at 25 per cent CAGR (the ACCC Market study scenario).

Data source: CIE.

6 Policy settings and how they should adapt to change

Key points:

- **Convergence between mobile and fixed line technologies will require technology-neutral policy settings.**
- **Policymakers should not respond by protecting the NBN from mobile competition, even where it becomes a partial commercial threat to the NBN. Instead, the NBN remit should evolve to enhance the performance of both fixed and mobile technologies.**

General policy principles

As mobile and fixed line services converge, from the perspective of being able to provide more similar services to the home, then there are a number of relevant general policy principles:

1 **Policy settings should aim to be technology-neutral.**
   - As mobile and fixed line services converge, the costs of different policy settings for each will become larger. This will be particularly important to manage given the government ownership of NBN which has supported, and will likely continue to support, NBN at a rate of return below what would be acceptable to a private operator.

2 **The outcome sought from government policies should be to maximise the welfare of the Australian people, not the financial outcome for government.**
   - Policymakers should embrace the opportunity for the NBN to be an enabler of all broadband services.
   - Government revenue from NBN and spectrum sales should not be the drivers of policy decisions.[51]
   - Maximising the welfare of the Australian people will require policies that do not add to costs, support competition and allow for rapid deployment of whichever new technologies are considered to best meet the needs of consumers.

3 **Government policy should promote economically efficient use of, and investment in, broadband infrastructure.**
   - Pricing of the NBN involves a trade-off between additional usage of the network and revenue recovery. The optimal pricing strategy for NBN should maximise

51 Hazlett, T. W., Muñoz, R. E., and Avanzini, D. B., 2012, "What really matters in spectrum allocation design" *Northwestern Journal of Technology and Intellectual Property*, Volume 3, Issue 3: Article 2.

consumer benefits for a given amount of revenue and sunk costs should not prevent infrastructure from being put to its highest use for the benefit of end-users.

4 **Regulation should promote competition and a level playing field.**
   - The importance of technology-neutrality has been recognised by Australian policymakers. For example, the objective of the Vertigan Panel in conducting a cost-benefit analysis of the NBN was: *To identify the market structure and regulatory arrangements that will deliver affordable and reliable communications services to all Australians, including fast broadband services, in the most economically efficient way*[52]
   - This objective is technology-neutral, in that it does not specify what technology or combination of technologies would provide services most efficiently.
   - Internationally, the OECD has highlighted the following general principles to guide regulatory reform in the light of convergence:[53]
     - Simplify rules and procedures to ease costs of transactions and reduce barriers to new entrants and new services.
     - Uphold technology neutral regulation where possible, including not tying scarce resources such as spectrum to specific networks, technologies or devices.
     - Promote investment along the whole value chain for broadband access services.
     - Promote competition and innovation without favouring particular platforms or participants, and promote a level playing field.

Spectrum allocation

- **NBN currently has large holdings of spectrum that could be used for the deployment of 5G services. Spectrum policy should be technology-neutral so that allocations are made based on the highest value use.**

Spectrum is a key input to the supply of mobile broadband services. It is segmented into bands and allocated by the Australian Communications and Media Authority (ACMA) through market-based or administrative mechanisms.

The spectrum bands used for mobile communication have generally been allocated through market-based mechanisms such as auctions. Spectrum is allocated separately by geographic area and separate telecommunications providers may use the same bands in different areas.

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52 Vertigan Panel, 2014, 'Independent cost-benefit analysis of broadband and review of regulation: Volume I', p. 45, available at: https://www.communications.gov.au/sites/g/files/net301/f/NBN-Market-and-Regulatory-Report.pdf

53 OECD, 2016, *Broadband policies for Latin America and the Caribbean: a digital economy toolkit*, p.213, available at: http://www.oecd-ilibrary.org/science-and-technology/broadband-policies-for-latin-america-and-the-caribbean_9789264251823-en

The principles of spectrum pricing are discussed in the *Spectrum Pricing Consultation Paper* published by the Department of Communications and the Arts,[54] which states that the following main principles apply to government allocation of spectrum:

- **Efficiency**: the allocation of spectrum should maximise the benefits of this resource to society. The CIE (2015) found that the economic value of Australia's spectrum to the national economy is estimated to be $177 billion over 15 years.[55] The Department of Communications and the Arts states that "as a general rule, this objective is more likely to be achieved if decisions on spectrum's use is more often made by spectrum users through market mechanisms, rather than government".
- **Cost recovery**: The costs of spectrum allocation and management should be recovered from those using spectrum. These costs are low and generally don't substantially affect allocations, particularly for high value spectrum used for mobile services.
- **Consistency and simplicity**: Allocation decisions should be made consistently. Simplicity eases the burden on licences and makes optimal use of spectrum easier.
- **Transparency**: The regulator should provide clear information on pricing decisions to allow for better decision-making.

Use of the 3.4 – 3.7 GHz spectrum band for 5G mobile

The spectrum requirements for 5G mobile networks are largely determined by internationally harmonised standards. The main spectrum range that is expected to be used for 5G deployment is the 3.4 – 3.7 GHz band, with countries such as Ireland allocating this band entirely for 5G mobile use. Additionally, a number of bands above 24.25 GHz are being explored (referred to as 'mmWave bands').[56] These bands are important for providing the ultra-high broadband speeds which represent a major improvement of 5G compared to 4G. Low band spectrum (below 1 GHz) is also useful for 5G, in particular for long-range connections and IoT.

The GSM Association (which represents the interests of mobile network operators worldwide) has emphasised the importance of spectrum allocations for 5G, citing particularly the 3.3 – 3.8 GHz bands and mmWave bands as of key importance for delivering widespread coverage and supporting the range of possible uses.[57] Chart A.4 provides a global snapshot of allocated or targeted spectrum bands for 5G. There are

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54 Department of Communications and the Arts, 2017, *Spectrum pricing: consultation paper*, May, available at: https://www.communications.gov.au/file/27171/download?token=-coc0amd

55 The Centre for International Economics, 2015, *The economic value of spectrum*, prepared for the Department of Communcations.

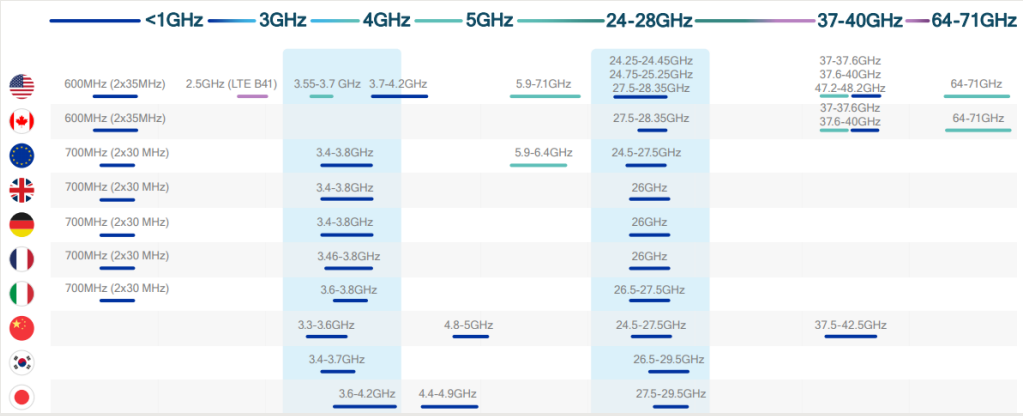
56 See the ACMA consultation regarding Spectrum for broadband in mmWave bands: https://www.acma.gov.au/theACMA/spectrum-for-broadband-in-mmwave-bands

57 GSMA, 2016, *5G spectrum: Public policy position*, November, available at: https://www.gsma.com/spectrum/wp-content/uploads/2016/06/GSMA-5G-Spectrum-PPP.pdf

prospects for shared allocations of 5G spectrum that may provide opportunities to get additional value from a given amount of spectrum.[58]

mmWave spectrum is a valuable *supplement* to 3.4 – 3.7 GHz spectrum and *not a substitute*. The major mobile network operators, in submissions to the ACMA, have highlighted the importance of different spectrum bands for 5G.[59] Low frequency (sub-1 GHz) spectrum is necessary to provide a wide coverage layer and supply access to regional areas. Medium frequency (sub-6 GHz) and high frequency (mmWave bands) provide coverage and capacity in urban and suburban areas. High frequency spectrum provides coverage within a small range (25-35 metres), because it suffers from limitation due to interference/attenuation due to manmade or terrain objects. However, it is useful for providing high speeds and capacity for high traffic areas.

