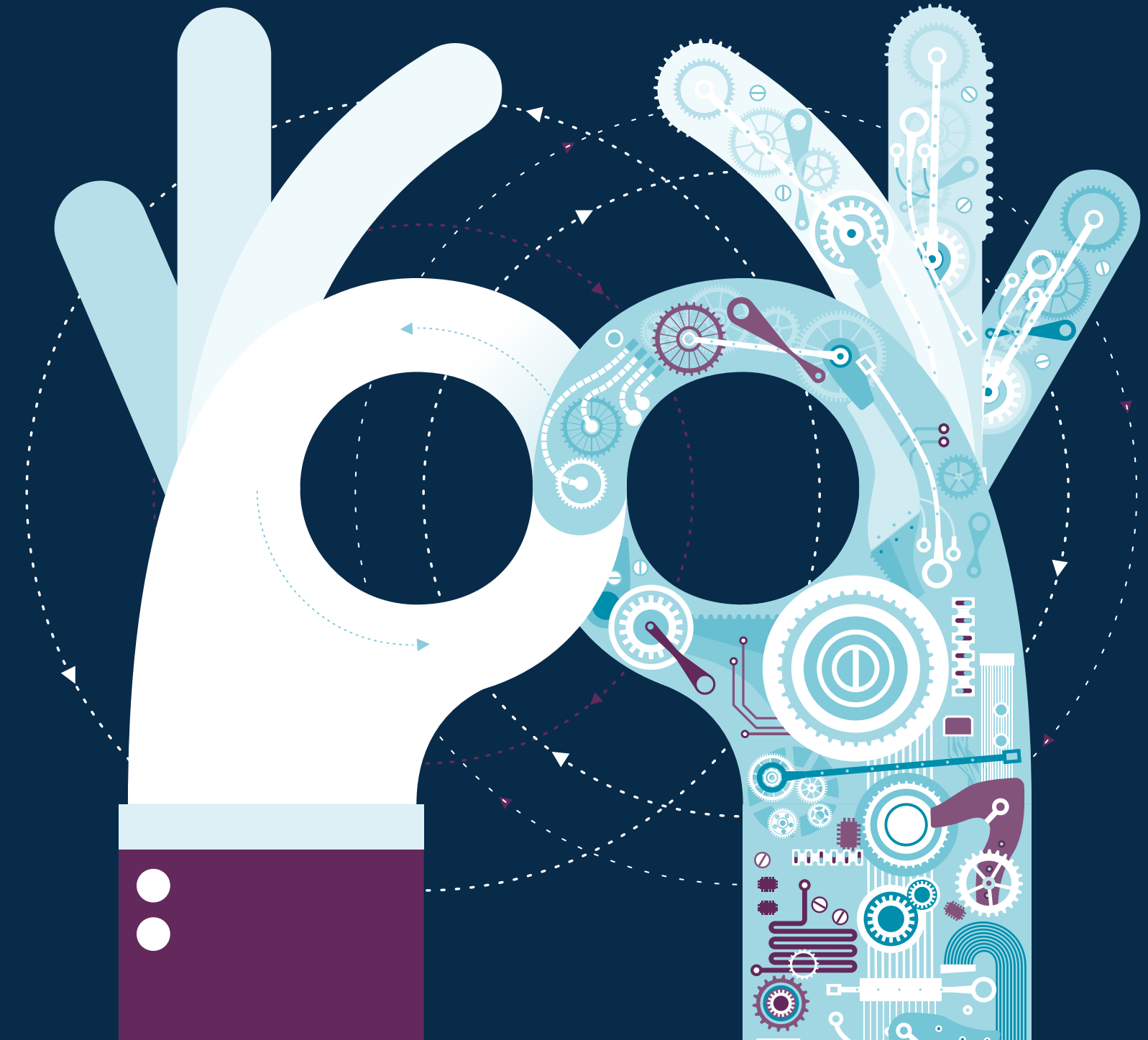


The Talented Mr. Robot

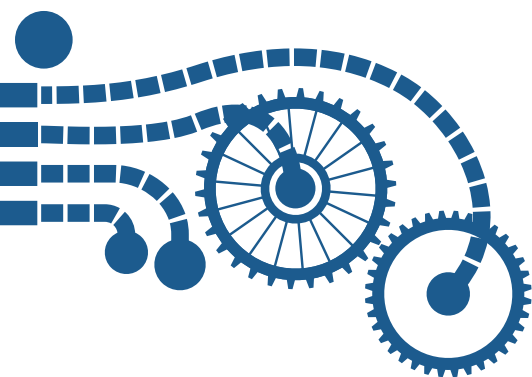
The impact of automation
on Canada's workforce

June 2016



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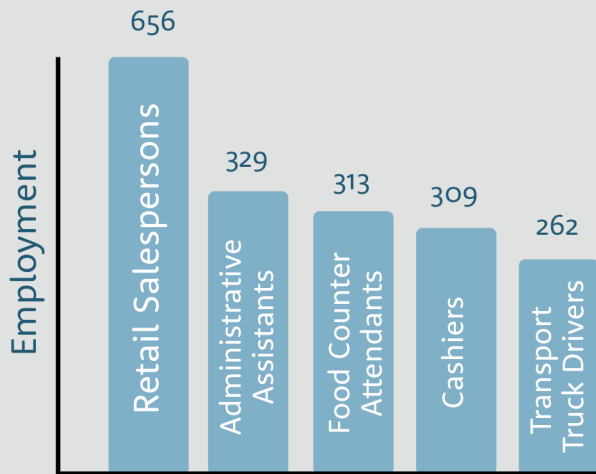
The Talented Mr. Robot: The impact of automation on Canada's workforce

OVER THE NEXT 10 - 20 YEARS...

42%

of the Canadian labour force is at a **high risk** of being affected by automation

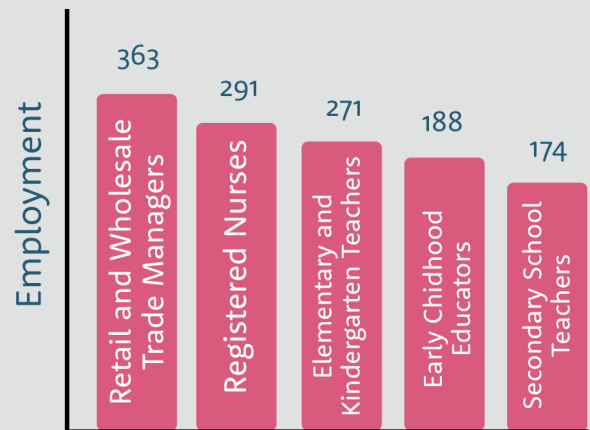
Top 5 jobs at a high risk of automation (1000s)



36%

of the Canadian labour force is at a **low risk** of being affected by automation

Top 5 jobs at a low risk of automation (1000s)



JOB GROWTH FROM 2014 - 2024...*

*Absent of automation

LOW RISK*

712,000

MEDIUM RISK*

339,000

HIGH RISK*

396,000

EXECUTIVE SUMMARY

Emerging technologies, such as artificial intelligence and advanced robotics, have the potential to fundamentally change our work and daily lives. In recent years, the understanding of how these technological trends will impact employment has been at the forefront of many recent public debates. Each week there seem to be more and more articles being released about how “robots are taking our jobs.”

For the most part, this rich discussion has been driven by the work of many prominent academics and researchers. Unsurprisingly, there are many competing viewpoints. Some argue that disruptive technology will be the driving force behind massive unemployment. Others posit that any potential job loss will likely be offset by productivity increases and employment growth.

Despite the extensive literature, this discussion is largely taking place without the use of Canadian data. Although we know that Canadians are not immune from the effects of automation, and that technological trends will likely have enormous implications for many Canadian industries. But the gap in Canadian-specific knowledge often means that we lack the tools to understand the impact of automation within our own borders. This limits our ability to begin to plan for potential disruption.

We therefore felt that it would be useful to apply the findings from the existing literature to the Canadian workforce. To do so, we used methodologies both from both Oxford professors Carl Benedikt Frey and Michael A. Osborne and from management consulting firm McKinsey & Company, which have been employed in other jurisdictions, and applied them both to Canadian data for the first time.

It is our goal to help Canadians better understand the effects that automation can have on our labour force.

Overall we found that nearly 42 percent of the Canadian labour force is at a high risk of being affected by automation in the next decade or two. Individuals in these occupations earn less and are less educated than the rest of the Canadian labour force. While the literature suggests that these occupations may not necessarily be lost, we also discovered that major job restructuring will likely occur as a result of new technology. Using a different methodology, we found that nearly 42 percent of the tasks that Canadians are currently paid to do can be automated using existing technology.

But the data does not paint an entirely negative picture. Using the Canadian Occupation Projection System (COPS), we found that the occupations with the lowest risk of being affected by automation are projected to produce nearly 712,000 net new jobs between 2014 and 2024.

As with any type of forecasting exercise, there is always going to be uncertainties associated with the predictions. However, we do hope that this study provides a tool to help guide future decision making.

Nearly 42 percent of the Canadian labour force is at a high risk of being affected by automation in the next decade or two.

