



The importance of 5G and the digital economy in Western Canada

November 2021



Table of contents:

Executive summary	1
1: The digital economy is important for Western Canada's post-COVID recovery and future high tech success	4
5G deployment enables the digital economy	4
COVID-19 accelerated adoption of digital ways of working and living	4
5G is forecasted to bring economic, environmental and societal benefits	5
2: Western Canada is aiming to grow through technology enablement and adoption	10
Traditional capital intensive and real estate industries are large parts of the Western Canadian economy	10
Western Canada's provincial governments have strategies for tech-enabled economic diversification	11
3: Western Canada stands to benefit from the growth of the digital economy as 5G-enabled use cases deliver benefits	15
5G and the digital economy are important for the growth of Western Canada	15
5G-enabled use cases are delivering benefits locally and globally	16
4: Canada's performance is behind peers; scale is a key enabler of delivering the full benefits of the digital economy	22
Canada's 5G performance is currently behind global peers	22
Large scale MNOs are needed to deploy 5G at pace	22

Executive summary

5G connectivity will enable new use cases in the digital economy, such as smart mining automation, connected and autonomous vehicles and automated smart farming, that are forecasted to deliver significant economic benefits for Western Canada. Economically, 5G is expected to enable an estimated increase in Western Canadian GDP of **\$34 billion annually by 2035**. All major industries are expected to benefit. For example, in mining, an important industry in Western Canada, self-driving trucks can be used to haul materials and improve efficiency by 10 to 30%¹² through optimizing driving patterns to reduce fuel consumption, engine wear and downtime.³

The adoption of the digital economy has been accelerated by COVID-19, which has had a widespread impact on the Western Canadian economic and social landscape. As a result, a range of existing socio-economic trends have been accelerated, increasing the demand for connectivity and the adoption of the digital economy.

Within this context, the deployment of 5G is expected to deliver significant environmental and societal benefits for Western Canada. These forecasted benefits include:

- Environmentally, 5G-enabled technologies can optimize operating conditions and inputs of existing industrial processes to reduce emissions and water consumption in important Western Canadian industries, such as mining, quarrying and oil & gas extraction, agriculture and manufacturing. Notably, precision agriculture techniques that use connected sensors to track moisture content can automate irrigation to reduce water consumption, and in smart mines, self-driving vehicles reduce emissions through AI-enabled driving algorithms that optimize driving patterns.
- Socially, 5G-enabled technologies will improve the quality of life of Western Canadians by improving the delivery of key social services such as healthcare, education and transportation. For example, automation in public transit can improve system efficiency, safety and user wait times.⁴ The deployment of 5G will also help to close the rural-urban digital divide, which is particularly important in Western Canadian provinces such as Manitoba and Saskatchewan where approximately 30% of the population live in rural areas. The provision of high-speed broadband through Fixed Wireless Access (FWA) will provide for increased access to remote education, healthcare and other services.

The digital economy represents the end-to-end digitization of business processes and every-day activities, and is achieved by integrating connectivity, software and hardware. The improvements in connectivity delivered by 5G will further accelerate the growth and impact of the digital economy, through enabling use cases that will deliver a range of economic, environmental and societal benefits.

¹ Accenture. 2020. "Mined Over Matter: The Not-Too-Distant Future of Autonomous Operations".

² Ericsson. 2018. "A case study on automation in mining".

³ Cisco. 2020. "Wireless Networks enabling autonomous vehicles for underground mines".

⁴ Zhai et al. 2020. "Assessing the Impacts of Autonomous Bus-on-Demand Based on Agent-Based Simulation: A Case Study of Fuyang, Zhejiang, China". *Journal of Advanced Transportation*.

The four provinces of Western Canada, Manitoba, Saskatchewan, Alberta and British Columbia, contributed \$733 billion to Canada's GDP in 2019 (42% of the national total). Large industries (in GDP) in Western Canada have historically been capital intensive industries such as mining, quarrying and oil & gas extraction (around 28% of GDP in 2019). The real estate and rental and leasing industry is also a substantial contributor to the Western Canadian economy, generating 14% of the total Western Canada GDP in 2019. Going forward, all four Western provincial governments have set out policies that aim for economic diversification and technological advancement of the economy and society, using increasing levels of technology; for example, Financial Technology Services, Education and Logistics/Transportation.

To assess the forecasted benefits of 5G deployment across Western Canada, this paper has divided the economy into three categories:

- ***Primary Industries:** Traditional capital intensive sectors, such as mining and oil & gas extraction as well as real estate and leasing and healthcare*
 - ***Priority Industries:** Industries that have been targeted by the provincial governments for economic growth in order to diversify and technologically advance the economy; for example, logistics/transportation and education*
 - ***Consumer focused Industries:** Industries that are primarily focused on consumer services; for example, public administration, utilities and retail trade*
-

The primary, priority and consumer focused industries reviewed within this report, account for around 90% of Western Canada's GDP, and around 95% of total employment.

- In primary industries, 5G-enabled use cases are forecasted to add around **\$16.4 billion** of value in Western Canada by 2035. Example use cases such as smart mining, smart automated construction and automated mobile robotics in manufacturing will bring benefits through increasing product yields and reducing operating costs.
- In priority industries, 5G-enabled use cases are forecasted to add around **\$7.4 billion** of value in Western Canada by 2035. Examples of use cases include driverless trucks in logistics and automated precision agriculture that will improve working conditions and provide for operational efficiencies that reduce costs.
- In consumer focused industries, 5G-enabled use cases are forecasted to add around **\$6.0 billion** of value in Western Canada by 2035, with technologies like smart cities, automated transportation and smart grids benefiting all Western Canadians, including rural and Indigenous communities.

A range of use cases are already being utilized today and delivering economic, environmental and societal benefits. For example:

5G's benefits will also extend beyond enabling industry use cases and smart cities in major urban areas. As access to education, healthcare and other necessities are increasingly tied to the ability to access fast, ubiquitous connectivity, closing the rural and urban digital divide is increasingly important. 5G-enabled use cases require broad ubiquitous coverage to reach businesses outside urban areas (mining, agriculture, oil &

gas, etc.) and enable use cases that are reliant on continuous connectivity (e.g., autonomous vehicles). The delivery of ubiquitous connectivity across all of Western Canada will be an important factor in addressing the digital divide. For instance, the deployment of 5G through Fixed Wireless Access (FWA) technology can deliver broadband connectivity to remote areas at a significantly lower cost.⁵

These forecasted benefits of 5G provide a clear incentive for Western Canada to deploy 5G at pace. However, deploying 5G at pace will be challenging due to three primary factors:

- *The high costs of 5G:* 5G is expected to be more expensive than previous generations, with the total cost of ownership (TOC) forecasted to increase by up to 71% compared to 4G networks.⁶ These costs are primarily driven by the capital costs required to install new equipment, densify infrastructure and the increased operational costs required to keep up with data use.
- *Increased competition in the digital economy:* The digital economy broadens MNOs' competitive landscape to include hardware, software and service providers. Notably, telcos will compete with large multinationals such as Google and Amazon, whose concentration of financial and human capital allows them to dominate markets with 5G-enabled solutions, but are not expected to fund 5G networks.
- *Canada is currently behind global peers in 5G performance:* Canada is behind global peers in 5G deployment ranking 14th among a group of 25 leading countries in download and upload speeds⁷, as it has yet to deploy the two bands (mid and high) of spectrum, which are required to fully enable 5G capabilities. Canada's lagging position is primarily a result of slow spectrum allocations and complex regulations for accessing passive infrastructure.

To deploy 5G at pace, and overcome these challenges, Canada will require a healthy telecommunications industry that has well-capitalized MNOs capable of funding national 5G deployment. To achieve this, Canada needs a supportive regulatory framework, that should: (i) maintain an appropriate level of market incentives, drive improved customer value and investment in innovation (ii) maintain predictable and fair regulations while being flexible to accommodate the evolving needs of the digital economy and (iii) consider the significant benefits of the digital economy, the role of 5G in enabling it, and the broader competitive landscape within it

⁵ GSMA. 2018. "Fixed Wireless Access: Economic Potential and Best Practices".

