COVID-19's impact on connectivity

Canada's post-COVID-19 connectivity needs

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pwc

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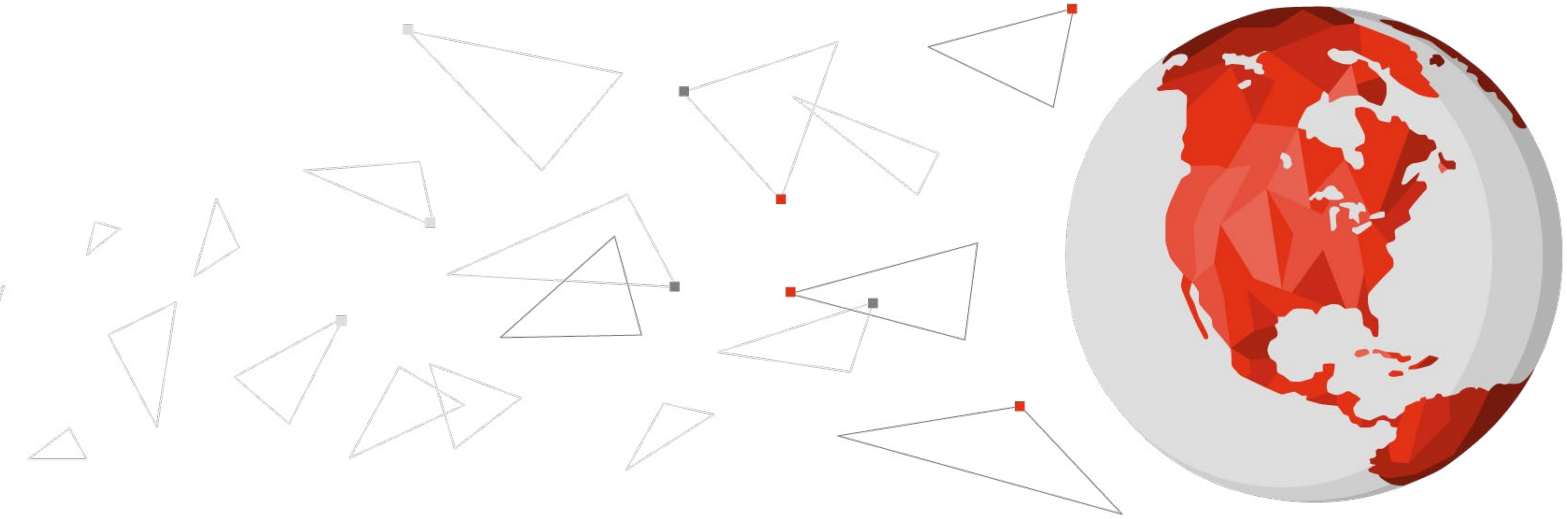


Executive summary

COVID-19 has had a widespread impact on the Canadian economic and social landscape, forcing many Canadians to fundamentally change the way they learn, work, interact with friends and family and access essential services. These changes are leading to the accelerated adoption of digital ways of working and living, the acceleration of a number of existing economic and social trends, as well as a significant shock to the Canadian economy. In response, the use of connectivity has increased, highlighting the importance of connecting all Canadians to high-speed broadband. This has a number of implications for the telecommunications industry, notably creating the need for increased cooperation across government, regulatory bodies, telecommunications companies, and broader industry.

Canada's health and fiscal policy response, combined with the high quality of Canada's connectivity networks which allowed industries to quickly adapt to digital ways of working, supported Canada's economic resiliency, with Canadian economic activity showing more resilience than the average of global peers during COVID-19.[2] In addition, Canadians' ability to use connectivity for social and entertainment purposes supported their social well-being during COVID-19. These uses of connectivity significantly increased overall broadband consumption in Canada, with daily average broadband usage increasing by 43% (Q2 2020 compared to Q2 2019) during the first lockdown period. During this period, Canada's overall average mobile download speed, which was 71% higher than the average of global peers pre-COVID-19, maintained its leading position relative to peer countries despite the significant increase in demand.[3]

Definitions:

Connectivity: Communication between devices over wireless and wireline networks.

Industry 4.0: The Fourth Industrial Revolution, "Industry 4.0" is the ongoing automation of traditional manufacturing and industrial practices using modern smart technology. It leads to the end-to-end digitization of all physical assets and integration across the value chain using Internet of Things (IoT) hardware, software and connectivity.

5G Networks: 5G is the fifth generation of wireless broadband technology providing higher speeds, lower latency, more reliability, massive network capacity and increased availability relative to 4G networks. 5G connectivity will be transmitted across low, medium and high radio frequency bands, which are generally allocated at spectrum auctions by governmental and regulatory agencies.

5G Spectrum Bands: Low bands (e.g. sub-1 GHz) support widespread coverage of 5G connectivity to support IoT connectivity requirements. Medium bands (3-24 GHz) provide a mixture of coverage and capacity to maintain higher levels of 5G service quality. High bands (26, 28 and 40 GHz) support the ultra-high broadband speeds needed to support the most advanced use-cases.[1]

Broadband Enabled Use-Cases: Broadband enabled use-cases, referred to throughout this report, are emerging applications of advanced technology including 5G connectivity, IoT devices, advanced analytics, AI, augmented reality (AR), virtual reality (VR), cloud computing and robotics. These use-cases span multiple industries and range across remote healthcare technologies, autonomous vehicles, drones, wearable technology and smart assets.

COVID-19 also had a financial and operational impact on Canada's telecommunications industry with a combined $828 million reduction in EBITDA in Q2 and Q3 of 2020 in comparison to Q2 and Q3 of 2019 across Rogers, Bell and TELUS.[4] Despite this impact, Canadian operators continued to provide connectivity to Canadians as well as contributing to Canada's COVID-19 response directly through a variety of corporate initiatives. Notably, operators waived data overage, roaming and long distance fees and committed to not disconnect customers who were not able to pay their bill. They also provided free and low-cost access to in-need communities, education institutions and small businesses.

Beyond the impact on Canadian daily average broadband usage and the telecommunications industry, COVID-19 has accelerated six key existing trends, which all have implications for connectivity and broadband enabled use-cases. These six key trends show that as the world adapts to COVID-19, future ways of working and living will have a greater emphasis on connectivity and connected devices. The six key trends are:

1. **Shifts in population centres:** The rate of population growth in large urban centres is expected to slow down due to increasing unaffordability in large urban centres and increased viability of remote working and learning.
2. **Shift in relationship and entertainment preferences:** Increased social media, video streaming and video chat usage habits are likely to persist post-COVID-19.
3. **Shifts in business operating models:** Employers are expected to accelerate digital transformation and automation plans to increase business resiliency, respond to future disruption and manage increased costs from localized supply chains.
4. **Shift to localized supply chains:** Supply chains are expected to continue to trend towards on-shoring to protect against geopolitical and unpredictable disruption risk.
5. **Shifts in service preferences:** Preferences for virtual services are expected to continue to increase, as COVID-19 has exposed consumers and businesses to new virtual service offerings.
6. **Shifts in consumer purchasing habits:** Canadians are expected to continue to increase eCommerce activity and their preference for digital service channels.

Supporting each of these trends is the demand for connectivity and enhanced broadband enabled use-cases, resulting in both increased bandwidth usage and network densification. For example, advancement in smart agriculture and product traceability use-cases will support the shift to localized supply chains by improving the productivity and supply within the Canadian agriculture industry, while assuring consumers that food and goods can be traced to Canadian farms and facilities. This will require additional network coverage and lead to increased bandwidth consumption in rural areas due to an increase in connected devices in the supply chain, while requiring increased network densification and connectivity between rural, industrial and urban areas to support the production and movement of goods within Canada. A summary of the broadband enabled use-cases and emerging trend implications can be seen in the following table.

Table 1: Summary of connectivity requirements of emerging trends and supporting broadband enabled use-cases

Trend	Supporting broadband enabled use-cases	Bandwidth impact		Network densi-fication impact	Bandwidth and densification implications
		Wireless	Wireline		
Shifts in population centers	Improved Fixed Wireless networks, remote healthcare and connected transit will enable remote working/learning viability to accelerate population shifts out of urban centers	◑	◔	●	• Increased video usage and time online will drive increases in bandwidth on fixed wireless/wireline networks • Network coverage will need to expand geographically as population disperses away from urban areas
Shift in relationship and entertainment preferences	Growth in gaming, digital event and media video streaming quality coupled with AR/VR use will support the shift in preference for online entertainment content	●	●	◑	• Increased video content usage will drive significant bandwidth consumption on all networks • Network coverage will need to improve to enable access to high quality video content across the country
Shifts in business operating models	Localized wireless connectivity, smart assets and AR/VR assisted operation will enable AI, analytics, robotics and rapid upskilling of the workforce to support shifts in business operating models	◑	◔	◑	• Increased digital processes will drive bandwidth increases on fixed/in-building wireless/wireline networks • Network coverage will need to strengthen to enable automation in new and existing industrial zones
Shift to localized supply chains	Connected distribution and delivery, smart agriculture and product traceability will improve competitiveness and ensure transparency of goods origin/production to support the shift to local supply chains	◑	◔	◑	• Increased connected endpoints within wireless networks across the supply chain will increase • Network coverage will need to improve along new and existing major transportation routes
Shifts in service preferences	Improvements in healthcare technology, automated service offerings and self-monitoring devices will support the shift in preference for increasingly digital service offerings	◔	◑	◔	• Increasing substitution of physical interactions with digital services on fixed networks increase consumption • Network coverage will be impacted by population shifts and increased digital service usage in rural areas
Shift in consumer purchasing habits	Augmented reality shopping, in-store digital experiences and improved purchasing security will reduce the gap between physical and digital channels to support the shift to increased digital purchasing habits	◔	◔	◔	• Increased content on eCommerce channels will drive increased mobile and fixed bandwidth consumption • Coverage impact will be limited due to a trend towards reduction in brick-and-mortar footprint

○ No impact ◔ Minimal impact ◑ Medium impact ◕ Large impact ● Significant impact

These trends will require the advancement of 5G networks, and support Canada's shift to the Fourth Industrial Revolution, "Industry 4.0." Industry 4.0 represents the end-to-end digitization of value chains, and increased productivity, efficiency and flexibility across the economy. In addition to enabling Industry 4.0, the economic benefit of 5G in Canada is forecasted to be CA$200 billion in incremental GDP contribution between 2020 and 2040.[5] However, according to analysis by the GSMA, 5G network deployment and their ongoing costs are expected to be up to 71% more expensive than previous network generations.[6] Additionally, around 90% of the value associated with 5G is expected to accrue to a wider ecosystem of hardware, software and service providers in the Industry 4.0 ecosystem, rather than to the connectivity providers that will be required to deploy the networks.[7] These factors make 5G different from previous network technology generations.

Due to the different nature and high costs of 5G networks, cooperation on 5G network deployment in Canada will be essential. Canadian telecommunications operators have historically had to invest more capital per wireless subscriber than the largest operators in peer countries, like the G7, Australia and South Korea.[4] This is due to Canada's leading network quality and three other main factors:

- **High population dispersion:** Canada's low population density and high population dispersion directly increases the cost of telecommunications network deployment.
- **Relatively small scale telecommunications operators:** The smaller scale of Canadian telecommunications operators reduces their ability to achieve economies of scale and increases the cost of building-out networks in Canada compared to global peers.
- **High spectrum costs:** According to NERA Consulting, Canada has had the highest total spectrum costs across all bands among high income countries on a price per MHz/population basis since 2008, which directly impacts the amount of earnings operators need to fund spectrum and network deployment.[9]

These higher costs make cooperation supporting the deployment of 5G networks even more important in Canada.

With the high levels of investment needed for increased bandwidth, network densification and 5G, Canada will need to maintain a financially healthy telecommunications market to fund network deployment. As well as a regulatory environment that does not disincentivize network deployment. Encouraging service-based competition in the Canadian wireless market, through the incentivization of Mobile Virtual Network Operators (MVNOs), would likely impact the capability and incentive of Canadian telecommunications operators to invest in expanding and enhancing 5G networks, as experience in peer markets shows.

Accordingly, many peer countries across the G7, Australia and South Korea have recognized the different nature of 5G and developed a regulatory framework that incentivizes 5G network deployment by acting as an investment catalyst. This is a departure from many governments' historic roles as net receivers, as many governments have traditionally viewed the mobile telecommunications sector as a source of capital from auctioning spectrum and not as a key enabler for mid to long term economic success. This report has found that, across the G7, Australia and South Korea, governments have enacted policies and regulations across six key levers that incentivize and facilitate private investment in the deployment of 5G faster and in different ways than market forces would likely dictate. These six key levers are:

1. **Spectrum timing, allocation and costs**
2. **Network investment incentives**
3. **Rural network subsidies**
4. **Regulatory standards**
5. **Research and innovation funding (technology development)**
6. **Vertical industry application funding (technology adoption)**

Below are a number of highlighted examples of a subset of countries' use of these levers:

- **The United States** has made extensive efforts to release 5G spectrum to wireless carriers as quickly as possible. The auction of high-band spectrum was prioritized in the US to promote the highest speed wireless services and the adoption of 5G use-cases.[10]
- **The United Kingdom** has supported 5G research and innovation by establishing a £200 million fund for 5G testbeds and trial programs to explore different connectivity solutions and business models.[11] Its Department for Digital, Culture, Media and Sport (DCMS) is helping fund integrated solutions to some of the key challenges of deploying 5G technologies in manufacturing, using 5G to test use-cases such as robotic assembly, reconfigurable product assembly lines and distributed and shared VR/AR.[12]
- **South Korea** has secured and auctioned 280 MHz of mid-band and 2400MHz high-band 5G spectrum frequencies (across 3.5GHz, 28GHz) to the major South Korean carriers.[13,14] The South Korean government has passed legislation to support the development and advancement of 5G use-cases within six key verticals by specific dates to spur economic growth.[15]

For Canada to act as an investment catalyst for 5G network deployment and Industry 4.0 adoption, cooperation between the telecommunications sector, industry, government and regulator is required. Drawing on PwC's global expertise on telecommunications practices, this report identifies potential actions across six key regulatory levers applicable to the Canadian telecommunications industry. Importantly, action will likely be required across each of the six levers, as a part of a broader Industry 4.0 strategy, within a consistent and predictable regulation framework. Below are a set of recommendations across each of the six levers:

1. **Spectrum timing, allocation and costs:** (i) Accelerate the date for the mid- and high-band spectrum auctions to ensure Canadian 5G rollout can keep pace with global peers. (ii) Incentivize carriers that are capable of deploying high-cost 5G networks at scale. (iii) Increase the amount of contiguous spectrum available at auctions to ensure support for high speeds and large amounts of traffic. This can be achieved by ensuring spectrum pricing is cost-effective. This will allow operators to dedicate more of their resources to building out networks and avoid the requirement to recover high-cost spectrum investments through service prices.
2. **Network investment incentives:** Identify core corridors and areas that may not have the highest demand today but are critical to economic success and the future of Industry 4.0, such as highways and industrial zones, to direct government funding and incentives for network investments. In addition, Canada can learn from regulation in peer wireless telecommunications markets, such as Europe, where countries that introduced regulated MVNO access to wireless networks have demonstrated lower coverage and adoption rates of network technology (3G, 4G, etc.).[8] Similar regulation in Canada could potentially reduce carriers' ability to invest and disincentivize them from maintaining their high levels of investment in networks.
3. **Rural network subsidies:** Continue to provide grants for rural network build-out, similar to the $1.75 billion Universal Broadband Fund (UBF), to overcome the high costs of rural network infrastructure and ensure access to 5G networks in rural and low economic areas.[16] Provide subsidies specifically for 5G network build-out in rural areas to promote private investment in rural 5G networks.

4. **Regulatory standards:** In recognition of the importance of streamlining and expediting the roll-out of 5G infrastructure, introduce a notification regime and/or shot clock to reduce the delay and costs associated with 5G approvals.
5. **Research and innovation funding:** Establish large-scale government-industry 5G testbeds to facilitate research and development of 5G technologies and applications while measuring potential economic and social benefits. Expand scope and funding for current research and innovation programs to increase focus on development of 5G technology across sectors and provinces, encouraging technological innovation of Canadian industries, helping them achieve scale and creating a supportive environment for startups.
6. **Vertical industry application funding:** Work with network operators, local governments and industry to introduce incentives, subsidies or grants that incentivize the adoption of 5G enabled use-cases across Canada. Expand current government programs to add incentives targeted at 5G use-case adoption within key economic and social industries such as manufacturing, agriculture, healthcare, energy, mining, oil and gas to ensure that key Canadian industries realize the maximum benefit from 5G technology and improve their global competitiveness.

With the acceleration of a number of trends by COVID-19 that are likely to increase future demand for connectivity and spur the adoption of broadband enabled use-cases, a window of opportunity has emerged for increased cooperation on the deployment of 5G network infrastructure and Industry 4.0 in Canada. The need for cooperation and for a shift in the government's role to become an investment catalyst is further emphasized by COVID-19's impact on the economy and the need for economic recovery, as network deployment can serve as an economic stimulus. Through cooperation between government and industry on 5G and Industry 4.0, Canada can support the mid to long term success of the economy, while providing the telecommunications networks required to meet the connectivity needs of Canadians' economic and social lives post-COVID-19.

COVID has disrupted Canadians' way of life

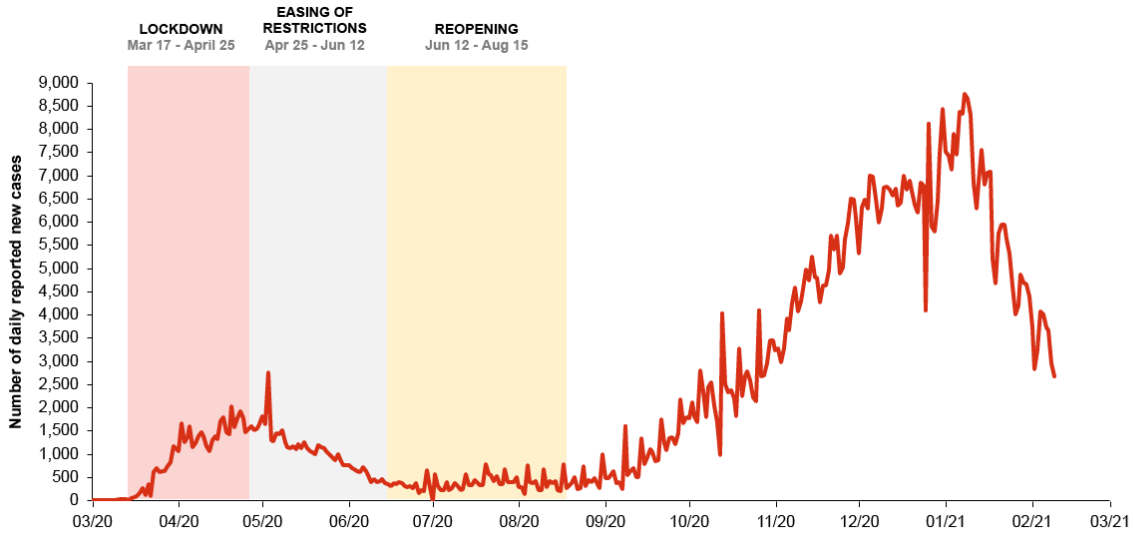
The onset of the COVID-19 pandemic sparked an unprecedented and unexpected shock to Canada and countries all around the world. A rapid spike in cases in early March 2020 drove the country into lockdown, disrupting all aspects of normal life in Canada, such as:

- **Ways of working:** Governments imposed safety-related mandatory closures on non-essential businesses across the country, forcing business to transition to digital ways of working to remain operational. Around 5 million Canadians started working from home in March 2020.[17]
- **Education:** Schools and post-secondary institutions were close and students were forced to transition to online learning programs. Around 5 million Canadians shifted to remote learning in March 2020.[17]
- **Travel:** Countries began closing borders to restrict the spread of the virus, effectively banning travel to other countries.
- **Social interaction:** Governments imposed social distancing measures to reduce the risk of the virus spreading and imposed bans on large gatherings of people.
- **Healthcare:** In an effort to manage COVID-19 cases and prevent the spread, restrictions were imposed on the types of health services available in person, leading to increased use of virtual healthcare services.

