THE UNIVERSITY OF SYDNEY

Associate Professor Tooran Alizadeh
Urbanism and Telecommunication Planning

15 January 2020

Submission to: Inquiry into the business case for the NBN and the experiences of small businesses

Dear Joint Standing Committee on the National Broadband Network,

Thank you for your invitation to make a submission to the inquiry into the business case for the NBN and the experiences of small businesses.

The purpose of this submission is to draw the Joint Standing Committee's attention to the evidence base developed in my research at the University of Sydney on topics relevant to the terms of reference of the Committee. My research is specifically relevant to item **'c. network coverage issues'** and item **'f. the future capacity of the NBN to meet the needs of small and medium business owners'** on the terms of reference.

In my research, I have followed the ups and downs of the NBN rollout since introduction and have 23 publications on the subject. My research on the equity and equality of the NBN rollout has been widely reported in the Australian and international media evidenced by numerous prime time TV and radio interviews, and hundreds of quotes in print media. My focus on the equity and equality of the NBN is not limited to the experiences of small businesses. However, the concerns and questions raised are applicable to the Committee's specific focus on the small businesses.

The submission is a combination of four publications; their relevance to the inquiry is briefly described below:

Alizadeh, T. (2017). The NBN: How a national infrastructure dream fell short. The Conversation. Retrieved: 5 June 2017, from https://theconversation.com/the-nbn-how-a-national-infrastructure-dream-fell-short-77780?utm_source=twitter&utm_medium=twitterbutton

This *Conversation* article provides a brief history of the NBN rollout; and points out some of the network coverage issues throughout the process. It provides a good foundation for the more recent publications below – with links to a number of my earlier academic publications.

Alizadeh, T. (2017). Turnbull's government must accept responsibility for delivering an equitable NBN for all Australians. The Conversation. Retrieved: 25 Oct 2017, from https://theconversation.com/turnbulls-government-must-accept-responsibility-for-delivering-an-equitable-nbn-for-all-australians-86221

This *Conversation* article provides a brief summary of the different levels of inequity and inequity in the network coverage which in turn impacts the future capacity of the NBN to meet the needs of Australians (including but not limited to the small and medium business owners).

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Alizadeh, T., Helderop, E., Grubesic, T. (2019). Around 50% of homes in Sydney, Melbourne and Brisbane have the oldest NBN technology. The Conversation. Retrieved: 9 May 2019, from https://theconversation.com/around-50-of-homes-in-sydney-melbourne-and-brisbane-have-the-oldest-nbn-technology-115131

This *Conversation* article provides an up to date (as of Feb 2019) analysis of the spatial patterns of the mixed-technology rollout adopted across the three metropolitan regions of Sydney, Melbourne and Brisbane. It shows that about 50% of the network across the major three metropolitan regions depend on the HFC (the oldest NBN technology). Independent reports plus statements from the NBN Co. are used to show the level of dissatisfaction experienced by those connected to the HFC. This has serious ramification in terms of the future capacity of the NBN to meet the needs of Australians (including but not limited to the small and medium business owners).

Alizadeh, T., Helderop, E., Grubesic, T. (2019) Socio-Spatial Patterns of the NBN Rollout: It is worse than what you think. Paper presented at the State of Australian Cities National Conference 2-5 December, Perth.

This article was presented as part of the latest *State of Australian Cities* (the most prestigious academic conference dedicated to Australian urban issues) in Dec 2019. It is an expansion of the previous *Conversation* article; as it includes further details in regard to network coverage issues focused on Sydney and Melbourne metropolitan regions.

I would like to thank the Committee for its consideration of this submission, and I would welcome the opportunity to elaborate further on the information contained in this submission if it would assist the Committee in its inquiry.

Please do not hesitate to contact me if there is any further questions regarding the material included in this submission.

Yours Sincerely

Associate Professor Tooran Alizadeh

Signature:_ _____Date 15 Jan 2020

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Alizadeh, T. (2017). The NBN: How a national infrastructure dream fell short. The Conversation. Retrieved: 5 June 2017, from https://theconversation.com/the-nbn-how-a-national-infrastructure-dream-fell-short-77780?utm_source=twitter&utm_medium=twitterbutton

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The national broadband network promised by the incoming Rudd government was politicised from the start. Lukas Coch/AAP

The NBN: how a national infrastructure dream fell short

June 5, 2017 6.24am AEST

Author

Tooran Alizadeh
Senior Lecturer, Director of Urban Design, University of Sydney

Eight years into the Australian government's National Broadband Network (NBN) project, the nation has an average internet speed – 50th in the global rankings – that lags well behind many advanced economy countries.

Ongoing secrecy around the NBN, a project that's likely to cost more than A$50 billion, makes it impossible for the public in most cases to know when and what quality service they will receive. Further, new research shows the NBN rollout was politically motivated and socioeconomically biased from the beginning.

It is perhaps time to remind ourselves of the ups and downs of the project that was once announced as a dream national infrastructure project for the 21st century. This requires a ten-year journey back in time, before we can figure out what needs to be done next.

The ups

In November 2007, after 11 years of Coalition government, Labor was elected on a policy platform that promised a national broadband network.

The NBN company was announced in April 2009 to provide terrestrial fibre network coverage for 93% of Australian premises by the end of 2020. Fixed wireless and satellite coverage would serve the

remaining 7%.

Looking back, it's hard to deny the influence the NBN has had on Australian politics. Perhaps the peak influence was when three independent MPs cited the NBN as one of the key reasons why they supported a Labor government over the Coalition when the 2010 federal election produced a hung parliament.

The final 60 early NBN rollout locations were then announced. The plan was for the first stage of the large-scale rollout to follow, connecting 3.5 million premises in 1,500 communities by mid-2015.

The downs

The early NBN rollout experienced significant delays. This attracted a great deal of "overwhelmingly negative" media coverage. Public opinion polls reflected growing dissatisfaction with the national project.

This dissatisfaction and the September 2013 federal election result changed the fate of the NBN. In 2013, the new Coalition government suspended the first stage of the large-scale fibre-to-premises NBN rollout to reassess the scale of the project.

In 2014, the government announced that the NBN rollout would change from a primarily fibre-to-premises model to a multi-technology-mix model. The technology to be used would be determined on an area-by-area basis.

This change of direction resulted in a prolonged state of uncertainty at the local government level. As it was rolled out, the NBN was widely criticised for being slow, expensive and obsolete.

Current state of play

Delays continue in the construction of the Coalition's NBN. What can only be described as a downgrade of the original national project is now seriously over budget.

In September 2016, a joint standing committee of parliament was established to inquire into the NBN rollout. The inquiry is continuing.

The bleak status quo only gets worse when the on-the-ground reality of the NBN rollout is considered. While fibre-to-premises rollout is supposed to be limited in the Coalition's NBN, disturbing examples of misconduct in the NBN installations are highly concerning.

The image below shows one example of many in which heritage-listed buildings (in this case also public housing) are disrespected to the point that suggests an absolute lack of communication between NBN contractors, local government, or heritage agencies.

One heritage-listed house with two NBN installations (Judge Street, Woolloomooloo, NSW). Image: Stacey Miers, Author provided

Who misses out?

In the Coalition's NBN, the provision of universal high-speed capacity – as envisioned in the original NBN – has been transformed into a patchwork of final speeds and different quality of service. This leads to an important question about equity. It also puts the 60 early rollout locations in the spotlight as these could potentially be the only ones across the nation that enjoy fibre-to-premises NBN.

My new research points to the political motivations in the selection of these lucky 60 sites. Voting patterns in these locations were compared with all electorates in the federal elections from 2007 to 2013. The analysis shows the selections were skewed for potential political gain.

ALP-held seats were the main beneficiaries of the early NBN rollout; safe Coalition-held seats were the least likely to receive the infrastructure.

Tony Windsor, one of the three influential independent MPs in 2010, famously said of the NBN:

> *Do it once, do it right, and do it with fibre.*

He secured priority access for his regional electorate to the early NBN.

Tony Windsor: 'Do it once, do it right and do it with fibre.'

However, most regional localities were not that lucky. Indeed, research on the sociospatial distribution of the early NBN rollout shows the limited share of regional Australia.

What to do?

It is convenient to blame one political party for the state of chaos that the NBN is in right now. However, politicisation of the project has been part of the problem since day one.

Instead, we call for telecommunication infrastructure to be considered for what it really is: the backbone of the fast-growing digital economy; the foundation for innovation in the age of smart cities and big data; and a key pillar of social equity and spatial justice.

In reality, however, in the age of big data and open data, the lack of transparency around the NBN is shocking. In evidence to the parliamentary committee inquiry in March 2017, the Australian Competition and Consumer Commission expressed concern about the lack of transparency on NBN performance.

Policing the leaks of NBN data is not going to clean up the mess. Quite the opposite: the Australian government needs to share the NBN data, so the exact nature and scale of the problems can be determined. Only then can we talk about finding a way forward in this long journey.

