Digital Differences

The impact of automation on the Indigenous economy in Canada

TED ROGERS SCHOOL OF MANAGEMENT | DIVERSITY INSTITUTE

Canadian Council for ABORIGINAL BUSINESS

Future Skills Centre

About CCAB Research

The research department at the Canadian Council for Aboriginal Business (CCAB) has worked across Canada for the last 10 years to quantify the size and impact of the Indigenous economy. While improving Indigenous Peoples' economic development potential is essential for reconciliation, it has been difficult to quantify. A cursory scan of the literature reveals little information about the current Indigenous economy and even less about where it is headed. Until Indigenous Peoples have equal access to economic opportunities, the full potential of the Indigenous economy will remain unknown. Oppressive policies from the past are still felt in the present, resulting in a raft of chronic and reinforcing challenges, including poverty, ill health, unemployment, educational inequality, and barriers to self-determination. Despite stiff headwinds, Indigenous communities and businesses have achieved sustained economic growth. Our job as researchers is to communicate effectively to Canadians, motivating them not to let this hard-earned progress be for naught.

In addition to producing bespoke research projects on various region and sector-specific topics, CCAB Research has three organizing themes: procurement, trade and export, and future of work. The unifying thread tying these themes together is Indigenous-led community development. As Indigenous people make up a progressively larger proportion of the young adult population in Canada — notably in the North and West — helping ensure Indigenous youth are well-positioned to thrive should be on the radar of all Canadians. The COVID-19 pandemic has put into stark relief many disproportionate impacts on the Indigenous economy, including Canada's deep digital divide. While much of the country's labour force has adapted to work-at-home measures, we cannot forget those on the margins. Indigenous people working for small businesses and those in rural and remote communities, where reliable internet service is often sparse or unaffordable, are likely unable to make the shift to remote work (Statistics Canada, 2020). Or, those in urban communities whose pre-existing socioeconomic status was disproportionately low and/or precarious (Arriaganda et al., 2020). Education, training, and employment opportunities suffer as a consequence. This is a current and ongoing example of how technological change can contribute to a rise in economic inequality.

At CCAB, we understand the importance of tracking technology trends that change the way we work and interact, and as such, we encourage collaboration with like-minded organizations, such as Ryerson University's Diversity Institute. Recent events have shed new light on old systemic barriers and we must now challenge our willingness to accept the status quo. Together, we can emerge more resilient from the crisis by identifying and addressing hurdles to technology use and design. This is how we create a culture of technology that works for all Canadians.

Contents

Executive Summary

Indigenous entrepreneurs and workers have made enormous strides in starting business, forming credit and lending organizations for Indigenous business-operators, and increasing the number of Indigenous employees in employment. Nonetheless, several reports indicate that automation may disproportionately impact Indigenous workers. This report investigates at a more granular level how technological change, specifically automation, will affect Indigenous workers by industry and region across Canada. This research builds on previous work that examined the implications of automation in Canada generally, and on Indigenous workers in specific industries abroad, by applying their methods to understand the impact of automation on Indigenous workers in Canada.

This report answers the key questions:

> How are Indigenous workers differentially at risk from the effects of automation?

> How do these differential risks vary for Indigenous workers by geography?

> We estimate the number of Indigenous workers in industries susceptible to automation using employment, income, and education data. In addition to modelling the number of Indigenous workers at high risk from automation by industry and region, we also include a review of Statistics Canada skills data to add depth to the analysis.

Key findings related to automation across industries include that:

> Approximately 250,000 jobs held by Indigenous workers are at high risk of automation in the 33 industries listed.

> The top five industries represent 131,000 Indigenous employees at high risk from automation.

> Using median wage data, the top five industries at risk account for approximately $2.43 billion of Indigenous wage revenue.

Key findings related to automation across regions of Canada include that:

> Prince Edward Island, British Columbia, and New Brunswick have the highest proportion of Indigenous workers currently employed in roles with a high risk of automation.

> Indigenous workers in Nunavut, British Columbia, Prince Edward Island, the Northwest Territories, Ontario, and Alberta are more at risk from automation than non-Indigenous workers in these provinces.

By industry, Indigenous employment is more concentrated in the top five industries at high risk from automation (accommodation and food services; retail trade; construction; transportation and warehousing; and management, administration and other services) relative to non-Indigenous employment in Canada. We find that in the five largest provinces, notably British Columbia and Alberta, Indigenous workers facing high risks of automation are concentrated in the top five industries listed above. A discussion of the findings and series of recommendations are provided at the conclusion of this report.

It is vitally important to understand what changes are coming to better prepare Indigenous business owners, workers, and policy-makers in this space for the risks and opportunities that come with automation for the Indigenous economy.

Indigenous children, youth, and adults have the right to access education, including skills and training required to upskill and pivot throughout one's career. It is vitally important to understand what changes are coming to better prepare Indigenous business owners, workers, and policy-makers in this space for the risks and opportunities that come with automation for the Indigenous economy.

Introduction

Purpose & background

Technological progress, and the anticipated increase in automation for certain industries and occupations, has resulted in rising fears of technologically catalyzed unemployment and its associated social impacts. Automation refers to the threat — both perceived and real — of emerging technologies such as robots, technological innovations, or artificial intelligence replacing the work done now by humans. Automation does make some jobs redundant, such as the telephone replacing former telegraph operators.

Emerging technologies, including artificial intelligence, machine learning, and advanced robotics, have the potential to automate many tasks currently performed by workers. This effect can have benefits, such as leading to job creation, increased manufacturing efficiencies, and even improvements to the quality or accuracy of a completed task. However, automation can also lead to job loss, hitting single-industry communities particularly hard, and can dislocate workers from new job opportunities. Dislocation can happen because jobs arise in different geographic locations, or because they necessitate new and different skill sets. Even when there is net positive gain, automation is disruptive and the management of transitions around automation can lead to drastically varied outcomes for those affected.

This report investigates how technological change, specifically automation, will affect Indigenous workers by industry and region across Canada. This work contributes to the Canadian Council of Aboriginal Business' (CCAB) research to support its members by building a detailed understanding of the future Indigenous economy in Canada.

Broad-based research has been conducted on the potential impacts of automation on workers in Canada across industry, skill level, and province (Di Matteo, 2019; Frank & Frenette, 2018; The Canadian Chamber of Commerce, 2018). Researchers have predicted that Canada's workforce will be both disrupted and changed by technology, altering how we work, where we live, how we socialize, and how we think about the pipeline between education and work (Policy Horizons Canada, 2019a; Policy Horizons Canada, 2019b; Thornton et al., 2019). In this vein of research, Oschinski and Wyonch's (2017) *Future Shock? The Impact of Automation on Canada's Labour Market* attempts to assess the Canadian labour market impact of technological change over the past 30 years, highlighting its future implications. The background to our research is informed by the key findings of this report, particularly that "some industries and types of occupations will be more disrupted than others" (Ibid., p.1).

The impact of technological innovation is not a zero-sum game for the labour force: while the increasing use of technology and automation in the workplace may result in fewer workers required to perform specific tasks (Lamb & Doyle, 2017), it will also translate into increased productivity and demand for higher-skilled employees (Mckay et al., 2019; Muro et al., 2019; OECD, 2012). Some have predicted that automation will catalyze redistribution — rather than loss — of jobs and have even made the case that members of groups previously overlooked in traditional workforces and the job market, like women, will benefit most from this redistribution (Madgavkar et al., 2019; Roberts et al., 2019). Still others predict that without adequate training and investment automation will lead to more inequality and worse outcomes for equity seeking groups (Blit et al., 2018; Frank & Frenette, 2018).

Although employment in any given industry is, in theory, at risk of redistribution or loss from automation, it does not follow that the jobs in question will necessarily be automated. The decision to automate will be determined by many factors, including "firm size, competitive pressure and the cost of a machine versus the cost of human labour" (Oschinski & Wyonch, 2017, p. 1). Where automation does occur, it may lead to increased demand for skilled labour capable of using the new technology to its full extent (Birnbaum & Farrow, 2018; Bughin et al., 2018). While some job loss may occur in the short run, automation can lead to wage increases for those remaining in their sector and increased productivity overall (Oschinski & Wyonch, 2017). This holds true for both the non-Indigenous and Indigenous economy.

Automation is not necessarily a labour-displacing force, although research has shown it can have the effect of decreasing the value-add of labour (Autor & Salomons, 2018). In fact, researchers have shown that an aging Canadian population twinned with a rise in automation may actually result in a labour scarcity over the coming decades — the opposite of what the business media has predicted around robots and automation taking human jobs (Di Matteo, 2019). Automation and changes in our digital environment, including the adoption of artificial intelligence and machine learning capacities, mean the impact of automation on any given industry or particular job is highly variable (Lamb et al., 2018). Still, analyses have been conducted predicting where we expect to see losses and gains in the Canadian job market, and several studies reinforce the indications through different metrics also shown in this report — that Indigenous workers are often in jobs and industries at risk of automation, and even overall decline (Rivera et al., 2020).

Although employment in any given industry is, in theory, at risk of redistribution or loss from automation, it does not follow that the jobs in question will necessarily be automated. The decision to automate will be determined by many factors, including "firm size, competitive pressure and the cost of a machine versus the cost of human labour.

Given that existing research establishes that the costs and benefits of automation will not be uniformly distributed across the workforce, we propose that the proportion of Indigenous workers employed in different industries and occupations will determine whether the effects of technological disruption are borne more, or less, by the Indigenous economy in Canada, and further, in specific geographies across the country. Specifically, we are interested in automation and the risk of automation and job redistribution away from Indigenous workers.

One particular reason for concern around automation risk is that researchers have found formal education attainment and basic literacy skills can mitigate against disruption and job loss. Indigenous workers in many sectors have below-average basic literacy and numeracy skills and are over-represented in jobs associated with lower-tier skill levels (Murray and Shillington, 2012). Authors of a recent report argue Indigenous workers in Canada are already disproportionately associated with jobs with less skills transferability (Skudra et al., 2020). The corollary of this finding is that "when we think about susceptibility to job loss through automation and the need to prepare for widespread digital upskilling, we see warning signs that Indigenous Peoples may be proportionally harder hit by disruptive technologies" (Ibid., p.17-18). Research has shown required levels of literacy are also rising across occupations, exacerbating both existing literacy skills gaps and increasing the challenge of making work transitions in the face of a newly digitally enabled workplace (DataAngel Policy Research Incorporated, 2009).

Even at similar levels of educational attainment, research shows Indigenous people fare worse in the job market (OECD, 2018). This effect varies depending on the Indigenous identity group, but non-Indigenous people with similar skill and education levels fare better than all Indigenous identity groups (Arriaganda & Hango, 2016). While people working in senior level management jobs are much less likely to lose their job in automation risk predictions, workers in jobs requiring minimal educational qualifications are most likely to lose them (Royal Bank of Canada, 2018). Indigenous Peoples — already disproportionately working jobs with low transferability and having below average levels of educational qualifications, literacy, and numeracy skills — are very vulnerable to the disruptive side of automation (The National Indigenous Economic Development Board, 2019). This context has led us to analyze data about automation risk and the Indigenous economy.

Previously published papers have discussed the implications of automation on Indigenous workers in specific industries (CEDEC, 2018; Holcombe & Kemp, 2018), but nothing provides a complete overview of the Indigenous economy in Canada. This report aims to fill this knowledge gap by answering the key questions:

> How are Indigenous workers differentially at risk from the effects of automation?