The stabilization and slight decline in cases allowed for an easing of restrictions at the end of April 2020 and a reopening of the economy between June and August of that year. However, economic and social behaviours have not returned to the pre-COVID-19 norms, and the rise of a second wave of cases driving the reintroduction of lockdown measures will continue to have a lasting effect on future behaviours.

Throughout the report, references are made to three phases of the COVID-19 period: (1) the lockdown, (2) easing of restrictions, and (3) reopening. These phases of COVID-19 can be seen in Exhibit 1. Currently, a spike in cases has driven the need for further federal intervention.

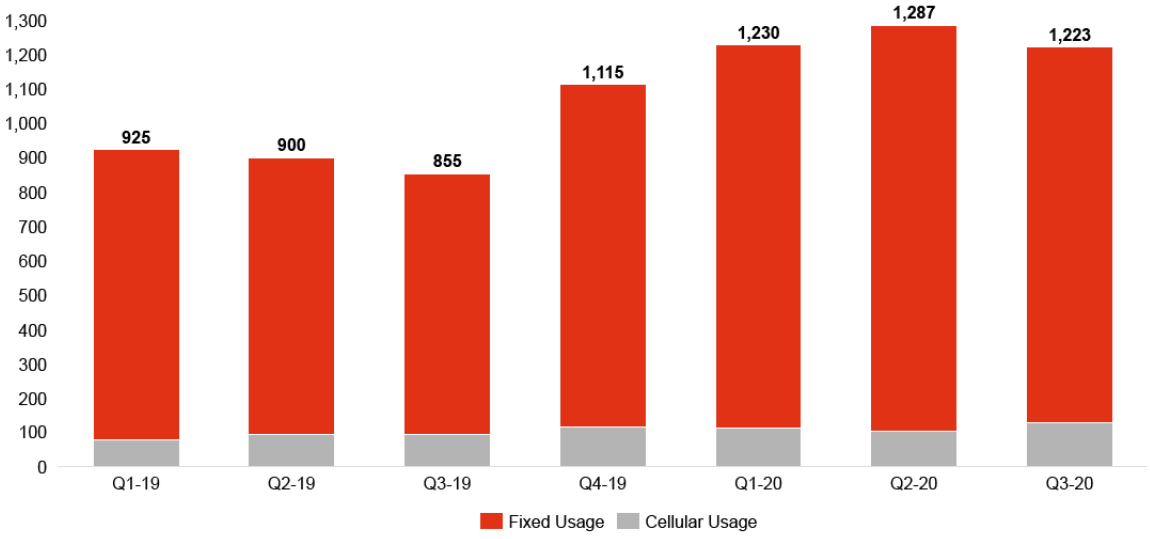
Exhibit 1: Daily COVID-19 cases Canada, March to November 2020[18]



Connectivity needs have increased significantly during COVID-19

These new economic and social behaviours resulted in a substitution of physical interactions with digital interactions, which has led to an increase in the use of connectivity throughout the COVID-19 period. Home internet usage increased by around 40% while voice call traffic doubled compared to the year before.[4] Data usage since the onset of COVID-19 increased significantly, with an increase in daily average fixed usage by 18% from 1,100 MB to 1,300 MB between March and April 2020.[3] The increased usage persisted throughout the lockdown period and could potentially spike again with the reintroduction of lockdown measures.

Exhibit 2: Daily average Canadian broadband usage[3]
(MB, Q1 2019 to Q2 2020)



Canada's high-quality telecommunications networks enabled increased usage

The increase in wireless and wireline usage during COVID-19 created a substantial demand shock on telecommunications networks across the country. While all telecommunications networks across the global peer group were able to support the increased connectivity needs effectively, Canadian networks provided among the best experience for consumers during COVID-19. Notably, Canada's networks were around 78% faster in mobile download speed and 10% faster in fixed download speeds than global peers during the COVID-19 lockdown period.[3]

Exhibit 3: Average monthly download speeds on mobile networks[3]
(Mbps, G7 countries plus Australia, South Korea)

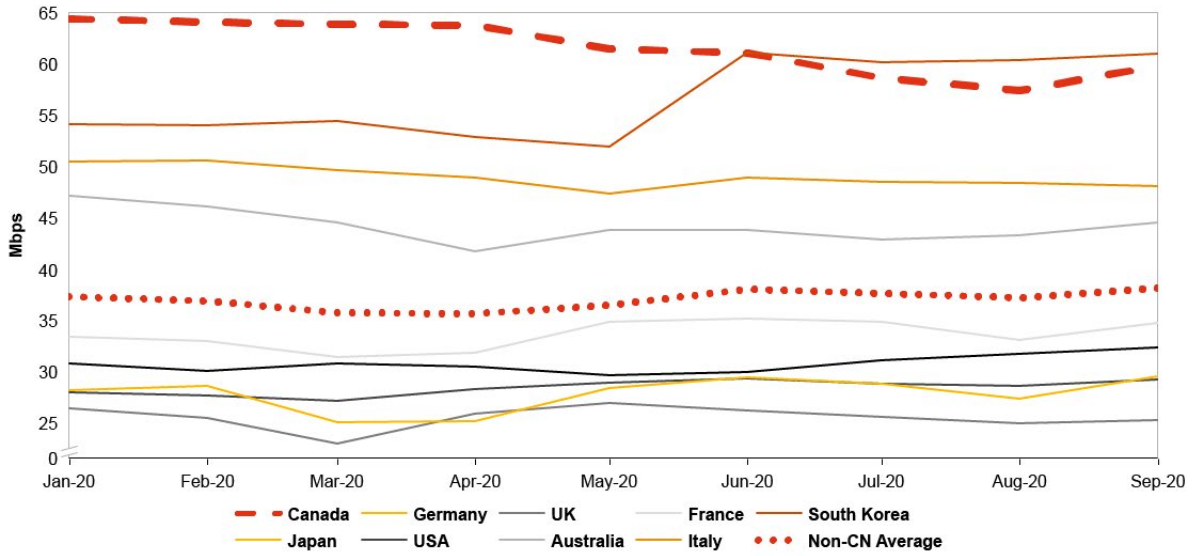
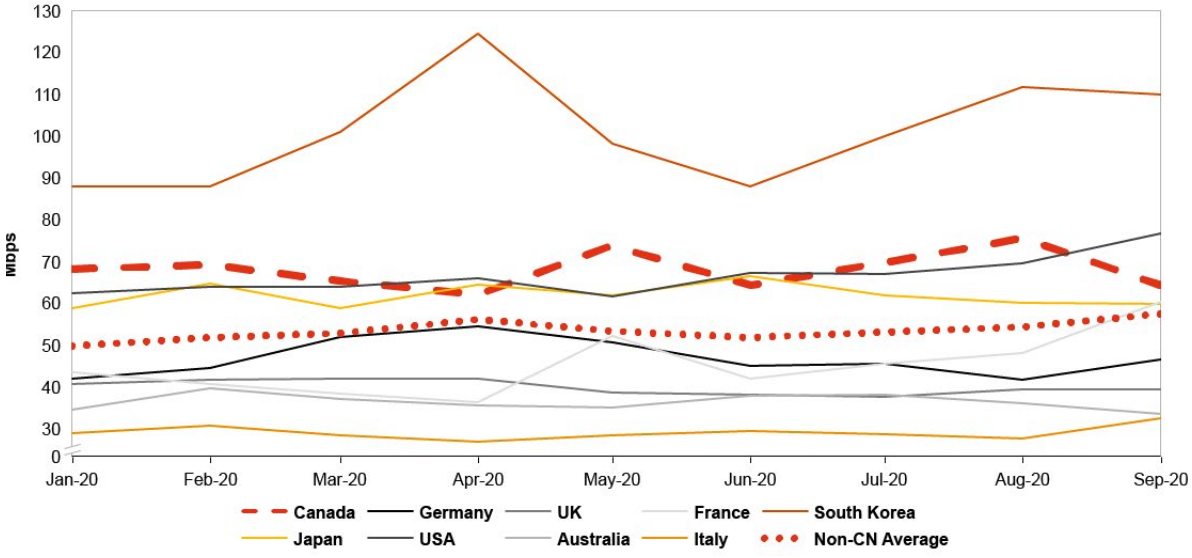


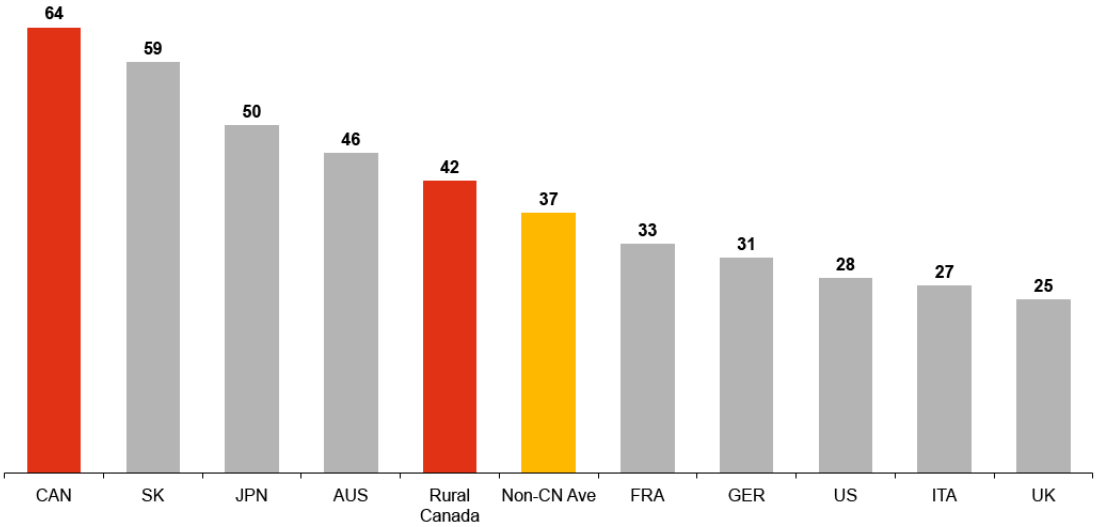
Exhibit 4: Average monthly download speeds on fixed networks[3]
(Mbps, G7 countries plus Australia, South Korea)



In spite of the large geographic span and low population density in Canada, Canadian networks rank among the highest quality networks in the world. Prior to lockdown, Canada's overall average mobile download speed was 71% higher than the average of global peers while rural Canadian networks' average mobile download speed was 14% higher than the average of global peers.[3,19]

Exhibit 5: Average mobile download speed in rural Canada and international peer group, January to March 2020[3,19]

(Mbps, data collected Jan 1 - Mar 30, 2020)

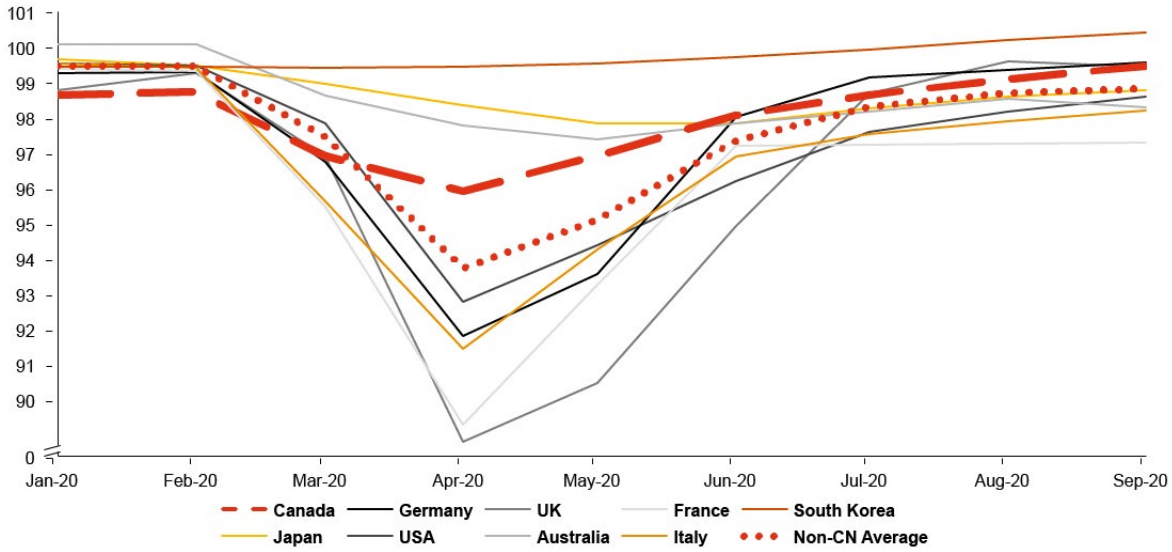


The strength of Canadian telecommunications networks has been a key enabler of economic and social continuity during COVID-19

Canada demonstrated one of the most resilient economies during COVID-19. The Canadian economy experienced a 2% lower decline in economic activity than the non-Canadian average during lockdown before recovering to Canada's long term average of economic activity by September, as measured by the Organisation for Economic Co-operation and Development (OECD)'s composite leading indicator.[2] Accordingly, Canada experienced on par GDP performance across the G7 between Q1 and Q3 2020.[20]

Exhibit 6: OECD composite leading indicator measurement 2020[2]

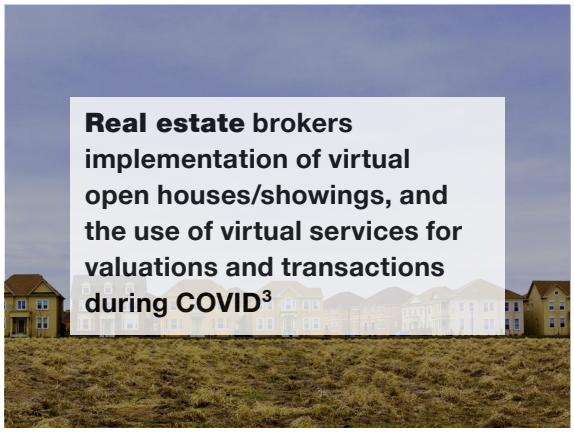
(Shows fluctuation from long-term economic activity based on country-specific factors, Jan – Sep 2020)

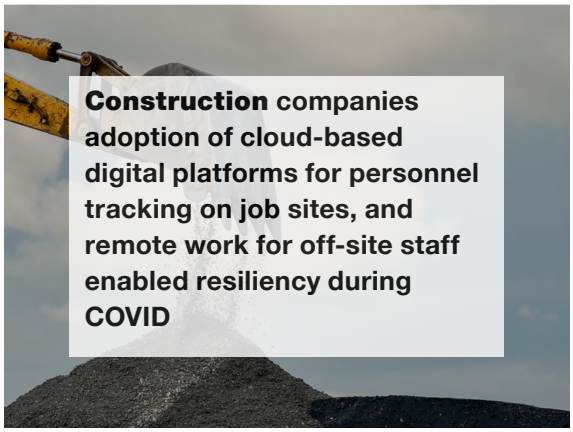


Many of Canada's key industries were resilient throughout COVID-19, using connectivity to transition to digital ways of working

Many of Canada's key industries have shown a rapid recovery since the shock experienced during lockdown. Excluding mining, energy, oil and gas industries, which have been impacted by both COVID-19 and a broader commodity downturn, four of Canada's top six industries by GDP have exhibited a recovery to pre-COVID-19 GDP levels between April and July.[21] The performance of key industries in Canada was underpinned by a number of factors, including the timing and quality of the government's health and fiscal policy response as well as their ability to use telecommunications networks to adapt to more digital ways of working.

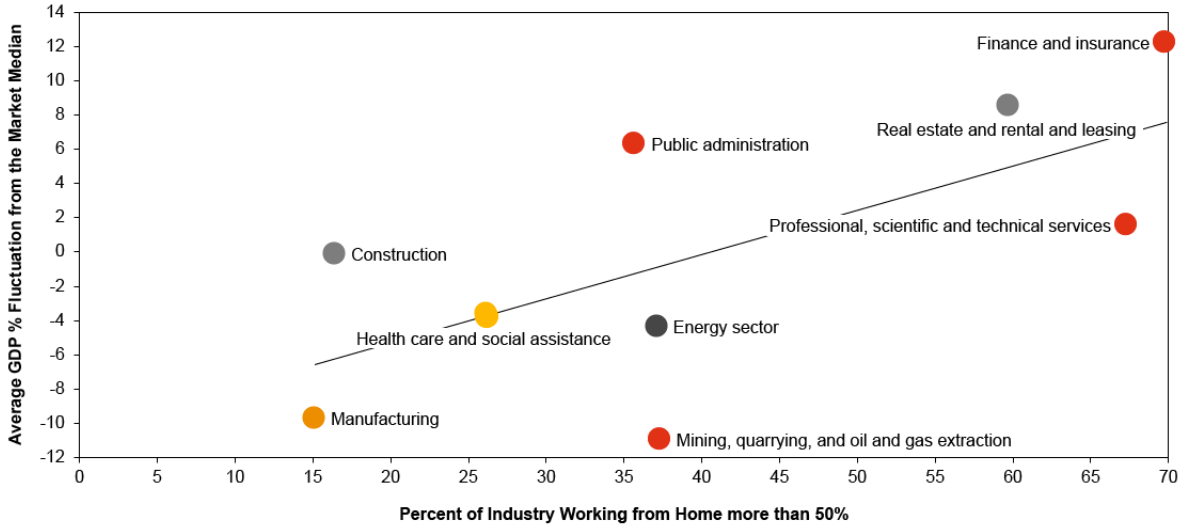
Exhibit 7: Digital capabilities used by major Canadian industries to withstand the impacts of COVID-19[22,23,24,25,26]





A key capability that drove businesses' ability to continue to operate was the shift of the majority of the workforce to a remote working environment. As shown in Exhibit 8, It is revealing that industries with the highest share of remote workforces showed greater growth in GDP since lockdown.[21,27] Without the resilient underlying networks to support the increased use of connectivity, it is unlikely that the increase in digital ways of working would have been possible.

