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Assessing the alignment of spectrum assignment to socioeconomic priorities

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Abstract

In Canada, there is no policy mechanism, formal or informal, that assesses whether spectrum policy is delivering against the government's overall objective for ubiquitous connectivity. As a scarce public resource, the assignment and deployment of spectrum should be a concern to regulators, providers, consumers, and citizens.

Connectivity is integral for a functioning economy and for social well-being. Improving connectivity requires spectrum policy that is designed to consider the relationship between policy, assignment, and deployment.

This report reviews existing literature and the economic impacts of connectivity; considers Canada's approach to spectrum policy allocation with comparisons to other jurisdictions; and proposes a performance framework for evaluating spectrum holistically with consideration of the alignment of spectrum policy to declared priorities for connectivity.

Executive summary

In Canada, there is no policy mechanism, formal or informal, that assesses whether spectrum policy is delivering against the government's overall objective for ubiquitous connectivity.

Connectivity is integral for a functioning economy and for social well-being. Improving connectivity requires spectrum policy that is designed with consideration of the relationship between policy, assignment, and deployment. The current performance framework does not make these linkages. **Canada needs a new performance measurement framework that considers how spectrum policy, assignment and deployment can be linked and leveraged to improve connectivity.**

Like a road, a bridge, or a stable regulatory environment, connectivity is a point of departure for innovation, research, and other market activities. To measure the impacts of connectivity, factors beyond the number of connected Canadians should be considered. The economic and social benefits of connectivity are broad, extending to research and innovation, access to health and social services, participation, inclusion, etc., and performance measurement should reflect that.

Current performance reporting from Innovation, Science and Economic Development Canada (ISED) and the Canada Radio-Telecommunications Commission (CRTC), tend to focus on end-user connectivity, with some assessment of spectrum focused on licence authorization and timeline for adjudicating applications. The indicators and annual reports are useful for monitoring trends and changes, but the information is not designed to assess the impacts of connectivity on socio-economic well-being. Furthermore, it is not clear how or if this information is linked to policy design and

decision-making about spectrum (i.e., linking decision-making at the front-end to desired results on the back-end).

The intent of a revised framework is to reset an understanding of the linkages between spectrum assignment and connectivity.

Category	Qualitative	Quantitative
Spectrum policy	1) What are Canada's spectrum priorities? 2) How are these priorities being enacted? 3) Are spectrum priorities differentiated for urban and rural places?	1) Was the policy reviewed? Y/N 2) Were updates made to meet changed priorities? Y/N
Assignment instruments	1) How are assignment instruments determined? 2) Are assignment of instruments aligned to spectrum priorities? 3) Are instruments differentiated based on different priorities?	1) How many instruments were used? 2) Which instruments were used? 3) How many stakeholders participated engaged with the instruments?
Deployment conditions	1) What deployment conditions were applied? 2) What results did deployment conditions generate?	1) How many providers met defined targets (%)? 2) How many providers met targets within defined timelines (%)?
Connectivity	1) How have connectivity rates improved in Canada? 2) Has there been consideration of connectivity versus uptake of technology/use of technology?	1) What are Canada's internet connectivity rates: a) Household - national b) Household – urban c) Household – rural d) Household – First Nations reserves 2) Leverage existing data from Statistics Canada to assess economic variables.

Other jurisdictions offer lessons and approaches to support connectivity at different points in the policy, assignment, deployment continuum. For instance, the United States differentiates its spectrum assignment practices for rural and urban places. In rural places, reverse auctions and deployment conditions are used to incentivize providers. Leading in 5G network coverage, South Korea's continuous dialogue with industry and their risk-reducing pilot projects create incentives for performance, with operators encouraged to surpass their licence conditions.

Using a variety of assignment approaches and deployment conditions, Canada could better meet the differentiated needs of a large and geographically diverse country with densely populated urban areas and sparsely populated rural ones.

Achieving declared political priorities for connectivity in Canada will require rethinking spectrum policy across various dimensions, including, location, e.g., rural v. urban, Indigenous communities; deployment conditions, e.g., ensuring spectrum is being used to deliver connectivity; and efficiency of assignment instruments, e.g., ensuring value-for-money for taxpayers and alignment of instruments to connectivity priorities. Putting these pieces together requires a performance measurement approach that considers connectivity holistically.

There are three takeaways from this report:

1) Adopt a holistic performance management framework to assess how spectrum policy is achieving the goal of connectivity.
2) Leverage approaches from other jurisdictions, e.g., differentiated assignment (e.g., Germany) and deployment conditions (e.g., United States), to refine current practices and improve the efficiency and effectiveness of spectrum assignment policy for connectivity.
3) Use broad and indirect indicators to measure and monitor the impact of connectivity on socio-economic benefits.

Introduction

The spectrum of electromagnetic frequencies is a public asset with private and public applications, with multiple uses at different wavelengths. A finite natural resource,[1] spectrum permeates everyday life from the light we see to mobile networks, to x-rays, to the microwave.

The assignment of this critical resource is managed by governments or designated national authorities, with national and international regulations to ensure availability and streamlined uses for countries, providers, and consumers.[2]

Spectrum allocation is about more than connectivity, with implications for economies and citizens.[3] Improving spectrum assignment is linked to expanding mobile access, services, and data,[4] with direct and indirect roles in many areas of industrial development and economic activity.[5] Spectrum assignment policy influences how spectrum is allocated and deployed among service providers, which then impacts uses by businesses, consumers, and governments.

Spectrum has a direct or indirect role in most areas of industrial development and economic activity.[6] From connectivity to medicine to transport and shipping, spectrum allocation policy has implications for economies. It can improve access to education, propel the development of new businesses, and open new markets, as connectivity is a driver and tool essential for growth. A critical resource, policy development associated to spectrum allocation and deployment merits closer attention.

How spectrum is assigned, who is using it, and what results are generated should be of concern to Canadians. With connectivity a core goal of spectrum assignment policy, how do we know if the policy is supporting connectivity, and ultimately, social and economic outcomes? We do not.

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[1] GSMA, "What Is Spectrum?" Spectrum, 2022. https://www.gsma.com/spectrum/what-is spectrum/.
[2] GSMA, "What Is Spectrum?" Spectrum, 2022. https://www.gsma.com/spectrum/what-is-spectrum/.
[3] Gaspard, Helaina, Alanna Sharman, Tianna Tischbein. "Governing Connectivity: How is Spectrum Policy Impacting the Lives of Canadians?" Policy Magazine, January 27, 2022.
[4] GSMA, "Best Practice in Mobile Spectrum Licensing - GSMA," 2022. https://www.gsma.com/spectrum/wp-content/uploads/2022/02/Mobile-Spectrum-Licensing-Best-Practice.pdf
[5] Nozdrin, Vadim. "Economic Efficiency of Spectrum Allocation." *ITU Journal on Future and Evolving Technologies* 2, no. 1 (2021): 67-76.
[6] Nozdrin, Vadim. "Economic Efficiency of Spectrum Allocation." *ITU Journal on Future and Evolving Technologies* 2, no. 1 (2021): 67-76.

What we do know:

- Canadians in urban places (99%) benefit from wired connectivity at the 50/10 standard compared to those in rural places (46%);[7]
- Connectivity in First Nations communities is a challenge (35% at the 50/10 standard); [8]
- Wireless coverage (at variable speeds) across Canada is high, with nearly 100% coverage in urban and rural areas and 90.5% coverage in First Nations;[9]
- Canadians pay some of the highest prices (relative to other countries) for their mobile coverage (for a variety of reasons, e.g., cost of spectrum, geography, etc.);
- Canada's spectrum auctions generate a lot of money for the Government of Canada (the July 2021 auction generated approximately $9B in revenues).[10]

The existing literature has had limited consideration of how spectrum policy impacts connectivity[11], and ultimately, economic, and social outcomes. With most analysis focused on rates of connectivity or approaches for assigning spectrum, understanding the direct connections from policy to connectivity were left largely unconsidered. Improved alignment of how spectrum policy is designed, influences assignment and deployment conditions, ultimately, impacting connectivity would be helpful to practitioners and policy makers.

Canada's current spectrum assignment policy is useful in promoting competition among service providers, especially in dense urban areas. For rural places, the approach is less effective. The business case in rural places with low population density and/or geographic complexities is limited or non-existent. To improve rural connectivity in Canada, policy on spectrum should be differentiated. This would be a first step in recognizing and addressing urban and rural differences in geography, population density, coverage objectives, and incentives for service providers.[12] The urban-rural difference is but one example of why spectrum assignment policy merits attention, because it has implications for its end uses.

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[7] Government of Canada, "Communications Monitoring Report Communications Monitoring Report." Canadian Television and Telecommunications Commission, December 10, 2020. https://crtc.gc.ca/eng/publications/reports/policyMonitoring/2020/cmr4.htm#a2.3.

[8] Government of Canada, "Communications Monitoring Report Communications Monitoring Report." Canadian Television and Telecommunications Commission, December 10, 2020. https://crtc.gc.ca/eng/publications/reports/policyMonitoring/2020/cmr4.htm#a2.3.

[9] Government of Canada, "Current trends – Mobile wireless," Canadian Television and Telecommunications Commission, last modified June 30, 2022, https://crtc.gc.ca/eng/publications/reports/PolicyMonitoring/mob.htm.

[10] Government of Canada, "3500 MHz auction – Process and results," Innovation, Science and Economic Development Canada (ISED), last updated July 29, 2021.

[11] For the purposes of this report, connectivity is understood as access via wireless means, associated to electromagnetic spectrum.

[12] Gaspard, Helaina, and Sahir Khan. "Assessing the Efficacy of Instruments for the Delivery of Rural Broadband." IFSD, 2021.

Canada uses auctions to assign spectrum (like nearly all its peers) but does not tend to leverage more nuanced tools or approaches to address context-specific needs or differences in spectrum assignment. For instance, the United States differentiated its rural broadband assignment practices recognizing that the incentives to generate connectivity were different in less densely populated places.[13] A mix of deployment conditions are applied to spectrum licences from coverage obligations to timelines for deployment in various countries, e.g., Japan, United States, etc. Some countries use a mix of assignment practices like auctions and administrative allocations or applications, e.g., Germany, to assign spectrum nationally or on a localized/industry-specific basis.

Across the assessed peer countries, spectrum assignment policy is not being explicitly linked to or tested against connectivity goals. Improving the linkage between policy framework and allocation practices could stand to improve connectivity, and ultimately, its associated socio-economic benefits.

This report considers existing literature, the practices of other countries, Canada's own practices, and proposes a framework to assess the alignment between spectrum assignment policy and declared priorities for connectivity.

Connectivity is being pursued as an important goal in Canada and elsewhere but achieving connectivity requires that spectrum be assigned and deployed in ways that align to that goal.

There are three parts to this report: Part I reviews existing literature and the economic impacts of connectivity; Part II considers Canada's approach to spectrum policy allocation with comparisons to other jurisdictions; Part III proposes a framework for evaluating spectrum holistically with consideration of the alignment of spectrum assignment policy to declared priorities for connectivity.

[13] See for instance, Gaspard, Helaina, and Sahir Khan. "Assessing the Efficacy of Instruments for the Delivery of Rural Broadband." IFSD, 2021. https://ifsd.ca/fr/blog/reports/Assessing%20the%20efficacy%20of%20instruments%20for%20the%20delivery%20of%20rural%20broadband.

Part I: Lessons from existing research

There are two dimensions of spectrum to consider from a policy perspective:

1) **Allocation:** Designated uses of spectrum, e.g., governed by international regulations, reassignment of spectrum from low-demand (television) to high-demand (mobile) uses.
2) **Assignment:** Determine who uses spectrum and how, e.g., through auctions.

Both *allocation* and *assignment* involve political and policy decisions. The impacts of allocation and assignment exist on different timelines and scales. For instance, spectrum assignment can have short-term impacts for end-users, depending on deployment conditions. Long-term impacts are possible with allocation decisions, e.g., new generation of mobile spectrum. Quantifying direct and indirect results of spectrum policy will require different timelines, that may not line up to political timelines.

This report will focus on spectrum assignment as it is managed domestically and influences connectivity. Existing literature tends to assess spectrum and related issues through three areas of analysis: instruments for spectrum assignment; deployment conditions; and connectivity.

From a policy perspective, there is a gap in the literature. Most consideration is given to the efficiency of assignment instruments, the effectiveness of deployment conditions, and the economic and social benefits of connectivity, with limited consideration – until recently[14] – on how policy priorities link to desired outcomes.

Spectrum assignment, ultimately, is about improving connectivity. Spectrum assignment is a necessary but alone, insufficient factor for ensuring connectivity for the end-user. Other policy tools and considerations, e.g., telecommunications infrastructure, spectrum sharing policy, end-user devices, etc. can also be leveraged to impact the breadth and quality of connectivity.

Better connectivity means social and economic benefits. Governments in different countries declare priorities associated to connectivity, without clear consideration of what it takes to get there. If declared commitments are not being assessed against policy and results, how do you know what is working? This is a critical missing piece of analysis.

[14] Nozdrin, Vadim, “Economic Efficiency of Spectrum Allocation.” *ITU Journal on Future and Evolving Technologies* 2, no. 1 (2021): 67-76.; Kalvin Bahia and Castells Pau. “The impact of spectrum assignment policies on consumer welfare.” *Telecommunications Policy, 46* (2021).; Kuś, Agnieszka, and Maria Massaro. "Analysing the C-Band spectrum auctions for 5G in Europe: Achieving efficiency and fair decisions in radio spectrum management."(2021).

Spectrum assignment

The literature on spectrum allocation is broad, and generally emphasizes improvements in efficiency through consideration of different instruments for allocation (e.g., auction, administrative auction) and associated terms/conditions, e.g., auction formats, set-asides, licensing terms, etc.[15] The literature covers outcomes of different auction approaches, e.g., multiple rounds, reverse auctions, etc. with lessons for assessing trade-offs in efficiency and cost. There is limited consideration of how assignment impacts economic and policy goals.

Spectrum allocation is about controlling a scarce resource and deciding how the resource will be used to achieve the goals of various stakeholders.[16] Spectrum assignment is about determining who gets to use the scarce resource and how. Operators and consumers are impacted by the amount of spectrum held by an operator, the timing of the assignment, and the cost of spectrum.[17] These variables impact a service provider's incentive for deployment, costs for service provision, with direct implications for consumers. For instance, Wood (2021)[18], suggests that Canadians risk losing out on the benefits of 5G because of the lag in spectrum assignment and high costs.

The most common instruments for spectrum assignment are the auction and administrative allocation ("beauty contest").