> How do these differential risks vary for Indigenous workers by geography?

In Section 2.2, we begin with an overview of Indigenous employment in Canada by industry and province. Section 3 outlines the methodology used to model the number of Indigenous workers potentially affected by automation. We then present the extent to which Indigenous workers are at a greater (or lesser) risk from automation than their non-Indigenous counterparts. In sections 4 and 5, we suggest further research before presenting concluding thoughts and considerations for education and skills training to lower the risk of automation for the Indigenous population. Appendix A provides additional charts and figures from the analysis.

Indigenous employment in Canada

This section discusses the industries and regions in Canada in which the Indigenous population have the highest revenue from employment and self-employment.

Indigenous people in Canada represent 4 percent of the total labour force and generate a combined household income of approximately $30 billion a year (Statistics Canada, 2018a). The population of self-employed Indigenous Peoples has grown while the rate of self-employment among non-Indigenous people has declined (Canadian Council for Aboriginal Business, 2016). Employment is broadly distributed across industry, income level, and job type, but there are documented differences between Indigenous workers and the greater population, which may have an effect on the level of risk these workers face from automation.

Appendix A, Table A1 provides an overview of the proportion of Indigenous and non-Indigenous employees by the North American Industry Classification System (NAICS) industry group, as well as their median wages. The largest five industry employers (health care and social services, retail trade, public administration, construction, and accommodation

and food services) cumulatively account for 54 percent of Indigenous workers in the Canadian economy. The numbers show Indigenous workers in each of these industries are proportionally overrepresented relative to non-Indigenous workers.

Using median wage and number of workers employed to estimate revenue generated by each industry highlights which industries are driving the Indigenous economy (see Table A1). Approximately 16% of wage revenues are generated in public administration, with health care and social assistance (14%) and construction (10%) as the top three. Despite employing a significant percentage of Indigenous workers, retail trade only accounts for approximately 6% of employment revenue due to the industry's low median wage, behind educational services (8%), mining, quarrying, and oil & gas extraction (7%), and manufacturing (7%).

Note that public administration also includes the subsector Aboriginal public administration (NAICS 914), which "comprises establishments of Aboriginal governments primarily engaged in providing to their constituents, a wide variety of government services that would otherwise be provided by federal, provincial or municipal levels of governments" (Statistics Canada, 2018). Statistics Canada reports workers in the Aboriginal public administration subsector make up about 25% of Indigenous workers employed overall in the public administration industry, accounting for 16% of the employment revenue generated from Indigenous workers in this industry.

The smallest four sectors of Indigenous employment (information and cultural industries, real estate rental and leasing, utilities, and management of companies and enterprises) also generate the least employment revenue. Only 3% of Indigenous employees work in the professional, scientific, and technical services industry, compared to 7% of their non-Indigenous counterparts, a substantial employment gap in this particular sector.

By province (see Appendix A, Table A2), Ontario, British Columbia, Alberta, Quebec, and Manitoba account for 79% of Indigenous employment in Canada, and 79% of Indigenous employment revenue. Although British Columbia employs just over 1% more Indigenous workers than Alberta, the province generates approximately 3.4% less wage revenue, which is attributable to Alberta's higher average wage revenue per capita.

Appendix A, Table A3, presents Indigenous self-employment rates by province in 2015. Self-employed individuals are defined as "working owners of an incorporated business, farm or professional practice, or working owners of an unincorporated business, farm or professional practice. The latter group also includes self-employed workers who do not own a business" (Statistics Canada, 2015). The provincial trends in the employed Indigenous population are mirrored here for the self-employed; Ontario, British Columba, Alberta, Quebec, and Manitoba have the highest proportion of Indigenous self-employed. The concentration of Indigenous self-employed workers in these provinces, at 84%, is slightly higher than the proportion of Indigenous employees (79%).

While the geographic concentration of Indigenous employees and the self-employed is quite similar, the sectoral distribution is different. A full 58 percent of Indigenous self-employed people work in the five most vulnerable industries, with the only two sectors that overlap being construction and health care and social assistance (see Appendix A, Table A4).

Diversity analysis

In the following analysis, the two main variables measured within the Indigenous worker population in Canada are region and risk of vulnerability. Risk of vulnerability is calculated by applying an automation risk measurement tool to NAICS data cross-tabulated with Statistics Canada employment data, a methodology described in more detail in Section 3.1.

In this broad, high-level analysis of region by risk level, we capture a unique set of insights for planning for automation in Canadian industries with high Indigenous worker populations. This information is critical for informing policy decisions and planning education and qualification pathways for Indigenous workers and students to mitigate against economic shocks and make smooth transitions.

In analyzing at this high level, we acknowledge that throughout this paper we largely ignore distinctions between Indigenous groups, with the exception of in our final figure, Figure 10. While the focus on region and risk dominates the main body of this paper, Appendix A provides a more detailed analysis of other identity differences, such as how gender, age, and Indigenous identity impact risk of automation. We encourage the reader to review data presented in this appendix to guide future work. To provide some analysis addressing gender and Indigenous identity factors, here are some highlights from Appendix A.

In Figure A2 we show there is no dramatic difference between Indigenous and non-Indigenous workers when it comes to worker age and automation risk. People in the 15 to 24-year age bracket are at the highest risk of their jobs being automated across groups. Similarly, Indigenous and non-Indigenous populations mirror a gender dynamic with men more at risk than women to having their jobs automated (Figure A3). Figure A4, Figure A5, and Figure A6 show industries by number of Indigenous employees and risk level generated to correspond to the three distinct Indigenous groups recognized in Canada — First Nations, Inuit and Métis. There are differences across the groups. For example, while health care and social assistance is a sector with high Indigenous representation, it is top for Métis and First Nations, while second for Inuit. This corresponds with the high employment rate of Inuit in public administration, likely a result of policies in Nunavut regarding Indigenous representation in government. More granular analyses on a sector-by-sector basis would reveal additional differences between these distinct groups.

Figure A7 shows skills gaps by Indigenous identity and again highlights important differences relating to automation risk. It shows the skills gap is highest for Inuit employed in what NAICS considers an advanced skills level position, narrowly followed by First Nations, and then Métis. These statistics support the concern that those who already have a skills gap at work will be more at risk of automation. As shown in Figure A8, the skills gap in advanced skills level positions is even greater among self-employed workers.

As noted, these secondary and additional figures given in the appendix indicate just how much more there is to know about gender and Indigenous identity differences in the Indigenous economy. We encourage future research to expand on these insights.

Analysis

Methodology

This report uses data from Oschinski & Wyonch (2017) on risk of automation by industry, as categorized by NOC (National Occupational Classification) level. These estimates were applied to Canadian Indigenous employment data to estimate the number of Indigenous workers in jobs at high risk of automation and the potential wage losses associated with those expected job losses.

Oschinski and Wynoch (2017) established a list of skills required by each occupation using "information provided by the Occupational Information Network (O*Net), a database containing detailed definitions for almost all occupations, and providing quantitative indicators on the importance and the level of skills used in each occupation." From this list, they selected skills that were difficult to automate, and "classified jobs between those that certainly can be automated and those we are most confident cannot" (Oschinski & Wyonch, 2017). The probability of automation was estimated for each occupation, and the data was then aggregated by industry in order to produce the probability of automation for employment by industry. A job is categorized as "high risk" if the probability of automation is 0.72 or greater.

In this report, we applied the metrics developed by Oschinski and Wynoch (2017) by quantifying the proportions of vulnerable employees by industry in Canada to Indigenous employment data. From this, we estimate the aggregate Indigenous employment effects expected from automation country-wide across industries, as well as determining a more granular picture of how Indigenous workers in specific geographies will be affected by these trends.[1] We also include a review of Statistics Canada skills data to add further nuance to the analysis. The NOC system allows us to separate jobs in each industry into the skill categories in order to estimate skill gaps by industry as presented in Table 1.

1 Note: There is an implicit assumption of an equal distribution of skill levels between Indigenous workers and the Canadian workforce in general. We show that there are persistent skill gaps across all industries (Figure 4), and lower skill jobs are at higher risk of automation. As such our estimates for jobs at high risk of automation and the estimated wage losses are lower bounds.

TABLE 1

NOC Skill Levels

Skill Level	Description
Skill Level A	Professional jobs that usually call for a degree from a university.
Skill Level B	Technical jobs and skilled trades that usually call for a college diploma or training as an apprentice.
Skill Level C	Intermediate jobs that usually call for high school and/or job-specific training.
Skill Level D	Labour jobs that usually give on-the-job training.

Source: Employment and Social Development Canada

We have applied Oschinski and Wynoch's (2017) risk of automation estimate, which was calculated at the level of occupation, to analyze industries as defined through the North American Industry Classification System (NAICS). While the application of this calculation of automation risk must be applied with caution from the NOC's occupational classification level to the NAICS industry classification level, authors contend that it is robust enough to indicate accurately the likelihood of automation risk to Indigenous workers at the level of industry.

Industry

This section examines how Indigenous workers are differentially at risk from the effects of automation by addressing the following questions:

> What are the most vulnerable and resilient industries in Canada? What is the Indigenous and non-Indigenous representation within these industries?

> How does representation differ between employment and self-employment?

> What are the number of jobs lost and the values of wages lost for Indigenous workers?

> Approximately 250,000 jobs held by Indigenous workers are at high risk of automation in the 33 industries listed.

> The top five industries represent 131,000 Indigenous employees at high risk from automation.

> Using median wage data, the top five industries at risk account for approximately $2.43 billion of Indigenous wage revenue.