⁶ GSMA. 2019. "5G-era Mobile Network Cost Evolution".

⁷ Opensignal

1: The digital economy is important for Western Canada's post-COVID recovery and future high tech success

The digital economy represents the end-to-end digitization of business processes and every-day activities, and is delivered by integrating connectivity, software and hardware. Enhanced 5G connectivity will enable the digital economy, bringing economic, environmental and societal benefits to all of Western Canada.

COVID-19 has changed the way Canadians learn, work, interact with friends and family and access essential services. With a set of economic and social trends that have been accelerated by COVID-19, this requires a more digitally enabled economy and social environment.

5G deployment enables the digital economy

The digital economy represents the end-to-end digitization of business processes and every-day activities, and is achieved by integrating connectivity, software and hardware. The improvements in connectivity delivered by 5G will further accelerate the growth of the digital economy, and deliver a range of economic, environmental and societal benefits.

5G will enable the new digital economy in which connectivity will support a growing number of consumer and business applications, with the number of connected IoT devices in Canada (e.g., sensors) forecasted to more than double from 2018 to 2023, increasing from around 120m in 2018 to approximately 270m in 2023. In comparison the growth in other mobile connected devices (e.g., smartphones) is forecast to be approximately 20% over the same period. This forecasted increase in connected IoT devices is indicative of the expected growth of the digital economy and the integral role connectivity plays in it.

COVID-19 accelerated adoption of digital ways of working and living

COVID-19 has had a widespread impact on Canada's and Western Canada's socio-economic environment, changing how Canadians work, learn and access essential services. Notably, the pandemic has accelerated six existing economic and social trends:

1. **Shifts in population centres:** The population growth rate in large urban centres is expected to slow as digital ways of working and learning continue to improve and cost of living increases.
2. **Shift in relationship and entertainment preferences:** Canadians are expected to continue to increase their preference for digital means of entertainment (e.g., online gaming, video streaming) and maintaining relationships (e.g., social media, video chat).
3. **Shifts in business operating models:** Businesses are expected to continue to prioritize digital transformation and automation plans to manage increased costs from localized supply chains and protect against future disruption.

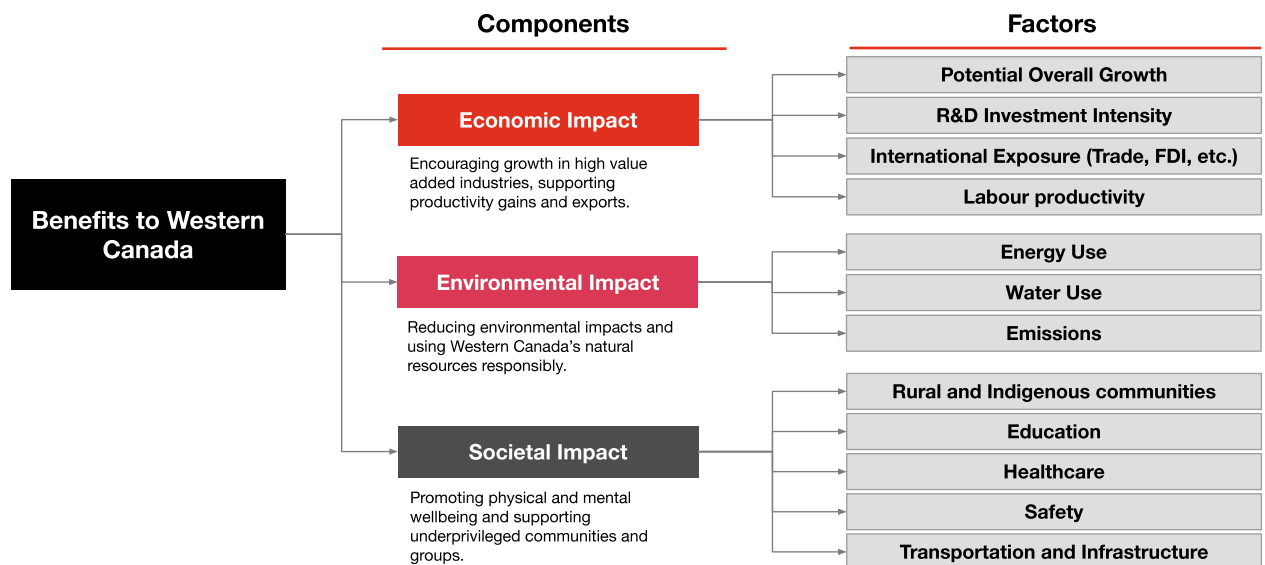
4. **Shift to localized supply chains:** Supply chains are expected to continue to utilize on-shoring and near-shoring to combat future disruption.
5. **Shifts in service preferences:** Consumers and businesses are expected to continue to prefer virtual services.
6. **Shifts in consumer purchasing habits:** Consumers are expected to continue to increase preference for online shopping channels.

These changes and the rapid adoption of digital ways of working and living have increased the demand for connectivity and adoption of the digital economy. As the post-COVID recovery gathers pace, the advancement of connectivity, in particular 5G networks, is needed to ensure Western Canada's recovery and future high tech success.

5G is forecasted to bring economic, environmental and societal benefits

The accelerated adoption of the digital economy along with the deployment of 5G connectivity will have significant economic, environmental and societal benefits for Western Canada. Exhibit 1 lays out the 5G benefit assessment framework, which is used to assess the benefits of 5G-enabled use cases. The framework identifies 13 key factors that catalog the economic, environmental and societal benefits of 5G-enabled technologies. While the factors are not exhaustive, the framework provides a lens through which to understand the breadth of impact that 5G-enabled use cases can deliver, including tangible examples of how this impact will be achieved.

Exhibit 1 - 5G Benefit Assessment Framework (not exhaustive)⁸



Economic impact: 5G-enabled technologies work to improve the utilization of inputs to reduce costs and provide opportunities to increase revenues through improved products and services. To assess these benefits, we can look across four economic measurement factors:

⁸ PwC Analysis, 2021. "Ontario's position for Industry 4.0 adoption"

- **Potential Overall Growth:** The adoption of 5G is important for Western Canadian industries' global competitiveness as 5G-enabled technologies will increase GDP and are being adopted in peer countries (e.g., the G7, Australia and South Korea). For example, the use of **precision agriculture** and **automated fleet management** will increase revenues by improving agricultural yields and improving fleet availability, and decrease operational costs by reducing the amount of raw materials needed and improving fleet utilization. The economic gains enabled by 5G will also translate into job creation, as the deployment of 5G networks is estimated to add more than 150,000 short-term jobs across Canada before 2026 while 5G applications will add more than 250,000 permanent jobs.⁹
- **R&D Investment Intensity:** Companies that are looking to develop and commercialize 5G-enabled technologies will need to invest in R&D. These investments in R&D can enable companies to develop new use cases, creating new revenue streams and job opportunities. Increasing R&D intensity is generally correlated with positive economic outcomes.¹⁰
- **International Exposure (Trade, FDI, etc.):** For companies that compete internationally, 5G enabled use cases help to improve productivity and deliver goods and services on a cheaper basis, thus maintaining global competitiveness. For example, the use of **automated smart mines** and **smart manufacturing** can reduce the cost of production, allowing companies to either improve their returns on investment. This would enable companies to re-invest in increased capacity, to attract further foreign direct investment and to create jobs.
- **Labour Productivity:** 5G is forecasted to help improve labour productivity and operational efficiency by optimizing existing processes (i.e., reducing the inputs required to generate the same outputs). For example, condition-based maintenance, which reduces asset downtime, allows operators to prioritize maintenance pre-emptively and streamlines it. Digital twin computerized models allow operators to better maintain optimal operating conditions for processes and equipment. This helps reduce asset downtime, leading to improvements in operational efficiency and reducing inefficiencies in daily operations. These types of use cases enable companies to increase their output per worker (i.e., labour productivity).¹¹