INTRODUCTION

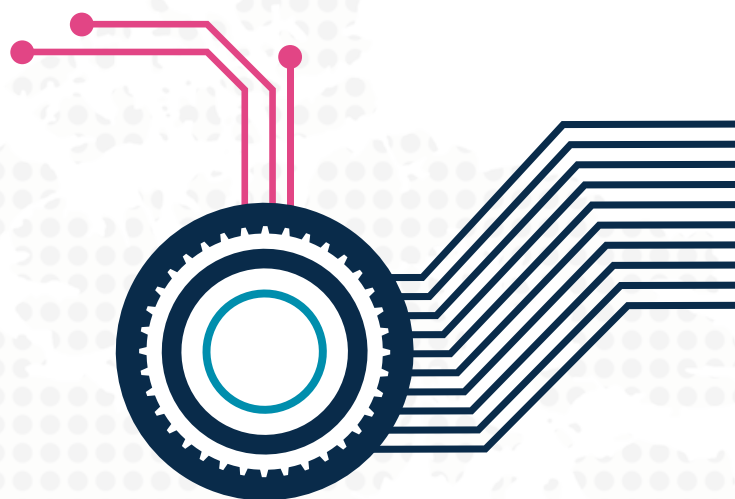
While job automation has been a key topic in many recent public discussions, it is not a new phenomenon. People have long been concerned that new technologies would make their job obsolete. But even after decades of rapid technological advances, historical evidence from the U.S. shows that technology has yet to have any measurable impacts on aggregate unemployment levels, even though in many industries technology has been the driving force behind major occupational shiftsⁱ.

However, experts also suggest that the emergence and rapid adoption of new technologies, such as artificial intelligence and advanced robotics, may result in the automation of occupations at an unprecedented rateⁱⁱⁱ. Examples of these disruptive technologies can be found everywhere from the 3D printer to the driverless car. Even jobs that we once thought were completely outside the realm of what a machine could do, such as truck drivers, are at risk of being automated.

While these technologies can potentially threaten existing jobs, it is also important to recognize that they are also significant job creators that have the potential to improve productivity and raise overall living standards.

So what do these technological trends mean for Canada? Are specific jobs at risk of being automated? Or, will technology be a great job creator? To understand the employment effects of technology, we applied methodologies from Oxford professors Frey and Osborne^{iv} and McKinsey & Company^v to Canadian labour force and demographic data.

Overall we discovered evidence from both sides of the debate. In certain occupations, job creation will likely occur, however, in others there will most likely be major task restructuring and, in some cases, potential job loss.



The following outlines some of our major findings:


- Nearly 42 percent of the employed Canadian labour force is at a high risk (70 percent or higher probability) of being affected by automation over the next 10 to 20 years. Occupations with the highest risk of being affected tend to be more routine, administrative and service oriented than other jobs. People who do these jobs are also less educated and earn less, on average, than the rest of the Canadian labour force. While this does not mean that these occupations will necessarily be lost, it does suggest that these occupations are more susceptible to being automated in the future.
- Using the Canadian Occupation Projection System (COPS), we found that the occupations with the lowest risk of being affected by automation, which are correlated with higher earnings and education, are projected to produce nearly 712,000 net new jobs between 2014 and 2024.
- We also examined how automation will impact the tasks performed in each occupation. We found that approximately 42 percent of work activities that Canadians are paid for can be automated using existing technologies. We also found that nearly 18 percent of occupations could have 70 percent or more of their work activities currently automated. This suggests that technology has the potential to result in major occupational restructuring relatively soon.

We do recognize that future predictions are fraught with risk and uncertainty. We also recognize that as a result of a number of factors' overall unemployment may not necessarily increase. However, we are hoping this report will help Canada's public and private sectors gain a deeper understanding of how automation impacts employment so that they can begin planning for the future.

Automation and its impact on the labour force has been the subject of academic inquiry for many years. To help Canadians understand the impact that technology can have on jobs, we drew upon the findings and methodologies of some of the major researchers in the field. The following section outlines the studies that we used to build or inform our analysis.

In 2003, D.H. Autor, et al, developed the Task Model to explain the impact of technological trends on workplace automation.

This model shows that:

- 
- (1) Technology can be a substitute for human labour in routine manual tasks,
 - (2) Technology also simultaneously increases productivity in non-routine, cognitive tasks. vi

These insights suggest that technology can result in labour market restructuring and not necessarily long-term unemployment. For occupations where technology easily substitutes for labour, jobs are often lost and workers are required to relocate to other industries. For the occupations that require significant creativity, thinking and problem solving, technology often complements labour, which raises productivity. This, in turn, lowers a firm's costs and prices, which can increase demand and subsequently increase the need for additional labour. This improved productivity may also result in increased individual earnings and thus more demand for other goods and services. This creates a virtuous cycle that ultimately results in job creation. vii viii ix

In a 2015 study of 17 countries, George Graetz and Guy Michaels showed that between 1993 and 2007, industrial robots increased labour productivity and had no significant effect on aggregate hours worked. However, they did find some evidence that these robots reduced hours worked for low-skilled and middle-skilled workers.

Two University of Oxford professors, Frey and Osborne, revisited the Task Model in their 2013 paper, *The Future of Employment: How susceptible are jobs to computerization?* They argued that, with advances in machine learning and mobile robotics, automation can occur much more easily in non-routine tasks. For Frey and Osborne, the expansion of what technology is capable of doing, as well as the current pace of technological progress, means that more jobs may be at risk than ever before.^{xi} Using a novel methodology, their paper found that 47 percent of total U.S. employment is at high risk of being affected by automation (with a 70 percent or more probability) over the next 10 to 20 years.^{xiii}

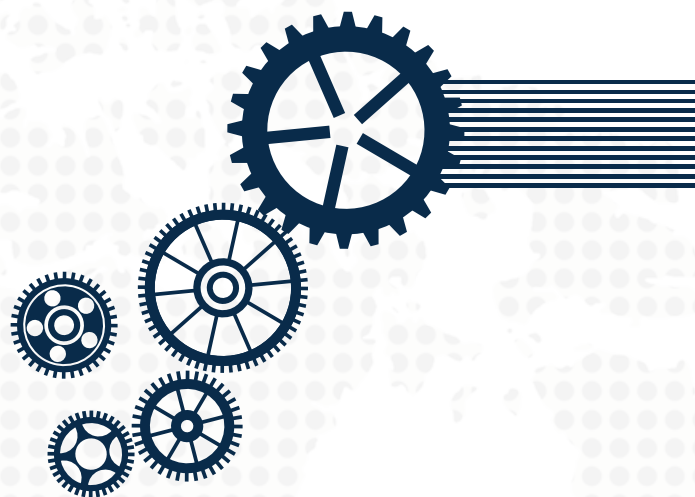
There are a number of critiques of Frey and Osborne's findings that suggest that automation may not occur at the scale predicted. The first critique is that their approach ignores many existing macroeconomic feedback mechanisms that result in increased labour demand. The second is that their estimates may have overstated the automation figure for a number of reasons, including: the speed and actual capabilities of technology, the relative cost of technology over labour, as well as societal preferences for humans over machines for many tasks.^{xiii xiv} Finally, many also suggest that a focus on occupations may be misleading and believe that specific tasks, rather than entire occupations, will be automated.^{xv}

Building off of some of these critiques, a 2015 McKinsey & Company research report entitled *Four Fundamentals of Workplace Automation*, analyzed automation from a task perspective rather than an occupation perspective. They suggested very few occupations will be fully automated in the near or medium term. However, many will undergo significant transformation as a result of new technologies. They found that 45 percent of work activities that people are paid for in the U.S. could be automated today using existing technology. However, they also found that fewer than five percent of occupations can be entirely automated.^{xvi}

A 2016 study by the Organization of Economic Co-operation and Development (OECD), entitled *The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis*, also examines automation from a task-based perspective. Using Frey and Osborne's findings and the Programme for the International Assessment of Adult Competencies (PIACC)¹ they estimated the probability of automation for a number of OECD countries.

Their approach also took into account that specific jobs and tasks, and not whole occupations, are vulnerable to automation.^{xvii} They found that only nine percent of the U.S. labour force is at a high risk of automation (with a 70 percent or more probability), compared to Frey and Osborne's 47 percent.^{xviii} Similarly, they also found that nine percent of the Canadian labour force is at a high risk.^{xix}

Drawing on many of these studies, the following sections outline our findings.

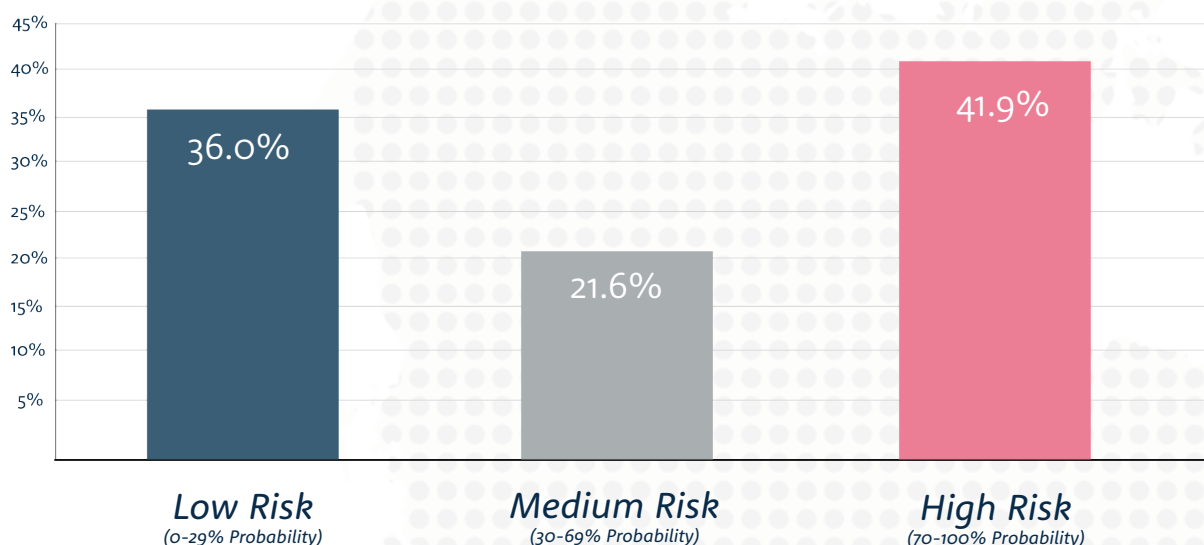


We began our analysis by using the findings of Frey and Osborne to assess what proportion of Canadian occupations are at risk of being affected by automation in the next 10 to 20 years. To do so, we used the 2011 National Household Survey^{xx} to assess the composition of Canada's labour force based on future risk of automation.

