Economic Impacts of 5G in Canada

Adapted from: The Socio-Economic Impacts of 5G

Deetken Insight was commissioned by TELUS to complete a comprehensive review of published research about 5G and its potential socio-economic impacts, with a particular focus on Canada. Access the full report including a bibliography here: https://deetken.com/socio-economic-impacts-of-5g/. We provide no opinion, attestation, or other form of assurance with respect to the completeness, accuracy, fair presentation, and findings from research of others that are presented in the report.

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Key Takeaways

- 5G will create economic growth and high paying jobs through increases in productivity, i.e., the efficiency with which labour, capital and other inputs are used to generate output. 5G drives productivity growth by making it easier and cheaper to use technologies that run on mobile and fixed networks to create value. For example, 5G is a necessary factor to make it economical to build self-driving vehicle systems or deploy remote-operated robots for mineral extraction.

- Productivity matters because it is by far the most significant driver of Canada's standard of living as measured by growth in GDP per capita, which itself is strongly correlated with wage growth over the run. In a 2021 forecast, the OECD places Canada last among advanced economies in GDP per capita growth between 2020 and 2030. Therefore, finding ways to increase productivity is critical to correcting this course.

- 5G is a central solution to Canada's long standing productivity challenge. Based on a review of numerous studies that estimate the potential economic benefits of 5G for Canada, as well as independent modeling undertaken for this report, 5G and related technologies could add between $100 billion and $120 billion in GDP in Canada by 2036, and account for approximately 4% of Canada's total GDP by 2036.

- 5G is also associated with high paying jobs. Average earnings in the wireless sector are almost 25% higher than in the wider business sector. 5G also plays a fundamental role in the wider digital economy. Employment in the digital economy is forecast to grow faster than in the overall business sector over the 2022-2025 period and account for 11% of total employment in the business sector by 2025.

Several studies reviewed for this report attempt to estimate the economic benefits of 5G and the technology advancements it enables. The estimates are necessarily speculative given the infancy of 5G-enabled use cases and, thus, vary considerably. The clarity of the methodologies used to generate the estimates also varies, making it difficult to assess the reasonableness of the estimates. **For this reason, a framework was prepared to evaluate these estimates and provide an independent and transparent viewpoint with which to consider the economic impact of 5G**. The design of the framework, its key assumptions and the results are described in this section of the report.

The framework incorporates a growth accounting approach consistent with Statistics Canada's published productivity data. Growth accounting is a method that separates economic growth into its contributing factors. Those factors are capital, labour and productivity – the efficiency with which capital and labour are used to generate output. The framework built for the report focuses on the potential economic gains enabled by 5G from increases in productivity. The most common measure of productivity is labour productivity. In the framework, labour productivity is defined as

GDP generated per hour worked. Growth in labour productivity can be separated into growth in capital intensity (more equipment such as machinery or tools per hour of labour), labour composition (an overall increase in the skill and/or experience of the labour force), and the unexplained residual component called multifactor productivity (MFP). Technological improvement is generally understood to be a key driver of MFP growth. Consider, for example, that personal computers in the workplace have improved in their performance over time while their real dollar value has stayed relatively constant: a worker gets more work done with a modern computer compared to an older computer and, hence, their productivity is higher. There are many other factors that can increase MFP such as business model, process and management practices improvements. Governments can also improve MFP by making regulatory and tax system changes that result in more efficient allocation and/or utilization of inputs.

Within this context, 5G can enable growth in both capital intensity and MFP. For example, with respect to capital intensity, 5G enables new forms of machinery and robotics that depend on next-generation network performance to operate effectively and safely. With respect to MFP, 5G helps put labour and capital to more efficient use. However, there are significant lags between the introduction of so-called "general purpose technologies" and observed increases in output attributable to these technologies. Complementary intangible investments to transform strategy, organization, and processes are also required to attain the value available from adopting these new technologies. The lag between the introduction of 5G technology and the attainment of value enabled by it is estimated as described further below.