Environmental impact: The introduction of 5G-enabled technologies will also help to mitigate environmental concerns and support Canada in achieving its global environmental commitments such as the Paris Agreement and the UN Sustainable Development Goals. This can be achieved by leveraging the vast amounts of data being generated across value chains to improve decision making and automation that can in turn deliver positive environmental impacts. To assess these environmental benefits, we can look across three factors:

- **Energy Usage:** 5G-enabled connectivity allows for increased data capture and sharing, which can improve decision making with regards to energy consumption. For example, **smart buildings and homes** provide stable and fast connection of multiple devices all working to improve comfort and optimize energy efficiency in homes and large buildings. Smaller **smart plants** utilize renewable energy to reduce fossil fuel consumption, and **smart grids** enhance reliability and availability of electricity distribution.
- **Water Usage:** 5G-enabled sensors can relay information and automate decision making to improve water consumption and quality. **Precision agriculture** techniques using soil sensors allow for automated irrigation of fields to reduce water wastage. This can reduce the water usage on a farm by as much as 30%.¹² Deploying smart **water sensors** as part of **smart cities** projects can improve water conservation practices through consumption-based feedback for customers.¹³ Sensors can also be used to monitor, in real time, water quality allowing for cities to quickly mitigate quality issues.¹⁴

9 Accenture. 2018. "Fuel for Innovation--Canada's path in the race to 5G".

10 McMorow, K. & Werner, R. 2009. "R&D capital and economic growth: The empirical evidence". *EIB Papers*.

11 Finlayson, J. & Williams, D. 2018. "Productivity and Living Standards in Canada and British Columbia". *Business Council of British Columbia*.

12 CIO. 2020. "Using 5G to revolutionize farming".

13 Cominola, A. et al. 2021. "Long-term water conservation is fostered by smart meter-based feedback and digital user engagement". *NPJ Clean Water*.

14 Shanahan, R. & Kingsford, A. 2021. "Technology & Water: How 5G and IoT Can Update Our Water Infrastructure". *Verizon*.

- **Emissions:** 5G-enabled smart analytics and automation can be leveraged to automate emissions monitoring and optimize emissions treatment strategies. **Smart manufacturing** processes that rely on automation and **condition-based maintenance** can reduce emissions by preventing unnecessary maintenance and in turn reduce fuel consumption. **Smart mines with IoT** sensors provide live data feeds to operators and emissions algorithms that are able to limit daily emissions and help reduce emission spikes during peak outputs. Self-driving vehicles reduce emissions through AI-enabled driving algorithms that optimize driving patterns.

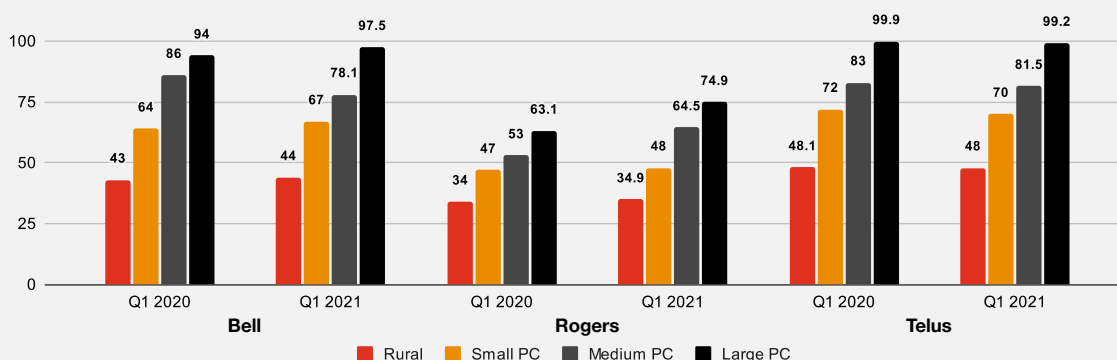
Societal impact: The deployment of 5G-enabled technologies will bring positive societal impacts for Western Canadians in urban, rural and Indigenous communities. 5G will allow for more, faster connectivity to rural and Indigenous communities and will also enable technological improvements in key social services such as education and healthcare. To assess these societal benefits, we can look across three factors:

- **Rural and Indigenous communities:** 5G will allow for near ubiquitous connectivity, making faster and more reliable connectivity available to previously underserved areas such as rural and Indigenous communities. It will support economic development and deliver positive societal outcomes. For example, high-speed broadband provided through 5G-enabled **Fixed Wireless Access (FWA)** could give rural and Indigenous communities new opportunities within the remote workforce as well as better access to connectivity-enabled services such as telehealth.

In focus – 5G helping bridge the urban rural digital divide

Rural users make up almost 18% of Western Canada's population¹⁵ and despite progress, a rural urban digital divide¹⁶ remains, with users' mobile network experience varying depending on proximity to urban areas. The rural-urban gap in download speed is significant, with urban users obtaining almost double the download speeds of rural users under certain conditions. However, rural Canadian users have seen download speeds improve, with an average improvement of between 0.3-0.6 Mbps from Q1-2020 to Q1-2021 (Exhibit 2).

Exhibit 2: Canada's rural and urban download speed experience¹⁷



As access to education, healthcare and other necessities are increasingly tied to the ability to access fast, ubiquitous connectivity, it is important that the rural urban digital divide is closed. 5G-enabled use cases require broad ubiquitous coverage to reach businesses outside urban areas (mining, agriculture, oil & gas, etc.) and to enable use cases (e.g., autonomous vehicles) that are reliant on continuous connectivity.

¹⁵ Statista: "Population distribution of (Manitoba, Saskatchewan, Alberta, British Columbia), Canada, in 2016, by rural/urban type"

¹⁶ The gap between the percent of rural / indigenous users who have access to high-speed internet and the percent of urban users who have access to high-speed internet

¹⁷ OpenSignal: The state of rural Canada's Mobile Network Experience – May 2020

Ubiquitous connectivity can be delivered by 5G Fixed Wireless Access (FWA), which offers a comparable substitute to wireline connectivity.¹⁸ FWA allows operators to provide high-speed internet access to areas where it is difficult to install and maintain wireline infrastructure, with potential to reduce costs by up to 74% compared to wireline connectivity. FWA allows for improved business and schooling conditions in rural and Indigenous areas and supports decreased urbanization out of urban centres due to the increased viability of remote working and learning.

US example: How 5G deployment is closing the digital divide in the US

157 million of ~330 million people do not use the internet at broadband speeds¹⁹

The US Federal Communications Commission (FCC) is devoting up to \$20 billion (USD) to funding the deployment of high-speed broadband networks in rural areas.²⁰ As enhanced connectivity brings a range of benefits including:

- Improving educational opportunities
- Advancing rural healthcare
- Enabling agricultural IoT use cases
- Ensuring critical communications for first responders



In order for T-Mobile to acquire Sprint for \$26.5 billion USD in 2020, the approval of the US Federal Communications Commission was required. In reviewing the deal, the FCC found that it would *“help close the digital divide and advance United States leadership in 5G and enhance competition in rural America”*. The FCC approved the merger on the condition that the merged entity deploy 5G to 97% of Americans within 3 years of the merger closing, with 90% of Americans having access to speeds of 100 Mbit/s or greater.

- **Education:** As COVID-19 has accelerated the adoption of online learning, improved connectivity has become integral to the education sector. For example, 5G-enabled **Fixed Wireless Access (FWA)** can provide high-speed internet access to previously underserved areas to increase access to online learning. 5G can also enable the development of new, more immersive teaching tools such as **VR and AR** headsets that allow students to experience digital re-enactments of historical events.²¹
- **Healthcare:** By 2041, Canadian governments are expected to spend 51% more per person on healthcare, due to factors such as population growth and aging.²² 5G-enabled technologies can reduce overall system costs and improve healthcare access and patient outcomes. For example, IoT-enabled **remote health monitoring** can reduce healthcare costs through shortening hospital stays and decreasing the need for in-person medical supervision such as personal support workers. **AI-enabled remote diagnostics** can improve healthcare access and patient outcomes²³ by transmitting patient data to specialists in real time, allowing physicians to treat patients without delay from any location, and by supporting decision making through the use of AI.