Our results show that nearly 42 percent (figure 1) of the employed Canadian labour force is at a high risk of being affected by automation over the next 10 to 20 years. This means that there is a 70 percent or higher probability that these jobs will be impacted by automation over this time period. However, based on the limitations of Frey and Osborne's findings, it is important to understand that while these specific occupations may be more likely to be automated, it does not necessarily mean that all of these jobs will be lost.

On the other hand, we also found that 36 percent of Canada's employed labour force is at a low risk of being affected by automation. In line with the Task Model literature, these occupations will likely be complemented by technological advances, which could offset some of the unemployment effects associated with automation.

Figure 1: Canadian Labour Market at Risk of Being Affected by Automation



National Household Survey 2011, Frey and Osborne (2013), BII + E Analysis

In a recent report, Deloitte UK, using Frey and Osborne's methodology, discovered that between 2001 and 2015 occupations at a low risk of being affected by automation in the UK grew by 3.5 million jobs, compared to the 800,000 high risk jobs that were lost. For Deloitte, this suggests that technology has potentially contributed to significant job growth in the UK.^{xxi}



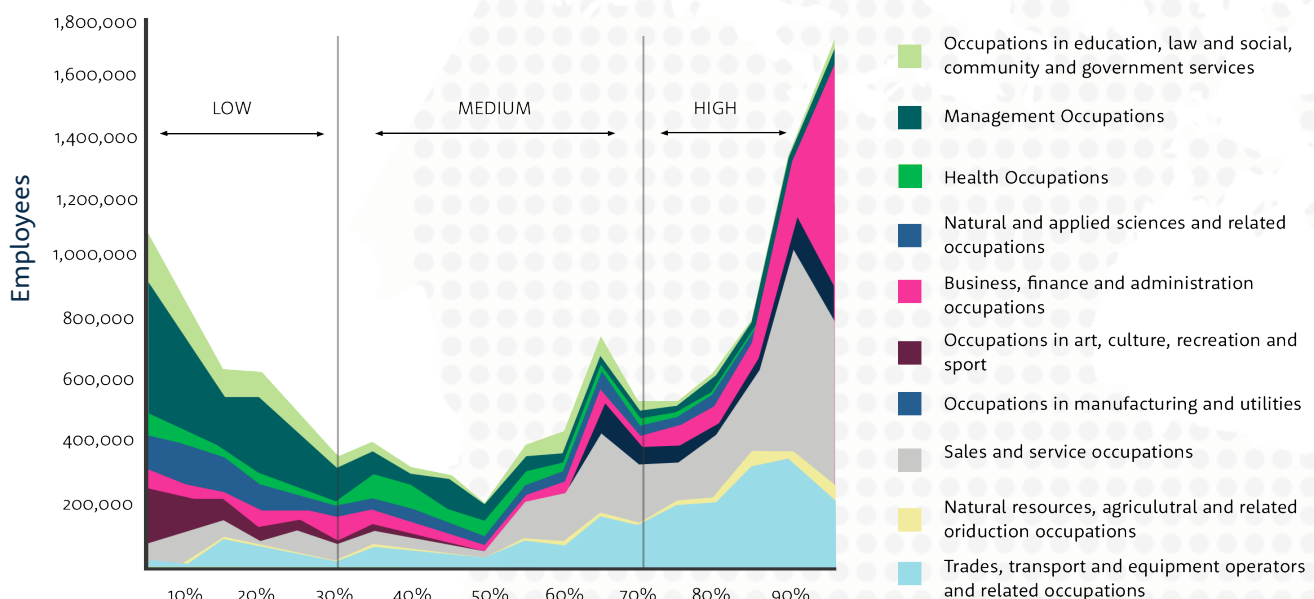
Impact of Automation on Occupation

Figure 2 shows employment for each high-level Canadian occupation category based on its probability of automation. The vast majority of occupations that have a high risk of being affected by automation are in trades, transportation and equipment operation, natural resources and agriculture, sales and service occupations, manufacturing and utilities, office support and general administration, and technical occupations in health, natural and applied sciences.

Occupations that have a low risk of being affected by automation are fairly diverse, spanning the arts, culture, recreation and sport, management and supervisory positions, and professional occupations in a number of different fields such as education, law, health, nursing, as well as natural and applied sciences.

When examining aggregate employment levels along the probability of automation axis, it becomes clear that there is a bimodal distribution. This shows that the bulk of Canadian employment falls into two distinct groups: one that is at a low risk of being affected by automation, and the other that is at a high risk of being affected by automation. Occupations directly in the middle of the spectrum occupy the lowest proportion of the Canadian labour force, but employment increases as probability approaches the high-risk threshold.

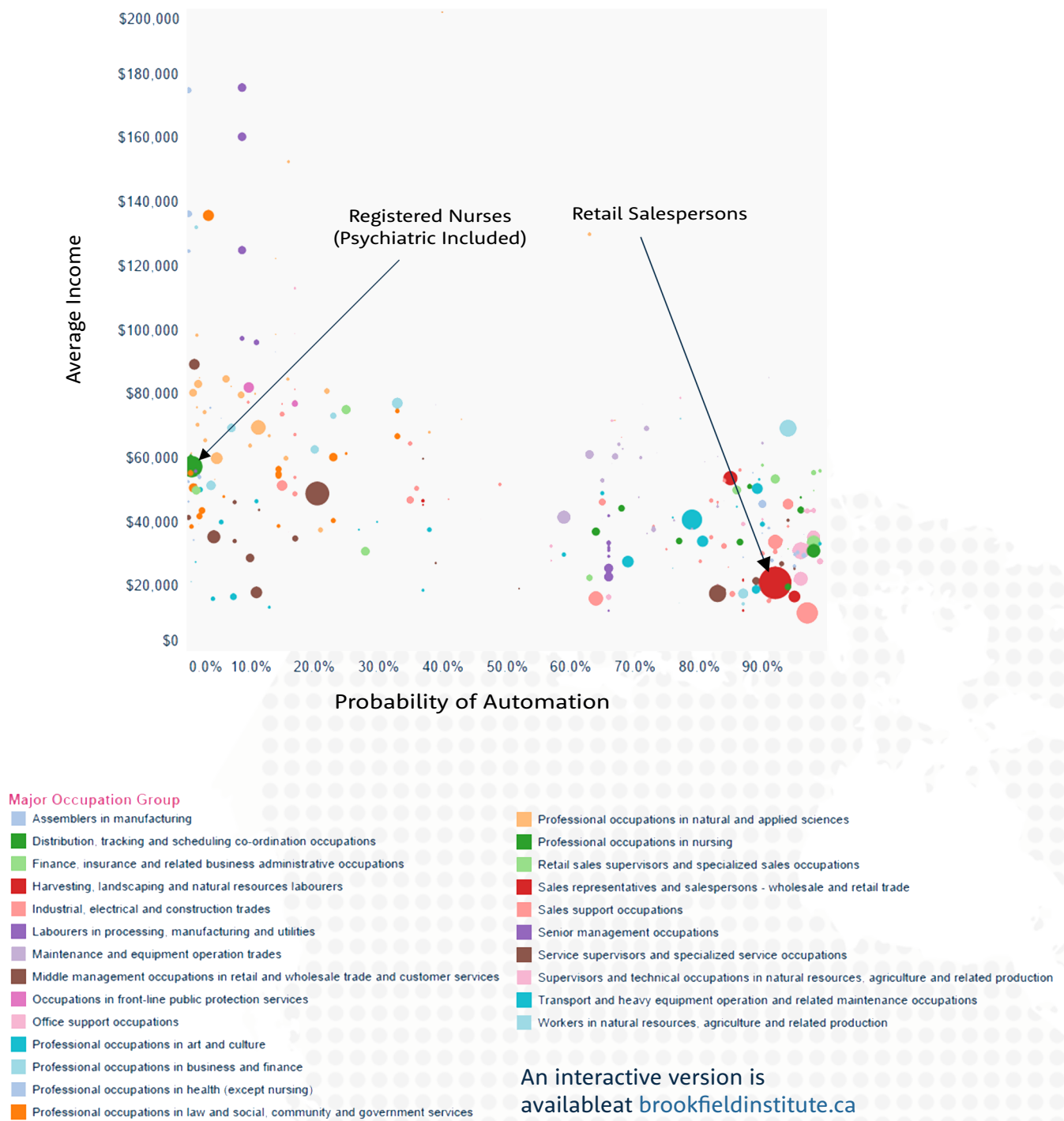
High-Level Canadian Occupations and Probability of Being Affected by Automation



2011. Frey and Osborne (2013), BII + E Analysis

Impact of Automation on Occupation

Figure 3: All Canadian Occupations and Probability of Being Affected by Automation



Impact of Automation on Occupation

Top Five High Risk Occupations

The data in figure 3 shows that the occupations at a high risk of being affected by automation with the most employees are:

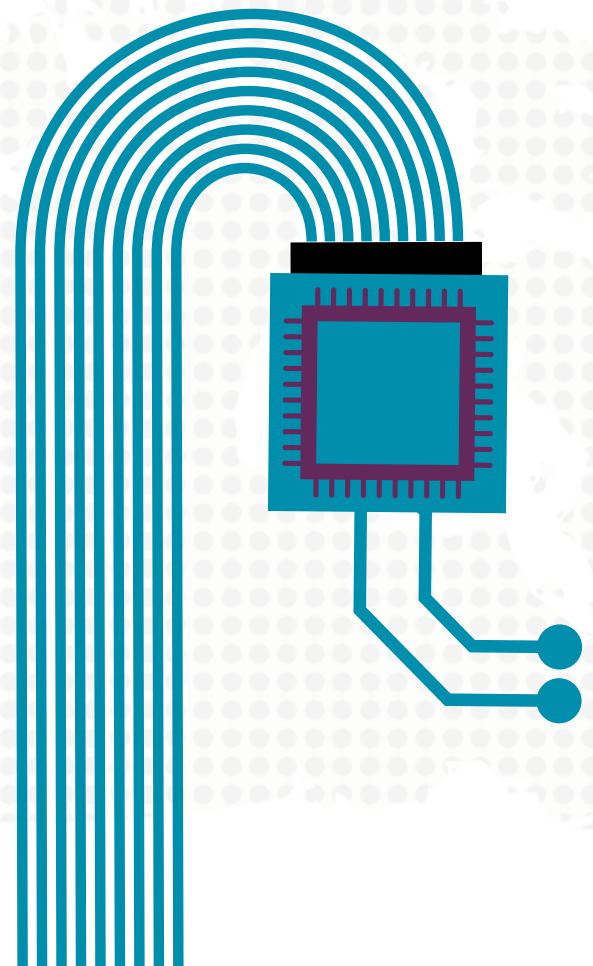
- **Retail sales persons**, 92% probability of automation and more than 656,000 employees,
- **Administrative assistants**, 96% probability of automation and nearly 329,000 employees,
- **Food counter attendants and kitchen and kitchen helpers**, 91.5% probability of automation and nearly 313,000 employees,
- **Cashiers**, 97% probability of automation and nearly 309,000 employees, and
- **Transport truck drivers**, 79% probability of automation and nearly 262,000 employees

Top Five Low Risk Occupations

The occupations at a low risk of being affected by automation with the most employees are:

- **Retail and wholesale trade managers**, 20.5% probability of automation and more than 363,000 employees,
- **Registered nurses (psychiatric included)**, 0.9% probability of automation and more than 291,000 employees,
- **Elementary and kindergarten teachers**, 0.4% probability of automation and more than 271,000 employees,
- **Early childhood educators and assistants**, 0.7% probability of automation and nearly 188,000 employees, and
- **Secondary school teachers**, 0.8% probability of automation and nearly 174,000 employees.

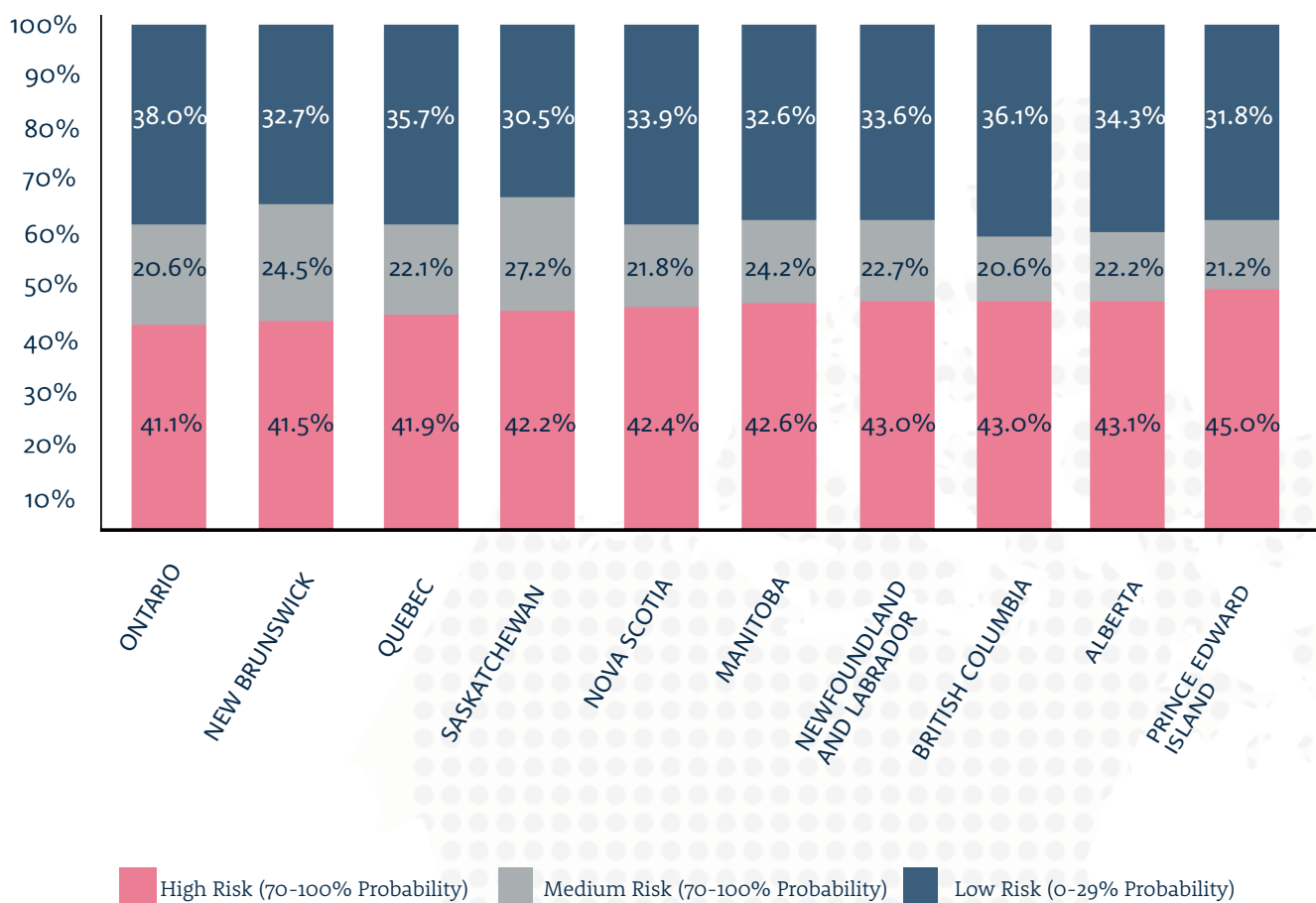
All of these findings suggest that over the next 10 to 20 years, automation will occur most significantly in occupations that are administrative, routine, or oriented toward sales and service. However, automation can also occur in jobs that are non-routine. The jobs least at risk appear to rely on humans' cognitive advantage over technology and require more job-specific skills, complex problem solving, as well as people management and oversight.



Referring to figure 4, the Canada-wide statistics for occupations at a high risk of being affected by automation remain relatively consistent across provinces.

Ontario has the lowest proportion of the employed labour force at a high risk of being affected by automation, at just over 41 percent, and P.E.I. has the highest proportion, at just over 45 percent.

Figure 4: Provincial Employed Labour Force by Risk of Being Affected by Automation



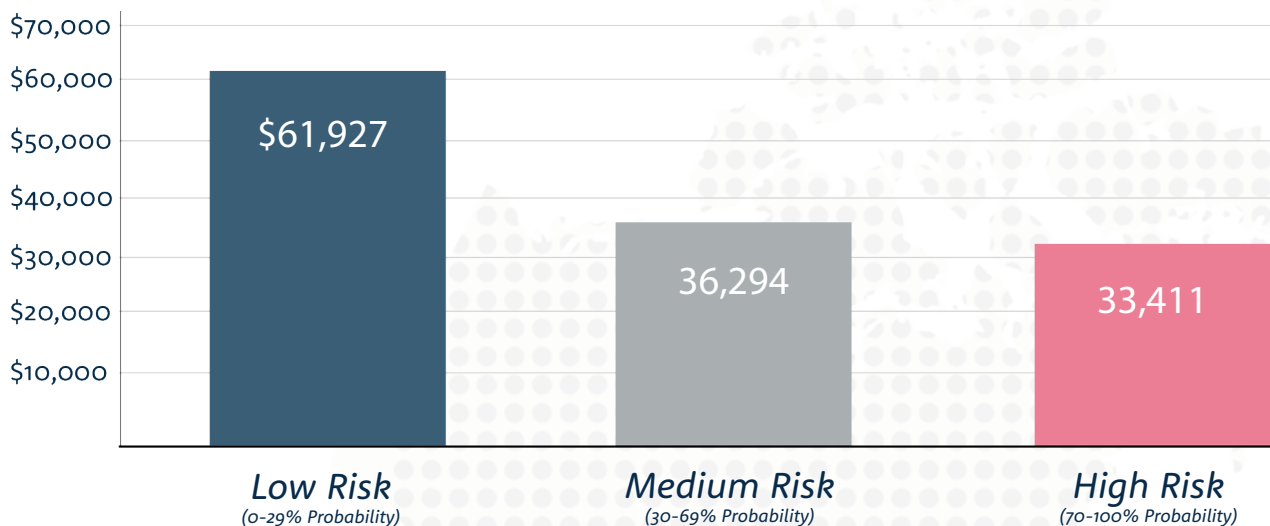
National Household Survey 2011, Frey and Osborne (2013), BII+E Analysis

Figure 5 indicates that the occupations most at risk of being affected by automation have a much lower average income (received as wages and salaries) than occupations in other risk profiles. On average, people in occupations at a high risk of being affected by automation make just over \$33,000 a year, which is nearly \$29,000 less than occupations at a low risk of being affected by automation.

We do acknowledge that wages and salaries are constantly in flux and have more than likely changed since 2011, but for the purposes of this analysis we are most interested in the relative incomes of occupations based on their risk of being affected by automation.

