

Tang, Xin; Howell, Bronwyn

## Conference Paper

# Spectrum Policy on Broadband Market To Reduce Digital Divide and Promote Market Competition

31st European Conference of the International Telecommunications Society (ITS): "Reining in Digital Platforms? Challenging monopolies, promoting competition and developing regulatory regimes", Gothenburg, Sweden, 20th - 21st June 2022

### Provided in Cooperation with:

International Telecommunications Society (ITS)

*Suggested Citation:* Tang, Xin; Howell, Bronwyn (2022) : Spectrum Policy on Broadband Market To Reduce Digital Divide and Promote Market Competition, 31st European Conference of the International Telecommunications Society (ITS): "Reining in Digital Platforms? Challenging monopolies, promoting competition and developing regulatory regimes", Gothenburg, Sweden, 20th - 21st June 2022, International Telecommunications Society (ITS), Calgary

This Version is available at:

<https://hdl.handle.net/10419/265671>

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# ***Spectrum Policy on Broadband Market***

## ***To Reduce Digital Divide and Promote Market Competition***

*Xin Tang; Bronwyn Howell*

Victoria Business School, Victoria University of Wellington,  
Wellington, New Zealand

### **Abstract**

A necessary condition for digital transformation is ubiquitous access to high-quality communications networks, leading to the construction of communications infrastructure accessible to all citizens featuring prominently in the policy agendas of many countries. In New Zealand, this is reflected in the investment focus of the country's Ultra-Fast-Broadband (UFB) program aiming to roll out FTTP to 87% of households by 2022, and the Rural Broadband Initiative (RBI) improving mobile network connectivity in underserved and unserved locations.

In recent years, technological innovation has led to new network typologies and changing cost structures for all network types. These innovations raise questions about whether the appropriate policy response to reduce "digital divides" in access to infrastructure should be to pay specific firms to build predetermined infrastructures. This paper will use New Zealand's policy context of the UFB and RBI, and existing spectrum policy framework, to explore policy options for addressing digital divides.

The inquiry uses Causal Loop Diagram (CLD) modelling as a tool to inform policy development and assessment. The CLD models will capture the interactions between policy, market, regulations and technologies, and allow comparative evaluation of the expected effects of different interventions. In particular, the models will explore how new technologies and spectrum policy influence competition between different network types.

### **KEY WORDS**

Spectrum Policy, FTTP, FWA, LEO satellite, network sharing, spectrum sharing, digital divide

## Introduction

In the digital economy era, broadband is one of the fundamental tools to help connect people, businesses and government. Providing high-performance broadband for people and business is the most fundamental policy action from governments worldwide. In New Zealand, this is reflected in the investment focus of the country's Ultra-Fast-Broadband (UFB) program aiming to roll out Fibre to the Premise (FTTP) to 87% of households by 2022, and the Rural Broadband Initiative (RBI) improving mobile network connectivity in underserved and unserved locations.

Government broadband policies were previously heavily based on fibre as the single technology. Although Mobile Network Operators (MNOs) offered wireless broadband decades ago, the spectrum policy had very little impact on the broadband market due to the large performance gap between wireless compared with wired solutions. With the technology evolution in particular the recent 5G and Low Earth Orbit (LEO) satellite deployment, wireless broadband now gains more appetite from consumers.

This change in the market dynamics brings several questions to the regulator and policymaker. First, is the regulatory framework largely built on fibre technology still fit the current and future market environment? Second, how to design the spectrum policy to promote fair market competition between broadband solution providers? And finally, instead of solely relying on subsidies from the government, can policymakers use spectrum policy to reduce the digital divide?

## Overview of New Zealand broadband market, government policies and regulations

### Broadband solutions in New Zealand

ICT industry is well developed in New Zealand and there is a range of broadband technologies for consumers to choose. According to the annual telecommunications monitoring report from Commerce Commission, 64% of NZ's total broadband connections use fibre technology (Commerce Commission, 2022). In recent years, fibre-to-the-premise (FTTP) has gradually replaced the digital subscriber line (DSL) with its decent performance and scalability. DSL, which currently represents 18% of the total connections will further diminish in the broadband market in the few years alongside the national cable operators Chorus announced the copper line services decommission in some areas. Fixed wireless connections have increased steadily in its market share, it representing 15% of the total connections in 2021. More subscriptions are expected when 5G based fixed wireless becomes widely available. Satellite broadband currently only represents a very small market share due to its cost and performance. However, the Low Earth Orbit (LEO) satellite constellations currently deployed or planned to deploy by international technology giants have significantly improved their capability. Unlike terrestrial service requires infrastructure close to users, satellite broadband can be ubiquitously accessed. In the future, it is expected more users, especially in the rural areas where terrestrial service is patchy or even not accessible, will subscribe to satellite broadband.

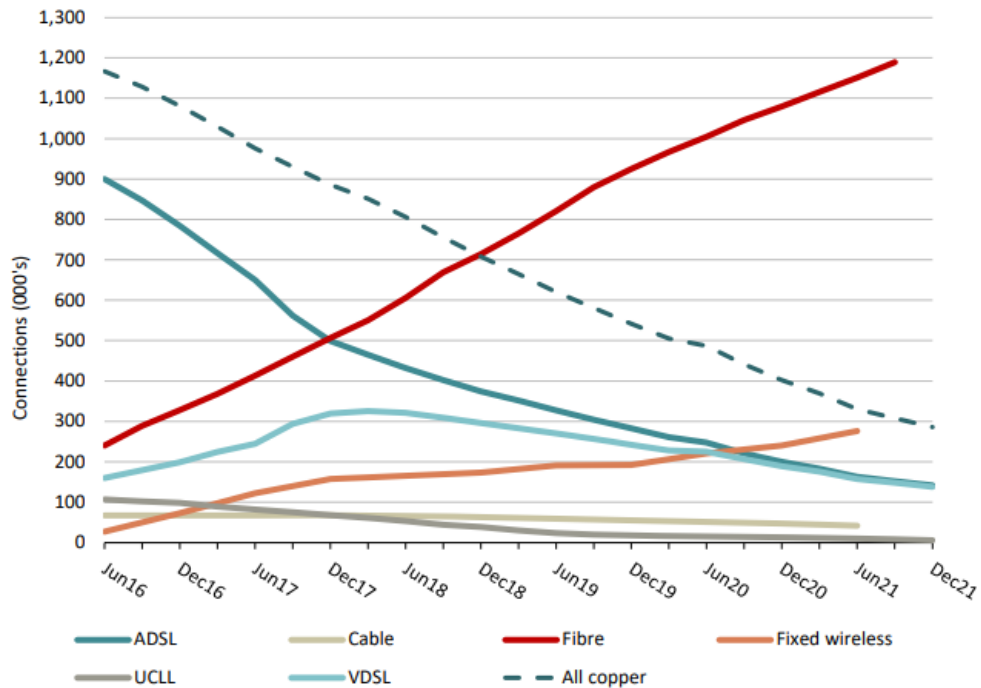


Figure 1 NZ Fixed-line broadband connections by technologies (Commerce Commission, 2022)