6.1 Allocations or targeted spectrum bands for 5G internationally



Note: Allocated or targeted bands are shown by blue bars. Green bars indicate unlicened or shared bands, and the pink bar shows an existing band.

Data source: Qualcomm (available at: https://www.qualcomm.com/documents/5g-spectrum-sharing slide 8).

Prior to the deployment of 5G, 3.4 – 3.7 GHz spectrum could be used for supply of 4G services. Allocation of additional spectrum by mobile service providers would result in avoided costs or improved service quality prior to the deployment of 5G.

Allocation of 5G spectrum to NBN

In 2014 the ACMA, at the direction of the Minister for Communications, administratively allocated 75 MHz of the 3.4 – 3.7 GHz band nationally to NBN for fixed wireless services. This includes metropolitan areas where there is no plan for NBN to rollout fixed wireless services.

- **The administrative allocation of 3.4 – 3.7 GHz spectrum to NBN means that the spectrum may not be put to its highest value use.**

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58 See https://www.qualcomm.com/documents/5g-spectrum-sharing

59 Telstra, Optus and VHA submissions to the ACMA in response to 'Questions for comment: Spectrum for broadband in the mmWave bands', 2017, available at: https://www.acma.gov.au/theACMA/spectrum-for-broadband-in-mmwave-bands

The price paid by NBN for this spectrum was significantly below the price paid at recent auctions for similar spectrum.[60] NBN paid a price of $0.03/MHz/population, which is equivalent to around $43 million for this spectrum allocation. By comparison, in spectrum sales at auction in December 2017:

- Telstra paid a price of $0.50/MHz/population for 32.5 MHz of 3.5 GHz spectrum in Brisbane
- NBN paid prices of $1.61 and $1.29/MHz/population for additional 3.5 GHz spectrum in Hobart and Launceston respectively.

There is a prospect that NBN might we willing to have spectrum reallocated or used for other purposes.[61] This would require changes to the hundreds of active sites using this spectrum.[62]

Another prospect for NBN's spectrum is that NBN would use it to provide a mobile wholesale network. However, it appears that NBN is not able to provide a mobile service because of agreements with Telstra.[63] These agreements are not publicly available and thus it is unclear whether this is a potential use case for the spectrum. This would be a preferable outcome to not using the spectrum, but less preferable than allocating the spectrum using a market mechanism. The longer-term implications of introducing greater government involvement in providing mobile services would also be questionable, given the success of private operators in comparison to the outcomes in fixed line markets that have been much more dominated by government provision.

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60 Crozier, R., 2018, 'NBN Co's 5G spectrum price blown away at auction', *iTnews*, 6 February, accessed 27 February 2018, https://www.itnews.com.au/news/NBN-cos-5g-spectrum-price-blown-away-at-auction-484470

61 Crozier, R., 2018, 'NBN Co 'open' to alternative use of its 5G spectrum', *iTnews*, 12 February, accessed 27 February 2018, https://www.itnews.com.au/news/NBN-co-open-to-alternative-use-of-its-5g-spectrum-484978

62 Crozier, R., 2018, 'NBN Co has hundreds of active sites in '5G spectrum'', *iTnews*, 23 February, accessed 27 February 2018, https://www.itnews.com.au/news/NBN-co-has-hundreds-of-active-sites-in-5g-spectrum-485705

63 This is based on comments by Bill Morrow (CEO of NBN), stating that "we cannot provide a mobile product in part because of the agreements that we have with Telstra and some other general agreements": Joint Standing Committee on the National Broadband Network, 2017, Public hearing on 1 August 2017, p.81 of transcript available at: http://parlinfo.aph.gov.au/parlInfo/download/committees/commjnt/be5b2953-7402-482b-8728-fa9a9c888ff7/toc_pdf/Joint%20Standing%20Committee%20on%20the%20National%20Broadband%20Network_2017_08_01_5304_Official.pdf;fileType=application%2Fpdf#search=%22committees/commjnt/be5b2953-7402-482b-8728-fa9a9c888ff7/0000%22

Impacts of inefficiently allocating spectrum

The economic impacts of additional spectrum release for mobile communications include:

- reduced capital and operating costs to provide mobile broadband — there is a trade-off between spectrum and sites. If there is more spectrum available this can reduce the number of sites required;
- improved quality of services, particularly speed and reliability;
- changes in government revenues from the sale of spectrum, which has the economic impact of changing the need to impose other taxes; and
- increased competition, with more spectrum potentially allowing more providers into the market.

These impacts may be very large. For example, if the market value of the spectrum was between $0.50–1.61/MHz/population, then this would be equivalent to a total value of $0.6–2.2 billion for NBN's current spectrum holdings.[64]

Even more importantly, the retention of this spectrum by NBN may have significant consequences for the future structure of the mobile market with the roll out of 5G. Optus already holds 100 MHz of the total 300 MHz of spectrum in the 3.4 – 3.7 GHz range as a result of the acquisition of Vivid Wireless in 2012. Combined with NBN's holdings, this leaves only 125 MHz to be auctioned in 2018. Three existing mobile network operators require 5G spectrum, plus a fourth operator (TPG) entering the mobile market. The current proposed allocation of 125 MHz allows for the possibility of just one or two companies acquiring the overwhelming majority of 5G spectrum which severely limits competition.

Spectrum must be divided into lots before being allocated through a market. As part of the planning process for offering 3.6 GHz spectrum for auction later this year, the ACMA is considering options for how best to configure spectrum lots, both in terms of their geography and frequency bandwidth. Box 6.2 provides an example of how geographical lot configuration can affect outcomes for efficiency and competition.

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64 This has been calculated by multiplying $0.50/MHz/population and $1.61/MHz/population by the number of MHz in NBN's allocation (75 MHz) and further by the population in greater capital city regions (16.2 million according to ABS *Regional Population Growth, Australia, 2016*, Cat. No. 3218.0). This may somewhat understate the population in 'metropolitan' areas where fixed wireless will not be rolled out by not including non-capital cities such as Newcastle and the Gold Coast. The price paid by Telstra is used as the lower bound for valuing this spectrum as it is the highest price paid by an alternative (i.e. non-NBN) user, while the price paid by NBN is used as an upper bound, since an alternative user may have been willing to pay anything up to this amount for 3.5GHz spectrum in Hobart/Launceston.

6.2 3.6GHz geographical lot configuration options

One key characteristic of spectrum lots is their geographical dimension. Spectrum lots may be national or may be constrained to particular areas, such as the Sydney metropolitan area. The definition of boundaries for these lots is important, and can result in less efficient allocations if not managed correctly.

For example, there are two main options being considered for the geographical configuration of 3.6 GHz lots:

- Large metropolitan lots and regional lots
- Metropolitan lots, outer metropolitan lots and regional lots.

The key cost associated with geographical lot design is that having more boundaries between lot regions creates more 'dead zones', where potential interference between spectrum users in boundary regions complicates and increases costs of deployment the closer to the boundary a licensee goes. In some cases, this interference at boundaries may prevent licence holders from deploying altogether in these areas. Different geographical configurations will result in boundaries in different areas, and the risk of dead zones would be reduced by having boundaries away from densely-populated metropolitan regions.

There are also implications for competition that depend on geographical lot configuration. For example, having geographically large lot sizes can result in higher barriers to entry for new entrants or smaller mobile network operators (MNOs). In order to obtain spectrum small providers would need to bid for allocations covering large areas to which they are not likely to supply services entirely.