To determine these figures, for each of the risk profiles a weighted average was calculated based on the average employment income for each specific occupation and the occupation's corresponding proportion of the employed labour force.

Figure 5: Average Income



National Household Survey 2011, Frey and Osborne (2013), BII+E Analysis

In addition to earning less, those in occupations with a high risk of being affected by automation are also less educated. Figure 7 shows that just 12.7 percent of the labour force at a high risk of automation had a university education at a bachelor level or higher. The proportion of low risk occupations with a university education is more than three times larger than the same proportion in high-risk occupations. This suggests that occupations that demand more university education are less likely to be at a risk of being affected by automation.

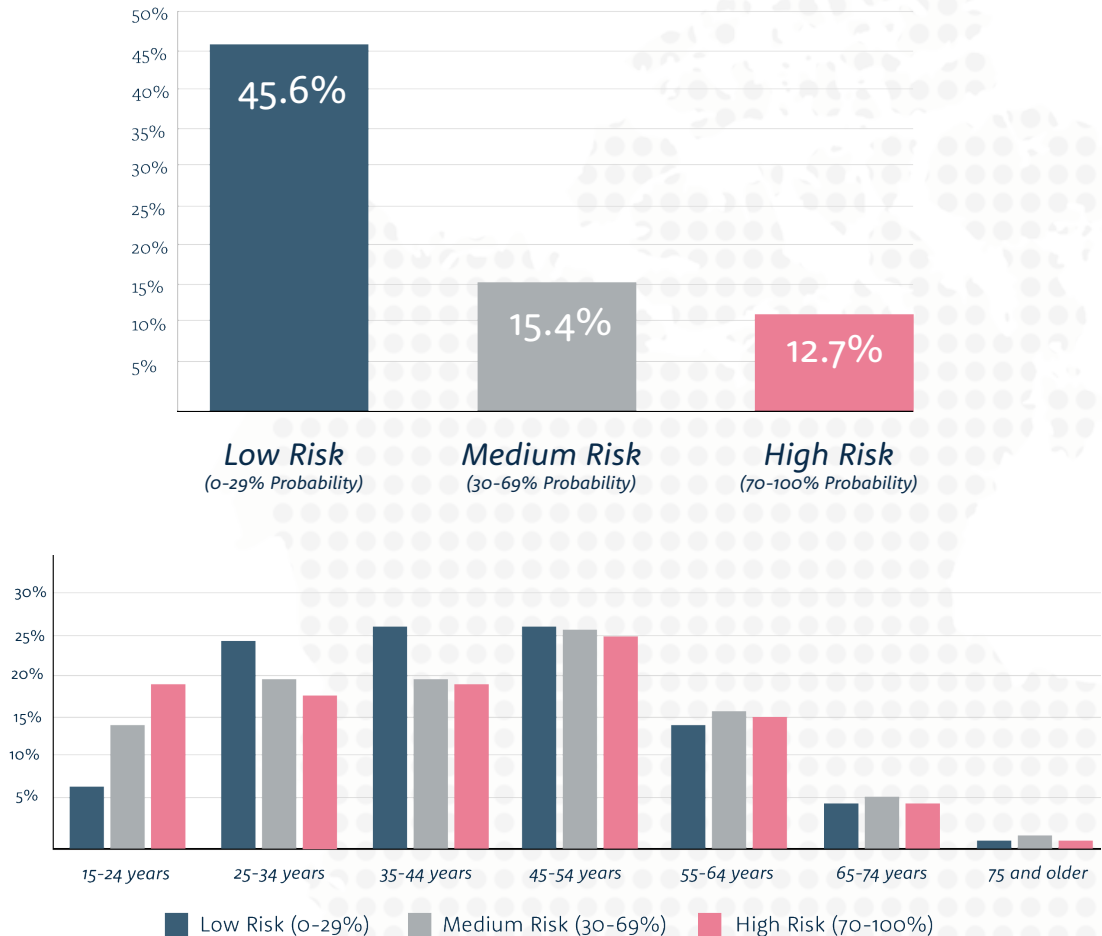
When examining the age profiles for each risk profile, a few trends emerge. Figure 7 shows that employees in occupations with a high risk of being affected by automation are

disproportionately between the ages of 15 to 24, whereas employees in occupations with a low risk of being affected by automation are more likely to be “prime-aged workers,” between 25 and 54. This means that Canada’s core working population is more likely to be at a low risk of being affected by automation.

However, it also means that Canada’s younger and, to a lesser extent, older populations are more likely to be vulnerable to the effects of automation.

This could suggest that younger workers are more likely to be employed in entry-level jobs, which may be at a higher risk of being affected by automation.

Figure 6: Proportion of Labour Force with University Degree (bachelor or above)



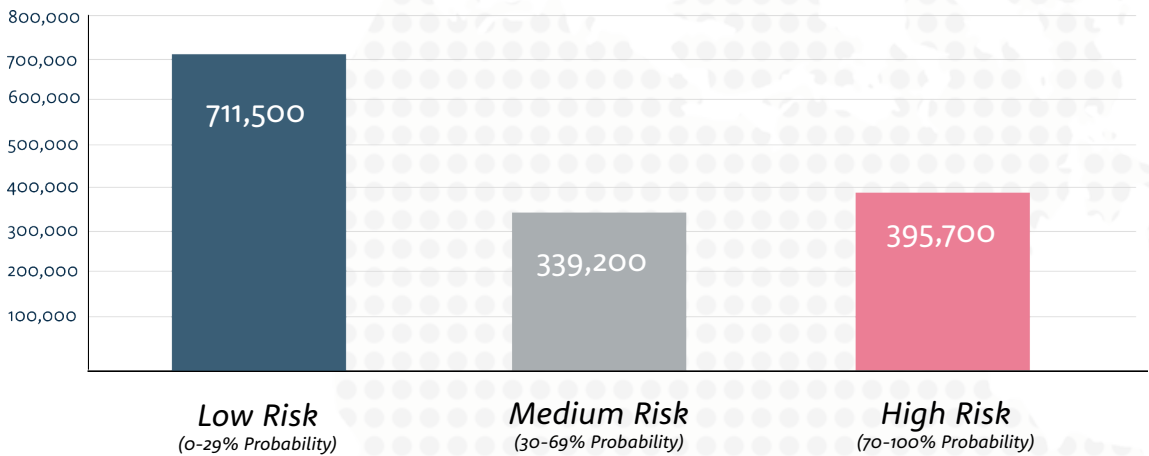
We also used the Canadian Occupation Projection System (COPS) to determine how jobs in different risk profiles are projected to expand over time. Overall, we found that occupations at a low risk of being affected by automation are expected to grow much more than those in the other risk profiles between 2014 and 2024. Figure 8 shows that in this period, there are expected to be nearly 712,000 new jobs in occupations with a low risk of being affected by automation, compared to nearly 396,000 new jobs in occupations with a high risk of being affected by automation.

It must be noted that these projections are based on a macroeconomic scenario that does not take automation into consideration. If automation impacts the Canadian labour force as predicted, employment in occupations at a high risk will likely grow more slowly than projected, or potentially contract. The effect of automation on projected job creation in low risk occupations will likely be more ambiguous.

Technology may complement labour, increase productivity and create more jobs in certain areas, but it may also substitute for labour in other areas.

However, using this system presented a few challenges for our analysis. Since COPS tracks aggregates of specific occupations, it only shows 292 occupation groups, as opposed to the full 500 occupations we considered in our analysis. To get around this, we calculated the average probability of all of the individual National Occupation Classifications (NOCs) for each COPS aggregate. We felt this was a reasonable estimate, since the probabilities under each aggregate were relatively similar.

Figure 8: Projected Employment Growth (2014-2024)



National Household Survey 2011, Frey and Osborne (2013), BII+E Analysis

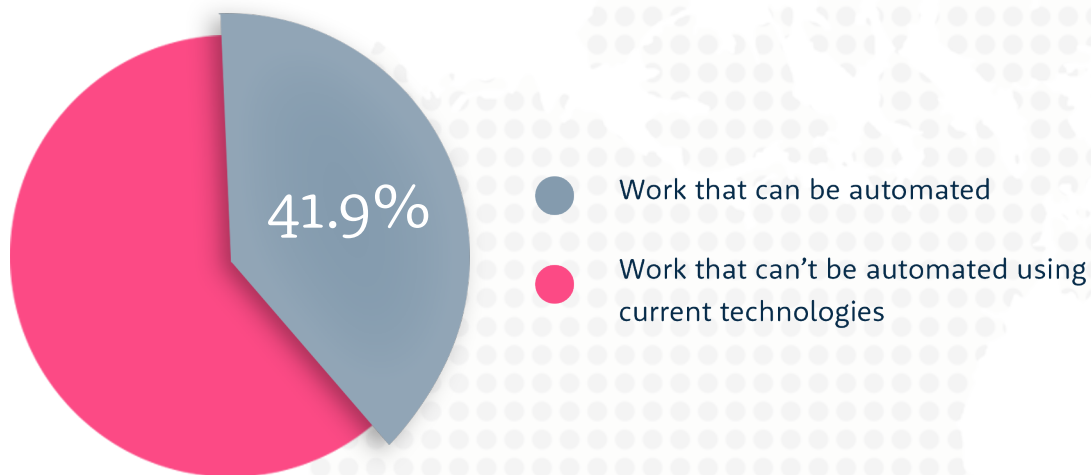
Impact Of Automation on Activities

We also applied the findings of the 2016 McKinsey & Company report to the Canadian context to examine the automation of tasks rather than full occupations in the near term. Using National Household Survey data, we estimated that nearly 42 percent of Canadian work activities could be automated using current technologies.