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Alizadeh, T. (2017). Turnbull's government must accept responsibility for delivering an equitable NBN for all Australians. The Conversation. Retrieved: 25 Oct 2017, from https://theconversation.com/turnbulls-government-must-accept-responsibility-for-delivering-an-equitable-nbn-for-all-australians-86221

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NBN delivery is variable across different states, but also within the same local council areas. from www.shutterstock.com

Turnbull's government must accept responsibility for delivering an equitable NBN for all Australians

October 25, 2017 6.04am AEDT

Author

Tooran Alizadeh
Senior Lecturer, Director of Urban Design, University of Sydney

On Monday night Four Corners asked Australia to consider "What's wrong with the NBN?".

Prior to the episode airing, a lot of the debate focused on the NBN's business model, and that it may not be profitable.

I, however, am not sure if the financial returns need be our biggest concern when referring to public service and critical infrastructure. My answer to the question "what's wrong with the NBN?" is quite simple: the NBN is inequitable.

Read more: The NBN: how a national infrastructure dream fell short

A "train wreck"

This week started with a fiery speech delivered by the Prime Minister, Malcolm Turnbull. He said the

NBN was a mistake, blamed the former Labor government for the set up, and described the NBN's business model as a "calamitous train wreck".

Turnbull's remarks triggered a number of responses, including one from former Labor Prime Minister, Kevin Rudd. He attached responsibility of NBN's failure to the current government, as they "changed the model completely" compared to the original design.

More broadly, the Four Corners program itself created mixed reactions on social media. It was criticised for being "weak", and not "challenging enough", but also praised as "exceptional".

I find it incredibly frustrating to see a national critical infrastructure project diminished to political ping pong. In my opinion, bipartisan commitment is required in order to deliver an equitable NBN for all Australians.

Inequity from the start

Introduced by Labor, the original NBN was announced in April 2009. The plan was to provide terrestrial fibre network coverage for 93% of Australian premises by the end of 2020, with the remaining 7% served by fixed wireless and satellite coverage. In other words, Labor's NBN was mainly equitable in terms of the advanced technology adopted across the board.

Read more: Three charts on: the NBN and Australia's digital divide

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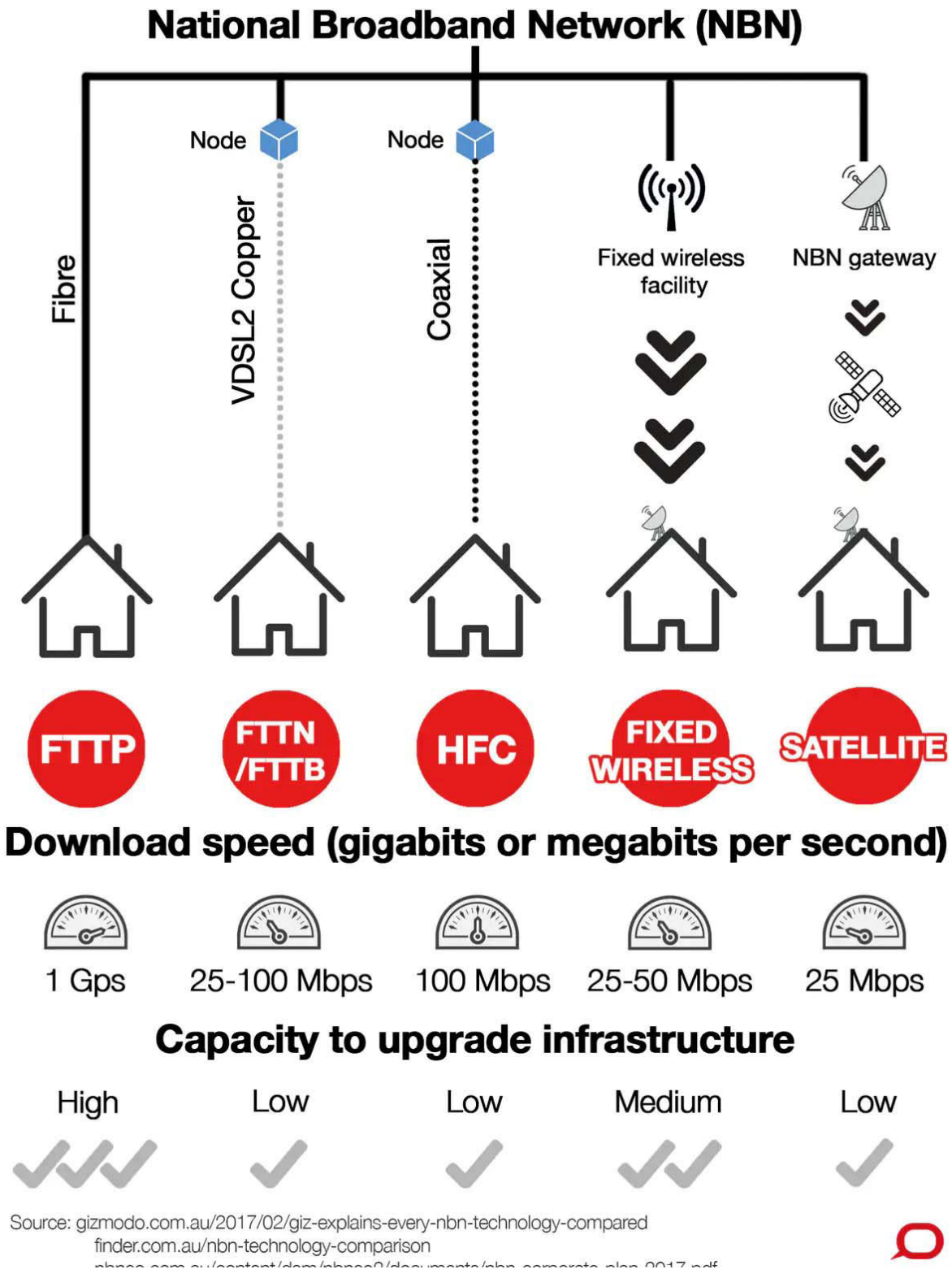
However, research on the early NBN rollout pointed out the issue of timing. Even under the most optimistic estimations, it was going to take over a decade to build the nation-wide infrastructure. So, there were always questions about who was going to get the infrastructure first, and who had to wait over a decade for a similar service.

The results of the 2013 Federal election changed the fate of the NBN. The elected Coalition government decided the NBN rollout should transition from a primarily fibre-to-premises model to a mixed-technology model.



Various/The Conversation, CC BY-ND

FTTP = fibre to the premises; FTTN/FFTB = fibre to the node/basement; HFC = Hybrid Fibre-Coaxial

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This added to the complexity of the NBN, and created new layers in the inequality concerns around the NBN. In the Coalition's NBN, many could be waiting quite some years and yet still only receive a lower quality level of access to the service.

Inequity in 2017

Now we're past the halfway point of NBN delivery, and inequality of the service is clear at two levels.

Large scale

Recent research shows there is a clear digital divide between urban versus regional Australia in terms of access to the NBN. Regional Australia is missing out, both in terms of pace and quality of delivery in the mixed-technology model. This pretty much means that WA and NT are the worst off parts of the nation, because of the spread and dominance of regional and remote communities within them.

"Fine grain" scale

As described on Four Corners, mixed-technology NBN within local government areas and neighbourhoods means some people are better off than others.

Some receive fibre-to-premises service while others have fibre-to-node. The quality of the service also depends on how far someone lives and works from a node, which basically suggests even people on the same fibre-to-nodes service could have varied level of (dis)satisfaction with their internet and phone services.

Research published in 2015 captured some of the frustrations on the ground at the local government level. Differing qualities of internet services available were perceived to have direct implications for local economic development, productivity, and sense of community at the local level.

The two layers of NBN inequality mean that while some customers may be happy with their NBN, many experience a frustrating downgrade of service after moving to the NBN. This may help explain the increase in the number of NBN complaints across the nation.

Read more: Lack of internet affordability may worsen Australia's digital divide: new report

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Let's start moving forwards

Politicising the NBN and blaming one party over another has been part of the national misfortune

around the NBN. But, I believe, the inequality of the NBN is part of a bigger trend in infrastructure decision making in Australia that fails to fully account for the socioeconomic implications. Other examples of this trend are seen in major (controversial) transport projects around the nation (e.g. East West Link in Melbourne, WestConnex in Sydney).

Current and future Australian governments must accept responsibility, and find a way forward for the NBN that is built on the notion of equitable service.

We can start with questions such as who needs the service the most, and who can do the most with it. These two questions refer to the social inclusion and productivity implications of the NBN.

The NBN, as a publicly funded national infrastructure project, has to be equitable to be a truly nation building platform. As long as it is failing some, it is failing us all as a nation.

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Living in an urban centre is no guarantee for new NBN technology. from www.shutterstock.com

Around 50% of homes in Sydney, Melbourne and Brisbane have the oldest NBN technology

May 7, 2019 12.43pm AEST

The NBN was touted as dream infrastructure, and the Coalition says it is close to completing the A$50 billion national broadband network.

But Australia recently slipped three spots to place 62nd in global broadband rankings, with our average download speed of 35.11 Mbps far below the global average of 57.91 Mbps.