FIGURE 1

Vulnerability to automation, Indigenous employment by industry, Canada
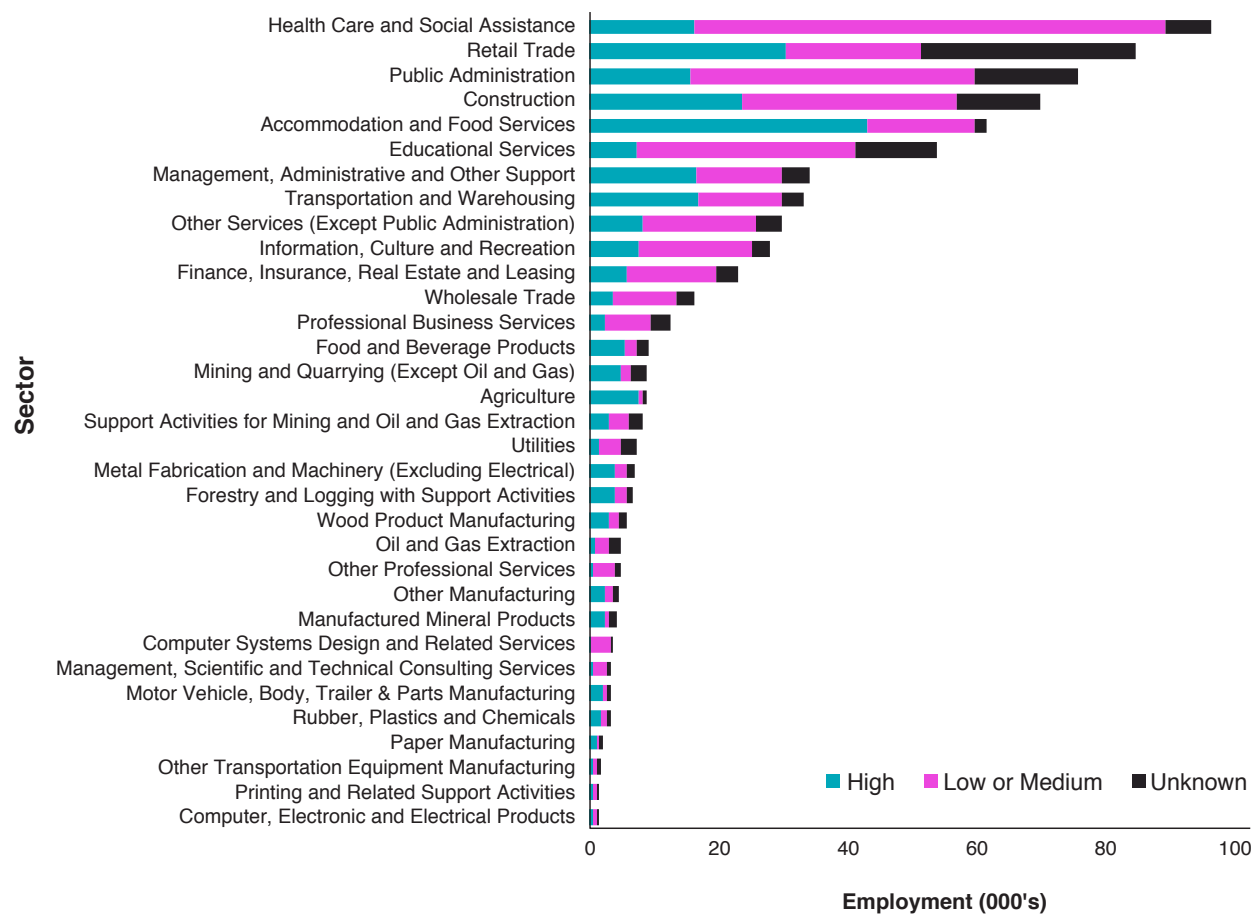
Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

Figure 1 shows the total number of jobs held by Indigenous workers per industry at high, low or medium, or of unknown risk to being lost due to automation in Canada. We find a total of approximately 250,000 jobs held by Indigenous workers are at high risk of automation in the 33 industries listed, with a median of 3,520 jobs represented by the wholesale trade sector. The five industry categories with the highest levels of automation risk, indicated in Figure 1 as risk level "High," in order of magnitude are: accommodation and food services; retail trade; construction; transportation and warehousing; and management, administrative, and other support. Those sectors cumulatively represent 131,000 Indigenous employees (54 percent of those at high risk from automation). Health care and social assistance (16,120 jobs), and public administration (15,486 jobs) respectively rank as numbers five and six in terms of the risk level pertaining to jobs held by Indigenous workers. Accommodation and food services, which alone accounts for 43,000 jobs held by Indigenous workers at high risk from automation, is both within the top five industries for employing Indigenous workers and has a high proportion (70 percent) of jobs at high risk from automation.

FIGURE 2

Vulnerable Indigenous vs. non-Indigenous employment in Canada by industry (percentage of total employment), Canada

Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

Using a probability-weighted estimate[2] of the potential wages lost to the Indigenous economy if automation were to eliminate high risk jobs, we see approximately $2.43 billion of "at risk" wage revenue is from the top five affected industries: construction ($615 million), public administration ($562 million), transportation and warehousing ($489 million), health care and social assistance ($396 million), and accommodation and food services ($368 million). Interestingly, despite the high number of jobs at risk in the accommodation and food services industry, the relatively low median wage in this sector diminishes the employment revenue impact relative to other industries, such as construction.

2 Note: (Median wage per worker by industry) x (number of jobs held by Indigenous workers at high risk of automation) x (0.72 – the lowest probability for a job to be categorized as being at high risk of automation). In this analysis we are assuming that the probability of a job being replaced by automation remains constant across all individuals across all industries at 0.72. A future research project might consider risk of automation were the probability of automation to vary across industries.

The five industries with the lowest proportion of workers at high risk of automation are: health care and social assistance (17%), management, scientific, and technical consulting services (14%), education services (13%), other professional services (12%), and computer systems design and related services (4%). These industries employ 161,995 (23%) of Indigenous workers across Canada but account for only 24,553 jobs at high risk.

Figure 2 compares the percentage of total Indigenous workers whose jobs have a high risk of automation to non-Indigenous workers with high risk across each industry (expressed as a percentage of total employment for the respective population group).

As shown, the top five industries at risk from automation for both Indigenous and non-Indigenous workers are: accommodation and food services, retail trade, construction, transportation and warehousing, and management, administrative, and other support. These industries account for approximately 54% of Indigenous workers and 49% of non-Indigenous workers at high risk from automation.

FIGURE 3

Vulnerable Indigenous vs. non-Indigenous employment in Canada by industry (percentage of total employment), Canada
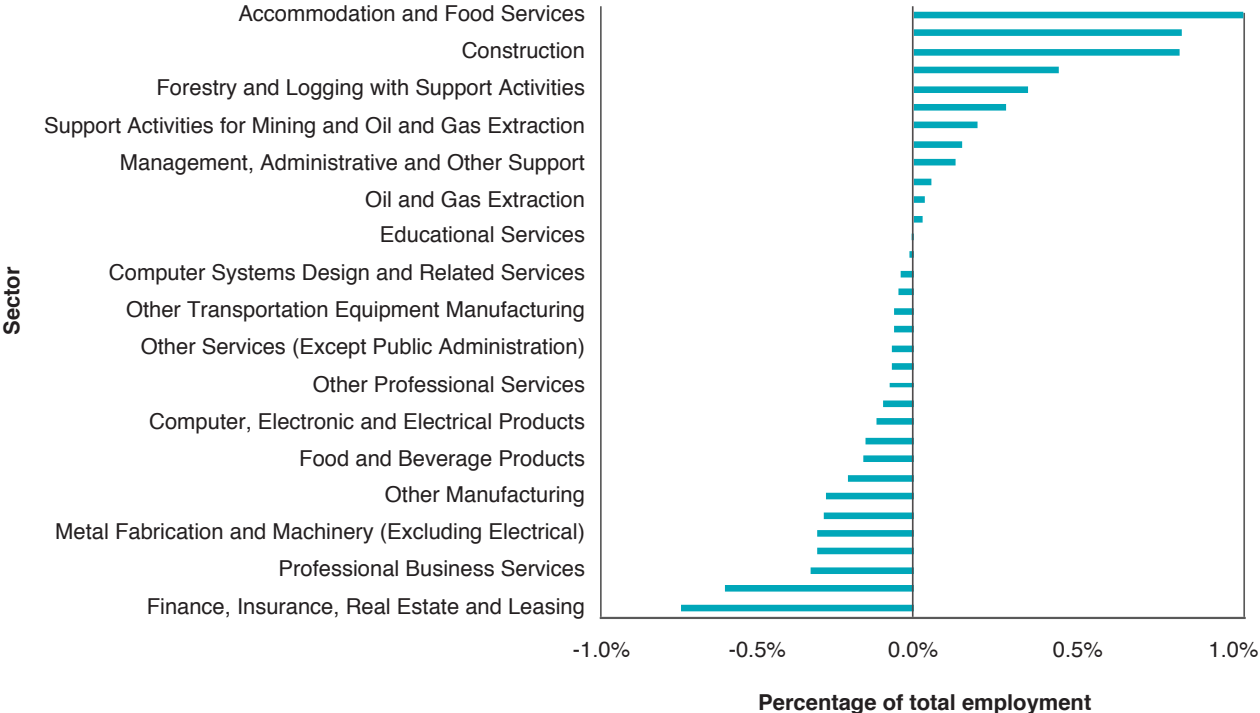
Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

Figure 3 presents the differences in percent of total employment at high risk of automation in each industry between Indigenous and non-Indigenous workers. Across the 33 NAICS industries listed, 12 contain a higher proportion of Indigenous employment at high risk from automation, while 21 contain a lower proportion of Indigenous employment at high risk from automation. Given Indigenous workers are highly employed in the public administration sector, it is notable that as a percentage of total employment, a higher proportion of jobs are at risk for Indigenous workers relative to non-Indigenous workers. The largest difference in the percentage of total employment between non-Indigenous and Indigenous workers is in the accommodation and food services industry (1.1 percent).

The five largest sectors of Indigenous employment (accommodation and food services, public administration, construction, healthcare and social assistance, and retail trade) all represent industries where a greater proportion of jobs held by Indigenous workers are at a high risk of automation. Although there are more industries (21) where a higher proportion of jobs held by non-Indigenous workers are at high risk from automation, overall the effect of the industries with a higher proportion of jobs held by Indigenous workers (12) puts Indigenous workers at a marginally (0.46 percent) higher probability of being at high risk from automation.

Figure 4 presents the difference in NOC skill levels by sector for Indigenous employees relative to non-Indigenous employees in Canada. It is clear that across all industries Indigenous workers are between 5 percent (i.e. printing and related support activities), to more than 20 percent (i.e. utilities, oil and gas extraction) less likely than their non-Indigenous counterparts to be employed in professional or managerial Skill Level A type roles. These occupations contain the non-routine cognitive tasks that make them less likely to be at risk from automation, where Skill Level C or D roles typically involve routine tasks that are more likely to be automated.

FIGURE 4

Skill gaps by sector for Indigenous employees vs. non-Indigenous employees, Canada
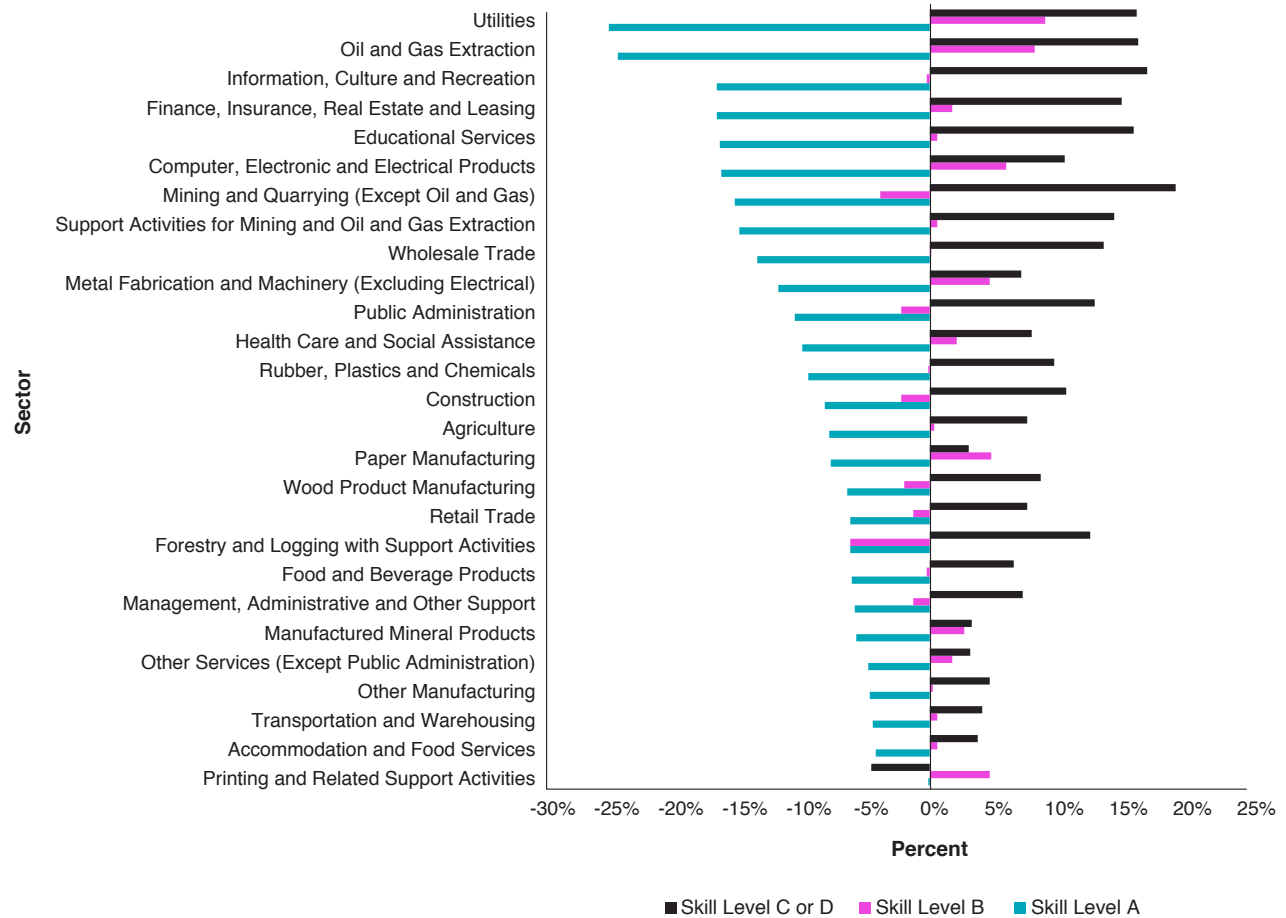
Source: Statistics Canada Custom Tabulation 2016 Census (2018c), Big River Analytics Calculations