The framework considers historical and forecasted figures published by trusted statistical agencies, including Statistics Canada and OECD, to establish key assumptions for estimating the potential economic growth that will be enabled by 5G. A description of these data and the corresponding assumptions built into the framework are as follows:

TABLE 4.1: ECONOMIC MODEL FRAMEWORK PARAMETERS

Framework Parameters	Description
Real GDP per capita	This is the size of the economy as measured by GDP in constant dollars divided by the population. Economic growth on a per-person basis supports a continuously rising standard of living for all Canadians and a strong foundation for the government to invest in evolving priorities (e.g., climate change, aging population). A recent OECD report forecasts real GDP per capita annual growth for Canada at 0.7% to 2030 and 0.8% from 2030 to 2060. These compare poorly to forecasts for the U.S. and Euro area: 1.2% and 1.0% to 2030 and 1.0% and 1.1% from 2030 to 2060 for the U.S. and Euro area, respectively.[1] Recent real GDP per capita growth in Canada, based on data published by Statistics Canada, is somewhat higher: the average annual growth was 1.1%, as was the compound annual growth rate.[2] Real GDP per capita is not used as an input, but rather is used as a reasonableness check on the outputs.

[1] Link to source: https://www.oecd-ilibrary.org/economics/the-long-game-fiscal-outlooks-to-2060-underline-need-for-structural-reform_a112307e-en.

[2] Links to sources: Statistics Canada. Table 17-10-0005-01 Population estimates on July 1st, by age and sex; Statistics Canada. Table 36-10-0222-01 Gross domestic product, expenditure-based, provincial and territorial, annual (x 1,000,000). The growth rate is based on annual data for years 2010 to 2019.

Framework Parameters	Description
Population	A forecast from the OECD is used for the population of Canada.[3]
Labour force	A study by Statistics Canada from 2018 provides labour force projections to 2036 that are used in the framework. Several scenarios are presented in that study based on different participation rates by age cohort. The framework uses the average of two of those scenarios: 1) the "reference" case, which assumes labour force participation rates of older Canadians continues to increase according to prevailing trends in 2018; and 2) the "constant" scenario, which assumes the participation rates in 2018 remain constant.[4] The size of the labour force has implications for the labour productivity growth required to achieve a given GDP per capita growth rate.
Hours worked	The number of hours worked by the labour force also has implications for the labour productivity growth required to achieve a given GDP per capita growth rate. Total hours worked per worker were compared to historical labour force figures from Statistics Canada and were found to have remained fairly constant over the 2010 to 2019 period. Therefore, the framework assumes that the total hours worked divided by the labour force remains constant.
Productivity	Labour composition growth (i.e., the degree to which the overall skill and experience of the workforce changes over time) has been relatively constant at 0.2%. The framework assumes this growth rate going forward and, to be conservative, none of this growth is attributable to the deployment of 5G technology; instead, this growth results from a gradually aging workforce and increase in the skill level of the workforce through attainment of higher levels of education. Meanwhile, capital intensity plus MFP in Canada grew at an average annual rate of 1.1% from 2010 to 2019, while the average 5-year growth rate over the 1997-2019 period was 0.8%. The framework assumes that capital intensity plus MFP will gradually increase to 1.3% as adoption of artificial intelligence and other digital technologies enabled by 5G grows. An increase in labour productivity from current levels has support from some academic research that foresees a rapid increase in output as investments in digital-related technologies begin to bear fruit.[5]
Adoption	To model the ramp-up of capital intensity plus MFP growth, assumptions were made about 1) the timing of the sales of different 5G spectrum classes; 2) the proportion of economic value that each of these classes represents in terms of the innovation they enable; 3) the relative size and timing of adoption cohorts (early, medium, and lagging adopters); and 4) the number of years that 5G adopters achieve productivity gains from 5G.
5G-enabled growth	The framework assumes annual combined MFP and capital intensity growth of 0.8% enabled by factors unrelated to 5G. There are many such potential factors. For example, the 2022 federal budget refers to a recent study by the International Monetary Fund which found that Canada could increase its GDP per capita by 4% through a complete liberalization of interprovincial trade in goods and goes to highlight its continued commitment to remove interprovincial trade barriers.[6] Adopters of 5G are assumed to achieve an addition 0.5% in annual combined MFP and capital intensity growth. The assumption that 5G can enable 0.5% in annual

[3] Link to source: https://stats.oecd.org/Index.aspx?DataSetCode=POPPROJ. Retrieved April 8, 2022.

[4] Link to source: https://www150.statcan.gc.ca/n1/pub/75-006-x/2019001/article/00004-eng.htm.

[5] Links to sources: https://www.technologyreview.com/2021/06/10/1026008/the-coming-productivity-boom/; http://www.csls.ca/ipm/37/OECD.pdf.