Competitive neutrality and subsidy arrangements

- **The NBN pricing model and Regional Broadband Scheme (RBS) levy raise potential competitive neutrality issues. If the 'commercial' part of the NBN is not earning a rate of return required by a private company, then this is a competitive neutrality issue.**
- **There is considerable duplication of subsidy mechanisms to provide telecommunications services in regional and remote Australia. In addition to the RBS, there is the Universal Service Obligation (USO) and the Mobile Black Spot Program.**
- **Policymakers should consider the competitive implications of the RBS in addition to these other measures. A more efficient outcome would be to consolidate these arrangements into a broader technology neutral framework. Additionally, universal service obligations should be contestable to promote competition.**

Competitive neutrality requires that government business activities should not enjoy net competitive advantages over their private sector competitors simply by virtue of public

sector ownership[65]. The 'commercial' part of NBN should be intending to provide a rate of return commensurate with that required by a private sector company.

The Australian Government Competitive Neutrality Review Office of the Productivity Commission found in 2011 that:

> In the absence of a quantification of the non-commercial benefits to be delivered by NBN Co, the targeted rate of return of NBN Co represents a potential ex ante breach of competitive neutrality policy.[66]

This reflected NBN not achieving a commercial rate of return through its pricing as a whole, in response to complaints from greenfield fibre providers. The financial outcomes expected for NBN have weakened materially since 2011. Based on current expectations of costs and revenues it appears that both the 'commercial' and non-commercial parts of NBN are likely to be loss-making, in the sense of not achieving a commercial rate of return.

Regional Broadband Scheme (RBS)

As a Government Business Enterprise which is currently required to ensure that its wholesale prices recover its full costs there may be an incentive for policymakers to constrain competition with the NBN. A clear example of this is the Regional Broadband Scheme (RBS).

The RBS is a $7.10 per premises-per month levy on other fixed line suppliers of high speed broadband services to assist in the funding of NBN non-commercial services in regional areas.

Depending on the costs and revenues that NBN will generate, the 'commercial' services could be a loss-making enterprise, meaning that both arms of the NBN business model would be making a return below that required by a commercial entity. Issues of competitive neutrality would be exacerbated if industry is required to contribute to non-commercial service losses through the RBS levy (chart 6.3).

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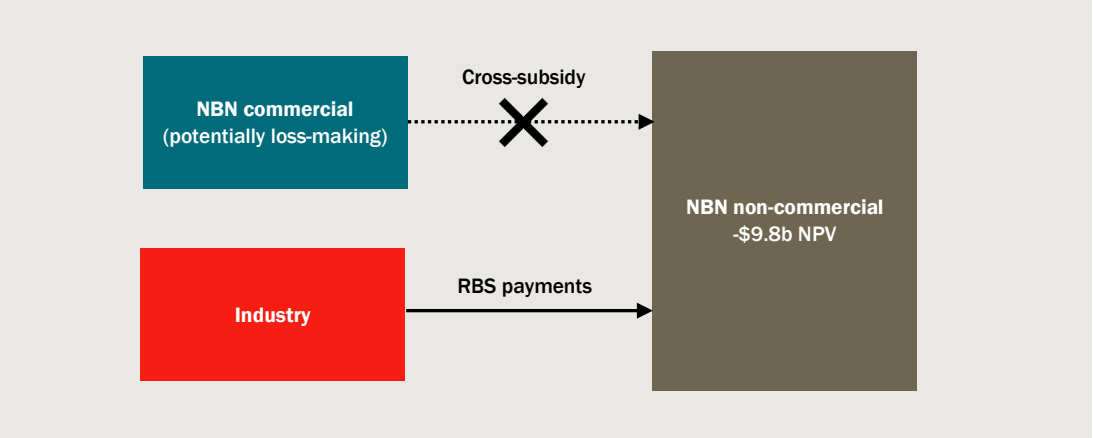
65 Commonwealth competitive neutrality policy statement, 1996

66 Australian Government Competitive Neutrality Complaints Office (Productivity Commission) 2011, NBN Co Investigation No 14, p. 33.

6.3 Competitive neutrality and non-commercial NBN services



Data source: CIE.

Universal Service Obligation (USO)

With a baseline level of broadband service to all premises in Australia enabled by the NBN, it is logical to reform the USO in combination with the RBS as part of a broader technology neutral framework.

The Government asked the Productivity Commission to undertake an inquiry into the future direction of telecommunication universal service obligations, given the evolving telecommunications market.[67]

The Productivity Commission found that: [68]

- For the vast majority (more than 99 per cent) of premises, the combination of the NBN and mobile networks is likely to meet or exceed minimum standards for universal voice and broadband service delivery.
- The USO can therefore be terminated once the NBN is fully rolled out and replaced by a set of targeted policy responses for premises in pockets of the NBN satellite footprint without adequate mobile coverage and cohorts of users with particular needs.
- Telstra's contractual obligations under the agreement with the Government lack transparency and accountability.

In response to this, the Productivity Commission recommended that:[69]

- The Government should commence negotiations with Telstra to terminate the USO shortly after the NBN is rolled out and remove Telstra's statutory obligations to provide the standard telephone service.

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67 Australian Government (2017), *Telecommunications universal service obligation Productivity Commission Inquiry Report No. 83,* Productivity Commission, p. iv, viewed 12 July 2017, http://www.pc.gov.au/inquiries/completed/telecommunications/report

68 Ibid, pp. 19 - 28

69 Ibid, pp. 19 - 28

- As a replacement for the standard telephone service, the Government should introduce a competitive tendering process for the delivery of 'baseline' voice services within the NBN satellite footprint where there is inadequate coverage and it is unviable to provide such coverage.
- The Government (in consultation with the States and Territories) should rationalise the telecommunications programs that share a universal service obligation to improve efficiency and cost effectiveness.

In line with the Productivity Commissions' report, the Government is assessing cost and delivery options to provide for a future Universal Service Guarantee (USG) and is currently consulting with industry and regional stakeholders. According to the government, a future USG will need to meet the following requirements:

- broadband services are available to 100 per cent of Australian premises, on request, at the completion of the NBN rollout in 2020;
- voice services are available to 100 per cent of Australian premises on request;
- any proposed new service delivery arrangements are cost effective compared to existing the USO contract (including any transitional costs); and
- a new consumer safeguards framework is in place following a review and associated public consultation process.

The growing relevance of broadband in communications, including voice (such as VoIP) highlights the redundancies of multiple policies duplicating funding for telecommunications in regional Australia. A clear example of such duplication is continuing to subsidise Telstra to maintain copper lines for voice services in areas covered by the NBN fixed wireless footprint which can deliver high quality voice services.

NBN products and pricing

- **The value of services on the NBN is reduced because of artificial restrictions in service quality.**
- **This is largely because NBN's pricing has not incentivised retailers to sell higher speed services at prices that consumers are willing to pay, and has provided a trade-off between maximising revenue and maximising usage of, and the value from, the NBN.**
- **Recently announced discounts for 50 Mbps services are a step in the right direction for NBN to deliver greater benefits to users, but further opportunities exist to change pricing and encourage greater use of NBN.**
- **Inefficient NBN pricing structures may lead to a greater level of usage of mobile networks in the home than is efficient.**

A critical finding of our scenario modelling on the future rate of mobile-only broadband subscribers relates to the relative prices of mobile broadband compared to fixed line services. Specifically, we find that if fixed line retail service prices were to remain unchanged, then a 90 per cent lower price per gigabyte of data made possible by future

advancements in 5G technology could lead to disruption in the home broadband market, with the mobile-only share of households doubling to around 35 per cent. On the other hand, if the price of fixed line relative to mobile services fell by 10 per cent and demand for usage continues to increase, we estimate that this would result in a fall in the mobile-only share to around 12 per cent by 2020.[70]

Elements of mobile substitution occurring today also relate to performance issues experienced over the NBN, with complaints having risen by 159 per cent by the end of 2017 compared to the previous year, as the number of NBN services increases[71]. Customer perceptions around price and service quality will also be important in driving the take-up rate of fixed or mobile-only broadband for home use.