Of the top five industries at high risk from automation (accommodation and food services, retail trade, construction, transportation and warehousing, and management, administrative, and other support), construction has the highest gap for Skill Level A (8.3%), and represents the median industry with respect to this skill level gap. The other four are below the median in terms of gap between Skill Level A in Indigenous relative to non-Indigenous workers (ranging from 6.2% for retail trade to 4.3% for accommodation and food services).

When we extend the skill gap analysis to the top five industries employing Indigenous workers, public administration and health care and social assistance are slightly above the median gap for Skill Level A (10.5% and 10.0%, respectively). Indigenous workers in these industries do exhibit an increased likelihood of being employed in a Skill Level C or D role, which may expose them to a higher risk of job loss through automation.

Among the sectors with fewest workers at high risk from automation, educational services has the fifth largest skills gap, with Indigenous workers far less likely to be found in a Skill Level A role and more likely to be found in a Skill Level C or D role, which again could indicate an increased risk of automation compared to a non-Indigenous worker in this sector.

Although technology will disrupt employees to the extent that their jobs are more, or less, susceptible to automation, the effects on the population of Indigenous self-employed workers is less clear. To the extent they are business owners who employ workers, they will benefit from the productivity increases and reduced labour costs that technological innovation affords. However, some self-employed individuals will have their own roles automated and may face reduced demand for their services.

FIGURE 5

Indigenous self-employment by industry, Canada

Source: Statistics Canada Custom Tabulation, 2016 Census (2018b), Big River Analytics Calculations

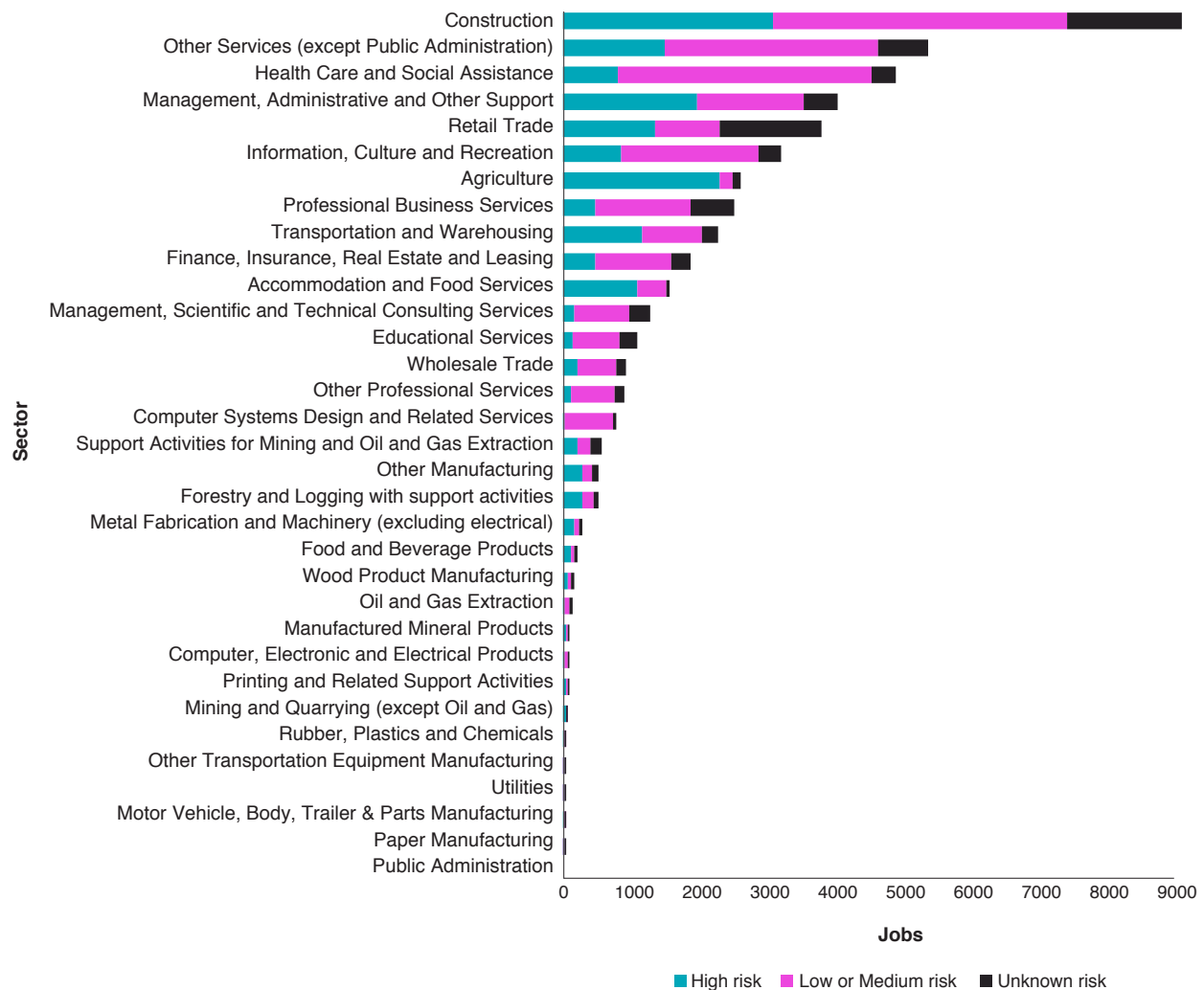Figure 5 illustrates the number of Indigenous self-employed by industry in Canada, with each industry split into the proportions of workers whose jobs are at high, medium and low, and unknown risk from automation. Approximately 49,000 Indigenous individuals are listed as self-employed, with the highest proportion in construction (9,100 individuals). 55 percent of Indigenous self-employed are represented by construction, other services (except public administration), health care and social assistance, management and other support, and retail trade.

Qualitative analysis suggests that to the extent self-employed Indigenous workers in construction are subcontractors, they may be subject to similar risks from automation as their employee counterparts. However, in the retail trade, where the self-employed may be represented by sole proprietors selling merchandise, these individuals would be less at risk from the unemployment effects of automation, and labour productivity may actually benefit from technological innovation (e.g. bookkeeping, inventory management, etc.).

FIGURE 6

Skill gaps by sector, Indigenous self-employed, Canada

Source: Statistics Canada Custom Tabulation 2016 Census (2018c), Big River Analytics Calculations

To add nuance to the effects of automation on Indigenous self-employment, Figure 6 identifies skill gaps by sector. The Indigenous self-employed in four out of five industries identified above have a below-median gap with non-Indigenous self-employed individuals in terms of Skill Level A. In these industries, Indigenous self-employed workers are less than 5 percent less likely to be in a Skill Level A category. However, in the health care and social assistance industry, this Skill Level A differential is 25 percent, suggesting that Indigenous self-employed workers may be more at risk from automation in this industry than their non-Indigenous colleagues.

Region

This section examines the differential risks for Indigenous workers by geography within Canada by addressing the following questions:

> What is the breakdown of industry within provinces and territories?

> Are there regions that are more or less vulnerable to automation for Indigenous employment?

Figures 7a and 7b give a provincial and territorial breakdown of industries with top representation of Indigenous workers. Figure 7a shows the top three industries for Indigenous worker representation in each province and territory. There is an unevenness between provinces and territories, with Indigenous representation in all three territories considerably higher in public administration than other industries. This figure shows while commonalities exist, the top three industries vary across province and territory.

Figure 7b provides a deeper analysis, showing the top industries in terms of automation, shown as a percentage of total Indigenous employment. This figure reveals a few key findings related to automation across regions of Canada:

> Prince Edward Island, British Columbia, and New Brunswick have the highest proportion of Indigenous workers currently employed in roles with a high risk of automation.

> Indigenous workers in Nunavut, British Columbia, Prince Edward Island, the Northwest Territories, Ontario, and Alberta are more at risk from automation than non-Indigenous workers in these provinces.

FIGURE 7A

Top three industries in each province and territory, as a percentage of total employment
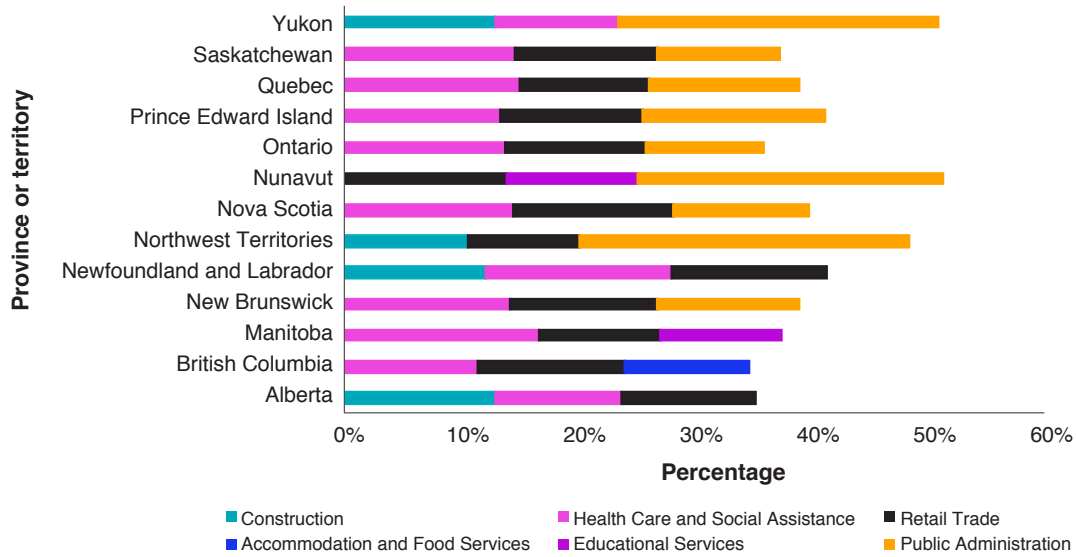
Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

