GSMA Intelligence

5G and economic growth

An assessment of GDP impacts in Canada

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GSMA Intelligence

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Executive summary

The mobile industry has begun the journey to upgrade its infrastructure and services to 5G, the next generation of digital technologies. 5G networks will deliver between 10 and 100× faster data rates, at signal response times up to 10× smaller, compared to 4G networks. These capabilities will in turn enable a range of other technologies (such as big data and cloud services) that will realise new and transformative applications and use cases. Canada is now entering the 5G era, even if the Covid-19 pandemic will slow adoption rates in the short term. In this report, we evaluate Canada's readiness for 5G, assess the expected macroeconomic impacts from the introduction of the technology, and identify key barriers for the rollout of 5G in Canada to reach its full potential and drive future economic growth.

5G will deliver $150 billion (USD)[1] in additional value add to Canada's GDP

As one of the most developed economies in the world, Canada has much to gain from the rollout of 5G. From virtual reality to artificial intelligence and autonomous cars, 5G has the potential to help address Canada's slow productivity growth and deliver new and innovative services for consumers.

We estimate that 5G networks will deliver approximately $150 billion in additional value add to the Canadian economy for the entire period 2020–2040, playing an important role in driving economic growth and supporting the recovery from the impact of Covid-19.

As an indication to the scale of the impact, the additional yearly economic activity generated by 5G in Canada will be similar in size to the value add generated by the aerospace industry every year, and will be significantly larger than the GDP contribution of many other sectors in the country. With the boost delivered by 5G, and taking into account the effects of mobile technology uptake more generally, we expect mobile technology overall, including 5G and previous network technologies, to drive an uplift to Canada's GDP in excess of an annual contribution of $65 billion in 2040, equivalent to 2.5% of Canada's annual GDP.

Key 5G spectrum bands are not yet available in Canada

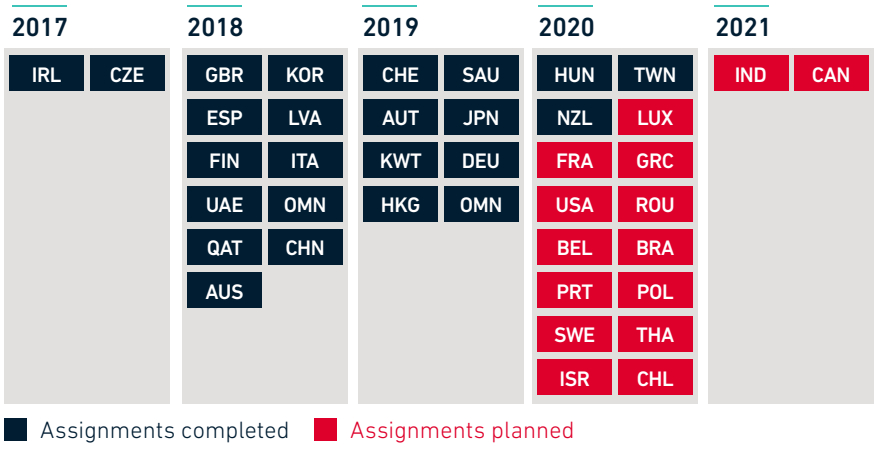
To obtain the full macroeconomic dividends that 5G technology can bring, policymakers and the telecoms industry will need to address a number of barriers. The speed of rollout, as well as the adoption, reach and quality of 5G services, will be heavily dependent on an appropriate policy environment being in place. This must include conditions that incentivise the large investments needed for next-generation networks.

Central to this enabling policy environment, and a particular challenge in Canada, is the need to offer timely access to the right amount and type of spectrum to encourage long-term investments in 5G networks. In particular, 5G networks need significant amounts of new spectrum across all bands. Without these, delivering 5G services that provide widespread coverage and support all potential 5G use cases will not be possible.

At a global level, mid-band spectrum in the 3.5 GHz band has clearly emerged as the key band for 5G networks. In Canada, however, this key band for 5G is not scheduled to be auctioned until June 2021, at which point 37 other countries will have already assigned 3.5 GHz spectrum (see Figure i).

Figure i

Global spectrum assignments in the 3.5 GHz band



Data correct as of end-Q2 2020
Source: GSMA Intelligence

> In Canada, the 3.5 GHz band – a key band for 5G – is not scheduled to be auctioned until June 2021, at which point 37 other countries will have already assigned 3.5 GHz spectrum.

1 All instances of $ in this report refer to US dollars.

Assignments of 5G spectrum in Canada are not aligned with international best practice

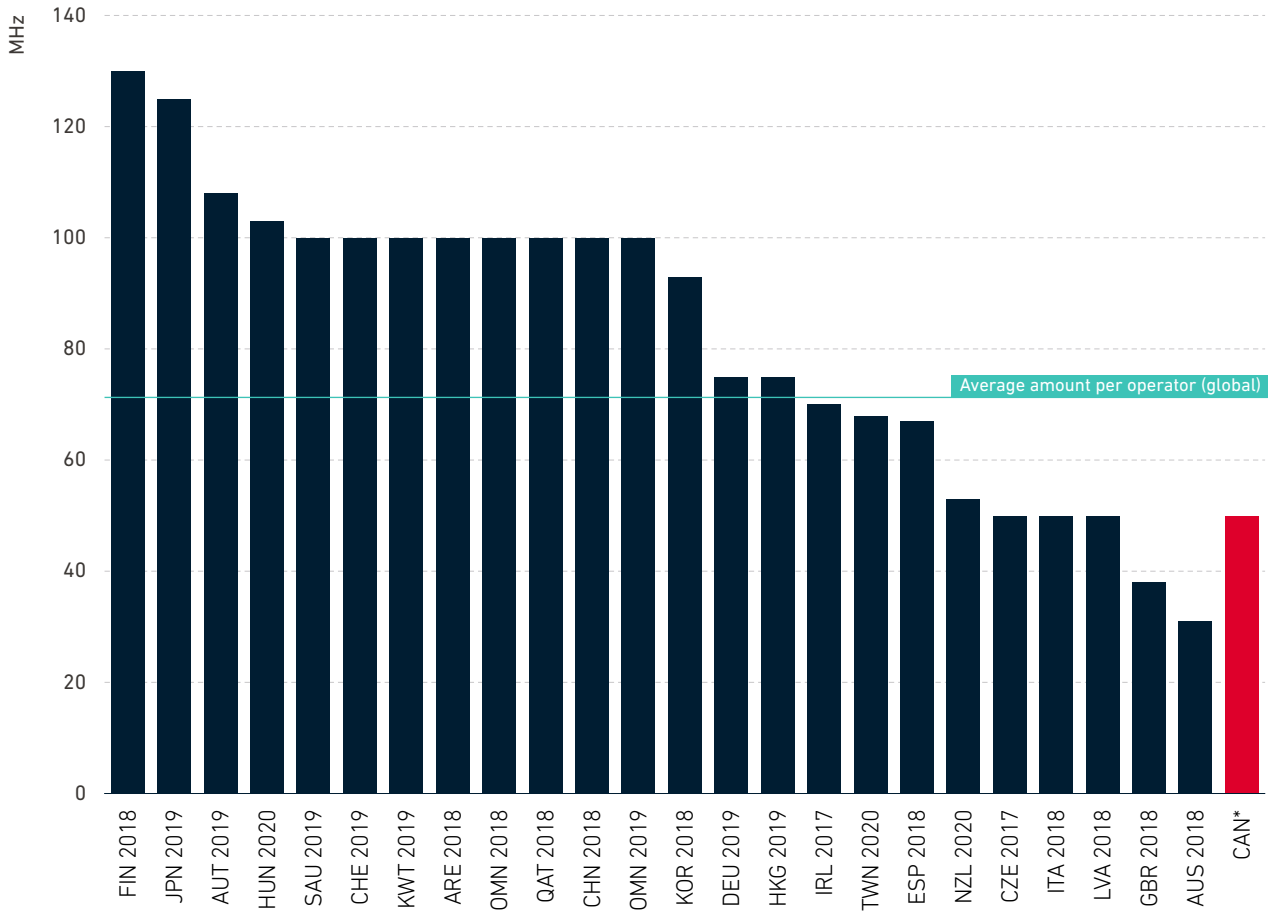
In addition to the above, Canadian operators will have access to a very limited amount of spectrum in the 3.5 GHz band (see Figure ii), with only 200 MHz planned for auction,[2] and with set-aside rules limiting this to a maximum of 150 MHz for the three nationwide operators: Bell, TELUS and Rogers. This is significantly below the International Telecommunication Union's (ITU) minimum requirement of 100 MHz per operator, and far less ambitious than the existing plans to release spectrum in the band by the US (360 MHz), Japan (500 MHz) and most European markets (typically 300–400 MHz).

Canada's existing 5G spectrum policy is primarily focused on promoting the growth of regional players. However, there are clear trade-offs that the government needs to recognise when formulating spectrum policy – in particular, the likely impact this could have on network operators' ability to invest and on the consumer experience and the economy more broadly.

While 5G is not a race, countries that assign spectrum earlier and facilitate the investments needed will be able to deliver benefits to consumers, businesses and the overall economy sooner. Making sufficient spectrum available, in contiguous channels and in a timely fashion, should therefore be a top priority to promote investment in next-generation networks and deliver wider economic benefits at sector and macroeconomic levels.

Figure ii

Spectrum assignments in the 3.5 GHz band – maximum average amount per national operator



*Based on the assumption that the three nationwide operators will win all the spectrum out of the 150 MHz to be assigned. This is an upper bound as regional operators can also bid for this spectrum.
Source: GSMA Intelligence

2 In August 2020, the Canadian government launched a public consultation on the potential to make additional spectrum available for 5G services on the 3.8 GHz band. The outcomes of the consultation are unclear at the time of writing this report.

Alternative 5G spectrum policies can deliver faster macroeconomic growth for the country

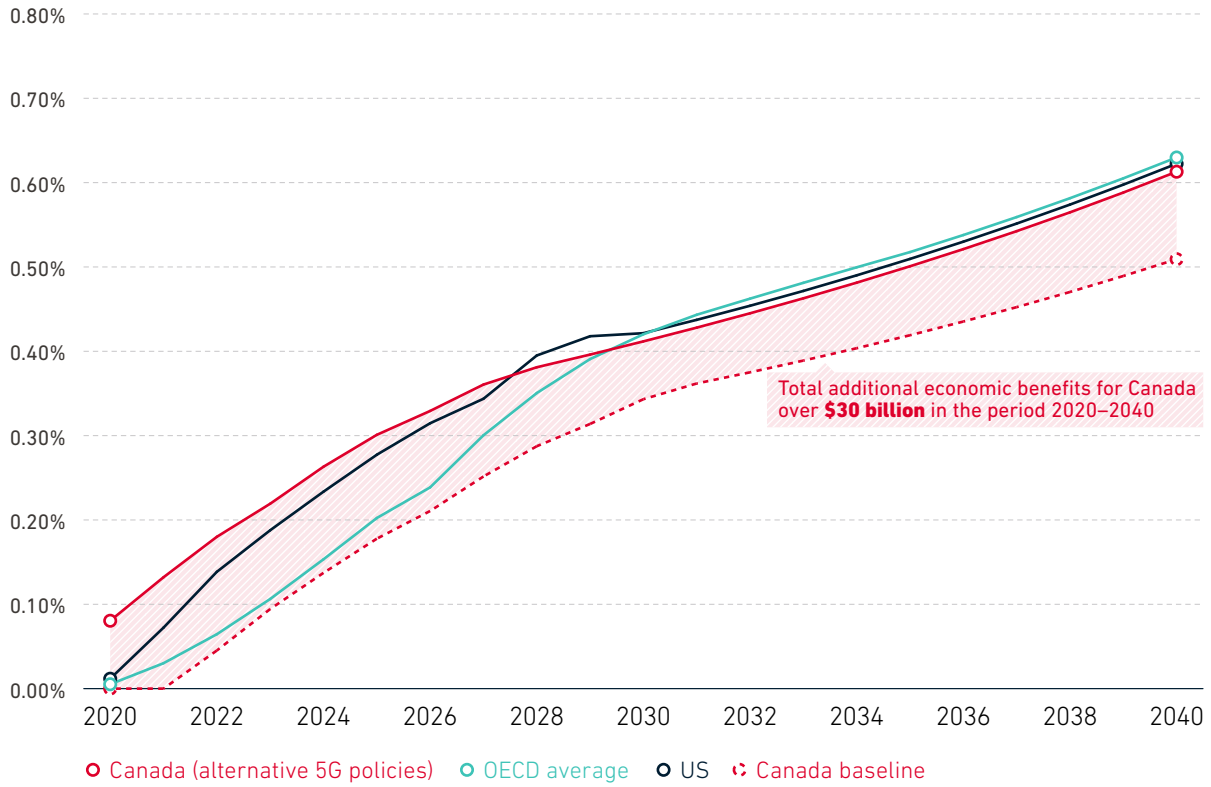
We estimate that bringing 5G spectrum policies in Canada in line with international best practice would deliver well in excess of a total of $30 billion in additional GDP growth for the entire period 2020–2040 (see Figure iii). This would bring the additional economic impact of 5G in Canada closer to its full potential and more in line with the average yearly effects that we expect to materialise in the US and most other OECD countries. It also shows how, in a post-Covid-19 world, policies that promote a robust and resilient digital infrastructure can help to address systemic problems while fuelling economic growth.

We estimate that bringing 5G spectrum policies in Canada in line with international best practice would deliver well in excess of a total of $30 billion in additional GDP growth for the entire period 2020–2040.

To maximise the potential of 5G for consumers and enterprises in Canada, the government needs to ensure a supportive regulatory and policy environment for operators so they can invest in the new technology, deliver better network quality and accelerate the rollout of 5G networks. Protecting the interests of Canada's consumers depends on promoting the conditions that incentivise the significant investments needed for next-generation networks.

Figure iii

Additional economic impact driven by 5G (as a percentage of annual GDP) – international benchmarks



Canada's alternative 5G policies scenario considers the impact on GDP if timings and amounts of spectrum in Canada were in line with international standards
Source: GSMA Intelligence

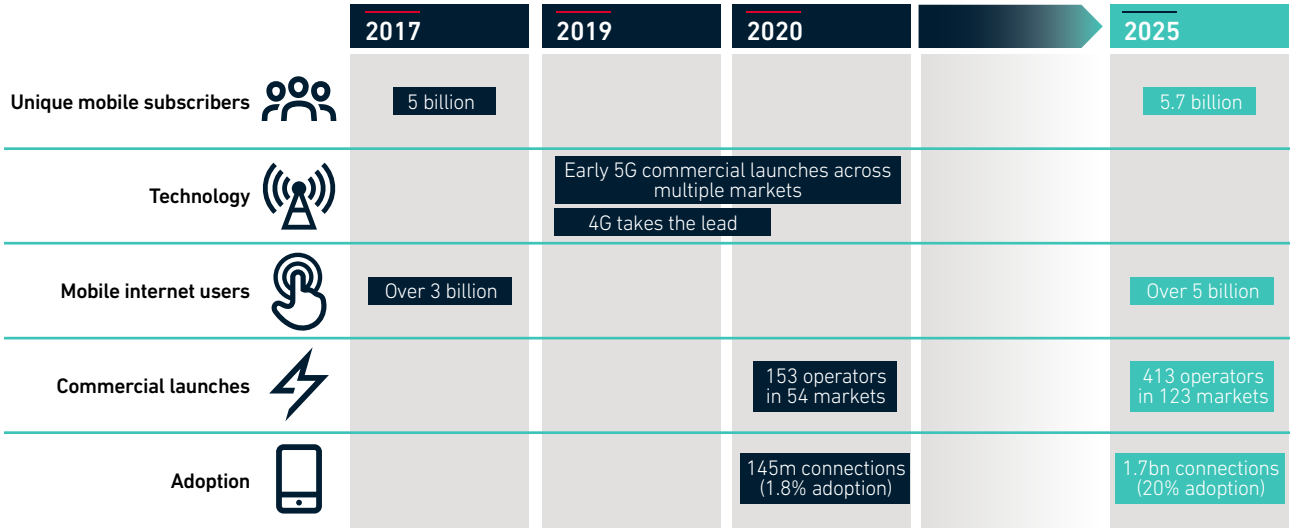
1 Entering the 5G era

The mobile industry has already started to upgrade its infrastructure and services to 5G, the next generation of technologies. 5G networks will deliver between 10 and 100× faster data rates, at signal response times up to 10× smaller, compared to 4G networks. These capabilities will in turn enable a range of other technologies (such as big data and cloud services) that will realise new and transformative applications and use cases.