Auction

The most used mechanism for spectrum assignment, auctions leverage market forces to determine the price of spectrum. Auctions are beneficial because operators who value it (and presumably, will deploy it for profit) will pay for access. The approach is known to generate higher revenues and promote efficiency in the assignment of

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[15] Nozdrin, Vadim, "Economic Efficiency of Spectrum Allocation." *ITU Journal on Future and Evolving Technologies* 2, no. 1 (2021): 67-76.; GSMA. "The Cost of Spectrum Auction Distortions: Review of spectrum action policies and economic assessment of the impact of inefficient outcomes". Coleago Consulting, GSMA (October 2014). https://www.gsma.com/spectrum/wp-content/uploads/2014/11/The-Cost-of-Spectrum-Auction-Distortions.-GSMA-Coleago-report.-Nov14.pdf; Kuś and Maria Massaro. "Analysing the C-band spectrum auctions."; Matinmikko-Blue, Marja, Seppo Yrjölä, and Petri Ahokangas. "Spectrum management in the 6G era: The role of regulation and spectrum sharing." In *2020 2nd 6G Wireless Summit (6G SUMMIT)*, pp. 1-5. IEEE, 2020.; Hwang, Junseok, and Hyenyoung Yoon. "A mixed spectrum management framework for the future wireless service based on techno-economic analysis: The Korean spectrum policy study." *Telecommunications Policy* 33, no. 8 (2009): 407-421.; Lundborg, Martin, Wolfgang Reichl, and Ernst-Olav Ruhle. "Spectrum allocation and its relevance for competition." *Telecommunications Policy* 36, no. 8 (2012): 664-675.

[16] Institute of Electrical and Electronics Engineers (IEEE), "IEEE Standard for Definitions and Concepts for Dynamic Spectrum Access: Terminology Relating to Emerging Wireless Networks, System Functionality, and Spectrum Management." Std 1900.1TM -2019, IEEE, 2019.

[17] Bahia, Kalvin, and Castells Pau. "The impact of spectrum assignment policies on consumer welfare." *Telecommunications Policy, 46* (2021).

[18] Wood, Rupert, "Falling Behind: Comparing 5G spectrum policies in Canada and OECD countries." Analysys Mason, last modified November, 2021. https://www.analysysmason.com/contentassets/3142cca88f924253be79605a6703503a/analysys_mason_5g_spectrum_canada_nov2021_rdnt0.pdf.

spectrum. When well-executed, the auction process can be transparent and efficient with public timelines, terms and conditions, etc.

As a scarce resource, using market forces to dictate price can promote efficiency, e.g., in time and administrative costs[19] and increase revenues (depending on demand).[20] There are a variety of auction formats, e.g., reverse auction, simple clock auction, combinatorial clock auction, simultaneous multi-round ascending auction, etc. Each auction approach accepts bids and awards spectrum differently. For instance, a simple clock auction is one in which the regulator sets a price and service providers bid. A service provider can bid below the list price but would only be eligible if others do not bid. In a reverse auction, the regulator effectively asks the market to solve a problem by presenting their best price to cover a geographic area, as done by Southwestern Integrated Fibre Technology (SWIFT) and the Federal Communications Commission (FCC) in their Rural Digital Opportunities Fund (RDOF) process.[21] (For a review of different approaches to spectrum auctions, see Australian Communications and Media Authority, 2021).[22]

While the auction approach is helpful in instances of high demand, it is less so when demand is low or when insufficient spectrum is made available. Price inflation is a risk of auctions (e.g., Canada), where operator access can be limited due to costs of spectrum.[23]

No single approach to spectrum assignment is a panacea. Factors that should be taken into consideration include the type and amount of spectrum being auctioned, as well as the coverage area. Ultimately, the goal should be to both transparently and fairly assign spectrum to the operator at the market value to minimize both risk and uncertainty.[24] Consider for instance, the utility of differentiating spectrum assignment for rural versus urban places.[25]

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[19] Kuś, Agnieszka, and Maria Massaro. "Analysing the C-Band spectrum auctions for 5G in Europe: Achieving efficiency and fair decisions in radio spectrum management." (2021).
[20] GSMA, "The Cost of Spectrum Auction Distortions: Review of spectrum action policies and economic assessment of the impact of inefficient outcomes". Coleago Consulting, GSMA (October 2014). https://www.gsma.com/spectrum/wp-content/uploads/2014/11/The-Cost-of-Spectrum-Auction-Distortions.-GSMA-Coleago-report.-Nov14.pdf.
[21] Gaspard, Helaina, and Sahir Khan. "Assessing the Efficacy of Instruments for the Delivery of Rural Broadband." IFSD, 2021. https://www.ifsd.ca/web/default/files/Blog/Reports/2021-0421_Final%20report_Assessing%20the%20efficacy%20of%20instruments%20for%20the%20delivery%20of%20rural%20broadband%20.pdf
[22] ACMA, "About Spectrum Auctions." ACMA. Australian Communications and Media Authority, last modified April 2021. https://www.acma.gov.au/about-spectrum-auctions.
[23] GSMA, "Best Practice in Mobile Spectrum Licensing - GSMA," 2022. https://www.gsma.com/spectrum/wp-content/uploads/2016/11/spec_best_practice_ENG.pdf.; GSMA. "Auction Best Practice - GSMA." GSMA, 2021. https://www.gsma.com/spectrum/wp-content/uploads/2021/09/Auction-Best-Practice.pdf.
[24] GSMA, "Auction Best Practice - GSMA." GSMA, 2021. https://www.gsma.com/spectrum/wp-content/uploads/2021/09/Auction-Best-Practice.pdf.
[25] See, for example, Gaspard, Helaina, and Sahir Khan, "Assessing the Efficacy of Instruments for the Delivery of Rural Broadband." IFSD, 2021.

Within auctions, there are tools that can be used to segment offerings. Set asides, for instance, are used in Canada with the declared intent of fostering access and entry of fourth players into the auction process by carving out spectrum blocks for them. This has been a source of contention. Service providers have charged that spectrum is preferentially acquired by fourth players and then left undeployed (known as spectrum 'squatting') at taxpayers' expense.[26] Studies indicate that the use of set-asides result in higher prices and failure in deployment.[27] In the Canadian context, Koutroumpis (2020)[28] and GSMA (2014),[29] suggest that Canada's high spectrum prices can be explained through the use of set-asides.

Administrative allocation

The administrative allocation or 'beauty contest' is an approach to spectrum assignment based on the assessment of proposed plans.[30] Operators develop plans and compete against one another in an administrative process to determine winners.[31] Japan uses the approach, citing the "equitable and efficient use of radio waves" [32] to allocate spectrum.

The approach can be beneficial in certain circumstances. Administrative allocation can encourage specificity of criteria and facility in balancing trade-offs. For instance, Germany uses administrative allocation and application processes for individual spectrum assignments (while also using auctions for general assignment). Specific fees

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https://ifsd.ca/fr/blog/reports/Assessing%20the%20efficacy%20of%20instruments%20for%20the%20delivery%20of%20rural%20broadband.

[26] Martínez-Cid, Ricardo, and Wenfei Jiao, "A Brief Review and Analysis of Spectrum Auctions in Canada." (2017).

[27] Koutroumpis, Pantelis, "The Impact of spectrum allocation on mobile communications in Canada". (2020). GSMA. "The Cost of Spectrum Auction Distortions: Review of spectrum action policies and economic assessment of the impact of inefficient outcomes". Coleago Consulting, GSMA (October 2014).; Martínez-Cid, Ricardo, and Wenfei Jiao. "A Brief Review and Analysis of Spectrum Auctions in Canada." (2017).; Cave, Martin, and Rob Nicholls. "The use of spectrum auctions to attain multiple objectives: Policy implications." *Teleco.* 2017. *https://www.sciencedirect.com/science/article/pii/S0308596116302828.;* GSMA Intelligence. "5G and Economic Growth: An Assessment of GDP Impacts in Canada." November 2020. https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=54165916&file=051120-5G-inCanada.pdf.; GSMA. "Auction Best Practice - GSMA." GSMA, 2021. https://www.gsma.com/spectrum/wp-content/uploads/2021/09/Auction-Best-Practice.pdf.

[28] Koutroumpis, Panteli, "The Impact of spectrum allocation on mobile communications in Canada".(2020).

[29] GSMA. "The Cost of Spectrum Auction Distortions: Review of spectrum action policies and economic assessment of the impact of inefficient outcomes". Coleago Consulting, GSMA (October 2014).

[30] Wood, Rupert, "Falling Behind: Comparing 5G spectrum policies in Canada and OECD countries." Analysys Mason. 2021.

[31] Wood, Rupert, "Falling Behind: Comparing 5G spectrum policies in Canada and OECD countries." Analysys Mason. 2021.

[32] MIC, "Process of Frequency Assignment." MIC The Radio Use Website | Frequency Assignment | Process of Frequency Assignment. Accessed February 16, 2022. https://www.tele.soumu.go.jp/e/adm/freq/process/.

or costs for spectrum can be set, with specific conditions for network infrastructure investments or coverage. In cases where demand does not exceed supply, the approach can be useful leaving the regulator to adjudicate applications. A major drawback is the potential for an attractive proposal without the requisite implementation capacity, which could risk leaving spectrum underused or undeployed. Transparency in selection criteria, i.e., facilitating corruption, bias, etc. can be problematic with this approach.[33]

In the literature on spectrum assignment, various contributions have noted that spectrum could be used more efficiently through improved assignment policies.[34] Improved assignment policies should also include consideration of how spectrum assignment links to connectivity, and its economic and social impacts.

Deployment conditions

Deployment conditions are requirements or obligations associated to the assignment of spectrum. Timelines for deployment, and other licensing conditions are used in conjunction with assignment instruments (e.g., auctions, administrative allocation) to enable/constrain deployment, sometimes with unanticipated results.

Different conditions are applied to spectrum licences to achieve various ends. For instance, Canada's use of set-asides was intended to promote fourth service providers in the Canadian market. The results, however, include higher spectrum prices and a failure (in many instances) of fourth service providers to deploy the spectrum due to costs.[35]

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[33] GSMA, "Best Practice in Mobile Spectrum Licensing - GSMA," 2022. https://www.gsma.com/spectrum/wp-content/uploads/2022/02/Mobile-Spectrum-Licensing-Best-Practice.pdf.

[34] Nozdrin, Vadim, "Economic Efficiency of Spectrum Allocation." *ITU Journal on Future and Evolving Technologies* 2, no. 1 (2021): 67-76.; GSMA. "The Cost of Spectrum Auction Distortions: Review of spectrum action policies and economic assessment of the impact of inefficient outcomes". Coleago Consulting, GSMA (October 2014).; Kuś, Agnieszka, and Maria Massaro. "Analysing the C-Band spectrum auctions for 5G in Europe: Achieving efficiency and fair decisions in radio spectrum management." (2021).; Matinmikko-Blue, Marja, Seppo Yrjölä, and Petri Ahokangas. "Spectrum management in the 6G era: The role of regulation and spectrum sharing." In *2020 2nd 6G Wireless Summit (6G SUMMIT)*, pp. 1-5. IEEE, 2020.; Hwang, Junseok, and Hyenyoung Yoon. "A mixed spectrum management framework for the future wireless service based on techno-economic analysis: The Korean spectrum policy study." *Telecommunications Policy* 33, no. 8 (2009): 407-421.; Lundborg, Martin, Wolfgang Reichl, and Ernst-Olav Ruhle. "Spectrum allocation and its relevance for competition." *Telecommunications Policy* 36, no. 8 (2012): 664-675.; Jung, Sang Yeob, Seung Min Yu, and Seong-Lyun Kim. "Optimization of spectrum allocation and subsidization in mobile communication services." *IEEE Transactions on Vehicular Technology* 65, no. 10 (2015): 8432-8443.; Cave, Martin. "Spectrum and the Wider Economy." (2015). https://ieb.ub.edu/wp-content/uploads/2018/06/Cave_2.pdf.

[35] Koutroumpis, Pantelis, "The Impact of spectrum allocation on mobile communications in Canada".(2020).; GSMA, "The Cost of Spectrum Auction Distortions: Review of spectrum action policies and economic assessment of the impact of inefficient outcomes". Coleago Consulting, GSMA (October 2014).; Martínez-Cid, Ricardo, and Wenfei Jiao. "A Brief Review and Analysis of Spectrum Auctions in Canada." (2017).; Cave, Martin, and Rob Nicholls. "The use of spectrum auctions to attain multiple objectives: Policy implications." *Teleco,* 2017.; GSMA Intelligence, "5G and Economic Growth: An

Many countries impose conditions on the licences allocated to operators, which could include the geographic area, coverage area, percentage/rate of coverage, or the frequency of the band.[36] Wood (2021)[37] highlighted several examples of conditions enacted across countries for the use of spectrum assignment licences. Canada, for instance, requires deployment of spectrum in a specific period of time, e.g., 5-years. South Korea defined infrastructure requirements for providers at a rate of 150,000 base stations. The United States requires reliable service with licensees obligated to provide reliable signal coverage and offer service within eight years to at least 45% of the population for certain spectrum blocks.

Deployment conditions are an important tool for ensuring deployment and coverage because spectrum can be assigned but not necessarily be used. Canada for instance, has a public Spectrum Management System[38] where you can look-up operator licences. There is no data however, on whether spectrum is being used. Taylor et al. (2017)[39] highlighted this problem of identifying gaps in spectrum use in downtown Toronto (a densely populated urban centre). This report suggested more public data on spectrum, further investigation of spectrum sharing (as current options were considered inefficient), and non-spectrum changes to improve connectivity, e.g., updating technology.

Aware of the commercial and consumer issues stemming from a lack of data on spectrum use, thinkRF[40] an Ottawa-based company developed software to analyze spectrum deployment. Their software monitors and measures how spectrum is being used in set geographic areas. Using sensors placed throughout a defined area, thinkRF captures and stores data about available connectivity infrastructure, current provider deployment, and spectrum use. While this information is valuable commercially, making such data publicly available could help to inform consumers and regulators of spectrum on use.

Improving the effectiveness and efficiency of spectrum use is a critical step to improving connectivity. Linking deployment conditions to assignment instruments and the

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Assessment of GDP Impacts in Canada." November 2020. https://data.gsmaintelligence.com/apiweb/v2/research-file-download?id=54165916&file=051120-5G-in-Canada.pdf.; GSMA, "Auction Best Practice - GSMA." GSMA, 2021. https://www.gsma.com/spectrum/wp-content/uploads/2021/09/Auction-Best-Practice.pdf.

[36] Wallsten, Scott, "Is there really a spectrum crisis? Disentangling the regulatory, physical, and technological factors affecting spectrum licence value." *Information Economics and Policy* 35 (2016): 7-29. https://www.sciencedirect.com/science/article/pii/S0167624516000020.