18 GSMA. 2018

19 Microsoft: Thanks to Congress, the FCC can now update America's broadband maps - December 2020

20 FCC Press release January 2020: FCC LAUNCHES \$20 BILLION RURAL DIGITAL OPPORTUNITY FUND TO EXPAND RURAL BROADBAND DEPLOYMENT

21 Verizon. 2019. "Virtual reality: you've never seen history like this before".

22 The Conference Board of Canada. 2020. "Health Care Cost Drivers in Canada".

23 Ahuja A. 2019. "The impact of artificial intelligence in medicine on the future role of the physician". PeerJ.

- **Safety:** 5G-enabled technologies can increase safety in everyday life and in the workplace. For example, the use of 5G-enabled autonomous vehicles could reduce the number of car accidents by 34% or more.²⁴ Workplace safety can be improved by 5G networks' ability to support high numbers of IoT sensors, each capable of processing large volumes of data in real time. For example, IoT sensors can be placed on the factory floor and signal emergency shut offs in reaction to environmental hazards such as unsafe temperatures. Employees can also wear IoT devices that monitor vitals, such as heart rate, and alert responders.²⁵
- **Transportation and infrastructure:** As COVID-19 has accelerated the migration away from large urban centres, transportation plays a greater role in many Canadians' lives. 5G-enabled technologies can make transportation systems safer and more resource efficient, which can enable cities to expand public transit systems. For example, IoT devices, such as cameras and sensors, can be installed throughout the city and on vehicles to increase safety by providing collision warnings and making autonomous driving decisions.²⁶ 5G-enabled autonomic transportation operations can optimize the use of resources and improve passenger wait times by reacting in real time to fluctuations in passenger demand.²⁷ 5G-enabled sensors can also be utilized to improve infrastructure maintenance practices by collecting data and optimizing maintenance operations.²⁸

24 Litman, T. 2021. "Autonomous Vehicle Implementation Predictions". *Victoria Transport Policy Institute*.

25 Samsung. "5G - Untethering Smart Manufacturing Operations".

26 Deloitte. 2020. "5G smart cities whitepaper".

27 Zhai et al. 2020. "Assessing the Impacts of Autonomous Bus-on-Demand Based on Agent-Based Simulation: A Case Study of Fuyang, Zhejiang, China". *Journal of Advanced Transportation*.

28 EY. 2019. "Four ways 5G connectivity will make cities smarter".

2: Western Canada is aiming to grow through technology enablement and adoption

The four provinces of Western Canada, Manitoba, Saskatchewan, Alberta and British Columbia, have historically utilized the availability of natural resources to grow more capital intensive industries such as mining and oil & gas extraction.²⁹ These four western provinces contribute around 42% of Canadian GDP, with significant contributions from these industries (**around 28% of Western Canadian GDP**) and the real estate and rental and leasing industry (around 14% of Western Canadian GDP). To diversify Western Canada's reliance on these industries, all four provincial governments have stated objectives of diversifying their economic base to promote a more balanced and sustainable economic model.

Traditional capital intensive and real estate industries are large parts of the Western Canadian economy

Western Canada contributed \$733 billion to Canada's GDP in 2019.³⁰ To assess the forecasted benefits of 5G deployment to Western Canada, this paper classified Western Canada's industries into three categories, primary, priority and consumer focused industries:

- **Primary industries** are the traditional capital intensive industries, real estate and rental and leasing, as well as healthcare.
- **Priority industries** are industries that have been targeted by western provincial governments for economic growth in order to diversify and technologically advance the economy; for example, logistics/transportation and education.
- **Consumer focused industries** are industries focused on consumer services.
















Exhibit 3 shows the top five industries in each category ranked by their contribution to Western Canadian GDP. The 15 industries shown account for around 90% of GDP and around 95% of employment in Western Canada.

The top five **primary industries** generate around 49% of Western Canadian GDP. The top two GDP contributing industries in Western Canada are the real estate and rental and leasing industry and the mining, quarrying and oil & gas extraction industry. Combined, these industries generate around 28% of Western Canadian GDP; however, they only employ around 10% of Western Canada's population. Comparatively, the top five **priority industries**, combined, generate around 22% of GDP and employ around 27% of the population and the top five **consumer focused industries** generate around 19% of GDP and employ around 32% of the population.

²⁹ The Canadian Encyclopedia: "Petroleum"

³⁰ 1. Statista: "GDP distribution of Manitoba"; 2. Statista: "GDP distribution of Saskatchewan"; 3. Statista: "GDP distribution of Alberta"; 4. Statista: "GDP distribution of British Columbia"

Exhibit 3 – Western Canada’s top five industries in Primary, Priority and Consumer focused Industries, by GDP contribution³¹

Western Canada's primary industries				Western Canada's priority industries				Western Canada's consumer focused industries			
		GDP	Employment Rate			GDP	Employment Rate			GDP	Employment Rate
	Real estate and rental and leasing	14%	6%		Logistics / Transportation	6%	5%		Public Administration	6%	5%
	Mining, quarrying and oil & gas extraction	11%	4%		Technology and Financial Services	5%	8%		Retail Trade	5%	15%
	Construction	9%	9%		Education	5%	8%		Consumer Services	5%	10%
	Manufacturing	8%	14%		Tourism	3%	4%		Utilities	2%	1%
	Healthcare	7%	6%		Agriculture	3%	2%		Arts, entertainment and recreation	1%	1%
Total		49%	38%			22%	27%			19%	32%

Western Canada’s provincial governments have strategies for tech-enabled economic diversification

All four Western provincial governments have set out strategies that aim for economic diversification (“the process of shifting an economy away from a single income source toward multiple sources from a growing range of sectors and markets”³²) with a focus on technological advancement of the economy and society. Each province has formalized and structured their growth targets in government issued papers as follows:

- Manitoba’s “Drivers of Growth” as per *Growing Manitoba’s Economy (2018)*³³
- Saskatchewan’s “The Next Decade of Growth” as per *Saskatchewan’s Growth Plan 2020-2030 (2020)*³⁴
- Alberta’s “Recovery Plan” and “Sector Strategies” as per *Government of Alberta Budget 2021-24 Fiscal Plan (2021)*³⁵
- British Columbia’s “Quality Economic Growth” as per *British Columbia’s Economic Plan 2019-2020 (2019)*³⁶

These documents set out ambitions to grow areas outside of traditional capital intensive industries and real estate (and rental and leasing). They are focused on areas where technology development and adoption will drive growth.

³¹ 1. Statista: “GDP distribution of Manitoba”; 2. Statista: “GDP distribution of Saskatchewan”; 3. Statista: “GDP distribution of Alberta”; 4. Statista: “GDP distribution of British Columbia”

³² United Nations: “Economic Diversification”

³³ Manitoba Government 2018: “Growing Manitoba’s Economy”

³⁴ Saskatchewan Government 2020: “Saskatchewan’s Growth Plan”

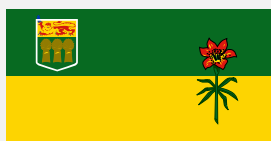
³⁵ Alberta Government 2021: “Fiscal Plan 2021-2024”

³⁶ British Columbia Government 2019: “Economic Plan 2019-20”



Manitoba's GDP was \$64 billion in 2019, making up 9% of Western Canada's GDP. Manitoba has a balanced economy that does not rely on any specific industry (the difference in GDP between the 1st and 5th largest industries is around 5% compared to the Western Canadian average of around 10%). Manitoba's relatively small population (1.4 million people) is highly distributed with around 27% of the population located in rural areas in 2016.³⁷ The Manitoban government has highlighted drivers for growth as set out by *Growing Manitoba's Economy (2018)*³⁸:

- **Strategic Sector Growth** – *"The development of sector strategies should be a priority. Each sector has its own unique advantages, assets and barriers, which need to be identified and addressed by the sector. As these strategies are developed, opportunities for collaboration and synergy will emerge."*
- **Research, Innovation and Technological Advancement** – *"The adoption of technology is critical to improving the competitiveness of Manitoba businesses and industries. Digital technologies are transforming traditional industries as diverse as manufacturing, financial services, agriculture, and arts and entertainment."*
- **Strategic Infrastructure Investment** – *"Investments in roads, rail, air service, broadband access and hydroelectric generation can all have a significant, positive impact on market access and the development and growth of Manitoba's economy."*



Saskatchewan's GDP was \$82 billion in 2019, making up 11% of Western Canada's GDP. Saskatchewan also has a well-developed mining, quarrying and oil and gas extraction industry, which is attributed to the province's natural resource availability. Notably, Saskatchewan has the smallest population in Western Canada (around 1.1 million people), with the largest rural distribution, at around 33% in

2016.³⁹ COVID-19 and the oil & gas price crash in 2020 negatively impacted Saskatchewan's economy, which is still experiencing the long-term effects of the oil & gas price crash of 2014. However, the provincial government has stated aims to focus on economic diversification to help grow the economy as efficiently and sustainably as possible, per the *Saskatchewan's Growth Plan 2020-2030 (2020)*⁴⁰:

- **Tripling the Growth of Saskatchewan's Technology Sector by 2030** – *"Saskatchewan's technology sector is a growth driver in our economy and an important future enabler of growth in our agricultural and resource sectors. The combination of existing research infrastructure and two new technological incubators has increased momentum in the province's digital economy, making Saskatoon the second fastest growing tech job market in Canada."*
- **Increase the Value of Saskatchewan Manufacturing Exports by 50 Per Cent by 2030** – *"Manufacturing plays a key role in Saskatchewan's economy, representing seven per cent of the province's GDP. From 2008 to 2018, Saskatchewan's manufacturing real GDP grew by 30 per cent, which was the second-fastest growth rate among the provinces."*
- **Growing Saskatchewan's Agri-Food Exports to \$20 billion by 2030** – *"Growth in agri-food exports will be a result of increasing primary production and value-added production in the province. In order to secure Saskatchewan's role as a global leader in the production and export of agri-foods, Saskatchewan's producers and industries need to have access to markets and the opportunity to grow international markets for their products. The Government of Saskatchewan will undertake market diversification efforts and capitalize on new market opportunities for Saskatchewan's agri-food products."*

³⁷ Statista: "Population distribution of Manitoba, Canada, in 2016, by rural/urban type"

³⁸ Manitoba Government 2018: "Growing Manitoba's Economy"

³⁹ Statista: "Population distribution of Saskatchewan, Canada, in 2016, by rural/urban type"

⁴⁰ Saskatchewan Government 2020: "Saskatchewan's Growth Plan"



Alberta's GDP was \$334 billion in 2019, making up 46% of Western Canada's GDP. The Albertan economy has benefited from a developed oil & gas industry (around 17% of Alberta's GDP), as a result of the province's oil reserves. However, the provincial government has stated aims to diversify the economy to produce a more inclusive and sustainable model. Notably, Alberta had the lowest GDP growth rate in Western Canada from 2019 to 2020 (-8.2%), which is mostly attributable to the impacts of COVID-19 and the oil & gas price crash in 2020, compounded by the long-term recovery from the oil price crash of 2014. The Albertan government has deployed numerous growth strategies, which are primarily focused on economic diversification and technological advancements, across all major industries to help kickstart economic growth, per the *Government of Alberta Budget 2021-24 Fiscal Plan*⁴¹:

- **Technology and Innovation strategy** – The three outcomes for this strategy are:
 - “Developing, attracting and retaining a future-ready workforce with skills aligned to diversify and grow Alberta’s economy.”
 - “Leading the country in attracting capital and investment by 2030.”
 - “Creating a competitive landscape and the right enablers to drive entrepreneurship and grow priority sectors.”
- **Energy strategy** – “Budget 2021 continues support for the Site Rehabilitation Program, the Alberta Petrochemicals Incentive Program, the Natural Gas Vision and Strategy, and Carbon Capture and Utilization technology.”
- **Agriculture strategy** – “The Agriculture Strategy focuses on attracting investment for value-added and diversification of agricultural products, broadening export opportunities and an historic expansion of irrigation infrastructure.”



British Columbia's GDP was \$253 billion in 2019, making up 35% of Western Canada's GDP, with the real estate and rental and leasing industry accounting for around 18% of British Columbia's GDP. The British Columbian government has stated aims for “Quality Economic Growth” which emphasizes supporting the financial success of the business community, while raising the standard of living for British Columbians, as set out by *British Columbia's Economic Plan 2019-2020*⁴²:

- **Investing in Technology and Innovation** – “Around the world, innovation continues to unlock new opportunity, increase productivity and drive competition at an ever-increasing pace. Technology enables progress cutting across economic sectors, making manufacturing processes, supply logistics, marketing, international shipping and communication more efficient. Technology and innovation include a suite of vastly different enterprises that provide computer enabled products or services ranging from entertainment and digital production, augmented and virtual reality, life sciences, quantum computing, and sector-specific technology development such as clean-tech, agri-tech, and technologies focused on natural resource operations such as mining, energy and forestry. While some technology enterprises are truly new, the telecommunications industry is a modern version of one of Canada's foundation sectors.”

⁴¹ Alberta Government 2021: “Fiscal Plan 2021-2024”

⁴² British Columbia Government 2019: “Economic Plan 2019-20”

- **Powering our CleanBC Future** – *“British Columbia has vast energy resources from oil and gas reserves, heritage hydroelectric facilities, biomass energy facilities and a range of intermittent renewable energy sources including solar and wind. Firm power is necessary to meet our household and industrial needs, keep our food refrigerated at safe temperatures, and maintain reliable supply for hospitals, financial institutions, emergency call centres, and more.”*
- **Investing in Transportation and Infrastructure** – *“For our economy to keep pace with projected population and trade growth, British Columbia needs an integrated transportation strategy that will be aligned across regions, able to address congestion on our trade corridors, enable the seamless movement of people and goods and encourage development of diverse, affordable, connected communities.”*

3: Western Canada stands to benefit from the growth of the digital economy as 5G-enabled use cases deliver benefits

The desire of each Western Canadian province to diversify their economies through the use of technology highlights the importance of 5G deployment. This paper analyzed:

- 5G-enabled technologies that are already being used today, applications that will likely see adoption within the next three years and applications that will likely see adoption in more than three years; and
- Use cases currently being used in Canada and globally for primary, priority and consumer focused industries.

5G and the digital economy are important for the growth of Western Canada

This paper has forecasted that 5G-enabled use cases have the potential to create approximately \$34 billion in incremental GDP for Western Canada by 2035.

Exhibit 4 – Annual impact of 5G on the Canadian economy and for select industries (\$CAD, Billions)⁴³