The world and Canada are now entering the 5G era, even if ongoing disruptions from the Covid-19 pandemic will slow adoption rates in the short term. While many regions have already seen initial network launches, commercial 5G networks will start to gain scale and greater adoption from the current year onwards. This will mark the true start of the 5G era, with the mobile industry delivering a platform that will enhance existing services and enable new business models and use cases. This will include, for example, the creation of smart cities, advanced robotic applications for manufacturing, and remote solutions for health and agriculture. Though operators universally recognise the potential for 5G to transform aspects of the consumer and enterprise experience, there is less certainty when it comes to specific use cases and how much scope there is to monetise the new services that 5G will enable. A number of countries are already leading the way and seeing 5G adoption rates accelerate. Figure 1 provides a global picture of how 5G has evolved in recent years and how it is forecast to evolve by 2025.

Figure 1

5G timeline, 2017–2025



Source: GSMA Intelligence

Canada is a leading mobile market globally

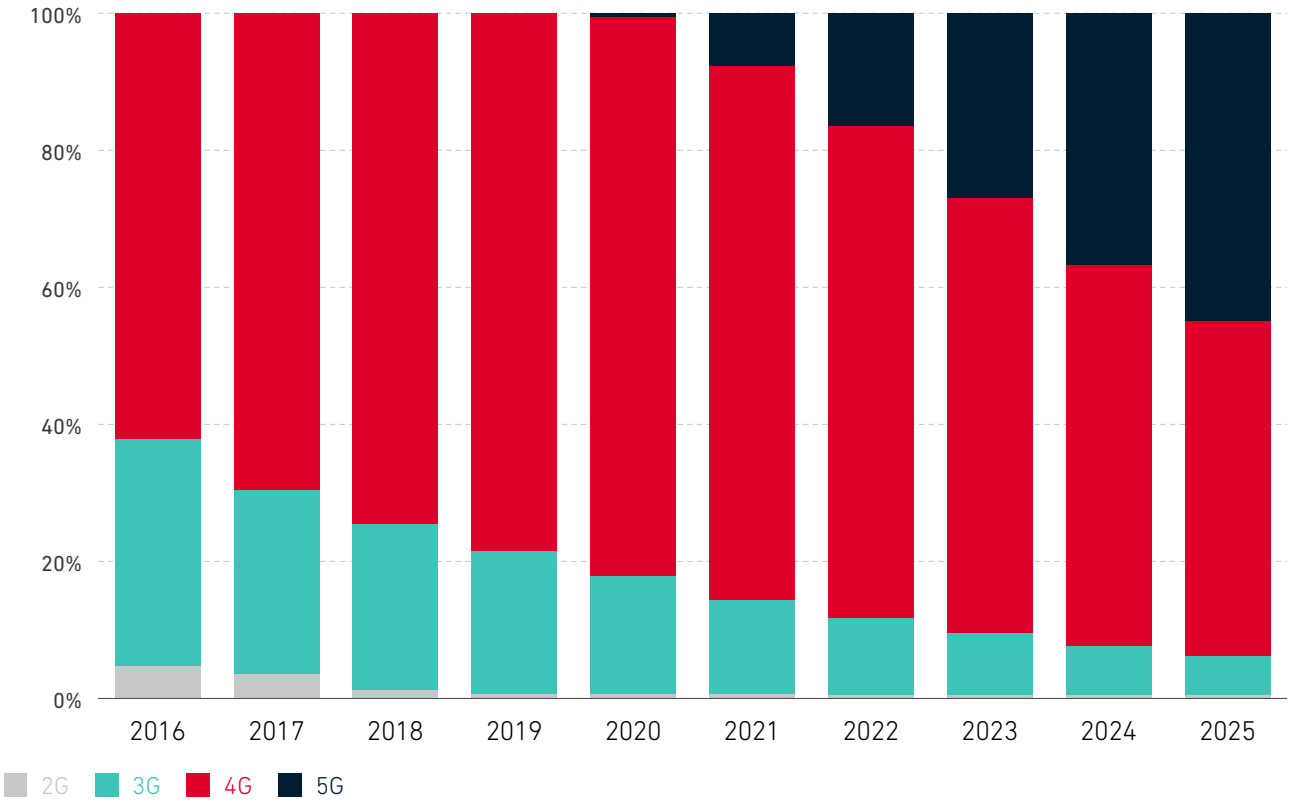
Canada is an advanced and mature mobile market, with 30 million unique mobile subscribers[3] at the end of Q2 2020, equivalent to about 80% of the population. This leaves Canada trailing slightly behind the developed market average of 85%. This difference can in large part be explained by the sheer geographic scale of Canada, as well as its large rural population, topography and climate. Modest subscriber growth will lift the penetration figure to 83% by 2025.

The Canadian market has already experienced widespread migration to 4G, which accounts for nearly 80% of the total connections base at the end of 2019, a figure that compares favourably with other developed markets. 4G will remain the dominant technology in Canada for the foreseeable future, accounting for close to 50% of connections by 2025, but 5G adoption will begin to accelerate from 2021 (see Figure 2). With the rapid adoption of 4G comes the widespread use of smartphones, which represented around 80% of devices[4] at the end of 2019. This will rise to 90% by 2025 (see Figure 3).

2G is now mostly absent from the Canadian market, with the main three operators having shut down their 2G networks in recent years. Niche service providers account for the remaining 2G connections, including the push-to-talk service offered by Airtel Wireless.

Figure 2

Mobile technology evolution in Canada, 2016–2025

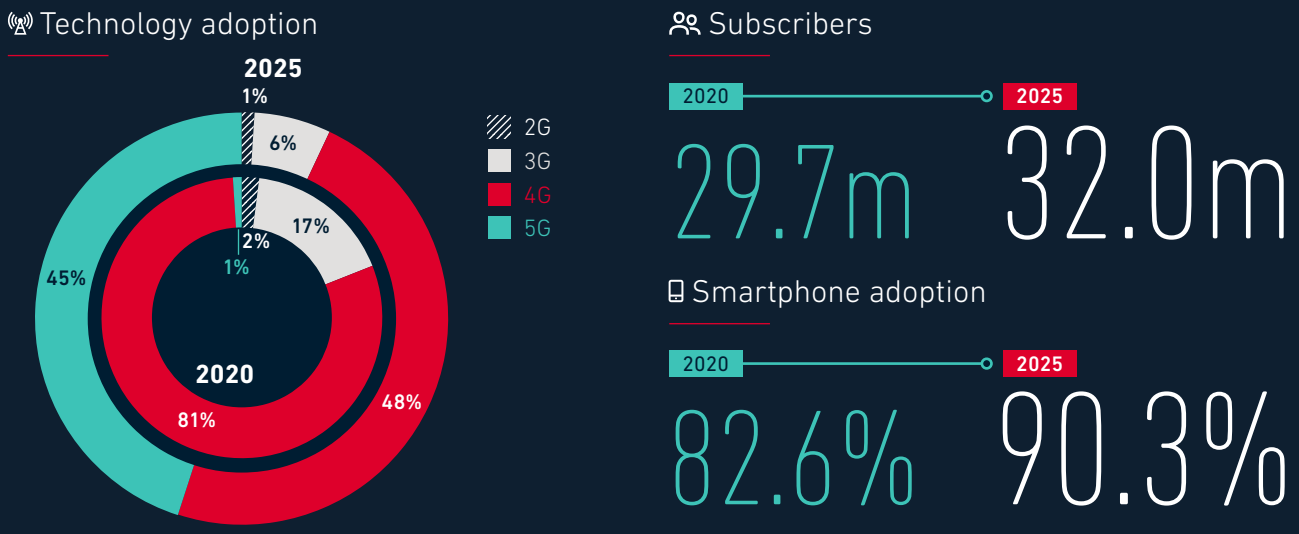


Source: GSMA Intelligence

3 Unique mobile subscribers are unique users who have subscribed to mobile services at the end of the period. Subscribers differ from connections, as a unique user can have multiple connections or SIM cards.
4 Consumer devices include smartphones, basic or feature phones and data-only devices.

Figure 3

Technology adoption, subscribers and smartphone adoption in Canada, 2020–2025



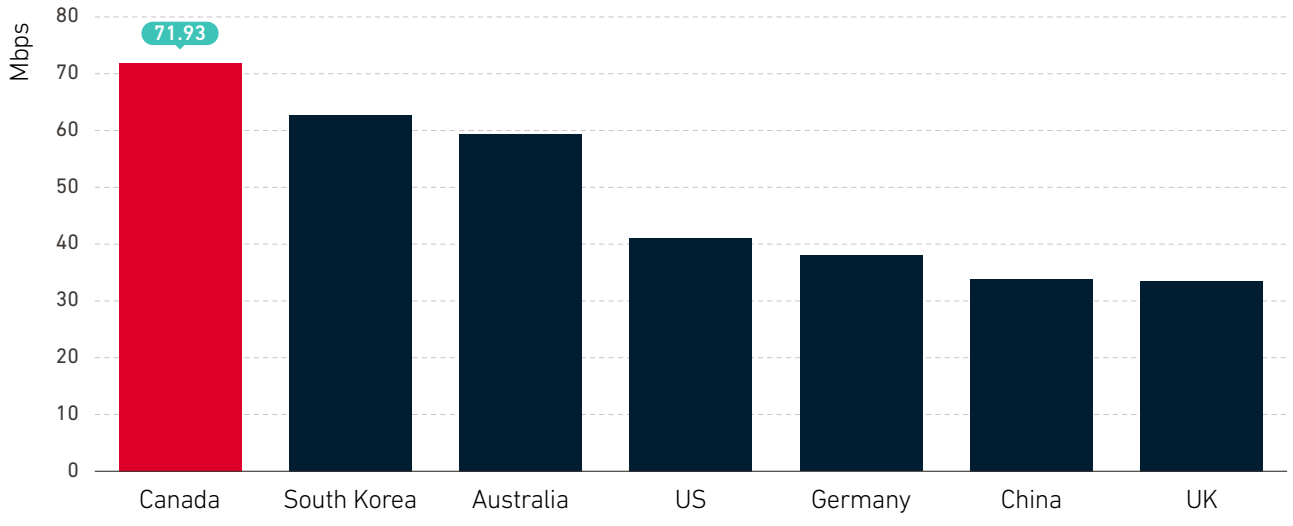
Source: GSMA Intelligence

Operators across Canada have seen significant improvements in download speeds in recent years, helped by investments in new technologies such as carrier aggregation and 4×4 MIMO (multiple input multiple output) technology to increase spectrum efficiency and capacity. These measures allowed Canadian operators to enable download speeds on LTE in excess of 70 Mbps in the quarter April to June 2020, according to Speedtest® results analysed by Ookla®.

The highest speeds were recorded by TELUS and Bell Canada at 90 Mbps and 86 Mbps respectively, with the two operators sharing their radio access networks (RANs) but operating separate network cores. Rogers and its subsidiary Fido Solutions (which operates the low-cost sub-brand MVNO, Fido) have nearly identical speeds at 72–75 Mbps, as the companies run on the same RAN. The two regional operators, Freedom and Videotron, score behind the main operators at 52 Mbps and 35 Mbps respectively.

Figure 4

Mean download speeds, LTE, international benchmarking



Source: GSMA Intelligence, based on analysis of Ookla Speedtest Intelligence® data for April–June 2020 (Ookla trademarks used under licence and reprinted with permission)

Preparing for 5G: ready for strong adoption despite challenges

Canada was not among the first wave of countries to launch 5G, but there is a growing focus within the industry and among relevant policymakers on the importance of 5G to the industry and broader economy. A number of constraints, including spectrum policy issues and an ongoing national security review of network equipment, are holding back wide-scale deployments in the short to medium term.

Despite these challenges, most Canadian operators have already undertaken large-scale trials, and the three national mobile operators have announced a targeted launch of 5G services in certain areas. Rogers has partnered with both the University of British Columbia and the University of Waterloo to develop 5G-powered campuses to test 5G applications, alongside edge-computing-enabled data centres. TELUS and Huawei launched a 5G wireless-to-the-home (WTTH) trial service using a 5G customer premise equipment (CPE) unit, which took place in their '5G Living Lab' in Vancouver. TELUS is now in discussions with the local government to launch a second 'living lab' in Edmonton, which would allow local consumers and enterprises to trial new 5G use cases. Bell was the first operator to trial 5G in Canada back in 2016 in one of the first global trials in collaboration with Nokia. Conducted at Bell's Wireless Innovation Centre in Mississauga, the trial leveraged spectrum in the 73 GHz range to achieve sustained data speeds more than six times faster than the top 4G mobile speeds available in Canada.

Table 1

5G commercial deployments in Canada, by operator

Operator	Launch details	Comments
Bell Canada	Initial deployments in Montreal, Toronto, Calgary, Edmonton and Vancouver. Bell expects to expand its current 5G network to 28 additional markets between 2020 and 2021.	Bell Canada selected Ericsson's 5G RAN technology to support its nationwide 5G mobile and FWA deployments.
TELUS Communications	Initial deployments in Vancouver, Montreal, Calgary, Edmonton and the Greater Toronto Area. Deployments will continue to expand to reach a total of 50 markets across Canada by the end of 2020.	Ericsson, Nokia and Samsung have been selected to support building its 5G network.
TeraGo	Trials in early 2020 in Toronto and the Golden Horseshoe area.	Partnering with Nokia for 5G fixed wireless access (FWA).
Rogers Communications	Initial deployments in Vancouver, Toronto, Ottawa and Montreal, with a broader commercial launch later in 2020.	The goal is to expand to another 20+ markets across Canada before the end of 2020.
Videotron	Late 2020 launch date.	Videotron to deploy LTE-A and 5G following supplier agreement with Samsung.

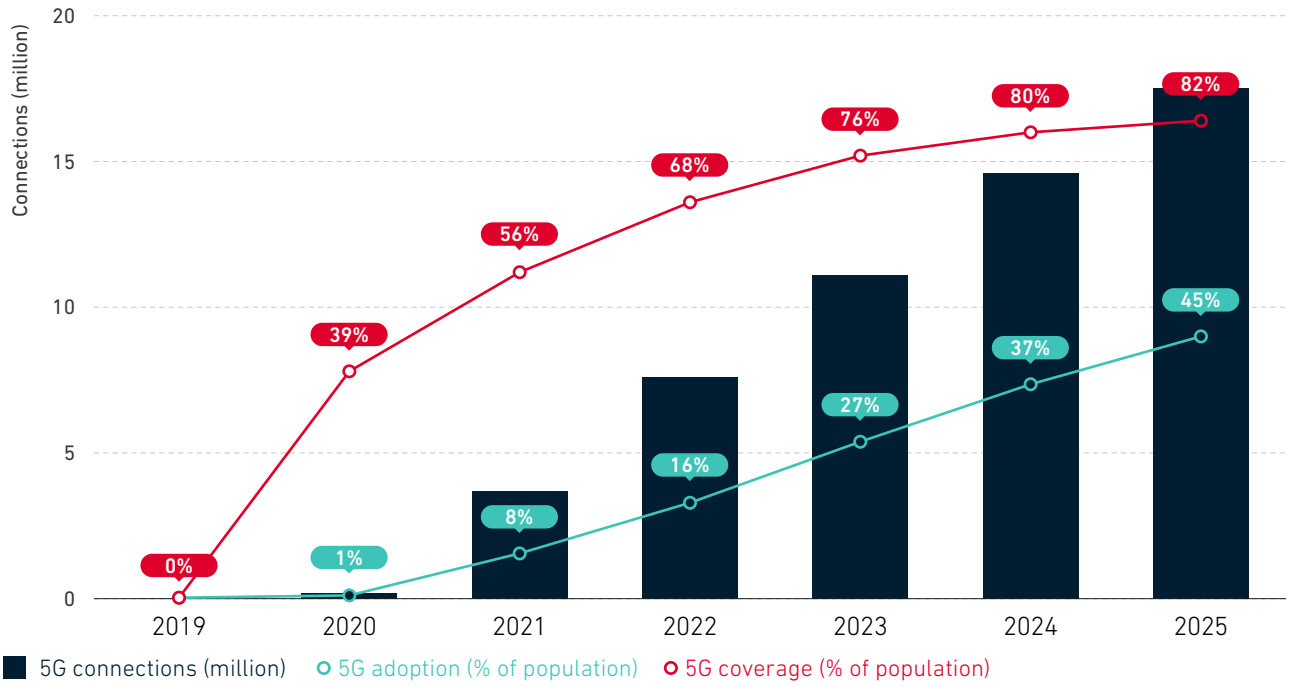
Source: GSMA Intelligence

With the first networks already launched, 5G adoption in Canada will slowly gather momentum in the coming years as more operators launch 5G, the technology begins to mature and the availability of 5G devices becomes wider. By 2025, 5G will account for 45% of the total connection base in Canada based on current forecasts (see Figure 5).[5]

This is a significant rate of adoption, but it will still trail the projected adoption rates of global leaders such as South Korea (80%) and the US (60%). Similarly, 5G coverage is projected to reach more than 80% of the Canadian population by 2025 – a high percentage, but lower than what is expected in South Korea (97%) and the US (96%).