The anatomy view of NZ telecommunication market is shown in Figure 2. By looking at different business models, the market can be vertically viewed into two layers. The top layer resides the broadband network infrastructure providers, which can be categorised as fibre providers like national fibre company Chorus and local fibre companies, mobile network operators, regional wireless internet service providers and satellite broadband operators based on their technology solutions. NZ's Telecommunication Act doesn't allow fibre companies to retail their services to end customers. The fibre companies can only wholesale their services to retail service providers (RSPs) which sit in the layer underneath. By contrast, the Act doesn't regulate the wireless industry on their business models, MNOs are thus vertically integrated though some may wholesale their services to virtual MNOs. In addition to mobile and wireless broadband services, the big three national MNOs - Spark, Vodafone and 2Degrees are also fibre broadband RSPs, they contribute a total of 79% of the fibre broadband market share. Satellite operators use a hybrid business model to reach consumers. There are some offer broadband direct to retail market like SpaceX, though other satellite operators prefer only doing wholesale business with MNO or WISPs only. Currently, the target market for satellite broadband is households in rural areas, where lack fibre and wireless broadband access prevails.

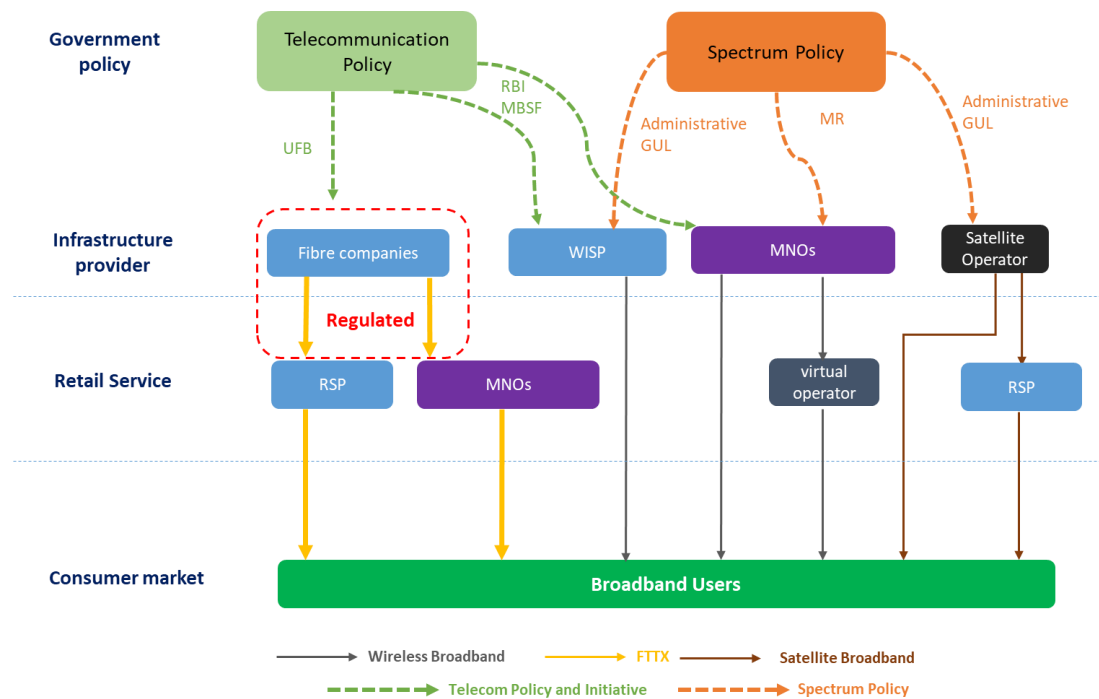


Figure 2 NZ Telecommunication market ecosystem and policies

## Government initiatives and the regulation

The fast adoption rate of fibre broadband is largely thanks to government’s UFB initiative. In 2009, The government initiated the UFB project that plans to roll out FTTP connections to 87% of New Zealanders by 2022. The UFB project is governed by Crown Infrastructure Partners Limited (CIP) under a public-private partnership arrangement. A range of service obligations had been agreed in the contract, and a wholesale only model as well as a price cap for UFB partners (CFH, 2018).

The contract set “line of business restriction” to the fibre network providers from retailing services direct to end consumers. Instead, it only allows the wholesale only model for UFB partners with a regulated price. Under the original UFB contracts, one of the policy requirements for the partners firms must be structurally separate network operators – that is, have no ownership interests in retail operations. Following the requirement, Telecom New Zealand structurally separated its retail and network operations on its legacy copper infrastructure as well as its frontier fibre infrastructure (Howell, 2013).

As the UFB contracts are set to expire on 31 December 2021, the government is developing a new regulatory regime for UFB services under the Telecommunication Act 2001 Part 6 – “Fibre fixed line access services” to replace the contract. This piece of regulation addresses fibre companies’ natural monopoly on fibre access network by giving the Commission responsibility for setting rules (‘input methodologies’) relating to matters such as maximum revenue fibre providers can earn and minimum network performance it must provide. It inherits the wholesale only from the UFB contract. This part also requires fibre providers who are subject to regulation must provide an “anchored service<sup>1</sup>” (MBIE, 2021), which is subject to a maximum wholesale price

<sup>1</sup> The term “Anchor Service” is defined under [Section 227, Telecommunication Act 2001](#). Under the draft regulation, the broadband anchor service refers “a broadband internet access service with a minimum download speed of 100 Mbps and a minimum upload speed of 20 Mbps, provided in accordance with regulations 7 and 8.

fibre companies can charge.