Exhibit 8: GDP % fluctuation from market median and % of industries working from home more than half the time[21,27]



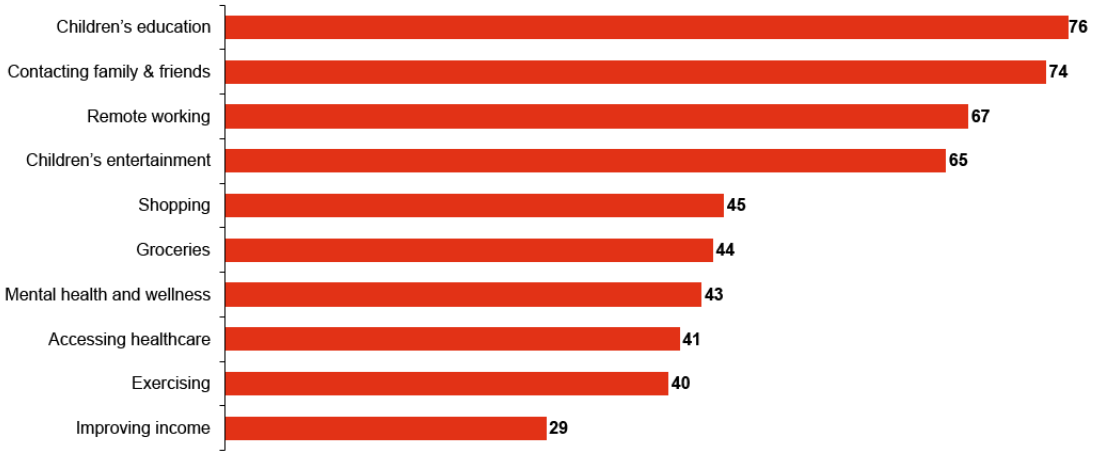
Connectivity has provided Canadians with access to digital entertainment and contributed to social well-being

While Canadians shifted into remote working and learning environments, they also adapted their social behaviours in response to COVID-19. This new lifestyle required a shift from typical social norms to new forms of interaction and entertainment. Hence, Canadians substituted past physical, out of home interactions with new digital options. Social distancing restrictions were placed on the healthcare systems, and patients were advised that a large portion of doctor and hospital visits could not be conducted in person due to the impact of COVID-19. Accordingly, telemedicine and virtual healthcare became an important outlet for Canadians to access healthcare services, with 34% of Canadians using phone healthcare services and 6% using virtual healthcare services.[28] Canadians also turned to increased use of digital entertainment such as browsing the internet, streaming, using social media, watching TV and movies and gaming. Accordingly, 60% of Canadians reported an increase in internet and TV screen time from pre-COVID-19 to March 2020, driving a 13% increase in time spent on WiFi during lockdown.[29,30]

COVID-19 impacted people in a variety of ways, including a set of negative effects on general well-being. Anxiety was a commonly reported symptom among Canadians during the COVID-19-induced lockdowns and social distancing guidelines.[31] As shown in Exhibit 10, people turned to connectivity use-cases to support their well-being and address the challenges of a new sedentary lifestyle, with a large portion of people using connectivity to contact family and friends, access healthcare and purchase goods. Access to education had been an issue across multiple countries, with schools and post-secondary institutions closing to prevent the spread of the virus. Connectivity played a key role in alleviating the effect of these lockdown measures, with 76% of people across 11 countries turning to connectivity to support the education of their children. In addition, connectivity was a contributor to coping with negative impacts to mental health, with 43% of people across 11 countries indicating that connectivity played a role in coping with mental health and wellness.[32]

Exhibit 9: Response to how connectivity helped cope with COVID-19[32]

(% share of respondents, 11,000 respondents in 11 countries)



These new social behaviours were a key contributing factor in the increased network usage during COVID-19. Without resilient underlying networks to support the increased use of connectivity, it is unlikely that these new behaviours would have been possible.

Canadian telecommunications operators have supported Canada's COVID-19 response through a variety of economic and corporately responsible measures

The reliance on connectivity throughout COVID-19 is a clear indicator of the importance of Canadian telecommunications operators' support of Canada's economic and social resilience. However, in addition to investing in networks, Canadian telecommunications operators also undertook a broad set of initiatives aimed at supporting Canada. These initiatives ranged from reduced fees for consumers, donations to schools and in-need communities and direct support for COVID-19 research in the healthcare industry.

> **"You've helped keep Canadians connected to their workplaces, their communities, their healthcare providers, support networks and their civic institutions at a time when they needed these connections most—and when these connections could be accessed only through your networks."**
>
> – CRTC Chair Ian Scott[33]

Support for public health initiatives[34]

- Donated more than $5 million to support the mental health response during COVID-19
- Committed more than $10 million to help build public healthcare capacity
- Worked with federal government to rapidly set up 1-800 numbers to call to offer or ask for extra help or personal protective equipment (PPE) during COVID-19
- Donated more than $7.5 million of PPE and essential supplies across the country
- Provided complimentary phones and airtime for first responders

Support for COVID-19 research[34]

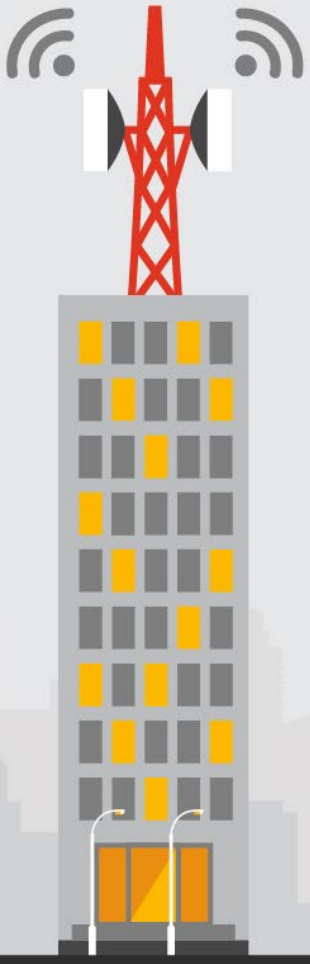
- Donated more than $5 million to support the COVID-19 response of charitable foundations across Canada
- Donated to foundations dedicated to finding compounds that fight COVID-19
- Donated directly to health initiatives to support the development of new medical technologies to battle COVID-19

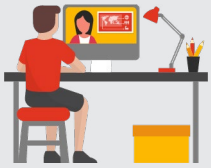
Support of in-need communities[34]

- Donated more than $5 million worth of mobile devices to in-need communities
- Donated months of free service and free internet to isolated seniors, social support services, permanent/temporary shelters and families in need
- Contributed more than 1 million meals and corporate donations to Food Banks Canada

Support for small/medium businesses[34]

- Offered businesses free access to various virtual work and collaboration tools
- Offered small businesses free equipment, professional installation and secure business services
- Committed $500,000 in expert advice to small businesses during COVID-19





Support for online learning[34]

- Offered low-cost, high-speed broadband internet to students in need
- Developed partnerships with technology companies to provide devices to students in low income families, equipped with free wireless data and pre-loaded learning materials

Support for consumers[34]

- Waived roaming and pay-per-use fees
- Waived data caps/extra usage fees
- Waived long distance charges
- Introduced flexible payment plans
- Committed to not disconnect customers who couldn't pay bills
- Offered free entertainment TV services

Canadian telecommunications operators rapidly adapted their business models in response to COVID-19

Similar to most industries in Canada, the telecommunications sector was significantly affected by COVID-19. The imposed social distancing restrictions required a major shift in pre-COVID-19 ways of working to ensure ongoing service to the public. These shifts included:

- **Large scale remote working:** 90% of stores closed during COVID-19. To maintain employment during the initial economic shock, operators redeployed the majority of their workforce, including those directly impacted by store closures, into other areas of the business. They also rapidly shifted their operating model to more online work and increased call centre capacity.
- **Remote customer service, install and repair:** Social distancing measures hindered technicians' ability to enter homes, leading to the development of new ways to install products and address customer issues virtually without entering premises. Additional investments were made in call centres to address the increase in phone and virtual support volumes.
- **COVID-19 safety measures:** In compliance with federal regulations, telecommunications operators introduced enhanced cleaning protocols, occupancy limits and mandatory face mask policies and practices across all operations to protect their own employees and the general public.

Similar to most Canadian industries, COVID-19 has had a financial impact on Canadian telecommunications operators

In aggregate, Rogers, Bell and TELUS experienced a combined $828 million reduction in EBITDA in Q2 and Q3 of 2020 compared to Q2 and Q3 of 2019.[4] This decrease was driven by a reduction in net new sales of 80–90% during COVID-19. Travel restrictions and roaming fee waivers for consumers resulted in a 90% reduction in roaming revenue over the period.[4]

However, the effects of COVID-19 were more profound on free cash flows due to the initiatives undertaken by telecommunications operators throughout the period. Telecommunications operators experienced a $426 million decrease in simple free cash flows in Q2, Q3 2020 year over year, driven by incremental COVID-19-related costs to ensure ongoing operations and consistent network performance.[4]

Moving forward, financial performance is likely to continue to be impacted by COVID-19's impact on the broader economy. The unemployment rate increased from 6% to 14% from March to May 2020 at the height of lockdown and has remained at around 9% in October 2020, driving a reduction in consumer spending.[35] There has been a 51% increase in business closures in Canada increasing from 58,000 to 88,000 businesses from March to April, resulting in a reduction in small and medium enterprise (SME) activity.[36] Canadian enterprises have seen an 8% reduction in corporate profits year over year between Q2, Q3 2019 and Q2, Q3 2020, driving a reduction on corporate spending.[37] This depressed earning environment during COVID-19 will have a direct and lasting impact on the performance of all Canadian industries, including the telecommunications industry.

As the world enters into a period of uncertainty with rising cases and planned immunization of the majority of the population by September 2021, COVID-19 will continue to influence economic and social behaviours, driving implications for the telecommunications networks.[38]

Canada's leading networks are driven by high levels of network investment

Canadian telecommunications networks are among the most expensive networks to build and maintain. To maintain their relatively strong global performance, and ability to meet the needs of Canadians in the future, as they have done during COVID-19, significant investments are required. As examined in a previously published PwC report titled, "The importance of a healthy telecommunications industry to Canada's high-tech success," the high costs of Canadian networks are due to three key factors:

- **High population dispersion:** Canada is the second largest country by area but 39th largest by population, leading to one of the lowest population densities compared to its global peers. In addition, its population is spread across many small towns, rather than being centered largely in urban areas as seen in Australia and other peer nations including the US. Canada's high population dispersion directly increases the cost of telecommunications network deployment.
- **Relatively small scale telecommunications operators:** The revenue of Canada's largest telecommunications operator is one-tenth that of the largest US telecommunications operator. The smaller scale of Canadian telecommunications operators reduces their ability to achieve economies of scale and increases the cost of building-out networks in Canada compared to global peers.
- **High spectrum costs:** According to NERA Consulting, Canada has the highest total spectrum costs across all bands among high income countries on a price per MHz/population basis since 2008.[9] Canada's high cost of spectrum directly impacts the amount of earnings operators need to fund spectrum and network deployment.

These three factors, along with other factors such as climate, average wages, tax policies and input prices, have driven high levels of investment into Canadian telecommunications networks as demonstrated by higher average Capital Expenditure, excluding spectrum costs, per subscriber in Canada than in peer countries.[39] In spite of the higher cost, Canadian telecommunications operators have cumulatively invested 181% more Capital Expenditure, excluding spectrum costs, per wireless subscriber than their global peers between 2014 and 2019, to support the strength and resilience of network performance in Canada.[39]

Exhibit 10: Average Capital Expenditure per wireless subscriber across peer countries[39]
(CA$)

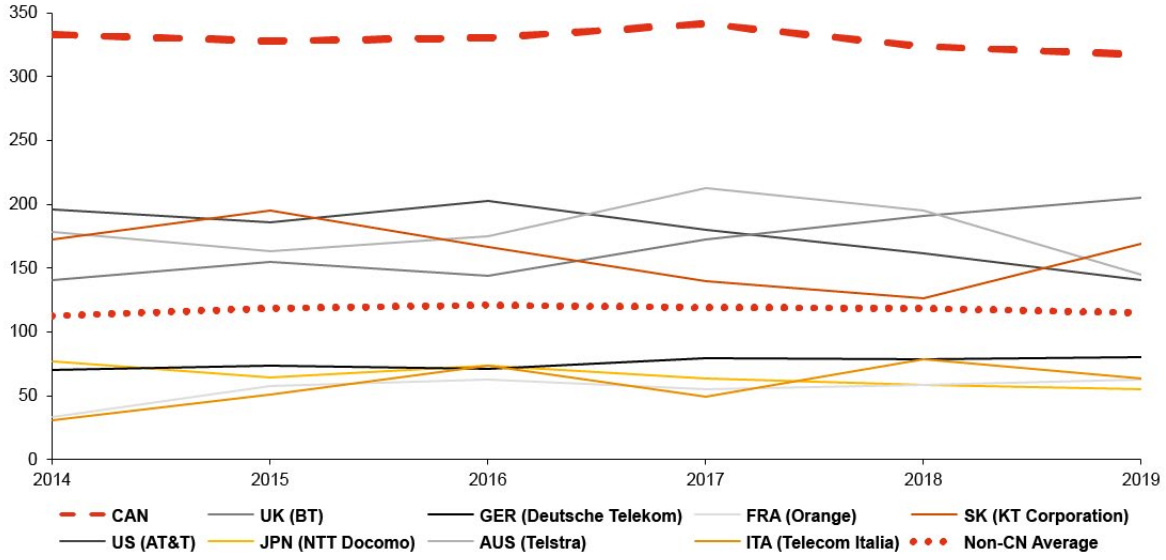
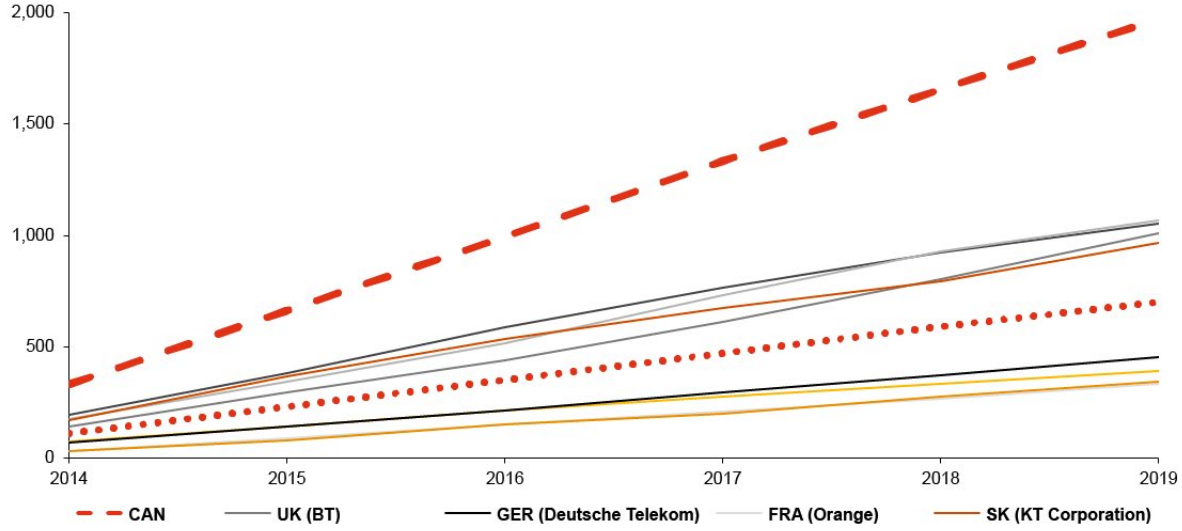


Exhibit 11: Cumulative Capital Expenditure per wireless subscriber across peer countries[39]

(CA$)



Higher network costs in Canada drive the need for higher Capital Expenditure spending in comparison to global peers

Over the past three years, Canadian telecommunications operators have invested 19% of their revenue on Capital Expenditure, which is 35% higher than peer countries surveyed, due to the higher factors of production outlined in the section above.[39] The significant amount of expenditure required to fund the high-cost investments in networks has also resulted in Canadian telecommunications operators' simple free cash flows to be on par with their global counterparts' in spite of their higher EBITDA margins. This highlights that Canadian telecommunications operators are commensurate with their investment into network capital and maintaining a healthy telecommunications industry within Canada.

Further regulations encouraging service-based competition in Canada will likely impact network investment

A recent proceeding undertaken by the industry regulator, the Canadian Radio-television and Telecommunications Commission (CRTC), examined the role of MVNOs in the Canadian wireless telecommunications market with the aim of reducing consumer wireless prices.[40] As shown in a previous PwC report titled, "Understanding the likely impacts of MVNOs in Canada - Part 2: Impact on Canada's transition to 5G," evidence from around the world indicates that the entrance of MVNOs into a market affects the amount of Capital Expenditure on the network, resulting in reduced rates of coverage and adoption of new technology in those markets.[41] In Canada, this impact would likely be felt first in the reduced and delayed deployment of 5G network infrastructure.

Canada's telecommunications market could mimic its global counterparts, potentially resulting in a decline in investment in telecommunications networks. Notably, large geography countries like the US that lead rollout typically have facilities-based competition due to the requirement to have the capacity and incentive to invest across large geographies. The regulation-mandated entrance of MVNOs into the Canadian market could impact incumbents' ability to invest and disincentivize them to continue investing in the network.

Case study

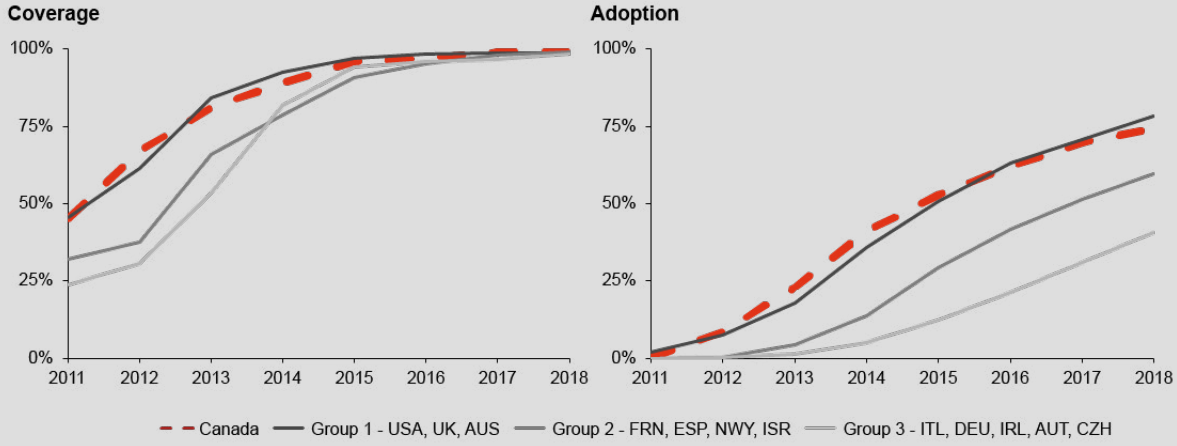
The following case study is taken from a previously published PwC report titled, "Understanding the likely impacts of MVNOs in Canada–Part 2: Impact on Canada's transition to 5G."

There are two key metrics with which to assess network rollout success: coverage and adoption. We define coverage as the percentage of the population that in principal has access to the new network and define adoption as the percentage of the population that is actually connected to it. Coverage alone does not imply realization of the economic benefits associated with the new network: benefit realization requires that subscribers actually use the network.

To assess the impacts of mandated wholesale MVNO access, global case studies were categorized into three groups: in Group-1 countries, no MVNO regulation was in place during either the 3G or 4G transitions, although MVNOs could compete freely via voluntary commercial arrangements; in Group-2 countries, MVNO regulation was introduced during the 3G transition (2006–2009); and in Group-3 countries, MVNO regulation was introduced during the 4G transition (2014–2016).

Comparison of network coverage and adoption of global 4G rollout

(Coverage as a % of subscribers with access to 4G coverage and adoption as a % of subscribers using 4G networks)



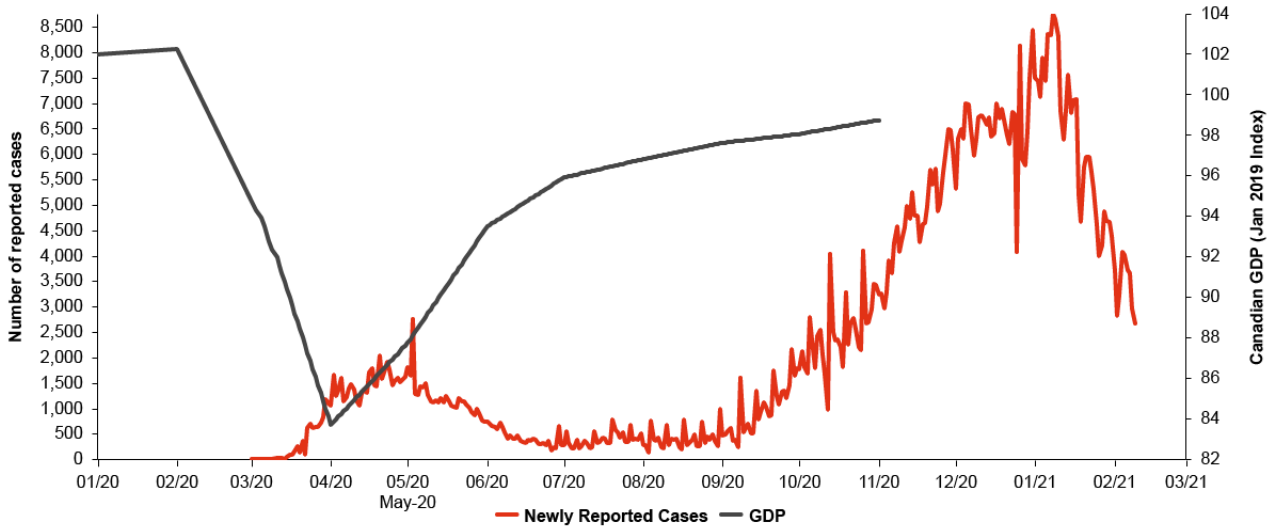
As shown in the figures above, countries in Group 1 with no MVNO regulation showed faster rates of coverage rollout and adoption, while countries in Groups 2 and 3 failed to keep pace with Group-1 countries.