Figure 5

5G adoption timeline in Canada, forecast



Source: GSMA Intelligence

Initial 5G deployment models will build on existing 4G networks

Like operators in most other markets around the world, it is likely that Canadian operators will initially follow a non-standalone (NSA) deployment model, with 5G acting as a supplementary capacity overlay to the 4G network.[6] This approach will contain overall investment levels by avoiding the need for a new set of base stations and should therefore improve the rate of return from incremental revenues from early 5G use cases, such as very high definition video streaming on mobile. LTE data traffic offload onto new 5G networks is a further benefit for operators given the high monthly data volumes.

Standalone (SA) builds are broader in scope, beyond the air interface, to embrace the RAN, transport network and a new 5G core. Crucially, SA requires operators to deploy a completely new core network only defined in the first 5G standards finalised in June 2018. Given the typical lag of 18 months from standard completion to commercial introduction of a new technology, the new 5G core will be used in trial deployments globally over the course of 2020 and will have widespread commercial deployments from 2021.

5 The forecasts out to 2025 have been updated to reflect the likely impact of the Covid-19 pandemic, with the greatest impact in the short term, while outcomes in the medium term remain largely unchanged.

6 Under an NSA deployment model, operators are able to use existing macro sites and LTE spectrum as an anchor connection, with a densified network of small cells and use of mid-band (1-6 GHz range) and upper-band (above 6 GHz) spectrum to facilitate high-speed data.

Although it may initially have higher costs, a key differentiator of the SA approach is that it allows operators to realise all the potential capabilities of 5G. These include network slicing (multiple logical networks on a single physical network) and ultra-reliable and low-latency transmission. This set of features makes an SA deployment more suitable for addressing the enterprise market, which is a crucial aspect of many operators' plans for 5G in Canada. While it is generally accepted that NSA is cheaper to deploy in the short term, SA may offer longer-term capital efficiencies while also avoiding the need to go through a second round of hardware and software upgrades, which NSA would need to as part of the inevitable migration to SA.

Table 2

Comparison of main features of SA and NSA

	Standalone	Non-standalone
Deployment period	2021 onwards (mainly 2022 and beyond)	2019 onwards
Network core	New 5G core (5GC) controlling 5G RAN (new radio (NR))	4G core (evolved packet core (EPC)) controlling 4G RAN (LTE) and 5G RAN (NR)
Use case	All use cases including IoT* and ultra-reliable low-latency communication	eMBB
Ultra-low-latency capable	Yes (around 1 ms)	No (around 5 ms)
Spectrum	5G RAN deployed in new frequency bands	Existing LTE network provides coverage, NR deployed on new 5G spectrum

*Massive IoT supported in future 3GPP releases but also available in some NSA scenarios.
Source: GSMA Intelligence

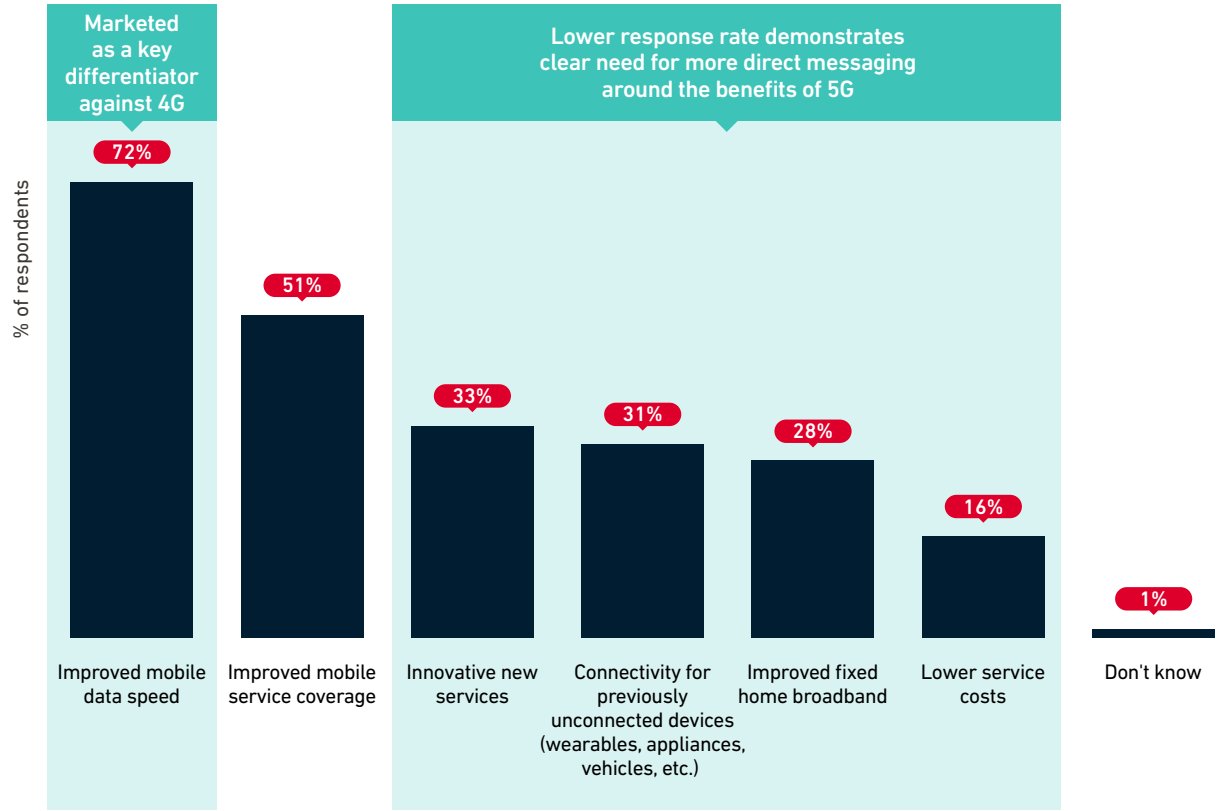
Consumers will have their expectations met, but will need to wait for the full 5G experience

Consumers in Canada already benefit from some of the fastest LTE networks in the world, but they also expect 5G to deliver a noticeable improvement in network speeds. Improvements in network speeds and mobile coverage are the two most common expectations among consumers in developed markets, which reflects the typical consumer experience from previous shifts in mobile generations. However, the expectation for higher speeds is especially apparent in Canada, as highlighted in the results of a GSMA Intelligence consumer survey conducted in 2019, with the results for Canadian respondents summarised in Figure 6. This provides both an opportunity and a challenge for operators as they look to deploy 5G and monetise the new service.

The lesson from the US is that operators using low-band spectrum for 5G (such as AT&T on 850 MHz) struggle to offer speeds that are higher than those currently delivered by LTE networks. Consumers in Canada may therefore be unable to experience the full speeds of 5G until the 3.5 GHz spectrum is available for use, with the auction currently not expected until June 2021.

Figure 6

What consumers in Canada expect 5G will deliver



Source: GSMA Intelligence Consumers in Focus Survey 2019

5G networks also offer the promise of a range of new and enhanced consumer experiences, drawing on higher data throughput and lower latency. Around a third of those we surveyed in Canada see this as a key opportunity for 5G, which falls in line with the developed world average but trails some of the leading 5G markets such as South Korea (54%) and China (43%).

These new services could include 4K and 8K ultra-HD video, 3D video, holograms, AR/VR, applications for gaming and immersive TV, and digital services and content for connected stadia and smart cities. A number of these have already had initial trials in Canada, with further trials in use cases such as AR/ VR expected over the next 12 months.

The enterprise market is the main new focus for 5G use cases

5G will enable a range of new services for businesses, including remote monitoring and industrial applications, edge computing and AR/VR. These will need to complement the broader move to enterprise digitisation and transformation that is already underway. Enterprise transformation is being led by a number of players across the ICT sector, including cloud providers, software companies and systems integrators. In common with operators in other markets across the world, mobile operators in Canada see 5G as an opportunity to better address the enterprise services market and gain incremental revenues. While the precise role of operators in many of the emerging use cases is still to be defined, there is an opportunity for operators and other ecosystem players to develop new revenue streams and expand the range of services they provide from the current focus on the provision of public and private connectivity.

Digital Innovation Hubs in Canada

Operators and other ecosystem players in Canada are undertaking trials to explore the potential of 5G. One example is highlighted below.

ENCQOR 5G is a public-private partnership focused on research and innovation around 5G. The project brings together industry players, SMEs, the public sector, centres for innovation and universities in order to unlock the technological promise of 5G and to help drive future economic growth in the country. ENCQOR 5G has signed MOUs with six telecoms operators to support its work, including Bell, Rogers, TELUS and Videotron.

The partnership has created five Digital Innovation Hubs, located in both Ontario and Quebec, providing a 5G platform where SMEs can develop and test new solutions. The goal is to allow companies to undertake pre-commercial services and then scale their offerings as the networks and devices become more widely available.

5G will facilitate new opportunities and applications for businesses across almost all sectors of the economy. Four broad categories of use cases will be enabled, each taking advantage of one or more of the innovations that this new mobile generation will enable. Table 3 describes each use case, along with the business needs that are addressed and the verticals where they will be implemented.

Table 3

5G use cases and descriptions

Use case	Description	Business need	Verticals
Fixed wireless access (FWA)	5G will allow network operators to deliver ultra-high-speed broadband to suburban and lower-density areas, supporting home and business applications where fibre is prohibitively expensive to lay and maintain. This will allow broader communities to be connected to the internet via an ultra-fast and reliable connection, bringing applications like telemedicine and remote education to more people. 5G FWA can therefore provide the benefits of fibre-like connectivity to rural communities.	Alternative to fibre connection	Education, healthcare, public administration, utilities
Enhanced mobile broadband (eMBB)	5G will provide the capacity to handle growing data traffic and grant operators an opportunity to develop new and improved services to consumers. This will enable a new range of applications, including highly reliable mobile internet services for mass gatherings and sports events – where current mobile technology is often stretched to the limit of its capabilities – and AR/VR applications that improve the customer experience in, for example, retail by supporting or even replacing traditional showrooms.	Immersive experience (AR/VR) 4K/8K streaming on mobile Increased service capacity	Retail, public administration, arts and events
Ultra-reliable low-latency communication (URLLC)	Low latency and high reliability will enable new applications in the fields of manufacturing, logistics, health and transportation. These applications include autonomous driving, connected robotic applications, AR/VR, drones and surgical/medical remote operations.	Autonomous driving Safety-critical applications Remote manufacturing Remote healthcare	Manufacturing, utilities, oil and gas, transport, healthcare
Massive IoT (mIoT)	5G will be able to facilitate a large network of IoT devices, supporting the creation of smart cities, smart infrastructures and, in the utility sector, smart grids capable of self-identifying issues on the networks. In the agricultural sector, farmers will benefit from the potential of a vast collection of sensors located directly in fields that are able to identify with pinpoint precision which areas need water, have disease or require pest management.	Remote control of crop conditions Advanced manufacturing Smart cities	Agriculture, utilities, manufacturing, public administration

Source: GSMA Intelligence

5G will also bring challenges for operators as they look to develop these new use cases and partnerships. As outlined previously, operators are already active in trials and many are investing in startups to develop new use cases and routes to monetise the potential of 5G. However, there are still knowledge and expectation gaps within the consumer and enterprise communities that operators must address if 5G services are to transition and scale from test cases to full deployments.

A particular challenge facing incumbent operators relates to the scale and cost of moving to a fully virtualised 5G network architecture, as well as the cost of deploying additional features such as edge computing capabilities. Operators would typically seek a robust business case with clearly identified revenue sources and sizes before embarking on significant new investments, such as the move to deploy distributed edge/cloud infrastructure. While this may appear prudent from a purely financial perspective, it can create inertia around new initiatives. In the rapidly evolving world of 5G and industry digitisation, it may lead to operators foregoing the opportunity completely. This may be a particular challenge in markets such as Canada, which trails the global and regional leaders in 5G deployments and, as a result, risks missing the opportunity to gain new revenues from emerging 5G services.

FWA solutions in Canada

5G-based FWA is a last-mile solution to provide broadband connectivity to consumers and enterprise customers, and one of the use cases identified for 5G. Commercial services have already been launched in a number of regions, including the US and several European markets. Indeed, on a global level just under half of all commercial 5G networks at the end of Q1 2020 offered 5G FWA.

FWA using the existing LTE networks is already in service in the Canadian market, with offerings from both the national players and also fixed wireless service providers (such as Xplornet and Corridor Communications), mainly targeted at providing broadband coverage in rural areas. 5G FWA has the potential to enhance this offering with higher speeds while also providing a capex-efficient solution to consumers (and enterprises) in urban areas. Data from the Canadian Radio-television and Telecommunications Commission indicates that in 2017, 84.1% of the Canadian population could receive broadband speeds in excess of 50 Mbps download and 10 Mbps upload; in rural areas this figure fell to 37.2%.[7] 5G as a mobile offering and 5G FWA can help to address this digital divide.

The potential for localised and targeted deployments, as opposed to ubiquitous rollouts, is even clearer when viewed against the backdrop of the potential cost for the requisite cell densification versus income constraints for many consumers. The economics of FWA will be highly sensitive to factors such as the uptake by households per site, as well as average revenue per subscriber.

7 *Communications Monitoring Report 2019*, Canadian Radio-television and Telecommunications Commission, 2020

2 The economic impact of 5G in Canada

5G will boost Canada's productivity and drive economic growth

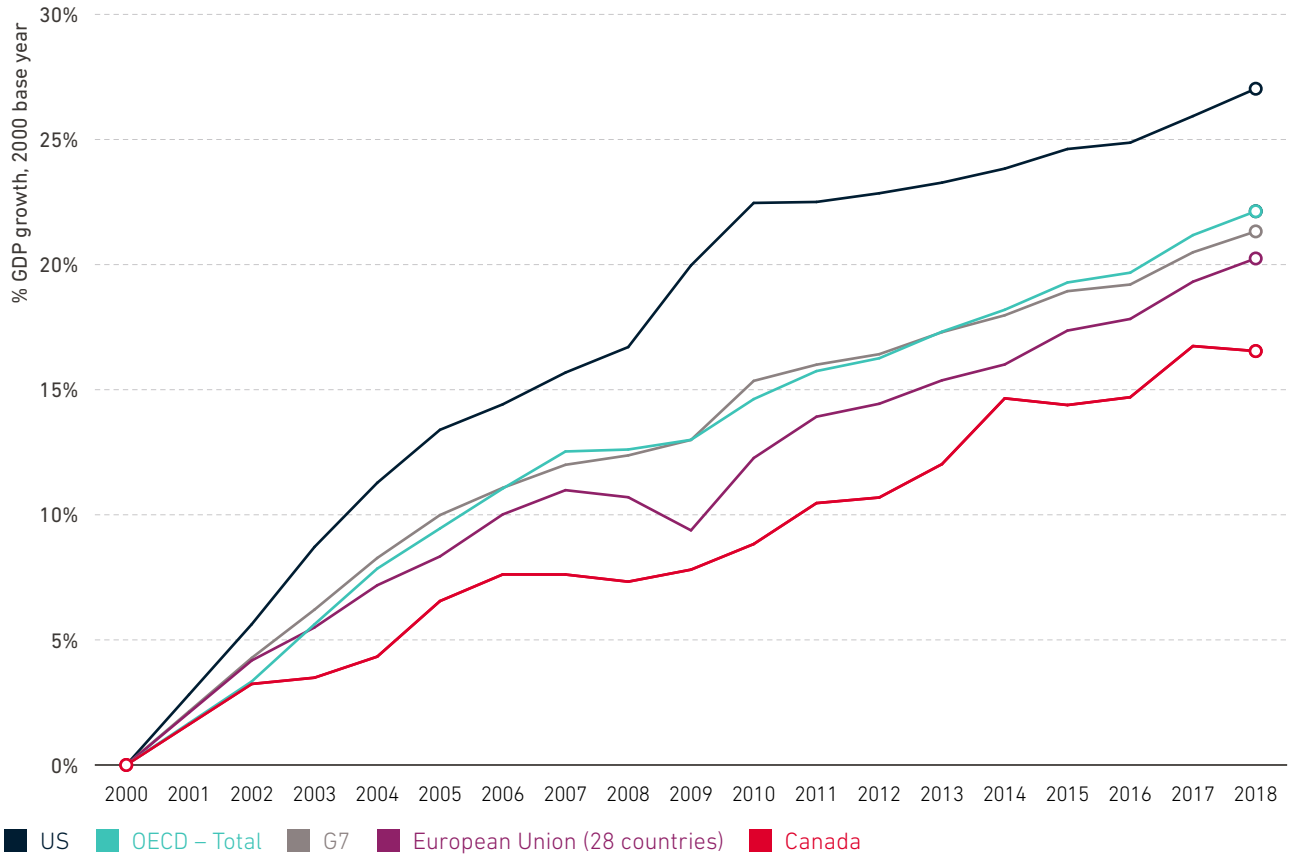
Canada has a thriving economy that includes a diverse range of world-leading industries, such as aerospace, oil and gas extraction, and information technology. Despite international trade tensions, including the renegotiation of the North American Free Trade Agreement (NAFTA), Canada's economy experienced above average growth rates in 2017 and 2018. However, significant headwinds have emerged since, first in the form of turmoil in the oil market in late 2019, followed by the devastating impact of the Covid-19 pandemic.