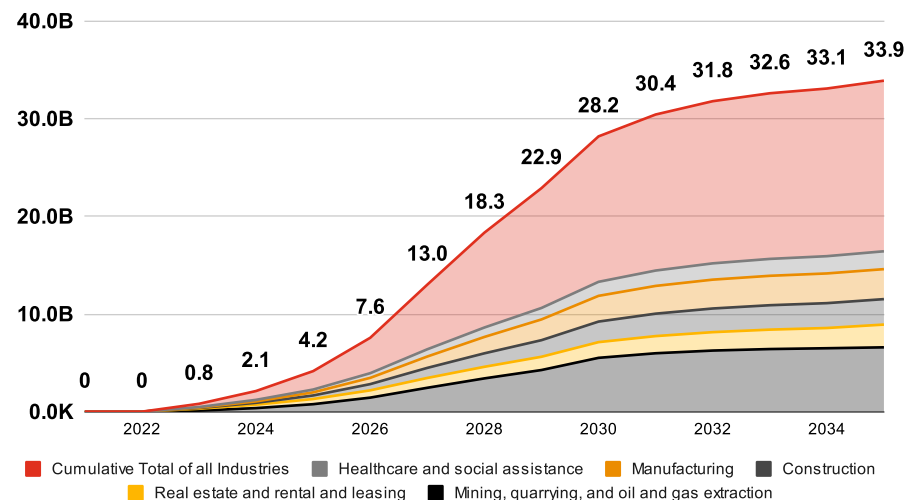
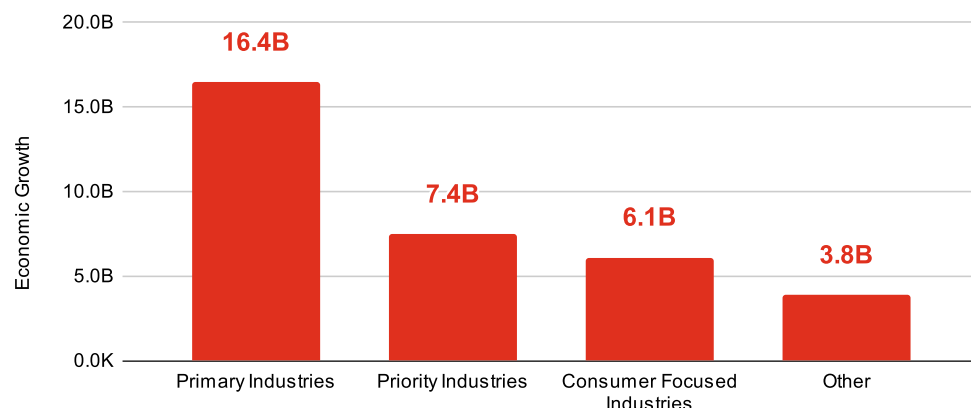


Exhibit 4 shows a stacked area graph of the expected annual GDP impact of deploying 5G networks, breaking out the five largest industries in Western Canada. These economic benefits accrue through the deployment of 5G-enabled technologies that work to improve the utilization of inputs to reduce costs and increase revenues through improved products and services. Exhibit 5 shows the expected annual GDP impact of deploying 5G networks across Western Canada's primary industries, priority industries and consumer focused industries.

⁴³ PwC Analysis, IHS Markit

Exhibit 5 – Annual impact of 5G on Western Canada’s economy (\$CAD, Billions)



5G-enabled use cases are delivering benefits locally and globally

5G-enabled use cases currently exist in each of Western Canada’s top five industries (by GDP contribution) in each of the primary (Exhibit 6), priority (Exhibit 8) and consumer focused (Exhibit 10) categories, with multiple new use cases forecasted to exist within the near and long term, as technologies mature. The adoption time frame for 5G-enabled use cases can be considered across three time horizons:

- Now – 5G-enabled technologies that are already being implemented;
- Near Term – applications that will likely start adoption within the next three years; and
- Long Term – applications that will likely start adoption in more than three years.

Exhibit 6 – 5G use cases and applications by primary industry⁴⁴

Western Canada’s primary industries by GDP						
		Real estate and rental and leasing	Mining, quarrying and oil & gas extraction	Healthcare	Construction	Manufacturing
Adoption timeframe	Now	<ul style="list-style-type: none">• Smart Homes• IoT sensors for Smart Buildings	<ul style="list-style-type: none">• Self Driving Vehicles for Material Handling• Asset Inspection Drones• Virtual Reality in Oilfields and Mines	<ul style="list-style-type: none">• Connected Ambulances (direct communication with hospital Emergency Room)• Community Epidemic Control	<ul style="list-style-type: none">• IoT sensors for Smart Buildings• Augmented Reality for Planning	<ul style="list-style-type: none">• Digital Twin computerized models for asset optimization• VR in Manufacturing Processes• Wearables for operators to improve safety• Autonomous Material Handling

⁴⁴ PwC Research & Analysis, 2020. “TELUS 5G Market Model”

Western Canada's primary industries by GDP

		Real estate and rental and leasing	Mining, quarrying and oil & gas extraction	Healthcare	Construction	Manufacturing
Adoption timeframe	Near-term (1-3 years)	<ul style="list-style-type: none"> Virtual viewings through AR/VR Virtual room furnishing through AR 	<ul style="list-style-type: none"> Automation in Mines and Oilfields Condition Based Maintenance (CBM) Augmented Reality Maintenance Digital Twin computerized models for asset optimization 	<ul style="list-style-type: none"> VR / AR Psychiatric Therapy VR-based Medical Training Remote Health Monitoring 	<ul style="list-style-type: none"> Construction Equipment Management IoT Environmental Monitoring 	<ul style="list-style-type: none"> Artificial Intelligence for Manufacturing for process optimization Automated Industrial Drones for site inspections Product Traceability throughout supply chain Condition Based Maintenance (CBM)
	Long-term (3+ years)	<ul style="list-style-type: none"> Smart automated Construction to reduce turnaround times Digital multi perspective viewings through drones 	<ul style="list-style-type: none"> Private Network with dedicated bandwidth for Oilfields & Mines Tele-operated Mobile Robotics for hazardous task automation and improved on site safety 	<ul style="list-style-type: none"> Private Network with dedicated bandwidth for Hospitals Smart Management of Hospital Assets AI-enabled Remote Diagnostics Drone-delivered Emergency Response Wireless Robotics-assisted Surgery Remote Surgery Drone-delivered Health Assets 	<ul style="list-style-type: none"> Smart automated Construction to reduce turnaround times Tele-operated Mobile Robotics for hazardous task automation and improved on site safety 	<ul style="list-style-type: none"> Private 5G Network with dedicated bandwidth for Manufacturing Tele-operated Mobile Robotics for factory floor automation

Exhibit 7 – Case studies: Global and Canadian use cases within primary industries are delivering economic, environmental and societal benefits

Mining, quarrying and oil & gas case study: Smart mining automation⁴⁵

In New Zealand, **Rio Tinto** has implemented smart mining automation across its operations. IoT sensors located throughout the mine and in material transportation vehicles, feed large quantities of data to an AI network. This network then automatically generates orebody models, organizes equipment dispatch and predicts and controls blasts. These automation improvements have produced significant gains in productivity by removing human error from calculations and relieving engineers and technicians of repetitive mechanical tasks.

⁴⁵ RioTinto: "Smart Mining"

Manufacturing case study: Smart factory analytics⁴⁶

In the US, AW North Carolina has implemented smart factory analytics to optimize their manufacturing process. The implementation of IoT sensors and advanced analytics that monitor, track and compute metrics continuously have reduced downtime, improved employee output, increased production and improved inefficiency identification, which will optimize processes even further.

Healthcare case study: Integrated health solutions⁴⁷

In the UK, Imperial College Healthcare NHS Trust has deployed an integrated health solution that automates admissions and recovery processes throughout the hospital. Automation of these processes has reduced the cost of supplies, increased on-time starts for surgeries, increased patient throughput, reduced waste and improved the retention of junior staff.

Construction case study: Smart construction platform⁴⁸

PCL Construction in Canada has introduced a smart construction platform to monitor environmental conditions and automate construction planning. Through the application of IoT sensors, continuous monitoring of environmental conditions has improved worker safety across construction sites. Specialized sensors that monitor concrete maturity and strength, gases, sound, vibration, air quality and energy consumption have all contributed to improved construction planning and automation and helped reduce energy costs and minimize downtime.