[37] Wood, Rupert, "Falling Behind: Comparing 5G spectrum policies in Canada and OECD countries." Analysys Mason. 2021.

[38] https://sms-sgs.ic.gc.ca/eic/site/sms-sgs-prod.nsf/eng/home

[39] Taylor, Gregory, Catherine Middleton, and Xavier Fernando, "A Question of Scarcity: Spectrum and Canada's Urban Core" Journal of Information Policy, vol. 7 (2017). https://doi.org/10.5325/jinfopoli.7.2017.0120.

[40] thinkRF, https://thinkrf.com/, accessed August 10, 2022.

connectivity results they generate would be additive to the literature and for practitioners, seeking to identify the right mix of factors to promote connectivity.

Connectivity and economic impact

An integral means for economic and social participation, connectivity can improve outcomes and generate unexpected opportunities and value.[41] Growth in gross domestic product (GDP) has been directly linked to improved wireless coverage.[42]

The economic impact of spectrum policy is best assessed through the breadth and quality of connectivity. Broad, reliable, and fast connectivity can contribute to economic output. While connectivity is well-studied, there is little research on the linkages between spectrum policy and the economics of connectivity. Accepting connectivity as a tacit factor of production and innovation (like labour) should warrant ongoing consideration of its management and impact across social and economic development.

In the early 1990s, connectivity shortened economic distance, i.e., the distance between suppliers and markets and among actors within markets. Today, given the ubiquity of connectivity at high speed for most market participants in Canada, connectivity can now be fairly viewed as an entry to be a participant in the marketplace. The economic value of connectivity is now tied to the services generated and delivered from this incremental connectivity. In the same way functioning roads and bridges are considered integral to a productive economy, so too is broadband connectivity.

There are two channels through which connectivity can impact economic activity. First, investment in broadband, like investment in any other infrastructure, increases demand for labour and material by the initial investor and all other sectors that supply inputs to

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[41] See, for example, Campbell, Sophia, Jimena Ruiz Castro, and David Wessel, “The Benefits and Costs of Broadband Expansion.” Brookings. Brookings, November 9, 2021. https://www.brookings.edu/blog/up-front/2021/08/18/the-benefits-and-costs-of-broadband-expansion/.; Chow, Wilson. “The Global Economic Impact of 5G. Powering Your Tomorrow.” PwC. 2021. https://www.pwc.com/gx/en/industries/technology/publications/economic-impact-5g.html.; GSMA Intelligence, “5G and economic growth: and assessment of GDP impacts in Canada.” November 2018. Retrieved from: https://data.gsmaintelligence.com/research/research/research-2020/5g-and-economic-growth-an-assessment-of-gdp-impacts-in-canada.; HIS Economics and IHS Technology. “The 5G Economy: How 5G Technology will Contribute to the Global Economy.” 2017. https://www.sipotra.it/wp-content/uploads/2017/01/The-5G-economy-How-5G-technology-will-contribute-to-the-global-economy.pdf.

[42] Forge, Simon, Robert Horvitz, and Colin Blackman. "Final Report for the European Commission." (2012).; Cave, Martin. "Spectrum and the Wider Economy." (2015). https://ieb.ub.edu/wp-content/uploads/2018/06/Cave_2.pdf.; Bazelon, Coleman, and McHenry, Giulia. "Mobile broadband spectrum: A vital resource for the US economy." *prepared for the CTIA by the Brattle Group* (2015). https://api.ctia.org/docs/default-source/default-document-library/brattle_spectrum_051115.pdf.; Bhattarai, Sudeep, Jung-Ming. J. Park, Bo Gao, Kaigui Bian and William Lehr, "An Overview of Dynamic Spectrum Sharing: Ongoing Initiatives, Challenges, and a Roadmap for Future Research," *IEEE Transactions on Cognitive Communications and. Networking*, vol. 2, no. 2: 110-128, June 2016.; Nozdrin, Vadim. “Economic Efficiency of Spectrum Allocation.” *ITU Journal on Future and Evolving Technologies* 2, no. 1 (2021): 67-76.

the initial investor.[43] In addition, the higher income generated due to the initial increase in demand leads to higher demand for all goods and services in the economy (the multiplier impact).[44] Second, the extent to which broadband services are used and the way they are used (adoption), can have significant impact on the economy and the well-being of people.[45] In general, internet and digital connectivity can improve the efficiency of production and allocation of resources. The use of digital technology can: facilitate skills training and transfer of knowledge; streamline production process, e.g., digitization of supply chains;[46] lead to innovation in production and delivery of goods and services;[47] expand markets for firms, offering an opportunity for amplification;[48] and lead to new services like Uber.[49]

Moreover, the use of digital connectivity in areas like health can improve social benefits as well as increase potential economic activity.[50] Access to health care through internet can lead to better diagnosis (especially, in rural or remote places) of health problems and thus prevention of more serious problems in the future.[51] Not only does this improve the quality of life but it also helps maintain a healthier and more productive

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[43] International Telecommunication Union, "Impact of Broadband on the Economy," Broadband Series, April 2012. https://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_Impact-of-Broadband-on-the-Economy.pdf.

[44] International Telecommunication Union, "Impact of Broadband on the Economy," Broadband Series, April 2012. https://www.itu.int/ITU-D/treg/broadband/ITU-BB-Reports_Impact-of-Broadband-on-the-Economy.pdf.

[45] GSMA Intelligence, "5G and Economic Growth: An Assessment of GDP Impacts in Canada." November 2020. https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=54165916&file=051120-5G-in-Canada.pdf.

[46] Enis Gezgin, Xin Huang, Prakash Samal, and Ildefonso Silva, "Digital transformation: Raising supply-chain performance to new levels," McKinsey & Company, November 17, 2017. https://www.mckinsey.com/business-functions/operations/our-insights/digital-transformation-raising-supply-chain-performance-to-new-levels.

[47] Dominique Guellec, Caroline Paunov and Sandra Planes-Satorra, "4. Digital innovation: Cross-sectoral dynamics and policy implications," Directorate for Science, Technology and Innovation, OECD, 2020. https://www.oecd-ilibrary.org/sites/ee2a2c2f-en/index.html?itemId=/content/component/ee2a2c2f-en

[48] "The Digital Transformation for SMEs," OECD, 2021. https://www.oecd.org/industry/smes/PH-SME-Digitalisation-final.pdf

[49] Tony D'Emidio, David Dorton, and Ewan Duncan, "Service innovation in a digital world," *McKinsey Quarterly*, February 1, 2015. https://www.mckinsey.com/business-functions/operations/our-insights/service-innovation-in-a-digital-world

[50] GSMA Intelligence, "5G and Economic Growth: An Assessment of GDP Impacts in Canada." November 2020. https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=54165916&file=051120-5G-in-Canada.pdf.

[51] *National Research Council (US) Committee on Enhancing the Internet for Health Applications: Technical Requirements and Implementation Strategies*, "Health Applications of the Internet," Washigton DC: National Academies Press, 2000. https://www.ncbi.nlm.nih.gov/books/NBK44714/#:~:text=In%20clinical%20settings%2C%20the%20Internet,accessible%20from%20the%20examination%20room; Lydia Ramsey, "How the internet is improving healthcare," World Economic Forum and Business Insider, January 3, 2017. https://www.weforum.org/agenda/2017/01/technology-is-changing-the-way-we-view-our-health-this-is-how.

labour force. PricewaterhouseCoopers (PwC) estimates that healthcare will be the sector to the see the highest increase in global output because of the 5G rollout.[52]

The continued roll-out of 5G is expected to lift GDP, along with other benefits (known and unknown) across industrial sectors.[53] With 5G, data speed, latency, and device connection density will improve.[54] This means that users (including individuals, industry, etc.) will be able to do more, faster, and with a larger number of devices interfacing with 5G technology. The full potential of 5G and its applications are to be defined.

Well before the roll-out of 5G, the impacts of connectivity were well-defined. The mobile telecommunications industry was estimated by Statistics Canada to have generated approximately $47B in 2019 through industry revenues, supply chains, and other impacts (direct and indirect) from expenditure of industry wages (in 2018, this represented just over 1% of GDP).[55] In addition, in 2019, the telecommunications industry, its supply chains, and wage impacts generated over 153,000 jobs in Canada.[56] Average annual earnings of such jobs were over $67,000, higher than the average annual service industry income of approximately $54,500.[57]

In a study of 22 OECD countries from 2002 to 2007, Koutroumpis (2009)[58] examined the impact of broadband on GDP growth. The study shows that the trend in broadband penetration and economic growth are correlated. Using a simultaneous regression model, the study estimates that a one percent increase in broadband penetration increases GDP growth between 0.012 to 0.025 percent.

There are also studies that use more micro-level data to demonstrate the economic impact of digital technology. For example, Aker (2010)[59] uses data from the staggered introduction of mobile phone coverage in different geographic areas in Niger in the early

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[52] PWC, "The global economic impact of 5G," n.d. https://www.pwc.com/gx/en/tmt/5g/global-economic-impact-5g.pdf

[53] Chow, Wilson, "The Global Economic Impact of 5G. Powering Your Tomorrow." PwC. 2021. https://www.pwc.com/gx/en/industries/technology/publications/economic-impact-5g.html. See also, 5G Americas, "Cellular communications in a 5G era," A 5G Americas whitepaper, January 2022, https://www.5gamericas.org/wp-content/uploads/2022/01/Cellular-Communications-in-a-5G-Era-InDesign.pdf.

[54] Link to report: https://www.accenture.com/_acnmedia/PDF-130/Accenture-Greece-Race-to-5G-Full-Report.pdf#zoom=50.

[55] Statistics Canada, "Connecting Canadians: Telecommunications in Canada," last updated May 12, 2022, https://www.statcan.gc.ca/en/subjects-start/digital_economy_and_society/telecommunications

[56] Statistics Canada, "Connecting Canadians: Telecommunications in Canada," last updated May 12, 2022, https://www.statcan.gc.ca/en/subjects-start/digital_economy_and_society/telecommunications

[57] Statistics Canada, "Connecting Canadians: Telecommunications in Canada," last updated May 12, 2022, https://www.statcan.gc.ca/en/subjects-start/digital_economy_and_society/telecommunications

[58] Koutroumpis, Pantelis, "The economic impact of broadband on growth: A simultaneous approach," *Telecommunications Policy* 33, no. 9, October 2009, 471-485. https://www.sciencedirect.com/science/article/pii/S0308596109000767#fn12

[59] Aker, Jenny C., "Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger." *American Economic Journal: Applied Economics* 2, no. 3, 46-59. 2010.

2000s.[60] He finds, on average, a 10% decrease in price dispersion amongst agricultural products as a result of mobile phone use.[61] Therefore, while very few, studies are able to produce a single estimate of the societal impact of spectrum policy, it is possible to demonstrate particular channels through which connectivity improves economic outcomes.

Most estimates on the impact of telecommunications infrastructure and broadband penetration for economic growth focus on developing countries. Moving from low levels of connectivity, their potential benefits from investment are greater.[62] For instance, Yidan Li (2019)[63] examines the impact of internet penetration on economic activity of 65 countries in the Belt and Road region. The results show that for every 1 percent increase in internet penetration GDP increases by 0.076%. The study also concludes that contextual factors influence results. The size of the impact of internet penetration was impacted by the level of economic development, industrial structure, and the level of international trade.

A World Bank study in 2009 highlighted the differences in economic impact of broadband connectivity between developed and developing economies. Using data from 120 developed and developing economies, the study estimated that a 1% increase in broadband penetration leads to 0.12% increase in per capita GDP for developed countries.[64] Scott (2012)[65] used the same model and methodology with more recent data and corroborated the estimate of the World Bank Study. Contextual factors, such as economic development, can bolster output potential, generating spin-off benefits from connectivity.

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[60] Aker, Jenny C., "Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger," American Economic Journal: Applied Economics 2, no. 3, July 2010, 46-59. https://www-jstor-org.proxy.bib.uottawa.ca/stable/pdf/25760219.pdf?refreqid=excelsior%3A63fafc08805f6e657ee55ebca566b97b&ab_segments=&origin=&acceptTC=1

[61] Aker, Jenny C., "Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger," American Economic Journal: Applied Economics 2, no. 3, July 2010, 46-59. https://www-jstor-org.proxy.bib.uottawa.ca/stable/pdf/25760219.pdf?refreqid=excelsior%3A63fafc08805f6e657ee55ebca566b97b&ab_segments=&origin=&acceptTC=1

[62] See, for example, GSMA and the World Bank, "The poverty reduction effects of mobile broadband in Africa: Evidence from Nigeria," December 2020. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2020/12/The-Poverty-Reduction-Effects-of-Mobile-Broadband-in-Africa-Evidence-from-Nigeria.pdf

[63] Yidan Li, "Influence of the Internet on the Economic Growth of the Belt and Road Region," *Global Journal of Emerging Market Economies*, December 31, 2019. https://journals.sagepub.com/doi/abs/10.1177/0974910119887054

[64] World Bank, "Extending Reach and Increasing Impact," Information and Communications for Development, 2009. Https://documents1.worldbank.org/curated/en/645821468337815208/pdf/487910PUB0EPI1101Official0Use0Only1.pdf

[65] Colin Scott, "Does broadband Internet access actually spur economic growth?" December 7, 2012. https://colin-scott.github.io/personal_website/classes/ictd.pdf

Holt and Jamison (2009)[66] review several studies that had attempted to estimate the influence of broadband on economic growth in the U.S. and conclude that:

> The lesson from the US appears to be that broadband has a positive economic impact, but that impact cannot be analyzed with any precision. One of the difficulties learned from studies of the effects of ICT is that impacts evolve, perhaps even going through periods of negative growth, while businesses experiment with applications and reorganize their operations.[67]

While digital connectivity positively impacts economic growth, the precise impact depends on the degree of penetration and other economic factors such as industrial structure and trade openness of the economy. In developed countries, the marginal rate of return from connectivity will be lower than for developing countries who would benefit more significantly. Economic benefits remain possible from connectivity, but in developed economies they are more likely to stem from 'spin-off' areas of industry, e.g., innovation, research and development, etc. This is about leveraging connectivity as a tool to achieve an economic or social benefit rather than having connectivity serve as the driver of impact.

The pandemic underscored the imperative of connectivity for all, notably in rural places beyond economic growth, for reasons of social well-being.[68] Connectivity is about participation, inclusion, and access to the market economy and society. The benefits of connectivity in established economies will be broader than GDP alone, and indirectly related to it through benefits in innovation, research, inclusion, etc. (see Table 1).

[66] Holt, Lynne and Market Jamison, "Broadband and contributions to economic growth: Lessons from the US experience," *Telecommunications Policy* 33, no. 10-11, November – December 2009, 575-581. https://www.sciencedirect.com/science/article/pii/S0308596109000962.