However, our findings also suggest that less than one percent of jobs in the labour market are fully automatable (meaning all of the tasks performed for the occupation could be automated). These occupations were primarily processing and manufacturing machine operators, and related production workers.

We also found that nearly 18 percent of Canada's labour force could have 70 percent or more of their work activities automated. When broken down, many of these occupations correspond to those at a high risk of being affected by automation, identified using the Frey and Osborne methodology. This suggests that in the near term major job restructuring could occur in many of these occupations.

Figure 9: Automation of Tasks



National Household Survey (2011), McKinsey & Company (2015), BII+E Analysis

PROFILES

Examining specific occupations helps to illustrate the automation predictions made using both methodologies. Transport truck drivers and retail salespersons both exhibit a high probability of being affected by automation over the next 10 to 20 years. The data also shows that a large portion of what individuals in these occupations are currently paid for can be automated using existing technology. In these cases, technologies as simple as the self-checkout in grocery stores or as complicated as self-driving trucks can already make obsolete significant portions of what people in these occupations do.

On the other hand, senior managers and specialist physicians are at a low risk of having their occupations affected by automation in the future, but could still have a large portion of what they do automated using currently demonstrated technology. In line with the rest of the labour force data, people in these low-risk occupations are more highly educated and earn more than others.

Job	Transport Truck Drivers	Retail Salespersons	Senior Managers	Specialist Physicians
Probability of automation in the next 10-20 years (Frey and Osborne)	79%	92%	9%	0.4%
Proportion of tasks that can be automated (McKinsey & Company)	69%	47%	24%	23%
Number of employees, 2011	261,775	656,395	54,880	36,550
Average Earnings, 2011	\$40,871	\$21,113	\$160,560	\$175,088
Proportion with university education	4%	12%	60%	98%

METHODOLOGY

To answer the question of how susceptible Canadian jobs are to automation, we utilized the findings of Frey and Osborne and McKinsey & Company. Both studies are designed to address the question of automation in two different ways.

Frey and Osborne estimate the proportion of occupations that can be automated over the next 10 to 20 years. They used the 2010 U.S. Department of Labor's O*Net data, which contains information about 903 occupations. They aggregated them to correspond to the 702 U.S. Standard Occupation Classification (SOC) codes. Frey and Osborne then drew from machine learning experts to classify 70 occupations as either automatable or not, based on their task structures. They next identified whether these subjective classifications were related to the bottlenecks of computerization, defined as tasks that cannot be substituted by computers in the near term, and which include perception and manipulation, creativity and social intelligence. To do so, for each of the 70 occupations they linked O*Net variables to each of the bottlenecks and developed a model to determine if they corresponded to an occupation's risk of being affected by automation. The estimates of this model were then used to predict the probability of automation for the remaining 632 occupations.^{xxii}

The authors of the McKinsey study took a different approach. They examined the percentage of work activities that could be automated using existing technologies. The authors analyzed 2,000 detailed work activities for 800 U.S. occupations. They then assessed these activities against 18 identified capabilities that they determined could be automated.^{xxiii}

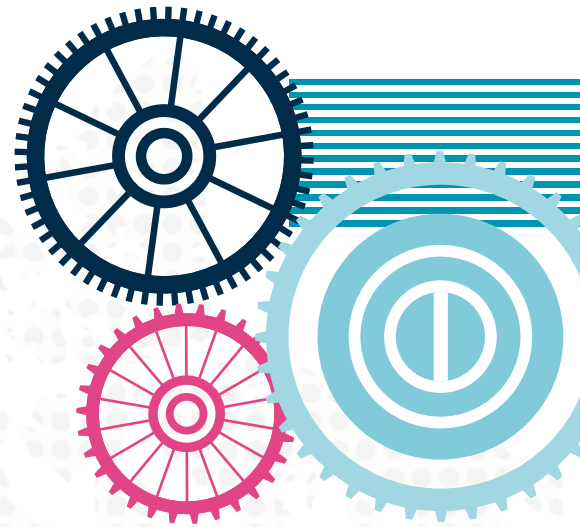
Both studies use U.S. SOC codes in their analysis. In Canada, we use the NOC system. To apply the U.S. studies' probabilities to the Canadian context, we linked all 500 four-digit NOC codes with six-digit U.S. SOC codes using a crosswalk methodology. While crosswalk methodologies vary, they have been successfully applied by Statistics Canada, the U.S. Bureau of Labor Statistics and Nesta.



To assess occupational matches, we used the NOC descriptor fields developed by Human Resources and Skills Development Canada and the detailed SOC descriptions in the US o*Net database. The crosswalk process involved a series of steps:

- Where possible, we created 1:1 matches between U.S. SOC codes and Canadian NOCs. From there, we applied the findings from each study on a one-to-one basis.
- When a single NOC matched more than one SOC, we selected all relevant SOC codes using descriptor fields. From there we took the average findings from the studies and applied them to the Canadian occupation.
- When a single SOC applied to more than one NOC, we linked it to all relevant NOCs and applied the findings.
- When there was an imperfect or unclear match between codes, we took advantage of existing crosswalks developed by Statistics Canada and the U.S. Bureau of Labor Statistics, linking occupation codes to the International Standard Classification of Occupations (ISCO). We were able to use ISCO codes as an intermediary, linking the NOC to the ISCO and the ISCO to the various applicable SOC codes.
- Military NOCs were removed from the study, as they had no equivalent SOC. Similarly, any occupation codes not included in either study were removed from the analysis. This resulted in six occupation codes being excluded from the analysis.

Both studies use U.S. SOC codes in their analysis. In Canada, we use the NOC system. To apply the U.S. studies' probabilities to the Canadian context, we linked all 500 four-digit NOC codes with six-digit U.S. SOC codes using a crosswalk methodology. While crosswalk methodologies vary, they have been successfully applied by Statistics Canada, the U.S. Bureau of Labor Statistics and Nesta.



Conclusion and Discussion

This goal of this report was to leverage existing studies to give Canadians a better understanding of the potential impact of automation in Canada. Our findings suggest that a large portion of the Canadian labour force is at a high risk of feeling the impact of automation in the next decade or two. At the same time, we also found that a large proportion of the tasks that Canadians currently perform can be automated using existing technology. This automation is predicted to take place primarily in occupations that are administrative, routine, or oriented toward sales and service. Our findings suggest that while these jobs may not necessarily be lost, they are more susceptible to the effects of automation than others and, in the near term, may be subject to significant task restructuring.

On the other hand, we also found Canada's employed labour force is comprised of a large number of occupations that require highly-skilled workers who command high wages and are at a low risk of being negatively affected by automation. These occupations are expected to grow much more quickly than the rest of the labour force. This suggests that more highly-skilled labour will be a significant driver of Canada's future growth.

It is also important when assessing these predictions to consider the role that technology can play in complementing labour, which has the potential to offset any negative employment effects.



Moving forward Canada's public and private sectors can help to mitigate the potential negative effects technology can have on employment, while ensuring Canadians are able to leverage technology to innovate, improve productivity and standards of living. The success of these efforts will require significant co-ordination between governments, educational institutions and the private sector. Some steps to be taken include:

Future study: A deeper dive into high-risk occupations will determine their ability to withstand automation and technology-based restructuring. It will also be important to know the demographic profile of these occupations. Whether individuals in so-called high-risk occupations are older and slated for retirement or mostly starting their careers will necessitate very different responses.

Focus on Canadian strengths: To offset any potential negative effects on employment, efforts should also be taken to identify Canada's domestic technological strengths and ensure that the innovators and entrepreneurs behind them, have the financing, talent and supports needed to innovate and scale up. This can help create new jobs that are not only at a low risk of being affected by automation, but are using new technology to grow.

Education and training: The negative effects of technology on employment can also be mitigated through education and training. From our study it is clear that jobs with the least risk of being affected by automation require the most education. Employees in high-risk occupations also tend to be disproportionately young and lower paid.

It is also important when assessing these predictions to consider the role that technology can play in complementing labour, which has the potential to offset any negative employment effects.

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END NOTES

- i Autor, 2015, pp. 4 to 5.
- ii Autor, 2015, p. 4.
- iii Frey & Osborne, 2013, p. 13.
- iv Frey & Osborne, 2013.
- v Chui et al., 2015.
- vi Autor et al., 2003, pp. 1285 to 1286.
- vii Autor, 2015, p. 5.
- viii Frey & Osborne, 2013, p. 13.
- ix Arntz, et al., 2016, pp. 23 to 24.
- x Graetz & Michaels, 2015, p. 4.
- xi Frey & Osborne, 2013, p. 13.
- xii Frey & Osborne, 2013, p. 37.
- xiii Arntz et al., 2016, pp. 21 to 24.
- xiv Fadel, 2014, p. 6.
- xv Arntz et al., 2016, p. 11.
- xvi Chui et al., 2015.
- xvii Arntz et al., 2016, p. 13.
- xviii Arntz et al., 2016, p. 14.
- xix Arntz et al., 2016, p. 33.
- xx The NHS provided the latest publicly occupation level data at the necessary level.
- xxi Deloitte, 2015, pp. 1 to 3.
- xxii Frey & Osborne, 2013, pp. 30 & 36.
- xxiii Chui et al., 2015.