Exhibit 8 – 5G use cases and applications by priority industries⁴⁹

Western Canada's priority industries						
Adoption timeframe	Logistics / Transportation		Technology and Financial Services	Education	Tourism	Agriculture
	Now		<ul style="list-style-type: none">ATM Remote TrackingPop up - digital branches	<ul style="list-style-type: none">Fixed Wireless Access in SchoolsVirtual Learning and Student Monitoring	<ul style="list-style-type: none">VR and AR enhanced social sharing	<ul style="list-style-type: none">Smart Agriculture using Fixed Wireless AccessSelf-driving vehicles for Agriculture
	Near-term (1-3 years)		<ul style="list-style-type: none">Smart Buildings Infrastructure for fully connected services and appliancesInsurance Telematics tracking through IoT	<ul style="list-style-type: none">AR / VR Onboarding and TrainingSmart schools and universities that provide communication and automation within classrooms and administration offices	<ul style="list-style-type: none">Connected Travel (Travel Agent guidance and suggestions)Smart hotels	<ul style="list-style-type: none">Monitoring and surveillance drones for farmsIoT sensor environmental monitoringCondition Based Maintenance (CBM)

⁴⁶ AW,2018: " Practical ways to drive efficiency in transmission manufacturing"

⁴⁷ Medtronic: "Imperial College Healthcare NHS Trust, UK"

⁴⁸ PCL, 2020: "PCL and AOMS Technologies partner to enhance smart construction"

⁴⁹ PCL,2020: "PCL and AOMS Technologies partner to enhance smart construction"

Western Canada's priority industries

	Logistics / Transportation	Technology and Financial Services	Education	Tourism	Agriculture
Long-term (3+ years)	<ul style="list-style-type: none"> Driver-assistive Truck Platooning Technology 5G-Enabled Railways, Targeting Complete Automation Driverless Trucks Drones for Distribution and Delivery 	<ul style="list-style-type: none"> High Frequency Trading for reduced latency in high volume trading Virtual personalized financial advisors 	<ul style="list-style-type: none"> Full and/or hybrid virtual schools 	<ul style="list-style-type: none"> Immersive cultural experiences through AR and VR 	<ul style="list-style-type: none"> Food Traceability throughout supply chain Tele-operated Mobile Robotics for farming automation

Exhibit 9 – Case studies: Global and Canadian use cases within priority industries are delivering economic, environmental and societal benefits

Logistics and transportation case study: Automated warehouse robotics⁵⁰

In Australia, **Synnex** has implemented automated warehouse robotics in its supply depots. The 3D robotics supply chain and warehousing system has reduced the amount of warehouse space required and optimized delivery routing, inventory management and fulfillment logistics, which have improved operational efficiencies, reduced operating costs and improved standard delivery times.

Tourism case study: Smart hotel⁵¹

In Japan, the **Henn na Hotel Hamamatsuchō** is the first hotel fully staffed by robots (excluding a few management staff members), aimed towards foreign business travelers that want to be served in their own language (the robots can communicate in six languages) and prefer minimal human interaction. The hotel also has a robot concierge that is capable of simple conversation required to assist guests with finding nearby restaurants, supermarkets and convenience stores and robotic cleaning staff that take care of daily cleaning tasks. Hotel rooms contain an automated clothes-dry cleaning appliance and a tablet that provides voice activated commands and virtual assistance in all suites. These technologies have improved customer experience while adding convenience and increasing information availability for all guests.

Education case study: Smart campus

The **University of Waterloo** is trialing a range of smart city infrastructure monitoring and asset tracking technologies on its campus. For example, as part of the university's research, they have deployed Canada's first driverless autonomous 5G transportation shuttle, which is operated remotely and makes a 5-stop, 2.7-kilometre journey around the Waterloo main campus.⁵² The university uses its own campus as a testing facility to "advance made-in-Canada 5G technology and commercialize 5G use cases, including launching and accelerating launching smart city, IoT and enterprise 5G applications".⁵³ The smart campus testbench

50 Kane: "Synnex Australia Automated Logistics Centre"

51 Nippon, 2018: "World's First Robot-Staffed Hotels Make Business Travel Inroads"

52 Rogers, 2021: "Advancing 5G Innovation"

53 Rogers, 2021: "Advancing 5G Innovation"

has created many new jobs for co-op students and new grads, as well as more recruitment programs and scholarships but the biggest benefit is the funded research of 5G in the areas of engineering, network design, applied mathematics and artificial intelligence, which will accelerate the development and deployment of future applications.⁵⁴

Agriculture case study: Automated smart farming⁵⁵

The city of Ottawa in Canada has funded an automated smart farm with soil condition monitoring, automated vehicles and drone surveillance. The automated farm has increased product yields, improved productivity and reduced inefficiencies in operations. As a result, the farm has realized higher profits with reduced environmental impact.

Exhibit 10 – 5G use cases and applications by consumer focused industries⁵⁶

Consumer focused Industries						
		Public Administration	Retail Trade	Consumer Services	Utilities	Arts, entertainment and recreation
Adoption timeframe	Now	<ul style="list-style-type: none"> Intelligent Traffic Management Body-Worn Cameras for improved safety Intelligent Parking management 	<ul style="list-style-type: none"> In-Store Contextualized Marketing Omni-Channel Operations provides an integrated shopping experience Customer Traffic Flow Monitoring Cashierless Checkout / Shopping 	<ul style="list-style-type: none"> Cloud Gaming Connected Cars High Quality Video Streaming Fixed Wireless Access for improved connectivity Remote Health Consultations Wearable Devices 	<ul style="list-style-type: none"> Smart Grids Residential smart meters 	<ul style="list-style-type: none"> Immersive media applications (ultrahigh-definition, AR,VR) Home entertainment subscription for cars
	Near-term (1-3 years)	<ul style="list-style-type: none"> Transport Proximity Management for vehicle capacity planning Environmental monitoring 	<ul style="list-style-type: none"> Endless Aisle AR lets shoppers scan entire inventories quickly Smart shelves Contactless Shopping 	<ul style="list-style-type: none"> Augmented Reality Virtual Reality Massive media car infotainment 	<ul style="list-style-type: none"> Augmented Reality Remote Maintenance Digital Twin computerized models for asset optimization Condition Based Maintenance (CBM) IoT sensor environmental monitoring Drone-led Critical Infrastructure Inspections 	<ul style="list-style-type: none"> Improved live event experiences with AR and multiple view angles Live virtual “in-stadium” experiences
	Long-term (3+ years)	<ul style="list-style-type: none"> Remote Search & Rescue Assisted Perception & Visual Communication for Public Safety Automated Public Transport 	<ul style="list-style-type: none"> Magic Mirror AR lets shoppers try on clothing and accessories virtually in store Dynamic Pricing Consumer 3D calls/holograms 	<ul style="list-style-type: none"> Self-driving System for Cars Urban Air Mobility (UAM) 	<ul style="list-style-type: none"> Private 5G Network with dedicated bandwidth for Utilities 	<ul style="list-style-type: none"> Connected haptic suits for improved virtual interactions 3D holographic displays

⁵⁴ University of Waterloo, 2020: “Waterloo partners with Rogers to create 5G smart campus”

⁵⁵ Invest Ottawa, 2020: “First Smart Farm of Its Kind in Canada Launches in Ottawa at Area X.O”

⁵⁶ PwC Research & Analysis, 2020. “TELUS 5G Market Model”

Exhibit 11 – Case studies: A range of use cases across consumer focused industries are delivering economic, environmental and societal benefits

Public administration case study: Smart city⁵⁷

Singapore City is a global leader in smart city implementation – technologies such as intelligent traffic management, facial recognition and sustainable smart housing solutions and automated transportation provide city residents with benefits like reduced traffic congestion, improved safety within the city, more affordable housing and reduced emissions.

Retail trade case study: Magic mirror virtual fitting⁵⁸

In Italy, **Sephora** has implemented an augmented reality makeup testing mirror, called the “magic mirror” in multiple stores. The augmented reality mirror provides an improved customer experience, better purchasing decisions and reduces in store time.

Utilities case study: Smart grid⁵⁹

In Mexico, **CFE Mexico** has implemented a smart grid utilities solution that provides real-time information sharing between energy assets and the workforce, and an improved energy transmission model for asset health benchmarking and monitoring. As a result, operating costs have been reduced, preventative maintenance is executed based on health benchmarking and monitoring and workforce efficiency has improved, as day to day operations are optimized through the use of data.

Arts, entertainment and recreation case study: Virtual concerts⁶⁰

The global Massively Multiplayer Online (MMO) game, **Fortnite**, performed a live virtual concert with live VR artist performances inside the game, where all players were able to watch and interact with the performance in game. This provides an additional form of entertainment on global platforms and new interactions with live artist performances that aren’t bound by geographic restrictions like in person performances.