Labor has ruled-out a large scale upgrade of the NBN if it wins the 2019 federal election, saying flaws in the NBN are due to “six years of vandalism” by the Coalition government.

Authors

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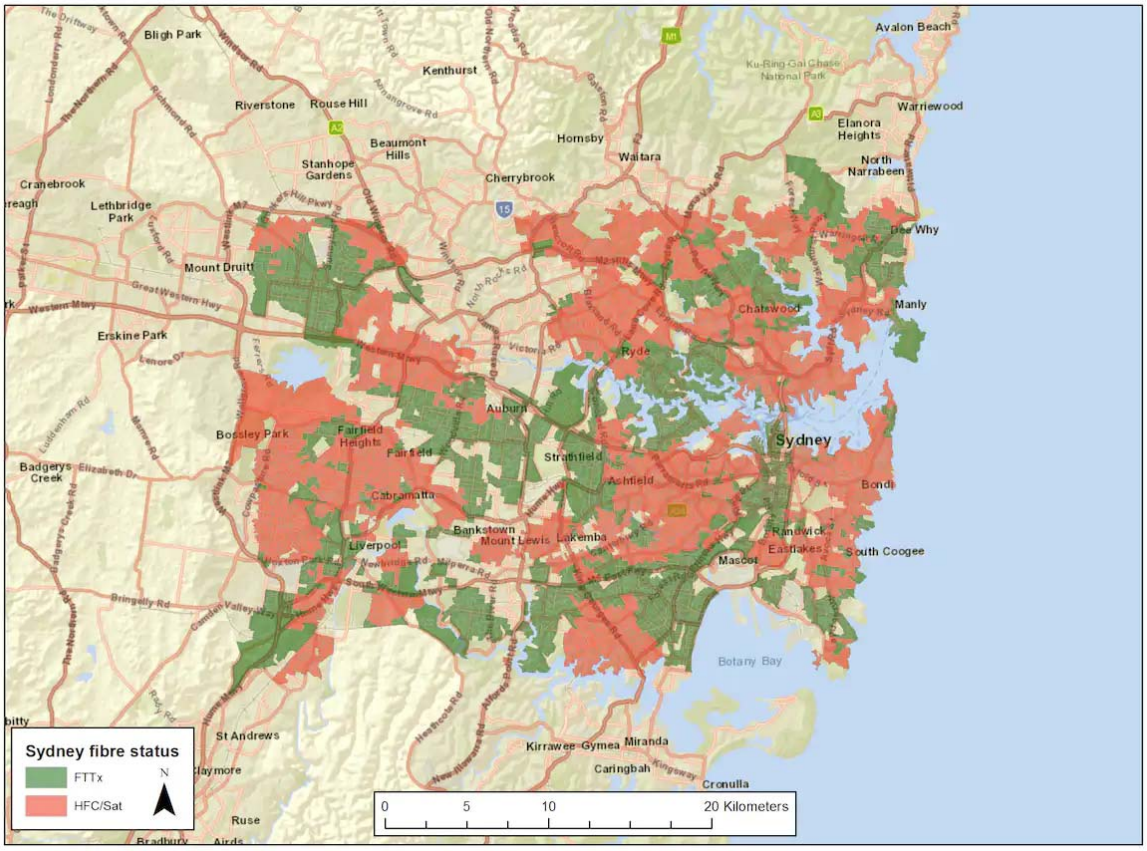
Read more: Labor will prioritise an NBN 'digital inclusion drive' – here's what it should focus on

In reality it's hard to get an accurate picture on the balance of NBN technologies that are already in place in Australia. To get around this opacity, we used the "check your address" tool on the NBN website as a way to collect data on the footprints of technologies currently or about to be in place in three Australian metropolitan cities of Sydney, Melbourne and Brisbane.

The data suggests around half (40-60%) of homes in the three cities only have access to very old technology: hybrid fibre-coaxial (HFC). For people in these residences, access to the so-called "fibre network" remains only a fairy tale.



Around 55% of homes have old NBN technology in Sydney. Green areas represents addresses with fibre technology (FTTX) and red areas represent addresses with older hybrid fibre-coaxial/satellite NBN (HFC/Sat). Tooran Alizadeh, Author provided

Real data on the NBN

Lack of data transparency is a vexing aspect of the NBN. In our experience, NBN Co does not disclose meaningful information on service footprints in a single, usable dataset. This makes it difficult to

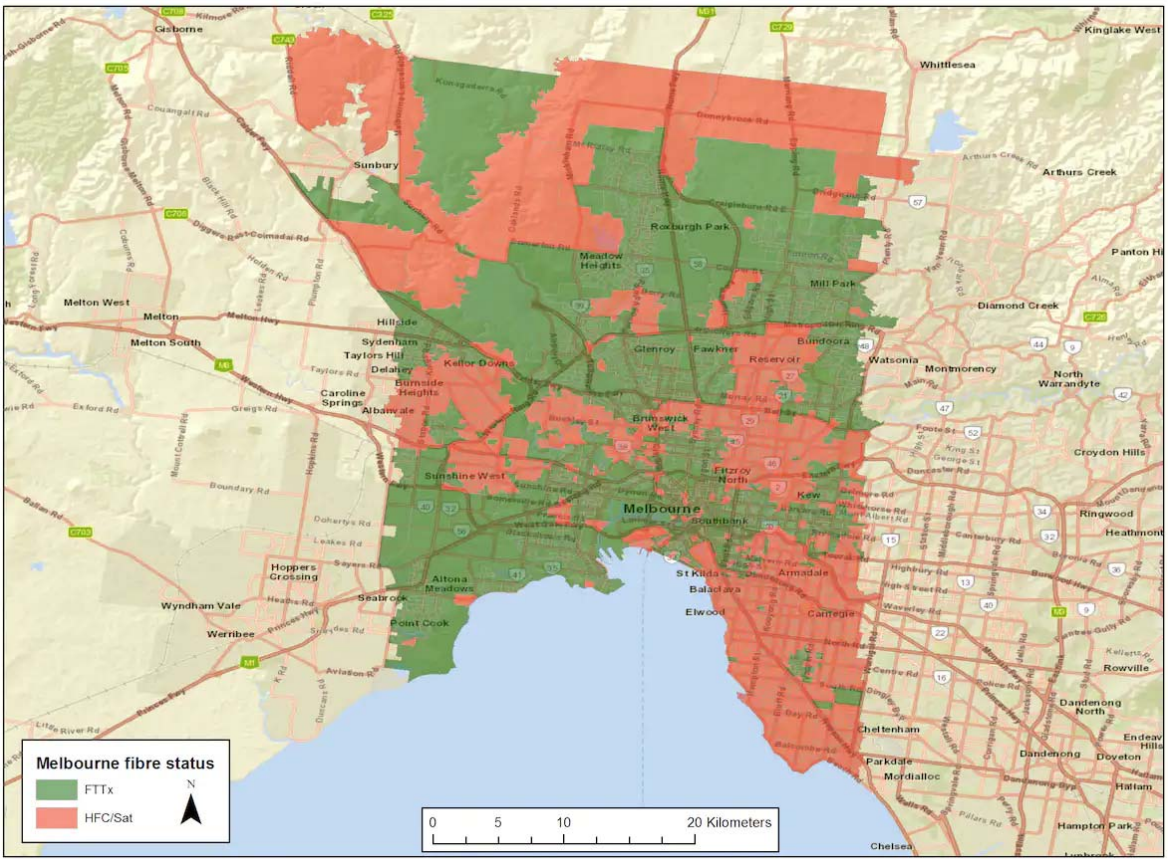
evaluate outcomes and perform policy analysis associated with the service.

Nevertheless, our latest research has collected some data we believe was undisclosed previously.

Over December 2018 to February 2019, we used the “check your address” search function on the NBN Co website along with basic data mining techniques to extract data from a representative sample of all addresses across the three metropolitan regions of Sydney, Melbourne, and Brisbane.

We uncovered footprints of mixed-technology NBN, including current or planned fibre to the premises (FTTP), fibre to the node (FTTN), fibre to the building (FTTB), fibre to the curb (FTTC), hybrid fibre-coaxial (HFC), fixed wireless and satellite (Sky Muster).

Here we mainly focus on hybrid fibre-coaxial (HFC), which is the oldest technology component of the NBN. HFC is the cable network you might have connected to in the past to get Foxtel subscription TV.