NBN pricing structure

The affordability and service quality customers experience over NBN are largely attributed to the NBN wholesale charging model, which involves a two-part charge to access seekers:

1 Access Virtual Circuit (AVC) – which is the fixed cost to supply a customer with an NBN service at a maximum-speed threshold.

2 Connectivity Virtual Circuit (CVC) – which is the variable charge based on how much dedicated network capacity a retailer acquires to achieve the required speed levels per customer.

The purpose behind this pricing structure is to charge access seekers and customers higher prices for higher speeds over the NBN with the goal of maximising revenues to recover costs. Both charges involve reducing the level of service a customer receives in order to price differentiate and obtain revenue. Neither of the charges reflects the underlying marginal cost of providing capacity over the NBN.

The outcomes of the charging structures have been that most customers have chosen low speeds, and retailers have purchased CVC that leads to even lower speeds during peak periods. For example, by December 2017, over 80 per cent of customers have opted for lower speed offerings of up to 25 Mbps[72]. The low willingness of customers to pay for higher speed tiers and low willingness to retailers to pay for greater amounts of CVC both indicate a high elasticity of response to prices.

The issues above have prompted NBN to offer discounted CVC bundles on higher speed packages to encourage a higher take-up of 50 Mbps plans. As a result, there has been a significant increase in CVC acquired by retailers, from 1.11 Mbps to 1.53 Mbps per user since the September 2017 quarter, an increase of 38 per cent.[73]

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70 See chart 5.13.

71 ACCC: Competition and price changes in telecommunications services in Australia 2016-17

72 NBN Wholesale market indicators report 31 December 2017

73 Ibid.

NBN products and pricing need to be optimised

A key potential benefit of the NBN for consumers is higher speeds. However, average speeds currently experienced on fixed line services are generally below those of mobile as result of barriers caused by the NBN pricing model, which is prohibitively costly for both retailers and their customers at higher speed tiers.

Conceptually, given that the costs of NBN are largely fixed, an efficient pricing structure would be similar to a Ramsay optimal tax. This leads to charging more for the pricing components to which consumers are least responsive.[74]

The optimal pricing structure of the NBN will depend on factors such as the following:

- *Price sensitivity* — if customers are highly price sensitive, then higher prices will be associated with greater than proportional decreases in usage of the NBN. Customers are more sensitive to prices in the presence of alternatives, such as 5G. Optimal prices will therefore aim to achieve a level whereby prices will minimise substitution to alternatives and increase usage of the NBN. Different segments of customers respond differently to price. Customers with lower data usage would be likely candidates to switch to mobile broadband if it were to offer comparable speed to today's NBN at a lower price.
- *Willingness to pay for speed* — the apparent lack of demand for higher speed tiers on NBN by customers has shown that prices have been too high. Recent AVC and CVC bundling packages offered by NBN have enabled retailers such as Vodafone to offer discounts on higher speed tiers, resulting in a higher take up of faster NBN plans. Similar measures would need to be implemented for higher speed tiers in order to maximise the potential of NBN.
  - Customers may also have difficulty in understanding the current pricing strategy around speed. This lack of understanding may not provide retail service providers with sufficient incentives to purchase enough CVC to guarantee adequate quality levels (this has prompted the ACCC to ensure that retailers provide information regarding typical evening speeds on different NBN packages[75]).

The pricing structures that are most efficient will need to understand these issues in detail.

Access to NBN infrastructure

- **Technology changes such as 5G will likely alter the importance of different parts of NBN's network both commercially and for regulators and access seekers.**
- **Regulation of NBN pricing to the premises may become less important and regulation of access to NBN infrastructure at other points further from the premises, such as by 5G mobile networks, will become more important.**

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74 Ramsey, Frank (1927). "A Contribution to the Theory of Taxation". *Economic Journal*, Vol. 37: pp. 47–61.

75 ACCC: Broadband Speed Claims, Industry guidance August 2017

NBN pricing is regulated because of the natural monopoly characteristics of its infrastructure. The regulatory framework used seeks to cap NBN from earning a return greater than its costs, with costs including its operating expenditure, return on its assets, depreciation and tax expenses. Its costs in total are called building block costs. However, the regulatory arrangements also apply price caps, which currently are below its building block costs[76].

Access to the NBN is regulated via the Special Access Undertaking (SAU)[77]. The SAU stipulates maximum prices for a selection of pre-specified wholesale services provided using the NBN. These services connect NBN Points of Interconnect (POIs) to customer premises using fibre, fixed wireless and other technologies.

The high costs of NBN could, if there is sufficient competition from other fixed line and 5G providers, mean that NBN pricing never recovers the building block costs. If there is sufficient competition, then the importance of regulation of wholesale prices at the premise will fall.

If 5G services provide a mechanism for reaching the premises, but would use other infrastructure of NBN's further from the premises, then the regulatory arrangements and NBN's commercial arrangements may need to evolve to focus on this role. Currently, mobile operators will typically have their own arrangements for transmitting information from mobile sites to other parts of their network and other networks. However, there will be many more 5G sites compared to 4G sites, which will make this component of costs more critical for efficient service delivery, and confer greater benefits from using NBN infrastructure.[78]

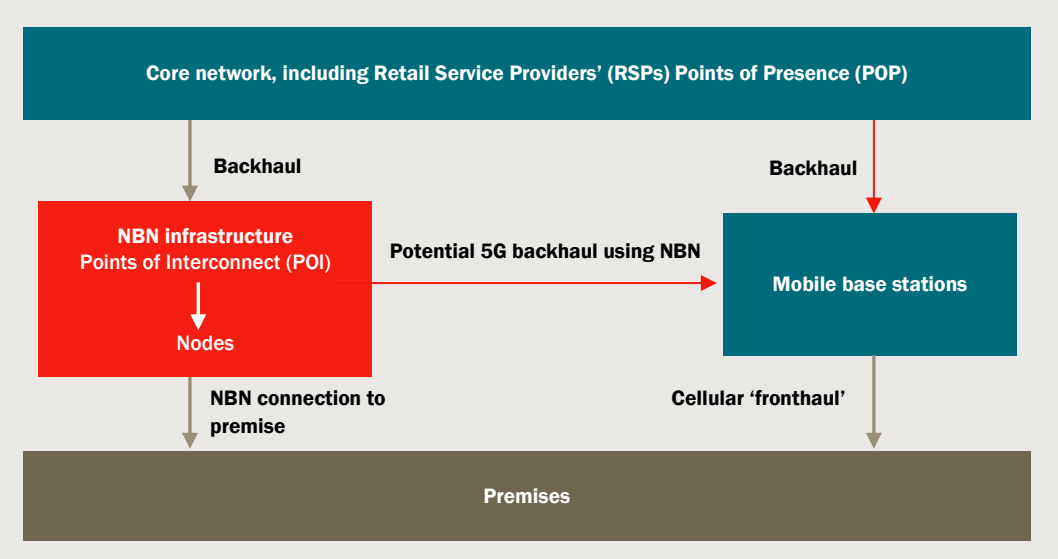
For example, a mobile base station may link to NBN infrastructure for the provision of mobile backhaul (transmission) services, as shown in chart 6.4.

76 ACCC Communications sector market study draft report, October 2017 p129-176

77 https://www.NBNco.com.au/content/dam/NBNco/documents/NBN%20Co%20SAU%20-%20Varied%20on%2018%20November%202013%20(clean%20version).pdf

78 Ciena, 2016, *5G wireless needs fiber, and lots of it*, available at: http://www.ciena.com/insights/articles/5G-wireless-needs-fiber-and-lots-of-it_prx.html

6.4 NBN provision of backhaul for 5G services



Data source: CIE.

NBN currently provides the cell site access service (CSAS), which uses the NBN to provide backhaul to mobile base stations. NBN's interim terms and conditions for CSAS state, however, that the service is only available in certain areas. It is unclear how this product would be covered by the current SAU.