All of these 5G-enabled use cases will support all four Western Canadian governments in delivering on their stated growth strategies to diversify and grow the economy. The 5G-enabled digital economy is forecasted to enable an estimated increase in Western Canadian GDP of approximately \$34 billion annually by 2035, helping to strengthen primary industries, support the growth of priority industries, and enable new consumer facing industries to deliver improved customer outcomes.

57 Thales, 2020: “Singapore: The world’s smartest city”

58 RIS News, 2019: “Inside Sephora’s Magic Mirror”

59 AVEVA: “CFE Mexico Smart Grid”

60 The Verge, 2020: “Fortnite is launching a concert series it hopes will become a ‘tour stop’ for artists”

4: Canada's performance is behind peers; scale is a key enabler of delivering the full benefits of the digital economy

Canada currently lags global peers in 5G network performance as its network is limited to low-band connectivity, and both mid- and high-band are required for 5G to fully enable the digital economy and unlock the promised economic, environmental and societal benefits. This gap has potential consequences for Western Canada's economic growth.

Canada's 5G performance is currently behind global peers

Canada is currently behind global peers in 5G performance, ranking 14th among a group of 25 leading countries in download and upload speeds (see Exhibit 12⁶¹), as it has yet to deploy mid- and high-band 5G networks. The primary factors causing this are (i) Canada's slow spectrum allocations and (ii) complex regulations for accessing the passive infrastructure that is needed for network deployment. For 5G to fully enable the digital economy, all three bands of 5G are needed to ensure the right connectivity for select technology use cases and innovation, and deliver near-ubiquitous geographic coverage to enable applications that are not employed solely in high-density areas such as autonomous vehicles and process automation in mining and agriculture.

**Exhibit 12 – Canada's 4G and 5G performance relative to 25 leading 5G countries
(Dec 2020 - Feb 2021)**

Category	4G Rankings	5G Rankings
Download speed (Mbps)	2nd	14th
Peak download speed (Mbps)	1st	16th
Upload speed (Mbps)	7th	14th

Source: Open Signal

Large scale MNOs are needed to deploy 5G at pace

To deploy 5G at pace and realize the forecasted benefits of the digital economy, Western Canada needs a healthy telecommunications industry that is incentivized to, and capable of, making the required network investments to meet the digital economy's connectivity needs. A healthy telecommunications industry requires a regulatory framework that:

1. Maintains the **appropriate level of market incentives** that encourage improved customer value and investment in innovation.
2. Maintains a **predictable and fair set of regulations that remains flexible** to meet the evolving needs of the digital economy.

61 | Khatri, H. 2021. "In the 5G era, Canada is losing global leadership due to spectrum challenges". *OpenSignal*.

3. Acknowledges the **broad benefits of the digital economy** and the role of 5G in enabling it. It also acknowledges the broader competitive landscape of the digital economy where large multinationals (e.g., Google, Amazon) who do not invest in network infrastructure are positioned to outcompete smaller players for the majority of the value pool enabled by 5G.

Further, an important factor in the telecommunications industry's ability to deploy 5G networks is the scale of MNOs. This is because scale supports:

1. **The ability of the telco to fund the increased cost of 5G:** 5G is expected to be more expensive than previous generations, with the total cost of ownership (TOC) forecasted to increase by up to 71% compared to 4G networks.⁶² These costs are primarily driven by the capital costs required to install new equipment and densify infrastructure and the increased operational costs required to maintain networks and support an increased data demand.
2. **The ability of the telco to fund and deliver 5G connectivity across Canada's dispersed geography:** Canada's unique factors of production, including its dispersed geography, weather and challenging landscape, make it challenging to roll out and maintain telecommunications networks. Consequently, Canadian network operators have a significantly higher ratio of capital expenses to subscribers than peer countries.⁶³ Larger scale, national operators are better positioned to fund these capital expenses and deploy 5G networks nationally across urban and rural geographies.
3. **The ability of the telco to fund 5G deployment in an ecosystem where the largest participants are not the companies investing in the 5G network:** A greater share of digital economy value chain is shifting towards companies that rely on 5G networks to provide 5G-enabled solutions, but that do not invest in network infrastructure. The shift in value away from connectivity makes the business case for Canadian telcos to invest in 5G networks uncertain. MNOs' scale allows them to better compete with multinationals and capture a larger share of value in the digital economy, supporting investment in the underlying 5G networks that will enable the digital economy.

⁶² GSMA. 2019. "5G-era Mobile Network Cost Evolution".

⁶³ PwC. 2020. "The importance of a healthy telecommunications industry to Canada's high tech success"

In focus – The European 3G experience – Why scale matters

Although Europe's loss of technology leadership can be attributed to multiple factors including a lack of unitary wireless market, the relocation of manufacturing jobs and innovation centres to the US and the evolution to a software driven ecosystem, there is clear evidence that the pace of network deployment was a contributing factor

It is widely recognized that many European countries lagged North America and Asia in the rollout of 3G, while a range of factors contributed to this, we identified three that stand out as key to contributing to the relative delay in 3G adoption in Europe:

1. Coordination issues between the EU and its member states delayed the release of 3G spectrum.
2. Expensive 3G spectrum auctions led to prolonged 3G business cases.
3. Fragmented markets with consistent price competition led to a downward trend in wireless average revenue per user (ARPU), creating a lack of operators with the scale and balance sheet strength to invest in 3G.⁶⁴

The impact of delayed adoption of 3G in Europe can be seen in the disruption caused in the wireless device manufacturing and software development industries:

- In the 2G era, Nokia, based in Europe (Finland), was a global leader in both wireless device manufacturing and software development. However, the lag in 3G launch coincided with Nokia's decline in both revenues and market share e.g., Symbian, Nokia's operating system and computing platform, experienced a significant fall in market share from 63% in 2007 to 12% in 2011.⁶⁵
- The US uptake of 3G (in contrast) in 2007 allowed Google and Apple to access high quality networks earlier than their European counterparts, and utilize those to build flexible platforms with innovative functionalities that were more user-friendly, encouraging a consumer preference shift towards American manufacturers.⁶⁶
- Ultimately, Nokia never fully recovered from falling behind and was acquired by Microsoft in 2013, who were unable to revive the once-iconic brand and in 2015 wrote off \$7.6 billion from the deal and announced 7,800 job cuts.

Ultimately, a healthy telecommunications industry with large scale MNOs capable of the required investments is integral for Canada, and Western Canada's rollout of 5G connectivity. The European 3G case study highlighted in the *In focus* section above illustrates the importance of fast deployments, as countries that lag behind in deploying the latest connectivity standards can see their competitive advantages eroded in key technological and innovation industries. In light of these lessons and the benefits of 5G, developing regulatory frameworks that enable a healthy telecommunications industry and that acknowledges the need for scale in the 5G era should be a priority for Western Canada.

⁶⁴ Europe protests pricy 3G auctions, ZD Net, March 27, 2001

⁶⁵ Recon Analytics: How America's 4G leadership propelled the US economy, Recon Analytics LLC, 2018

⁶⁶ Recon Analytics: How America's 4G leadership propelled the US economy, Recon Analytics LLC, 2018



This publication has been prepared for general guidance on matters of interest only and does not constitute professional advice. You should not act upon the information contained in this publication without obtaining specific professional advice. No representation or warranty (express or implied) is given as to the accuracy or completeness of the information contained in this publication, and, to the extent permitted by law, PricewaterhouseCoopers LLP, its members, employees and agents do not accept or assume any liability, responsibility or duty of care for any consequences of you or anyone else acting, or refraining to act, in reliance on the information contained in this publication or for any decision based on it.

© 2021 PricewaterhouseCoopers LLP, an Ontario limited liability partnership. All rights reserved. In this document, "PwC" refers to the Canadian member firm, and may sometimes refer to the PwC network. Each member firm is a separate legal entity. Please see www.pwc.com/structure for further details.

.....