In addition to the UFB, there are two other government initiatives to help address the challenge of rural broadband performance and mobile coverage. The Rural Broadband Initiative (RBI) seeks to provide fast broadband to the under-served rural homes and businesses within the funding available and contribute towards achieving similar rates of access to fast broadband by rural end users across all regions of New Zealand. A joint venture between three MNOs and Wireless Infrastructure Service Providers (WISPs) is partnered with the Crown is building the infrastructure. The Mobile Black Spots Fund (MBSF) aims to improve the availability of mobile services to support safety on state highways and enhance visitor experience at key tourist destinations, which do not currently have coverage from any mobile operators. The project is accessed by three national MNOs with equal access right on the mobile sites. Both the RBI and MBSF are fully government funded projects governed by the CIP.

Providing fibre broadband to those sparsely populated areas can be very expensive. However, the absence of building clusters makes the rural areas ideal for radio waves to propagate. Fixed wireless broadband is by far the most cost-efficient solution in rural. Sharing is widely used in rural broadband as it can reduce the cost of deploying wireless services significantly. Currently, MNOs use 4G MOCN technology to share their RAN infrastructure and spectrum assets. 错误!未找到引用源。 shows the sharing arrangement among three MNOs. The RAN infrastructure is shared as well as the backhaul service. Three MNOs have their separated core networks connected at a common point of interconnect (POI).

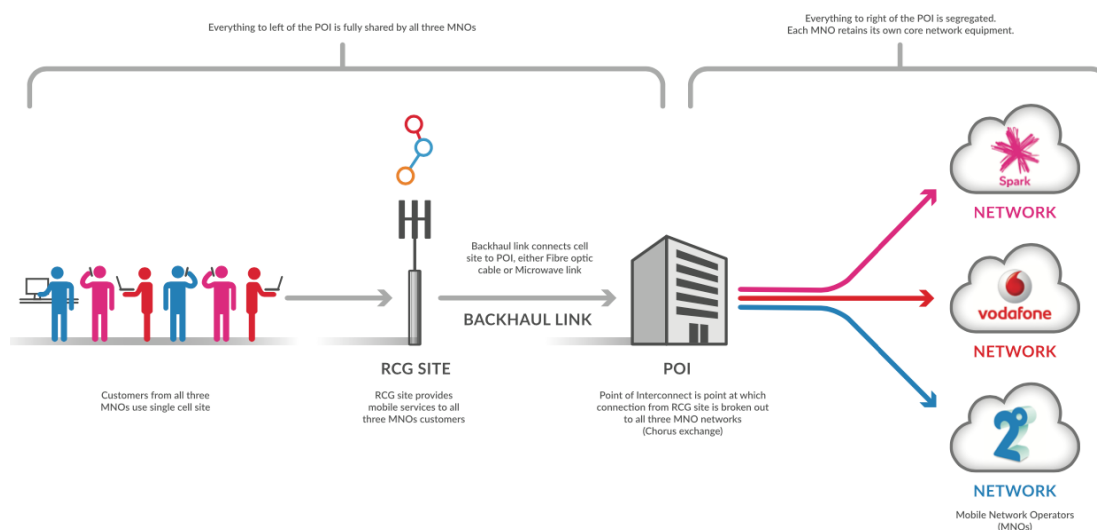


Figure 3 NZ RCG JV model of network sharing (Rural Connectivity Group, 2021).

## Spectrum policy

In contrast with fibre, wireless broadband is very lightly regulated in NZ. MNOs are free to differentiate their services and price them. The performance and cost of wireless broadband are largely affected by the radio spectrum assets MNOs hold. The Radiocommunications Act 1989 enables legislation for the use of radio spectrum in New Zealand. Under the Act, spectrum is authorised to use in three different regulatory regimes.

The Management Right (MR) is a tradable property rights regime, modelled on the Torrens system for land transactions. It was established to facilitate a spectrum market to meet the needs of deregulation in the spectrum usage, as it puts in place a framework of spectrum rights for assignment to those users who valued them most, thus obtaining their maximum economic value to society (Radio Spectrum Management, 2005).

The regime was proved to be very effective and efficient for telecommunication operators. MNOs can bid for and purchase spectrum and deploy certain technologies which suit their business cases most, with the prices revealed reflecting the best societal use of the scarce resource. These licences can be traded, but regulatory approval of the sale and purchase is usually required to preclude an operator from obtaining market power over the spectrum and thus services offered over it.

Where the demand for the spectrum is not high, the regulator uses an administrative licensing regime. Access to the spectrum is on a first-come-first-served basis with no competitive assignment and licences are not tradable as assets under the regime. Most of the non-cellular wireless communications services are provided under the administrative licensing regime. In contrast to MR, the administrative regime has more conditions for using the spectrum, for instance, licensees must follow certain technical and policy requirements, as well as equipment compliance.

The third regime is General User Licence (GUL). In some countries, it is also called licence-exempt or unlicensed. GUL uses typically includes low power, short-range communications such as Wi-Fi, Bluetooth, Ultra-Wide-Band communications, etc. The key consideration when using the GUL regime is whether there are significant public interest and the risk level of interference with other licensed services.

## **System analysis on digital divide and market competition**

System Dynamics (SD) modelling is commonly used in public policy design. A system is described as a “set of elements that is coherently organised and interconnected in a pattern or structure that produces a characteristic set of behaviours, often classified as its function or purpose” (Meadows, 2008, p. 188). The SD model recognises that a linear view linking goals and situations to problems, decisions, actions and results is likely to miss, inter alia, feedback loops between decisions and the environment and may also miss how the players in the system respond (Cadman, Curram, & Exelby, 2021). A system is considered in SD to have two features: stocks and flows, and feedback loops that may be either reinforcing or balancing.

Telecommunications is a highly complex system interlinked by technologies, economics, market and regulation. SD can be a very effective way to map the complex interrelationships within the system. First, SD goes beyond the linear model to map the cause and effect, it links decisions and all the consequences by using forward and feedback loops that reinforce or balance those outcomes. By showing the flow and stock in the system, SD can point to the time and place to put any policy intervention in the context of the system. There are a few academics using this model to explain telecommunication policy. (Davies, Howell, & Martin, 2009) use causal loop diagram (CLD) to map the relationship between intervention and outcome of the regulatory action on unbundling telecommunication local loops in New Zealand. (Howick & Whalley, 2007) use SD to understand the drivers of broadband adoption in rural and remote areas of Scotland.