Around 42% of homes have old NBN technology in Melbourne. Green areas represents addresses with fibre technology (FTTX) and red areas represent addresses with older hybrid fibre-coaxial/satellite NBN (HFC/Sat). Tooran Alizadeh, Author provided

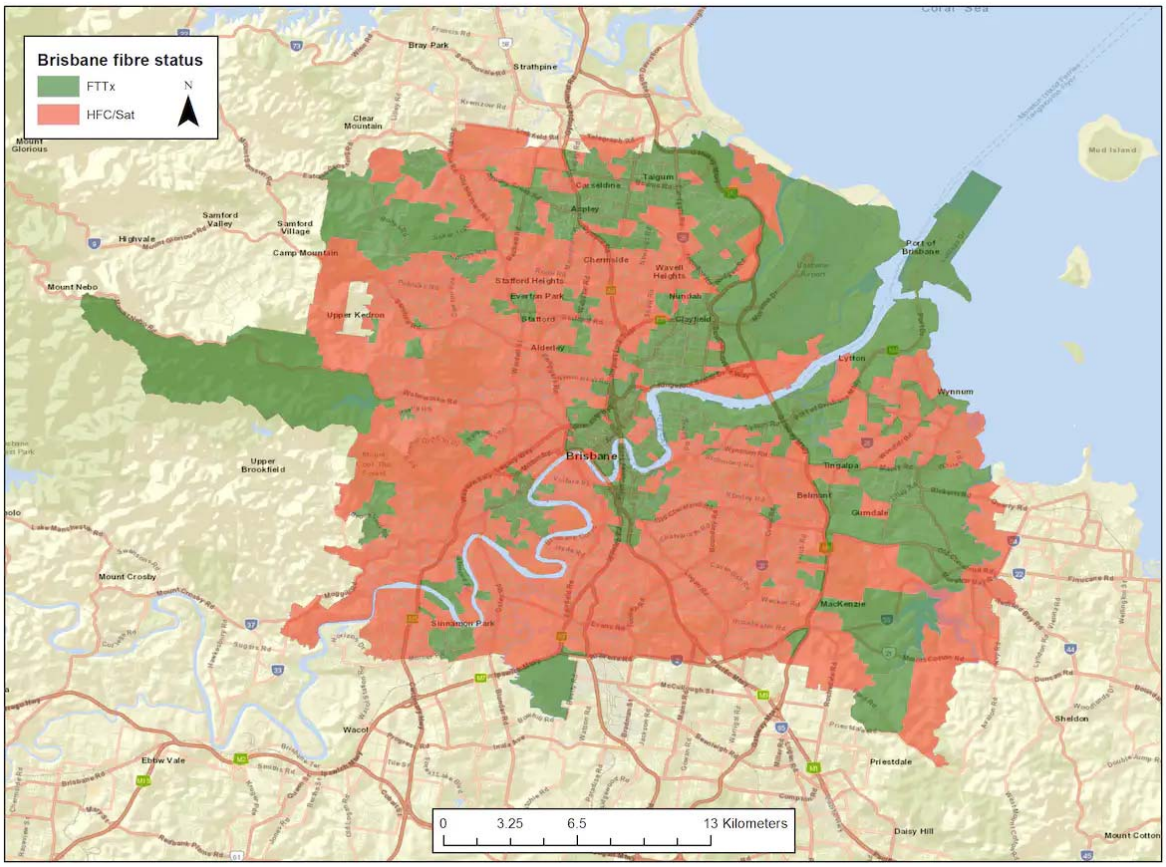
Major cities rely on HFC

The three maps shown here represent the spatial presence of fibre infrastructure versus more inferior HFC/satellite NBN in three metropolitan regions of Sydney, Melbourne and Brisbane (In reality very few urban homes use satellite, as shown in bar graphs below).

The three maps suggest inferior NBN technology is in abundant use across all three metropolitan

cities. 62% of all addresses in the greater Brisbane region, 42% of all addresses in Melbourne, and 55% of all addresses in Sydney are (or will soon be) connected to the NBN via HFC.

These figures are at odds with a recent claim by Minister for Communications Mitch Fifield that his government is rolling out “a new network” to the whole nation. For about half of the addresses in three major Australian metropolitan regions, the NBN “rollout” looks like a re-branding exercise using an old cable network.



Around 62% of homes have old NBN technology in Brisbane. Green areas represents addresses with f bre technology (FTTX) and red areas represent addresses with older hybrid fibre-coaxial/satellite NBN (HFC/Sat). Tooran Alizadeh, Author provided

Socioeconomic patterns of the NBN

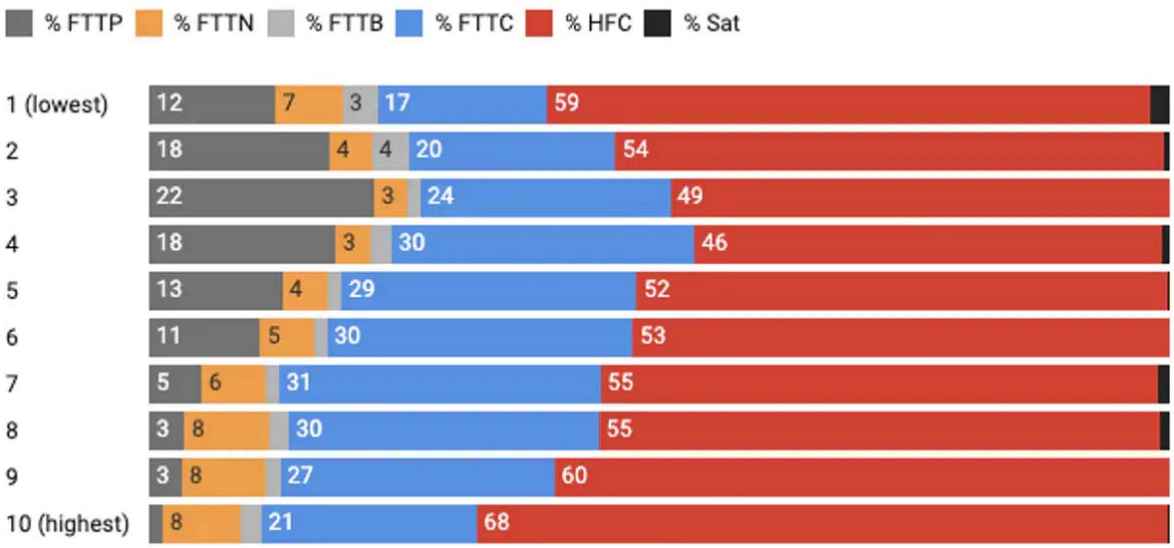
To look at socioeconomic patterns of the NBN rollout, we used the Australian Bureau of Statistics’ (ABS) socio-economic indexes for area (SEIFA) and its index of Relative Socio-economic Advantage and Disadvantage (IRSAD) from 2016. We then cross examined the SEIFA data (divided into ten ranked groups known as “deciles”) with the NBN data extracted via the data mining exercise (described above).

It’s clear in the graphs below that a mix of both old and new technologies are in play across the three metropolitan regions of Sydney, Melbourne and Brisbane.

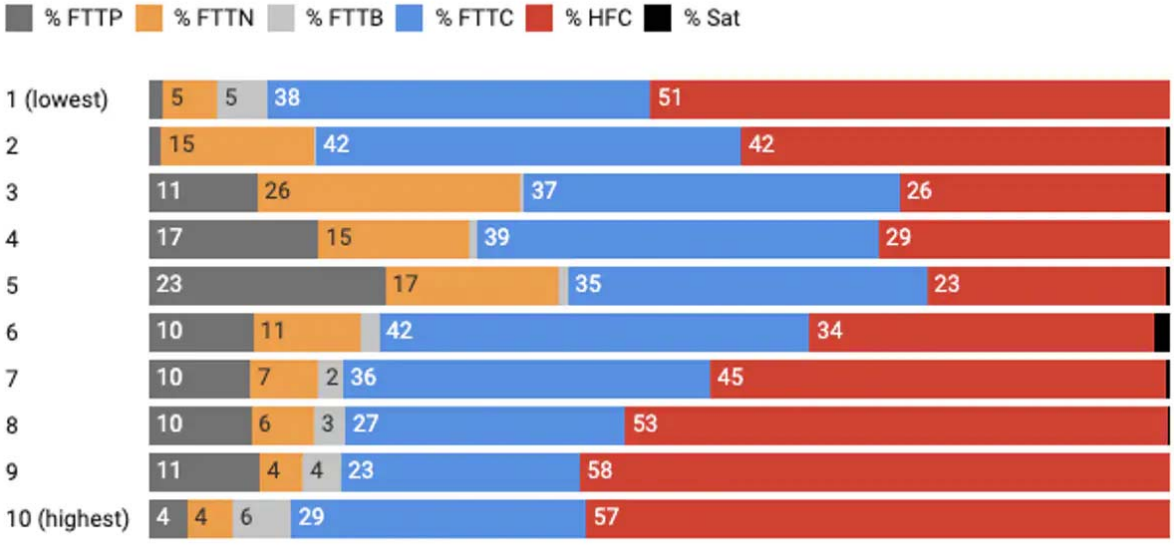
The analysis did not find any clear socioeconomic patterns comparing better-off SEIFA deciles of 8-10 versus worse-off deciles of 1-3. Nevertheless, the size of HFC adoption across the socioeconomic

spectrum in all three major cities is quite concerning.