[67] Holt Lynne, and Market Jamison, "Broadband and contributions to economic growth: Lessons from the US experience," *Telecommunications Policy* 33, no. 10-11, November – December 2009, 575-581: 580. https://www.sciencedirect.com/science/article/pii/S0308596109000962.

[68] Dahiya, Shefali, Lila N. Rokanas, Surabhi Singh, Melissa Yang, and Jon M. Peha, "Lessons from internet use and performance during COVID-19." *Journal of Information Policy* 11, no. 1 (2021): 202-221.; Weeden, S. Ashleigh and Wayne Kelly for the Canadian Rural Revitalization Foundation. "Rural Insights Series: COVID-19, 1.5: Addressing the Digital Divide: COVID-19 and the Importance of Connecting Rural Canada." (2020).

Table 1: Variables for measuring socio-economic benefits of connectivity

Variable	Relation to Connectivity
GDP	Sectors that use spectrum contribute to GDP as do adjacent sectors such as the manufacturers of smart devices.[69] Spending on these products and services has a multiplying effect across the economy.[70] Moreover, these spectrum-using services are inputs for other sectors of the economy.[71] This means that increases in connectivity drive up production in industries that do not use spectrum directly. It is common in the literature to break down this increase in GDP by sector.[72] Note that although this increase in GDP could be a result of improved Labour Productivity, that is not necessarily the case.
Labour Productivity	The rise of information and communications technology (ICT) played a major role in the labour productivity increases of the late 1990s and early 2000s.[73] The rollout of 5G, especially coupled with the rise of AI and IoT, is expected to drive future growth in labour productivity.[74] Note that Labour Productivity refers to how much is being produced per worker. This is not the same as an increase in GDP which refers to how much is being produced overall. However, an increase in Labour Productivity could incentivize a company to increase their production which would constitute an increase in GDP. Therefore, Labour Productivity and GDP growth are closely related but not identical.
Consumer Surplus	Higher levels of connectivity imply that more consumers have access to a higher quantity and quality of services.[75]
Health Outcomes	Wireless technology can improve the quality and accessibility of healthcare.[76]
Standard of Living	Especially in a developing context, mobile technology is associated with poverty alleviation.[77] Even 2G cell service improved outcomes by, for instance, allowing those experiencing poverty to access mobile money[78] and making it easier for suppliers to access information about markets.[79] Recent research about Nigeria has also demonstrated the poverty alleviation effects of mobile broadband.[80]
Gender Equality	Especially in a developing context, mobile technology grants women more autonomy, especially in accessing services.[81] Gender Equality is measured in the literature using a variety of variables such as maternal and child mortality; use of contraception; involvement in household decisions; antenatal visits; or pre-existing gender equality indices.[82]
Carbon Emissions	Smart technologies in areas such as transport and agriculture allow for the provision of services at a lower carbon footprint.[83]

[69] Cave, Martin, "Spectrum and the Wider Economy." (2015). https://ieb.ub.edu/wp-content/uploads/2018/06/Cave_2.pdf.

[70] Bazelon, Coleman, and McHenry, Giulia. "Mobile broadband spectrum: A vital resource for the US economy." *prepared for the CTIA by the Brattle Group* (2015). https://api.ctia.org/docs/default-source/default-document-library/brattle_spectrum_051115.pdf.
[71] Chow, Wilson, "The Global Economic Impact of 5G. Powering Your Tomorrow." PwC. 2021. https://www.pwc.com/gx/en/industries/technology/publications/economic-impact-5g.html; GSMA and WRC. "The WRC Series: Study on Socio-Economic Benefits of 5G Services Provided in mmWave Bands." December 2018. https://www.gsma.com/spectrum/wp-content/uploads/2019/10/mmWave-5G-benefits.pdf.
[72] Castells, Pau, Stefano Suardi, Dennisa Nichiforov-Chuang, and David Geroge, GSMA Intelligence. "5G and Economic Growth: An Assessment of GDP Impacts in Canada." November 2020. https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=54165916&file=051120-5G-in-Canada.pdf;m GSMA and WRC. "The WRC Series: Study on Socio-Economic Benefits of 5G Services Provided in mmWave Bands." December 2018. https://www.gsma.com/spectrum/wp-content/uploads/2019/10/mmWave-5G-benefits.pdf.
[73] Cave, Martin, "Spectrum and the Wider Economy." (2015). https://ieb.ub.edu/wp-content/uploads/2018/06/Cave_2.pdf.
[74] Castells, Pau, Stefano Suardi, Dennisa Nichiforov-Chuang, and David Geroge, GSMA Intelligence. "5G and Economic Growth: An Assessment of GDP Impacts in Canada." November 2020. https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=54165916&file=051120-5G-in-Canada.pdf.
[75] Bazelon, Coleman, and McHenry, Giulia, "Mobile broadband spectrum: A vital resource for the US economy." *prepared for the CTIA by the Brattle Group* (2015). https://api.ctia.org/docs/default-source/default-document-library/brattle_spectrum_051115.pdf; Hazlett, Thomas W., and Roberto E. Muñoz, "A welfare analysis of spectrum allocation policies." *The RAND Journal of Economics* 40, no. 3 (2009): 424-454.
[76] GSMA and WRC, "The WRC Series: Study on Socio-Economic Benefits of 5G Services Provided in mmWave Bands." December 2018. https://www.gsma.com/spectrum/wp-content/uploads/2019/10/mmWave-5G-benefits.pdf; Castells, Pau, Stefano Suardi, Dennisa Nichiforov-Chuang, and David Geroge. GSMA Intelligence, "5G and Economic Growth: An Assessment of GDP Impacts in Canada." November 2020. https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=54165916&file=051120-5G-in-Canada.pdf.
[77] "The poverty reduction effects of mobile broadband in Africa: Evidence from Nigeria," GSMA and the World Bank, December 2020. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2020/12/The-Poverty-Reduction-Effects-of-Mobile-Broadband-in-Africa-Evidence-from-Nigeria.pdf.
[78] Suri, Tavneet, "Mobile Money." *Annual Review of Economics* 9, no. 1, 497-520.
[79] Aker, Jenny C.,"Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger." *American Economic Journal: Applied Economics* 2, no. 3, 46-59. 2010; Castells, Pau, Cruz, Genaro, Masaki, Takaaki, and Castelán, Carlos Rodríguez. "Expanding Mobile Broadband Coverage is Lifting Millions out of Poverty." *World Bank Blogs*, December 2020. https://blogs.worldbank.org/developmenttalk/expanding-mobile-broadband-coverage-lifting-millions-out-poverty.
[80] Castells, Pau, Cruz, Genaro, Masaki, Takaaki, and Castelán, Carlos Rodríguez, "Expanding Mobile Broadband Coverage is Lifting Millions out of Poverty." *World Bank Blogs*, December 2020. https://blogs.worldbank.org/developmenttalk/expanding-mobile-broadband-coverage-lifting-millions-out-poverty; "The poverty reduction effects of mobile broadband in Africa: Evidence from Nigeria," GSMA and the World Bank, December 2020. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2020/12/The-Poverty-Reduction-Effects-of-Mobile-Broadband-in-Africa-Evidence-from-Nigeria.pdf.
[81] Rotondi, Valentina, Kashyap, Ridhi, Pesando, Luca Maria, Spinelli, Simone, and Billari Francesco C., "Leveraging Mobile Phones to Attain Sustainable Development." *Proceedings of the National Academy of Sciences* 117, no. 24, June 2020, 13413-13420.
[82] Rotondi, Valentina, Kashyap, Ridhi, Pesando, Luca Maria, Spinelli, Simone, and Billari Francesco C., "Leveraging Mobile Phones to Attain Sustainable Development." *Proceedings of the National Academy of Sciences* 117, no. 24, June 2020, 13413-13420.

Savings	Connectivity supports IoT and IoE, which allow the public and private sectors to adopt cost-saving technologies such as smart buildings.[84]
Jobs Created	The telecommunications sector generates jobs which have a multiplier effect across the economy.[85] It is also worth noting that this variable depends on the allocation of spectrum. For instance, spectrum allocated to TV broadcasters generates fewer jobs than spectrum allocated to mobile providers.[86]

[83] GSMA and Carbon Trust, "The Enablement Effect: The Impact of Mobile Communications Technologies on Carbon Emission Reduction." n.d. https://www.gsma.com/betterfuture/wp-content/uploads/2019/12/GSMA_Enablement_Effect.pdf.

[84] Bazelon, Coleman, and McHenry, Giulia, "Mobile broadband spectrum: A vital resource for the US economy." *prepared for the CTIA by the Brattle Group* (2015). https://api.ctia.org/docs/default-source/default-document-library/brattle_spectrum_051115.pdf; Kash, Wyatt. "Internet of Things: 8 Cost-Cutting Ideas for Government 2." *Information Week*, 2014. https://www.informationweek.com/leadership/internet-of-things-8-cost-cutting-ideas-for-government-2.

[85] CTIA, "The 4G Decade: Quantifying the Benefits." 2020. https://www.ctia.org/news/report-the-4g-decade-quantifying-the-benefits; HIS Economics and IHS Technology. "The 5G Economy: How 5G Technology will Contribute to the Global Economy." 2017. https://www.sipotra.it/wp-content/uploads/2017/01/The-5G-economy-How-5G-technology-will-contribute-to-the-global-economy.pdf azelon, Coleman, and McHenry, Giulia. "Mobile broadband spectrum: A vital resource for the US economy." *prepared for the CTIA by the Brattle Group* (2015). https://api.ctia.org/docs/default-source/default-document-library/brattle_spectrum_051115.pdf.

[86] Nozdrin, Vadim, "Economic Efficiency of Spectrum Allocation." *ITU Journal on Future and Evolving Technologies* 2, no. 1 (2021): 67-76.

In general, it is broadly accepted that the use of digital connectivity has a positive impact on the economy and on the quality of life. The magnitude of the economic and social impact, however, depends on how connectivity is used and the degree of maturity in broadband connectivity. The benefits of connectivity must be considered through other lenses, as marginal benefits of an increase in connectivity likely decline as the maturity increases. At high levels of connectivity maturity, benefits of connectivity, e.g., broadband, must be understood through measures beyond connectivity alone.

Broad and indirect indicators could be used to measure and monitor the impact of connectivity on socio-economic benefits. The variables in Table 1 represent a starting point for measuring and monitoring the socio-economic benefits of connectivity. With the broad benefits of connectivity established, defining the discreet linkage between connectivity and socio-economic output can be a challenge as the causal relationships are tenuous. Connectivity, like a road, a bridge, or a stable regulatory environment, is a point of departure for innovation, research, and other market activities.

Part II: Canada in-context

The past two governments have made various commitments surrounding connectivity, notably in rural or harder to reach places in Canada. In 2021, mandate letters for two ministers focused commitments on connectivity to Canadians in rural places and deployment conditions for providers. These updated commitments were a shift from the broader connectivity goals from previous mandate letters which included Infrastructure and other departments.

The Minister of Rural Economic Development was asked to:

> […] recognize the unique realities and challenges faced by rural communities, including measures to support economic recovery, growth and resilience. Key among these is access to fast and reliable high-speed Internet, which is essential to ensuring that Canadians in rural and remote communities have equal access to services, supports, and economic and job opportunities. [and] […] accelerate the delivery of broadband service across Canada to ensure that all Canadians, no matter where they live, have access to high-speed internet.[87]

The Minister of Innovation, Science and Industry was tasked to:

> Accelerate broadband delivery by implementing a "use it or lose it" approach to require those that have purchased rights to build broadband to meet broadband access milestones or risk losing their spectrum rights.[88]

The mandate letters indicate the government's intention of pursuing the goals of efficiency and connectivity. While both useful in promoting the benefits of connectivity, it is worth considering how these goals can be achieved in practice. Reaching the goals of connectivity and efficiency are more likely to be achieved when there is coherence between decisions on spectrum assignment, deployment, and connectivity.

Canada's current approach to spectrum assignment combines policy, regulatory documents, and political decisions. When considered as a single approach, Canada's spectrum policy emphasizes competition, connectivity (for consumers and for security), and costs. The priorities include:[89]

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[87] Government of Canada, "Minister of Rural Economic Development Mandate Letter," Prime Minister of Canada, December 2021, https://pm.gc.ca/en/mandate-letters/2021/12/16/minister-rural-economic-development-mandate-letter

[88] Government of Canada, "Minister of Innovation, Science and Industry Mandate Letter," Prime Minister of Canada, December 2021, https://pm.gc.ca/en/mandate-letters/2021/12/16/minister-innovation-science-and-industry-mandate-letter

[89] See for instance, Innovation, Science and Economic Development Canada, August 2020, "Consultation on the 3650-4200 MHz Band," last modified December 7, 2020, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11627.html#s11%20http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11627.html#s11; "Spectrum Outlook 2018 to 2022," Innovation, Science and Economic Development Canada, June 2018, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11403.html; "SPFC - "Framework for Spectrum Auctions in

- Encourage market competition and the growth of fourth service providers
- Boost connectivity, especially in rural and remote areas;
- Promote the deployment of new technologies that rely on 5G networks;
- Strengthen affordability in cellular and wireless services;
- Generate government revenue through auctions;
- Ensure procedural fairness and efficiency in spectrum auctions; and
- Remain vigilant to national cyber security concerns.
- The government seems to understand a clear link between its spectrum allocation policy and many of its broader priorities.

There is a tacit interaction between spectrum assignment, deployment, and connectivity in the priorities. Whether the priorities are being pursued with consideration of the interactivity of individual components is less clear. For instance, the 2021 mandate letter for the Minister of Innovation, Science and Industry highlighted the importance of deployment conditions, which is positive and necessary to promote expedited deployment. The deployment conditions alone, however, do not correct for needed changes in spectrum assignment to differentiate between urban and rural places, the other connectivity-related goal for the Minister of Rural Economic Development.

Current spectrum policy promotes competition in urban areas among providers where service demands exist due to population density. Providers are incentivized to deploy spectrum to generate revenue from services. This business case is limited at best in rural and less populated areas. The approach is also expensive relative to peer countries. Costs of spectrum in Canada were 164% the average price paid in the United States (the country with the next highest average price paid, after Canada), 10 times the cost in France, and 11 times those in the United Kingdom.[90] Set-asides, aimed at providing space for competition for smaller regional players and providing opportunities for competition are criticized for frequent use. The high costs of spectrum acquisition by service providers are passed on to consumers with higher connectivity prices.

When assessed more closely, Canada does not maximize the potential utility of previously tried and tested approaches to refine and specialize its approach to spectrum assignment. Consider for instance, the use of reverse auctions in the United States by the FCC to assign spectrum and promote connectivity in rural places. Canada could feasibly differentiate its approaches to spectrum assignment (while maintaining auctions

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Canada," Innovation, Science and Economic Development Canada, last modified March 2022, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01626.html; Spectrum Policy Framework for Canada," Innovation, Science and Economic Development Canada, last modified May 2011, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08776.html.