Six key trends will shape post-COVID-19 economic and social behaviours, with implications for connectivity

Canada has experienced a steep decline and sharp rise, a V-shaped recovery pattern, since the COVID-19-induced economic shock in April as business sentiment rose, driving GDP recovery to 95% of pre-COVID-19 levels within three months.[42] The Canadian population's ability to quickly adapt to the modified ways of working and living was a key contributing factor to the V-shaped recovery.

As the country enters a second wave and spike in cases, restrictions have been reintroduced. Countries are now turning to hopes of a vaccine, which has begun to be delivered and planned to be administered to the majority of the population by September 2021.[38] Hence, COVID-19-induced economic and social behaviours are likely to have a lasting effect.

Exhibit 12: Canada GDP and daily reported COVID-19 cases[18,42]



Six key economic and social trends have been impacted by COVID-19

With the COVID-19 pandemic continuing to impact economies across the globe, these new behaviours will drive a set of emerging economic and social trends that will shape a more digitally enabled post-COVID-19 economy and social environment that will require more connectivity and connected devices. The expected trends are as follows:

- **Shifts in population centres:** The rate of population growth in large urban centres is expected to slow down due to increasing unaffordability and increased remote working and learning viability.
- **Shift in relationship and entertainment preferences:** Increased social media, video streaming and video chat usage habits are likely to persist post-COVID-19.
- **Shifts in business operating models:** Employers are expected to accelerate digital transformation and automation plans to increase business resiliency, respond to future disruption and manage increased costs from localized supply chains.
- **Shift to localized supply chains:** Supply chains are expected to continue to trend towards on-shoring to protect against geopolitical and global unpredictable disruption risk.
- **Shifts in service preferences:** Preferences for virtual services are expected to continue to increase, as COVID-19 has exposed consumers and businesses to new virtual service offerings.
- **Shifts in consumer purchasing habits:** Canadians are expected to continue to increase eCommerce activity and their preference for digital service channels.

Each of these emerging trends will have a significant effect on the use of connectivity and the need for strong digital infrastructure. In addition to the effect of COVID-19, advances in broadband enabled use-cases will support these emerging trends to move Canada to a more digital and connected ecosystem. A summary of these trends, broadband enabled use-cases and their effects on network requirements can be seen in Exhibit 16.

Shifts in population centres will drive the need for network densification outside major urban centres

Prior to COVID-19, the trend of shifts in population centres towards large urban centres was evident in spite of increasing unaffordability in major cities. COVID-19 has acted to slow the trend of growth in large urban centres through increased viability of remote working across industries. This report identifies three key drivers that have been impacted by COVID-19 to support the increased feasibility of living outside of major urban centres.

1. Remote working viability: Prior to COVID-19, the workforce had 39% teleworking capacity across all industries, although the adoption of telework was significantly lower, with only 6% of the workforce spending 80% or more time working remotely.[43] Adoption of remote working was greater in professional, scientific, technical services and information and cultural industries, with 12–14% of their workforces spending 80% or more time working remotely.[43]

COVID-19 acted as a catalyst for increased remote working due to the widespread lockdown measures imposed on businesses. During COVID-19, 13% more employees work remotely, driving a total of 19% of the workforce to spend 80% or more time working remotely.[43] Professional, scientific, technical services and information and cultural industries showed greatest adoption, with 39–51% of their workforces spending 80% or more time working remotely during COVID-19, compared to 12–14% pre-COVID-19.[43]

Exhibit 13: Summary of connectivity implications of emerging trends and supporting broadband enabled use-cases

Trend	Supporting broadband enabled use-cases	Bandwidth impact		Network densi-fication impact	Bandwidth and densification implications
		Wireless	Wireline		
Shifts in population centers	Improved Fixed Wireless networks, remote healthcare and connected transit will enable remote working/learning viability to accelerate population shifts out of urban centers	◑	◔	●	• Increased video usage and time online will drive increases in bandwidth on fixed wireless/wireline networks • Network coverage will need to expand geographically as population disperses away from urban areas
Shift in relationship and entertainment preferences	Growth in gaming, digital event and media video streaming quality coupled with AR/VR use will support the shift in preference for online entertainment content	●	●	◑	• Increased video content usage will drive significant bandwidth consumption on all networks • Network coverage will need to improve to enable access to high quality video content across the country
Shifts in business operating models	Localized wireless connectivity, smart assets and AR/VR assisted operation will enable AI, analytics, robotics and rapid upskilling of the workforce to support shifts in business operating models	◑	◔	◑	• Increased digital processes will drive bandwidth increases on fixed/in-building wireless/wireline networks • Network coverage will need to strengthen to enable automation in new and existing industrial zones
Shift to localized supply chains	Connected distribution and delivery, smart agriculture and product traceability will improve competitiveness and ensure transparency of goods origin/production to support the shift to local supply chains	◑	◔	◑	• Increased connected endpoints within wireless networks across the supply chain will increase • Network coverage will need to improve along new and existing major transportation routes
Shifts in service preferences	Improvements in healthcare technology, automated service offerings and self-monitoring devices will support the shift in preference for increasingly digital service offerings	◔	◑	◔	• Increasing substitution of physical interactions with digital services on fixed networks increase consumption • Network coverage will be impacted by population shifts and increased digital service usage in rural areas
Shift in consumer purchasing habits	Augmented reality shopping, in-store digital experiences and improved purchasing security will reduce the gap between physical and digital channels to support the shift to increased digital purchasing habits	◔	◔	◔	• Increased content on eCommerce channels will drive increased mobile and fixed bandwidth consumption • Coverage impact will be limited due to a trend towards reduction in brick-and-mortar footprint

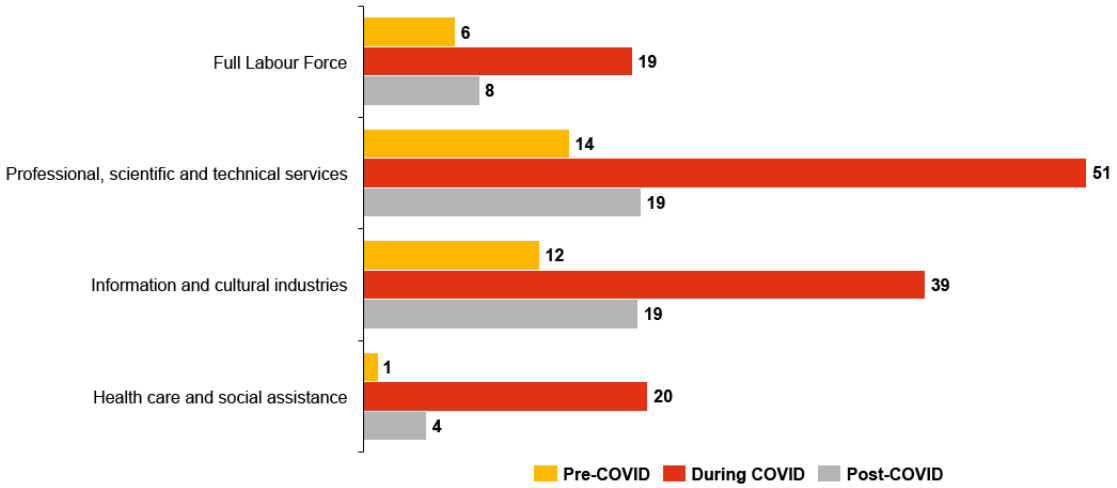
○ No impact ◔ Minimal impact ◑ Medium impact ◕ Large impact ● Significant impact

In addition, essential services such as healthcare and social assistance accelerated teleworking ability, shifting from 1% of the industry's workforce to 20% of the workforce spending 80% or more time working remotely during COVID-19.[43]

Following recovery from COVID-19, remote working will become a permanent option for some employees around Canada as businesses continue to adapt to new ways of working. According to a survey conducted by Statistics Canada, 33% more people will be working remotely more than 80% of the time, representing a total of 1.5 million Canadians, following recovery from COVID-19.[43]

Exhibit 14: Percentage by industry of 80% or more of workforce remote working pre/during COVID-19 and expected post-COVID-19[43]

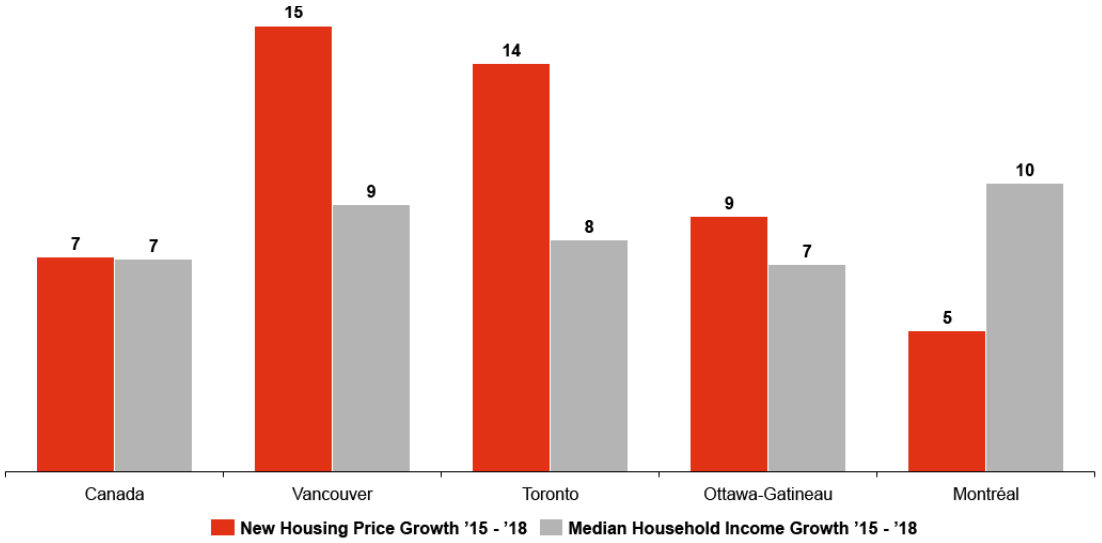
(Industries shown based on highest remote working adoption, and healthcare and social assistance industry)



2. Housing prices and affordability: Housing affordability in major cities is an ongoing issue for Canadians. On average, between 2015 and 2018, new housing prices and median household income grew at the same rate across Canada. As shown in Exhibit 18, when analyzing major urban centres such as Vancouver and Toronto, new housing prices increased at 1.5 times the rate of median household income.[44,45]

Exhibit 15: New housing price growth, median household income growth in major Canadian cities, 2015 to 2018[44,45]

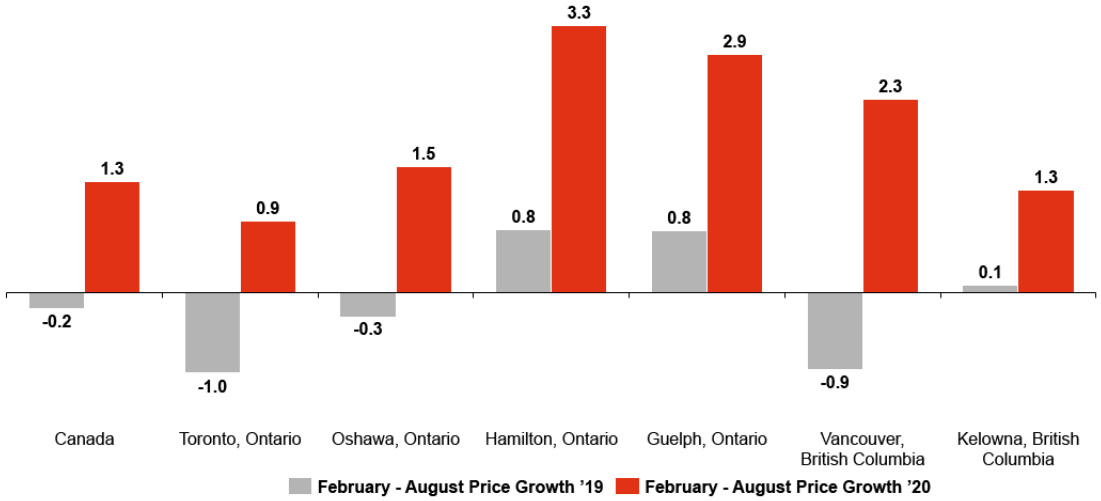
(% change)



The rising house price to income disparity in these major urban centres contributed to increased housing demand outside Toronto and Vancouver as home prices in the surrounding areas outpaced major city price growth between February and August 2019.[44] COVID-19 acted as a catalyst for decreasing population growth in large urban centres as remote working and remote learning reduced the reliance on proximity to the workplace. This shift was most profound in Toronto as new housing prices in surrounding areas outpaced major city price growth by 1.5–3.5 times between February and August 2020.[44]

Exhibit 16: New housing price growth in select Canadian cities between February and August, 2019–2020[44]

(% change)



The rate at which Canadians with teleworking capability move to urban areas will continue to slow down as affordability continues to be a concern. According to a survey conducted by the real estate company RE/MAX, 32% of Canadians have indicated that they no longer want to live in large urban centres such as Toronto and Vancouver.[46]

3. Remote learning viability: Prior to COVID-19, post-secondary institutions had begun integrating online courses, although schools continued to place emphasis on in-class learning. Across post-secondary institutions, 76% of universities and colleges in Canada reported offering for-credit online courses in 2019.[47] COVID-19 provided an opportunity for both schools and post-secondary institutions to increase the uptake of remote learning capabilities. However, during the reopening phase, schools were the first to reopen, indicating that a long term shift to remote learning within schools is unlikely due to the emphasis on in-person learning at younger ages. On the other hand, post-secondary institutions will continue to invest in digitization to allow for increased online courses and accreditations, reducing the need for students to move to the population centres in which many of the largest post-secondary institutions are concentrated.

Supporting broadband enabled use-cases for shifts in population centres

Advancements in improved fixed wireless networks, remote healthcare and connected transit will increase remote working and learning viability to support the trend of reduced population growth in large urban centres. Adoption of these use-cases will likely have a broader economic and social impact to improve healthcare accessibility, productivity, education quality and public safety in Canada.

The effects of each of these use-cases can be seen in Table 2.

Table 2: Emerging broadband enabled use-cases and economic and social benefits related to shifts in population centres

Emerging broadband enabled use-cases	Impact on trends	Economic and social benefits
Improved Fixed Wireless Access (FWA)	High	• Provision of a comparable substitute to wireline connectivity will allow for improved business and schooling conditions in rural areas. • Improved FWA will support decreased urbanization out of urban centres due to increased remote working/learning viability.
Remote Healthcare	High	• Connection to high-quality healthcare facilities across the country will improve the quality of life for Canadians across the country. • Access to high-quality remote healthcare will accelerate the shift out of urban centres across the country.
Emergency Services	Medium	• Addition of connected devices, robotics and drones to emergency services will allow for increased scale of operations to improve health and safety conditions in larger areas. • Improved health and safety conditions through connected emergency services will support increased population dispersion across Canada.
Connected Transport	Low	• Connected cars and transit systems will allow for increased productivity and travel experience in urban areas. • Improved commuting experience will support population shifts out of urban centres to surrounding areas.
Traffic Management	Low	• Intelligent traffic management will improve productivity and travel experience by reducing congestion and journey times. • Improved travel experience will support population shifts out of urban centres to surrounding areas.

Connectivity implications for shifts in population centres

Time spent online on fixed wireless and wireline networks will increase as the population shifts to increased remote working and learning. Consumption will increase substantially as online activity shifts to digital video collaboration and learning tools.

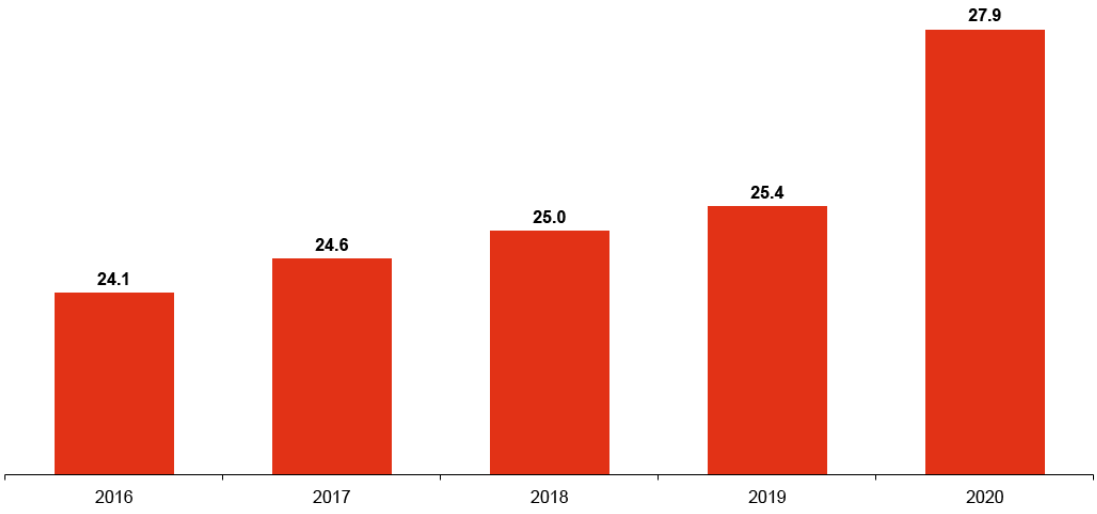
Network densification in non-urban areas will need to increase to provide all Canadians with access to new digital tools.

Shifts to more digital relationship and entertainment preferences will increase network consumption

The trend of increased use of social media, media streaming and digital social interaction was evident before COVID-19. COVID-19 has acted as the catalyst to accelerate the shift to more digital relationship and entertainment preferences. This report identifies three key drivers that have been impacted by COVID-19 to support the increased use of online entertainment.

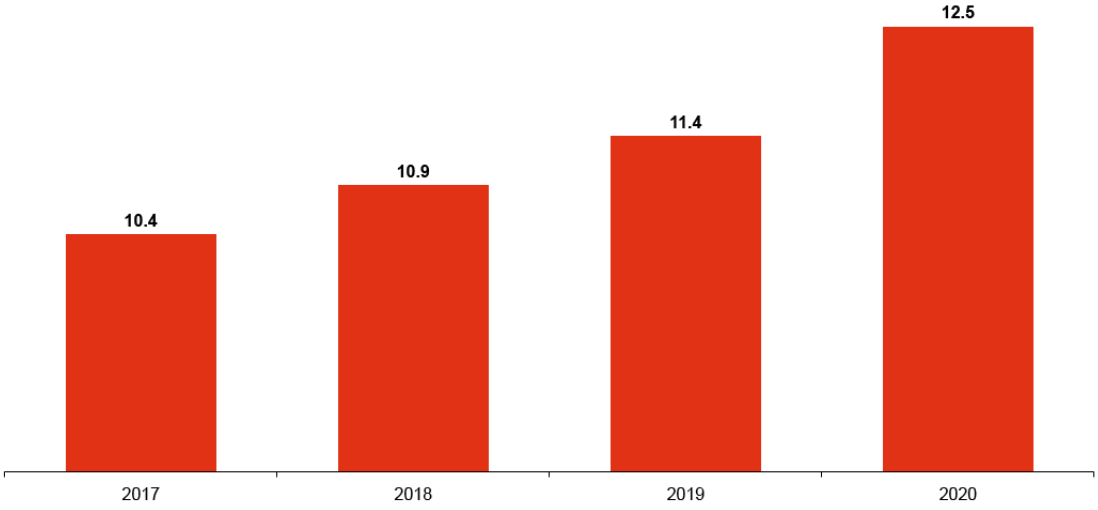
1. Social media usage: Prior to COVID-19, social media had seen increasing popularity in Canada, with 82% of Canadian internet users over the age of 15 reporting having a social media account.[48] Social distancing and quarantine drove increased use of social media to connect and communicate over the internet. Accordingly, 41% of Canadians have increased their use of social media during COVID-19, accelerating the annual growth rate of social media usage from 1.7% from 2016–2019 to a forecasted 10% in 2020.[49,50] Social media usage is likely to continue to grow faster post-COVID-19 due to new habits being formed.