[6] Link to source: https://budget.gc.ca/2022/pdf/budget-2022-en.pdf.

Framework Parameters	Description
	labour productivity growth is a rough estimate based on literature from proponents of the viewpoint that intangible digital-related investment will drive an upswing in output. For example, Erik Brynjolfsson and Georgios Petropoulos wrote in the *MIT Technology Review* in June 2021 that U.S. productivity growth, which averaged 1.1% from 2010 to 2020, could reach or exceed levels observed in the 1990s, which averaged 2.3% from 1990 to 2000, due to digital technologies.[7] However, a growth rate of 0.5% is on the high end compared to, for example, "general purpose technology" use cases included in a 2018 report by the Australian government about the potential economic benefits from 5G.[8]

The results of the analysis are summarized in Figure 4.1 and Table 4.2 below. Based on the assumptions, the analysis suggests that 5G-enabled growth could add an estimated $51 billion in real GDP by 2030 (14% of total GDP growth) and $109 billion by 2036 (16% of total growth) relative to a 2021 baseline of $2,152 billion. Increases in labour composition, productivity growth from sources other than 5G-related innovation, and growth in the labour force account for the remainder of GDP growth. Compound annual growth rates are also included in the table. Real GDP grows at an annual rate of 2.0% to 2030 and 2.0% to 2036, while real GDP per capita grows at an annual rate of 0.9% to 2030 and 0.9% to 2036. The growth rates converge slightly because of a gradually aging population and a corresponding decline in labour force participation among those 15 years of age and older.

While the results seem optimistic given the OECD's projections about Canada's real GDP per capita (i.e., annual rates of between 0.7% and 0.8% during the 2022-2036 timeframe) and the average annual labour productivity growth from 2010 to 2019 was just 1.3%, they are reasonable because of the expected increase in output that will be unlocked by adoption of digital services, including those enabled by 5G.

[7] Link to source: https://www.technologyreview.com/2021/06/10/1026008/the-coming-productivity-boom.

[8] Australian Government, Impacts of 5G on productivity and economic growth, April 2018. Figure 5 page 16. Link to source: https://www.infrastructure.gov.au/sites/default/files/impacts-5g-productivity-economic-growth.pdf.

FIGURE 4.1: REAL GDP AT MARKET PRICES, CHAINED (2012) DOLLARS, GROWTH BY SOURCE FROM 2021 BASELINE

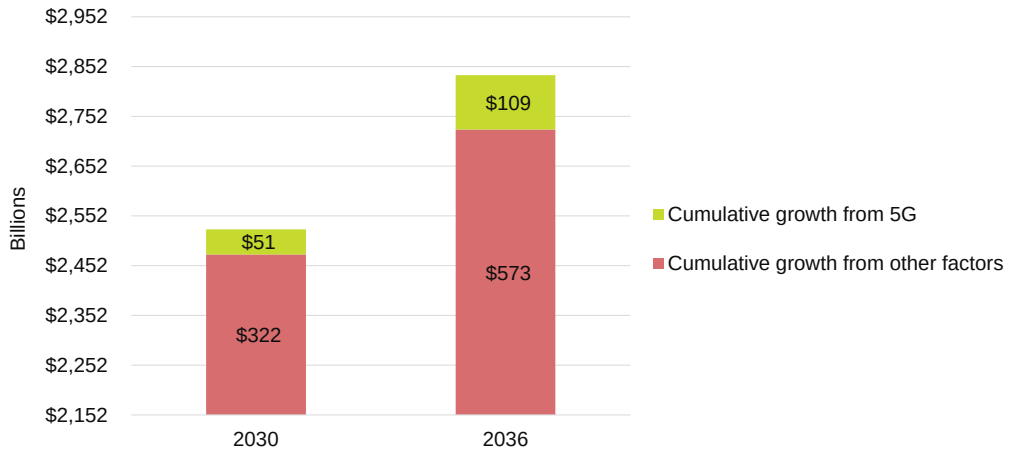

TABLE 4.2: ECONOMIC MODEL FRAMEWORK RESULTS

Real GDP at Market Prices, Chained (2012) dollars, billions	2030		2036	
	Value	*% of Total*	*Value*	*% of Total*
2021 baseline	$ 2,152	85%	$ 2,152	76%
5G-enabled	**$ 51**	**2%**	**$ 109**	**4%**
Labour composition	$ 40	2%	$ 69	2%
Other productivity improvement	$ 165	7%	$ 287	10%
Labour force	$ 118	5%	$ 218	8%
Total	$ 2,525	100%	$ 2,835	100%