[90] Wood, Rupert, "Falling Behind: Comparing 5G Spectrum Policies in Canada and OECD Countries," Analysys Mason, August 2021, p. 2 https://www.analysysmason.com/contentassets/3142cca88f924253be79605a6703503a/analysys_mason_5g_spectrum_canada_nov2021_rdnt0.pdf

to maximize competition) and better achieve its declared goal of rural connectivity by ensuring spectrum is assigned in a way that incentivizes coverage and deployment.

Canada's approach to spectrum assignment
The Minister of Industry has the statutory authority to set spectrum policy (*Department of Industry Act*, *Radiocommunication Act*, and *Telecommunications Act*).[91] As the Minister of Industry has the authority to set spectrum policy, it is important to consider that political commitments, e.g., as defined in platforms, ministerial mandate letters, etc., as well as innovation and economic development strategies, can shape approaches to the operationalization of spectrum policy.

There are four framework documents that support the operationalization of spectrum assignment. Taken together, the documents define the principles for assigning spectrum, procedural approaches to auctions, plans for the next five years, and the duty to consult. The documents are reviewed below with additional detail in Appendix A.

1) *Spectrum policy framework for Canada (2007)*

As its name suggests, this document is the 'foundation' for spectrum allocation policy in Canada.[92] The document defines a broad frame, with a long-term outlook. While implementation details are limited, it does define guiding principles, as well as the need for consultation. The overarching objective for spectrum assignment is to seek to maximize "economic and social benefits" for Canadians.

The framework policy advocates for a market-based approach that considers critical security and sovereignty requirements, while ensuring services to Canadians. Such a broad framework can be conducive to achieving changing political, economic, and social priorities.

2) *Framework for spectrum auctions (2011)*

In this document, a procedural approach that ISED should use to allocate spectrum licences is articulated, including ISED's role in using auctions to foster competitiveness in the wireless market.[93] Within the approach, auctions are said to be a sound allocation mechanism when demand for spectrums is expected to exceed supply, and government objectives can be met through auction.

The criteria appear straightforward but are not fully defined, assuming to permit flexibility to account for changing objectives and priorities. For instance, what constitutes market demand is not defined, with acknowledgement of the difficulty in measuring demand for spectrum.

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[91] "SPFC - Spectrum Policy Framework for Canada," Innovation, Science and Economic Development Canada, last modified May 2011, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08776.html.
[92] "SPFC - Spectrum Policy Framework for Canada," Innovation, Science and Economic Development Canada, last modified May 2011, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08776.html.
[93] "Framework for Spectrum Auctions in Canada," Innovation, Science and Economic Development Canada, last modified March 2022, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01626.html.

The framework makes no apparent reference to the competitive effects of a provider's failure to make use of spectrum licences. It does not suggest any solution or penalty for slow deployment. However, ISED does reserve the right to re-auction any un-sold licences or distribute them on a first-come, first-serve basis.

3) Spectrum Outlook (2018-2022)

In the outlook document, ISED's planned activities related to spectrum allocation over a five-year period are defined, with the intent of providing predictability and transparency to industry stakeholders.[94] The three pillars defined in the outlook include quality, coverage, and prices.

From a planning perspective, the guidance document can be a helpful signal to stakeholders engaged in medium-term business planning. Elements such as approximate timelines for the roll-out of bands is included, as are medium-term priorities, such as the emergence of 5G technology and the need to keep pace with leading international jurisdictions.

4) Band-specific Consultations on Policy and Licensing Frameworks

In accordance with its duty to consult, ISED releases priorities ahead of a spectrum auction. Details are usually specific to a particular band wavelength and a specific geographic region, but they may also reflect government objectives toward spectrum allocation generally. Details on consultations for the next auction include ensuring "high quality" universal regional access; promoting economy-wide innovation; and promoting a robust and competitive wireless industry.[95]

These priorities have remained largely constant over the past several spectrum auctions (dating as far back as 2012[96]), although the most recent consultations have included more express callouts for 5G technology and remote communities.[97] There are concerns with respect to the speed and predictability of Canada's spectrum allocation policy.[98] Specifically, industry players have noted that Canada's recent 5G allocations have occurred after most OECD countries because of a slow combinatorial clock auction procedure. In the "combinatorial clock" auction format, participants bid on several "blocks" or regional spectrum licences at once. The format is slower to

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[94] "Spectrum Outlook 2018 to 2022," Innovation, Science and Economic Development Canada, June 2018, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11403.html.

[95] Innovation, Science and Economic Development Canada, August 2020, "Consultation on the 3650-4200 MHz Band," last modified December 7, 2020, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11627.html#s11%20http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11627.html#s11

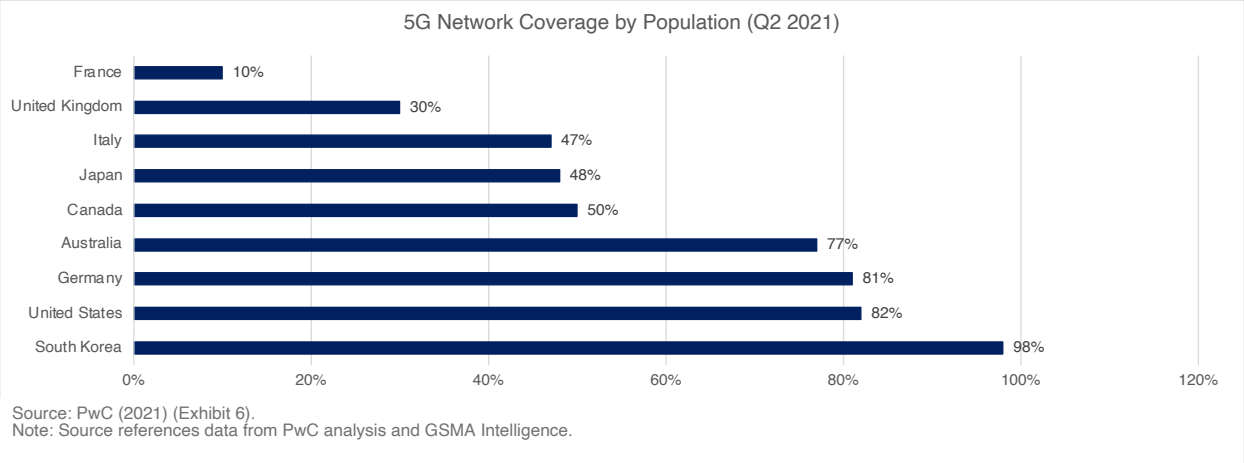
[96] "Consultation on a Licensing Framework for Broadband Radio Service (BRS) — 2500 MHz Band," Innovation, Science and Economic Development Canada, last modified October 2012, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf10471.html#sec2.

[97] See "Consultation on the 3650-4200 MHz Band," Innovation Science and Economic Development Canada.

[98] "High Spectrum Costs, Regulatory Impediments Slow 5G Rollout: Telecommunications Policy Working Group," CD Howe Institute, April 2021, https://www.cdhowe.org/council-reports/high-spectrum-costs-regulatory-impediments-slow-5g-rollout-telecommunications-policy-working-group.

accommodate a more complex multiple bid system. Canada is not alone in using this auction format, it is used in other jurisdictions in the G7, Australia, and South Korea, among others. Relative to other OECD countries, Canada is a mid-performer in the rollout of 5G technology by population coverage (Figure 1).

Figure 1: 5G network coverage by population



Source: PwC (2021) (Exhibit 6).
Note: Source references data from PwC analysis and GSMA Intelligence.

The five-year time horizon expressed in the government's Spectrum Outlook has been criticized as too long to adequately assist providers in business and network planning, more frequent updates could be helpful for planning.[99] The lack of regular information is compounded by the fact that most of the Government's policy details are presented during the consultation period at the beginning of a specific auction, and not in longer-term documents, making it difficult for businesses to plan.

Spectrum assignment in other jurisdictions

To contextualize Canada's approach to spectrum assignment and connectivity, the practices of G7 countries (Canada, France, Germany, Japan, Italy, United States, United Kingdom), plus Australia and South Korea were surveyed. These countries were selected as comparisons because they are democracies with developed economies that have a variety of geographies, populations, and systems of governance. While sharing core characteristics, their internal differences provide helpful contexts through which to assess approaches to spectrum policy and identify lessons and practices for improvement.

These countries were compared against three dimensions:

1) Spectrum priorities: How a country defines its use of spectrum and related policy goals.

[99] C.D. Howe Institute, "Communique #4: High Spectrum Costs, Regulatory Impediments Slow 5G Rollout," Telecommunications Policy Working Group, April 2021, https://www.cdhowe.org/sites/default/files/attachments/communiques/mixed/CWGR_2021_0421_0.pdf

2) Operational context: The particular institutional and geographic environments that shape (enabling/constraining) spectrum policy.
3) Assignment practices: The approaches and rules that determine who uses spectrum and how.

When considered together, the three dimensions help to define the linkages between policy, assignment, deployment, and connectivity for assessing the alignment of spectrum policy to economic priorities.

There is variability on the levels, speeds, and technologies for connectivity among the jurisdictions when captured on the basis of household connectivity (Table 2). Jurisdictions have different approaches to fostering and reporting on connectivity. In Table 2, data is captured as consistently as possible, with recognition that there is a mix of mobile and fixed types of connectivity being reported. Canada, for instance, has a 50/10 connection standard for broadband, higher than other jurisdictions, e.g., the United States (25/3), Australia (defined as "internet access"). At a national level, coverage across the countries varies from a score of 76/100 in Australia to a high of 96.5% in South Korea.

Breadth of coverage does not imply equal speed and reliability. For those jurisdictions that report differences in connectivity between urban and rural areas, the United Kingdom is leading with rural coverage at 83%, followed by the United States (74%). While Canada's upload and download speeds are higher, its rural coverage is lowest when reported as wired connectivity at 46%. When wireless coverage is considered, Canada performs well with nearly 100% coverage in urban and rural areas and 90.5% coverage in First Nations, all at variable speeds.[100]

[100] Government of Canada, "Current trends – Mobile wireless," Canadian Television and Telecommunications Commission, last modified June 30, 2022, https://crtc.gc.ca/eng/publications/reports/PolicyMonitoring/mob.htm.

Table 2: Household connectivity rates in different countries

Country	Connectivity rates of households Note: various speeds and technologies
Australia (2020)[101]	"Internet access," part of the Australian Digital Inclusion Index (ADII), presented as a score out of 100 National: 76 Capitals: 78 Rural: 73
Canada (2019)[102]	50/10 Mbps National: 87% Urban: 99% Rural: 46% First Nations reserves: 35%
France (2021)[103]	National: 93%
Germany (2021)[104]	National: 92%
Italy (2021)[105]	National: 90%
Japan (2020)[106]	National: 93% (broadband)
Korea (2021)[107]	National: 96.5%

[101] Thomas, Julian, Jo Barraket, Chris Wilson, Indigo Holcombe-James, Jenny Kennedy, and Ellie Rennie, "Measuring Australia's Digital Divide." The Australian Digital Inclusion Index 2020. RMIT and Swinburne University of Technology, 2020. https://apo.org.au/sites/default/files/resource-files/2020-10/apo-nid308474.pdf.
[102] Government of Canada, "Communications Monitoring Report Communications Monitoring Report." Canadian Television and Telecommunications Commission, December 10, 2020. https://crtc.gc.ca/eng/publications/reports/policyMonitoring/2020/cmr4.htm#a2.3.
[103] Eurostat Statistics Explained, "Digital Economy and Society Statistics - Households and Individuals." *Digital economy and society statistics - households and individuals,* December 2021. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Digital_economy_and_society_statistics_-_households_and_individuals.
[104] Eurostat Statistics Explained, "Digital Economy and Society Statistics - Households and Individuals." *Digital economy and society statistics - households and individuals,* December 2021. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Digital_economy_and_society_statistics_-_households_and_individuals.
[105] Eurostat Statistics Explained, "Digital Economy and Society Statistics - Households and Individuals." *Digital economy and society statistics - households and individuals,* June 2022. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Digital_economy_and_society_statistics_-_households_and_individuals.
[106] Statista, "Japan: Share of Internet Connection Types among Households 2021." Statista, 2022. https://www.statista.com/statistics/1140408/japan-share-internet-connection-types-among-households/.
[107] Nina Jobst, "Topic: Internet Usage in South Korea." Statista, 2022.

United Kingdom (2021)[108]	"Superfast" broadband, at least 30Mbps (download) National: 96% Urban: 98% Rural: 83%
United States (2019)[109]	25/3 Mbps (minimum) National: 94% Urban: 98% Rural: 74% Tribal regions: 68%

https://www.statista.com/topics/2230/internet-usage-in-south-korea/#dossierKeyfigures.

[108] Ofcom, "Connected Nations 2021 ." Ofcom, 2021. https://www.ofcom.org.uk/__data/assets/pdf_file/0035/229688/connected-nations-2021-uk.pdf.

[109] CRS, "Broadband Internet Access and the Digital Divide: Federal Assistance Programs." *Congressional Research Service,* October 25, 2019. https://sgp.fas.org/crs/misc/RL30719.pdf

Figure 2: Indigenous connectivity overview

Indigenous connectivity

Reconciliation with Indigenous Peoples has been a central consideration of Canadian politics. Moving forward on reconciliation is not a single action but one that has been increasingly defined as the pursuit of substantive equality, i.e., equalizing points of departure to optimize long-term well-being. This approach is informing reforms to programs such as First Nations child and family services, which led to an historic $40B settlement through the rulings of the Canadian Human Rights Tribunal. When considered through the lens of reconciliation through substantive equality, connectivity in First Nations is about access to services, economic opportunity, and participation from their land. The essential linkage to place and space can be maintained by First Nations while connecting outward when connectivity is available. Creating an enabling environment in which First Nations can connect from their homes and lands is critical to building an equitable point of departure for well-being.

Jurisdiction	Indigenous group	Percentage of Indigenous community with internet access	Percentage of general population with internet access	Year
Canada	First Nations reserves (households)	35% (50/10 Mbps unlimited)	46% (rural households)	2019[110]
New Zealand	Māori (having access to Internet)	87%	90 % (amongst those of European ethnicity only)	2017[111]
Australia	Aboriginal and Torres Strait Islander ("households…accessing the internet.")	72%	84% ("other households")	2016[112]

[110] CRTC, "Communications Monitoring Report ." Canadian Radio-television and Telecommunications Commission, 2020. https://crtc.gc.ca/pubs/cmr2020-en.pdf.