While macroeconomic conditions may improve in the medium term, a bigger threat to the competitiveness of Canada's economy in the long term is the stagnant growth in productivity. In the past two decades, productivity has performed poorly, relative to both historical and international benchmarks.

Figure 7 compares labour productivity growth between Canada, the US, G7 countries, the European Union (28 countries) and the OECD. Canada has been outperformed consistently throughout the whole 20-year period.

Figure 7

GDP per hour worked, constant prices, cumulative growth



Source: OECD Compendium of Productivity Indicators 2019

As a result, Canada's average labour productivity in 2018 was $50 GDP per hour worked, below the OECD average of $54. By contrast, the US produced roughly $65 in GDP per hour worked. And the fastest-growing OECD country in the past three decades, Ireland, stands at $84 GDP per hour worked. This means that with the same amount of labour, Canada is able to produce less output (GDP) than other countries.

Investment in technology, including ICT and telecommunications infrastructure, are of paramount importance to boost Canadian productivity and provide additional sources of economic growth. 5G technology, with its range of use cases applied to industry, advanced services and ICT, has the potential to be a major driver of change.

Compared to currently available 4G /LTE technology, 5G networks will provide 10–100× faster data rates at latencies up to 10× smaller.[8] This improved performance will come from a more advanced core network and the use of more efficient radio technologies (i.e. spectral efficiency), more spectrum bandwidth (i.e. spectral capacity) and greater network densification (i.e. spectral reuse). 5G is developing in parallel with rapid advancements in AI and IoT: the combination of flexible, high-speed and low-latency 5G networks with AI and IoT will enable new applications and use cases in almost all sectors of the economy, with considerable potential to deliver significant productivity and growth opportunities.

8 Network latency is defined as the time required for a set of data to travel between two points. A network with high latency can be inefficient for some applications, such as gaming and AR/VR, where high network latency can result in lag, which creates a delay between the action of the players/operators and the actual responses within the game/application.

5G will unlock $150 billion of additional GDP growth over the next 20 years

As one of the most developed economies in the world, Canada has a lot to gain from a 5G rollout. To assess this potential, we developed an economic model that estimates the additional impact of 5G on Canada's GDP and sector-by-sector implications in the medium to long term.

For the purposes of this study, we estimate the macroeconomic effects of 5G in Canada based on the results of a recent econometric assessment[9] that finds that, on average, a 10% increase in mobile adoption increased GDP by 1%. Furthermore, the study shows that this effect increases by approximately 15% when connections upgrade from one mobile network technology to another (in this case, from 4G to 5G). These findings are in line with most studies conducted to date: they identify positive and statistically significant effects of mobile technology on economic growth.[10]

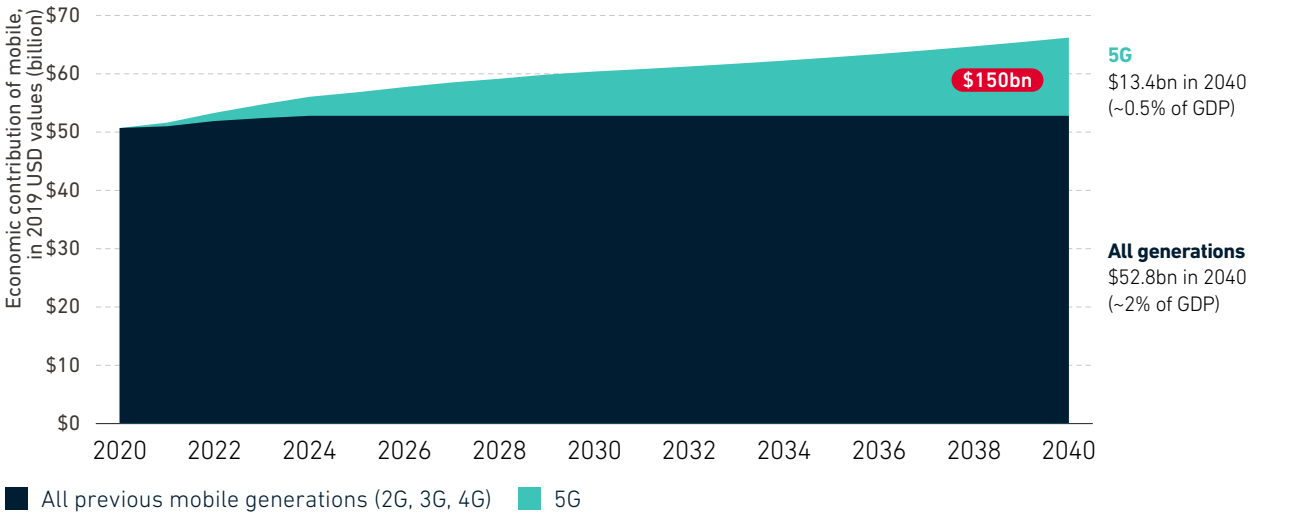
These results are combined with the expected adoption profile of 5G technology in Canada (see Figure 5) to calculate the additional impacts that will be delivered in each year between 2020 and 2040. Finally, these economic benefits are distributed across each sector of the Canadian economy based on both the readiness of each sector to adopt new technologies and on the relevance of the identified 5G use cases for each sector. This provides an indication of the sectors that will benefit the most from the 5G rollout. The annex discusses the methodology in detail.

For the whole period 2020–2040, we estimate that 5G networks will deliver a total of approximately $150 billion in additional value add to the Canadian economy (see Figure 8). Overall, taking into account the productivity boost delivered by mobile technology uptake and subsequent network upgrades from 2G to 5G, the use of mobile technology by firms in Canada will deliver in excess of $65 billion per year in 2040, equivalent to 2.5% of Canada's GDP in that year. Figure 9 shows the total economic contribution of mobile over the period of analysis (2020–2040).

If normalised over the timeframe of the analysis, these results also mean that, on average, 5G will bring an additional annual contribution of $7 billion to Canada's GDP; for comparison, the aerospace industry contributes around $8 billion per year to the Canadian economy, the chemical industry around $5 billion per year, and the animal production sector around $5 billion per year.[11]

Figure 8

Additional economic impact driven by 5G across Canada



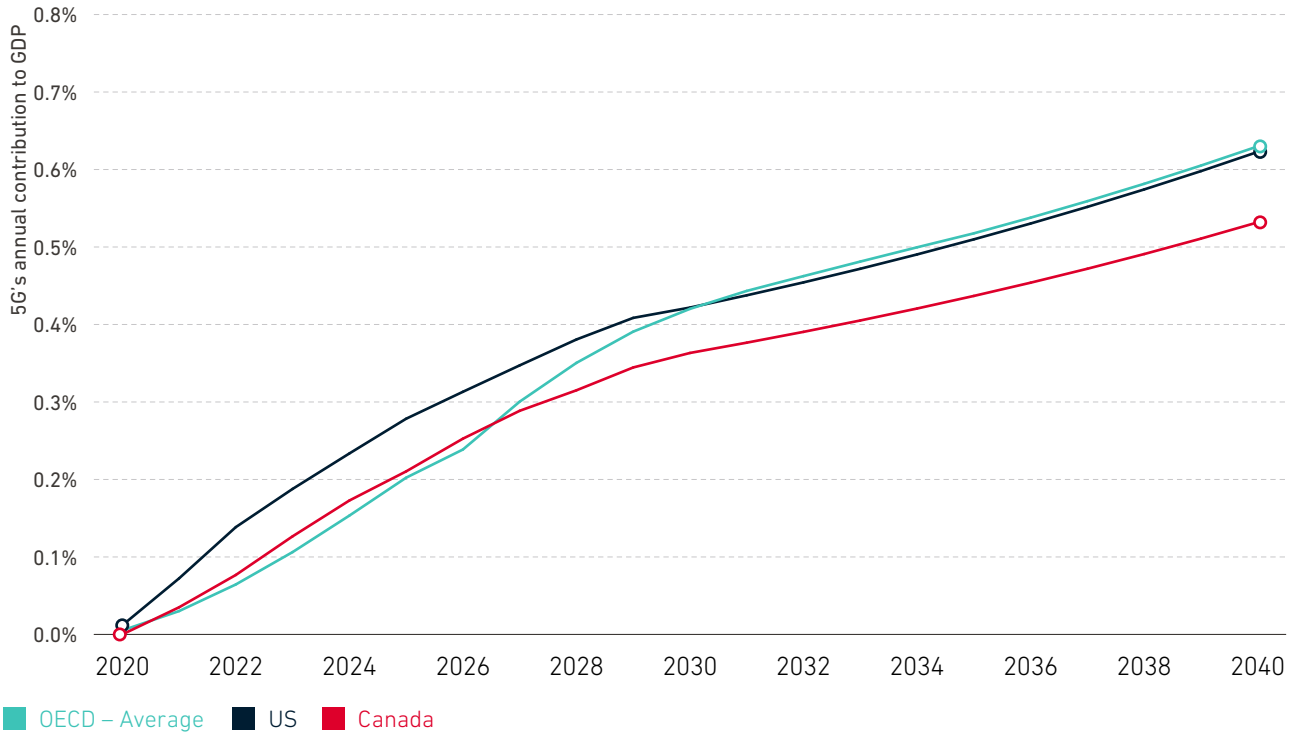
Source: GSMA Intelligence

9 *Mobile technology: two decades driving economic growth*, GSMA Intelligence Economic Research Working Paper, by Bahia, K., Castells, P. and Pedros, X
10 See for example "How important are mobile broadband networks for the global economic development?", 2018, Information Economics and Policy, 45, pp. 16–29, Edquist, H., Goodridge, P., Haskel, J., Li, X. and Lindquist, E.; and "The economic contribution of broadband, digitization and ICT regulation", 2018, Expert reports series, ITU, Katz, R. and Callorda, F.
11 Statistics Canada: Table 36-10-0434-06 Gross domestic product (GDP) at basic prices, by industry, annual average

Despite these large impacts on economic growth, the economic effects of 5G in Canada are not predicted to materialise at the same levels as in the US or other OECD countries (Figure 9). As we discuss in Section 3, the conditions that incentivise the large investments needed for next-generation networks differ significantly in Canada compared to benchmark countries, leading to impacts on GDP being below the potential of 5G on the economy.

Figure 9

Additional economic impact driven by 5G as a percentage of GDP



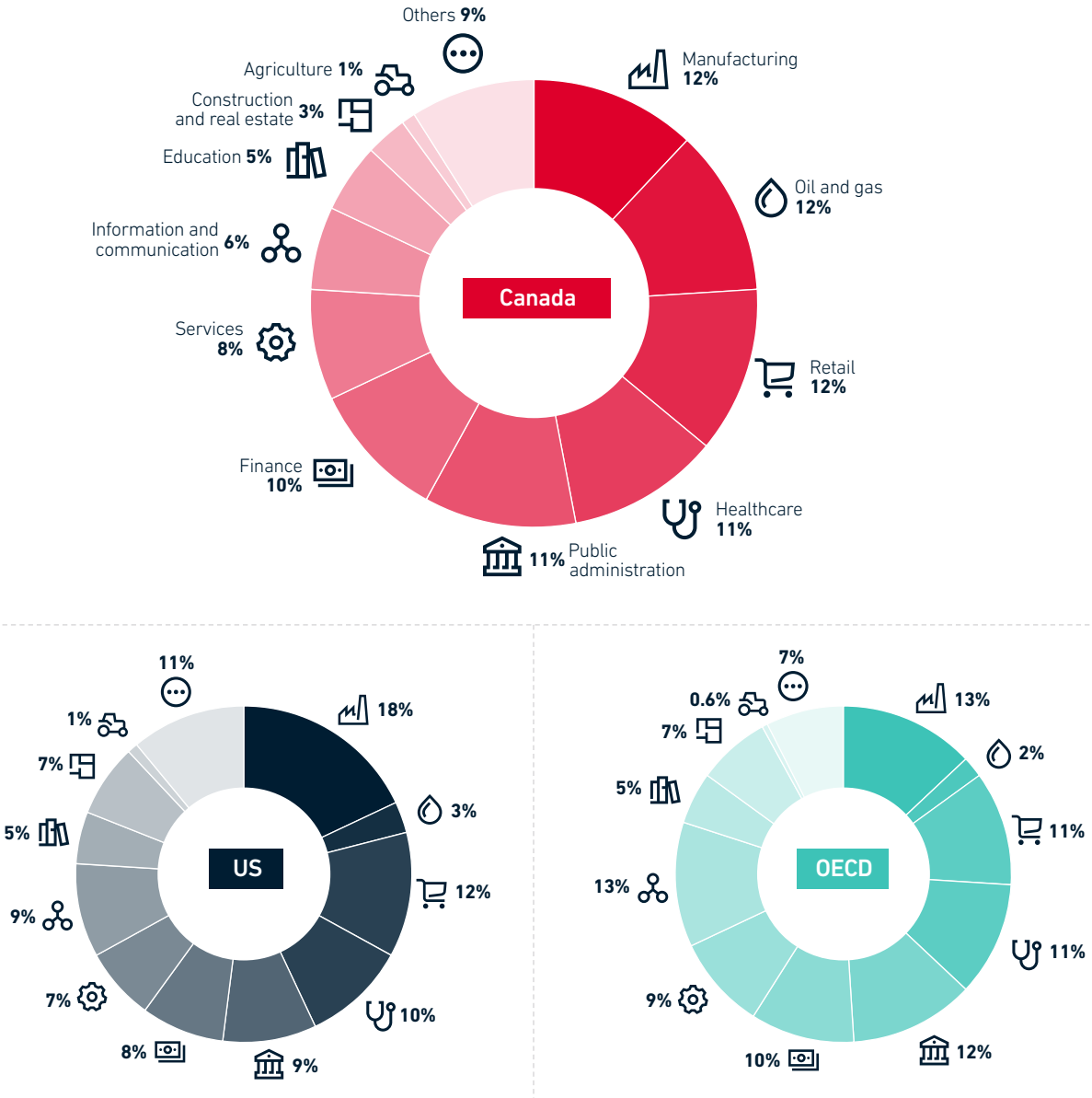
Source: GSMA Intelligence

Large impacts distributed across most sectors

Not all Canadian economic sectors will benefit equally from the rollout of 5G. The readiness of each sector to adopt new technology will play an important role. Another factor is the extent to which use cases enabled by 5G are applicable to the sector. In Canada, the economic impact of 5G will deliver the overall greatest boost to the manufacturing, oil and gas, healthcare and retail industries (Figure 10). The distribution of overall 5G benefits in Canada is broadly in line with the US and OECD average, with the exception of the oil and gas sector in Canada (12% versus 2% (US) and 3% (OECD)) and the information and communication sector (6% versus 13% (US) and 9% (OECD)). These differences are mostly related to the size and relevance of the two sectors in the Canadian economy. The oil and gas industry represents a larger share of Canada's economy than in OECD countries and the US, while the information and communication sector's role on the overall economy is smaller in Canada than in most OECD countries and the US.

Figure 10

5G benefit distribution, by sector – Canada, the US and OECD average



"Other" includes transport, accommodation and food, utilities, and arts, entertainment and recreation.
Source: GSMA Intelligence

Oil and gas sector

5G will play an important role in helping Canadian oil and gas businesses improve operational efficiency, reduce costs and increase profitability. Our model foresees a sector-GDP uplift of almost $16 billion in additional value add over the period 2020–2040, mostly driven by gains in the oil industry – $15.6 billion – and supporting activities.

The use of IoT sensors in combination with real-time HD video can help companies make smarter, proactive and cost-efficient decisions when it comes to maintenance. By establishing a centralised operations control centre, oil and gas companies can concentrate the knowledge and intelligence of operations engineers to better predict and resolve problems before they arise. These technologies are not new, but the demands of industrial monitoring and remote operations technology are approaching the limits of existing communication networks. Through a 5G network, connection reliability and information security can be improved, allowing oil and gas operators to deploy more pervasive sensors and monitoring devices to transmit more data in real time through a more reliable infrastructure. This could reduce unplanned downtime and the risk of catastrophic disasters associated with equipment or facility failures that can have large impacts on employee safety, the natural environment in which these companies operate and, eventually, the financials of the companies themselves.

Agricultural sector

Canada's agricultural industry is mostly focused on the production of crops, which represent around 70% of the sector's contribution to the economy. Over the last few decades, Canada's agriculture sector has specialised in the production of canola, of which 90% is exported to markets around the world.