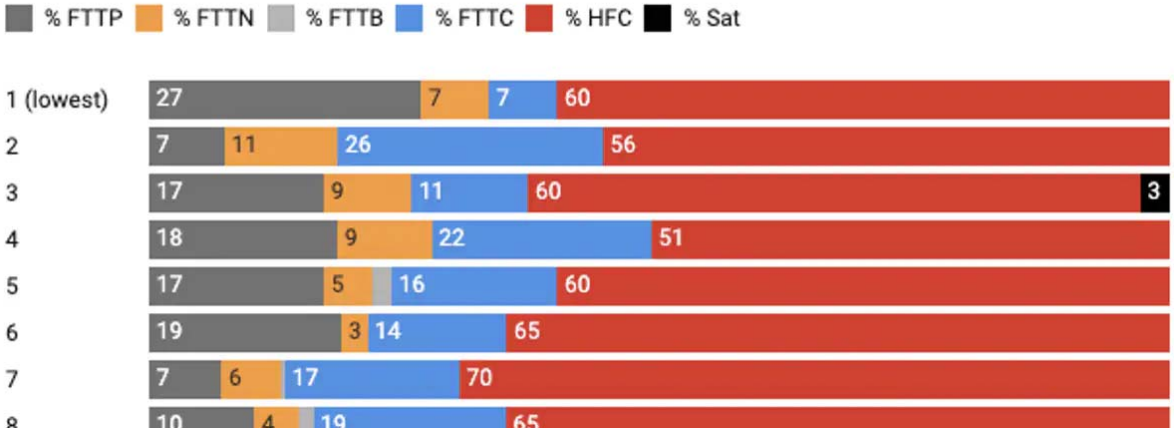
Sydney



Melbourne



Brisbane



Availabilities of different technologies across different socioeconomic deciles (1 = lowest socioeconomic status, 10 = highest) in Sydney, Melbourne and Brisbane. NBN technologies are FTTP (fibre to the premises), FTTN (fibre to the node), FTTB (fibre to the building), FTTC (fibre to the curb) and the older HFC (hybrid f bre-coaxial) and Sat (satellite).

The second most dominant technology in the three major cities is fibre to the curb (FTTC). This is a technology that was only added to the mix 12 months ago, as a partial solution in response to the mounting issues related to the HFC network.

If it was not for this late addition to the network, the NBN footprint may have had an even higher dominance of old HFC technology than currently. It's also clear that the rate of FTTC adoption in greater Brisbane is well below that in Melbourne and Sydney.

An NBN upgrade is inevitable

Since the announcement of mixed-technology NBN, experts have warned against the serious shortcomings of the old HFC technology.

While these were mostly ignored initially, Bill Morrow (then CEO at NBN) later admitted that NBN speed was slowed by reliance on copper network. Supporting this, an analysis by the Australian Communications and Media Authority (ACMA) revealed that the average household on the HFC network was reporting between 2 to 3.6 times more faults than those on fibre, and making between 3 and 5 times more complaints.

It's also been reported that about 40% of the NBN is fibre to the node (FTTN) which has its own fair share of issues.

Interestingly, there have already been some partial upgrades within NBN Co's plans, as FTTC reportedly accounts for about 12% of the national network, to serve the areas that were previously assigned to receive HFC.

Having said this, Labor's latest announcement seems to be focusing on what can be described as "improving consumer experience" without making any commitment for more fibre-to-the-premises (FTTP), or at least more fibre.

We argue that for Australia and Australian major cities to be competitive on the global platform, an NBN update is inevitable.

Internet **NBN** **Inequality** **Broadband** **NBN Co** **National Broadband Network** **NBN network** **Inequity**

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Alizadeh, T., Helderop, E., Grubesic, T. (2019) Socio-Spatial Patterns of the NBN Rollout: It is worse than what you think. Paper presented at the State of Australian Cities National Conference 2-5 December, Perth.

Socio-Spatial Patterns of the NBN Rollout: It is worse than what you think

Tooran Alizadeh[1], Edward Helderop[2], and Tony Grubesic[2]
[1]The University of Sydney
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Abstract: The paper focuses on the socio-spatial patterns of the National Broadband Network (NBN) that using a mixed-technology platform is being rollout across the Australia. One of the vexing aspects of the mixed-technology NBN is the lack of data transparency which has drastically limited the ability of evidence-based telecommunication policy analysis. The purpose of this paper is to leverage basic data mining techniques, combined with census-based socio-spatial data (SEIFA), to uncover the geographic intricacies of the NBN at the metropolitan regions of Sydney and Melbourne. The findings in terms of the dominance of some of the inferior technological options (e.g. HFC) across the two major metropolitan regions, are quite shocking. The paper concludes with a discussion of equity implications, and calls for telecommunication infrastructure to be accounted for in the future strategic planning.

Key words: *National Broadband Network; Sydney; Melbourne; HFC; mixed-technology*

Introduction

Broadband is a generic term for high-speed internet, delivered by a range of platforms (e.g. cable, fibre, wireless and satellite). The Federal Communications Commission in the US defines broadband as at least 25 Mbps downstream and 3 Mbps upstream. More importantly, broadband has evolved into an essential determinant of social equity and economic prosperity, providing access to e-health, e-education, e-business, and e-governance among other online services (Alizadeh, 2015b; Baum, et al., 2012; Latulippe, et al., 2017).

Nevertheless, inequity of access has been a persistent feature of this fast growing critical infrastructure in many parts of the world. At a global level, the digital divide is well alive and perhaps widening (Pearce and Rice, 2017; Ragnedda and Muschert, 2013). The gap is not just limited to the global north versus the global south. Focusing on the OECD countries only, nowhere have the equity gaps been more pronounced than with fibre broadband (OECD, 2016b). Geographically smaller, densely populated countries such as Japan, South Korea, and Latvia lead in the deployment of fibre broadband infrastructure. In contrast, in larger, more geographically dispersed countries such as the US, Canada, and Australia, fibre adoption lags behind the OECD average.

The emphasis on fibre broadband in telecommunication discussions is timely, as recent studies warn that calls for the death of wireline systems (Grubesic, et al., 2018; Worstall, 2013a, 2013b) are premature, the wireless spectrum is heavily constrained, and wireless transmission remains susceptible to environmental interference, reducing its reliability (Grubesic, 2017; Vantage Point, 2015). As a result, wireline fibre broadband remains the most logical platform for accommodating growing demands for quality telecommunication services.

It is, however, important to acknowledge that the main barrier restricting research on telecommunication infrastructure deployment, in general, and of fibre networks, in particular, is the lack of data transparency (Grubesic and Alizadeh, 2019; Helderop, et al., 2019). There is a long, well-documented history of resistance by telecommunication companies to sharing information on provision/service footprints, pricing, quality of service and expansion plans (Alizadeh, et al., 2017; Flamm and Chaudhuri, 2007; Grubesic, 2012). The oft-cited excuse used against data transparency around telecommunication infrastructure is that the disclosure information either puts providers at a competitive disadvantage, or threatens the security of the infrastructure network (Grubesic, et al., 2018; Grubesic and Mack, 2015). These concerns can be valid in certain circumstances, but over time data obfuscation drastically limits the ability of policy analysts to evaluate equity implications associated with the telecommunication provision.

This paper builds on the growing arguments in the literature on the equity implications of telecommunication infrastructure, and the data challenges around the topic. It then focuses on the National Broadband Network (NBN) in Australia as an example of a large scale telecommunication infrastructure project, made possible by public funding. The paper offers a brief review of the ups and downs of the NBN acknowledging the data restrictions around the project which has highly limited evidence-based research on its equity implications. We will then describe details of our study in which basic data mining was leveraged to uncover the spatial presence

of the NBN across metropolitan regions of Sydney and Melbourne. The NBN data is then combined with census-based socio-spatial data (SEIFA), to uncover the geographic intricacies of the network, accounting for the differences in the quality of mixed-technologies involved, and socio-economic status of the populace served. The paper concludes by a call for further policy implication analysis focusing on the links between telecommunication infrastructure quality and strategic planning.

Equity Implications of Telecommunication Infrastructure

There is a broad consensus that telecommunication infrastructure has the potential to increase economic growth and social well-being (OECD, 2016a; World Bank, 2015), and yet there is widespread concern about a growing digital divide in which digital inequalities exacerbate existing inequalities (Grubesic and Mack, 2015; Haight, et al., 2014; Schram, et al., 2018). Indeed, since the turn of the century, a growing number of countries including the UK (Galloway, 2007), Korea (Oh and Larson, 2011), Germany (Katz, et al., 2010), New Zealand (Apatov, et al., 2018) and Australia (Alizadeh, 2015a) have undertaken substantial direct government investment in broadband infrastructure, often justified by reference to long-term social equity and economic prosperity grounds.

In parallel, a growing number of studies document inequity of access to telecommunication infrastructure at national levels. Several US-based studies (Grubesic, 2017) detail gaps in availability, speed, price, and quality of service when comparing broadband in urban and rural/remote areas. It is then argued that rural and remote regions in the US are often one or two technology generations behind larger urban markets (Grubesic and Mack, 2015). Having said this, telecommunication provision in the US – to a large extent – is based on commercially-driven business models as private providers are the major players in the telecommunication market.