Exhibit 17: Social media usage in Canada[50]
(Millions of users)



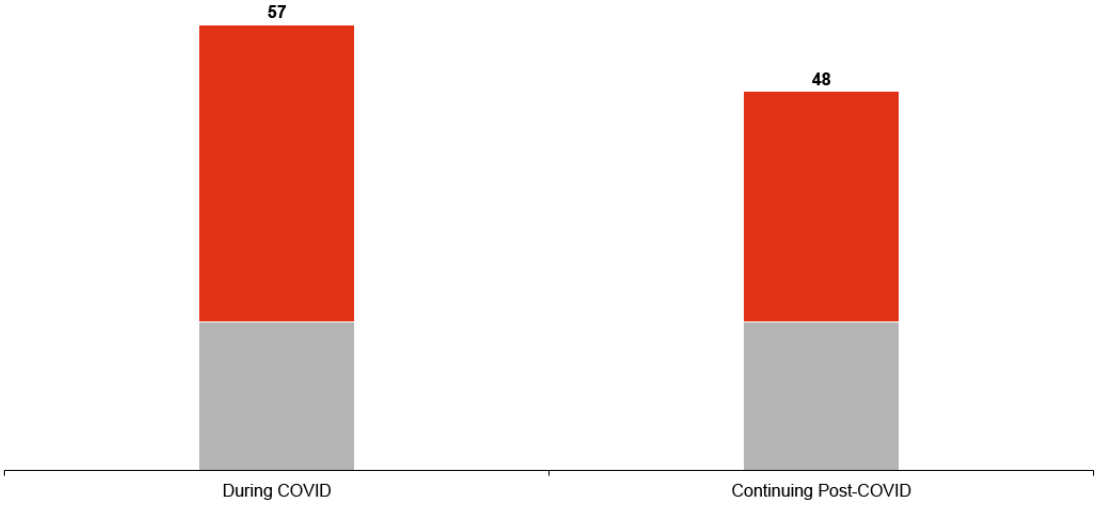
2. Media streaming usage: Prior to COVID-19, data consumption had been steadily increasing, primarily due to increased use of video-on-demand services. COVID-19 has acted as a catalyst for accelerated use of media streaming with reduced competition from live events/physical entertainment and increased streaming from celebrities. During COVID-19, 46% of Canadians have increased their use of video streaming. The annual growth rate of streaming video users from 4.7% from 2017-2019 to a forecasted 9.6% in 2020.[51] Media streaming usage will continue to grow faster post-COVID-19 due to the increased exposure to digital entertainment during COVID-19.

Exhibit 18: Video streaming users in Canada[51]
(Millions of users)



3. Social interactions: Quarantine and social distancing measures during COVID-19 have driven consumers to search for alternative methods to connect and communicate with friends and family. Video chat platforms have been the preferred method of communication for many consumers, indicated by a 2,900% increase in Zoom peak daily meeting participation from December 2019 to April 2020.[52,53] According to a survey conducted by Ipsos, 38% of respondents indicated using video chat platforms for the first time during COVID-19, with 29% of new consumers planning to continue using video chat platforms post-COVID-19.[54] Video chat will continue to see accelerated growth in the future as consumers become more accustomed to using digital communication tools.

Exhibit 19: Video chat usage in Canada during and post-COVID-19[54]
(% share of respondents)



Supporting broadband enabled use-cases for shifts to more digital relationship and entertainment preferences

Growth in gaming, digital event and media video streaming quality, coupled with increased AR and VR use, will support the shift in preference for online entertainment content. Adoption of these use-cases will likely have a broader economic and social impact to potentially promote Canadian culture through increased distribution of Canadian media content and increase access to broader entertainment.

The effects of each of these use-cases can be seen in Table 3.

Table 3: Emerging broadband enabled use-cases and economic and social benefits related to shifts in relationship and entertainment preferences

Emerging broadband enabled use-cases	Impact on trends	Economic and social benefits
Gaming	High	• Improving connectivity has enabled the shift to online gaming and increase in popularity of e-sports as a source of entertainment. • Growth in the online gaming industry and the popularity of e-sports will support the shift to online entertainment preferences.
Video Streaming	High	• Improved fixed and mobile networks will drive the ability for Canadian content producers to distribute high-quality video content to a larger audience. • Growth of the video streaming industry will support the shift in video streaming entertainment preferences.
Digital Events	Medium	• Improved quality of video streaming, coupled with increased use of AR and VR, will drive the increased availability of digital events, reducing costs of production and increasing availability of live content for remote audiences. • Increased accessibility to live events through digital channels will support shifts in entertainment preferences.
Virtual Reality	Low	• Technological advancements and responsiveness improvements in VR will enable increasingly life-like interactions and simulations over digital channels. • Improvements in VR will support shifts in relationship preferences by reducing the gap between physical and digital experiences.

Connectivity implications for shifts to more digital relationship and entertainment preferences

Data consumption will increase significantly due to the proliferation of video content downloads and streaming both in-home and on the go. Bandwidth consumption will increase as consumers substitute physical entertainment and interactions with digital alternatives.

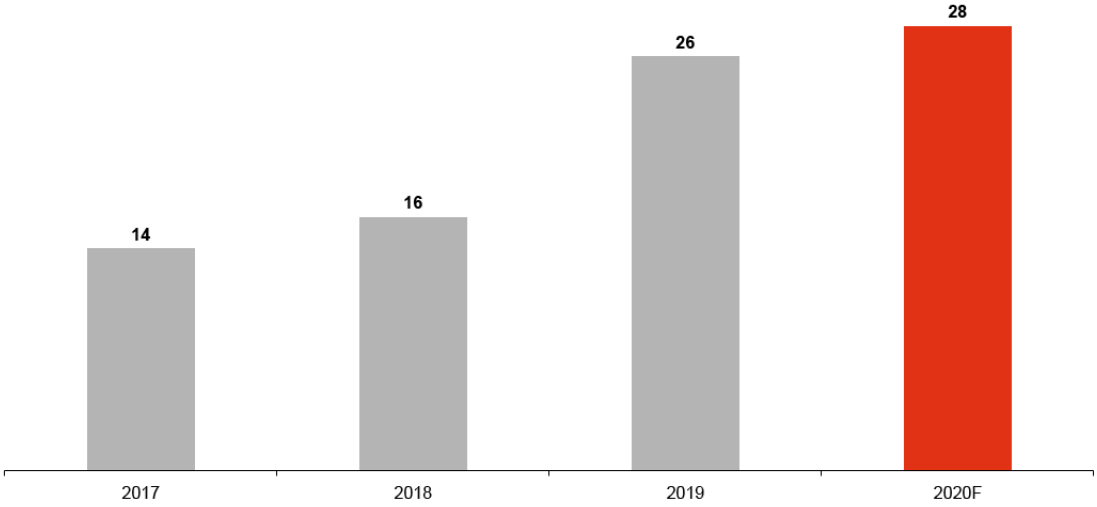
Increased mobile consumption of video content will require increased network densification to ensure constant connection and bandwidth availability as consumers move and travel. Networks will need to accommodate access to higher quality media content across the country, including rural areas.

Shifts to more digital and automated processes will drive increased business connectivity needs

The trend of increased digital transformation and automation of processes within industries was evident before COVID-19. COVID-19 has acted as an accelerator for this change. This report identifies three key drivers that have been impacted by COVID-19 that are likely to result in improved business resilience and global competitiveness.

1. Digital transformation: Prior to COVID-19, businesses had begun to increase spending on digital transformation in an effort to improve efficiency within their business models. Digital transformation spending experienced 37% compound annual growth rate between 2017–2019.[55] COVID-19-induced business closures emphasized the need for continued digital transformation spending within businesses to increase resiliency and business continuity. In a survey conducted by the IDC, 85% of organizations indicated that planned digital transformation projects would go ahead during COVID-19.[56]

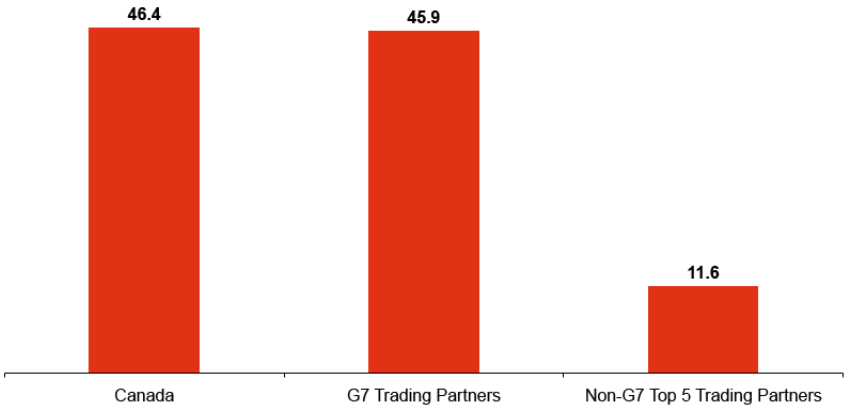
Exhibit 20: Digital transformation spending Canada, 2017–2020[55]
(CA$ Billions)



Digital transformation will accelerate post-COVID-19 as businesses search for methods to build operating model resilience and protect against future disruption risk. According to the World Economic Forum, 84% of employers indicated acceleration of digitization in response to COVID-19.[57] Additionally, advances in 5G and IoT in the short to medium term are expected to drive increased digital transformation activity.

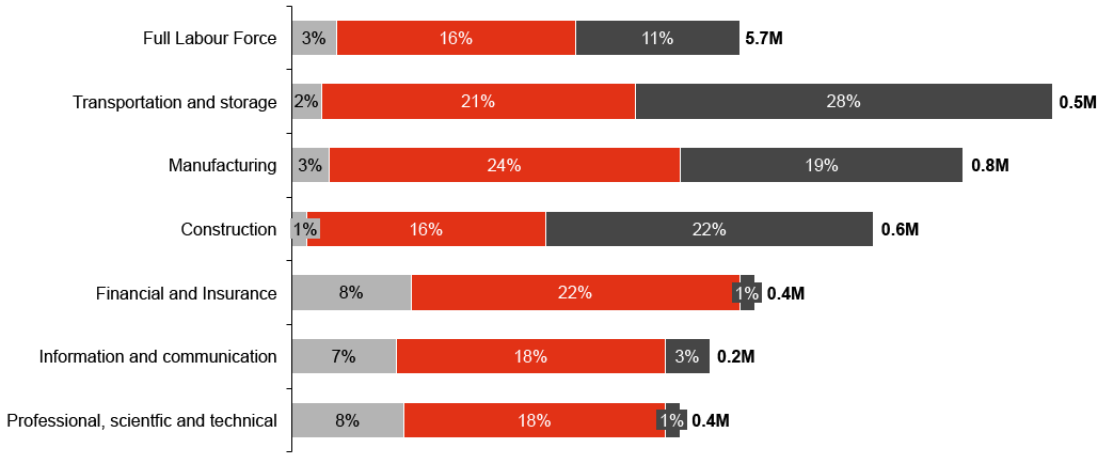
2. Cost of production and labour: High Canadian labour costs have driven many companies to outsource production to lower cost countries. Canada's labour costs are higher than the G7 average and four times higher than the average of its top five non-G7 trading partners.[58] These high costs created strain on businesses during lockdown periods and the subsequent lack of demand throughout COVID-19, driving business to reduce their workforce in an effort to manage expenses. According to Statistics Canada, 27% of businesses indicated they were laying off 50% or more of their workforce due to COVID-19.[59] Increased on-shoring and near-shoring of the supply chain will drive increased automation within businesses to manage higher costs of labour and maintain competitiveness in the global market.

Exhibit 21: Gross national income per capita, top 11 trading partners 2019[58]
(Countries included: France, Germany, US, Italy, Japan, UK, China, India, Mexico, Vietnam, South Korea)



3. Automation: Advancement in technology and evolution of business processes have driven the adoption of automation across industries. COVID-19 has reinforced this trend. A global study conducted by PwC prior to COVID-19 indicated that 5.7 million jobs were susceptible to high risk of automation by the mid 2030s, with the largest wave of automation expected in the late 2020s.[65]

Exhibit 22: Share of global jobs at high risk of automation by mid-2030s[60]
(% share of workforce, Total number of jobs affected)



Increased social distancing measures and business closures during COVID-19 has meant automation is a key priority for business leaders across the world. According to the World Economic Forum, 50% of employers indicated that they would accelerate automation of processes in response to COVID-19.[57] In Canada, this acceleration in automation could impact up to 1.5 million additional jobs in the early 2020s, primarily in the transportation and storage, manufacturing and construction industries.[60]

Through the accelerated push to automation, businesses will increase focus on upskilling the workforce to enable new ways of working. These shifts will support the resiliency of the Canadian workforce to protect against potential future disruption while supporting Canadian businesses' international competitiveness.

Supporting broadband enabled use-cases for shifts to more digital and automated processes

Advancements in localized wireless connectivity, smart assets and AR/VR assisted operation, will enable AI, analytics, robotics and rapid upskilling of the workforce to support shifts towards increased digital transformation and automation within operating models. Adoption of these use-cases will likely have a broader economic and social impact to potentially increase productivity, improve worker safety and support upskilling of the workforce.

The effects of each of these use-cases can be seen in Table 4.

Table 4: Emerging broadband enabled use-cases and economic and social benefits related to shifts in business operating models

Emerging broadband enabled use-cases	Impact on trends	Economic and social benefits
Localized Wireless Connectivity	High	• Improved in-building wireless connectivity will enable increased use of IoT devices, sensors, robotics, artificial intelligence and driverless machinery within offices, warehouses and production facilities. • Improved connectivity speed and reliability will support the increased data usage and automation of business processes.
Smart Assets	High	• Connected assets will allow communication between devices to improve responsiveness to changes in operations and the environment while extending asset life. • Increased smart infrastructure will support automation through enabling asset self-monitoring and communication.
Technology-assisted Operation	Medium	• Advancement in wearable, AR and VR technology will drive rapid upskilling of the workforce through improved training effectiveness (e.g. VR simulation), driving increased productivity, health and safety through technology-assisted operations. • Increased use of technology and improved digital upskilling will support the increase in digital transformation and automation.

Connectivity implications for shifts to more digital and automated processes

Bandwidth consumption will increase due to the substitution of physical processes with digital/automated processes. Increased bandwidth consumption will occur via fixed wireless, in-building wireless and wireline networks across businesses in Canada.

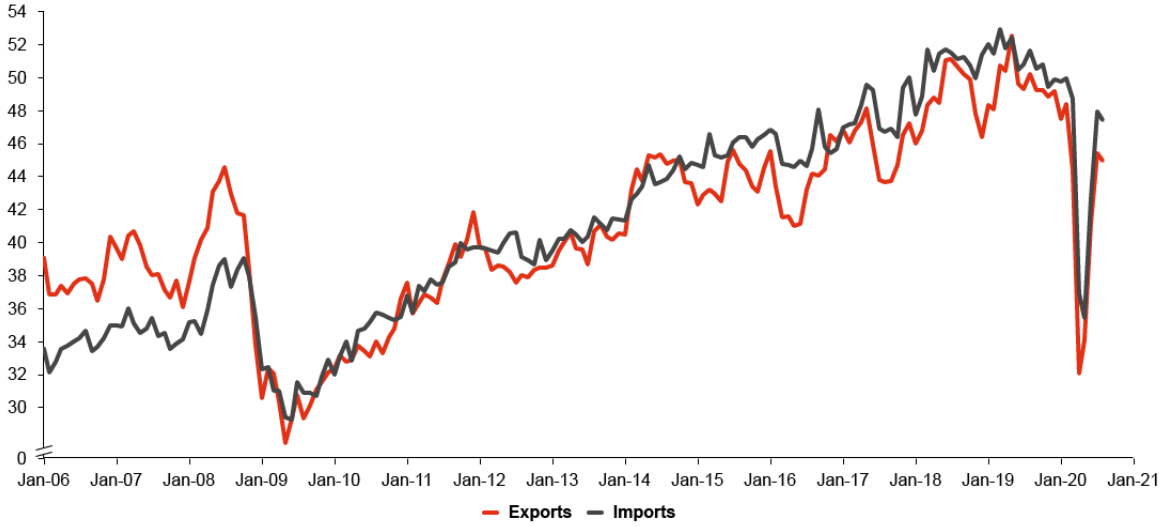
Networks in existing industrial zones will require densification and strengthening to enable increasing digital and automated use-cases. New network infrastructure will be required in areas with newly established industrial zones in rural and suburban areas.

Shifts to localization of supply chains will increase connectivity needs across Canada

The trend to localization of supply chains was evident with the reduction in trade volumes leading up to the start of COVID-19. COVID-19 has emphasized the importance of localized supply chains to protect against future disruptions. This report identifies two key drivers that have been impacted by COVID-19 that are likely to result in increased supply chain resiliency and local goods production.

1. Trade policies: Canada had seen a steady increase in trade volumes after recovering from the financial crisis of 2008 up to 2019. An increase in trade restrictions with Canada's major trading partners, including steel tariffs with the US and tensions with China, initiated a trend of declining trade volumes starting in 2019 and continuing through February 2020.[61] COVID-19-induced border restrictions and a general decline in consumer discretionary spending led to a 34% reduction in imports and a 26% reduction in exports from February to April 2020.[61] Trade volume has since returned to near pre-COVID-19 levels.

Exhibit 23: Canada import and export volumes[61]
(CA$ Trillions)



In addition to declining trade volumes, COVID-19 drove many countries to introduce export prohibitions and restrictions on PPE and consumer staples. During COVID-19, 73 countries enforced trade restrictions on face and eye protection products, while 17 countries introduced restrictions on foodstuffs.[62] Increasing trade restrictions and rising trade tensions have elevated the importance of manufacturing goods locally to reduce risks of future supply chain disruptions.

2. Supply chain resiliency: Historically, Canada has relied on the US and China for the supply of PPE, accounting for 37% and 21% of total imports respectively.[63] This reliance has been driven by the emphasis of cost-based supply chain decision-making and widespread use of just-in-time inventory systems. During COVID-19, global just-in-time inventory systems struggled with the supply and demand shocks leading to a shortage of PPE and other consumer staples. This impact has emphasized the need for vertical integration and/or diversification of supply chains.

> **I think that one of the consequences of coronavirus is going to mean, for the economy, a shift from a sort of just-in-time, get-the-very-cheapest-input-possible model, to a model that puts a greater emphasis on resilience, puts a greater emphasis on supply chains that are closer to home.**
>
> – Chrystia Freeland, Deputy Prime Minister of Canada[64]

Moving forward, critical supply chains are expected to begin building resiliency by shifting towards localization of production and reducing the reliance on international trade. Further, global macroeconomic conditions and local political concerns are likely to impact trade policies. This shift will drive increased demand for local production capabilities and potentially generate increased job opportunities and requirements for production efficiency within Canada.