Canola and crop farming in general require careful oversight of cropland to promote the growth and yield of successful crops while fighting invasive plants, harmful insects and disease. This includes the use of fertilisers and pesticides that are currently sprayed using manned aircrafts or tractors. This approach is proven to be often ineffective, as over- or under-spraying certain areas puts not only crops at risk but also human health and the wider environment.

5G can help improve current farming techniques by enabling 'precision agriculture', a farming management technique that aims to micro-optimise agricultural processes and practices through the massive collection, analysis and utilisation of data about soil, crops, labour, weather, pesticides and more. Although some of the technologies associated with precision agriculture are already commonplace in many large-scale farming operations across Canada, 5G's promise of eMBB, greater throughput and the proliferation of sensors will enable the scaling of current use cases to capture significant additional benefits.

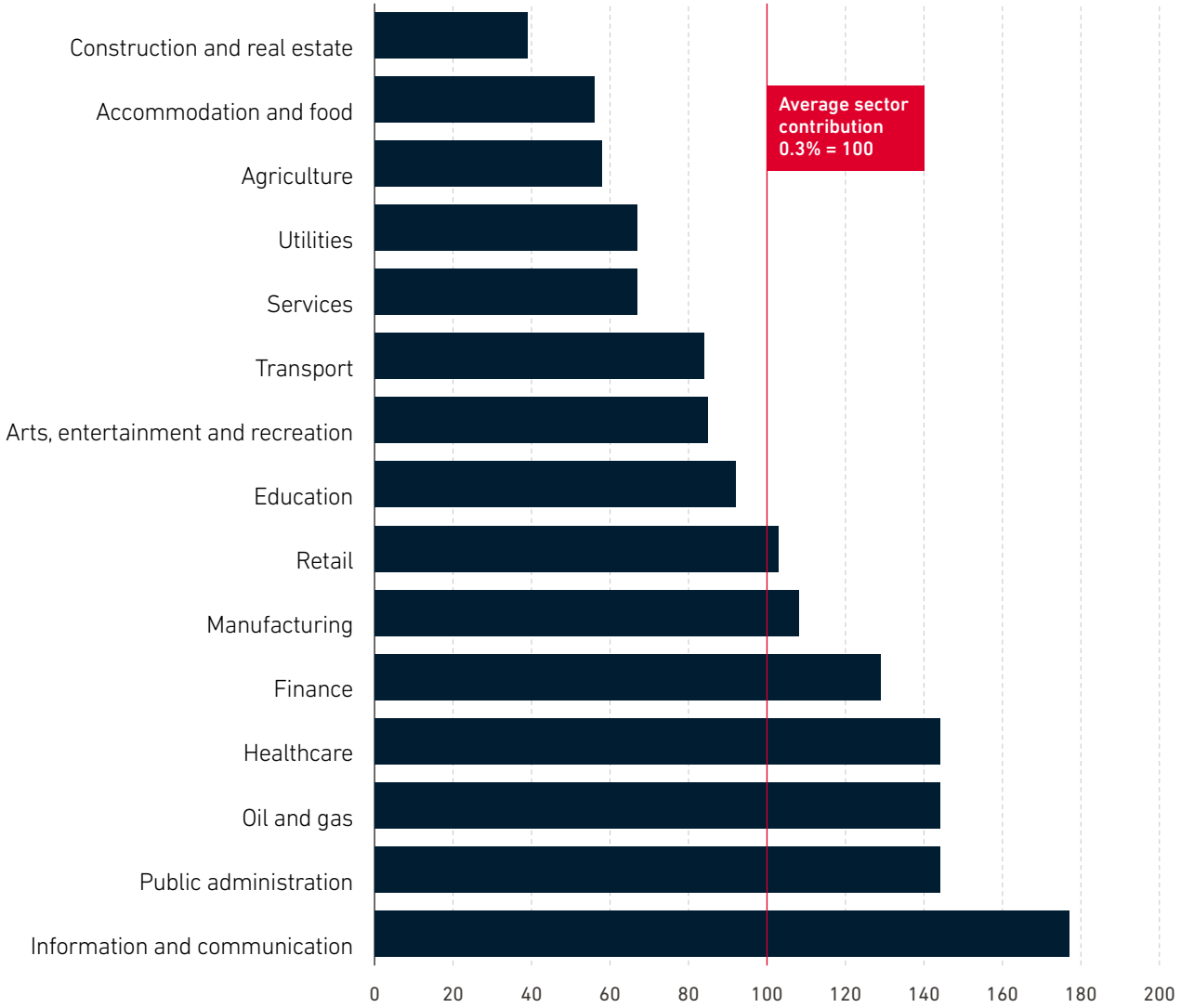
This will help farmers gauge the need for fertiliser and pesticides – minimising the use of pesticides is becoming a priority for farmers and the food industry – which will reduce costs, increase quality and protect the ecosystem.

In order to understand the relative impact of 5G on each individual sector (i.e. the extent to which 5G technology will drive faster growth in some sectors than others, regardless of their current overall importance of a sector on Canada's GDP today), we compared the impact of 5G within a sector to each sector's contribution to overall GDP today (Figure 11).

Figure 11

5G economic benefits as a percentage of sector value add

(100 = economy average)



Source: GSMA Intelligence

The analysis indicates that in relation to its current contribution to GDP, the information and communication sector stands to benefit the most from the 5G rollout. This is due to the new wave of applications that will drastically change the way we will communicate in the future thanks to 5G, including rural areas being connected.

The public administration sector will also benefit greatly because of 5G's ability to support new smart city applications, which will allow public administration cost savings and increased efficiency. Similarly, the benefits for the oil and gas sector will be above average because of the new applications that will be enabled by faster, more reliable and smarter mobile connectivity. Healthcare is another sector that is expected to benefit more than other sectors from the 5G rollout, as described below.

Healthcare sector

Healthcare organisations in Canada will be boosted by the use of 5G technology, generating an additional $16 billion in value add for the entire period 2020–2040. This makes healthcare one of the sectors that stands to benefit the most from the 5G rollout. Several factors explain this:

- 5G will allow a further extension of telemedicine, especially into rural areas. Currently, telemedicine requires a network that can support real-time high-quality video. With 5G, healthcare systems will be able to regularly handle telemedicine appointments.
- 5G's low latency will be a game changer for the use of AR/VR and spatial computing for surgical/medical operations. While AR/VR and spatial computing are already being used in healthcare on a limited basis, 5G will further enhance a doctor's ability to deliver innovative treatments.
- 5G will enable an extended network of IoT devices, including medical ones. By using IoT devices, healthcare providers will be able to monitor patients and gather data that can be used to improve personalised and preventive care. Remote monitoring technology usage is currently limited by the capacity of the network to handle the data. With 5Gs low latency and high capacity, healthcare systems will be able to offer remote monitoring more widely, delivering benefits to residential care and social services facilities, with up to $4 billion in savings associated with new 5G applications.

The nature of 5G's economic benefits will change significantly over time

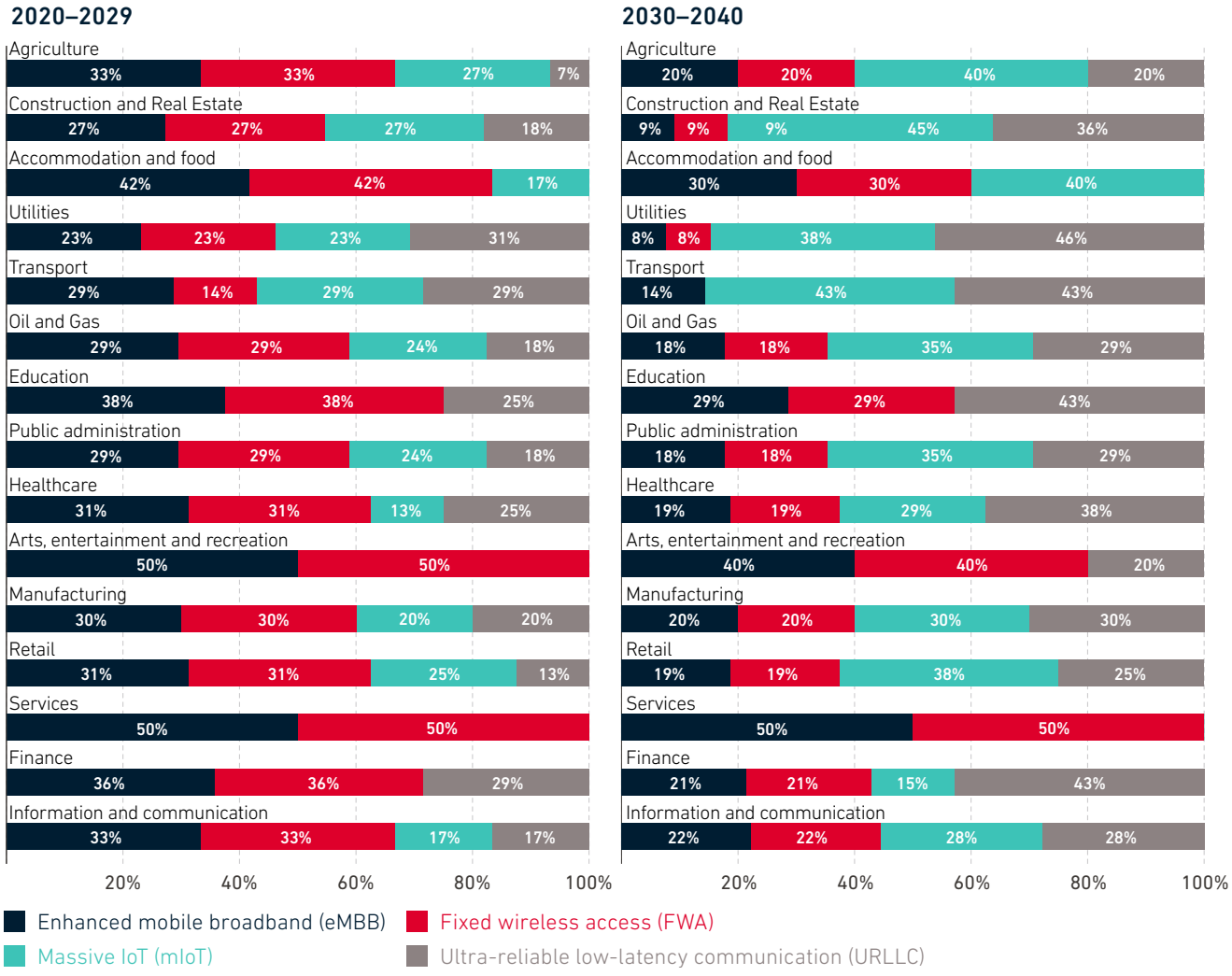
The productivity impact of 5G on each sector will vary over time. In the first decade of our analysis, between 2020 and 2030, eMBB and FWA will be the most extensively implemented use cases and the drivers of the main economic benefits across most sectors. In particular, the ability to provide fast and reliable connections to more consumers, in urban and rural areas, will have positive impacts across services, retail, public administration, education and information and communication.

Figure 12 shows the impact of the four use cases by sector. In the first decade (2020–2029), enhanced mobile broadband (eMBB) and fixed wireless access (FWA) will enable the applications that will drive the majority of the benefits. In the second decade (2030–2040), massive Internet of Things (mIoT) and ultra-reliable low-latency communication (URLLC) applications will play an increasingly central role in driving the economic benefits of 5G across some of the sectors.

After 2030, most of the 5G use cases will reach maturity in Canada, including URLLC and mIoT, taking advantage of reduced delay performances of 5G networks and their ability to support large IoT networks. The associated applications of these use cases, including smart cities, smart agriculture, intelligent transportation and utility management, will drive most of the impact in sectors such as services, public administration, transport and oil and gas.

Figure 12

Benefits by sector, by use case weight



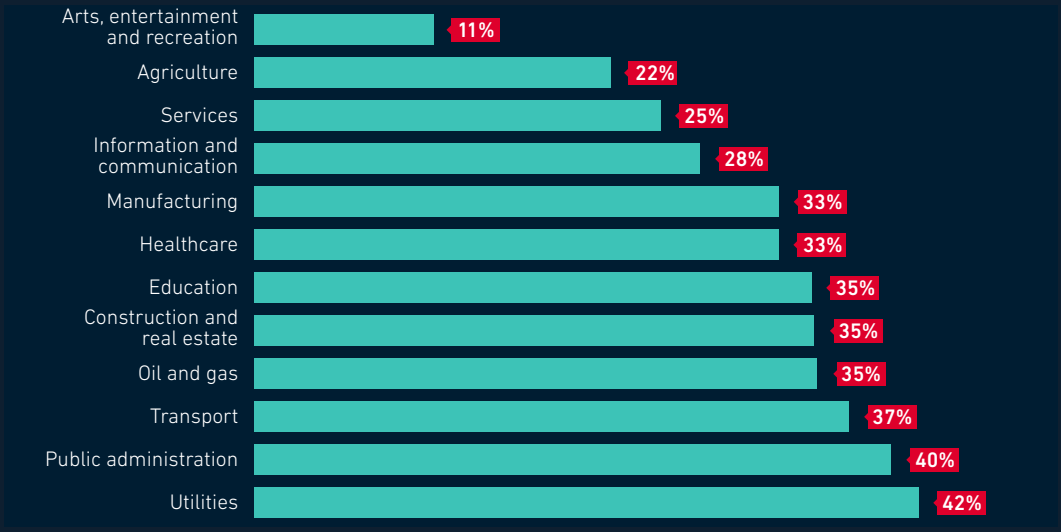
Source: GSMA Intelligence

Massive IoT and the electrical grid

One of the most highly anticipated applications related to 5G is the possibility to support mIoT networks, which are capable of enabling smart cities and utility management applications. As shown in Figure 13, the impact of 5G on the utilities, public administration, transport and oil and gas industries is heavily dependent on the successful implementation of mIoT use cases.

Figure 13

mIoT-driven share of 5G benefit by industry, 2020–2040



Source: GSMA Intelligence

Energy consumption per person in Canada is expected to decrease in the next 20 years because of many factors, including greater energy efficiency and a more efficient electrical grid.[12]

mIoT will enable greater demand-side energy management, supporting load balancing, helping reduce electricity peaks and ultimately lowering energy costs. Consumer devices will also allow better visibility into residential energy use, enabling households to take more proactive steps in managing consumption. Densifying smart grids with 5G sensors will also enable self-healing capabilities of future smart grids that can diagnose maintenance issues in real time and automatically react to avoid outages.

Cities can also utilise 5G networks in the deployment of smart street lighting, especially as more vendors start to integrate 5G and advanced sensors into new lighting poles. Smart lighting systems consume 50–60% less energy than traditional lamps due to the use of LED and the increased capability to adjust brightness.

5G-enabled smart grid pilots are currently ongoing in different parts of Canada, including in New Brunswick, where the provincial government is working with Siemens on smart grid technology to develop a world-leading demonstration grid.

12 Canada's Energy Future 2019, Canada Energy Regulator

3 5G spectrum policy and economic growth

From virtual reality to artificial intelligence and autonomous cars, 5G has the potential to help address Canada's slow productivity growth and deliver new and innovative services for consumers. However, the speed of rollout, as well as the adoption, reach and quality of 5G services, will be heavily dependent on an appropriate regulatory and policy environment being in place. This must allow conditions that incentivise the large investments needed in next-generation networks.

To obtain the full macroeconomic dividends that 5G technology can bring, policymakers and the industry will need to address a number of obstacles. In most countries this includes regulatory barriers to access site locations or the need to facilitate the deployment of new small cells[13] and backhaul solutions[14]. Governments and regulators should also adopt national spectrum policy measures to encourage long-term investments in 5G networks. This includes having long-term licences, a clear renewal process and a spectrum roadmap, as well as avoiding policies that artificially inflate spectrum prices.

Central to this enabling policy environment – and a particular challenge in Canada – is the need to offer timely access to the right amount and type of spectrum. Without sufficient spectrum across low-, mid- and high-spectrum ranges, it will not be possible to deliver 5G services that provide widespread coverage and support all potential 5G use cases.

13 5G will require denser networks, involving in some areas the deployment of equipment on poles, towers, rooftops and also at the street level, utilising street furniture and light poles as physical infrastructure.
14 Increased network requirements will require higher capacity wireless backhaul links per cell site.

Key 5G spectrum bands are not available yet in Canada

5G needs a significant amount of new harmonised mobile spectrum, so defragmenting and clearing key spectrum bands should be prioritised. In particular, 5G networks need a combination of spectrum across low- (sub-1 GHz), mid- (1–6 GHz) and high-bands (above 6 GHz).