The question of equity of telecommunication infrastructure, is of even greater importance when and where telecommunication infrastructure is provided using public funding (Alizadeh, 2017b; Athavaley, 2017). In Australia, for example, the significant public investment in the infrastructure – in the format of the National Broadband Network (NBN) – was justified on the equity grounds (Alizadeh, 2015c). Indeed, in August 2011, the Standing Committee on Infrastructure and Communications of the Parliament of Australia tabled its report on the potential of the NBN to enhance economic and regional development and social and community activity (Parliament of Australia, 2011). Throughout the report there was a great emphasis on the significant role of the NBN to ensure greater equity across Australia's communities in regard to access to government services through e-government, e-health, and e-education particularly in regional and rural areas, and for people who are geographically isolated.

Ups and Downs of the NBN

The roots of government investment in a national broadband network in Australia goes back to 1994, when under an Australian Labor government concerns were raised in the senate about monopoly power in Australia's telecommunication infrastructure (Schram, et al., 2018). Later in 1995, then Prime Minister Paul Keating noted "…that access to the national information infrastructure will be no less a general right than access to water, or public transport or electricity" (Keating, 1995). However, before any initiatives commenced, a conservative Coalition government was formed in 1996 which marked the beginning of an eleven year period of a national broadband strategy that prioritised subsidises for market actors to support development in regional and remote areas. By failing to address the initial concerns, in the mid-2000s Australian telecommunication company, Telstra, held the single largest telecommunications monopoly in any developed economy. It is argued (Gregory, 2017; Ryan, 2017) that Telstra's market dominance allowed it to delay broadband upgrades.

The federal election in November 2007 saw a return of a Labor government which was elected on a policy platform that promised a national broadband network (NBN). Then Australian Labor Government on several occasions declared that the NBN would lead to a major structural reform of telecommunication across the nation (DBCDE, 2010). The NBN Co. was announced in April 2009 to provide terrestrial fibre network coverage for 93% of Australian premises by the end of 2020. Fixed wireless and satellite coverage would serve the remaining 7%. Soon after this announcement the early rollout began, first in the island of Tasmania and then on mainland Australia. The early NBN was gradually announced and included 60 locations across the nation. Additionally, in March 2012, NBN Co. announced plans for the first stage of the large-scale rollout to follow, connecting 3.5 million premises in 1,500 communities by mid-2015 (NBN Co. Ltd., 2012). The early NBN rollout, however, experienced significant delays. This attracted a great deal of "overwhelmingly negative" media

coverage (Saarinen, 2014). Further, previous research showed that the early NBN rollout was perhaps politically motivated (Alizadeh and Farid, 2017) and socioeconomically biased (Alizadeh, 2015b).

In 2013, then recently elected Coalition government suspended the first stage of the large-scale fibre-to-premises NBN rollout to reassess the scale of the project. As a result, the Coalition fundamentally altered the implementation strategy for the NBN (Alizadeh, 2017b); replaced approximately 60% of the fibre-to-the-premise (FTTP) rollout with a multi-tech mix of fibre-to-the-node (FTTN) and hybrid fibre coaxial (HFC). FTTN and HFC, as well as the fixed wireless, and satellite are all inferior to FTTP in terms of "…speed and capacity delivery, maintenance costs, reliability, longevity and upgrade costs" (Grubesic and Mack, 2015; Quigley, 2016).

Following this change of direction, the Coalition has been facing heavy criticism itself (Coyne, 2016; Tucker, 2015, 2016) as the NBN remained behind schedule and over budget, while delivering an inferior product. More importantly, the ongoing secrecy around the NBN, has made it difficult to properly assess the progress of the national infrastructure project (Pinnell, 2017). Indeed, the first formal evaluation of the Coalition's plan was to come from the NBN Co. to the Federal Coalition government. However, the NBN report was omitted from any public documentation and repeated freedom of information requests for its release were denied (Schram, et al., 2018). The NBN Co. report, later leaked to the public, revealed a damning assessment of the Coalition plan. NBN Co. had advised that the proposed FTTN would not deliver the Coalition's policy promise of guaranteed 50Mbps services; and instead it would produce lower revenues, keep prices higher, face resistance from local government, and threaten the ability to provide proper e-government, e-health and other online services across the network.

Equity implications of the NBN

Concerns around the equity implications of the NBN are not new. Indeed, previous studies focusing on the early stages of the NBN rollout in Australia warned against the equity implications of the infrastructure project (Alizadeh, 2013, 2015b). It has been argued that the early-rollout was not set to benefit the least well-off in the society; was politically motivated; and could possibly exacerbate social inequities and divisions already in place (Alizadeh and Farid, 2017). Nevertheless, the analysis of the early-rollout was never comprehensive enough to make a solid judgment on the implications of a national project such as the NBN.

More recently, there has been an attempt to evaluate health equity implications of the NBN, considering the huge impact of the national infrastructure project on e-health (Schram, et al., 2018). This analysis was based on the one occasion in which, on 07 December 2016, the NBN Co. released a dataset including NBN status (including service available, build commenced, or build preparation), and service type (brownfields fibre, greenfields fibre, fixed wireless, or 'other' [satellite]) at the postcode and suburb level. In this work, Schram and her team (2018) showed that across Australia, areas with greater disadvantage had received proportionately less NBN fibre technology (and consequently more fixed wireless and satellite technology) relative to areas with least disadvantage. Further, the socio-economic gradient of NBN technology was present even when holding the level of remoteness constant. That is, the gradient was present when the analysis was restricted to only major cities of Australia, or to only inner regional areas, or to only outer regional areas. In saying so, it is important to acknowledge that, the Dec 2016 dataset did not capture the complexity of the mixed-technology NBN as it did not offer detail information on the full range of technological options. Moreover, there was a gap in the study conducted by Schram and her team (2018) as it lacked spatial dimension; and the geographic patterns of the NBN rollout were mostly unexplored (there was no mapping). Our study focuses on this gap.

Our Study

It aims to understand the unfolding equity effects of NBN rollout, by portraying and analysing the spatial distribution of mixed-technology NBN across the two largest metropolitan regions in Australia, namely Sydney and Melbourne. However, we, by no means, claim to portray a comprehensive analysis of the socio-spatial equity implications of the national telecommunication infrastructure in Australia. Instead, we hope to show the need for quality NBN data to inform a more nuanced and reliable evidence base foundation on which to formulate future policy.

Data challenges

Several researchers focusing on the NBN, including the authors of this paper, have had unsuccessful experiences in seeking any information from the NBN more than what is publicly available (Schram, et al., 2018). The NBN Co refuses to share aggregated information on service footprints or the quality of services

offered at any meaningful level. The current system on the NBN website offers interfaces to make rudimentary spatial queries, at a very coarse level of data, and no data can be downloaded at all for any research or analysis.

Data mining

To address the shortcomings of the publicly available NBN data, we adapted and applied an automated data mining technique to harvest information on the NBN rollout. It is similar to the suite of tools used to harvest Google Fiber for several US cities (Alizadeh et al. 2017). The NBN Co. offers a 'check your address' function on its website which gives individual businesses and residences information about the status of the NBN rollout for a specific address. This tool provides information detailing the current connectivity status of that address. For addresses that are currently connected, the search tool details the type of technology used (e.g., FTTP, HFC, etc.). For addresses that are not connected, the tool provides the likely future technology, a date range by which the NBN Co. plans to connect the address, and the approximate current stage of construction.

Unfortunately, the 'check your address' tool interface is limited. Only a single address can be searched at any given time and there is no native way to download the provided data for a given address via the website or tool. To circumvent these limitations, we implement a grid-based spatial sampling strategy to capture a representative sample of addresses across metropolitan Sydney and Melbourne. We also automate the process for retrieving the NBN information for each address.

The cities that comprise our study area, Sydney and Melbourne contain 1,233,856, and 968,149 addresses respectively. Given the limitations of the data-gathering tool, it is not feasible to check individually each of these addresses for NBN status. Instead, we drape a fishnet-grid of polygonal cells over each city. The cells were square, consisting of 40 acres (402 meters per side). Each cell inherits a random, representative address (drawn from all addresses geographically located within a cell) for representation. This reduced the sampling load from over 2.5 million addresses to 4,767 (Sydney), and 5,202 (Melbourne) representative addresses. It is important to note that our sampling method does not account for address density, so for example a grid cell that contains only a few addresses will still have one representative address and be sampled once, while one that contains hundreds of addresses will likewise receive just one and be sampled once. In other words, the reason Melbourne has more sampled addresses than Sydney is because the total area we covered in our fishnet grid was larger. Again, this is similar to a method that has been used effectively to harvest Google Fiber data from Kansas City, Provo, and Austin within the United States (Alizadeh et al. 2017; Grubesic et al. 2018). The grid generation and address sampling was performed with Python 2.7.

Each of these 9,969 addresses were then systemically checked on the NBN 'check your address' tool using AutoHotkey. AutoHotkey is a scripting language that automates keyboard and mouse inputs, and was used in this case to copy and paste addresses into the NBN tool, and then copy and paste the resulting information back into a master database. After examining the resulting database for errors, we connect service addresses (and NBN provision information) to the grid cell shapefile using Python 2.7 and analyse/visualize the data in ArcGIS 10.5.1. For metropolitan Sydney, we collected data three times November 2018, December 2018, and January 2019. Based on the consistency between these datasets, we are satisfied that the NBN Co.'s tool provides up-to-date information and that our sampling method is valid.[1] Melbourne's results were gathered in January 2019.