Spectrum policy includes the mechanism of spectrum allocation and usage, this includes spectrum access rights, the method to allocate the spectrum, pricing and use obligations. In the complex telecommunication market, the spectrum policy input can have multiple consequences developed by the forward and feedback loops. The following chapter uses CLD to model the policy input and consequences. The CLD analysis will help to develop a policy that can address the market issue and challenge both in the short period and long run.

Globally, reducing digital divide is almost on top of every country's policy agenda. Providing high-performance broadband for communities with poor digital infrastructure is a prerequisite for achieving the policy objective. A lot of rural areas lack the economics of scales for either the public and private sectors to

invest efficiently. This challenge is even bigger in NZ where the population density is small and people live sparsely. For instance, lots of rural communities have a population density in rural areas less than 50/km<sup>2</sup>. By contrast, this number is over 500/km<sup>2</sup> in urban areas like Auckland, Hamilton, Wellington and Christchurch.

It is quite common that improving rural connectivity requires government policy intervention. RBI uses government funding to build the telecommunication infrastructure in the rural areas, the investment helps to reduce the digital divide between urban and rural by providing fast broadband connectivity to the under-served rural homes and businesses. Infrastructure is a key element for the rural economy to develop. With the high-performance broadband connectivity, more people are willing to migrate to the rural areas, which will build the economy of scale. With an economy of scale, more private investment can be expected in the areas. This eventually decreases the reliance on government subsidies. As shown in Figure 4, the RBI policy aims to create a rural economy and investment reinforcement loop.

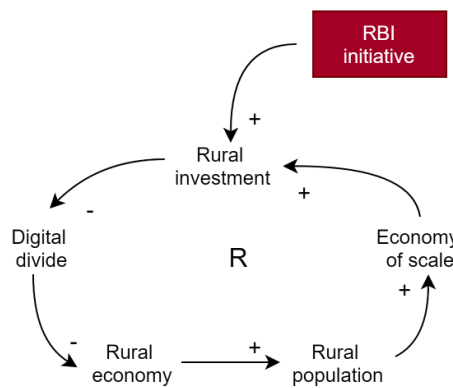


Figure 4 The reinforcement loop to reduce digital divide and increase investment

Despite investment from the government over the years, there is still a large digital divide between urban and rural in NZ. A recent broadband performance measurement from Commerce Commission shows the performance of wireless broadband is well behind fibre. For instance, the average downlink speed for wireless broadband is only 38.9Mbps, compared with 300Mbps for fibre which most urban users have access to.

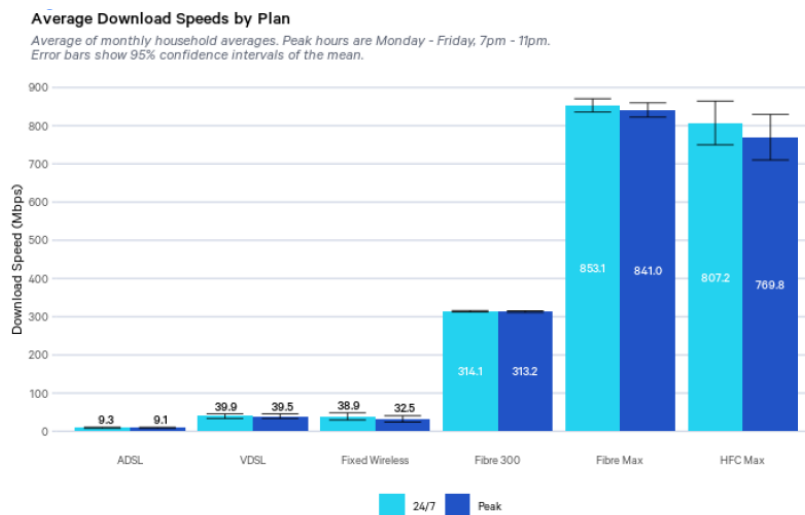


Figure 5 Average download speeds by different fibre plans



The popularity of wireless broadband in rural areas implies spectrum policy can be a powerful tool to address digital divide. Spectrum as a crucial resource to wireless broadband can be allocated in many ways with different policy objectives. Optimising the spectrum access opportunity can be quite critical to improving broadband performance in rural areas.

In NZ, Spectrum used for telecommunication is usually auctioned to MNOs on a nationwide basis. Usually, interest parties who want to acquire spectrum are required to meet certain conditions set by policymaker. Those conditions normally require parties to show proven records of deployment as well as spectrum utilisation plans. Take 4G spectrum allocation as an example, the auction condition requires parties who acquired spectrum to provide services to 50% of NZ's resident population within 5 years (Radio Spectrum Management, 2013). These stringent conditions determine only nationwide MNOs are eligible to purchase the spectrum. Spectrum rights are also exclusively allocated. The national right allocation mechanism creates a clear spectrum property boundary, it gives MNOs more business certainty and makes interference easy to manage. However, the allocation method lacks the inability of addressing the digital divide. The nation level auction simply averages the spectrum value without reflecting the demography difference between urban and rural areas. When spectrum is acquired, MNOs prioritise their resource in deploying services in urban areas to get a fast return of investment (ROI). For rural areas, as ROI usually takes much longer to achieve, there are significantly fewer business incentives. This was evidenced in NZ's 4G rollout. After the government auctioned 4G spectrum in 2013, MNOs soon started 4G mobile broadband deployment in urban areas, now people living in urban cities generally have good mobile broadband access. However, research found the average download and upload speeds observed in the rural areas are still much slower than those seen in urban areas even after 8 years of 4G rolling out (Fenwick, 2021).