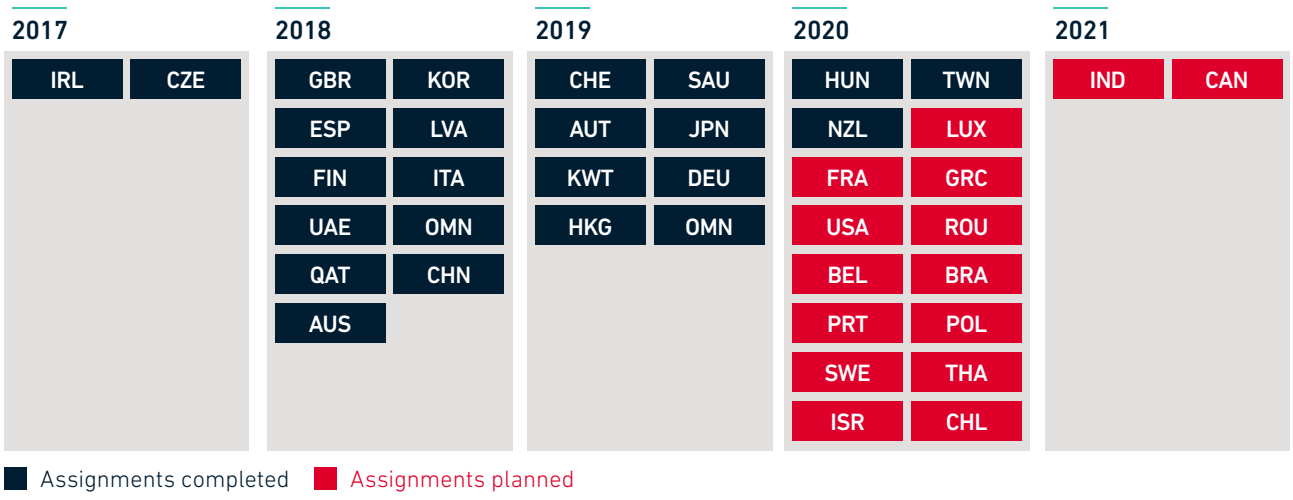
Regulators should aim to make available at least 80–100 MHz of contiguous spectrum per operator in prime mid-bands (e.g. 3.5 GHz) and around 1 GHz per operator in high-bands (e.g. mmWave spectrum). At a global level, the 3.5 GHz band has clearly emerged as a key band for 5G; there are currently 23 countries[15] that have already assigned spectrum in this band and in 17 of these countries, 5G networks have been launched using this frequency. In Canada, however, the release of spectrum in the 3.5 GHz band is currently scheduled for June 2021.

Figure 14 shows that Canada is significantly lagging behind most of the comparable markets when it comes to the assignment of the 3.5 GHz band. Globally, the first market to license 5G spectrum in this band was Ireland in 2017; other markets, including the UK, South Korea and Spain, then followed suit. Even countries with less mature mobile markets, such as Poland, Brazil and Romania, have plans to assign the band for 5G use before Canada. By June 2021, 37 other countries will have already assigned 3.5 GHz spectrum.

Because of the critical importance of the 3.5 GHz band to the deployment of the first wave of 5G services, coupled with the delay of the assignment of the band in Canada, 5G adoption levels in Canada will lag behind those of other countries, at least in the first few years of rollout.

Figure 14

Global spectrum assignments in the 3.5 GHz band



Data correct as of end-Q2 2020
Source: GSMA Intelligence

While 5G is not a race, countries that assign spectrum earlier and facilitate the investments needed are expected to be able to deliver benefits to consumers, businesses and the overall economy sooner. This is especially important in the mobile market, where long-term value, innovation and cost reductions are driven by relatively short network technology cycles of approximately 8–10 years. For example, 4G delivered a new set of services to consumers and businesses, including high-speed mobile broadband, video and live TV streaming or mobile videoconferencing. As discussed in the previous section, 5G will deliver additional benefits for consumers and businesses in the form of a wide range of transformative use cases.

In a recent study conducted by GSMA Intelligence,[16] we found clear empirical evidence that the timely release of sufficient amounts of spectrum is vital to ensuring new services can be launched and existing services can meet consumer demand for high-speed connectivity and data. Making additional spectrum available in a timely fashion should be a top priority for accelerating advanced network deployment to deliver wider economic benefits at industry and macroeconomic levels.

15 24 assignments in 23 countries (Oman assigned spectrum in this band both in 2018 and 2019).
16 The impact of spectrum prices on consumers, GSMA Intelligence, 2019

Assignments of 5G spectrum in Canada are not aligned with international best practice

Spectrum in appropriate bands and in sufficient quantity is a prerequisite for commercial 5G launches. In Canada, general availability of spectrum is a major issue, especially in terms of the 'new' key bands available for 5G deployments.

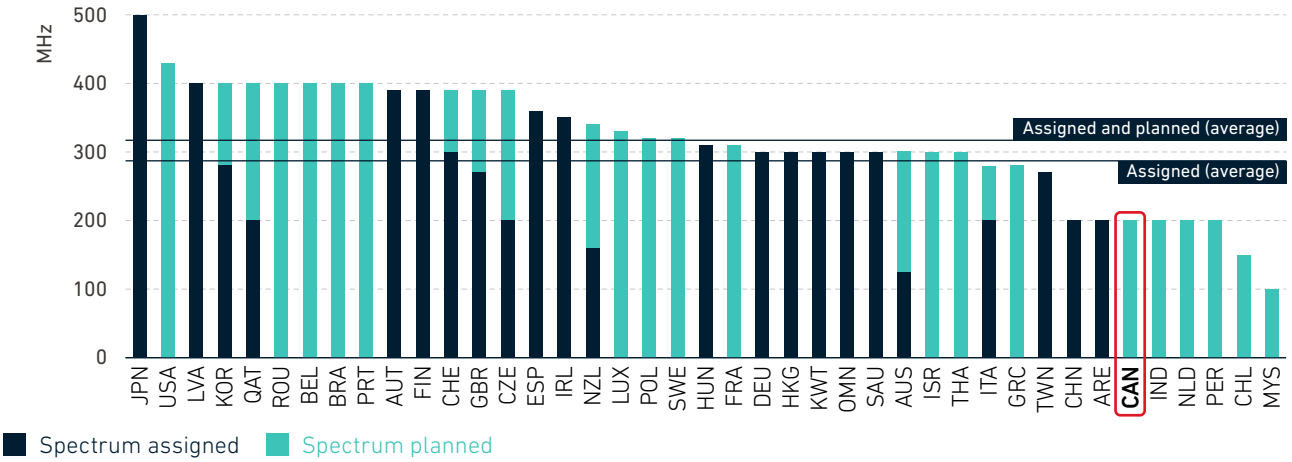
Canada auctioned its 600 MHz spectrum (earmarked for 5G) in 2019. However, the band is still not entirely cleared from incumbent users and Covid-19 related delays are further pushing out its availability for 5G. Further, while the 600 MHz is key for achieving very wide coverage for future 5G networks, there is insufficient spectrum available in the band to deliver the fastest 5G services in most urban areas. Hence, there is a need for mid-bands (e.g. 3.5 GHz) and mmWave bands (e.g. 28 GHz), which can support wider bandwidths. In the absence of 'new' mid-band frequencies, some operators have pushed ahead with deployments in reconfigured spectrum that is already used for 4G. Rogers, TELUS and Bell launched NSA 5G on the 2500 MHz band used for LTE or the AWS band (or both).

Canadian operators will also have access to a limited amount of spectrum in the 3.5 GHz band, with currently only 200 MHz planned for auction[17] and set-asides limiting this to a maximum of 150 MHz for the three national carriers (Figure 15). This is considerably less than the amount of spectrum assigned in leading markets, such as Japan with 500 MHz or most European markets with typically 300–400 MHz per country. For comparison, the US is in line with these benchmarks and will assign a total of 360 MHz in the 3.5 GHz band in 2020.[18]

Apart from the delay in spectrum availability, the limited amount to be assigned poses further constraints for Canadian operators. By design, if it is to work optimally, 5G requires wide contiguous spectrum blocks for operation. To meet the performance requirements associated with 5G usage scenarios, the aim should be to make available 100 MHz of spectrum per operator (according to the ITU[19]). With only 200 MHz planned for release and shared between three national operators and regional players in most geographical areas, this will have an impact on both deployment and the quality of network. Furthermore, in order to deliver high-quality 5G services it is recommended that operators have contiguous spectrum. This will not be possible in Canada even if all the auctions currently planned or being consulted on are completed successfully – some 5G use cases that have extremely demanding network performance requirements may therefore be put at risk. This includes applications such as remote robotics applied in manufacturing, autonomous driving and safety-related applications, and AR/VR.

Figure 15

Amount of spectrum assigned and planned in the 3.5 GHz band globally



Source: GSMA Intelligence

17 In August 2020, the Canadian government launched a public consultation on the potential to make additional spectrum available for 5G services in the 3.8 GHz band. The outcomes of the consultation are unclear at the time of writing this report.

18 The US plans to assign 80 MHz in CBRS in July 2020 and an additional 280 MHz in the 3.5 GHz band in December 2020. There are further plans to release more spectrum after 2020 in the 3450–3550 MHz.

19 Minimum requirements related to technical performance for IMT-2020 radio interface(s), ITU, 2017

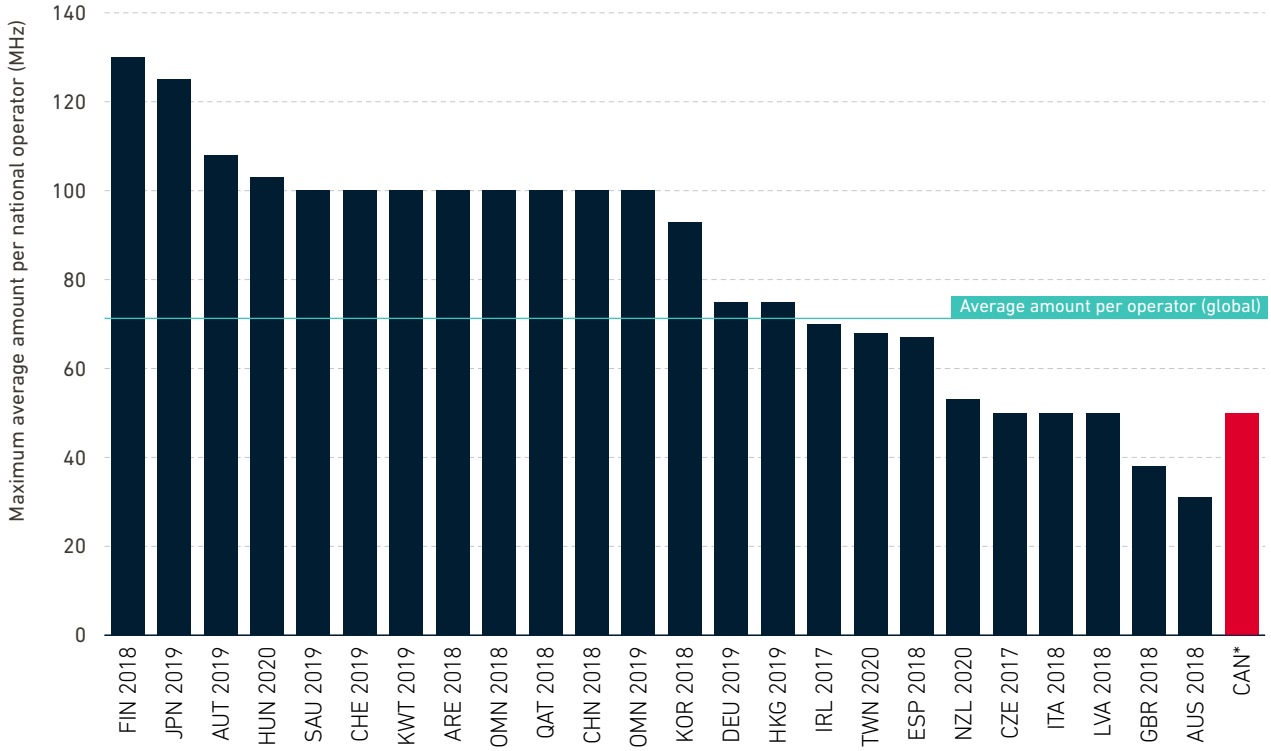
Spectrum set-asides will further reduce the maximum amount of 5G spectrum available for national operators

Where 5G spectrum is held back from the market, commercial 5G services are likely to suffer. A particular concern is set-asides for specific industrial applications, new entrants or regional players in core 5G bands (i.e. 3.5 GHz and 26/28 GHz).

In Canada, the design of the 3.5 GHz band auction includes very significant set-asides and preferential conditions for regional players. Of the 200 MHz put up for auction, 50 MHz of spectrum will be set aside for eligible players, excluding the major national operators.[20] Spectrum set-asides mean national operators and their customers will have access to less 5G spectrum. As a result of the set-asides, national Canadian operators will have one of the lowest amounts of spectrum available globally in the critical 3.5 GHz band to launch 5G services (see Figure 16).

Figure 16

Spectrum assignments in the 3.5 GHz band



*Based on the assumption that the three nationwide operators will win all the spectrum out of the 150 MHz to be assigned. This is an upper bound as regional operators can also bid for this spectrum
Source: GSMA Intelligence

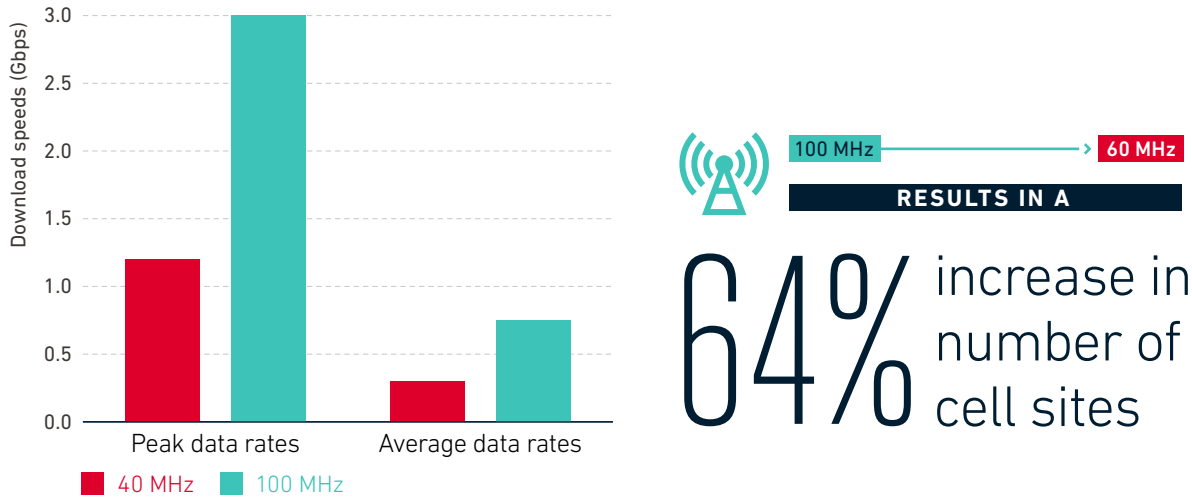
To understand the extent to which set-asides for new entrants are being used by regulators globally, we analysed all the 5G spectrum assignments that had been conducted as of Q1 2020 (34 assignments in 28 countries).[21] Of the 28 countries analysed, two markets (Italy and the US) included a form of reserved spectrum in 5G auctions of low-band spectrum (the 700 MHz and 600 MHz bands respectively), and three markets (Hong Kong, Japan and Germany) put set-asides in place, reserving spectrum for vertical (non-mobile operator) users. No market included spectrum set-asides in 3.5 GHz band auctions with the objective of enhancing further competition in mobile consumer services.

Less spectrum means either slower 5G services or greater investment needed to achieve the same network quality. When less spectrum is available in

20 There is even less spectrum available for auction in rural areas since incumbent fixed wireless providers were allowed to retain significant 3.5 GHz spectrum holdings.
21 These include 24 assignments in the 3.5 GHz band, 8 assignments on 600/700 MHz and 9 assignments on mmWave. Note that some assignments are multi-band so that there are 41 bands assigned across 34 spectrum assignments.

Figure 17

Impacts from the amount of 5G spectrum available on network speed and investment



Source: Nokia, Huawei submission to the European Electronic Communications Committee (2018)

5G bands, the prices paid for licences can also be significantly higher, and this can take capital away from network deployment. Figure 17 shows some examples of the direct impact of making less spectrum available on network speeds and network investments. Less spectrum per operator (for example, 40 MHz instead of 100 MHz) means that operators' mobile networks can host less traffic and provide lower download speeds. Less spectrum (for example, 60 MHz instead of 100 MHz) also means that operators have to deploy more sites, thereby increasing deployment costs.