There are a number of points in the telecommunications network where NBN could be involved in the market, such as providing backhaul to mobile cell sites, including small cells. If NBN was a non-monopolist competitor, they would have a greater incentive to seek out these opportunities to earn revenue from infrastructure with sunk costs, given the incremental costs of doing so would be very low. However, their position as a monopolist facing increased competition from 5G means that they have a disincentive to provide these services, thus potentially warranting a role for regulation of these services.

7 *The pathways and consequences of different policy directions*

KEY POINTS

- **Mobile could become a substitute for fixed line services for an increasingly large share of the population.**
  - **Whether this occurs will depend on how the technology and costs evolve.**
  - **This could have negative impacts on NBN as the main provider of fixed line infrastructure, but could also open up opportunities as a provider of services to mobile network operators.**
- **The cost-recovery of NBN may no longer be viable. Policy responses include:**
  - **Reducing prices and/or improving service quality to compete with other infrastructure. This would be unlikely to see NBN able to cover its costs but would increase its market share, or;**
  - **Government protection of NBN through policies to favour NBN over alternatives such as 5G.**
- **The optimal policy pathway would see technologies competing on the service they offer to consumers.**
  - **Government's role would be to ensure a level playing field, and ensure regulatory barriers did not increase costs.**
- **The worst policy pathway would see restrictions on non-NBN technologies or competitors and policies to favour NBN.**
  - **Past evidence has shown enormous gains to Australians from the development of mobile technologies. These gains have and are likely to continue to, relate to the use of mobile technology outside the home. Gains from mobile technology use in the home may be important, but are not likely to be as important as gains outside of the home.**
  - **Policies to protect NBN that increase the cost or reduce the competition from mobile services could therefore have impacts beyond those on the use of broadband in the home.**
  - **Policies that unintentionally lead to a more concentrated market for 5G services are likely to be the most detrimental to Australian consumers, leading to higher prices.**

The role of mobile technology

This paper has focused on the potential role of mobile as a competitor to fixed line infrastructure in supplying broadband services to the home. Depending on how the cost of data on mobile networks evolves, capacity, cost and growth in data demand, next generation networks such as 5G mobile broadband could have a larger impact on the in-home broadband market than they do now.

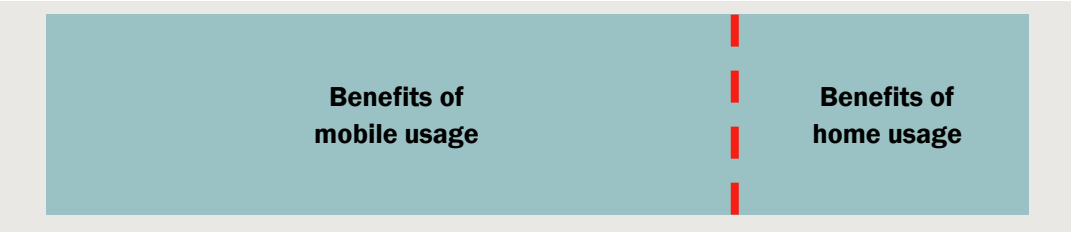
However, most of the benefits from advances in mobile technology are likely to occur outside of the home (chart 7.1). Mobile technology has in the past driven major gains in productivity for businesses, as well as benefits for others, which have primarily reflected the role that mobile technology has played in allowing people and businesses to be connected on the go.

The historic economic benefits of mobile broadband are well documented and one only has to look at the recent past to understand the positive impacts on the Australian economy. For instance, a study by the CIE and Analysys Mason for the Australian Communications and Media Authority found that mobile broadband increased the size of the economy by $33.8 billion by the year 2013.[79] The impacts of mobile broadband included:

- productivity growth in the mobile communications sector leading to an increase of $7.3 billion increase in economic activity; and
- time savings for businesses as a result of mobile broadband use leading to a further $26.5 billion increase in economic activity.

3G was largely the dominant technology at this time and given the growth in capability since provided by 4G (and yet to be provided by 5G), these benefits would be larger now and even larger in the future.

7.1 Economic benefits of mobile broadband – mobile versus in-home



Data source: CIE Illustration

Should an increasing share of the population choose to use mobile services for their home internet connection, this will reduce the cost-recovery of NBN. Government may seek to respond to this with policies to ensure that NBN recovers its costs. Critically, this could have an impact on the home broadband market and the mobile broadband market. Policies that seek to protect NBN from competing technologies could have unintended consequences by preventing realisation of the benefits of mobile usage out-of-home, which are potentially much larger than the benefits of mobile within the home.

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79 The Centre for International Economics, 2014, *The economic impacts of mobile broadband on the Australian economy, from 2006 to 2013*, prepared for the ACMA, p.2.

Costs of a poor policy pathway

The worst policy pathway would see restrictions on non-NBN technologies or competitors and policies to favour NBN. There are two potential impacts from such a pathway:

- the market structure for mobile broadband becomes more concentrated; and
- mobile technology is delayed or rolled-out at higher cost.

Both impacts would increase the prices of mobile technology to Australian consumers.

A more concentrated market for mobile services

Policy responses to next generation networks such as 5G can have direct impacts on the state of competition in both the fixed line and mobile broadband markets. Depending on the motive of government with respect to the competitiveness of NBN, possible responses might include:

- **Changing policy to reduce NBN prices** – this would primarily impact on NBN's market share to the home, and would reduce the extent to which mobile technologies and other infrastructure providers were taken up in the home. While this would be a competitive distortion, in that NBN would likely be pricing below cost, it would not be likely to materially alter the market structure of the mobile sector itself
- **Hindering competitors to NBN in the home** – the three main tools government could use to help or hinder competitors are: (i) access to spectrum; (ii) access to NBN infrastructure; and (iii) levies for regional broadband provision. The first issue - spectrum - could materially alter the market structure of mobile broadband. The second and third may also make some impact on market structure. For example, government may prevent the re-allocation of NBN's spectrum holdings within the 3.4 – 3.7 GHz band. This could result in only two viable providers of 5G services, significantly reducing competition in the mobile market. The impacts of reducing competition on prices and innovation can be significant:

Hazlett and Muñoz (2008)[80] found that higher levels of competition were a critical driver of prices for consumers of mobile services, using data on 452 mobile operators across 28 countries. Applying their findings to the Australian market structure, a decrease in competition because spectrum allowed only two 5G networks could increase prices for consumers by around 40 per cent.[81] In a similar study, Genakos et al (2017)[82] estimate the impact of market structure on prices across 33 OECD countries between 2002 and

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80 Hazlett, T. and Muñoz, R., 2009, 'A welfare analysis of spectrum allocation policies', *RAND Journal of Economics*, 40(3), pp.424 – 454, available at: https://techliberation.com/wp-content/uploads/2010/10/Hazlett.Munoz.RandJournalofEconomics.pdf

81 This assumes that after reducing from three current operators to two operators, the two remaining operators have equal market share, and that VHA retains half its current market share from providing 4G services.

82 Genakos, C., Valletti, T.M. and Verboven, F., 2017, 'Evaluating market consolidation in mobile communications', CESifo Working Paper, No. 6509, available at: https://www.econstor.eu/bitstream/10419/167495/1/cesifo1_wp6509.pdf

2013. Applied to the Australian context, having two providers of 5G mobile services would imply prices that are 30 per cent higher than if there were three providers. [83] These studies highlight the *potential* extreme sensitivity of pricing to market structure issues for mobile broadband. Whether or not this level of price impact would occur in the Australian context and with 5G services is difficult to know.

Delays or higher costs for 5G roll-out

Government policies could impact on the cost of providing mobile services or delay mobile technologies. Possible examples of this could include:

- the timing of spectrum releases; and
- access to NBN infrastructure for mobile operators.

A two-year delay could, if benefits from 5G match past benefits from mobile broadband, reduce future Australian economic activity by around $10 billion each year, and reduce economic growth by 0.3 per cent.[84] This would occur by delaying:

- new uses of mobile networks such as IoT;
- falling prices of mobile data and a wider variety of applications for consumers; and
- productivity improvements realised by industrial applications such as autonomous vehicles, pervasive sensor networks and smart factories.