APPENDIX

NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
0011	Legislators	4.0%	\$ 56,003	7,465	1.5%
0012	Senior government managers and officials	24.0%	\$ 97,517	19,840	8.8%
0013	Senior managers-financial, communications and other business services	24.0%	\$ 160,560	54,880	8.8%
0014	Senior managers-health, education, social and community services and membership organizations	19.8%	\$ 96,268	25,300	11.0%
0015	Senior managers-trade, broadcasting and other services, n.e.c.	24.0%	\$ 125,102	49,905	8.8%
0016	Senior managers - construction, transportation, production and utilities	24.0%	\$ 175,909	54,710	8.8%
0111	Financial managers	34.0%	\$ 90,078	73,145	6.9%
0112	Human resources managers	14.0%	\$ 82,615	50,825	0.6%
0113	Purchasing managers	36.0%	\$ 84,906	14,870	3.0%
0114	Other administrative services managers	35.0%	\$ 74,177	29,725	73.0%
0121	Insurance, real estate and financial brokerage managers	16.0%	\$ 77,691	48,670	81.0%
0122	Banking, credit and other investment managers	34.0%	\$ 98,088	73,450	6.9%
0124	Advertising, marketing and public relations managers	9.7%	\$ 76,959	56,220	2.3%
0125	Other business services managers	24.4%	\$ 76,612	12,975	23.2%
0131	Telecommunication carriers managers	19.0%	\$ 88,551	13,170	25.0%
0132	Postal and courier services managers	31.0%	\$ 66,054	4,305	59.0%
0211	Engineering managers	17.0%	\$ 121,257	17,795	1.7%
0212	Architecture and science managers	17.0%	\$ 90,159	7,500	1.7%
0213	Computer and information systems managers	19.0%	\$ 97,444	52,935	3.5%

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NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
0311	Managers in health care	36.0%	\$ 78,930	26,690	0.7%
0411	Government managers- health and social development and program administration	28.0%	\$ 90,523	5,770	25.0%
0412	Government managers- economic analysis, policy development and program administration	28.0%	\$ 90,054	8,625	25.0%
0413	Government managers- education policy development and program administration	28.0%	\$ 93,889	1,060	25.0%
0414	Other managers in public administration	28.0%	\$ 87,426	10,330	25.0%
0421	Administrators- post-secondary education and vocational training	16.0%	\$ 75,416	15,020	1.0%
0422	School principals and administrators of elementary and secondary education	15.5%	\$ 89,689	32,270	1.0%
0423	Managers in social, community and correctional services	5.0%	\$ 59,447	29,260	0.7%
0431	Commissioned police officers	19.0%	\$ 98,009	2,200	9.8%
0432	Fire chiefs and senior firefighting officer	46.0%	\$ 92,143	2,310	0.4%
0511	Library, archive, museum and art gallery managers	28.0%	\$ 57,416	4,345	25.0%
0512	Managers- publishing, motion pictures, broadcasting and performing arts	28.0%	\$ 60,363	10,750	25.0%
0513	Recreation, sports and fitness program and service directors	28.0%	\$ 45,272	12,540	25.0%
0601	Corporate sales managers	7.0%	\$ 89,412	80,045	1.3%
0621	Retail and wholesale trade managers	28.0%	\$ 49,043	363,285	20.5%
0631	Restaurant and food service managers	7.0%	\$ 35,501	114,560	4.3%
0632	Accommodation service managers	40.0%	\$ 41,544	20,775	0.4%

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NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
0651	Managers in customer and personal services, n.e.c.	48.5%	\$ 34,986	28,485	17.1%
0711	Construction managers	17.0%	\$ 75,676	72,000	7.1%
0712	Home building and renovation managers	17.0%	\$ 36,693	36,665	7.1%
0714	Facility operation and maintenance managers	16.0%	\$ 62,451	46,280	81.0%
0731	Managers in transportation	31.0%	\$ 72,547	29,285	59.0%
0811	Managers in natural resources production and fishing	29.5%	\$ 143,590	13,180	36.0%
0821	Managers in agriculture	31.0%	\$ 23,919	168,020	47.0%
0822	Managers in horticulture	31.0%	\$ 47,214	4,725	47.0%
0823	Managers in aquaculture	31.0%	\$ 41,840	1,170	47.0%
0911	Manufacturing managers	38.0%	\$ 83,373	72,920	3.0%
0912	Utilities managers	34.5%	\$ 130,038	11,585	31.0%
1111	Financial auditors and accountants	12.0%	\$ 69,455	203,470	94.0%
1112	Financial and investment analysts	11.0%	\$ 73,346	37,245	23.0%
1113	Securities agents, investment dealers and brokers	46.0%	\$ 132,247	17,165	1.6%
1114	Other financial officers	1.0%	\$ 77,301	92,395	33.0%
1121	Human resource professionals	11.0%	\$ 62,819	60,120	20.1%
1122	Professional occupations in business management consulting	3.0%	\$ 69,542	62,005	7.1%
1123	Professional occupations in advertising, marketing and public relations	13.0%	\$ 51,577	74,135	3.9%
1211	Supervisors, general office and administrative support workers	22.0%	\$ 54,685	11,510	1.4%
1212	Supervisors, finance and insurance office workers	22.0%	\$ 58,776	15,720	1.4%
1213	Supervisors, library, correspondence and related information workers	22.0%	\$ 29,632	6,390	1.4%

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NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
1214	Supervisors, mail and message distribution occupations	22.0%	\$ 46,921	8,820	1.4%
1215	Supervisors, supply chain, tracking and scheduling coordination	22.0%	\$ 51,139	34,960	1.4%
1221	Administrative officers	54.0%	\$ 45,404	246,875	96.0%
1222	Executive assistants	51.0%	\$ 54,737	40,545	86.0%
1223	Human resources and recruitment officers	22.0%	\$ 50,007	27,645	31.0%
1224	Property administrators	16.0%	\$ 46,922	49,935	81.0%
1225	Purchasing agents and officers	2.0%	\$ 58,732	45,785	77.0%
1226	Conference and event planners	9.0%	\$ 34,616	20,665	3.7%
1227	Court officers and justices of the peace	26.0%	\$ 51,610	5,485	64.0%
1228	Employment insurance, immigration, border services and revenue officers	41.0%	\$ 54,865	33,985	41.8%
1241	Administrative assistants	54.0%	\$ 32,691	328,825	96.0%
1242	Legal administrative assistants	69.0%	\$ 39,496	37,485	94.0%
1243	Medical administrative assistants	54.0%	\$ 32,418	14,960	30.0%
1251	Court reporters, medical transcriptionists and related occupations	41.0%	\$ 30,197	9,075	69.5%
1252	Health information management occupations	49.0%	\$ 43,915	4,555	91.0%
1253	Records management technicians	75.0%	\$ 45,395	7,855	95.0%
1254	Statistical officers and related research support occupations	60.0%	\$ 46,574	4,455	66.0%
1311	Accounting technicians and bookkeepers	86.0%	\$ 33,573	134,090	98.0%
1312	Insurance adjusters and claims examiners	81.0%	\$ 55,564	25,340	98.0%
1313	Insurance underwriters	35.0%	\$ 56,109	13,850	99.0%
1314	Assessors, valuers and appraisers	37.0%	\$ 57,883	11,355	90.0%
1315	Customs, ship and other brokers	79.0%	\$ 49,912	4,760	98.0%

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NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
1411	General office support workers	61.0%	\$ 31,173	218,825	96.0%
1414	Receptionists	53.0%	\$ 22,390	155,355	96.0%
1415	Personnel clerks	51.0%	\$ 40,974	13,335	90.0%
1416	Court clerks	54.0%	\$ 40,993	2,570	46.0%
1422	Data entry clerks	86.0%	\$ 27,846	43,285	99.0%
1423	Desktop publishing operators and related occupations	70.0%	\$ 37,032	1,940	16.0%
1431	Accounting and related clerks	86.0%	\$ 35,410	142,445	98.0%
1432	Payroll clerks	87.0%	\$ 43,562	33,935	97.0%
1434	Banking, insurance and other financial clerks	81.0%	\$ 43,734	30,985	98.0%
1435	Collectors	34.0%	\$ 34,539	14,555	93.0%
1451	Library assistants and clerks	80.0%	\$ 21,955	17,200	95.0%
1452	Correspondence, publication and regulatory clerks	78.0%	\$ 39,498	26,135	87.0%
1454	Survey interviewers and statistical clerks	60.0%	\$ 16,685	36,060	66.0%
1511	Mail, postal and related workers	81.0%	\$ 33,862	33,390	86.5%
1512	Letter carriers	73.0%	\$ 44,421	31,915	68.0%
1513	Couriers, messengers and door-to-door distributors	39.0%	\$ 19,846	27,520	94.0%
1521	Shippers and receivers	79.0%	\$ 31,103	116,090	98.0%
1522	Storekeepers and partspersons	85.0%	\$ 37,127	47,085	64.0%
1523	Production logistics coordinators	49.0%	\$ 51,236	19,245	88.0%
1524	Purchasing and inventory control workers	2.0%	\$ 34,204	31,135	77.0%
1525	Dispatchers	40.0%	\$ 43,874	34,160	96.0%
1526	Transportation route and crew schedulers	40.0%	\$ 47,780	5,090	96.0%
2111	Physicists and astronomers	9.5%	\$ 82,483	2,920	7.1%
2112	Chemists	37.0%	\$ 64,001	15,450	10.0%
2113	Geoscientists and oceanographers	65.0%	\$ 130,061	12,650	63.0%
2114	Meteorologists and climatologists	34.0%	\$ 71,841	1,345	67.0%
2115	Other professional occupations in physical sciences	60.0%	\$ 72,187	2,040	43.0%