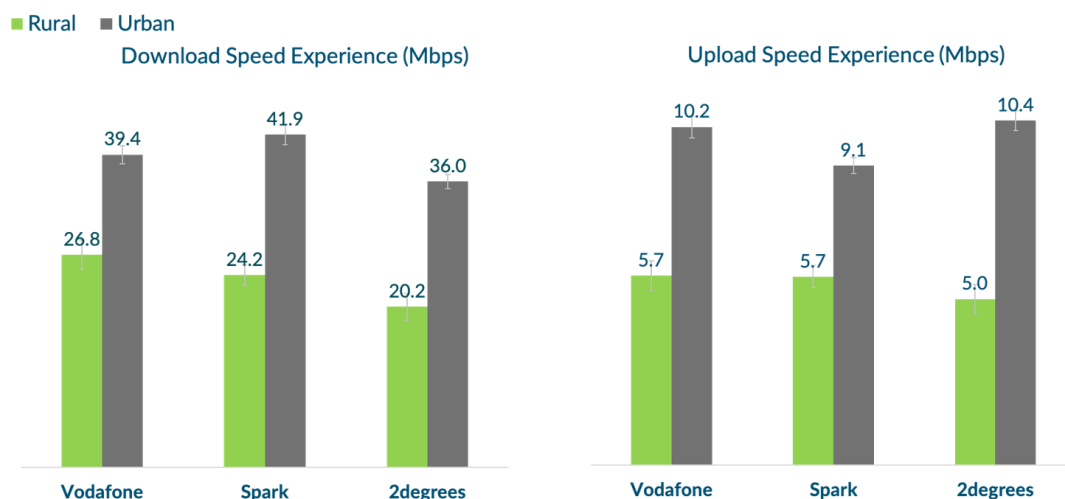


Figure 6 Mobile broadband speed comparison between urban and rural areas

As we analysed in the above section, the absence of business model regulation and revenue cap inclines MNOs to grow wireless broadband business. However, wireless broadband's market growth is constrained by MNOs' network capacity, which is largely determined by the amount of spectrum MNOs can access. A growing number of subscribers with no additional spectrum means the current spectrum will become more congested, which results in poorer network performance. Without more spectrum to improve their network capacity, MNOs will not be able to accommodate more subscribers. The amount of spectrum holdings will eventually constrain the growth of wireless broadband subscribers. The left diagram in Figure 7 models how the spectrum amount limits the growth of wireless broadband subscribers in a balanced loop.

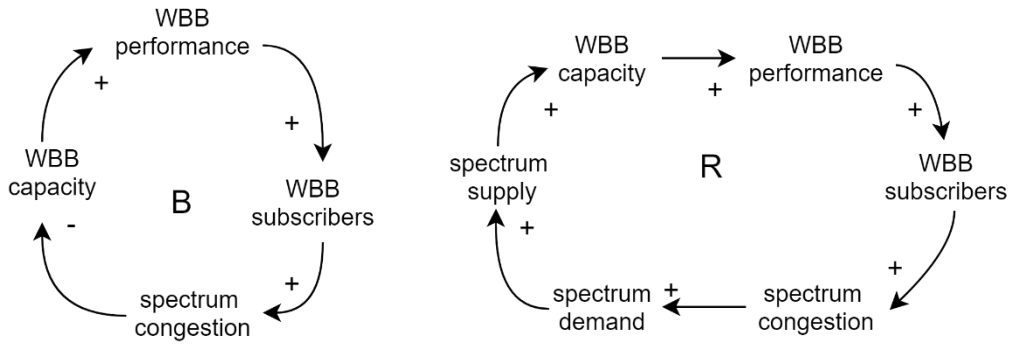


Figure 7 Spectrum supply to leverage the wireless broadband growth

To improve the network throughput, operators can make each cellular cell size smaller and increase the spectrum reuse rate. However, there are a few disadvantages of using this strategy. First, making the cell smaller will result in more cellular cells being required to serve a certain area, this means more infrastructure investment is needed and OPEX will be increased. Acquiring a site in some high-density areas can also be expensive and difficult. A smaller cell also means increased spectrum reuse, this will also create more co-channel interference problems, particularly when user terminals are located at the cell edges.

Therefore, to accommodate the growth of subscribers, there is a strong incentive for MNOs to acquire more spectrum to grow their business. More spectrum supply can ease the network congestion and increase capacity. With an increased capacity, MNOs are able to improve their performance, this leads to more users subscribing to wireless broadband services. As shown in the right diagram of Figure 7, by increasing the spectrum supply, the policymaker can create a reinforced loop to grow MNOs' wireless broadband business.

The national spectrum licensing gives MNOs exclusive right of using the spectrum, it excludes local network operators, vertical industry players and large businesses who have interests in building a localised network that could serve rural communities. Without government subsidies, the investment in rural areas will be way behind. This is exactly the case NZ has, on one side, MNOs advocate strongly for allocating more spectrum to grow the wireless broadband business. On the other side, the government has to invest heavily for MNOs to roll out broadband services in rural areas. The CLD in [错误!未找到引用源。](#) explains how the spectrum policy can potentially increase the digital divide. By using the nation level spectrum allocation policy, the more spectrum allocated to MNOs, the wider digital divide can be resulted between urban and rural.

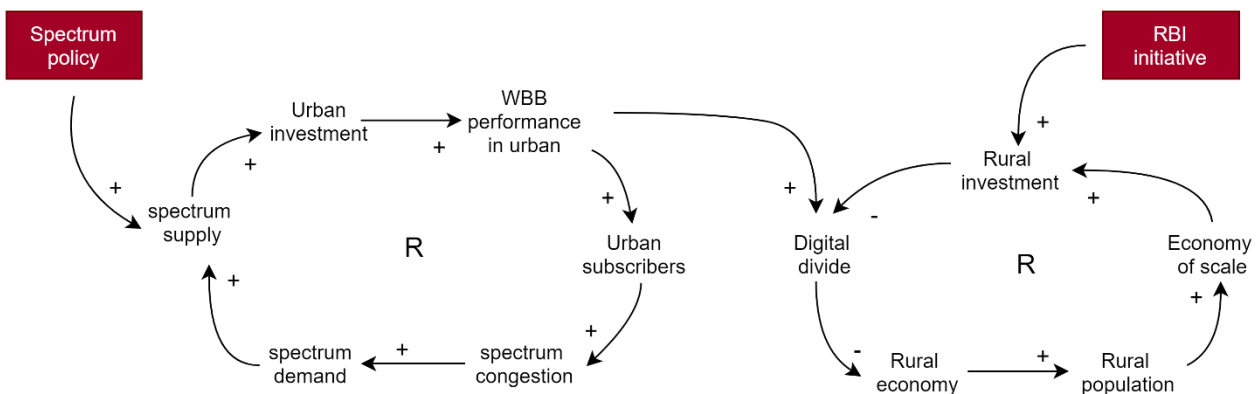


Figure 8 CLD of spectrum policy and RBI on digital divide

Allocating more spectrum to help grow wireless broadband can also affect fibre broadband market. The demand for fibre broadband is inelastic if the market only has one broadband solution. In an inelastic market, consumers are less sensitive to a price move. In the inelastic demand curve shown in [错误!未找到引用源。](#) (a), the quantity of demand doesn't change much as a consequence of the price moves. Benefiting from its wide availability and its improved performance, wireless broadband becomes a competitive solution with fibre. This gives consumers more choices when selecting their broadband providers. With such competition, demands for a certain type of broadband solution will become more elastic. In an elastic market, consumers are more sensitive to price change. As the demand curve in [错误!未找到引用源。](#) (b) shows, the quantity of demand changes ( $Q_2 - Q_1$ ) is more than (a) at the same price change from  $P_1$  to  $P_2$ .