Supporting broadband enabled use-cases for localization of supply chains

Advancements in connected distribution and delivery, smart agriculture and product traceability, will improve competitiveness and ensure transparency of goods origin/production to support the shift to local supply chains. Automation use-cases have been covered in the previous section, although their impact will also translate into improved supply chain productivity. Adoption of these use-cases will likely have a broader economic and social impact to potentially increase jobs and improve productivity while supporting the environment through reduced fuel consumption.

The effects of each of these use-cases can be seen in Table 5.

Table 5: Emerging broadband enabled use-cases and economic and social benefits related to shifts to localized supply chains

Emerging broadband enabled use-cases	Impact on trends	Economic and social benefits
Distribution and Delivery	High	• Driverless trucks, digital railways and connected ports will improve the efficiency of local supply chains through reduced labour costs, fuel consumption and travel time. • Increasingly connected distribution and delivery will support localization of supply chains by increasing the global competitiveness of Canadian goods and services.
Smart Agriculture and Food Security	High	• Connected equipment, driverless machinery and end-to-end monitoring will drive increased crop yields, reduced pesticide usage and food traceability within the Canadian agriculture industry. • Smart agriculture will drive the acceleration of localized food supply chains by reducing food costs, increasing scalability and ensuring farm to table food traceability.
Product Traceability	Medium	• Increased connected IoT devices will enable product traceability by tracking the movement of goods through the supply chain. • Product traceability will support the shift to localized supply chains by providing transparency to consumers.

Connectivity implications for localization of supply chains

The number of connected endpoints will increase as IoT devices increase throughout the supply chain and between distribution and delivery points, driving increased bandwidth use across fixed and mobile networks.

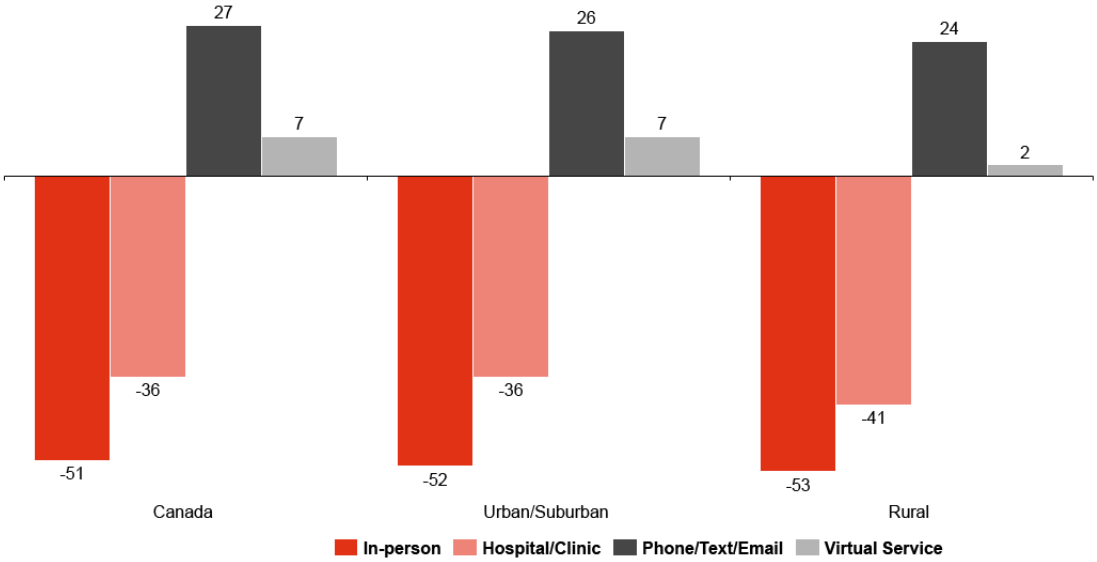
Use-cases will fall along established transportation routes, which will require the strengthening of existing networks. New network infrastructure requirements will be limited to areas with newly established transportation and shipping routes.

Shifts to increased preference for virtual services will create new demand for connectivity

The trend in increased demand for virtual services was evident in a subset of industries before COVID-19. COVID-19 has emphasized the need for access to virtual services such as healthcare and banking services, with likely impacts on future broadband enabled use-cases and broadband connectivity. This report identifies two key drivers that have been impacted by COVID-19.

1. Virtual healthcare: Prior to COVID-19, the majority of the population had become accustomed to in-person health services, with only 12% of Canadians exposed to phone or virtual health services.[28] Pre-COVID-19, increasing demand for healthcare services in Canada placed a strain on hospital resources. The major shock to healthcare systems, created by the onset of COVID-19, served as a catalyst for increased use of virtual health services across Canada. According to a survey conducted by the Canadian Medical Association (CMA), 27% more Canadians used phone/text/email services and 7% more Canadians used virtual services to address illnesses during COVID-19.[28] Moving forward, the same CMA survey indicated that 42% of Canadians indicated a preference for telehealth and virtual health services as their first choice health channel.[28]

Exhibit 24: Change in Canadians' use of health channels during COVID-19[28]
(% change from pre-COVID levels)



2. Other virtual services: Prior to COVID-19, consumers showed low uptake of virtual services for fitness centres, museums and financial services. COVID-19-induced store closures and social distancing measures have forced consumers to pursue virtual channels rather than brick-and-mortar facilities. A PwC consumer survey showed 27% of consumers increased use of online banking during COVID-19 to continue managing their finances.[65] According to Fidelity National Information Services, 31% of consumers will continue to use more online and mobile banking in the future.[66]

Supporting broadband enabled use-cases for increased preference for virtualized services

Advancements in healthcare technology, automated service offerings and self-monitoring devices, will support the shift in preference for increasingly digital service offerings. Adoption of these use-cases will likely have a broader economic and social impact to potentially improve quality of healthcare, improve productivity and support social well-being.

The effects of each of these use-cases can be seen in Table 6.

Table 6: Emerging broadband enabled use-cases and economic and social benefits related to shifts in service preferences

Emerging broadband enabled use-cases	Impact on trends	Economic and social benefits
Healthcare Technology	High	• Private wireless networks in hospitals, connected devices, artificial intelligence (AI) diagnostics, robotics and remote surgical/diagnostic health services will significantly improve health levels across the Canadian population. • Advancements in medical technology will support the preference for virtual healthcare, especially in rural and remote areas.
Automated Front-line Services	High	• Increased use of robotics and automated services will reduce business costs through reduction of labour and space required for operations. • Advancement in automated services will support the shift in digital/automated services through increased exposure and efficiency.
Self-monitoring Devices	Medium	• Behaviour and health monitoring data collected and communicated from connected devices will enable increased personalization of services to reduce costs, improve functionality and support personal preferences. • Improved service offerings will support the preference for digitally enabled services.

Connectivity implications for increased preference for virtualized services

Consumption will increase due to the substitution of physical service interaction with digital interactions over fixed wireless and wireline networks. Increased video usage to supplement digital services and remote monitoring will drive increased bandwidth consumption within relevant industries.

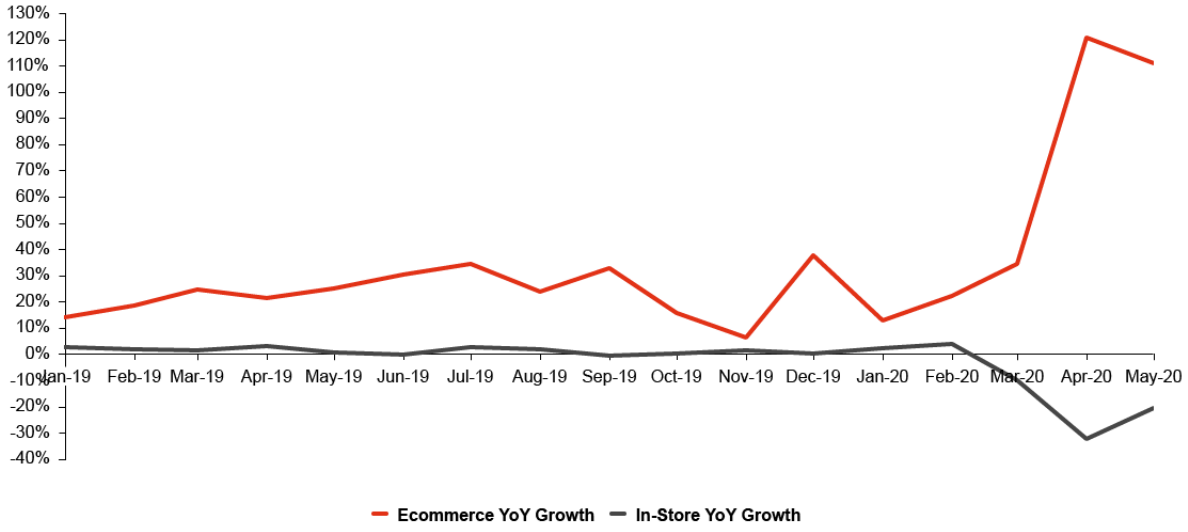
Network densification requirements will be driven by shifts in populations, as demand for service access will spread geographically. Increased virtual services will drive the requirement for increased densification to provide access to rural populations.

Shifts to increased eCommerce will drive increased demand for connectivity

The trend in increased use of eCommerce, relative to in-store purchasing, was evident before COVID-19. COVID-19 has accelerated the shift of increased eCommerce and online shopping. This report identifies two key drivers that have been impacted by COVID-19 to drive a shift in consumer purchasing habits.

1. eCommerce and online shopping: Prior to COVID-19, consumers were turning to online shopping to meet their daily needs, driving an increase in eCommerce share to 4% of total retail trade sales.[67] COVID-19 acted as a catalyst for increased uptake of eCommerce sales as consumers adapted to social distancing and store closures by shifting to online shopping channels. eCommerce growth accelerated during COVID-19 to outpace in-store sales growth by an average of 110% between March and May 2020, increasing its retail trade share to 7%.[67] eCommerce growth is likely to continue to grow as COVID-19 buying habits are reinforced and businesses invest in resilient online sales channels. Reopening of stores following recovery will slow the rate of eCommerce growth although eCommerce is likely to continue to outpace in-store sales growth post-COVID-19.

Exhibit 25: eCommerce and in-store sales growth in Canadian retail trade[67]



2. Customer service and online policies: Prior to COVID-19, businesses had begun investments in online support channels to address increasing eCommerce activity and to reduce customer service costs. Social distancing and increased eCommerce activity during COVID-19 drove consumers to online service channels prompting businesses to extend their policies to make online shopping easier for consumers, including extending return periods. Consumers are likely to increase their use of online support channels following increased exposure and new habits formed during COVID-19. This will prompt businesses to accelerate investment in online channels to improve online customer experience.

Supporting broadband enabled use-cases for shifts to increased eCommerce

Advancements in broadband enabled use-cases, including AR shopping, in-store digital experiences and improved purchasing security, will reduce the gap between physical and digital channels to support the shift to increased digital purchasing habits. In addition, adoption of these use-cases will likely have a broader economic and social impact to potentially increase demand and access to goods across Canada.

The effects of each of these use-cases can be seen in Table 7.

Table 7: Emerging broadband enabled use-cases and economic and social benefits related to shifts in consumer purchasing habits

Emerging broadband enabled use-cases	Impact on trends	Economic and social benefits
Augmented Reality	High	• Advancement in AR will allow consumers to instantly locate goods, encountered in the physical world, on eCommerce channels. • Ease of eCommerce shopping using AR will support the shift to eCommerce channels.
In-store Digital Experience	Medium	• Increasing use of AI, robotics and digital catalogues within brick-and-mortar stores will transform the physical retail experience to an increasingly digital experience similar to the eCommerce experience. • Reduction in the gap between physical and digital retail experiences will support the shift to online shopping channels.

Connectivity implications for shifts to increased eCommerce

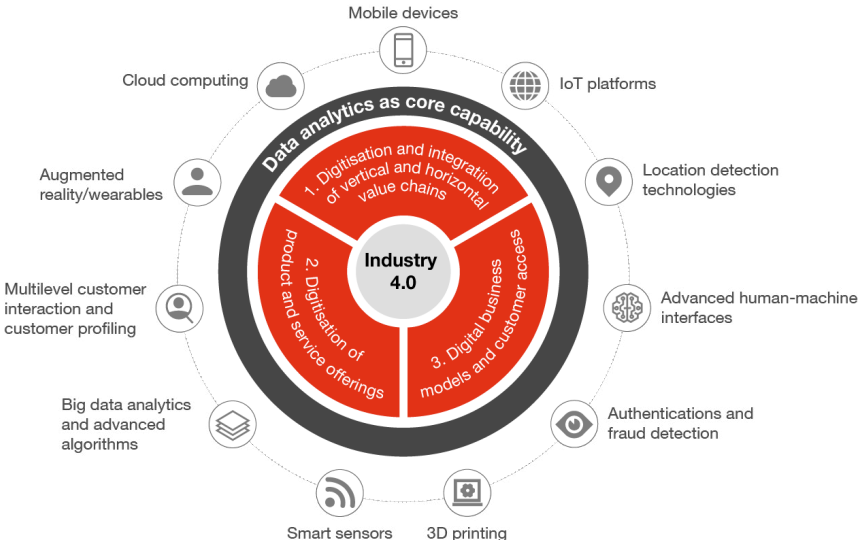
Connectivity consumption will increase as online shopping channels begin to incorporate increased video marketing and shopping content. Consumption increases within retail outlets to accommodate AR/VR will be limited to a subset of sectors and a subset of the retail footprint.

Network densification requirements will increase to connect consumers to online shopping channels across the country.

Moving forward, adoption of Industry 4.0 enabled by 5G network connectivity will support Canada's future economic success

As new production technologies continue to advance at a rapid pace, countries around the world must be prepared to support the underlying fabric of a digital economy to ensure future economic success. The fourth industrial revolution, "Industry 4.0," is the end-to-end digitization of all physical assets and integration across the value chain using IoT hardware, software, and connectivity. It is expected to be the foundation for economic high-tech success in the mid- to long-term for global economies.[68]

Exhibit 26: Industry 4.0 ecosystem[68]



Canada's Digital Charter sets forth 10 principles to ensure that privacy is protected, data is kept safe and Canadian companies can lead the world in innovations that fully embrace the benefits of the digital economy.[69] As an extension of this charter, Innovation, Science and Economic Development Canada (ISED) has established multiple initiatives and programs to support technological innovation and adoption within Canada. This is part of a broader Innovation Agenda to create an open playing field among countries, give citizens new-found ways to collaborate and allow Canada's industries to compete globally.[70] The Innovation and Skills Plan is an effort to help establish Canada as one of the most innovative countries in the world which includes a Digital Technology Supercluster, a government-industry collaboration program aimed at development, deployment, and scaling of Canadian-made digital technologies to accelerate Canada's return to prosperity and drive global competitiveness.[71] Similarly, the $1.75 billion UBF aims to bring high-speed 50/10 Mbps internet to 98% of Canadians, including rural and remote communities, by 2026 to provide them with the opportunity to innovate and participate in the economy using new digital tools and technologies.[16] Connectivity will provide the backbone infrastructure, which will act as the foundation for technological innovation, advancement and adoption within these programs and the broader economy.

In 2017, ISED created the Economic Strategy Tables, a cooperation mechanism between major industry players in Canada, to bring industry leaders together with policy makers to set targets for the evolving digital economy. The targets for the Advanced Manufacturing and Digital Industries Economic Strategy Tables include:[72,73]

- Canada moves into the top 10 of the world's most innovative countries on the Bloomberg Innovation Index by 2025
- More than double the proportion of SMEs selling products and services online, from 27% to 60% by 2025
- 100% of Canadian homes, business, and public institutions are directly connected to internet services that hit global benchmarks for fast, low latency, unmetered wired and wireless connectivity, with universal access by 2025
- Canada is in the top 10% for global internet speeds by 2025
- Increase the percentage of manufacturing small, medium enterprises adopting Industry 4.0 from 39% to at least 75% by 2030
- Reduce Canada's information and communications technology (ICT) investment gap with the U.S. by 20% to 30% by 2030
- Become a top-10 country for government procurement of advanced technology products by 2030
- Grow at least 25 SMEs into large companies (500 or more employees) or anchor firms by 2030

Enhanced connectivity, notably through 5G networks providing increased speed, reduced latency, and reliability, is a key enabler for Industry 4.0. It will support the technological innovation goals, and contribute to meeting ISED's Economic Strategy Table targets and Canada's broader technological innovation goals. Investment in 5G is not only important for Industry 4.0 and Canada's mid to long term economic success, but further investment in network infrastructure is needed to add to the resiliency of the Canadian economy and society against disruptions such as COVID-19. Further, as the Canadian economy recovers from the economic shock of COVID-19, government support for network investments could be considered an indirect form of government stimulus. This stimulus will potentially create economic activities and jobs across Canada and promote digital inclusion of the population while supporting the future economic high-tech success of the Canadian economy relative to global peers. The economic benefit of 5G connectivity is forecasted to be CA$200 billion in incremental GDP contribution to the Canadian economy between 2020 and 2040 while enabling adoption of Industry 4.0 and advanced broadband use-cases.[5]

Government-industry cooperation will likely be required to deliver 5G and Industry 4.0 at pace with global peers

As demonstrated throughout the COVID-19 pandemic, telecommunications networks act as the technological backbone for digitally enabled economic and social continuity. Transformation to a more digital economy with the adoption of Industry 4.0 use-cases will be a key factor to establishing resiliency in the workforce and supporting international competitiveness. However, current networks will be insufficient for future use-cases and failure to support the continued investment in those networks that is required could hinder future economic success. 5G networks improve speed, reduce latency and support a greater number of connected devices to enable broadband enabled use-cases. Governments and regulators around the world have acknowledged the role of improved connectivity in their countries' economic success and have taken a varied approach to cooperation with telecommunications industries to support the rollout of 5G networks.

Analysis of leading practices from global peers indicates that there is an opportunity for Canada to foster additional government-industry cooperation and strengthen the regulatory framework to support Canada's international competitiveness and future economic success.

Spectrum allocation is a key driver of the speed of 5G network rollout

The ability for telecommunications operators to provide access to 5G networks is dependent on the amount of spectrum available. Across global peers, governments and/or regulators hold the authority on the amount and release timeline of spectrum allocation. These spectrum allocation decisions directly impact 5G infrastructure rollout. In effect, spectrum allocation and pricing decisions will have implications for the advancement of the digital economy and adoption of Industry 4.0.

Countries that have quickly allocated sufficient 5G spectrum have led the rollout of 5G infrastructure in their networks, providing 5G access to consumers and businesses across their networks. Importantly, low-band spectrum allocations will support mostly consumer connectivity applications, while mid- and high-band spectrum allocations will support mostly business connectivity applications and form an enabler for Industry 4.0. Hence, the availability of both mid- and high-band spectrums will be important to high-tech economic success.

The price of spectrum is also a key consideration in the efficient and effective rollout of network infrastructure as operators are required to set aside a portion of the total investments to purchase spectrum. Canada's spectrum prices are amongst the highest in comparison to its peer group. According to NERA Consulting, Canada has the highest total spectrum costs across all bands among high income countries on a price per MHz/population basis since 2008.[9]

South Korea, the first country to commercialize 5G, auctioned the mid- and high-band 5G spectrum in June 2018, suggesting a willingness to expedite the 5G rollout and desire to be a leader in 5G networks. On the other hand, Canada is one of the last countries to auction low- and mid-band 5G spectrum, and the date for high-band spectrum auction(s) has yet to be announced, as shown in Exhibit 30.