FIGURE 7B

Top three industries with the highest percentage of jobs at risk in each province and territory, as a percentage of total employment
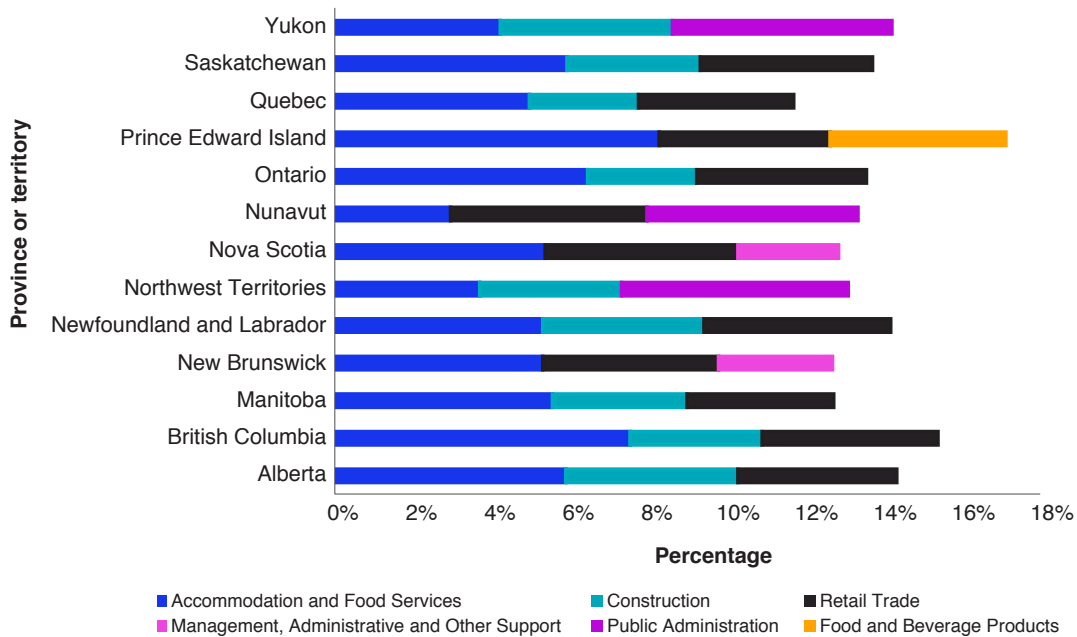
Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

These insights about the potential impacts of automation across regions lead directly to Figure 8, which examines the percentage of Indigenous and non-Indigenous workers whose jobs are at high risk of automation in each province or territory. Figure 8 shows that Canada-wide 33.81% of Indigenous workers are currently employed in roles with a high risk of automation, with Prince Edward Island (36.89%), British Columbia (36.12%), New Brunswick (34.37%), Ontario (34.14%) and Alberta (33.94%) all above the national average.

FIGURE 8

Vulnerable Indigenous vs. non-Indigenous employment by region

Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

Next, we investigate the different exposure to high automation risk between Indigenous and non-Indigenous workers by region as a percentage of total employment. Shown in Figure 9, we find that nationally Indigenous workers in Canada are at a marginally higher risk from automation than the non-Indigenous working population. Indigenous workers in Nunavut, British Columbia, Prince Edward Island, the Northwest Territories, Ontario, and Alberta are more at risk from automation than non-Indigenous workers in these provinces.
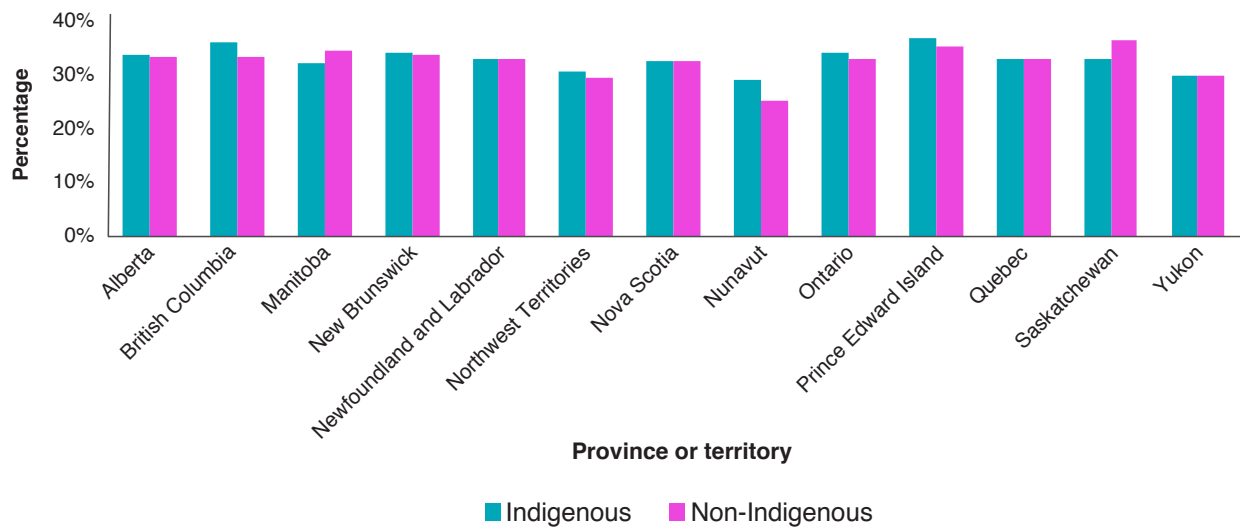
Further, Nunavut, a territory with a lower percentage of high-risk jobs for automation among both Indigenous and non-Indigenous workers, has a marked differential in the percentage of respective workforce exposure to a high-risk disruption due to automation. This is because Indigenous workers in Nunavut are more likely to be employed in retail trade, accommodation and food services, or mining and quarrying than non-Indigenous workers, exposing them to higher risks of job automation. Further, the data suggests Indigenous workers in Quebec, Manitoba, and Saskatchewan

FIGURE 9

Differential risk from automation to Indigenous vs. non-Indigenous employment by region (as a percentage of total employment)
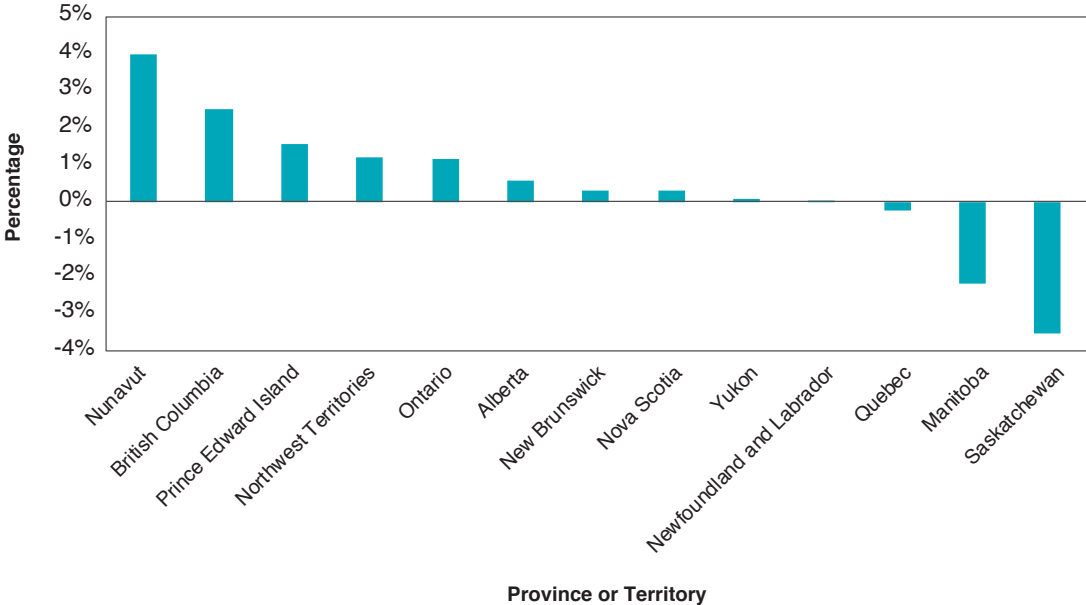
Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

are less at risk from automation than non-Indigenous workers in these provinces. In Manitoba and Saskatchewan this is due to a higher percentage of non-Indigenous workers in agriculture, an industry with the second highest risk of automation at 92.2 percent.

As highlighted in Section 2, the five largest provinces in terms of Indigenous employment (Ontario, British Columbia, Alberta, Quebec, and Manitoba) account for 79% of Indigenous workers, equivalent to 575,000 jobs. Across all industries in these provinces, 196,000 (34%) jobs held by Indigenous workers are at high risk from automation. In order to analyze these provinces by industry, we look at the top four industries where jobs are at high risk from automation (accommodation and food services, retail trade, construction, and transportation and warehousing).

Indigenous workers in Quebec, Manitoba, and Saskatchewan are less at risk from automation than non-Indigenous workers in these provinces.

Jobs in these industries account for 45-50% of Indigenous employment at risk in Ontario, British Columbia, Alberta, and Manitoba, with Quebec being slightly less concentrated with these sectors accounting for 42%.

FIGURE 10

Percentage of employment at high risk of automation by Indigenous identity group and region
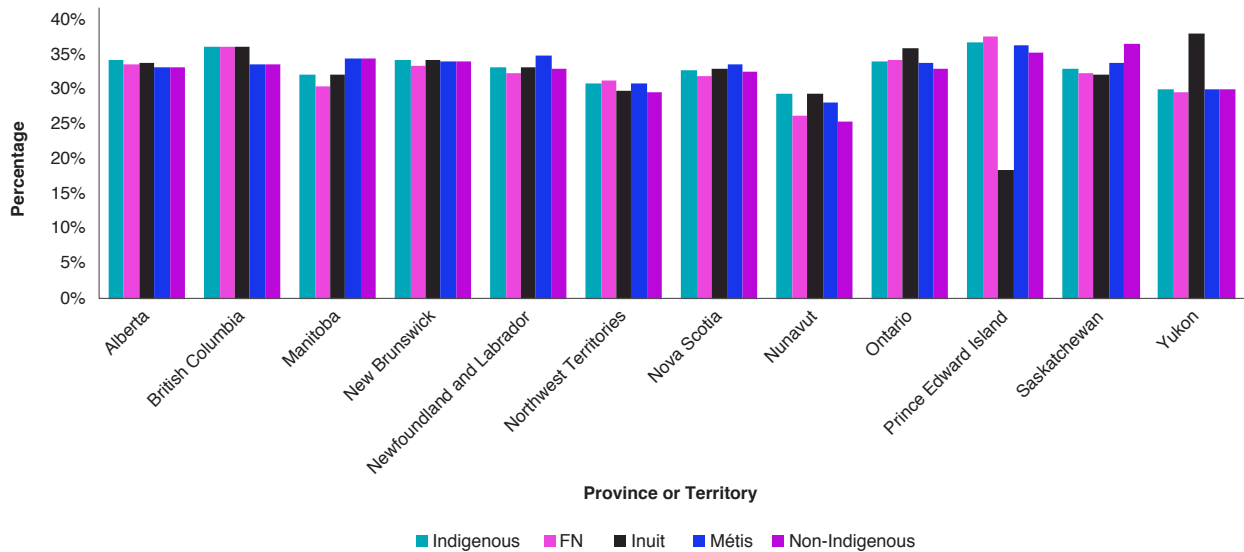
Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

Figure 10 presents the percentage of Indigenous workers in positions facing a high risk of automation by Indigenous identity group and by region. Nunavut has the lowest percentage of workers at high risk of automation, ranging from 25.4% for non-Indigenous workers to 29.6% for Inuit workers. First Nations workers have the lowest risk of automation in most provinces, and Inuit have the highest risk of automation in most provinces. Non-Indigenous workers typically face lower risk of automation. These differences are driven by employment in different industries, and will be exacerbated by Indigenous groups that have larger skill gaps at level A.