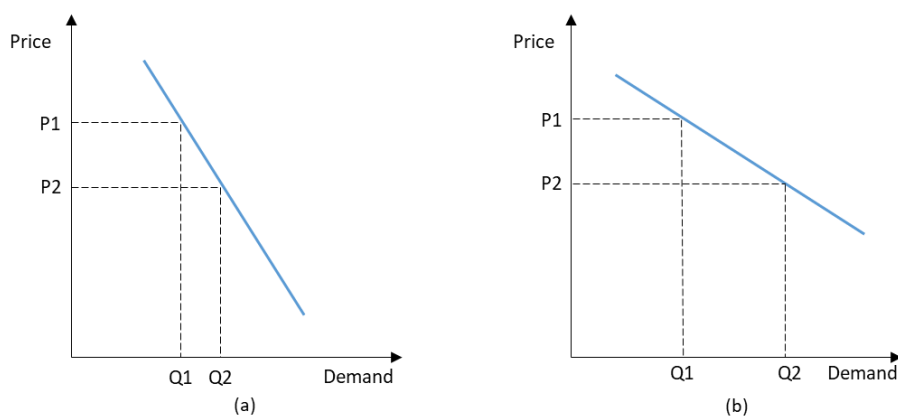


Figure 9 Demand elasticity (a) Inelastic demand; (b) Elastic demand

Therefore, increasing spectrum supply could foster the broadband market competition by reducing fibre companies' monopoly and making the demand more elastic. However, this policy can inadvertently create a negative impact on the fibre company's business given their business model is highly regulated. Under the structure separation regulation, the broadband services RSPs offer are almost homogeneous, the market is close to a perfect competition environment and every RSP has a similar cost. This leads to a thin profit they could earn. However, service providers are vertically integrated in the wireless broadband market, MNOs can easily differentiate their services to satisfy different consumers' needs, thus the profit margin is much higher. This regulatory nature provides a strong incentive for MNOs to offer their customers wireless broadband than fibre. For instance, Spark (NZ's largest MNO by market share) currently serves around 25% of its broadband customer base with fixed wireless and is targeting between 30% and 40% by 2023.

The UFB initiative was funded by the government with interest free loans to fibre companies. It was expected the fibre companies will repay the investment once FTTP are subscribed by consumers. The initial government investment allows fibre companies to sunset the legacy copper broadband networks faster and replace them with FTTP. Alongside the premium performance, the affordable fibre broadband prices will nudge consumers to switch from their DSL to fibre. The more users subscribe to the UFB, the more revenue fibre companies will receive, this leads to a faster repayment of the initial investment funds. The revenue generated from user subscriptions will contribute further investment in the network and technology, which would make fibre companies less reliant on government investment in the future. With more investment in the fibre network, fibre companies will be able to retain and gain more customers with improved broadband performance over time. The objective of the UFB investment policy is to create a reinforcement loop as shown in Figure 10 to build better broadband for consumers and make fibre companies more self-

dependent.

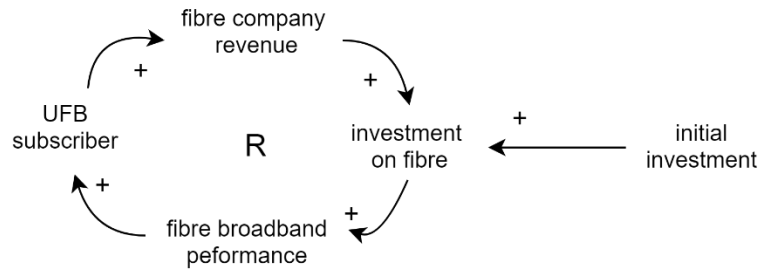


Figure 10 The reinforcement loop to improve the fibre broadband connectivity

To compete with fibre broadband providers, MNOs tend to price wireless broadband more competitively. In the elastic demand market as we analysed above, consumers are more sensitive to a price change. A lower price can make more consumers switch to wireless broadband services. With more subscribers acquired, the average cost per user will further decrease, this gives MNOs a more competitive advantage. On the other side, with fewer fibre broadband subscribers, less revenue will be earned by fibre companies, which can jeopardize their future investment to improve the broadband performance. The CLD in Figure 11 explains the competition dynamics between broadband solution providers.