Canada's 5G spectrum policies are unusual when compared to international benchmarks

Assigning spectrum to those that will be able to extract the most benefit for society as a whole is widely recognised as the main public policy objective of spectrum management. But policymakers can have legitimate reasons for pursuing other objectives when assigning spectrum. In Canada, consumer prices have been the subject of an intense policy debate, with the government making commitments to take steps to reduce consumer prices for mobile services (the evidence of consumer prices being higher in Canada is at best mixed, however, with detailed analysis showing that prices are actually lower than international benchmarks[22]).

Empirical evidence shows that there is a clear trade-off and governments need to recognise this when formulating spectrum policy. In the most detailed econometric study ever conducted into spectrum management, we assessed how spectrum policies had an impact on consumer welfare in 64 countries during the 2010–2017 period.[23] We found clear evidence that spectrum set-asides that limit the supply of spectrum increase spectrum prices, which in turn can cause negative consumer outcomes, including less network coverage and lower network quality.

22 An accurate price comparison of communications services in Canada and select foreign jurisdictions, NERA, 2018
23 The impact of spectrum prices on consumers, GSMA Intelligence, 2019

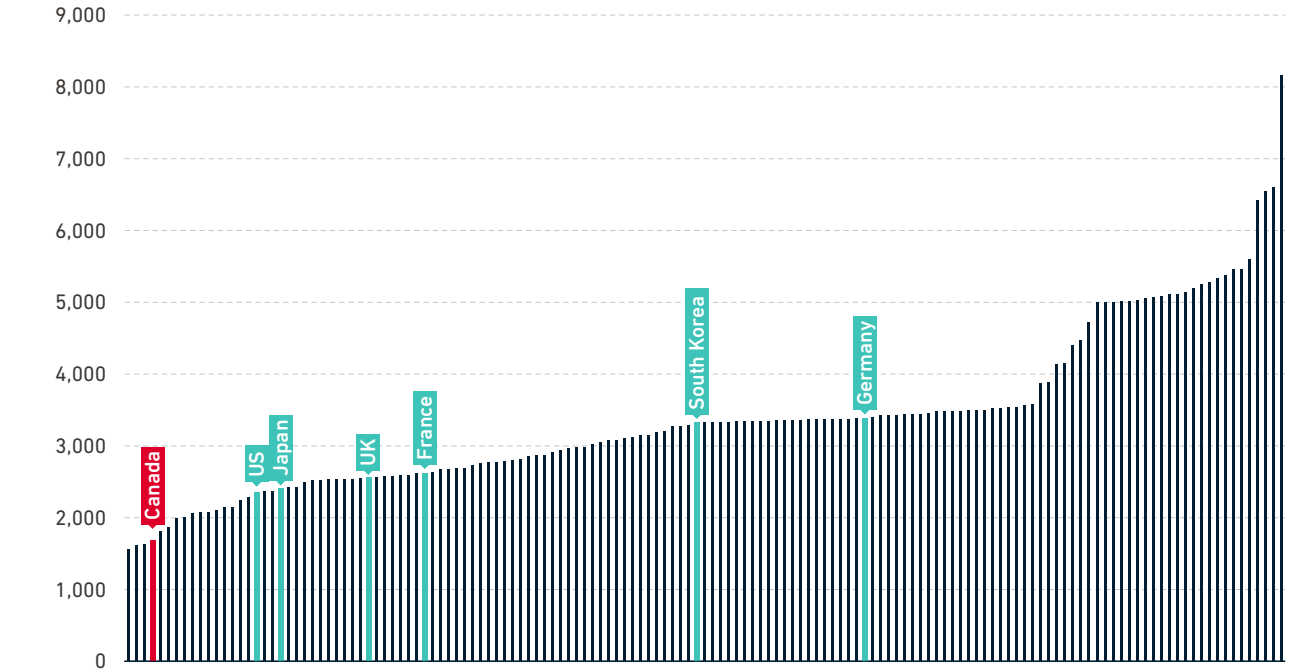
In another recent study, we examined how European mobile markets performed during the 4G era and how different market structures affected network quality, coverage and investment.[24] The results suggest that, in this period, more concentrated markets provided consumers with better performance, especially on network quality. The study also showed clear evidence of a link between more concentrated markets and increased investments per operator. Such market structures not only allow operators to monetise data growth but also to raise investments, which can in turn lead to better outcomes for consumers in terms of network quality and coverage.

Canada has a competitive market, with three national providers and a number of regional players of differing sizes. Canada's Herfindahl-Hirschman Index (HHI)[25] score is already among the lowest across a number of developed markets, which suggests that further moves to stimulate competition may have negative impacts on operator investment levels. If the goal is to maximise the potential of 5G for consumers and enterprises in Canada, regulators need to be mindful to ensure a supportive regulatory and policy environment for operators to invest in the new technology.

This is further emphasised by the distribution of spectrum for mobile services in the country, with Canada being the fourth-least concentrated market in the world (Figure 18). The proposed spectrum set-aside policy in Canada, targeting further de-concentration in the distribution of spectrum, will only exacerbate the situation.

Figure 18

Index of spectrum concentration[26] (Herfindahl-Hirschman Index), by country



Source: GSMA Intelligence

It is important for governments, regulators and competition authorities to consider the relative advantages of more concentrated market structures in terms of investments and network quality, both of which are essential for the rollout of 5G networks.

While every market is unique, regulators that are aiming to increase the number of players, for example through spectrum set-asides, should reflect carefully on the likely impact this could have on the ability of network operators to invest, and on the consumer experience and the economy more broadly.

24 Mobile market structure and performance in Europe: Lessons from the 4G era, GSMA Intelligence, 2020
25 HHI is a measure of market concentration, with values ranging from 0 if a market has an infinite number of competitors to 10,000 in a market that has a monopoly.
26 Spectrum concentration measures the distribution of spectrum holdings across operators in a country. If one operator holds all the spectrum in the country, the spectrum concentration index takes a value of 10,000. If there is an infinite number of operators holding spectrum, the value of the index is 0.

Alternative 5G spectrum policies can deliver faster macroeconomic growth

The economic impact of 5G in Canada will not materialise at the same level compared to other OECD countries. The regulatory conditions around 5G, particularly spectrum policy, will likely result in Canada's 5G rollout lagging behind those of other countries, keeping the potential boost of 5G on GDP growth below its true potential (see Section 2).

In order to understand the effects of alternative spectrum policies on 5G rollout and the impact across the economy, we developed two alternative scenarios and modelled their effects on macroeconomic growth in Canada.

We draw on the results of a robust empirical study analysing the effects of spectrum policy on market development.[27] From these, we establish the likely impact on 5G market development from a hypothetical alternative spectrum policy that delivered greater amounts of spectrum to operators (alternative policy 1) and one that assigned spectrum at an earlier point in time (alternative policy 2), bringing Canada's spectrum policy in line with international standards.

The resulting alternative 5G adoption paths are subsequently used as inputs into the 5G economic impact model presented in Section 2 to analyse the extent to which they can deliver additional macroeconomic benefits for Canada.

27 The impact of spectrum prices on consumers, GSMA Intelligence, 2019

Alternative policy 1

Bring spectrum assignments per operator in line with international benchmarks

As a result of the limited amount of spectrum available and the additional artificial scarcity imposed by set-asides, national operators in Canada will have one of the lowest amounts of assigned spectrum globally in the critical 3.5 GHz band for the launch of 5G services. Instead of the recommended 100 MHz per operator, major Canadian operators will only be assigned a maximum of 50 MHz on average.

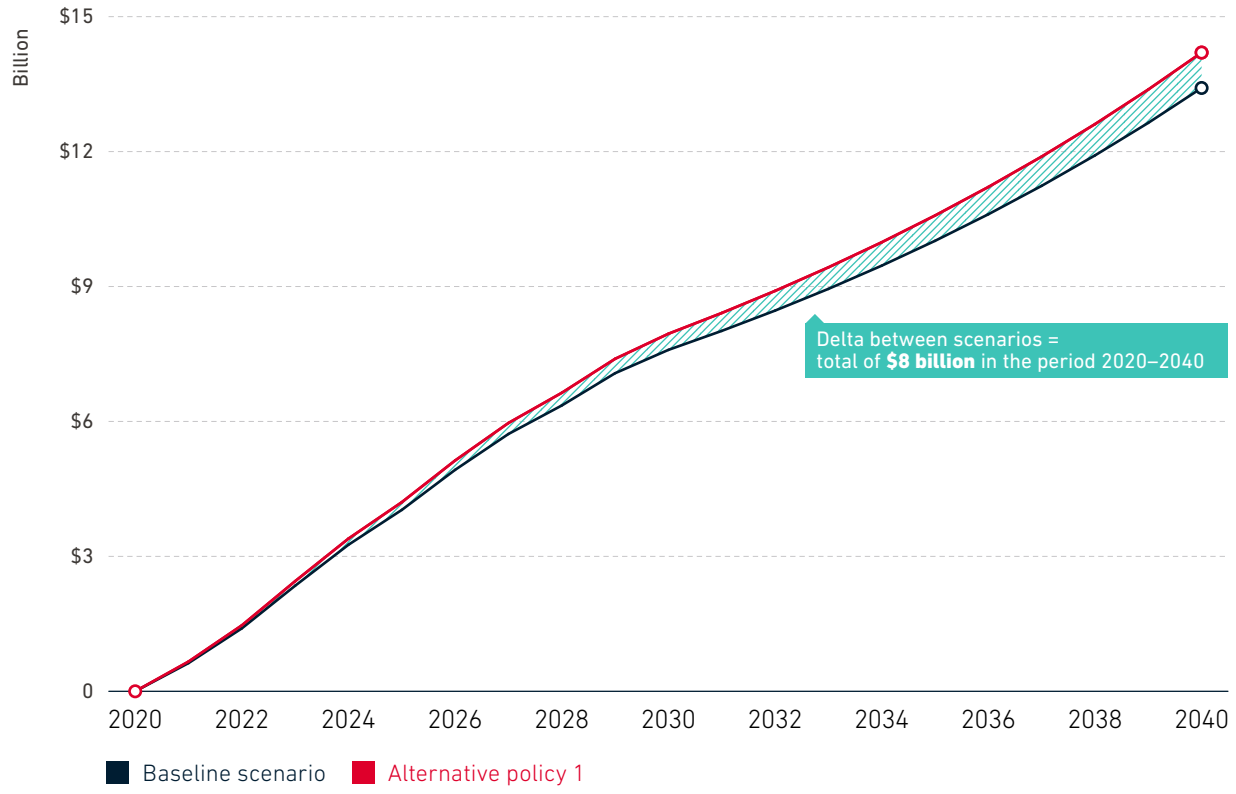
With less spectrum available per operator, the costs of the rollout will be higher and deployment rates slower. A reduction to the total supply of spectrum has been shown to be negatively and statistically significantly linked with a slower rollout of new mobile network technologies. In our global study on the effects of spectrum policy on the rollout of 4G, we found that the amount of spectrum licensed to mobile operators had a significant impact on network deployment rates: every additional 10 MHz of 4G spectrum assigned to an operator increased on average the network coverage of 4G deployments by 1.5 percentage points of the population of a country.

Increasing the amount of 5G spectrum in the 3.5 GHz band is likely to result in similar effects, accelerating the rollout. Applying the results of the econometric study to the 5G rollout, and if Canadian operators were assigned on average 100 MHz of spectrum on the 3.5 GHz band each (instead of the maximum of 50 MHz currently expected on average if the spectrum that is not set aside is allocated to Canadian operators fully), the 5G rollout could accelerate significantly and reach an additional 7.5 percentage points of population coverage earlier. As a result, the adoption of 5G and its economic impact would also be brought forward, providing a potential additional source to accelerate economic recovery in Canada.

Figure 19 shows that bringing spectrum assignments in the 3.5 GHz band in line with international benchmarks with this alternative policy would deliver an additional total of $8 billion in GDP growth to the Canadian economy across the period of analysis.

Figure 19

Additional economic impact driven by 5G: prediction versus alternative policy 1



Source: GSMA Intelligence

Alternative policy 2

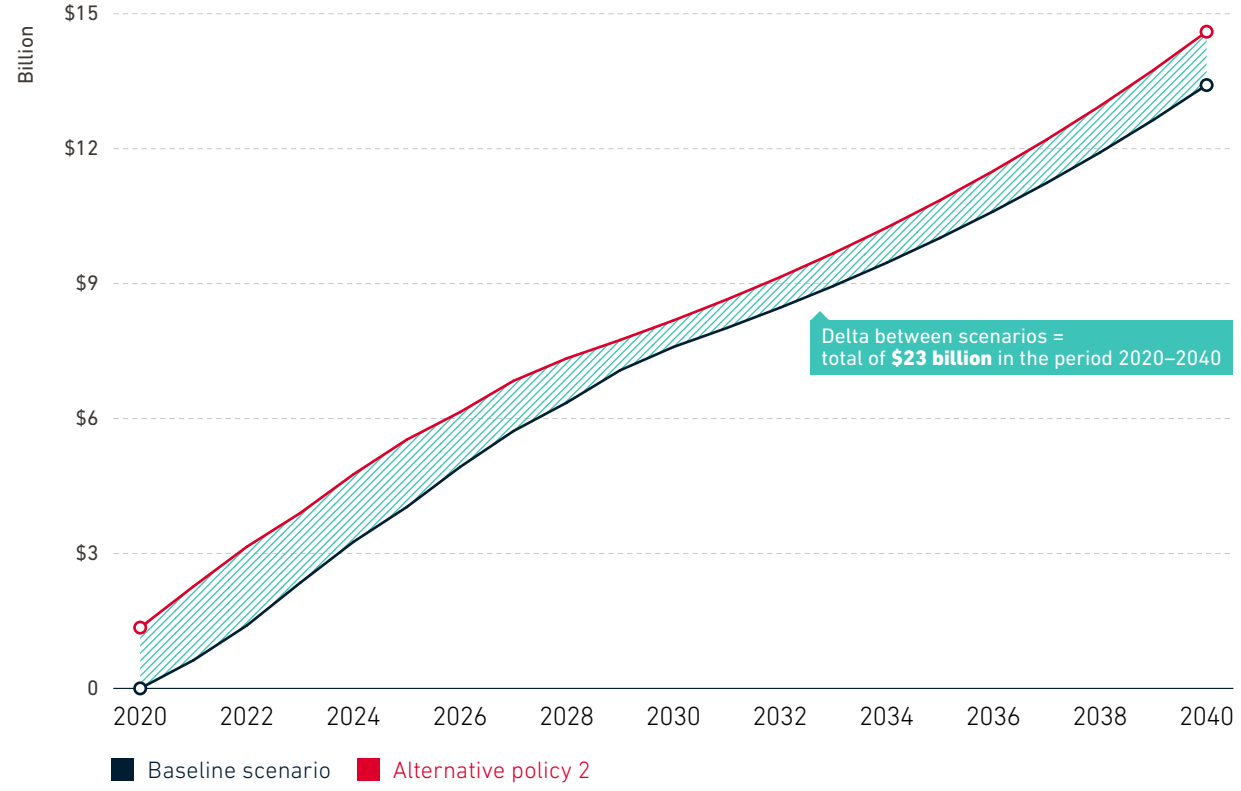
Timely release of critical 5G spectrum bands, in line with other advanced mobile markets

We also consider an alternative policy with an earlier release of spectrum. In order to model these effects, we modify the 5G rollout profile that is applied to our economic impact model and hypothetically bring the start of mass rollout in Canada forward by two years, in line with countries such as Japan and Germany.

The results indicate that this scenario can also lead to an earlier delivery of the economic impact of 5G. Figure 20 shows the effect of this scenario, with $23 billion in additional economic growth generated in Canada if the timelines of spectrum assignments were brought in line with international benchmarks.