Exhibit 27: 5G spectrum allocation dates

Country	Low-Band	Mid-Band	High-Band
United Kingdom[75]	March 2013	April 2018	Not auctioned
South Korea[76,77]	August 2011	June 2018	
Italy[78]	October 2018		
Australia[77,79]	April 2013	December 2018	Not auctioned
Japan[77,80]	June 2012	April 2019	
Germany[77]	June 2015	June 2019	Not auctioned
United States[77]	July 2011	August 2020	January 2019
France[77]	November 2015	October 2020	Not auctioned
Canada[77,81]	**September 2018**	**June 2021**	**Not auctioned**

In addition to the timing and pricing of spectrum auctions, the amount of contiguous spectrum made available is an important factor contributing to telecommunications operators' ability to roll out 5G networks effectively. The International Telecommunication Union (ITU) recommends that 80–100 MHz of spectrum in the 5G mid-band should be allocated per carrier to ensure support for high speeds and large amounts of traffic.[1] Given the current framework for the 3500 MHz spectrum auction scheduled for June 2021, it is highly unlikely that any carrier will secure the 80–100 MHz of contiguous spectrum that the ITU recommends for optimal 5G performance.[81]

5G availability is the measure of the average proportion of time that a 5G subscriber spends on a 5G network relative to an earlier generation network. Countries that have auctioned spectrum are further ahead in deployment. South Korea auctioned 5G spectrum early and accelerated 5G network rollout to drive high 5G availability. By comparison, Canada has lagged in 5G spectrum allocation and exhibits one of the lowest 5G availability rates relative to global peers.[82]

Canada's mid-band spectrum auction, scheduled for June 2021, and yet to be announced high-band spectrum auction will have an effect on the rollout of 5G networks across Canada. Slow 5G spectrum roll-out will also limit the ability of Canadian industries to adopt Industry 4.0 and enable advanced broadband enabled use-cases. As other countries outpace Canada in 5G availability, Canada's economy risks falling behind in the adoption of Industry 4.0.

Six key levers are being used by global governments to incentivize 5G deployment and broadband enabled use-cases

There are a number of other policy levers that countries are currently using to support and incentivize 5G deployment. Through analysis of policies and regulation in the G7, Australia and South Korea, this report has identified six key levers that directly affect 5G network investment:

1. **Spectrum timing, allocation and costs:** Spectrum allocation is the key enabler for the provision of 5G connectivity to consumers. Without securing spectrum, operators cannot plan infrastructure deployment or allocate funds effectively. Reducing spectrum fees can allow operators to reallocate previously budgeted funds to network investment and potentially ensure that high costs are not transferred to consumers.
2. **Network investment incentives:** 5G infrastructure deployments require high Capital Expenditure to expand, upgrade and densify existing networks. However, the benefits and financial gains associated with advanced broadband enabled use-cases are mainly realized by players in the digital value chain, outside of connectivity. Connectivity is forecasted to benefit from only 11% of the value associated with advanced broadband enabled use-cases.[7] This creates a potential barrier for network operators who need to fund network deployment but are not currently well positioned to monetize it, as the benefits of 5G are expected to accrue to the economy more broadly.
3. **Rural network subsidies:** Rural network deployments require higher investment costs due to rugged terrain and large coverage areas while generating less revenue due to lower population density and higher population dispersion. Support for rural network build-out is necessary to incentivize operators to invest in these locations and ensure all citizens receive access to 5G connectivity. Notably, 5G deployment is forecasted to be 39%–71% more expensive than 4G rollout, making the incentive to deploy 5G in rural areas even lower than with previous technology generations (e.g. 3G, 4G).[6]
4. **Regulatory standards:** Impediments in the regulatory process that facilitates 5G infrastructure rollout will create delays and complications for operators planning on investing in the network. Regulations and policies must ensure a streamlined process with minimal barriers to approval to support network build-out, notably in relation to right of way access and streamlined government application processes.
5. **Research and innovation funding (technology development):** Research and innovation in the advancement of 5G technology and associated use-cases will support Canada's international competitiveness by providing Canadian businesses with access to innovative technology. Committees, coalitions and think tanks dedicated to researching new 5G technologies or direct funding for new 5G testing/innovation projects will support 5G advancement. These initiatives will help spur the adoption and innovation of Industry 4.0 and accelerate the benefits gained from improved networks.
6. **Vertical industry application funding (technology adoption):** Adoption of Industry 4.0 use-cases across sectors will require access to strong 5G networks. The benefits of use-cases such as advanced analytics, AI and robotics will drive the efficiency and competitiveness of Canadian businesses across industry verticals. Governments can support businesses by ensuring funds and programs are available to support and incentivize adoption of innovative use-cases within industry verticals that are of importance to the mid-long term success of the Canadian economy.

Global leading practices provide a framework for the government to act as an investment catalyst for 5G deployment and Industry 4.0

Investment in 5G networks will allow for adoption of Industry 4.0 use-cases and will support emerging connectivity needs following recovery from COVID-19. Countries that surpass their peers in the advancement of 5G telecommunications networks will hold a competitive advantage by supporting the foundation necessary for adoption of new and emerging broadband enabled use-cases. Accordingly, the OECD shares the view that the advancement of production technologies will act as a conduit for improved productivity and inclusiveness in the workforce to achieve economic, social and environmental goals.[74]

Best practices in government, industry and regulator cooperation from Canada's global peers can serve as the guide for potential cooperation frameworks applicable to the Canadian telecommunications industry to support a resilient workforce and ensure future economic success. Accordingly, the Canadian government should change its mindset from net-receiver of capital from spectrum auctions, to investment catalyst for 5G rollout by promoting government and regulator cooperation with the telecommunications industry. In addition, the benefits of encouraging cooperation between government, industry and the regulator will support Canada's GDP growth.

Based on the analysis of global peers (the G7, Australia and South Korea) in this report, a set of directional recommendations can be established for potential Canadian government, regulator and industry cooperation in support of 5G network deployment in Canada, and in support of securing Canada's mid- and long-term high-tech economic success through Industry 4.0:

1. **Spectrum timing, allocation and costs:** (i) Accelerate the date for the mid- and high-band spectrum auctions to ensure Canadian 5G rollout can keep pace with global peers. (ii) Incentivize carriers that are capable of deploying high-cost 5G networks at scale. (iii) Increase the amount of contiguous spectrum available at auctions to ensure support for high speeds and large amounts of traffic. This can be achieved by ensuring spectrum pricing is cost-effective. This will allow operators to dedicate more of their resources to building out networks and avoid the requirement to recover high-cost spectrum investments through service prices.
2. **Network investment incentives:** Identify core corridors and areas that may not have the highest demand today but are critical to economic success and the future of Industry 4.0, such as highways and industrial zones, to direct government funding and incentives for network investments. In addition, Canada can learn from regulation in peer wireless telecommunications markets, such as Europe, where countries that introduced regulated MVNO access to wireless networks have demonstrated lower coverage and adoption rates of network technology (3G, 4G, etc.).[8] Similar regulation in Canada could potentially reduce carriers' ability to invest and disincentivize them from maintaining their high levels of investment in networks.
3. **Rural network subsidies:** Continue to provide grants for rural network build-out, similar to the $1.75 billion UBF, to overcome the high costs of rural network infrastructure and ensure access to 5G networks in rural and low economic areas.[16] Provide subsidies specifically for 5G network build-out in rural areas to promote private investment in rural 5G networks.
4. **Regulatory standards:** In recognition of the importance of streamlining and expediting the roll-out of 5G infrastructure, introduce a notification regime and/or shot clock to reduce the delay and costs associated with 5G approvals.

5. **Research and innovation funding:** Establish large-scale government-industry 5G testbeds to facilitate research and development of 5G technologies and applications while measuring potential economic and social benefits. Expand scope and funding for current research and innovation programs to increase focus on development of 5G technology across sectors and provinces, encouraging technological innovation of Canadian industries, helping them achieve scale and creating a supportive environment for startups.
6. **Vertical industry application funding:** Work with network operators, local governments and industry to introduce incentives, subsidies or grants that incentivize the adoption of 5G enabled use-cases across Canada. Expand current government programs to add incentives targeted at 5G use-case adoption within key economic and social industries such as manufacturing, agriculture, healthcare, energy, mining, oil and gas to ensure that key Canadian industries realize the maximum benefit from 5G technology and improve their global competitiveness.

Accelerate mid- and high-band spectrum auctions, increase contiguous spectrum and ensure pricing allows Canada to keep pace with global peers

Mid- and high-band 5G spectrum auctions in Canada are behind global peers, reducing the ability to keep pace with global peers in 5G rollout. Spectrum costs in Canada are among the highest relative to global peers due to a set of factors which include the bidding process and the auctioning authority's decision to limit availability. The Canadian government restricts the incumbent network operators' bandwidth access to a proportion of the total available, while setting aside the remainder for new entrants at a lower cost. This is done in an effort to encourage new entrants into the market. In addition, Canada's plan for the mid-band spectrum auction in 2021 does not allocate the ITU recommended 80–100 MHz sufficient contiguous spectrum per operator to allow for effective 5G rollout by Canada's carriers.[1]

Global peers have taken a different approach to spectrum auctioning in order to support 5G rollout in their respective countries. Japan has demonstrated the importance of 5G technology to economic and social success by providing operators with access to spectrum at no cost in exchange for a commitment to roll out 5G infrastructure across the country.[83] The US has demonstrated the importance of 5G networks to innovation in industrial use-cases by accelerating the high-band spectrum auction as a priority.[11]

The opportunity to support 5G rollout through spectrum allocation policies exists in Canada. Due to the high costs of investment required to roll out 5G networks, the government should look to incentivize carriers that are capable of deploying networks at the scale required to provide 5G connectivity across Canada. Canada can accelerate the date for the mid- and high-band spectrum auctions to ensure it can keep pace with global peers in the rollout of 5G networks across the country. Canada should also provide sufficient contiguous spectrum, and ensure spectrum pricing is cost-effective. Such changes will allow operators to build out networks and avoid the translation of high-cost investments to higher service prices.

Incentivize network investment in Canada to mitigate higher network costs and promote 5G network rollout

Canadian networks are among the most expensive networks to build and maintain due to Canada's low population density, relatively small scale telecommunications operators and high spectrum costs. These high costs pose a barrier to network operators to procure the necessary capital required to roll out network infrastructure across the country, especially with 5G network rollout projected to be 39%–71% more expensive than 4G network rollout.[6]

A number of global peer governments have supported network operators to overcome the high costs of network infrastructure investments in their respective countries through regulation designed to incentivize network deployment in areas that are critical to economic success. As outlined in the PwC report titled "Understanding the likely impacts of MVNOs in Canada–Part 2: Impact on Canada's transition to 5G", mandated access to MVNOs is a key factor that affects the ability and incentive for carriers to invest in network infrastructure. Countries with mandated MVNO access, such as in the European telecommunications markets, have demonstrated lower coverage and adoption rates of past network technology (3G, 4G, etc.).[7] A healthy telecommunications market, structured in a facilities-based competition model, allows operators to incentivize and fund the continued capital investments necessary to build-out networks across the country.

A continued commitment to facilities-based competition will help Canada to keep pace with global peers in 5G rollout by ensuring operators are incentivized and able to maintain the ongoing high levels of network investment. Canada can also identify core corridors and areas that are critical to economic success, such as highways, industrial zones and areas with high economic activity, to direct additional government support and funding for 5G network investments. By these means, Canada would be able to incentivize the deployment of 5G at a pace more in line with global peers and ensure that 5G network deployment supports economic success.

Continue to support rural network investments to ensure access to 5G networks across Canada

Rollout of rural 5G networks is more challenging than rollout in urban or suburban areas due to the low population densities and large geographical spans. Canada's rural infrastructure is especially expensive due to Canada's large landmass, low population and high dispersion. The Canadian government has made strides towards providing access to rural networks through subsidies such as the UBF, which aims to provide high-speed broadband access to all Canadians by 2030 to close the Digital Divide.[16] During COVID-19, the importance of access to connectivity in rural networks was highlighted by the 75% increase in the Canadian UBF from $1.0 billion to $1.75 billion in the Fall Economic Statement 2020 and acceleration of the date to connect 98% of Canadians by 2026.[84,85] Other initiatives include a $750 million rural broadband subsidy by the CRTC, $1 billion by the Canada Infrastructure Bank to provide flexible financing for network infrastructure and $585 million under the Connect to Innovate program for broadband connectivity in rural and remote areas.[86,87]

Global peers share the view that rural connectivity is an important factor in a country's economic success and have attempted to subsidize rural network coverage using both monetary and non-monetary means. The US has enacted a $20.4 billion Rural Digital Opportunity Fund program to support 5G rural broadband deployment.[88] The UK has contributed £5 billion to rural connectivity through the Rural Gigabit Connectivity program, although only £1.2 billion has been allocated for investment over the next four years. while matching telecommunications operators' £530 million investments in rural networks with £500 million in government subsidies.[89,90]

The importance of rural connectivity will continue to grow as businesses continue to adopt Industry 4.0 use-cases to build resiliency and improve competitiveness. The Canadian government is currently focused on supporting rural connectivity across the country through multiple programs. Its continued support throughout the 5G era is recommended, as a number of peer countries are already directing rural incentives not to fixed broadband networks but to 5G technology. This is because advancement in production technologies, automation of processes and localization of supply chains will drive the adoption of broadband enabled use-cases in Canada's key industries such as agriculture, mining, energy, oil and gas, which will require strong 5G connectivity in rural areas. In addition, strong 5G networks in rural areas will ensure all Canadians receive access to the most advanced education and healthcare technology.

To further strengthen rural connectivity, Canada can supplement its current subsidy programs with targeted support for investment in rural 5G networks.

Reduce barriers to 5G infrastructure deployment

Regulatory approvals for 5G infrastructure rollout can be one of the key barriers to rapid deployment of 5G networks. Support from the government and regulator is necessary to ensure that regulations streamline 5G infrastructure approval timelines and reduce barriers to deployment to avoid disincentivizing operators to build out networks.

Global peers have implemented a variety of measures designed to streamline the deployment of 5G. The US has focused on reducing the regulatory impediments of 5G small cell deployment by standardizing timelines of applications with the introduction of a 90-day shot clock for municipal 5G approval, introducing caps on small cell costs and fees and streamlining the process for access to municipal infrastructure.[91] Similarly, the UK's DCMS has recommended rule reforms to improve access to public sites to address local deployment barriers.[92] The UK government is also planning on bringing together a working group of local areas, government departments, landowners and industry to provide an accurate picture of local area requirements and plan for the deployment of 5G networks.[93] In Japan, local municipal governments, such as Tokyo, are updating policies regarding the use of municipal buildings and facilities by major telecommunications operators to promote 5G installation.[14]

The rollout of 5G networks will require support from governments to streamline approvals for network deployment. Canada can follow best practices from global peers through a framework that facilitates all types of sharing agreements for 5G. Canada should also have a regulatory framework that allows for voluntary sharing of private infrastructure between operators. Similar to the US, Canada can introduce a notification regime and/or shot clock to reduce the delay and costs associated with 5G approvals. This will provide operators with clarity around network deployment requirements to streamline network build-out across the country.

Increase funding for 5G technology research and innovation to promote Canadian economies and capabilities in the use of 5G technology

Connectivity providers are forecasted to benefit from around 11% of the value associated with advanced broadband use-cases, with the remainder of value attributed to the economy in aggregate.[7] Accordingly, support for 5G technology advancement and innovation will translate into support for the larger economy. Currently, federal and provincial Canadian governments have collaborated with private sector partners to develop ENCQOR, a 5G testbed for innovators in Ontario and Quebec aiming to uncover the extent of 5G's technological promise.[94]

Global peers leading the rollout of 5G networks have focused on advancement of connectivity technology to support Industry 4.0 and other broadband enabled use-cases. The UK has set up 5G trials and testbeds to accelerate the deployment of 5G networks and ensure businesses can take early advantage of the applications those networks can enable. The initiative is the UK government's nationally coordinated program for 5G investment. This includes a range of competitions to encourage innovative applications of 5G technology and projects to explore innovative uses of 5G technology across multiple industries in both urban and rural communities.[12] Japan has taken a similar approach by investing in the future of 5G technology through the "Beyond 5G" program. The program focuses on providing financial support for 5G R&D platforms like emulators, testbeds and shared research initiatives using tax incentives, prizes and public funding. Japan is also providing government funding for research in low energy consumption 5G networks.[95]

The Canadian government has supported innovation and the advancement of technology within Canada through broad programs such as the Strategic Innovation Fund and National Research Council Industrial Research Assistance Program.[96] These programs administer assistance to a wide range of technological research and development projects. The federal government also provides support for R&D by businesses of all scales through the Scientific Research and Experimental Development (SR&ED) Tax Incentive amounting to CA$3 billion per year.[97] Canada can expand these programs to include a specific focus on 5G technology, similar to the ENCQOR 5G testbed, to promote innovation in 5G networks that will act as the foundation for broader technological innovation and adoption of Industry 4.0. Canada can also establish large-scale government-industry 5G testbeds to facilitate research and development of 5G technologies and applications while measuring potential economic and social benefits. Direct funding in research and development targeted at 5G technology will provide an incentive for Canadian 5G innovation, support Canadian technologies to achieve scale and create a supportive environment for startups adopting advanced technology use-cases.

Introduce 5G industry use-case programs to ensure Canadian businesses realize the maximum benefit from 5G technology across important industries

As outlined in this report, the main benefits of 5G connectivity will be realized by businesses adopting Industry 4.0 and other broadband enabled use-cases. These benefits will be a key driver of advancement in the digital economy to build a resilient workforce, improve international competitiveness and support Canada's future economic success. Currently, Canada has set up five superclusters in digital technology, protein industries, next generation manufacturing, scale AI and ocean, with $950 million in federal government funding, matched by private industry funding, to develop and scale high-potential technologies in Canada.[98] These superclusters, however, are focused on advancement of the use of technology within industries without a focus on the ways in which deployment of 5G technology can advance the international competitiveness of Canadian businesses. The Canadian government has implemented multiple programs to support innovation and technological adoption within all Canadian industries, although direct funding for 5G use-case adoption within industries at a significant scale is yet to be introduced. Direct funding for 5G use-cases forge a pathway for Canadian businesses to adopt broadband enabled use-cases to meet targets such as the ISED Economic Strategy Table Advanced Manufacturing, Industry 4.0 and Digital Industries targets.

Global peers have taken an industry-specific approach to 5G use-case funding based on the key applications to support their respective economies. South Korea has passed legislation to ensure 5G use-cases are supported and adopted in five key areas spanning immersive content, autonomous vehicles, smart manufacturing, smart cities and digital healthcare. This legislation includes specific targets

for 5G vertical adoption such as development of 5G-based emergency medical services by 2021, with 20% having access to 5G systems by 2025 and operation of self-driving shuttle buses in major cities by 2020, and 5G enabled buses by 2025.[76] Italy has invested €60 million through the Bari-Matera plan on 10 application areas including media and VR, smart port, smart city, smart agriculture, public safety, Industry 4.0, healthcare, road safety, tourism and culture and environmental monitoring.[99] The UK's Department for Culture, Media & Sport is helping fund integrated solutions to some of the key challenges to deploying 5G technologies in manufacturing, using 5G to test use-cases such as robotic assembly, reconfigurable product assembly lines and distributed and shared VR and AR.[92]

Similar to the approach taken by global peers, Canada can work with network operators to introduce tax incentives, subsidies or grants that fund 5G and broadband enabled use-cases within key economic and social industries such as manufacturing, agriculture, healthcare, energy, mining, oil and gas. Additionally, the scope of existing programs such as the innovation superclusters can be expanded to include specific targets for adoption of 5G use-cases to ensure that Canadian businesses aim to utilize the most advanced technology. Cooperation with network operators will ensure that the underlying networks are capable of enabling technological adoption across Canada's key industries to ensure that Canada's economy can realize the potential of 5G networks.

Appendix: Overview of peer countries' use of levers to incentivize 5G rollout

Canada's global peers (the G7, Australia and South Korea) have used one or more levers to incentivize 5G network deployment, support Industry 4.0 and promote the mid-long term high-tech success of the respective economies. Global peers' key actions across the six key levers have been reviewed to establish an overview of examples of actions within each lever. The following examples are non-exhaustive and do not cover all actions taken by the respective governments and regulators.