Compound Annual Growth Rates compared to 2021 baseline	2030	2036
Real GDP	2.0%	2.0%
Real GDP per capita	0.9%	0.9%

A key limitation of the framework is endogeneity with respect to how 5G-enabled innovation is considered. Specifically, the impact of 5G is presented as both an output and an input. A more robust "bottom-up" approach would consider individual use cases and their impact at the sector level and aggregate these results. However, the **purpose of the framework is to establish a test for reasonableness when evaluating the estimates observed in other research**, which is discussed below. The reasonableness of the framework itself is, again, established by the assumptions described above.

Five reports on 5G's impact on Canadian economic growth were evaluated. All five describe the nature of growth similarly: growth driven by an accelerated transition towards the digital economy enabled by the deployment of 5G connectivity.

TABLE 4.3: ESTIMATES OF 5G IMPACTS ON CANADA GDP FROM REVIEWED REPORTS

Author, Year Published	Estimates
PwC, 2021	A 2021 report by PricewaterhouseCoopers (PwC) estimates that 5G-enabled GDP will increase to $78 billion by 2030 and grow more slowly to $94 billion in 2035.[9] The methodology is not described.
GSMA Intelligence, 2020	A 2020 report by GSMA Intelligence estimates that 5G-enabled GDP will reach US$150 billion (CA$201 billion) by 2040.[10] The estimates are across all sectors and are based on historical and forecasted correlations between GDP growth and the number of mobile connections.
BCG, 2019	A 2019 report by Boston Consulting Group (BCG) similarly estimates 5G-enabled GDP to grow to $200 billion by 2040.[11]
ICTC, 2018	A 2018 report by Information and Communications Technology Council (ICTC) estimates the GDP impact by 2030 to be $26.1 billion.[12] The estimates are based on historical and forecasted correlations between GDP growth and mobile subscriptions per capita.
Accenture, 2018	A 2018 report by Accenture estimates the GDP impact by 2026 to be $40 billion.[13] This report's estimates also appear to be based on historical and forecasted correlations between GDP growth and service penetration.

Based on the analysis framework prepared for this report, the following are key observations about the economic growth potential enabled by 5G:

- **It is reasonable to expect 5G-enabled real GDP in Canada to grow to approximately $40 billion to $60 billion by 2030 and $100 billion to $120 billion by 2036.** This growth is optimistic, though reasonable, given guardrail assumptions and considerations with respect to real GDP per capita, population, labour force, hours worked, etc., as described above.
- This growth depends on a host of factors, including the expedient deployment of 5G infrastructure and the preceding release of 5G spectrum.
- If productivity enabled by 5G grows at the same rate as the OECD aggregate level as is assumed for Canada, 5G-enabled real GDP across the OECD is estimated at CA$2 trillion by 2030 and CA$4 trillion by 2036.[14]

[9] Link to source: https://www.pwc.com/ca/en/communications/publications/5g-the-digital-economy-and-canadas-global-competitiveness.pdf.

[10] Link to source: https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=54165916&file=051120-5G-in-Canada.pdf. US-CAN average annual exchange rate for 2020 (1.3415) sourced from Bank of Canada, accessed on April 18, from webpage https://www.bankofcanada.ca/rates/exchange/annual-average-exchange-rates/.

[11] Link to source: https://media-publications.bcg.com/flash/dotbcg_other/CCF%20Digital%20Infrastructure-%20In%20the%20Balance.pdf.

[12] Link to source: https://www.ictc-ctic.ca/wp-content/uploads/2019/03/ICTC_5G-Jumpstart_2018_EN_Mar14.pdf.

[13] Link to source: https://www.5gcc.ca/wp-content/uploads/2018/06/CWTA-Accenture-Whitepaper-5G-Economic-Impact_Updates_WEB_06-19-2018.pdf.

[14] Based on comparing real GDP for OECD total to Canada in 2019 in Million US$. OECD total was 34 times that of Canada. Data sourced from OECD on April 18, from webpage https://data.oecd.org/gdp/gross-domestic-product-gdp.htm#indicator-chart.