Rewards from technology neutrality

Technology-neutral policy-making would provide:

- **Better outcomes for consumers:** policies that promote competition and enable new technologies such as 5G will result in lower prices, greater innovation and higher quality services for consumers.
- **Adaptability to technological change:** the capabilities and costs of fixed line and mobile technologies will continue to evolve, likely in line with the trend of convergence. Technology-neutral policy will promote the efficient use of and investment in infrastructure, particularly in ensuring that consumer benefits from the NBN are maximised.
- **Adaptability to changing preferences:** consumer preferences over speed, mobility, reliability and other preferences are changing over time, and policies that do not lock in dominance of a particular technology will ensure that the technology mix in the market can respond. For example, if demand for data usage increases by more than

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83 We make the same assumption as above: the two remaining operators have equal market share and VHA retains half its current market share from providing 4G services.

84 This assumes GDP of $1.7 trillion: ABS, *Australian National Accounts: National Income, Expenditure and Product, Dec 2017*, Cat no. 5206.0, series A2304755F (Gross domestic product: Chain volume measures).

The Centre for International Economics, 2014, *The economic impacts of mobile broadband on the Australian economy, from 2006 to 2013*, prepared for the ACMA

expected, an adaptable and competitive NBN can respond with additional investments or changed pricing strategies.

Just as has been found for spectrum policy, in making policy decisions, governments should focus on the welfare of the Australian people, rather than the commercial outcomes for government and the NBN.

A Hedonic modelling of fixed-line and mobile plans

The price that consumers pay for purchasing mobile and fixed line services can be broken down into the price of the subcomponents of each plan.

The formal method for comparing similar plans is called 'hedonic pricing'. The hedonic pricing method assumes that the value of a product is based on the value consumers place on the characteristics of the product. For example, in the context of mobile phones, the value of a phone plan is dependent on characteristics such as:

- number of included call minutes;
- amount of included data usage;
- entertainment content included; and
- mobile network providing the service.

This breaks up the overall price of a plan into the prices of sub-components, such as voice minutes, provider and data allowances. It does so using statistical models to decompose the price paid for products into the value of each characteristic. It has been used to determine the value placed on various characteristics of real estate, automobiles and other products such as personal computers.[85] We have used this method in the past for the valuation of characteristics of mobile and fixed line plans and estimation of Telstra's market premium.[86]

We have collected data on 103 different post-paid phone plans and 50 fixed line plans in order to determine the extra amount consumers are willing to pay for each characteristic. For example, it estimates the price consumers are willing to pay for an extra gigabyte of included data usage.

Fixed line

We have collected data on plans from Telstra, Optus, TPG and iiNet. These providers together comprised 81 per cent of market share in June 2016.[87]

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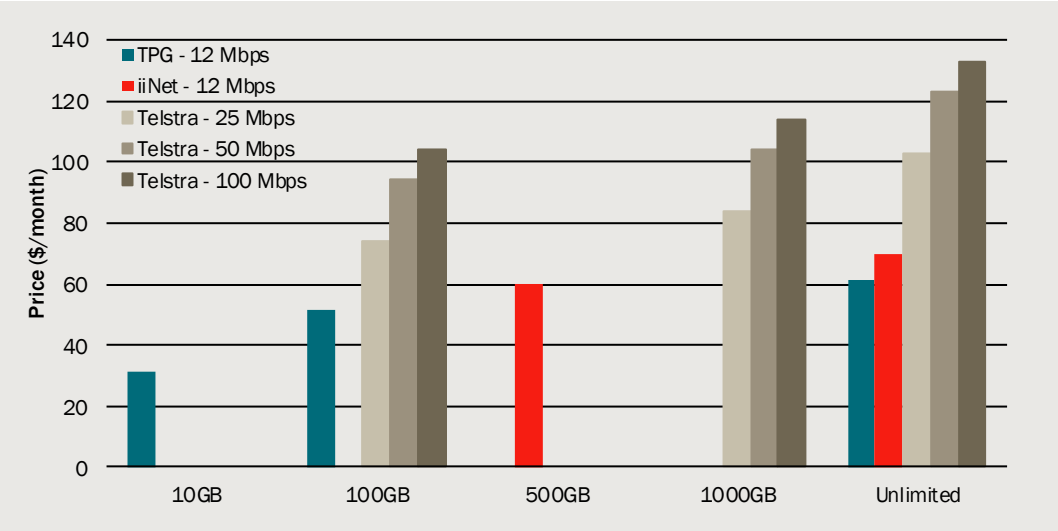
85 Triplett, J. (2004), *Handbook on Hedonic Indexes and Quality Adjustments in Price Indexes – Special Application to Information Technology Products*, Organisation for Economic Cooperation and Development, Paris. http://browse.oecdbookshop.org/oecd/pdfs/free/9306081e.pdf

86 The CIE, 2016, *Telstra's price premium: the premium paid by consumers for fixed and mobile services*, prepared for Vodafone Hutchison Australia, available at: http://www.thecie.com.au/wp-content/uploads/2017/03/CIE-Report_VHA_Price-Premium-Update-VHA-01122016.pdf

87 *ACCC Telecommunications Report 2015–16*, published February 2017, https://www.accc.gov.au/system/files/ACCC%20Telecommunications%20reports%202015%E2%80%9316_web.pdf

It is difficult to estimate the price of data (in $/GB) for fixed line plans due to the proliferation of unlimited data plans. Some providers such as Telstra, TPG and iiNet have plans with and without unlimited data allowances (chart A.1). Plans from these major providers have 10GB, 100GB, 500GB or 1000GB options for data allowances as shown. The prices of plans from TPG and iiNet with unlimited data allowances are below the price of the cheapest Telstra plan.

A.1 Prices and data allowances of example fixed line plans

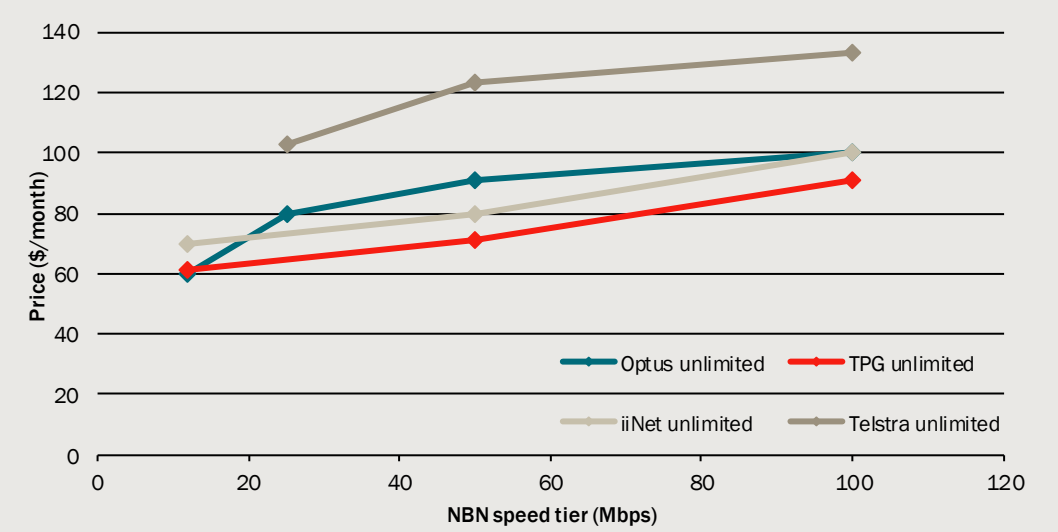


Data source: TPG, iiNet and Telstra websites, CIE.

Other providers, such as Optus, only have plans with unlimited data allowances. For example, Optus offers a plan with an unlimited allowance for $60 per month. Where the data allowance is unlimited, the price of data (in $ per GB) is not defined.

Among unlimited data plans, the main determinants of price are speed and which telecommunications company is providing the service. Plans on higher speed tiers cost more, and Telstra plans are relatively more expensive than plans from other providers for the same speed tier (chart A.2).