South Korea

South Korea was the first country to commercialize 5G. The country's 5G+ Strategy emphasizes a collaborative 5G launch between three major telecommunications operators to encourage investment, incentivize 5G's role in key industries and services in the public sector and address institutional barriers to innovative solutions. Further, South Korea has launched a taskforce with the mandate to help expand 5G network coverage to rural areas.

Network Investment Incentives

- Government to provide tax credits/reductions for major telecommunications companies, with the goal of expanding from 14.3% to 70% nationwide 5G coverage by 2025[100]
- 3% tax cut on network construction[101]

Spectrum Timing, Allocation and Costs

- Ministry of Science and ICT (MSIT) secured and auctioned 280 MHz of mid- and high-band 5G spectrum frequencies (across 3.5GHz, 28GHz and 2400 MHz bands) to SKT, KT and LG Uplus[77]

Rural Network Subsidies

- A taskforce has been launched by South Korea's Ministry of Science and ICT and the country's three mobile network operators with a view to helping expand 5G coverage into rural areas by designating specific areas for network rollout to each of the three major operators. Operators will then enter into network sharing agreements on the deployed infrastructure[102]

Regulatory Standards

- The Ministry of Science and ICT has revised legislation so telecommunications operators have better access to local, government-owned areas and facilities management agencies to install 5G equipment[103]
- South Korea's legislative body has been actively involved in passing or revising laws that target potential barriers to 5G commercialization[76]

Research and Innovation Funding

- Encourage investment by funding 5G testbeds, demonstration infrastructure and innovations/use-cases for 5G in leading industries[76]
- Universities (e.g. Seoul National University and Hanyang University) and think tanks (e.g. KDI and KIEP) are pursuing large-scale R&D projects that research innovation in 5G enabled technologies (e.g. digital healthcare)[76]

Vertical Industry Application Funding

- Promised to develop vertical industries such as:[76]
    - Digital healthcare: promised development of 5G-based emergency medical services by 2021, with 20% having access to 5G systems by 2025
    - Autonomous driving: promised operation of self-driving shuttle buses in major cities by 2020, and 5G enabled buses by 2025
- Support demonstration of five core services: immersive content, autonomous vehicles, smart manufacturing, smart cities and digital healthcare[76]
- With regards to President Moon's campaign to be the "first in global [5G] quality," South Korea aims to capture a high global market share for 5G enabled technology that services specific use-cases (e.g. digital health and AI), keeping international policies surrounding security at top of mind[76]

United States of America

Under the Federal Communications Commission (FCC)'s 5G Fast Plan, the US is heavily pushing more spectrum into the marketplace.[11] It is updating infrastructure and regulation policies to reduce federal regulatory barriers to infrastructure deployment while incentivizing rural network investment through direct subsidies.

Network Investment Incentives

- Bills like the USA Telecommunications Act aim to award grants (via the Department of Commerce) to support deployment and use of Open RAN 5G Networks, with specific emphasis on:[104]
    - Encouraging competitiveness in the supply chains of Open RAN 5G networks
    - Accelerating the deployment of Open RAN equipment
    - Increasing the integrity of Open RAN equipment by promoting the use of security features

Spectrum Timing, Allocation and Costs

- Auction of high-band spectrum was prioritized to promote the highest speed wireless services and adoption of 5G use-cases[10]
- In March 2019, the FCC created a new licensing category, permitting spectrum usage in the 95GHz-3 THz range for up to 10 years (with part of the range being free to use without a licence)[105]

Rural Network Subsidies

- US$20.4 billion Rural Digital Opportunity Fund program that allocates US$9 billion for 5G broadband deployment in rural areas (aims to connect more than 4 million rural households over 10 years)[88]

Regulatory Standards

- New federal legislation adopted to reduce regulatory impediments to deploy small cells[10]
  - Streamlined application process to access municipal infrastructure
  - Caps on costs and fees (e.g. San Jose reduced cost per small cell from $3,500 to $750)
  - Standardized timelines for consideration of cell site applications (i.e. establishing "shot clocks" in the reviewing process)

Research and Innovation Funding

- Defense Advanced Research Projects Agency is testing the viability of 5G in various environments by developing an electric wave simulator called the Colosseum[106]
  - A Spectrum Collaboration Challenge was also held to research innovative ways of using Colosseum to develop highly efficient/fast 5G technologies

Vertical Industry Application Funding

- Virtual communication between patients and their healthcare providers approved and guided by the Food and Drug Administration[107]

United Kingdom

The UK's 5G strategy is dedicated to supporting rural network build-out, primarily through direct funding and matched investments. The UK government also directly invests in 5G testbeds, innovative use-cases and future industry applications.

Network Investment Incentives

- In 2018, regulators granted "Relief from Non-Domestic Tax Rates" for building fibre and 5G infrastructure to incentivize rollout[108]

Spectrum Timing, Allocation and Costs

- The UK was one of the first countries to auction mid-band spectrum across the peer group[75]
- To ensure spectrum is shared with other key users, the government will prioritize making 5G spectrum available for the public sector (provided the users have a clear and demonstrable value case) to ensure spectrum is allocated effectively[75]

Rural Network Subsidies

- Provided the telecommunications operators committed to a £530 million investment in rural 5G, the government would match that amount by £500 million to incentive rural network build-out[90]
- Rural Gigabit Connectivity program dedicated £5 billion to "future-proofing" connectivity in the hardest to reach 20% of UK (the "Outside-In" approach) although only £1.2 billion has been allocated for the next four years[89,90]

Regulatory Standards

- DCMS recommended rule reforms to improve access to public sites and power supplies to address local deployment barriers[92]

- Government will bring together a working group of local area government departments, landowners and industry to provide an accurate picture of local area requirements for the deployment of 5G networks[93]
- Electronic Communications Code works to facilitate telecommunications operator access to small cell and macro infrastructure on both public and private land[109]

Research and Innovation Funding

- £200 million fund for 5G testbeds and trial program to explore different connectivity solutions and business models[92]
    - £30M package to support an open competition (5G Create), to examine how 5G could create new opportunities in industries like film, TV, video games, logistics and tourism
- UK business also able to apply for funding for 5G road and rail transport trials in urban communities[110]

Vertical Industry Application Funding

- DCMS is helping fund integrated solutions to some of the key challenges to deploying 5G technologies in manufacturing, using 5G to test use-cases such as robotic assembly, reconfigurable product assembly lines and distributed and shared VR/AR[92]
- To promote development of emerging technology like AI, IoT, etc., the government launched "Immerse UK" to promote immersive technologies by running events, providing funding and encouraging knowledge sharing platforms[12]

Germany

Germany's 5G strategy makes frequencies available based on demand. It funds research ventures and innovative 5G use-cases in key industries to incentivize early 5G deployment in key towns and cities.

Network Investment Incentives

- The German government will organize a 5G competition for districts, cities and municipalities with funding of at least €2 million available for the development of detailed project concepts[111]

Spectrum Timing, Allocation and Costs

- On June 12, 2019, the Federal Network Agency's spectrum auction was successfully completed[77]
- In the auction, frequencies in the 2 GHz and 3.5 GHz range were auctioned[77]
    - The user rights for the auctioned frequencies have a lifetime until 2040

Rural Network Subsidies

- Committed to investing €20 billion in building base stations, especially focused in sparsely populated rural areas where it's hard for telecommunications operators to profit in an effort to reach 99% 5G coverage by 2025[112]

Regulatory Standards

- The federal government is examining whether there is a need to adapt the existing distance regulations with regard to antenna sites during the site certification procedure and is expanding fibre optic networks to connect base stations[111]

- The Act on the Facilitation of the Deployment of High-Speed Digital Networks (DigiNetzG), adopted in 2016, defines requirements with regards to the use of public infrastructures for fibre optics and small cell deployment[111]

Research and Innovation Funding

- Electric wave emulator for 5G developed within German FraunhoferGesellschaft (research institute that bridges academia and industry)[113]
- Europe's largest 5G research network, powered by Ericsson 5G products and solutions, has gone live in Aachen, Germany[114]
- The focus is on three research priorities: "reliable wireless communications in the industry," "5G: industrial internet" and "5G: tactile internet," for which up to €80 million will be made available[111]

Vertical Industry Application Funding

- The government has focused on three research priorities: "reliable wireless communications in the industry," "5G: industrial internet" and "5G: tactile internet," for which up to €80 million will be made available[111]
- The government is beginning to push 5G use-cases through the Digital Healthcare Act (2019), which lays out a set of requirements that medical apps have to meet to be covered by German state health insurance schemes (e.g. high level of data security, privacy law compliance, proof of concept, etc.)[107]

Japan

Japan's 5G strategy directly incentivizes network build-out through tax credits and accelerated depreciation. Japan's strategy also emphasizes innovation and standard setting through international partnerships with global network service and equipment providers.

Network Investment Incentives

- 15% tax credit or 30% bonus depreciation, a higher than normal depreciation rate in the first year of investment, for providers to invest in 5G infrastructure and abide by security and supply chain standards[95]

Spectrum Timing, Allocation and Costs

- Telecommunications operators received 5G spectrum licences at no cost with a commitment to rollout of 5G infrastructure across the country[83]
- Opened up high frequency bandwidth spectrum that can easily be used for fixed periods under "Beyond 5G"[95]

Rural Network Subsidies

- Telecommunications operators received 5G spectrum licences, provided they commit to:[83]
    - Launching 5G services in every prefecture within two years
    - Installing base stations in at least 2,500 zones within five years
    - Over 90% 5G coverage within five years for two operators (NTT and KDDI), and an agreed upon capital investment in 5G

Regulatory Standards

- Local governments (e.g. Tokyo) are updating policies surrounding opening up municipal buildings/ facilities to major telecommunications operators to promote 5G installation[14]
- Operators can install 5G base stations on 208,000 traffic lights across the country[14]
- Government proposed that operators and local administrators share the costs of using traffic lights for 5G sites[14]

Research and Innovation Funding

- Future Investment Committee established "Beyond 5G" promotion strategy in June 2020[95]
    - Focuses on providing financial support for 5G R&D platforms like emulators, test beds and shared research initiatives through tax incentives, prizes and public funding
    - Funding research for low energy consumption 5G
    - Emphasis on fostering international partnerships for innovation and standards setting (e.g. through global coalitions and industry partnerships like NTT, Intel and Sony with specific interests in AI, cyber security and quantum computing)

Vertical Industry Application Funding

- The Japanese government is providing a tax incentive for companies investing in innovative technology, starting in the form of a 25% deduction of investments from taxable income[115]
- The Japanese government is providing tax incentives for companies that adopt 5G technologies in their business practices in areas such as smart agriculture, smart factories and artificial intelligence[115]

Italy

Italy was one of the first European countries to auction 5G spectrum. Further, Italy has allocated funds for research and innovation, and the Bari-Matera plan focuses on 10 5G applications, including smart ports, smart agriculture and environmental monitoring, comprising more than 70 use-cases.

Spectrum Timing, Allocation and Costs

- 700 MHz/3.5 GHz auctions in October 2018; 26 GHz spectrum auctions in October 2018, first in Europe.[99]
- Launch of Vodafone and TIM 5G services in June 2019[116]

Rural Network Subsidies

- 80 MHz winners in the 3.6–3.8GHz band need to reach coverage of at least 10% of all Italian municipalities under 5,000 inhabitants; 20 MHz winners need to reach coverage of 5% of the population in each region[99]
- In the 700MHz FDD band, the awarded company shall ensure a coverage of at least 80% of the national population and 99.4% within 54 months from the availability of the spectrum[117]

Regulatory Standards

- The Italian government provided provisional licences to operators to allow for 5G network infrastructure rollout in five cities across Italy where 5G technology could be trialed and tested[99]

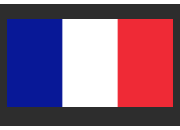
Research and Innovation Funding

- Italy's Ministry of Economic Development (Ministero dello Sviluppo Economico, or MiSE) has allocated more than €4 million (US$4.5 million) in funding for six projects to develop emerging 5G applications[118]

Vertical Industry Application Funding

- The €60 million Bari-Matera plan focuses on 10 application areas including media/VR, smart port, smart city, smart agriculture, public safety, Industry 4.0, healthcare, road safety, tourism and culture and environmental monitoring, covering over 70 use-cases[99]

France



France recently auctioned the 3.4–3.8 GHz spectrum with conditional obligations to deploy cell sites in low-density areas and transport corridors to support industrial adoption of 5G technology. The French Government also supports research and development in innovative 5G use-cases within key vertical industries.

Spectrum Timing, Allocation and Costs

- The main auction for 3.4–3.8 GHz band frequencies was completed on October 2, 2020[119]
- In October 2019, Autorité de Régulation des Communications Électroniques et des Postes (Arcep) announced that 11 players had been selected to carry out trials in the 26 GHz band[119]

Rural Network Subsidies

- 25% of the cell sites deployed in the 3.4-3.8 GHz band for 2024 and 2025 must be deployed in an area that includes municipalities that are part of low-density areas and so-called territories of industry, outside the country's main metropolitan areas[120]
- Obligations that apply specifically to transport corridors are also planned, with two main targets: coverage of the country's motorways (16,642 km) by 2025, and then, by 2027, coverage of the main roadways (54,913 km). These obligations stipulate connection speeds of a minimum of 100 Mb/s at each cell site[120]

Regulatory Standards

- The French government will chair working groups to identify expectations and undertake actions in areas that will undergo 5G network deployment[12]

Research and Innovation Funding

- The government and regulator announced trials in 11 French cities to test the use of 5G technology enabling use-cases such as connected transit[121]

Vertical Industry Application Funding

- To help vertical industries, Arcep is asking operators to prioritize the most innovative 5G functions (e.g. slicing, or the ability to deliver tiered services) by 2023[99]

Australia

Australia's 5G deployment has prioritized allocating spectrum efficiently by developing a simplified spectrum licence system and contributing to research and innovation platforms for 5G use-cases.

Spectrum Timing, Allocation and Costs

- In December 2018, the Australian government completed a regional auction of spectrum in the 3.575–3.7 GHz band[77]
- The Australian government is investing AU$7.1 million in digital auction systems to update and simplify the digital spectrum licence system[122]

Rural Network Subsidies

- The Australian national broadband network aims to provide high-speed internet broadband access to all Australians in both urban and rural areas, which has amounted to AU$57 billion since its inception[123]

Regulatory Standards

- Australia will set up a working group made up of government and industry with a mandate to seek out opportunities and tackle issues related to 5G[124]
- Australia will review existing regulatory arrangements to streamline the approval process and allow mobile network operators to build and deploy 5G infrastructure more quickly[124]

Research and Innovation Funding

- AU$22.1 million to establish the Australian 5G Innovation Initiative to encourage 5G commercial trials and testbeds in key industry sectors[125]

Vertical Industry Application Funding

- As part of the Job Maker Digital Business Plan, the Australian government is investing AU$21 million in 5G use-case adoption across smart factories and warehouses, logistics management and autonomous vehicles[125]

Canada

Canada has an emphasis on rural network coverage and has established superclusters, including a digital supercluster, that can be leveraged for 5G research and innovation. The provincial governments of Quebec and Ontario have invested in a $400 million 5G testbed to uncover the extent of 5G's technological promise.[119]

Network Investment Incentives

- The Accelerated Investment Incentive (AII), announced in the 2018 Fall Economic Statement, encourages businesses to invest in network capabilities and is expected to help deploy 5G across the country by insuring Canada's tax policies support 5G investment and innovation by allowing operators to write down investment in longer term equipment more quickly[86]
- The Canada Infrastructure Bank (CIB) has committed $2 billion over the next 10 years to improve access to broadband internet[126]

Spectrum Timing, Allocation and Costs

- Canada is auctioning spectrum in the 3500 MHz band on June 15, 2021[81]
- Additionally, ISED had auctioned the 600 MHz band in 2019[81]

Rural Network Subsidies

- In budget 2019, the government committed $1 billion dollars in investment over the next 10 years as part of the Universal Broadband Fund (UBF) with an additional $750 million announced during COVID-19 to total a $1.75 billion fund[85,86]
    - Aims to connect 98% of Canadians across the country to high-speed internet by 2026, with the goal of connecting all Canadians by 2030
- The CRTC has also promised $750 million for rural and remote broadband in coordination with provinces and territories[86]
- The Connect to Innovate program has committed $585 million by 2023 targeted at connecting rural and remote communities[87]

Regulatory Standards

- The federal government is developing and updating policies to allow easier access to public infrastructure for fibre and 5G deployment, mainly focusing on:[127]
    - Standardizing the construction, installation and maintenance of infrastructure assets (e.g. underground conduits, utility poles and wireless towers)
    - Laying fibre lines while road construction is already underway to reduce costs to telecommunications providers

Research and Innovation Funding

- Canada invested $40 million to help telecommunications companies meet the needs of 5G technology by establishing a Nokia Bell Labs with Nokia Canada[128]
- Federal and provincial governments collaborated with private sector partners to develop ENCQOR, a $400 million 5G testbed for innovators in Ontario and Quebec to develop vertical industry applications and use-cases, establish adoption initiatives and uncover the extent of 5G's technological promise[94]
- The federal government has instituted a Scientific Research & Economic Development (SR&ED) Tax incentive which provides $3 billion annually to support R&D[97]

Vertical Industry Application Funding

- Canada has set up five superclusters in digital technology, protein industries, next generation manufacturing, scale AI and ocean technology, with $950 million to develop and scale high-potential technologies[71]

Study limitations

Receipt of new data or facts: PwC reserves the right at its discretion to withdraw or make revisions to this report should we receive additional data or be made aware of facts existing at the date of the report that were not known to us when we prepared this report. The findings are as of January–February 2021 and PwC is under no obligation to advise any person of any change or matter brought to its attention after such date that would affect our Findings.

This report and related analysis must be considered as a whole: Selecting only portions of the analysis or the factors considered by PwC, without considering all factors and analysis together, could create a misleading view of our findings. The preparation of our analysis is a complex process and is not necessarily susceptible to partial analysis or summary descriptions. Any attempt to do so could lead to undue emphasis on any particular factor or analysis.

Data limitations: PwC has relied on the information sourced from GSMA, OECD, CapitalIQ, NERA Consulting, Federal Communications Commission USA, Department for Digital, Culture, Media & Sport, UK 5G Innovation Network, Analysysmason, Samsung, Korea Economic Institute of America, Government of Canada, Statistics Canada, Opensignal, IBM, Canada Health Infoway, TC Energy, Royal LePage, CBRE, Barrick Gold, Teck Resources, Agnico Eagle Mines LTD, Ipsos, Ericsson, Canadian Medical Association, Canadian Wireless Telecom Association, CTV New, RE/MAX, Canadian Digital Learning Research Association, Statista, Zoom, IDC, World Bank, World Trade Organization, ITC, CBC, Fidelity National Information Services, Ofcom, Australian Communications & Media Authority, European 5G Observatory, Government of United Kingdom, ENCQOR, Ministry of Internal Affairs and Communications Japan, RCR Wireless News, Light Reading, Commsupdate, United States Congress, Redact, DARPA, World Economic Forum, House of Commons Library, UK Innovation Funding Service, Federal Ministry of Transport and Digital Infrastructure Germany, Reuters, CMS, Autorité de Régulation des Communications Électroniques et des Postes, Department of Infrastructure, Transport, Regional Development and Communications, Canada Infrastructure Bank, among others. PwC has relied upon the completeness, accuracy, and fair presentation of all information and data obtained from participating business and the various data sources, which were not audited or otherwise verified. The findings in this report are conditional upon such completeness, accuracy, and fair presentation, which have not been verified independently by PwC. Accordingly, we provide no opinion, attestation or other form of assurance with respect to the results of this study.

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