Indigenous employment is more concentrated in the top five industries at high risk from automation (accommodation and food services, retail trade, construction, transportation and warehousing, and management, administration, and other services) relative to non-Indigenous employment in Canada.

Conclusions

This report has extended existing research to address the impact of automation on the Indigenous economy to better understand the future of Indigenous work in Canada. We applied the methods used in Oschinski and Wyonch's (2017) *Future Shock? The Impact of Automation on Canada's Labour Market* in order to more fully address where the effects of automation might be felt among Indigenous workers, both employees and those who are self-employed.

By industry, Indigenous employment is more concentrated in the top five industries at high risk from automation (accommodation and food services, retail trade, construction, transportation and warehousing, and management, administration, and other services) relative to non-Indigenous employment in Canada. Indigenous employees are also overrepresented in health care and social services, and public administration. We find that in the five largest provinces or territories, notably British Columbia and Alberta, Indigenous workers facing high risks of automation are concentrated in the top five industries listed above.

Adjusting for skill gaps, we find that workers in the top five industries at high risk from automation have a below-median gap in Skill Level A (with the exception of construction, which represents the median). However, two significant contributing industries to Indigenous employment (public administration and health care and social services) exhibit an above median skill gap in Skill Level A employees, with more employees in Skill Level C or D roles, which are perceived as being at a higher risk of automation.

Although report findings show Indigenous workers in the Canadian economy are at a higher risk from automation than their non-Indigenous counterparts, it should be noted that the costs and benefits from technological change are expected to occur gradually, and that although specific tasks may be automated, a number of higher skilled jobs will also be created for Indigenous workers, resulting in increased productivity, economic output, and prosperity.

Recommendations

This report represents a first glance at the potential impacts of automation on Indigenous employment in Canada.

To study this topic further, recommendations for future research include:

> conducting a more in-depth analysis of the distribution of Indigenous workers in each industry by occupation type to identify where they would be at increased risk from automation;

> investigating the social impact of job automation;

> estimating the cost of retraining workers; and

> estimating productivity gains from automation.

This research can also inform considerations for Indigenous education and skills training. Further assisting workers with skills training where there are documented skills gaps would be a good first step in decreasing the risk differentials of unemployment due to automation between Indigenous and non-Indigenous workers.

Parity with the non-Indigenous population in university attainment continues to be elusive and this constraint is holding back Indigenous people in Canada from competing for Skill Level A positions. These jobs rely on degree-level qualifications, which are increasingly important to employability in a knowledge-driven economy (Đonlagić & Kurtić, 2016). In 2016, 10.9% of Indigenous people aged 25 to 64 in Canada had a university degree above a bachelor level: 9.6% of First Nations people, 13.2% of Métis, and 5.3% of Inuit (Statistics Canada, 2016). The proportion of Indigenous people with a bachelor's degree or higher has increased over a 10-year period from 7.7% in 2006, a difference of 2.3 percentage points. Despite this modest improvement, a gap remains at the highest levels of education. In 2016, the comparable percentage for their non-Indigenous counterparts was 29.3%, more than twice the proportion of Indigenous people with at least a bachelor's degree (Statistics Canada, 2016).

There was also a stark difference in the proportion of Indigenous and non-Indigenous people with "no certificate, diploma or degree". In 2016, 25.6% of Indigenous people aged 25 to 64 in Canada did not have a certificate, diploma, or degree: 30% of First Nations people, 18% of Métis, and 43.9% of Inuit (Statistics Canada, 2016). The corresponding percentage for the non-Indigenous population was 10.81%. This is unacceptable and must be a critical focus of efforts to future-proof the Indigenous population in the changing world of work.

There is a silver lining. Indigenous Peoples have higher attainment rates than non-Indigenous Canadians in college and the trades. Among those with a post-secondary education, Indigenous people (38.3%) were more likely than non-Indigenous graduates (36.2%) to complete a program below the bachelor's level (trades or college programs). This is an encouraging trend and every effort should be made to upskill the Indigenous workforce to participate in jobs that require more technical skills and are better insulated from the effects of automation. For employers, this could mean facilitating formal and informal training opportunities to learn new skills and build on existing ones.

Why is Indigenous educational attainment still so difficult and contentious? It is a different experience for Indigenous people to attain higher education than non-Indigenous students due to a host of well-documented challenges, including remoteness (Sharpe & Lapointe, 2011), intergenerational effects of Indian Residential Schools (Bombay et al., 2014; Bougie & Senécal, 2010), and lack of funding for education on reserves (Drummond & Rosenbluth, 2013). Has Indigenous educational attainment improved? Yes. More Indigenous graduates are completing college and university programs, but the gains are incremental and cannot keep pace with the rapidly changing skillsets needed in the new economy.

The solution will require greater collaboration between all tiers of government, the private sector, and Indigenous leadership and community-based organizations. First, educational reform must focus on delivering high-quality and culturally appropriate curricula and resources to both urban and remote reserves and ensure that Indigenous youth living on and off reserve have access to educational opportunities on a par with non-Indigenous Canadians.

Second, organizations that employ a large number of Indigenous people have an obligation to anticipate industry trends that may put segments of their workforces at risk of automation and implement an upskilling program to help retain Indigenous workers. This program should measure core skills and competencies and then develop a strategy to address current and future skills deficits. As with early school-age, so it is with continuing education. Education and training programs designed for Indigenous people of all ages and educational backgrounds must be sensitive to historical and cultural differences. For more specific and detailed recommendations on how to reconceptualize program design and "Indigenize" STEM education and the future of learning, please refer to CCAB's (2019) *Digital Directions: Toward skills development and inclusion of Indigenous Peoples in the new economy*.

Experts claim automation will raise productivity growth to unprecedented heights (Manyika et al., 2017). We look forward to seeing how Indigenous business owners adapt novel technology to improve business performance and serve Indigenous culture and values. In the transition to a knowledge economy, our most pressing concern is how to protect Indigenous employees that are already underrepresented in the labour force in Canada, while harnessing new and exponential technologies to the benefit of the Indigenous economy.

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Appendix

TABLE A1

Indigenous and non-Indigenous population percentage of workers employed and median wage, by NAICS industry group

Industry	Indigenous workers (%)	Indigenous - median wage	Indigenous employment revenue generated (%)	Non-Indigenous workers (%)	Non-Indigenous - median wage
Health care and social assistance	13.30%	$34,145	15.76%	11.61%	$40,073
Retail trade	11.71%	$16,700	13.60%	11.68%	$21,943
Public administration	10.44%	$50,379	10.38%	6.29%	$63,132
Construction	9.65%	$35,920	8.32%	7.21%	$42,043
Accommodation and food services	8.49%	$11,902	7.45%	7.03%	$14,664
Educational services	7.45%	$37,247	7.39%	7.55%	$44,615
Manufacturing	6.00%	$41,073	5.86%	8.89%	$46,234
Administrative and support, waste management and remediation services	4.65%	$19,327	5.48%	4.32%	$23,541
Transportation and warehousing	4.57%	$40,020	3.80%	4.79%	$42,028
Other services (except public administration)	4.10%	$25,020	3.07%	4.37%	$26,061
Professional, scientific and technical services	3.32%	$38,203	3.03%	7.23%	$47,909
Mining, quarrying, and oil and gas extraction	3.03%	$82,102	2.75%	1.45%	$97,387
Agriculture, forestry, fishing, and hunting	2.91%	$20,299	2.69%	2.35%	$21,150
Arts, entertainment, and recreation	2.50%	$14,727	2.57%	2.14%	$15,440
Wholesale trade	2.24%	$40,909	2.19%	3.68%	$48,459
Finance and insurance	1.92%	$44,842	1.77%	4.42%	$53,950
Information and cultural industries	1.36%	$36,358	1.48%	2.33%	$51,132
Real estate and rental and leasing	1.25%	$31,250	1.17%	1.76%	$35,680
Utilities	1.02%	$71,631	1.10%	0.75%	$90,647
Management of companies and enterprises	0.08%	$51,633	0.12%	0.16%	$65,877
Totals	100.00%	$30,246	100.00%	100.00%	$37,522

Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

TABLE A2

Indigenous workers employed and wage income generated, by province

Province	Workers employed	Employment (% of total)	Wage revenue generated[3] ($)	Wage revenue generated (% total)	Avg wage revenue per capita[4] ($)
Ontario	169,290	23.35%	5,647,418,785	23.10%	33,359
British Columbia	122,410	16.88%	3,766,182,665	15.40%	30,767
Alberta	114,710	15.82%	4,589,133,430	18.77%	40,006
Quebec	85,455	11.79%	2,678,579,070	10.96%	31,345
Manitoba	83,535	11.52%	2,644,957,260	10.82%	31,663
Saskatchewan	60,815	8.39%	2,088,692,575	8.54%	34,345
Nova Scotia	24,795	3.42%	755,206,470	3.09%	30,458
Newfoundland & Labrador	23,430	3.23%	816,150,590	3.34%	34,834
New Brunswick	13,490	1.86%	341,398,135	1.40%	25,307
Nunavut	11,675	1.61%	434,698,725	1.78%	37,233
Northwest Territories	9,805	1.35%	484,894,110	1.98%	49,454
Yukon	4,280	0.59%	171,415,590	0.70%	40,050
Prince Edward Island	1,420	0.20%	30,041,795	0.12%	21,156
Totals	725,110	100%	24,448,769,200	100%	-

Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

TABLE A3

Indigenous self-employment rates by region (2015)

Province	Self-employed (%)
Ontario	23.46%
British Columbia	20.75%
Alberta	16.70%
Quebec	15.13%
Manitoba	8.69%
Atlantic Provinces	6.80%
Saskatchewan	6.72%
Northwest Territories	0.67%
Yukon	0.54%
Nunavut	0.54%
Totals	100%

Source: Statistics Canada Custom Tabulation 2016 Census (2018b), Big River Analytics Calculations

3 "Wage Revenue Generated" = Employment*Median Wage per Province
4 "Average Wage Revenue per Capita ($)" = "Wage Revenue Generated"/"Employment"

TABLE A4

Indigenous self-employment rates by industry (2015)

Industry	Indigenous self-employed (%)
Construction	18.16%
Professional, scientific, and technical services	10.97%
Other services (except public administration)	10.72%
Health care and social assistance	9.77%
Administrative and support, waste management and remediation services	8.00%
Agriculture, forestry, fishing, and hunting	7.95%
Retail trade	7.59%
Arts, entertainment, and recreation	4.54%
Transportation and warehousing	4.53%
Manufacturing	3.27%
Accommodation and food services	3.15%
Real estate and rental and leasing	2.32%
Educational services	2.17%
Wholesale trade	1.87%
Information and cultural industries	1.84%
Mining, quarrying, and oil and gas extraction	1.58%
Finance and insurance	1.42%
Management of companies and enterprises	0.08%
Utilities	0.05%
Public administration	0.00%
Total	**100%**