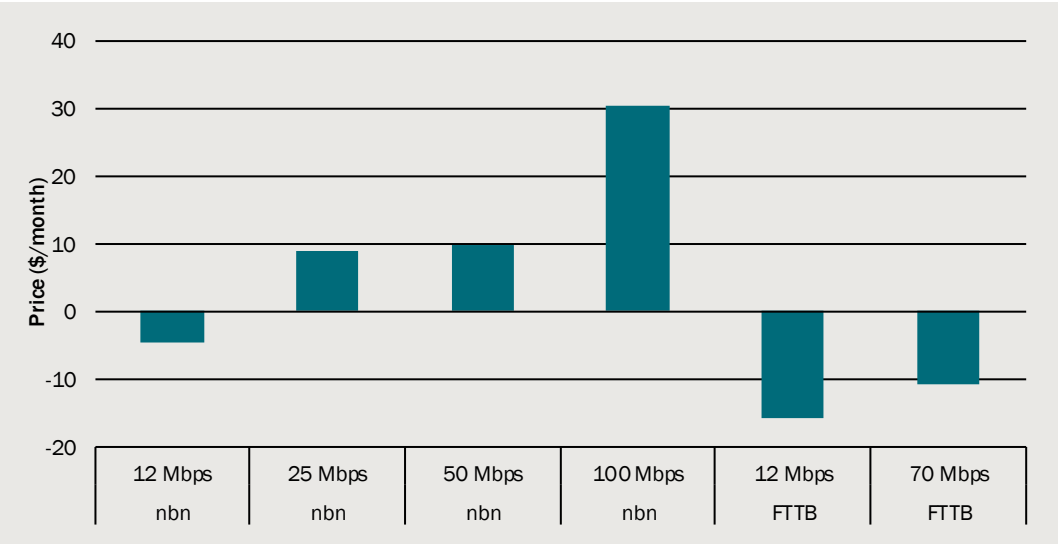
A.2 Prices and speeds of selected NBN plans



Data source: CIE.

Chart A.3 shows the price premiums for NBN and Fibre to the Basement (FTTB) plans of varying speeds relative to ADSL/cable plans. A price premium of $5 for 50 Mbps plans on the NBN means that prices for these plans are, on average, $5 more expensive than ADSL/cable plans, controlling for other variables such as the included data allowance. NBN plans with 12 Mbps speeds have a negative price premium relative to ADSL/cable plans. This may be associated with "temporary land grab phenomena" whereby carriers are aggressively pricing the 12 Mbps plans to gain market with the roll-out of the NBN. ADSL and HFC plans are generally priced at the same level as each other by the major carriers, despite having significant speed differences. These technologies are not substitutes, and customers will be connected to HFC wherever it is available to the premises.

A.3 Price of fixed line technologies and speed tiers relative to ADSL/HFC



Note: Price premiums shown in the chart are the price premiums relative to ADSL/cable plans.
Data source: CIE.

We estimated the following main model specification for fixed line plans:

$$Price_t = \beta_0 + \beta_1 \times unlimited\ data_t + \beta_2 \times data_t + \beta_3 \times data_t^2 + \sum_i^3 \beta_i \times provider_t + \sum_{s=1}^{6} \beta_s \times technology_t + \beta_{13} \times line\ rental_t + \beta_{14} \times local\ calls_t + \beta_{15} \times mobile\ calls_t + \varepsilon_t$$

which estimates the price of plan t for providers i, and technology types s. The technology dummy variables specify both the technology used and the speed. For example, a separate price effect for NBN (12Mbps maximum speed) and NBN (25Mbps maximum speed) is estimated. The $line\ rental$, $local\ calls$ and $mobile\ calls$ variables are indicator variables for whether these features are included in the plan (e.g. are calls to Australian mobiles included in the plan, or do they cost extra). Each plan observation is weighted by the market share of the provider (based on ACCC, 2017) multiplied by the reciprocal of the number of plans from that provider in the dataset. Table A.4 presents the estimated coefficients from this model.

A.4 Fixed line plans hedonic model

Variable	Coefficient	P-value
	$/month	
Data	0.08	0.000
Data-squared	-0.00007	0.000
Unlimited data	31.1	0.000
Carriers		
TPG	-6.4	0.000
Telstra	33.8	0.000
iiNet	-5.3	0.001
Technology and speed		
FTTB/12	-15.6	0.000
FTTB/70	-11.5	0.000
NBN/100	26.5	0.000
NBN/12	-4.4	0.001
NBN/25	-2.0	0.163
NBN/50	11.7	0.000
Line rental	8.4	0.000
Local calls	9.5	0.000
Mobile calls	14.3	0.000
Constant	33.7	0.000

Note: The excluded value of 'technology' is ADSL/Cable and the excluded carrier is Optus. The coefficients for each technology and carrier reflect the price premium relative to these excluded values.

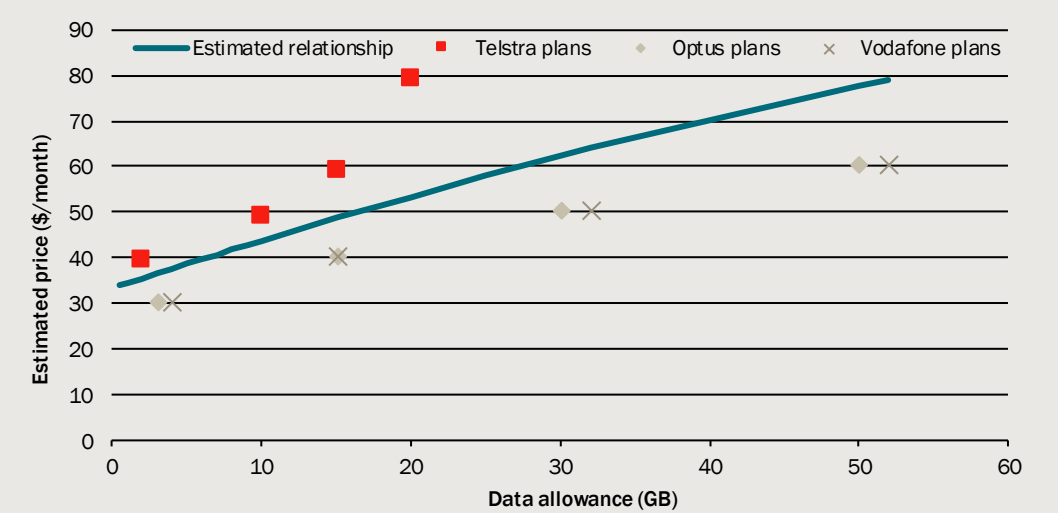
Source: CIE.

Mobile plans

We have collated data on post-paid mobile plans provided by Telstra, Optus, Vodafone, Virgin, TPG, iiNet and Amaysim, which together represent between 94–100 per cent of market share.

Chart A.5 shows the data allowance and price of mobile plans from Telstra, Optus and Vodafone. It also shows the estimated relationship between data allowance and price. It is clear that the relationship between data allowance and price is steeper for Telstra plans than for Optus or Vodafone plans. We have estimated only a single relationship between data demand and price, because the focus is on obtaining the average price of data across all providers.

A.5 Prices and data allowances of selected mobile plans



Data source: Telstra, Optus and Vodafone websites, CIE.

We estimated the following main model specification for post-paid plans:

$$Price_t = \beta_0 + \beta_1 \times data_t + \beta_2 \times data_t^2 + \beta_3 \times unlimited\ data_t + \sum_{h=1}^{2} \beta_t \times handset_t + \beta_6 \times International\ minutes_t + \beta_7 \times month - to - month_t + \beta_8 \times Foxtel_t + \varepsilon_t$$

which estimates the price of plan t for handsets h. The $International\ minutes$ variable is a continuous variable measuring the number of included international minutes in the plan. The $month - to - month$ variable indicates whether the plan has no lock-in contract. The $Foxtel$ variable counts the number of included Foxtel Now starter packs (with a 12-months subscription) included in the plan. Each plan observation is weighted by the market share of the provider (based on ACCC, 2017) multiplied by the reciprocal of the number of plans from that provider in the dataset.