Additional research reviewed for this report found significant economic gains from upgrading to previous next-generation mobile technologies. For example, a study by GSMA Intelligence, which considers data from 160 countries from 2000 to 2017, estimates up to 0.07% and 0.05% increases in GDP from a 10% increase in adoption of 3G (over 2G) and 4G (over 3G), respectively, controlling for factors such as the number of mobile connections and labour and capital endowments.[15] Another GSMA report observes that 4G accounted for nearly 80% of mobile connections in Canada by the end of 2019 which "compares favourably with other developed markets," [16] suggesting Canada has done a good job in building the infrastructure and harvesting the benefits available from 4G adoption.

There is good reason to expect higher economic gains from 5G adoption given it enables productivity-enhancing digital capabilities, such as AI and automation, that promise potential benefits **across all sectors** in the economy. While 3G enabled integrated voice, video, and data and led to the mass adoption of cell phones, and 4G, coupled with cloud-based computing, enabled new business models such as ride-sharing services, live-streaming media, and other rich-feature software-as-a-service applications, the use cases enabled by 5G, as described in this report, demonstrate the next-level transformative potential of 5G networks. An indicator of 5G's nature as an "industry play" is the number of IoT connections. In a 2022 report, Ericsson predicts that IoT connections will more than double from 14.6 billion in 2022 to 30.2 billion in 2027. Meanwhile, 5G subscriptions will increase from under 1 billion in 2021 to 4.4 billion in 2027 and will account for 48% of total mobile subscriptions by 2027.[17]

As this report shows, there are numerous use cases across industries and the public sector to enhance quality and efficiency through 5G-enabled digitalization. 5G and digitalization are critically important to enhancing Canada's productivity and standard of living and to counteracting its aging population and resultant drag on labour market growth.

5G is also an enabler of job growth. According to the Information and Communications Technology Council (ICTC), employment growth in the digital economy will continue to outpace employment growth in the general economy and will account for roughly 11% of total employment in Canada by 2025.[18] Tech workers in its report include 30 National Occupational Classification (NOC) codes, while the tech sector is defined by 18 North American Industry Classification System (NAICS) codes. Although these are detailed in the report, they almost certainly include individuals working in the wireless sector. According to Statistics Canada, the wireless sector accounted for 55,192 direct jobs plus an additional 57,344 indirect and 33,164 induced jobs in

[15] Link to source: https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=54165922&file=121120-working-paper.pdf.
[16] Link to source: https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=54165916&file=051120-5G-in-Canada.pdf.
[17] Link to source: https://www.ericsson.com/49d3a0/assets/local/reports-papers/mobility-report/documents/2022/ericsson-mobility-report-june-2022.pdf.
[18] Link to source: https://www.ictc-ctic.ca/wp-content/uploads/2021/08/digital-talent-outlook-for-2025.pdf.

2020.[19] Meanwhile, average weekly earnings in the wider wired and wireless telecommunications carriers sector were 24% higher than in the service industry in 2020.[20]

It is important to highlight, however, that 5G drives economic growth primarily through productivity gains rather than job creation; that is, 5G and the applications that run on it have the potential to make labour more productive (which, recall, tends to increase wages). More so than creating new jobs, 5G and its related technologies place demands on workers to adapt to new ways of work that are more digitally intensive and require digitally aware skills. In more extreme cases where 5G-enabled technologies such as automation eliminate jobs, impacted workers will need to get re-skilled for a different occupation. On aggregate, however, technologies such as automation and robots may be associated with higher levels of employment. For instance, a 2022 study by the Centre for Future Work finds that business machinery & equipment investment as a percent of GDP is positively correlated with annual changes in employment when looking at years 1976 to 2020 in Canada.[21]

[19] Link to source: Statistics Canada. Table 36-10-0669-01 Wireless telecommunications carriers industry economic impact. Direct jobs reflect those working in the sector. Indirect jobs reflect demand for inputs from other Canadian businesses. Induced jobs reflect the economic activity that arises because of workers involved in the direct or indirect activity spending part of their earnings on other goods and services provided by Canadian businesses.

[20] Link to source: Statistics Canada. Table 14-10-0204-01 Survey of Employment, Payrolls and Hours (SEPH) Average Weekly Earnings by Industry, annual.

[21] Link to source: https://centreforfuturework.ca/wp-content/uploads/2022/04/Where-Are-The-Robots.pdf.