Source: Statistics Canada Custom Tabulation 2016 Census (2018b), Big River Analytics Calculations
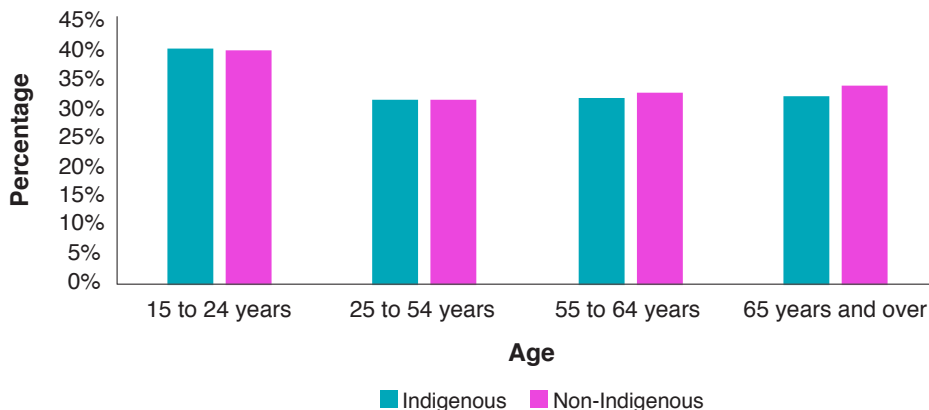
FIGURE A1

Vulnerable to automation non-Indigenous employment by industry, Canada
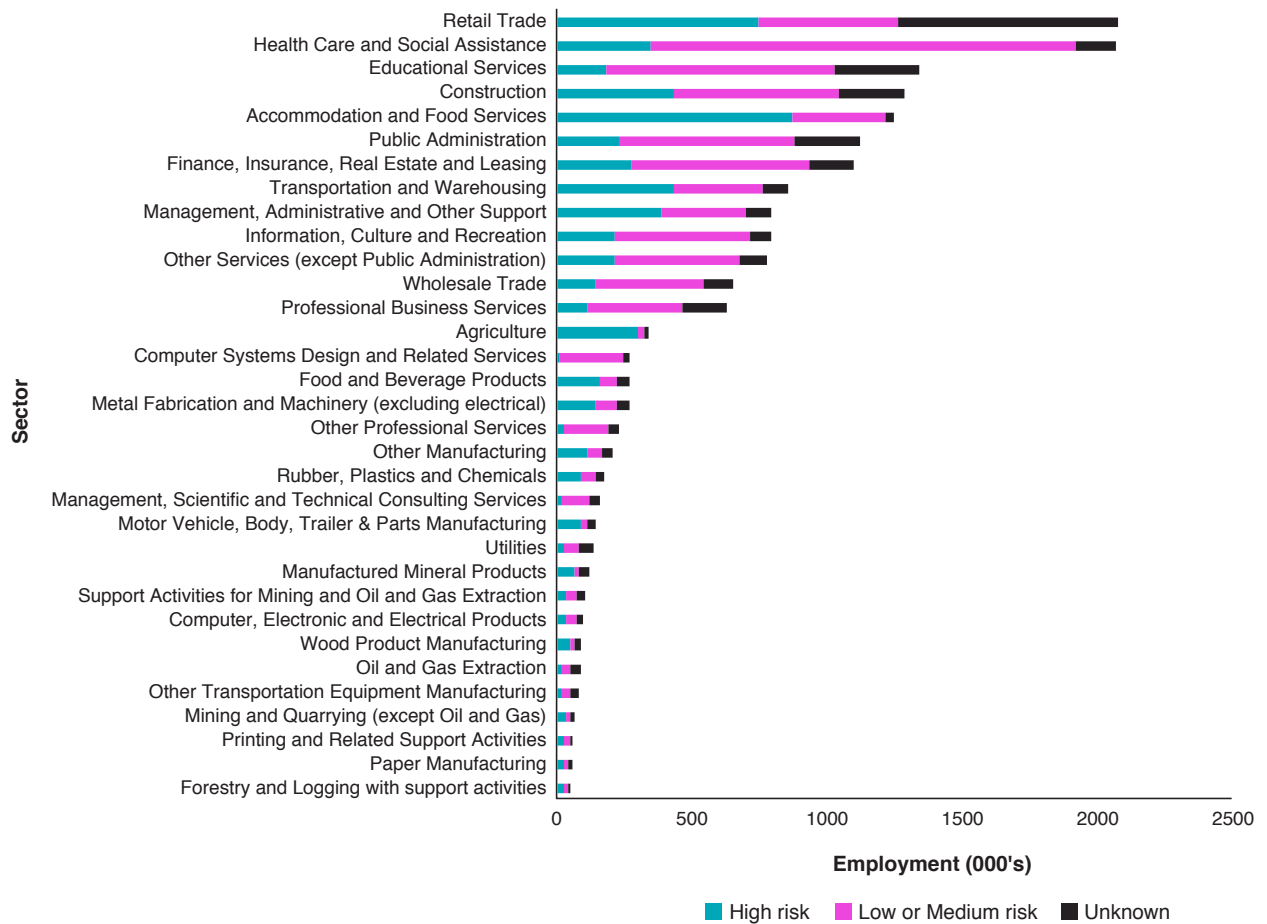
Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations
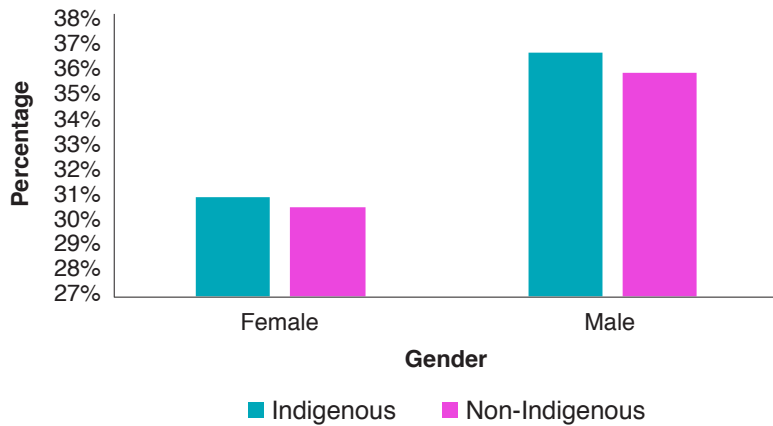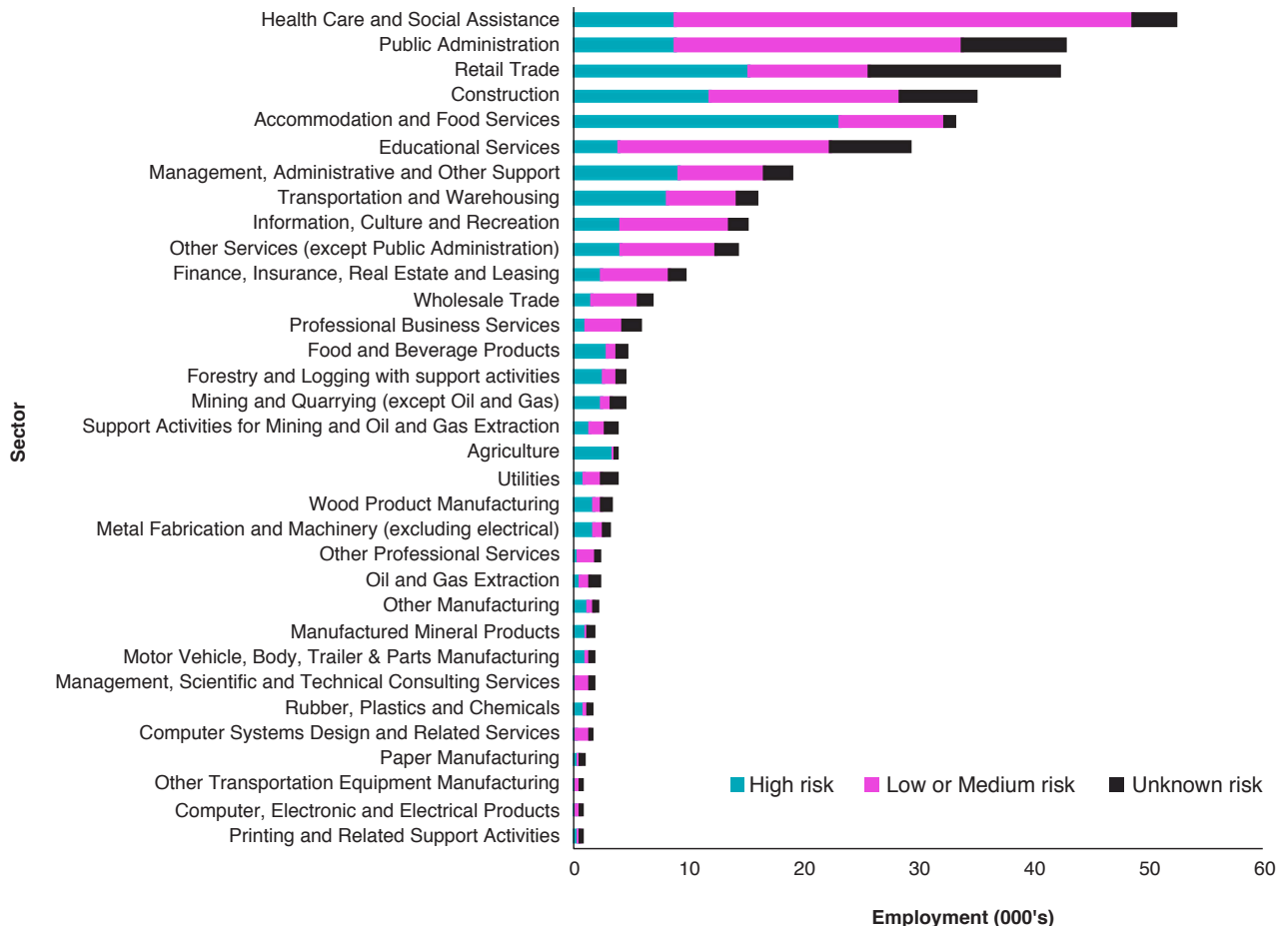
FIGURE A2