Socio-Economic Index for Areas (SEIFA)

The Australian Bureau of Statistics Census-based Socio-Economic Index for Areas (SEIFA) scores are the most widely used general measure of socio-economic status in Australia. While there has been some criticism of the SEIFA in the past, they have proved to be a reliable overall measure of socio-economic status and the only nation-wide measure available at a local level. A number of urban studies over the last decade have shown that there are important theoretical and practical lessons to be learned using SEIFA indexes. In a sense, we build upon the methodological advances proposed in earlier urban research on the socio-economic distribution of infrastructure (e.g. transport, telecommunication, and housing) (Alizadeh, 2013, 2015b; Alizadeh, et al., 2018; Dodson, et al., 2007).

[1] For example, some address data collected in November 2018 suggested a connection date for December 2018. In revisiting these addresses during the December and January scans, a verification procedure confirmed changes in connection dates (or verified a connection) during subsequent data harvests.

This paper uses the 2016 SEIFA as its main analytical dataset to critically examine the socioeconomic patterns on the NBN rollout. More specifically, we used the SEFA Index of Relative Socio-economic Advantage and Disadvantage which encompasses the entire socio-economic spectrum, a continuum of advantage (high values) to disadvantage (low values), and is derived from Census variables related to both advantage and disadvantage. For each index, every geographic area in Australia is given a SEIFA score which shows how that area is compared with other areas in Australia. In each index, all areas are then ordered from lowest to highest SEIFA score, with the lowest 10% of areas given a decile number of 1 up to the highest 10% of areas given a decile number of 10. We then cross examine the SEIFA decile data with the mixed-technology NBN data extracted via the data mining exercise (described above); to uncover the socio-economic patterns of the service distribution.

In our study, the ABS Statistical Area Level 1 polygons (SA1) are the primary geographical entity for analysis. Across Australia, there are just over 57,000 SA1 polygons, and contain an average population of 400 people. In order to combine our NBN technology data (at the grid cell level) to SA1 polygons (which are far more irregularly shaped), each SA1 polygon was assigned NBN technology results based on the majority coverage of the grid cells that fall within its borders.

Results

Spatial patterns of the mixed-technology NBN

Figures 1-2 show the spatial distribution of the mixed-technology NBN across two metropolitan regions of Sydney and Melbourne. The uncovered mixed-technology network footprint, across both regions, is a combination of fibre to the premises (FTTP), fibre to the node (FTTN), fibre to the building (FTTB), fibre to the curb (FTTC), hybrid fibre-coaxial (HFC), fixed wireless and satellite (Sky Muster) – see Table 1 for detail information about the share of each technology in the network.

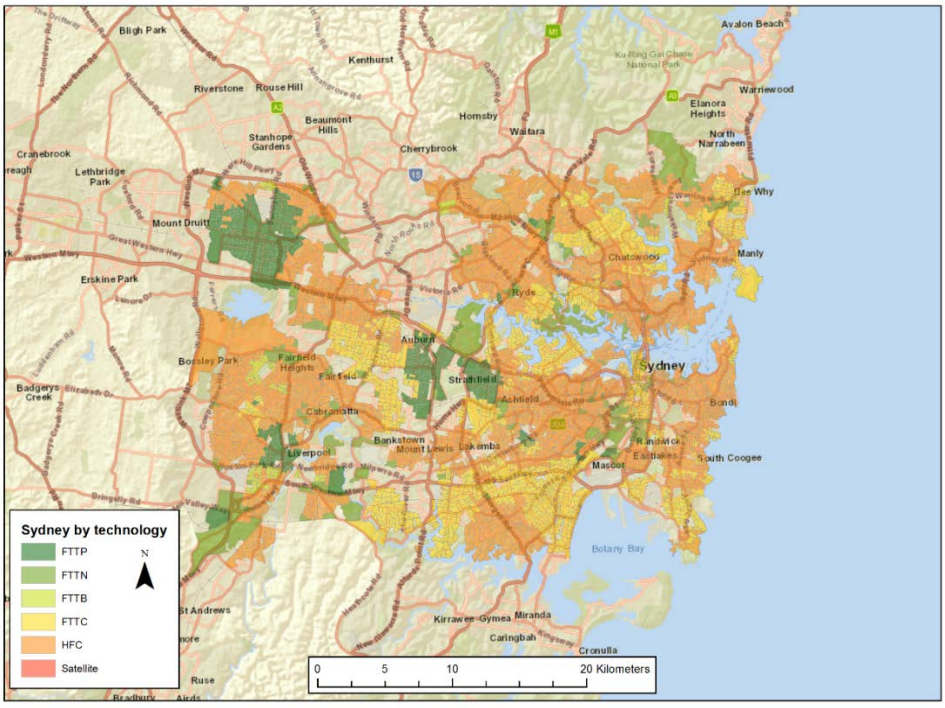

Figure 1. Spatial patterns of the mixed-technology NBN across the Sydney metropolitan region

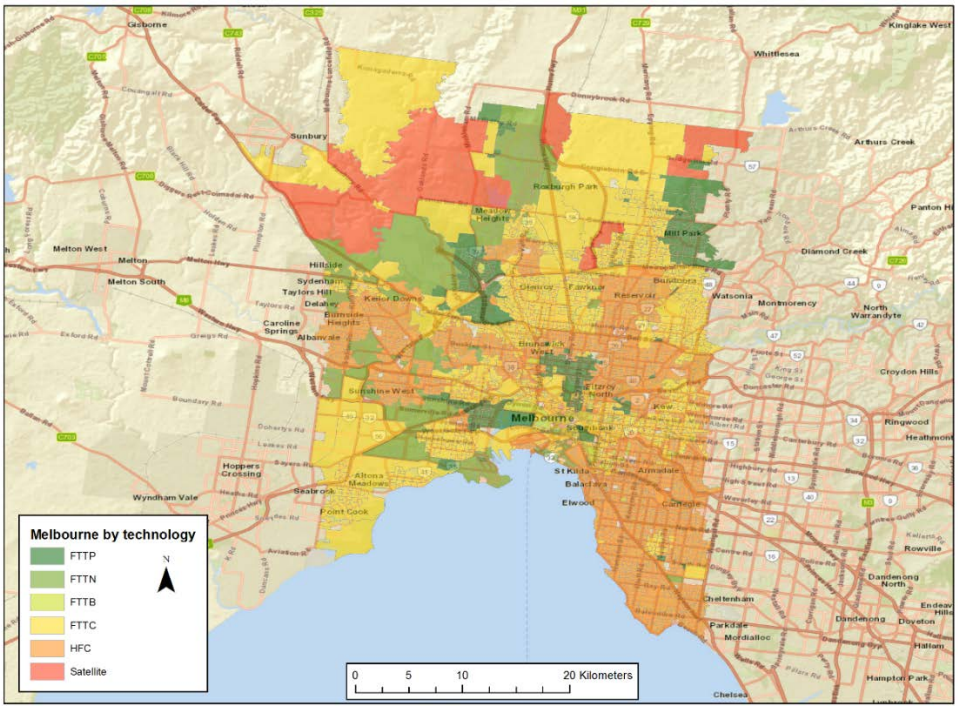

Figure 2. Spatial patterns of the mixed-technology NBN across the Melbourne metropolitan region

55% of all addresses in the Sydney metropolitan region are or soon will be connected to the NBN using HFC, which is the oldest technology available in the NBN mix. The presence of HFC is strong across the whole metropolitan region especially in the eastern suburbs (including but not limited to Bondi, Coogee, Eastlake), inner west (Marrickville, Dulwich hill, Leichardt), North and North-west Sydney (e.g. Lane Cove, North Ryde), and also western Sydney (e.g. Fairfield, Wetherill Park). It is the most dominant technology available across the Sydney metropolitan region, only seconded by fibre to the curb (FTTC) which covers 26% of all addresses.

On the other hand, just over 10% of the addresses (10.7%) are or soon will be connect to the NBN via the fibre to the premises (FTTP) which is the most advanced technology available in the mixed-NBN platform. FTTP connections are scattered across the metropolitan region with some pockets being identified in western Sydney (parts of Auburn and Strathfield), and outer-western Sydney (Blacktown and Liverpool). Fibre to the node (FTTN), which was criticized widely in terms of its service quality and reliability only accounts for 5.7% of the addresses across the Sydney metropolitan region. While this is relatively a very small percentage of all addresses, some of the locations covered by the FTTN are quite concerning. For example, presence of pockets of FTTN in inner Sydney (over Newtown, Alexandria, and Erskineville), and in western Sydney (around Sydney Olympic Park and Wentworth Point) does not align with the emphasis put on those as development and employment priority areas in the strategic metropolitan plan for Sydney (GSC, 2018).