[111] "Digital Inclusion and Wellbeing in New Zealand," New Zealand Digital government, 2017. https://www.digital.govt.nz/dmsdocument/161~digital-inclusion-and-wellbeing-in-new-zealand/html#Table11.

[112] ABS, "Main Features - Aboriginal and Torres Strait Islander Population Article." Australian Bureau of Statistics, 2016. https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/2071.0~2016~Main%20Features~Aboriginal%20and%20Torres%20Strait%20islander%20Population%20Article~12.

United States	Tribal Lands ("Fixed Terrestrial 25/3 Mbps and Mobile 4G LTE with a Minimum Advertised Speed of 5/1 Mbps")	78.9%	82.4% (rural only) 98.8% (urban only)	2019[113]

In Canada, connectivity is inconsistent across First Nations (reserves), with connectivity rates lower than those in rural places. Comparing connectivity with Indigenous Peoples in other jurisdictions is a challenge. The data in the table below is presented as available, note the differences in speeds, which makes comparisons between jurisdictions a challenge. First Nations in Canada may have faster speeds, but their breadth of wired coverage is the lower than the connectivity reported for Australia, New Zealand, and the United States. However, wireless coverage among First Nation's reserves in Canada is stronger than wired connection, at a reported rate of 90.5% in 2020.[114] Improving connectivity in First Nations is an important step in supporting thriving communities.

The country comparisons suggest that jurisdictions have similar spectrum policy objectives and employ approaches to assign spectrum to national service providers. With some exceptions, most countries rely on auctions as the primary vehicle of allocation. Innovation, competition, and affordable access are widely recognized as important economic and social objectives.

There is, however, a strong variance between jurisdictions in the ambitiousness of national goals and supporting industrial policy (Table 3). For instance, South Korea has set an explicit goal of becoming a world-leader in telecommunications broadly, and in 5G technology specifically. This emphasis on securing a first-mover advantage in a "strategic industry" has resulted in very close collaboration between government and industry, the encouragement of "national champion" providers, and an openness to experimentation in policy development. There is a general recognition of the importance of spectrum allocation among jurisdictions, but little assessment of how it can be measured against declared priorities or desired outcomes.

[113] FCC, "Fourteenth Broadband Deployment Report." Federal Communications Commission, February 1, 2021. https://www.fcc.gov/reports-research/reports/broadband-progress-reports/fourteenth-broadband-deployment-report.
[114] Government of Canada, "Current trends – Mobile wireless," Canadian Television and Telecommunications Commission, last modified June 30, 2022, https://crtc.gc.ca/eng/publications/reports/PolicyMonitoring/mob.htm.

Table 3: Spectrum priorities of different countries

Country	Spectrum priorities
Australia	With consideration of spectrum as an economic resource, the goal is to "…make the most of this resource and to reduce interference between users."[115]
Canada	"To maximize the economic and social benefits that Canadians derive from the use of the radio frequency spectrum resource."[116]
France	A resource, spectrum management is critical for 'cohabitation' of users, and management of frequencies.[117]
Germany	Uninterrupted mobile broadband coverage, with the "provision of spectrum in objective, transparent and non-discriminatory proceedings […]"[118]
Italy	Efficient use of scarce spectrum resources for transition to new technologies and the development of services.[119]
Japan	Committed to efficient and effective use of spectrum allocation to meet the needs of 'Society 5.0' (a future society to which Japan aspires) and beyond.[120]
Korea	Already working ahead to 6G considerations with government and universities engaged in planning and the study of applications for end-users.[121]
United Kingdom	With a broader goal of "making communications work for everyone," spectrum management includes ensuring sufficiency, clearance, and awards, among other activities.[122]

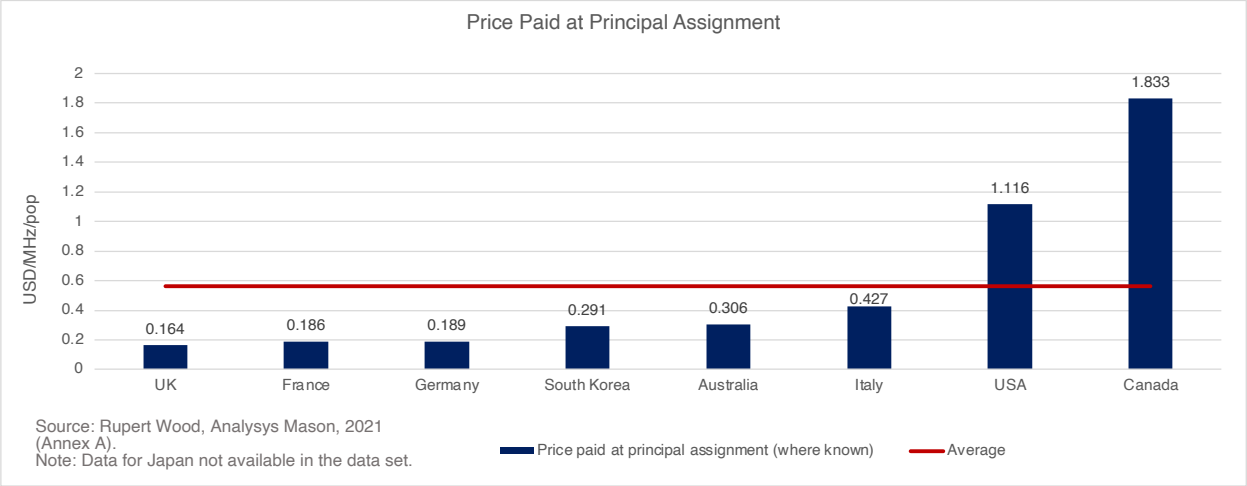
[115] Australian Communications and Media Authority. "Our Role to Manage Spectrum." ACMA. Australian Communications and Media Authority, 2019. https://www.acma.gov.au/our-role-manage-spectrum.
[116] "SPFC - Spectrum Policy Framework for Canada," Innovation, Science and Economic Development Canada, last modified May 2011, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08776.html.
[117] L'Agence nationale des fréquences. "Qui Sommes-Nous ?" ANFR, February 1, 2022. https://www.anfr.fr/l-anfr/qui-sommes-nous/.
[118] BNeztA, "Spectrum Compass 2020." Bundesnetzagentur, 2020. https://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/Areas/Telecommunications/Companies/TelecomRegulation/FrequencyManagement/ElectronicCommunicationsServices/SpectrumCompass2020.pdf?__blob=publicationFile&v=1.
[119] AGCOM, "ASSIGNMENT PROCEDURES AND RULES FOR THE USE OF THE FREQUENCIES AVAILABLE IN THE 694-790 MHz, 3600-3800 MHz AND 26.5-27.5 GHz BANDS FOR TERRESTRIAL SYSTEMS OF ELECTRONIC COMMUNICATIONS IN ORDER TO FAVOR THE TRANSITION TO 5G TECHNOLOGY, UNDER THE LAW 27 ." L'Autorità per le Garanzie nelle Comunicazioni, 2018, https://www.agcom.it/documents/10179/10517165/Allegato+7-8-2018/637af9a9-8a60-4b3e-8ac0-3ce2cd808ac4?version=1.2.
[120] MIC, "Frequency Reorganization Action Plan." MIC The Radio Use Website, Frequency Assignment. Accessed January 14, 2022. https://www.tele.soumu.go.jp/e/adm/freq/search/actionplan/.
[121] Ministry of Science and ICT, "6G, Korea Takes the Lead Once Again - 6G R& D Implementation Plan Established." Press Releases, Accessed June 28, 2022. https://www.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&mPid=2&pageIndex=1&bbsSeqNo=42&nttSeqNo=517&searchOpt=ALL&searchTxt=spectrum.
[122] Ofcom, "Spectrum Management." Ofcom, 2022. https://www.ofcom.org.uk/spectrum/spectrum-management.

United States	"Encouraging the highest and best use of spectrum domestically and internationally," a competitive framework to support the economy, and "[p]romoting competition, innovation and investment in broadband services and facilities."[123]

When compared to its peers, Canada performs differently based on the assessment criteria. On one hand, international studies have recognized the strong quality of Canada's wireless network and services speeds.[124] On the other, Canada's spectrum auction prices are the most expensive of any jurisdiction. Networks construction cost is similarly cost leading,[125] and its roll-out of 5G to consumers has been slower than many of its peers (see Figure 1).[126] Consider Figure 3 with data from Analysys Mason (2021) on the prices paid by operators at principal assignment.[127] The data is helpful in illustrating the significant difference in spectrum assignment costs between operators in the listed countries. Prices paid by Canadian operators are the highest followed by the United States, well-above the average of the jurisdictions assessed in this report. As previously noted, Canada's prices are 10 times those of France and 11 times those of the United Kingdom.[128]

[123] FCC, "What We Do." Federal Communications Commission, July 10, 2017. https://www.fcc.gov/about-fcc/what-we-do.
[124] PricewaterhouseCoopers (PwC), "Understanding the cost and quality of networks across the G20" September 2021. https://www.pwc.com/ca/en/communications/assets/understanding-the-cost-and-quality-of-networks-across-the-g20-en.pdf
[125] PwC, "Understanding the cost and quality of networks across the G20" September 2021. https://www.pwc.com/ca/en/communications/assets/understanding-the-cost-and-quality-of-networks-across-the-g20-en.pdf
[126] Delaporte, Anne and Bahia, Kalvin. GSMA Intelligence. "The State of Mobile Internet Connectivity 2021," September 2021, https://www.gsma.com/r/wp-content/uploads/2021/09/The-State-of-Mobile-Internet-Connectivity-Report-2021.pdf
[127] Wood, Rupert, "Falling Behind: Comparing 5G Spectrum Policies in Canada and OECD Countries," Analysys Mason, August 2021, https://www.analysysmason.com/contentassets/3142cca88f924253be79605a6703503a/analysys_mason_5g_spectrum_canada_nov2021_rdnt0.pdf
[128] Wood, Rupert, "Falling Behind: Comparing 5G Spectrum Policies in Canada and OECD Countries," Analysys Mason, August 2021, p. 2 https://www.analysysmason.com/contentassets/3142cca88f924253be79605a6703503a/analysys_mason_5g_spectrum_canada_nov2021_rdnt0.pdf

Figure 3: Spectrum price paid at principal assignment



A significant difference between high performing jurisdictions which benefit from both high speeds and breadth of coverage, like South Korea and Canada is their active industrial policy. State intervention has spurred strategic industries and helped to establish robust network infrastructure. The results are evident in high levels of wireless penetration and the early adoption of 5G networks across urban and rural markets. [129] South Korea's continuous dialogue with industry and their risk-reducing pilot projects create incentives for performance, with operators encouraged to surpass their licence conditions.[130] South Korea's networks are not flawless[131], but they are a leading example of how to promote cutting-edge connectivity broadly.

Canada is typically compared to the United States for reasons of geography, population dispersion, and proximity (it should be noted, however, that Canada has lower population density, notably in colder parts of the country with more complex terrain). Connectivity varies within the two countries with higher levels of connectivity in urban versus rural parts of the country due to population density and costs of connectivity. The United States has helpful lessons for Canada on the targeted use of assignment tools and deployment conditions to address connectivity challenges in rural places. The FCC has leveraged assignment tools, i.e., the incentive-based auction (or reverse

[129] Ramirez, Elaine, "Nearly 100% of Households in South Korea Now Have Internet Access, Thanks to Seniors." Forbes Magazine, January 31, 2017. https://www.forbes.com/sites/elaineramirez/2017/01/31/nearly-100-of-households-in-south-korea-now-have-internet-access-thanks-to-seniors/?sh=7dc2f9cb5572; PricewaterhouseCoopers. "Understanding the cost and quality of networks across the G20" September 2021. https://www.pwc.com/ca/en/communications/assets/understanding-the-cost-and-quality-of-networks-across-the-g20-en.pdf

[130] Hong, Een Kee and Ryu, Je Myung and Lee, Elyse Jee Hyun, "Entering the 5G Era : Lessons from Korea," Innovation and Technology Note Series, World Bank Group Korea Office, 2021, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/35780 Licence: CC BY 3.0 IGO."

[131] Morris, Anne, "South Korea Adopts 5G Network Sharing to Boost Rural 5G." https://www.lightreading.com/asia/south-korea-adopts-5g-network-sharing-to-boost-rural-5g/d/d-id/768817.

auction),[132] as well as set asides to improve rural connectivity. These targeted interventions work with service provider incentives to build solutions to generate connectivity. Rural connectivity rates in the United States are higher than those in Canada, although speeds differ (see Table 2).

The analysis of practices from other jurisdictions highlights the various approaches and tools to improving connectivity. The transferability of the tools and approaches, however, is context-dependent. Tools and approaches at the level of assignment and deployment conditions are the most practical to consider for transferability, whereas state-level economic practices will be far more complex and challenging to emulate. Consider for instance, the state interventions of South Korea and Japan that have yielded leading rates of connectivity, but are not easily replicated. For Canada, more practical lessons come from the United States' reverse auctions, and Germany's hybrid assignment practices. These administration oriented approaches can be integrated into existing operations without requiring a wholesale reform to economic policy priorities.

Table 4: Operational considerations in spectrum assignment in different countries

Country	Operational considerations
Australia	Large and varied geography with urban/rural divides. Unique nationalized approach to connectivity infrastructure; high costs, unclear returns.[133]
Canada	Large and varied geography with urban/rural divides. High spectrum costs. Slower 5G roll-out relative to peers.[134]
France	Prioritization of European integration and harmony with broader policies. Consultations are important.[135]
Germany	Ambitious 5G coverage goals (reach 98% of households by 2022). State-corporate interaction is well-established.[136]
Italy	Active collaboration with EU counterparts and governing bodies. Not a leader in telecommunications.[137]
Japan	Active industrial policy with close coordination and planning between industry and the state. Lead in 4G roll-out but trailing on 5G.[138]
Korea	Active industrial policy with a high-level of state involvement to spur success in identified strategic industries. The government's spectrum allocation policy has followed this approach. Leading in 5G.[139]
United Kingdom	Active engagement, consultation, and reporting on spectrum considerations. Not a 5G leader.[140]
United States	Traditionally has had a relatively lower level of state involvement in its industrial policy. Large and varied geographic territory, like Canada.[141]

[133] Henderson, Angus, The Technology, Media and Telecommunications Review. 12th edition. Ch 1. 2021 Law Business Research Ltd.
[134] Delaporte, Anne and Bahia, Kalvin, GSMA Intelligence. "The State of Mobile Internet Connectivity 2021"
[135] Saarinen, Myria, The Technology, Media and Telecommunications Review. 12th edition. Ch 7. 2021 Law Business Research Ltd.