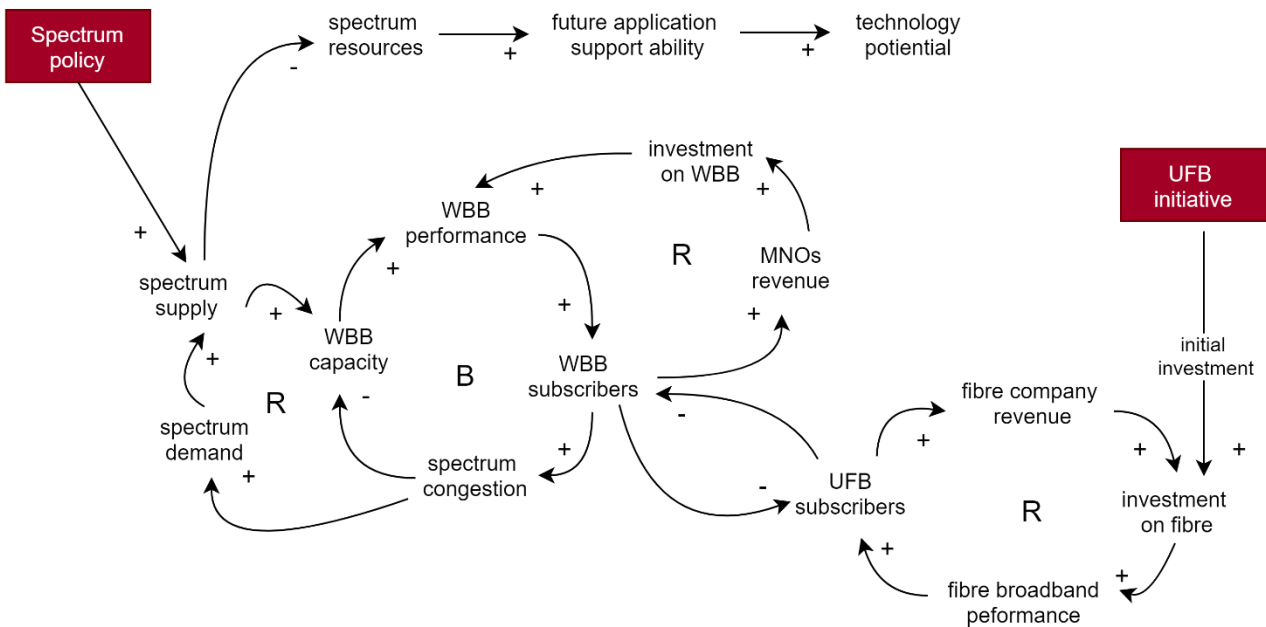


Figure 11 CLD of spectrum policy and UFB initiative on broadband competition

More spectrum allocation to enhance wireless broadband can also have a negative impact on the future mobile technology application. Under the IMT-2020 vision, 5G can provide enhanced Mobile Broadband (eMBB), ultra-Reliable Low Latency Communication (uRLLC) and massive Internet of things (IoT) services. The uRLLC will enable applications like intelligent transportation and industrial automation. The massive IoT is critical to applications like smart cities, drone delivery and digital supply chain etc. Currently, uRLLC and massive IoT are still in the development stage. In 5G advanced stage for the next 5 years, it is forecast that development will see up to several thousand devices per square metre in metropolitan areas. To support

such applications, a large chunk of spectrum needs to be easy to access. Allocating more spectrum for broadband connectivity will potentially cause spectrum shortage when vertical industries emerge, and it can threaten technology and business innovation.

## Using mixed spectrum policy to achieve different objectives

The demographic characteristics difference between urban and rural areas determines the need for different digital policies. This implies the spectrum allocation should reflect such difference. The competition dynamic is determined by the size of the market and cost of service implementation. In urban high-density areas, there are enough customers to allow multiple operators to operate, the policy objective is to provide affordable, high-performing broadband services by promoting market competition as well as driving technology and business innovation. While the rural area does not have such density for multiple operators to compete. The policy objective should be to reduce the digital divide and incentivise investment. Using a single spectrum allocation method has the limitation of achieving different policy objectives. It is necessary for the policymakers to distinguish urban and rural areas for designing different spectrum allocation methods. In urban areas, spectrum demand is high. When demand exceeds supply, auction is an effective way to allocate the spectrum. Spectrum is allocated efficiently to the parties that value them the most. For rural areas where spectrum demand is low, policymakers can use administrative licensing or general use licensing methods to lower the spectrum access hurdle and incentivise local operators or vertical industry players to invest in broadband infrastructure.

### Promote competition in urban areas

Allocating spectrum for wireless broadband in the urban areas places a threat to fibre companies' business inadvertently. However, it does not necessarily mean policymakers should not allocate spectrum for wireless broadband to foster market competition. Healthy competition in the market benefits both consumers and industry in the long run. It helps to reduce the price of broadband thus more users can access the services, which increases the total economic surplus. Competition will also catalyse innovation and improve service quality in the long term. In a competitive market, it reduces the need for intervention and regulation from policymakers.

The provision of a healthy competition environment also requires policymakers to take a technology neutral approach. In areas with low population density or high construction costs, the FTTP may not be the most cost-efficient way to provide broadband service. (Healya, Palcicb, & Reevesb, 2021) analysed Ireland's national broadband plan, finding deploying FTTP solution for the intervention area is one reason for cost escalation given Ireland's low population density in rural areas. The current UFB project uses FTTP as the sole technology solution. However, if the policy allows fibre companies to use fixed wireless as complementary to their fibre network in certain areas, it can reduce the cost and make the service deployment more efficient. For example, operators can terminate fibre network at the curb or outside an apartment building and then use fixed wireless to connect the last hundreds of meters. At present, the UFB definition does not consider such connections to amount to "fibre connections", even though users may themselves deploy wireless connections to distribute broadband connectivity to various parts of their premises (e.g., a hotel operator or building owner providing Wi-Fi service to rooms or tenants).

Instead of regulating a certain type of technology to achieve a target penetration rate, policymakers can focus on service quality target. A broadband policy can be set with a percentage of households having a



useful (as per the merger guidelines “safe harbours”). This is especially necessary going into a 5G world, as the business cases for use of this spectrum are newer and much more uncertain than were the cases of earlier allocation rounds, where the uses for telephone and vanilla broadband access were both clearer and with more easily-definable demands. Careful planning by taking into consideration of spectrum demand, population density and technical conditions are also needed.

### Improve the rural connectivity by optimising spectrum allocations

While the policy for urban areas focuses on competition and service efficiency, for rural areas the objective should be to reduce cost and incentivise investment. Exclusive licensing is by far the most popular method to authorise spectrum access. The regime defines a clear property right of spectrum. Within its spectrum right, licence holders have exclusive use. Exclusive licensing either use auction or beauty test to allocate spectrum. However, worldwide measurements revealed that these licensing systems rarely utilize their assigned frequency resources efficiently from a time and space perspective (Kryszkiewicz, Canfield, Bhada, & Wyglinski, 2022). Spectrum is usually well exploited in urban but poorly implemented in rural areas. The low spectrum utilization efficiency showed its weakness in addressing the digital divide. The exclusive licensing also makes sharing arrangements very complicated. New entrants must negotiate with the current spectrum holders to access their spectrum even though the spectrum is not being used at new entrants’ interesting places. Anti-competitive behaviour can also happen, incumbents can use the framework to hinder competitors from entering into the market. For new business innovators, the absence of spectrum access can jeopardise innovation and service transformation.

There is some degree of spectrum and infrastructure sharing in RBI, it is coordinated under a Joint-Venture among three national MNOs. MNOs pool their spectrum asset together and share the same access and backhaul network. However, the scope of sharing is only limited to three national MNOs and their spectrum pool is still exclusively accessed by themselves. Local operators and verticals like schools, councils and enterprises do not have the right to access even though they may be interested in providing broadband services.