Figure 20

Additional economic impact driven by 5G: prediction versus alternative policy 2



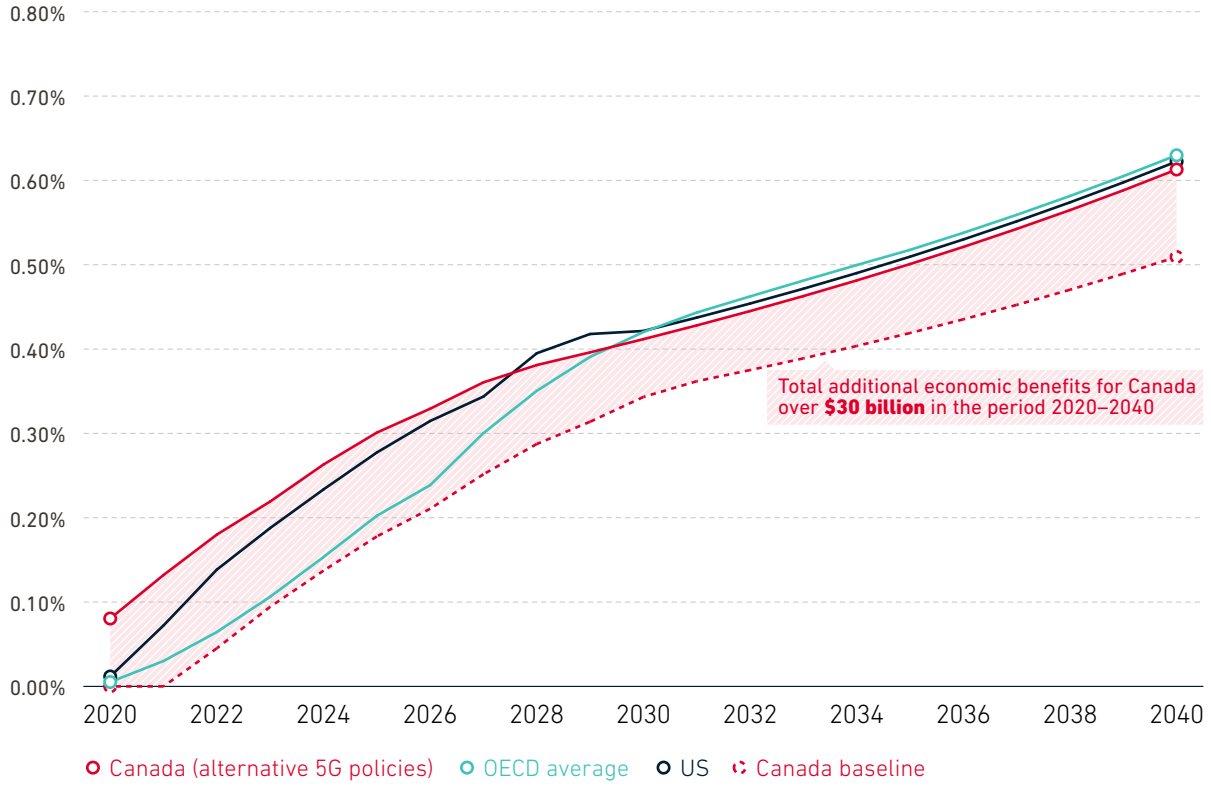
Source: GSMA Intelligence

Overall, the implementation of spectrum policies in Canada that are in line with international benchmarks would deliver well in excess of $30 billion in additional GDP growth for the entire period 2020–2040. Figure 21 shows that the additional economic impact of 5G in Canada would be closer to its full potential and more in line with the average yearly effects currently expected to materialise in the US and across OECD countries.

Figure 21 shows the additional economic impact in Canada from implementing the two alternative policies (red line), and compares it to the economic impact delivered in Canada by 5G without them (dotted red line). Economic impacts are also compared to those expected in the OECD average (turquoise line) and the US (navy line).

Figure 21

Additional economic impact driven by 5G (as a percentage of annual GDP) – international benchmarks



Source: GSMA Intelligence

Conclusion

Canada has much to gain from the rollout of 5G: the next mobile technology has the potential to enable a range of new and transformative applications and use cases. From virtual reality to artificial intelligence and autonomous cars, 5G has the potential to help address Canada's slow productivity growth and deliver new and innovative services for consumers.

Our economic model shows that 5G networks could deliver a total of $150 billion in additional value add to the Canadian economy over the entire period 2020–2040, playing an important role in driving economic growth and supporting the recovery from the impact of Covid-19.

However, to obtain the full macroeconomic dividends that 5G technology can bring, policymakers and the telecoms industry will need to address a number of barriers. The speed of rollout, as well as the adoption, reach and quality of 5G services, will be heavily dependent on an appropriate policy environment being in place. A key aspect of this enabling policy environment is the need to offer timely access to the right amount and type of spectrum to encourage long-term investments in 5G networks. 5G technology will need significant amounts of new spectrum across all bands.

In Canada, key 5G spectrum bands are not scheduled to be auctioned until June 2021, at which point 37 other countries will have already assigned 3.5 GHz spectrum. Further, Canadian operators will have access to a very limited amount of spectrum in this band, with only 200 MHz planned for auction, and with set-aside rules limiting this to only 150 MHz for nationwide operators. This is significantly below the ITU's minimum requirement of 100 MHz per operator and far less ambitious than the existing plans to release spectrum in the band by the US (360 MHz), Japan (500 MHz) and most European markets (typically 300–400 MHz).

Countries that make sufficient spectrum available in a timely fashion will facilitate the investments needed and deliver greater benefits to consumers, businesses and the overall economy sooner. We estimate that bringing 5G spectrum policies in Canada in line with international best practice would deliver a total of $30 billion in additional GDP growth in the period 2020–2040. This would bring the additional economic impact of 5G in Canada closer to its full potential and more in line with the average yearly effects that we expect to materialise in the US and most other OECD countries.

To maximise the potential of 5G for consumers and enterprises in Canada, the government needs to ensure a supportive regulatory and policy environment for operators so they can invest in the new technology, deliver better network quality and accelerate the rollout of 5G networks. Protecting the interests of Canada's consumers depends on promoting the conditions that incentivise the significant investments needed in next-generation networks.

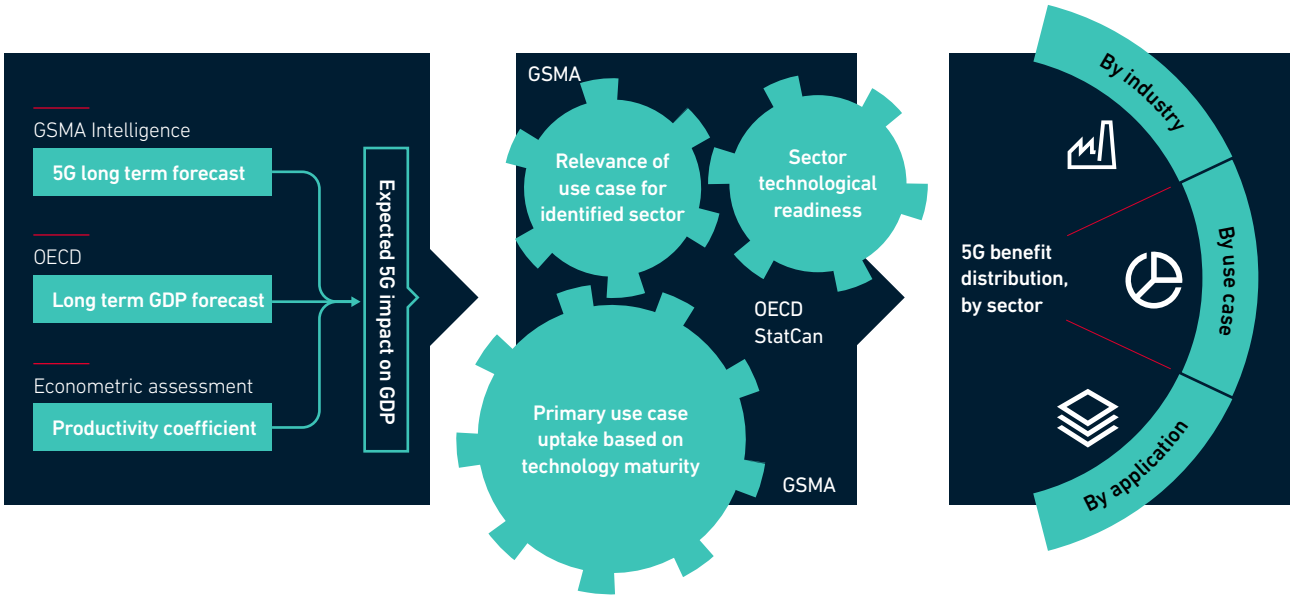
Annex: modelling the economic impact of 5G

The economic model underpinning the results presented in the study is designed to assess the benefits of implementing 5G technology in Canada in the period 2020–2040.

The model is built around two main pillars: the first assesses how different use cases – applications and new/upgraded industrial processes supported by 5G technology – can boost productivity and benefit the economy; the second looks into the impact on productivity and economic growth of 5G-based technologies and their impact on productivity. Together, these two pillars allow the model to forecast the impact on each sector of the economy, as shown in Figure 22 below.

Figure 22

Model: high-level methodology



Source: GSMA Intelligence

Economic impact of 5G on GDP

To predict the macroeconomic impact of 5G technology on GDP, we assume that the transition from existing network technologies (primarily 4G) in Canada to 5G will deliver an economic impact per mobile connection of a similar magnitude as the one delivered by previous technology transitions.

A recent econometric study,[28] based on the most comprehensive dataset used to date and covering globally the rollouts of 2G, 3G and 4G, finds that, on average, a 10% increase in mobile adoption increased GDP by 1%. Importantly for our analysis, it also finds that the economic impact of mobile adoption increases by approximately 15% when connections upgrade from 2G to 3G, and increases further by also approximately 15% when connections transition from 3G to 4G. As a consequence, the higher the mobile technology adoption, the higher the benefit with respect to GDP.

We therefore assume that the transition from 4G to 5G in Canada will deliver macroeconomic impacts per connection on GDP of a similar magnitude as those delivered by the transition from 3G to 4G, but adjusting for differences in the adoption of each technology i.e. the economic impact of mobile technology connection on 4G will increase by 15% for each connection that transitions to 5G.

The benefit at country level is calculated as a function of 5G penetration rate, as follows:

t = time α = 5G penetration rate
i = country β = 5G productivity impact

$$TotalBenefit_{it} = GDP_{it} * (\alpha_{it} - \alpha_{it-1}) * \beta$$

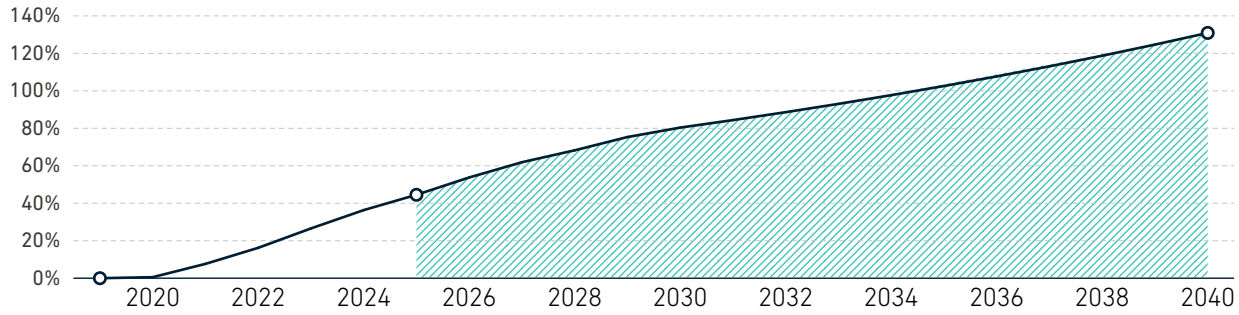
In the case of Canada, the α parameter is based on the 5G long-term forecast presented below, while for the β parameter, the model assumes a value of 0.5%, which translates to a GDP increase of 0.05% for every 10% increase in 5G connections uptake. This value is calculated based on the results of Bahia, K., Castells, P. and Pedros, X., 2020.[29]

5G long-term forecast

As reflected in the equation above, the model requires a 5G penetration rate at country level for all the years considered in the period of analysis. We use GSMA Intelligence forecasts for the expected growth in 5G connections in Canada until 2025. For 2025 to 2040 (shaded area in Figure 23) we extend the forecast and produce a stylised trend based on historical long-term trends in mobile network technology adoption. We allowed penetration rate to grow above 100%, as it is expected that some users will have more than one 5G connection, as has been the case with previous mobile network technologies.

Figure 23

Forecast of Canada 5G connections uptake as a percentage of population, 2020–2040



Source: GSMA Intelligence

28 *Mobile technology: two decades driving economic growth*, 2020, GSMA Intelligence Economic Research Working Paper, by Bahia, K., Castells, P. and Pedros, X.
29 Ibid.

GDP long-term forecast

To calculate the overall 5G benefit in the period 2020–2040 a long-term GDP forecast is required. Between 2020 and 2024, we use GDP forecasts by the IMF. For the years 2025–2040, GDP forecasts are based on the OECD long-term GDP forecast – this is available for a limited number of major economies, up to 2060, including Canada.[30]

Technology readiness by sector

Each economic sector in Canada is assigned a score based on its readiness to adopt technology, with 0 being the lowest readiness and 5 being the highest readiness and aptitude to benefit from mobile technology adoption compared to other sectors. For example, the agricultural sector has the lowest score, indicating that the sector is generally not well placed to adopt new technology. On the contrary, technology-intensive sectors, such as financial and information and communications, are characterised by a higher score.

We inform this aspect of the model through the use of two main sources. First, scores are informed by the results of the OECD Science, Technology and Industry Scoreboard studies to identify the sectors most prone to technological innovation, with particular reference to the mobile sector. Second, we use the results of Statistics Canada's Survey of Advanced Technology to understand the technology readiness of firms in each sector specifically in the Canadian context. The results of this Canadian survey, together with OECD data, highlight important differences in the degree of technological innovation of Canadian industries – for example, with higher-than-OECD-average scores for the oil and gas sector, where Canada is at the forefront of technological innovation.

Table 4

Technology readiness coefficient, by sector, Canada-specific and OECD average

Sector	Score (Canada)	Score (OECD average)
Agriculture	1.5	1.3
Construction and real estate	1.4	1.6
Accommodation and food	2.0	2.0
Utilities	2.0	2.0
Transport	2.3	2.3
Oil and gas	3.3	2.3
Education	2.4	2.4
Public administration	3.3	2.6
Healthcare	3.5	2.8
Arts, entertainment and recreation	3.0	3.0
Manufacturing	2.1	3.1
Retail	2.5	3.2
Services	2.6	3.3
Finance	3.6	3.6
Information and communication	3.8	3.8

Source: OECD 2018 and SAT Survey 2015

30 https://data.oecd.org/gdp/real-gdp-long-term-forecast.htm

Relevance of 5G use cases by sector

5G use cases are classified according to four main groups (see Table 5).

Table 5

5G use cases

Primary use case	Example applications
Enhanced mobile broadband (eMBB)	Data-intensive mobile connectivity
	AR/VR
	Broadband to public transport
Fixed wireless access (FWA)	Ultra-low-cost networks in rural areas
	Dynamic hotspots
	Stationary or near-stationary monitoring networks
Ultra-reliable low-latency communications (URLLC)	Connected vehicles
	Edge computing
	Industrial automation
Massive Internet of Things (mIoT)	Remote object manipulation
	Precision agriculture
	Predictive maintenance

Source: GSMA Intelligence

Using input provided by a panel of GSMA 5G experts we associate a score for each use case, based on its relevance to the sector, assigning a score of 0 in the case of no relevance and 6 in the case of maximum relevance. For example, URLLC is considered to be of limited relevance for the agricultural sector (low score), but very relevant for the manufacturing, utilities and financial sectors (high scores).

The model considers two different period of analysis, in which different use cases are responsible for the 5G economic benefit in each sector. Some use cases will be ready to be implemented earlier than others. The scores are therefore adjusted to reflect changes over time to the potential impacts of each use case.

Table 6

Sector – use cases matrix 2020–2030

Sector	eMBB	FWA	mIoT	URLLC
Agriculture, forestry and fishing	5	5	4	1
Construction and real estate	3	3	3	2
Accommodation and food service activities	5	5	2	0
Utilities	3	3	3	4
Transportation and storage	4	2	4	4
Mining and quarrying	5	5	4	3
Education	6	6	0	4
Public administration and defence; compulsory social security	5	5	4	3
Human health and social work activities	5	5	2	4
Arts, entertainment and recreation	6	6	0	0
Manufacturing	6	6	4	4
Retail	5	5	4	2
Services	6	6	0	0
Financial and insurance activities	5	5	0	4
Information and communication	6	6	3	3

Source: GSMA Intelligence

Table 7

Sector – use cases matrix 2030–2040

Sector	eMBB	FWA	mIoT	URLLC
Agriculture, forestry and fishing	3	3	6	3
Construction and real estate	1	1	5	4
Accommodation and food service activities	3	3	4	0
Utilities	1	1	5	6
Transportation and storage	2	0	6	6
Mining and quarrying	3	3	6	5
Education	4	4	0	6
Public administration and defence; compulsory social security	3	3	6	5
Human health and social work activities	3	3	4	6
Arts, entertainment and recreation	4	4	0	2
Manufacturing	4	4	6	6
Retail	3	3	6	4
Services	4	4	0	0
Financial and insurance activities	3	3	2	6
Information and communication	4	4	5	5

Source: GSMA Intelligence

Distribution of 5G impacts across economic sectors

To summarise, the benefits are distributed by sector following these steps:

1. Based on Statistics Canada collected data, the contribution (%) of the sector of the economy is calculated.
2. Based on OECD scoreboard/taxonomy, a weight is associated with each sector.
3. Based on the use cases matrix and expert opinion, a weight is associated with each sector.

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