Table 1. Presence of mix-technology NBN across metropolitan regions of Sydney and Melbourne

	FTTP (%)	FTTN (%)	FTTB (%)	FTTC (%)	HFC (%)	Sat (%)
Sydney	10.7	5.7	2	26	55	0.6
Melbourne	9.75	11	2.4	34.85	41.75	0.25

The mixed-technology NBN's distribution in the Melbourne metropolitan region is similar but slightly different to Sydney. In comparison to Sydney, Melbourne has a lower rate of HFC (less than 42%); and a higher rate of FTTC (just below 35%). While these aforementioned figures are somehow positive, it is important to note that the Melbourne region also has a higher rate of FTTN take up (11%), and a lower rate of FTTP take up (less than 10%). In terms of geographic distribution, most of eastern side of Melbourne region (south of Metropolitan Ring Road) are covered by the HFC with pockets of FTTC in Bundoora, Macleod, and Kew. The distribution pattern is western side of Melbourne is much more mixed with a combination of all of the technologies involved in the mix.

Major cities rely on HFC

Looking at Figures 1-2 and Table 1, it is clear that both major metropolitan cities of Sydney and Melbourne rely on the Hybrid Fibre-Coaxial (HFC). HFC is the oldest technology component of the NBN, based on the old cable network many Australian households might have connected to in the past to get Foxtel subscription TV. As pointed out earlier, 42% of all in greater Melbourne, and 55% of all in Sydney already are or will soon be connected to the NBN via the inferior HFC technology. These figures strongly question the ongoing claims of the government around building "a new network"; as for about half of the population in both major Australian metropolitan regions, the NBN looks like a rebranding exercise using an old cable network.

Since the announcement of the mixed-technology NBN, several experts warned against the serious shortcomings of the old HFC technology (LeMay, 2015). While the early expert warnings were mostly ignored, later on the NBN CEO admitted that the NBN speed slowed by reliance on copper network (Karp, 2018). Indeed, an ACMA analysis, revealed that the average household on the HFC network was reporting between 2 to 3.6 times more faults than those on fibre, and making between 3 and 5 times more complaints (ACMA, 2017).

Interestingly, the second most dominant technology across all areas is Fibre to the curb (FTTC): a technology that was a late addition to the mixed-technology platform. Indeed, FTTC was added to the mix as a partial solution (Sas, 2018) in response to the mounting issues related to the HFC network (Mason, 2017). In other words, if it was not for this late addition to the network, the NBN footprint would be even more dominant by the old HFC technology, than it is right now.

Socioeconomic patterns of the mixed-technology NBN

In order to examine socio-economic patterns of the NBN rollout, we used the Australian Bureau of Statistics' (ABS) socio-economic indexes for area (SEIFA) and its index of Relative Socio-economic Advantage and Disadvantage (IRSAD) from 2016. Two graphs embedded in Figure 3 represent mixed results across the metropolitan regions of Sydney, and Melbourne; as we cannot necessarily identify any clear socio-economic patterns across better-off SEIFA deciles (8-10) versus worse-off deciles of 1-3. The highly concerning presence of HFC is seen all across the socio-economic spectrum.

The mixed socio-economic patterns of the NBN rollout is perhaps a reflection of the NBN Co – over the years and on multiple occasions - insisting that the network has been rolled out across Australia regardless of any socio-economic mapping (Alizadeh, 2013, 2015b; Schram, et al., 2017).

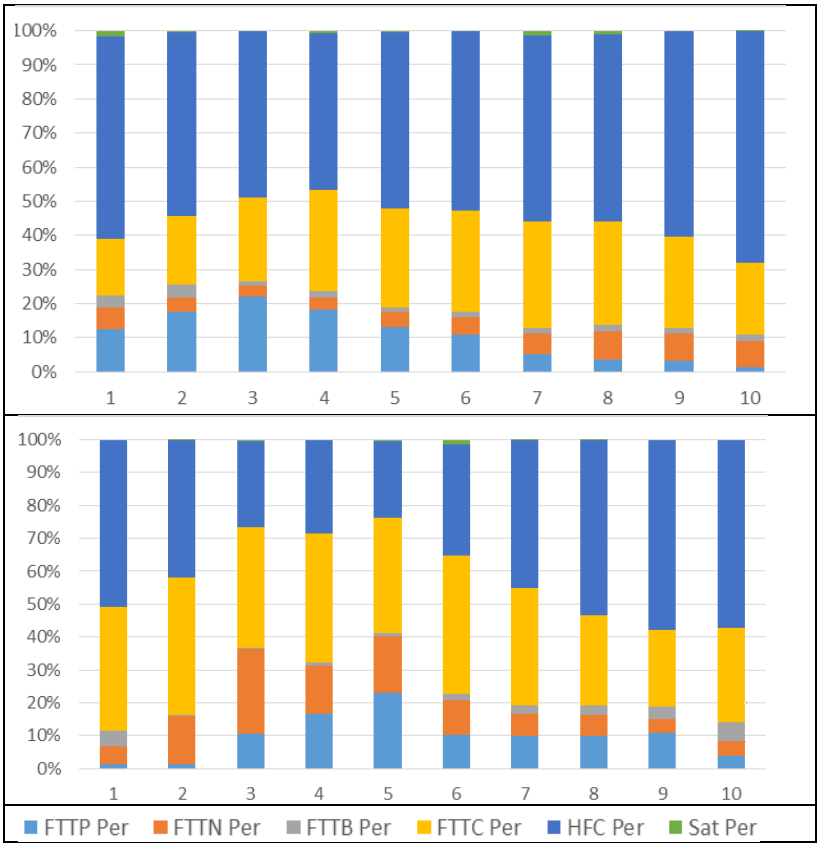

Figure 3. All addresses divided by NBN technology type, across the SEIFA deciles in the metropolitan regions of (from top to bottom) Sydney and Melbourne

Inadvertently, the NBN's insistence on not considering any socio-economic mapping may in fact help explain the mixed patterns observed in Figure 3. For example, in in Melbourne, the two lowest socio-economic areas (deciles 1 and 2)

have the smallest share of the FTTP which is the most advanced technology available on the NBN platform. This is contradictory to Sydney metropolitan region where the highest socio-economic areas (deciles 8-10) have the lowest share of FTTP.

The impact of these confusing and contradicting patterns on the urban equity is yet to be known. Indeed, we can only make such an analysis is the data for regional Australia and outside the metropolitan centres were also provided. However, what is clear is that once an infrastructure system (in this case the NBN) is laid out, it will create its own inertia implications for socio-economic growth or decline – depending on the quality of services provided (or the lack of in case of the inferior technologies involved in the NBN, for example).

The failure to enact an equitable NBN is likely to have long-term socio-economic consequences for the country. Inferior quality rollout will have lag effects for regional, remote, or smaller and medium sized cities in achieving economic growth. The resulting patterns of uneven spatial development at the national level may lead to unsustainable and inefficient urban forms, stunt economic growth for regions and smaller and medium sized cities, affect patterns of population concentration (as more populations will be progressively attracted to the big metros), thereby increasing the congestion and affordability pressures on the metropolitan regions, and increasing the already wide spatial inequalities between the big metro regions and the rest of the country. Therefore, further research on the economic geography of infrastructure rollout is essential and urgently needed.

Conclusion

In the absence of data transparency around the National Broadband Network (NBN) in Australia, this paper leveraged basic data mining techniques, combined with census-based socio-spatial data (SEIFA), to uncover the geographic intricacies of the NBN across major metropolitan regions of Sydney and Melbourne. By doing so, it –one more time – put emphasis on the importance of quality data to enable evidenced-based telecommunication policy discussions in Australia and beyond.

The findings in terms of the dominance of some of the inferior technological options (e.g. HFC) across the two major metropolitan regions, are quite shocking. In particular, the spatial patterns of the NBN rollout across the two metropolitan regions, open a discussion on how the telecommunication provision aligns (not) with the strategic plans put forward to direct the growth and future development of our cities and regions. Cross-examination of the NBN data against SEIFA only intensifies the need for alignment of telecommunication planning and strategic planning. This seems like the logical approach to make sure that priority areas identified as engine of growth and employment in our strategic planning documents have access to the high-quality reliable telecommunication infrastructure that is needed in the twenty-first century. It could be argued that future research on such alignment may be able to inform any future plan for future partial update of the NBN. This is especially significant, considering that the Australian government has rejected the call for a full transition to FTTP (Gregory, 2019). So, partial update focused on priority areas embedded in strategic plans are the only practical way forward for the NBN in Australia.

While the NBN is specific to Australia, there is significant international relevance. As additional countries pursue investment in broadband as an essential service, decision makers should look carefully to the successes and failures of the NBN. A national project that started as a dream infrastructure (Alizadeh, 2017a), has unfortunately turned to what the New York Times describes as the ‘what not to do’ of the broadband world (McMillen, 2017). Here, there is a lesson for other countries to follow the advice of the Broadband Commission for Sustainable Development (2016) and commit to long term investment in essential telecommunication infrastructure that will contribute to inclusive and sustainable development.

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