The price of data has been falling over time, and the maximum data allowance provided by mobile plans has increased dramatically since 2014, particularly in the past year (chart A.6).

A.6 Mobile plans hedonic model

Variable	Coefficient	P-value
	$/month	
Data	1.0	0.000
Data-squared	-0.0038	0.000
Unlimited data	66.8	0.000
Handsets		
Samsung Galaxy	38.2	0.000
iPhone X	65.2	0.000
Carriers		
Optus	18.2	0.000
TPG	11.8	0.000
Telstra	39.8	0.000
Virgin	17.5	0.000
Vodafone	16.6	0.000
iiNet	7.7	0.000
International minutes	0.009	0.000
Month-to-month	16.4	0.000
Foxtel included	7.2	0.000
Constant	5.2	0.000

Note: The excluded carrier is Amaysim. The coefficients for each carrier reflect the price premium relative to Amaysim.

Source: CIE.

The price of a data allowance of 10GB is $9.85,[88] which means that the price of data in $/GB is around $1 for a plan with 10GB.

88 That is, $1.0 x 10GB + (-0.0038) x 10^2 = $9.85.

B Modelling choices between fixed line and mobile

In order to better understand the decision between fixed line and mobile-only, we use the survey dataset to model substitution between these two services. This appendix provides more detail about the modelling methodology, estimated coefficients and measurement of the impacts of the falling price of data.

Methodology

We estimate a logit model that seeks to predict the choice of individual households between two options: fixed line or mobile-only. Logit models are a type of regression model where the dependent variable can take two values; in this case, either fixed or mobile-only. Consumers are assumed to purchase the option that gives them the greatest utility/benefit.[89]

The logit model we estimate has the following form:

$$\text{logit}\, P(fixed) = \log \frac{P(fixed)}{P(mobile)} = \beta_0 + \beta_1 data + \beta_2 data^2 + \sum_{k=1}^{K} \beta_k x_k$$

where:

- $\text{logit}\, P(fixed)$ is the log-odds of a customer choosing to purchase fixed line services rather than mobile services
- $data$ is the data usage of an individual household (in GB/month)
- x_k are a series of individual characteristics including the following:
  - an indicator variable for whether the household is in a capital city or not
  - variables for the number of adults, the number of children under 5 years-old
  - the number of children between 5 and 18 years-old in the household
  - an indicator variable for the sex of the respondent[90]

89 Cardona et al. (2007) explain how utility maximisation is the basis for these types of logit models: Cardona, M., Schwarz, A., Yurtoglu, B.B. and Zulehner, C., 2007, 'Demand estimation and market definition for broadband internet services', Working paper, available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1081261

90 This variable is particularly important for the 25-34 year-old cohort, and excluding this variable has a noticeable impact on the estimated coefficients of interest (β_1 and β_2). The relationship between sex of the respondent and the choice between fixed and mobile is statistically significant at the 5 per cent level for 25-34 year-olds. While it is not statistically significant for other age cohorts, estimated coefficients and model fit are negligibly affected by inclusion/exclusion of this variable in models for other age cohorts.

  - indicator variables for the annual income band of the household ($18 200 or less, $18 201–37 000, $37 001–87 000, $87 001–120 000, $120 001–$180 000, $180 000 or more), and
  - indicator variables for the highest qualification level of a household member (including High school level, Certificate level, Advanced diploma and diploma, Bachelor degree and above).
- β_0, β_1, β_2 and β_k are coefficient estimates, which can be interpreted as the estimated change in logit $P(fixed)$ resulting from a one-unit change in the respective dependent variables such as $data$.

This model allows us to estimate the share of households which are mobile-only under different scenarios for the explanatory variables.

We estimate separate models for each age cohort. That is, respondents are segmented by their age group, and separate models (and, therefore, coefficients) are estimated for each. This approach has been taken because different age groups are expected to have different relationships between usage and their choice of fixed or mobile. For example, younger cohorts are expected to switch between fixed and mobile more easily than older cohorts.

Estimated model

Table B.1 presents the estimated coefficients of usage and usage-squared for each age group. The coefficient of usage is positive, while the coefficient of usage-squared is negative. This suggests a positive but decreasing relationship between usage and the probability of choosing fixed-line.[91]

These coefficient estimates are difficult to interpret because they measure the impact of one-unit changes in usage and usage-squared on the *log-odds* of choosing fixed line. As a result, the impact of a one-unit change in usage on the *probability* of choosing fixed line will depend on both the starting point for usage and the starting point of the probability of choosing fixed line. The table shows a simple calculation of the mobile-only share that would be implied if usage increased from the current average of 266GB to 316GB. The current mobile-only share for each age group is used as a starting point (shown in the column corresponding to 266GB average usage). This calculation illustrates how sensitive the mobile-only share is to changes in usage, showing that the 18-24 age group responds most to changes in usage.[92]

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91 At very high levels of usage such as 8000GB or more depending on the age group, the model predicts that the probability of choosing fixed line falls as usage increase. This level of usage is not commonly observed in the dataset or projections of data usage, and thus this feature of the coefficients has at most a trivial effect on model predictions.

92 This calculation does not account for deviation between actual usage of individuals and the average usage across each age group (i.e. the distribution of usage). Therefore, it implicitly assumes that all households in each age group have usage equal to average usage, and all households experienced the same 50GB increase in usage. The change in the mobile-only share is generally lower (for a given change in average usage) once the distribution of usage is accounted for.

Table B.1 also shows the proportion of internet-using households in each age group based on the survey.[93] These shares are used to convert estimates of the mobile-only share for each age group into estimates of the mobile-only share across all households.

B.1 Estimated coefficients of choice model by age group

Age group	Usage coefficient	Usage-square coefficient	Mobile-only share with 266GB average usage	Mobile-only share with 316GB average usage	Share of internet-using households in age group
			Per cent	Per cent	Per cent
18-24	0.09281	-0.00001140	21.0	0.3	12.2
25-39	0.00645	-0.00000077	15.2	11.7	28.0
40-54	0.00893	-0.00000091	13.2	9.1	25.1
55+	0.00972	-0.00000106	20.9	14.2	34.7

Source: CIE.

Modelling the impact of the falling price of data scenarios

We have modelled the impact of this fall in the price of data by modifying the coefficients β_1 and β_2 from the logit model (shown in table B.1). That is, to model the impacts of a 50 per cent reduction in the cost of data for mobile relative to fixed plans, we reduce the magnitude of β_1 and β_2 each by 50 per cent for each age group. This is an appropriate to reflect changes in the price of mobile data because the estimated coefficients reflect the relationship between data usage and the choice of fixed or mobile. At an extreme, if the price of mobile data fell to almost zero, data usage would no longer be expected to affect the choice between fixed and mobile.

This assertion relies on the assumption that data usage is positively related to the probability of choosing fixed line only because data usage is costly for mobile but almost costless for fixed line. This assumption is approximately true, as shown by the proliferation of unlimited data allowances among fixed plans and the fact that the marginal cost to the network owner of additional fixed line network traffic is almost 0.

The impact of changing the logit model coefficients can be represented by the following equation:

$$\frac{P(fixed_{p1})}{P(mobile_{p1})} \Bigg/ \frac{P(fixed_{p0})}{P(mobile_{p0})} = \frac{e^{\beta_{1,p1} data} + e^{\beta_{2,p1} data^2}}{e^{\beta_{1,p0} data} + e^{\beta_{2,p0} data^2}}$$

where $p1$ and $p0$ refer to the current price ($p0$) and increased/reduced price ($p1$) scenarios and e refers to the exponential function.

93 These estimated proportions of internet users by age group closely align to population shares by age group (based on ABS Census 2016 data).

This function is derived by exponentiating the original logit model equation, and then taking the ratio between the odds of the equation with coefficients $p1$ and the equation with coefficients $p0$ (assuming that the other coefficients and independent variables are unchanged). As with modelling the usage scenarios, we have modelled each tier of the usage distribution separately to account for 'saturation' of the mobile-only share among low-usage households.

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