Percentage of employment at high risk of automation by identity and age, Canada

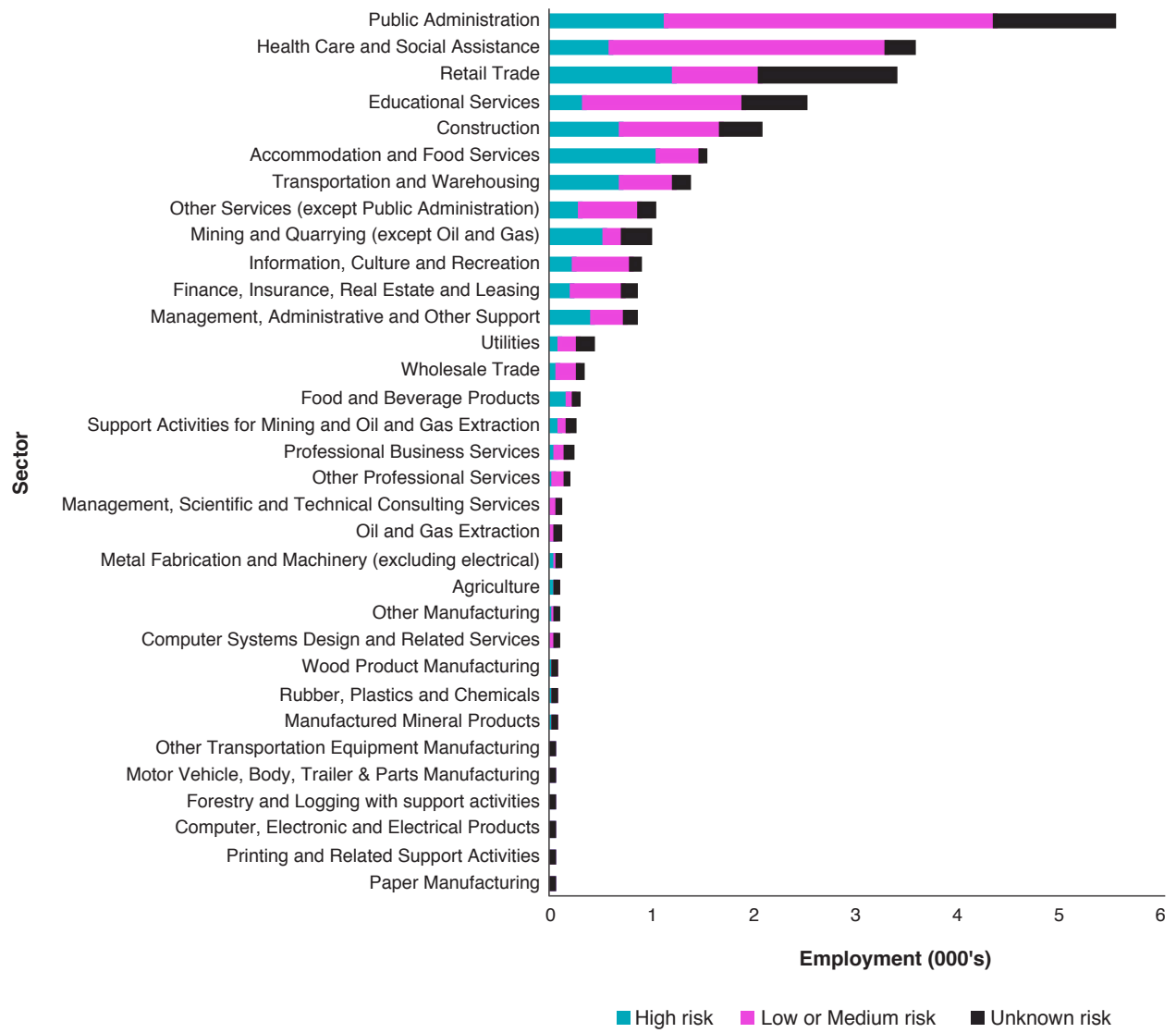Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

FIGURE A3

Percentage of employment at high risk of automation by identity and gender, Canada

Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

FIGURE A4

Employment by risk of automation, First Nations, Canada

Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations
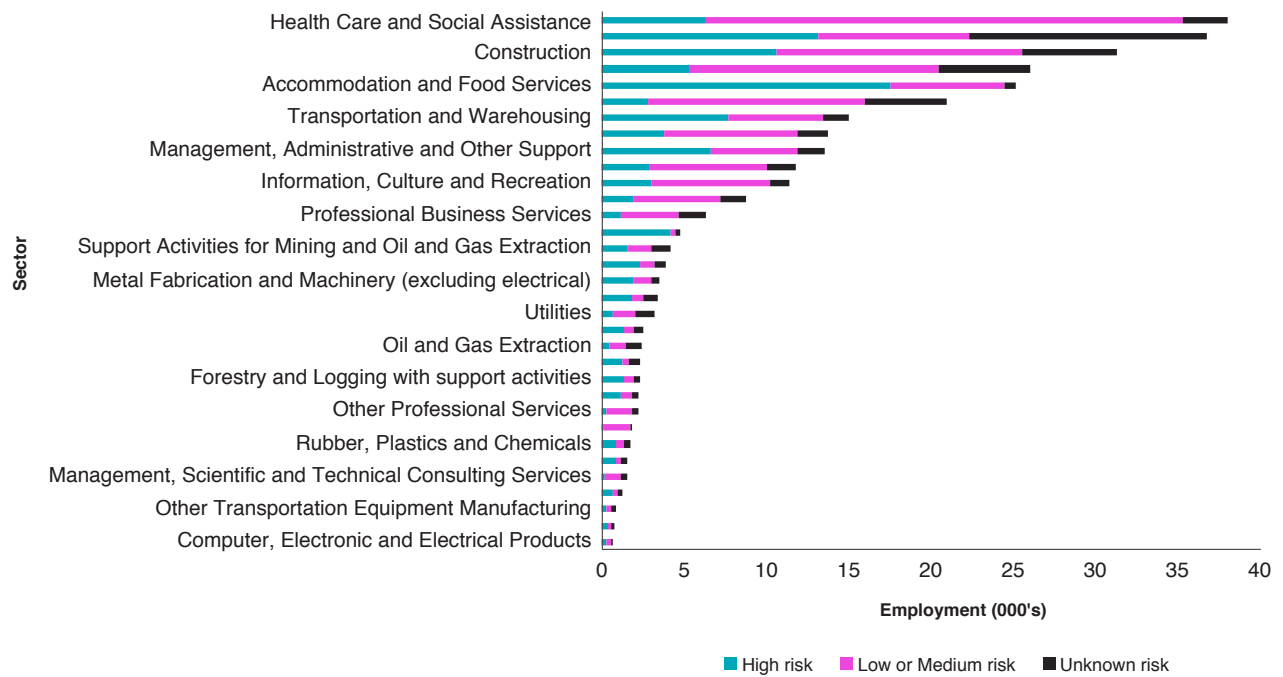
FIGURE A5

Employment by risk of automation, Inuit, Canada

Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations
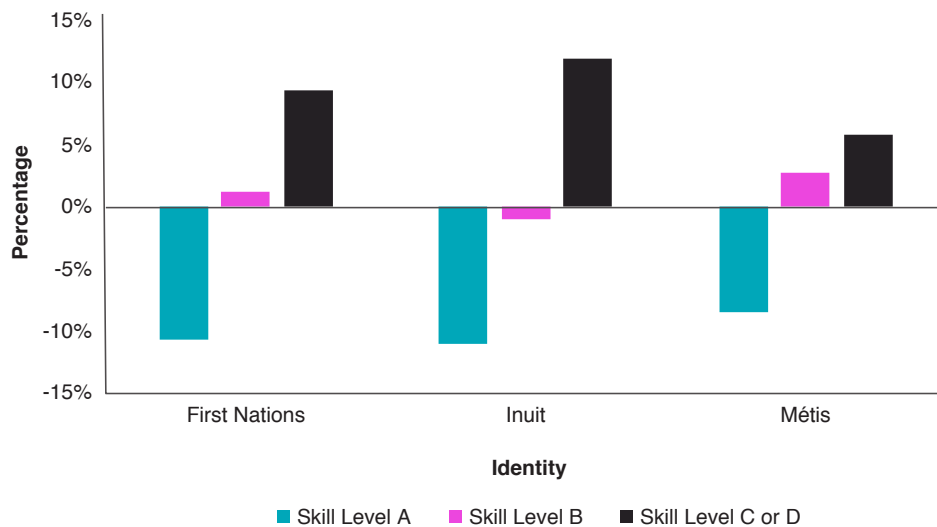
FIGURE A6

Employment by risk of automation, Métis, Canada

Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations

FIGURE A7

Skill gaps, Indigenous employees, Canada

Source: Statistics Canada Custom Tabulation 2016 Census (2018c), Big River Analytics Calculations
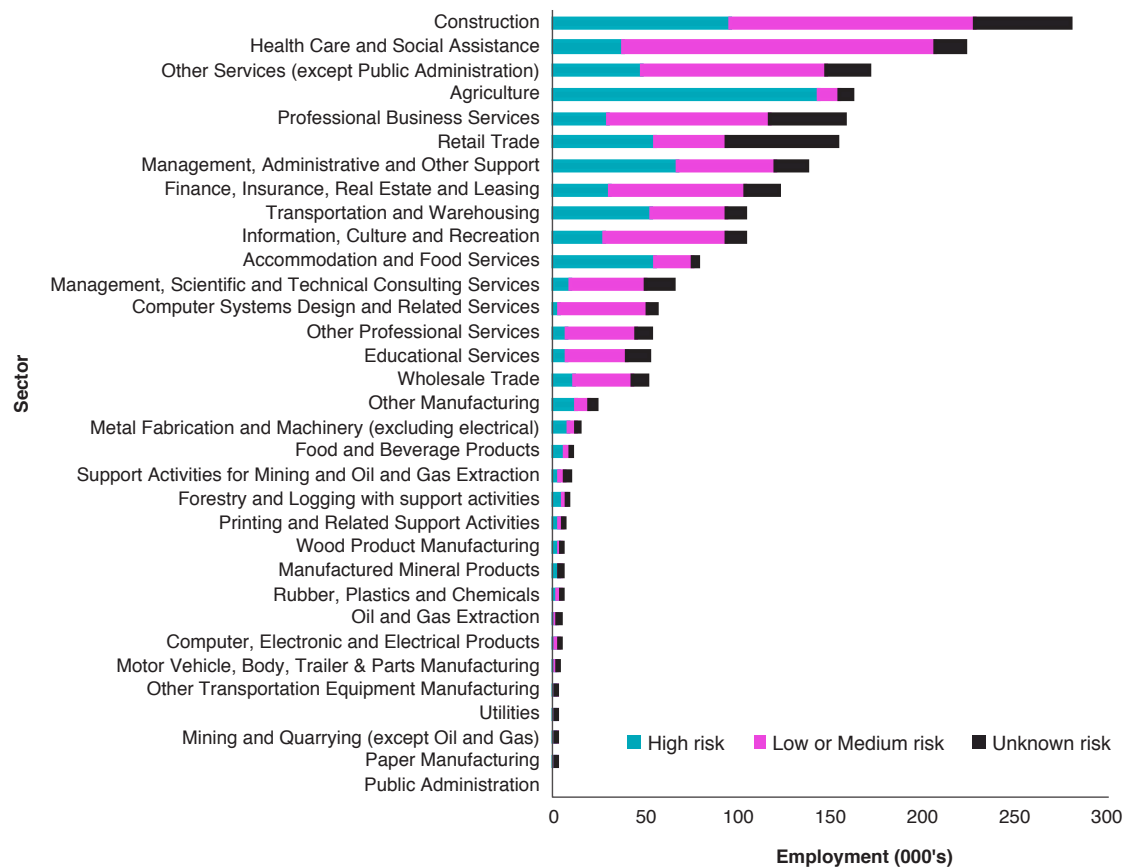
FIGURE A8

Skill Gaps, Indigenous self-employed, Canada

Source: Statistics Canada Custom Tabulation 2016 Census (2018c), Big River Analytics Calculations

FIGURE A9

Vulnerable non-Indigenous self-employment by industry in Canada

Source: Statistics Canada Table 98-400-X2016359, Big River Analytics Calculations