Furthermore, they are tested approaches that can be targeted to solving specific Canadian connectivity challenges. States with active industrial-research partnerships improve 5G roll-out and ongoing innovations in coverage (see Table 4). Geography and population dispersion impact business cases for connectivity.

Improving connectivity requires consideration of a country's spectrum priorities, operational context, and assignment practices. Countries all recognize the value and importance of spectrum but express their goals and priorities differently. Generally, approaches to measuring the impact of spectrum assignment are limited. This is a noted gap in the literature that could be addressed by reconsidering the role of spectrum assignment in achieving connectivity, which is linked to economic growth and social well-being.

Geography and population density need to be considered. Large, topographically diverse countries with dispersed populations like the United States and Canada may not have the public will or public finances to pursue the infrastructure investments required to connect all citizens wherever they may live. For this reason, assignment practices and related deployment conditions become essential tools for generating and improving connectivity. The countries reviewed here principally use auctions to assign spectrum, with exception to Japan that relies on administrative allocation.

Table 5: Spectrum assignment practices in different countries

Country	Assignment practices
Australia	Auctions are primarily used to assign spectrum, as demand exceeds supply.[142]
Canada	Auctions are primarily used to assign spectrum, with the use of set-asides.[143]

[135] Saarinen, Myria, The Technology, Media and Telecommunications Review. 12th edition. Ch 7. 2021 Law Business Research Ltd.
[136] Forge, Simon and Vu, Khuong. "Forming a 5G Strategy for Developing Countries: A Note for Policy Makers". National University of Singapore.
[137] D'Ostuni, Marco, The Technology, Media and Telecommunications Review. 12th edition. Ch 11. 2021 Law Business Research Ltd.
[138] McKinsey & Company, "Japan at a crossroads – The 4G to 5G (r)evolution". January 2018
[139] Dippon, Christian and Claman, Jason, A Comparison of the Mobile Wireless Value Proposition" NERA Economic Consulting. Washington, DC, USA. March 2, 2020.
[140] Ofcom, "Ofcom's Consultation Principles." July 15, 2019. https://www.ofcom.org.uk/consultations-and-statements/how-will-ofcom-consult.; Pricewaterhouse Coopers. September 2021.
[141] Wood, Rupert, "Falling Behind: Comparing 5G spectrum policies in Canada and OECD countries." Analysys Mason. 2021. https://www.analysysmason.com/contentassets/3142cca88f924253be79605a6703503a/analysys_mason_5g_spectrum_canada_nov2021_rdnt0.pdf.
[142] "Australia Sets Caps for 5G Spectrum Auction," Mobile World Live, August 9, 2021. https://www.mobileworldlive.com/asia/asia-news/australia-sets-caps-for-5g-spectrum-auction.
[143] "Framework for Spectrum Auctions in Canada," Innovation, Science and Economic Development Canada, last modified March 2011. https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01626.html.

France	Two-step hybrid auction: 1) application for fixed price, uniform amount; 2) successful assignees bid for additional spectrum through auction.[144]
Germany	Spectrum is assigned through auctions, administrative act, or through application.[145]
Italy	Auctions are used to assign spectrum. They have been criticized for cost and complexity.[146]
Japan	Unique allocation practices. In contrast to most other OECD countries, Japan directly allocates spectrum to operators through administrative allocation.[147]
Korea	Auctions primarily used to assign spectrum between providers, using the combinatorial clock format.[148]
United Kingdom	Auctions are primarily used to assign spectrum. In rural places, mobile coverage commitments required from operators.[149]
United States	Primarily relies on auctions to allocate spectrum to service operators, including reverse auctions.[150]

Countries have leveraged a mix of approaches and tools in spectrum assignment to improve connectivity (Table 5). From a mix of auctions, administrative allocation, and applications in Germany to the reverse auctions for rural connectivity in the United States, there are several tested means of assigning spectrum to achieve desired results. Deployment conditions can be especially helpful in incentivizing desired actions and outcomes from industry. Several jurisdictions, e.g., Japan, France, Italy, United States, have coverage obligations for service providers from population coverage to geographic areas. While coverage obligations are not typical for the United Kingdom, Ofcom required its service providers to contribute to the Shared Rural Network[151] as part of their licence requirements ensuring coverage in rural places.

A clear commitment to using spectrum for achieving specific goals is a necessary first step in driving connectivity, and ultimately, economic benefits. Consider the differences in South Korea's v. Italy's declared spectrum priorities, and their connectivity results.

[144] Arcep, "5G." Accessed March 26, 2022. https://en.arcep.fr/news/press-releases/view/n/5g-23.html.
[145] Forge, Simon and Vu, Khuong, "Forming a 5G Strategy for Developing Countries: A Note for Policy Makers". National University of Singapore.
[146] Domingo, Santo, "The Italian approach to the licensing of spectrum in 5G pioneer bands". Cullen International. 27 August 2019.
[147] McKinsey&Company, "Japan at a crossroads – The 4G to 5G (r)evolution".
[148] Hong, EK and MR Je, World Bank Group. "Entering the 5G Era: Lessons from Korea". June 2021.
[149] Crawford, Gail, The Technology, Media and Telecommunications Review. 12th edition. Ch 24. 2021 Law Business Research Ltd.
[150] Murchison, Mathew, The Technology, Media and Telecommunications Review. 12th edition. Ch 25. 2021 Law Business Research Ltd.
[151] The Shared Rural Network is an agreement between the Government of the United Kingdom and the country's four main operators (EE, Telefónica UK (O2), Three and Vodafone), to increase coverage, promote consumer choice, and achieve service standards across the country's landmass. Shared Rural Network, "About the Shared Rural Network," last accessed March 30, 2021, https://srn.org.uk/about/. Shared Rural Network, "Frequently Asked Questions," accessed on March 30, 2021, https://srn.org.uk/faqs/.

While no single jurisdiction is assessing spectrum assignment against economic goals, there are tacit linkages that a jurisdiction can draw out to improve the alignment of spectrum assignment and connectivity.

Part III: Assessing the performance of spectrum policy in Canada

As an area of federal activity and regulation, spectrum policy should be actively reviewed and assessed for its alignment to connectivity, for economic and social benefits. Canadians should want to ensure that spectrum policy is designed to generate value, as consumers and beneficiaries of economic growth and social well-being.

The Treasury Board of Canada Secretariat's *Policy on Results*[152] requires that departments report clearly on their objectives and regularly on their performance against those objectives. This information is meant to benefit Parliament and Canadians, supporting their assessments of expenditures and operational efficiency. Canadians should be getting value for money and improved connectivity for broader economic and social benefits through spectrum policy that is aligned to priorities.

Both *allocation* (designated uses of spectrum) and *assignment* (determining who uses spectrum and how) involve political and policy decisions. The impacts of allocation and assignment exist on different timelines and scales. Quantifying direct and indirect results of spectrum policy will require different timelines that may not line up to political timelines (Figure 4).[153] The focus in this report is on *assignment*.

Figure 4: Illustrative timelines for economic impact of spectrum allocation

Allocation (Designated use of spectrum)	Illustrated timelines for economic impact				
	1-3 years	3-5 years	6-10 years	10-20 years	Unknown or N/A (public good)
Radio					Wireless baby monitors, wireless cameras, emergency vehicles communications, aviation
Mobile: 3G					
Mobile 4G:					
Mobile 5G: (estimated)					
Space Operations					Weather Forecasting, Radio astronomy, Amateur astronomy

[152] The Treasury Board of Canada's *Policy on Results* is a whole-of-government approach intended to:

> 3.1.1 Improve the achievement of results across government; and
>
> 3.1.2 Enhance the understanding of the results government seeks to achieve, does achieve, and the resources used to achieve them.
>
> Government of Canada, "Policy on Results," Treasury Board of Canada Secretariat, last updated July 1, 2016, https://www.tbs-sct.canada.ca/pol/doc-eng.aspx?id=31300

[153] The authors wish to recognize discussions with Dr. Martin B.H. Weiss which informed the overview of timelines, allocation, and assignment.

Spectrum policy should be understood holistically, with consideration of instruments for allocation and deployment conditions, which ultimately impact connectivity. Existing literature and policy design does not link policy with assignment instruments, deployment conditions, and outcomes.

An evaluation framework captures the resources, products, and results a policy delivers in a particular context (Table 6). Used in reverse, the framework can help to develop policy linked to desired results. When applied to spectrum policy, the framework highlights the gaps in connecting inputs – outputs – and outcomes.

Table 6: Evaluation framework

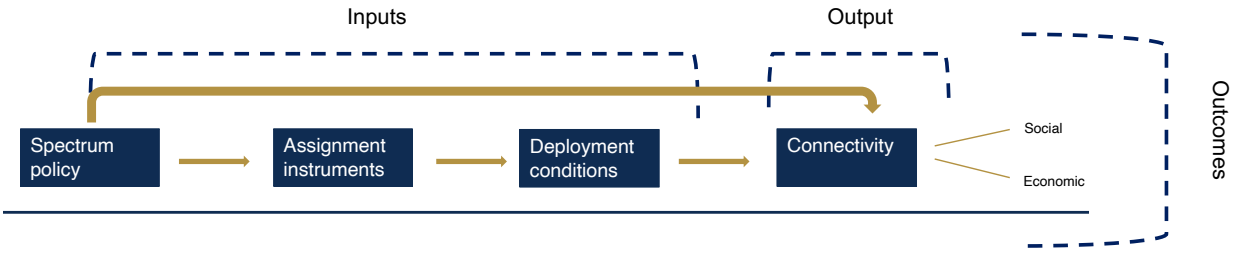
Framework component[154]	Description and guiding questions	Examples
Context *Consider the social and political environments in which the policy was designed, adopted and implemented.*	In what social, political and institutional environment did the policy emerge, and was it designed and adopted?	Laws, e.g. constitution, rules; institutions; norms; incentives
Inputs *Consider initial required resources and on-going ones, if applicable.*	What resources were required to operationalize the policy?	Human resources and capacity; financial resources; data; infrastructure
Outputs *Consider the purpose of the policy and whether or not it yielded the expected products/services.*	What did the policy deliver?	Service; physical output, e.g. bridge
Outcomes *Assess the results of the policy on an interim basis (assuming the policy is ongoing) to ensure consistency with desired goals.*	Was the policy a success? How will it be determined if the policy is working (should it be a work in constant progress)?	Results, whether intended or unintended in the medium- to long-terms.

The policy goal of spectrum allocation should be connectivity, as increasing the breadth and quality of connectivity can deliver economic and social benefits. With improved efficiency of allocation, and effectiveness of deployment, connectivity improves with added benefits for consumers, industry, and governments.

[154] Reproduced from Gaspard, Helaina, forthcoming, "Principles for language policy implementation," in *The Routledge Handbook of Language Policy and Planning*, (eds.), M. Gazzola, F. Grin, L. Cardinal, and K. Heugh, London: Routledge.

Ideally, spectrum policy and connectivity should be linked (Figure 5). If desired outcomes are improved connectivity for socio-economic benefits, there are a series of outputs and inputs that need to align to achieve that goal. For instance, auctions and conditions should incentivize connectivity.

Figure 5: Linkages between spectrum policy, assignment instruments, deployment conditions and connectivity



Achieving declared political priorities for connectivity in Canada will require rethinking spectrum policy across various dimensions:

- Location, e.g., rural v. urban, Indigenous communities.
- Deployment conditions, e.g., ensuring spectrum is being used to encourage connectivity.
- Efficiency of assignment instruments, e.g., ensuring value-for-money for taxpayers and alignment of instruments to connectivity priorities.

As a scarce public resource, spectrum assignment and conditions for use should align to declared priorities, against which performance can be assessed. There are two considerations that underpin the proposed approach:

1) Connectivity improves economic activity (from various direct and indirect measures, e.g., output, participation, inclusion, etc.)
2) If connectivity is the goal of spectrum assignment policy, how do we know if spectrum assignment policy is supporting connectivity?

Linking spectrum policy and outcomes

Different departments and agencies of the Government of Canada capture information on various dimensions of connectivity and report publicly. The Canadian Radio-Television and Telecommunications Commission (CRTC), Innovation, Science and Economic Development Canada (ISED), and Statistics Canada monitor and report on connectivity matters from household spending on wireless to infrastructure investment.

Beyond the research or public reporting from different departments and agencies, the Government of Canada has a reporting architecture that requires annual public reporting on how departments and agencies plan to use public money to deliver on declared goals and priorities and their actual results.[155] The process aligns to a

[155] "Policy on Results," Government of Canada, Last modified: July 1, 2016, https://www.tbs-sct.canada.ca/pol/doc-eng.aspx?id=31300

standard financial cycle. Before the start of a new fiscal year (on April 1), departments and agencies release a Departmental Plan. This plan lays out the entity's priorities, its programs, anticipated expenditures and human resource requirements, and corresponding performance indicators. Departmental Plans are supporting documents in the Appropriations process, in which the Government asks Parliament to approve its spending plans for the upcoming fiscal year. At the time of reporting on the previous fiscal year (October/November), departments and agencies release their Results Reports to report on their activities in relation to the plan they had laid out. These documents support the Public Accounts that are tabled for Parliament's review and approval, in an accounting of the Government of Canada's spending and results for the previous fiscal year.

To understand how connectivity and related issues are being monitored by the Government of Canada, the Results Reports of CRTC and ISED were reviewed. InfoBase[156] was then used to identify and capture indicators, targets, and their results. The information presented below is for the results reporting for fiscal year 2020-2021 (the most recent fiscal year available). From the indicators, current reporting tends to focus on end-user connectivity, with some assessment of spectrum focused on licence authorization and timeline for adjudicating applications (Table 7 and Table 8).

Consider the following examples:

- Number of communities accessing "Connect to Innovate" funding for internet backbone infrastructure (ISED)
- Percentage of households with internet connection, including underserved people/areas (ISED)
- Percentage of households with access to ultrafast broadband (ISED)
- Percentage of households with fixed broadband internet services (CRTC)
- Percentage of households with access to latest deployed mobile technologies (CRTC)
- Etc.

In reviewing the indicators from CRTC and ISED, there is helpful information available on connectivity access, subscriptions, licence applications, etc. The indicators and annual reports are useful for monitoring trends and changes, but the information is not designed to assess the impacts of connectivity on socio-economic well-being. Furthermore, it is not clear how or if this information is linked to policy design and decision-making about spectrum (i.e., linking decision-making at the front-end to desired results on the back-end).

[156] InfoBase is the Government of Canada's public reporting platform, through which program expenditures, performance criteria, and results are accessible.

Table 7: CRTC results reporting for fiscal year 2020-2021.
*Text reproduced directly from GC InfoBase unless otherwise indicated.