In recent years, there is a growing momentum from worldwide policymakers to establish shared spectrum accessed regime. Spectrum sharing is now widely recognised as a powerful policy tool to reduce digital divide. The principle of shared access is to promote investment incentive and business innovations. In order to achieve this policy objective, policymakers need to design a proper sharing mechanism that can effectively increase the number of parties that have access to spectrum—e.g., to include new entrants—and thus spectrum is more efficiently utilized. The spectrum policy framework should permit such sharing, across operators and technologies, under specific conditions designed to mitigate the potential for harmful interference, and in a manner that facilitates access by new operators (which otherwise might be impossible with exclusive use spectrum), local operators and verticals.

Many countries have already started using spectrum sharing to improve connectivity in rural areas. In general, there are two main spectrum access regimes to allow shared access. The first one uses tiered access system. Spectrum in different tiers has different access priorities. A notable example is CBRS spectrum in the U.S. The FCC designed a three-tier system to protect incumbent federal use and allow multiple tier users to share the spectrum. The priority access tier consists of Priority Access Licenses (PALs) that will be licensed on a county-by-county basis through competitive bidding. Below the PALs, General Authorized Access (GAA) permits open, flexible access to the band with no licence fee and interference protection. This tiered access regime could particularly help rural areas is the adoption of a “use it or share it” policy that discourages

operators with national spectrum allocations from blocking others from using that spectrum in areas where the operator doesn't provide coverage. Since the framework started in 2020, using CBRS to create wireless broadband services is proved to be a very effective way for smaller operators to offer broadband in rural communities.

The second most popular shared access regime use different spectrum allocation methods in areas with different population density. In high density areas like urban cities, where spectrum demand exceeds supply, spectrum is allocated through a competition method, for instance, auction. Outside the high-density areas where competition is not intense, a light licensing or even licence-exempt is often used to allow shared access. This framework is commonly used in Australia as the country's demographic is quite disparate between urban, regional and rural. This mixed licensing regime incentivise various levels of operators. For spectrum users in regional and rural areas, the barrier to accessing spectrum is much lower than in the high demand areas. This mixed licensing rule makes the spectrum more efficiently utilized.

Not only for small operators, shared access also benefits large MNOs through a new business model called neutral host. A neutral host is a service provider that builds and operates an integrated technology platform that is solely for sharing purposes (Lähtenmäki, 2021). Traditional MNOs are usually limited by their resource capacity to deliver services inside buildings or in rural areas. This problem becomes even more challenging in 5G as the radio waves used in 5G has high propagation attenuation and building penetration loss. Neutral host can help them to extend their service reach in a much quicker and cost-efficient way. The company that provides the neutral network, is not necessarily affiliated with any MNOs. Instead, it builds a neutral access network for MNOs to use. For example, an enterprise could build their own private 5G access network and provide connectivity for their staff and customers who are also MNOs' subscribers via a neutral host "roaming" relationship.



Figure 13 spectrum based neutral host

Being technology neutral is also crucial in incentivising investment. Wireless access technologies are evolving fast these days. Different technologies have their own strengths in solving different connectivity challenges. Allowing spectrum to be used by any technology allows operators to choose the most appropriate solution for rural connectivity. It also allows operators to evolve as technology and the market advance and to continue to use spectrum efficiently to meet customer demand. One of the challenges of being technology neutral is an increased risk of interference between spectrum users. However, this challenge can be addressed by proper coordination rules such as maximum allowed emission, unwanted emission levels and power spectral density requirement, etc.

The causal loop in Figure 14 shows how spectrum policy can reduce digital divide and reliance on government subsidies. A low spectrum access barrier will lead to a low cost of providing broadband service. The lower cost can incentivise investment in rural broadband as more service providers will be able to make a profit. Being technology neutral allows operators to use the most suitable technologies in underserved areas, this reduces their service cost and incentivises investment. The more investment from private sectors, the less digital divide will rely on government direct investment.



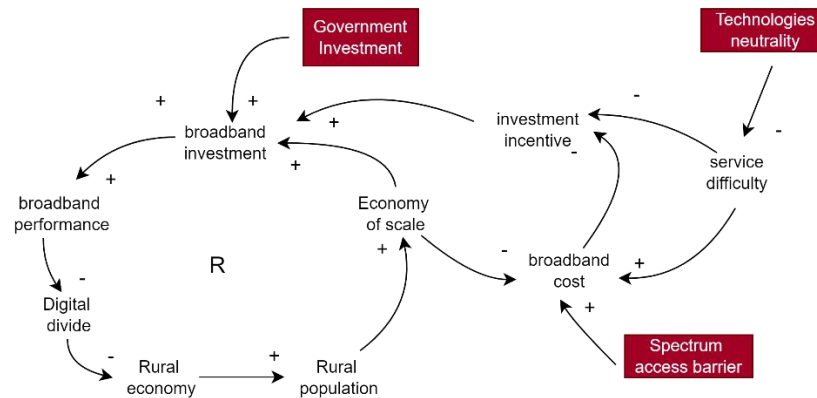


Figure 14 Use spectrum policy to reduce digital divide

## Conclusion

In the digital era, it's hard to deny broadband is a public utility for its importance in connecting people, businesses and government. Technology development has made wireless broadband a competitive solution for connectivity needs. This technology evolution leads to a change in broadband market dynamics. In the past, broadband over wired network dominates the market. Now, with the 4G and 5G fixed wireless, traditional mobile operators are able to compete with fibre broadband providers.

Change in the market dynamics brings questions to policymakers on how to provide a fair competition environment among different technology operators. Wireless broadband use spectrum to send and receive data. Governments' spectrum policy has a substantial impact on the level of market competition. To deliver the best outcome for businesses and consumers, policymakers need to view the broadband market as a holistic system. This means when overseeing the broadband market, policy should focus on service quality rather than a single technology.

The development of wireless broadband has great benefits for rural broadband as rural areas always present a challenge for wired solution. A proper spectrum policy can fully exploit the value of wireless technology. The demographic characteristics determine sharing is necessary in rural broadband. Spectrum policy thus should enable more efficient sharing in rural areas. Shared spectrum access can incentivise small operators to invest in building the broadband infrastructure, thus enabling more business models for connectivity. When designing the licensing framework and spectrum allocation method, it is very crucial for policymakers be aware of the demographic difference and use the most suitable methods to enable spectrum access.

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