Department	Indicator*	Target	Result	Target achieved Y/N
CRTC	% of total fixed broadband subscriptions that are high capacity network connections compared to the OECD average	At least 7.9%	7.4%	N[157]
CRTC	% of households that have access to fixed broadband Internet access services	At least 90%	89.5%	N ("Result to be achieved in the future")[158]
CRTC	% of households that have access to the latest generally deployed mobile wireless technology	At least 100%	99.54%	N ("Result to be achieved in the future")[159]
CRTC	Percentage of households that have access to fixed broadband Internet services	At least 90%	89.5%	N ("Result to be achieved in the future")[160]
CRTC	% of Canadian subscribers with access to public alerting through wireless service providers	At least 90%	99.97%	Y[161]

[157] "Results" in "Infographic for Canadian Radio-television and Telecommunications Commission," Infobase, Treasury Board of Canada Secretariat, 2021, https://www.tbs-sct.canada.ca/ems-sgd/edb-bdd/index-eng.html#infographic/dept/93/results
[158] "Results" in "Infographic for Canadian Radio-television and Telecommunications Commission," Infobase, Treasury Board of Canada Secretariat, 2021, https://www.tbs-sct.canada.ca/ems-sgd/edb-bdd/index-eng.html#infographic/dept/93/results
[159] "Results" in "Infographic for Canadian Radio-television and Telecommunications Commission," Infobase, Treasury Board of Canada Secretariat, 2021, https://www.tbs-sct.canada.ca/ems-sgd/edb-bdd/index-eng.html#infographic/dept/93/results
[160] "Results" in "Infographic for Canadian Radio-television and Telecommunications Commission," Infobase, Treasury Board of Canada Secretariat, 2021, https://www.tbs-sct.canada.ca/ems-sgd/edb-bdd/index-eng.html#infographic/dept/93/results
[161] "Results" in "Infographic for Canadian Radio-television and Telecommunications Commission," Infobase, Treasury Board of Canada Secretariat, 2021, https://www.tbs-sct.canada.ca/ems-sgd/edb-bdd/index-eng.html#infographic/dept/93/results

Table 8: ISED results reporting for fiscal year 2020-2021.
*Text reproduced directly from GC InfoBase unless otherwise indicated.

Department	Indicator*	Target	Result	Target achieved Y/N
ISED	Percentage of population with access to ultrafast broadband	At least 80%	Not stated	N/A[162]
ISED	Percentage of households with an Internet connection (including across underserved individuals, such as low-income)	At least 100%	94%	N ("Result to be achieved in the future.")[163]
ISED – Bridging Digital Divides	Number of communities targeted by Connect to Innovate projects that will build new backbone infrastructure	At least 975 (communities)	696	N ("Result to be achieved in the future.")[164]
ISED – Spectrum and Telecommunications	Percentage of new listings in Radio Equipment List (REL)/Telecommunications Apparatus Registry (TAR) processed within service standards.	At least 90%	100%	Y[165]

[162] "Results" in "Infographic for Innovation, Science and Economic Development Canada," Infobase, Treasury Board of Canada Secretariat, 2021, https://www.tbs-sct.canada.ca/ems-sgd/edb-bdd/index-eng.html#infographic/dept/130/results
[163] "Results" in "Infographic for Innovation, Science and Economic Development Canada," Infobase, Treasury Board of Canada Secretariat, 2021, https://www.tbs-sct.canada.ca/ems-sgd/edb-bdd/index-eng.html#infographic/dept/130/results
[164] "Results" in "Infographic for Innovation, Science and Economic Development Canada," Infobase, Treasury Board of Canada Secretariat, 2021, https://www.tbs-sct.canada.ca/ems-sgd/edb-bdd/index-eng.html#infographic/dept/130/results
[165] "Results" in "Infographic for Innovation, Science and Economic Development Canada," Infobase, Treasury Board of Canada Secretariat, 2021, https://www.tbs-sct.canada.ca/ems-sgd/edb-bdd/index-eng.html#infographic/dept/130/results

ISED – Spectrum and Telecommunications	Percentage of licence applications completed within services standards	At least 90%	94%	Y[166]

[166] "Results" in "Infographic for Innovation, Science and Economic Development Canada," Infobase, Treasury Board of Canada Secretariat, 2021, https://www.tbs-sct.canada.ca/ems-sgd/edb-bdd/index-eng.html#infographic/dept/130/results

The purpose of a performance framework is to consider the linkages between inputs (resources); outputs (products/services); and outcomes (results). In their current assessments, ISED and CRTC defined various connectivity-focused goals, with limited consideration of the impacts of spectrum policy on those results.

To improve the current framework, it may be useful to consider two types of data:

1) Quantitative: Indicators to measure and monitor connectivity, e.g., household connectivity, GDP, jobs created.
2) Qualitative: Data to build a narrative and understanding around quantitative indicators that may come from stakeholders.

If a new performance approach to assessing connectivity were to be designed (Table 9), it could be done by leveraging qualitative and quantitative information across four dimensions: spectrum policy, assignment instruments, deployment conditions, and connectivity. The intent of this revised framework and related questions is to reset an understanding of the linkages between spectrum assignment and connectivity.

This four-part performance framework is intended to revisit the connection between policy and outcome. The qualitative questions are intentionally broad and designed to encourage policy analysts to reflect on the ways in which existing frameworks are contributing (or not) to declared priorities for spectrum and connectivity in Canada. The quantitative variables are in place to monitor changes over time, providing an easily aggregated set of metrics for public reporting.

Table 9: Proposed performance framework for holistic spectrum policy evaluation

Category	Qualitative	Quantitative
Spectrum policy	1) What are Canada's spectrum priorities? 2) How are these priorities being enacted? 3) Are spectrum priorities differentiated for urban and rural places?	1) Was the policy reviewed? Y/N 2) Were updates made to meet changed priorities? Y/N
Assignment instruments	1) How are assignment instruments determined? 2) Are assignment of instruments aligned to spectrum priorities? 3) Are instruments differentiated based on different priorities?	1) How many instruments were used? 2) Which instruments were used? 3) How many stakeholders participated engaged with the instruments?
Deployment conditions	1) What deployment conditions were applied? 2) What results did deployment conditions generate?	1) How many providers met defined targets (%)? 2) How many providers met targets within defined timelines (%)?
Connectivity	1) How have connectivity rates improved in Canada? 2) Has there been consideration of connectivity versus uptake of technology/use of technology?	1) What are Canada's internet connectivity rates: a) Household - national b) Household – urban c) Household – rural d) Household – First Nations reserves 2) Leverage existing data from Statistics Canada to assess economic variables.

Conclusion

Connectivity is integral for a functioning economy and for social well-being. Improving connectivity requires spectrum policy that is designed to consider the relationship between policy, assignment, and deployment.

As a scarce public resource, the assignment and deployment of spectrum should be a concern to regulators, providers, and consumers (as citizens). There is a missing link in the current approach when considering how policy priorities connect to desired outcomes. That missing link is evidenced by the blanket approach taken to spectrum assignment policy in Canada.

The review of practices from other jurisdictions indicates that Canada's performance on spectrum assignment is consistent with its peers (through the auction format), but could be improved by refining its approach. No single jurisdiction has the solution for aligning spectrum to economic and social benefits. Using different assignment approaches and deployment conditions, Canada could better meet the differentiated needs of a large and geographically diverse country with densely populated urban areas and sparsely populated rural ones.

To review and refine its approach to spectrum assignment, Canada can leverage its existing evaluation and reporting requirements. A refined performance assessment approach that links spectrum policy, assignment instruments, deployment conditions, and connectivity, would offer a holistic portrait of spectrum assignment and its results. This broader perspective would incorporate quantitative and qualitative metrics to require policymakers to consider the implications of spectrum assignment policy on its operationalization.

Achieving declared political priorities for connectivity in Canada will require rethinking spectrum policy across various dimensions, including, location, e.g., rural v. urban, Indigenous communities; deployment conditions, e.g., ensuring spectrum is being used to encourage connectivity; and efficiency of assignment instruments, e.g., ensuring value-for-money for taxpayers and alignment of instruments to connectivity priorities.

There is a marginal rate of return (in terms of economic growth) for increasing connectivity in developed economies. However, the economic and social benefits from connectivity are much broader extending to research and innovation, access to health and social services, participation, inclusion, etc. To measure the impacts of connectivity, factors beyond the number of connected Canadians should be considered.

There are three takeaways from this report:

1) Adopt a holistic performance management framework to assess how spectrum policy is achieving the goal of connectivity.
2) Leverage approaches from other jurisdictions, e.g., differentiated assignment (e.g., Germany) and deployment conditions (e.g., United States), to refine current practices and improve the efficiency and effectiveness of spectrum assignment policy for connectivity.
3) Use broad and indirect indicators to measure and monitor the impact of connectivity on socio-economic benefits.

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Appendix A – Spectrum policy framework documents

The Minister of Industry has the statutory authority to set spectrum policy (*Department of Industry Act*, *Radiocommunication Act*, and *Telecommunications Act*).[167] As the Minister of Industry has the authority to set spectrum policy, it is important to consider that political commitments, e.g., as defined in platforms, ministerial mandate letters, etc., as well as innovation and economic development strategies, can shape approaches to the operationalization of spectrum policy.

There are four framework documents that support the operationalization of spectrum assignment. Taken together, the documents define the principles for assigning spectrum, procedural approaches to auctions, plans for the next five years, and the duty to consult. The four framework documents are:

1) The Spectrum Policy Framework for Canada (2007);
2) The Framework for Spectrum Auctions in Canada (2011);
3) The Spectrum Outlook 2018 to 2022; and
4) Band Specific Consultations on Policy and Licensing Frameworks.

1) Spectrum policy framework for Canada (2007)

As its name suggests, this document is the 'foundation' for spectrum allocation policy in Canada.[168] The document defines a broad frame, with a long-term outlook. While implementation details are limited, it does define guiding principles, as well as the need for consultation. The overarching objective for spectrum assignment is to seek to maximize "economic and social benefits" for Canadians.

To achieve this goal, the document offers guidance to inform a government's approach. The considerations include:

- Maximum reliance on market forces;
- Reservation for services in the "public interest";
- Reservation for "sovereignty, security and public safety";
- Efficient, effective, and "minimally intrusive" regulations;
- Transparent policy making and use of public consultation;
- Minimal administrative burden and responsive technological modernization;
- Defense of Canada's spectrum interests abroad; and
- Promoting the efficient functioning of markets.

In essence, the framework policy advocates for a market-based approach that considers critical security and sovereignty requirements, while ensuring services to

[167] "SPFC - Spectrum Policy Framework for Canada," Innovation, Science and Economic Development Canada, last modified May 2011, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08776.html.
[168] "SPFC - Spectrum Policy Framework for Canada," Innovation, Science and Economic Development Canada, last modified May 2011, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08776.html.

Canadians. Such a broad framework can be conducive to achieving changing political, economic, and social priorities.

2) *Framework for spectrum auctions (2011)*

In this document, a procedural approach that ISED should use to allocate spectrum licences is articulated, including ISED's role in using auctions to foster competitiveness in the wireless market.[169] Within the approach, auctions are said to be a sound allocation mechanism when two criteria are met:

1) Demand for spectrum is expected to exceed the available supply; and
2) Government policy objectives can be fully met through an auction.

The criteria appear straight forward but are not fully defined, assuming to permit flexibility to account for changing objectives and priorities. For instance, what constitutes market demand is not defined, with acknowledgement of the difficulty in measuring demand for spectrum.

The framework empowers ISED to restrict firm participation auctions and in setting licence aggregation limits in certain instances should the limitation produce a greater benefit or desired end-goal. These situations include:

1) The department may *restrict* an organization's participation where:
   a) It has market power in the relevant service and geography;
   b) A new entrant is likely to use the licence to compete; and
   c) Potential "economies of scope" justify any anti-competitive effects.
2) The department may *set aggregation limits* where:
   a) The successful bidder would not face effective competition from other providers; and
   b) The anti-competitive effects would not be offset by lower prices or higher valued services resulting from a single entity holding the same amount of spectrum.

The framework makes no apparent reference to the competitive effects of a provider's failure to make use of spectrum licences. It does not suggest any solution or penalty for slow deployment. However, ISED does reserve the right to re-auction any un-sold licences or distribute them on a first-come, first-serve basis.

3) *Spectrum Outlook (2018-2022)*

In the outlook document, ISED's planned activities related to spectrum allocation over a five-year period are defined, with the intent of providing predictability and

[169] "Framework for Spectrum Auctions in Canada," Innovation, Science and Economic Development Canada, last modified March 2022, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01626.html.

transparency to industry stakeholders.[170] There are three pillars defined in the outlook:

1) Quality: faster and higher quality networks;
2) Coverage: better coverage and reliable services across geographies; and
3) Prices: affordable prices and more choice in services.

From a planning perspective, the guidance document can be a helpful signal to stakeholders engaged in medium-term business planning. Elements such as approximate timelines for the roll-out of bands is included, as are medium-term priorities, such as the emergence of 5G technology and the need to keep pace with leading international jurisdictions.

Explanatory and planning documents can be useful in defining and redefining the position of a regulator as consultations are undertaken or changes are made. For instance, Ofcom, the United Kingdom's regulator, regularly produces public reports and documents on its consultations, findings, and adjustments to its approach. As with ISED, Ofcom's governing principles commit the office to continued consultation with industry stakeholders. However, in contrast to the Canadian experience, Ofcom's consultations do not primarily occur in the lead-up to a given spectrum auction. Instead, Ofcom conducts regular conversations with industry, including around longer-term planning for the wireless industry. The Office releases an annual plan every year, outlining its most immediate priorities. Notably, Ofcom's consultation documents and guidelines are published in colloquial English, with an emphasis on clarity and minimal use of technical language.[171] The documents offer stakeholders and citizens a view into the ongoing dialogue and changes in telecommunications policy.

4) Band-specific Consultations on Policy and Licensing Frameworks

In accordance with its duty to consult, ISED releases priorities ahead of a spectrum auction. Details are usually specific to a particular band wavelength and a specific geographic region, but they may also reflect government objectives toward spectrum allocation generally. Details on consultations ahead of the next auction have emphasized the following objectives:

- Ensuring "high quality" universal regional access;
- Promoting economy-wide innovation; and
- Promoting a robust and competitive wireless industry.[172]

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[170] "Spectrum Outlook 2018 to 2022," Innovation, Science and Economic Development Canada, June 2018, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11403.html.
[171] Ofcom, "Ofcom's Consultation Principles." Ofcom, July 15, 2010. https://www.ofcom.org.uk/consultations-and-statements/how-will-ofcom-consult.
[172] Innovation, Science and Economic Development Canada, August 2020, "Consultation on the 3650-4200 MHz Band," last modified December 7, 2020, https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11627.html#s11%20http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11627.html#s11