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NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
2121	Biologist and related scientists	42.0%	\$ 60,060	21,020	15.6%
2122	Forestry professionals	11.0%	\$ 61,597	4,980	0.8%
2123	Agricultural representatives, consultants and specialists	3.0%	\$ 51,980	6,340	49.0%
2131	Civil engineers	13.0%	\$ 83,276	50,340	1.9%
2132	Mechanical engineers	17.0%	\$ 80,536	47,095	1.1%
2133	Electrical and electronics engineers	21.0%	\$ 84,856	42,370	6.3%
2134	Chemical engineers	38.0%	\$ 98,509	11,400	1.7%
2141	Industrial and manufacturing engineers	11.0%	\$ 74,474	15,825	2.9%
2142	Metallurgical and materials engineers	18.0%	\$ 85,164	2,405	2.1%
2143	Mining engineers	24.0%	\$ 122,472	3,710	14.0%
2144	Geological engineers	24.0%	\$ 98,770	2,390	14.0%
2145	Petroleum engineers	19.0%	\$ 152,721	9,315	16.0%
2146	Aerospace engineers	14.0%	\$ 75,954	6,010	1.7%
2147	Computer engineers (except software engineers and designers)	25.0%	\$ 81,062	25,625	22.0%
2148	Other professional engineers, n.e.c.	15.3%	\$ 80,194	5,675	10.8%
2151	Architects	11.0%	\$ 70,528	15,255	1.8%
2152	Landscape architects	15.0%	\$ 53,403	1,735	4.5%
2153	Urban and land use planners	3.0%	\$ 67,086	10,640	13.0%
2154	Land surveyors	56.0%	\$ 68,186	8,605	38.0%
2161	Mathematicians, statisticians and actuaries	13.3%	\$ 84,795	11,455	15.9%
2171	Information systems analysts and consultants	38.0%	\$ 69,692	146,835	11.3%
2172	Database analysts and data administrators	48.0%	\$ 65,675	14,920	3.0%
2173	Software engineers and designers	17.0%	\$ 79,859	37,330	8.6%
2174	Computer programmers and interactive media developers	40.0%	\$ 60,066	98,600	4.8%
2175	Web designers and developers	45.0%	\$ 37,656	22,740	21.0%

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NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
2211	Chemical technologists and technicians	53.0%	\$ 46,165	26,180	57.0%
2212	Geological and mineral technologists and technicians	50.0%	\$ 61,729	11,315	91.0%
2221	Biological technologists and technicians	69.0%	\$ 38,067	10,320	30.0%
2222	Agricultural and fish products inspectors	21.0%	\$ 48,108	5,165	94.0%
2223	Forestry technologists and technicians	38.0%	\$ 42,426	6,945	42.0%
2224	Conservation and fishery officers	28.2%	\$ 47,351	5,090	36.1%
2225	Landscape and horticulture technicians and specialists	9.0%	\$ 30,470	16,685	95.0%
2231	Civil engineering technologists and technicians	21.0%	\$ 52,920	20,075	75.0%
2232	Mechanical engineering technologists and technicians	23.0%	\$ 57,985	20,335	38.0%
2233	Industrial engineering and manufacturing technologists and technicians	7.0%	\$ 52,213	19,525	3.0%
2234	Construction estimators	14.0%	\$ 62,844	16,405	57.0%
2241	Electrical and electronics engineering technologists and technicians	23.0%	\$ 55,600	45,130	84.0%
2242	Electronic service technicians (household and business equipment)	44.0%	\$ 39,423	44,655	41.0%
2243	Industrial instrument technicians and mechanics	41.0%	\$ 81,699	8,185	67.0%
2244	Aircraft instrument, electrical and avionics mechanics, technicians and inspectors	71.7%	\$ 64,161	7,370	63.0%
2251	Architectural technologists and technicians	21.0%	\$ 45,711	9,255	52.0%
2252	Industrial designers	3.0%	\$ 47,468	7,405	3.7%
2253	Drafting technologists and technicians	19.3%	\$ 44,650	31,390	67.0%

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NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
2254	Land survey technologists and technicians	61.0%	\$ 39,382	4,665	96.0%
2255	Technical occupations in geometrics and meteorology	39.5%	\$ 51,180	8,315	41.5%
2261	Non-destructive testers and inspection technicians	61.5%	\$ 67,304	6,405	79.5%
2262	Engineering inspectors and regulatory officers	46.0%	\$ 66,694	5,290	61.0%
2263	Inspectors in public and environmental health and occupational health and safety	24.0%	\$ 63,815	28,730	8.0%
2264	Construction inspectors	37.0%	\$ 54,152	13,615	63.0%
2271	Air pilots, flight engineers and flying instructors	72.0%	\$ 89,101	15,635	18.0%
2272	Air traffic controllers and related occupations	56.0%	\$ 95,792	5,045	11.0%
2273	Deck officers, water transport	76.0%	\$ 71,510	5,150	27.0%
2274	Engineer officers, water transport	19.0%	\$ 72,374	2,605	1.0%
2275	Railway traffic controllers and marine traffic regulators	43.0%	\$ 71,894	1,295	89.5%
2281	Computer network technicians	71.0%	\$ 55,047	62,590	3.0%
2282	User support technicians	65.0%	\$ 46,633	53,445	65.0%
2283	Information systems testing technicians	21.0%	\$ 47,095	7,215	22.0%
3011	Nursing coordinators and supervisors	36.0%	\$ 60,604	10,585	0.7%
3012	Registered nurses and registered psychiatric nurses	29.0%	\$ 57,451	291,380	0.9%
3111	Specialist physicians	23.0%	\$ 175,088	36,550	0.4%
3112	General practitioners and family physicians	31.0%	\$ 136,456	44,970	0.4%
3113	Dentists	23.0%	\$ 124,790	18,780	0.4%
3114	Veterinarians	12.0%	\$ 75,811	9,230	3.8%
3121	Optometrists	36.0%	\$ 93,262	4,865	14.0%
3122	Chiropractors	4.0%	\$ 61,186	6,905	2.7%
3124	Allied primary health practitioners	17.0%	\$ 72,524	4,715	5.5%

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NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (and Osborne)
3125	Other professional occupations in health diagnosing and treating	22.0%	\$ 39,418	3,855	2.0%
3131	Pharmacist	47.0%	\$ 89,908	32,190	1.2%
3132	Dietitians and nutritionists	44.0%	\$ 46,510	9,955	0.4%
3141	Audiologists and speech-language pathologists	41.5%	\$ 58,065	9,015	0.5%
3142	Physiotherapists	32.0%	\$ 54,162	20,950	2.1%
3143	Occupational therapists	25.0%	\$ 52,750	13,945	0.4%
3144	Other professional occupations in therapy and assessment	17.2%	\$ 34,498	8,895	1.2%
3211	Medical laboratory technologists	45.0%	\$ 55,513	19,570	90.0%
3212	Medical laboratory technicians and pathologists' assistants	64.0%	\$ 39,686	23,470	47.0%
3213	Animal health technologists and veterinary technicians	53.0%	\$ 26,869	13,560	2.9%
3214	Respiratory therapists, clinical perfusionists and cardiopulmonary technologists	39.0%	\$ 58,518	9,605	6.6%
3215	Medical radiation technologists	47.0%	\$ 61,135	19,530	23.0%
3216	Medical sonographers	48.0%	\$ 60,544	4,380	35.0%
3217	Cardiology technologists and electrophysiological diagnostic technologists, n.e.c.	45.0%	\$ 44,410	2,655	23.0%
3219	Other medical technologists and technicians (except dental health)	53.0%	\$ 28,126	45,545	40.0%
3221	Denturists	23.0%	\$ 54,108	2,375	0.4%
3222	Dental hygienists and dental therapists	13.0%	\$ 45,325	23,325	68.0%
3223	Dental technologists, technicians and laboratory assistants	97.0%	\$ 44,310	7,165	97.0%
3231	Opticians	16.0%	\$ 39,731	8,595	71.0%
3232	Practitioners of natural healing	19.0%	\$ 17,942	7,025	15.8%
3233	Licensed practical nurses	16.0%	\$ 37,948	55,545	5.8%

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NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
3234	Paramedical occupations	35.0%	\$ 60,738	24,715	4.9%
3236	Massage therapists	0.0%	\$ 20,786	25,910	54.0%
3237	Other technical occupations in therapy and assessment	49.6%	\$ 35,947	6,925	37.3%
3411	Dental assistants	40.0%	\$ 29,999	29,785	51.0%
3413	Nurse aides, orderlies and patient service associates	38.7%	\$ 28,213	194,250	38.5%
3414	Other assisting occupations in support of health services	53.4%	\$ 29,105	27,960	59.4%
4011	University professors and lecturers	9.2%	\$ 81,771	69,010	3.2%
4012	Post-secondary teaching and research assistants	23.0%	\$ 19,464	59,050	65.0%
4021	College and other vocational instructors	9.2%	\$ 52,114	99,000	3.2%
4031	Secondary school teachers	15.0%	\$ 58,413	173,975	0.8%
4032	Elementary school and kindergarten teachers	14.0%	\$ 53,198	271,200	0.4%
4033	Educational counsellors	14.0%	\$ 49,331	19,265	0.9%
4111	Judges	21.0%	\$ 199,599	3,005	40.0%
4112	Lawyers and Quebec notaries	23.0%	\$ 135,937	80,515	3.5%
4151	Psychologists	10.3%	\$ 55,426	21,535	0.7%
4152	Social workers	13.0%	\$ 50,801	55,415	1.2%
4153	Family, marriage and other related counsellors	16.0%	\$ 41,949	26,450	2.1%
4154	Professional occupations in religion	0.0%	\$ 43,729	30,610	2.5%
4155	Probation and parole officers and related occupations	24.0%	\$ 61,509	6,460	25.0%
4156	Employment counsellors	14.0%	\$ 38,701	15,220	0.9%
4161	Natural and applied science policy researchers, consultants and program officers	13.5%	\$ 66,933	24,855	33.0%
4162	Economists and economic policy researchers and analysts	13.5%	\$ 74,813	14,975	33.0%

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NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
4163	Business development officers and marketing researchers and consultants	18.0%	\$ 60,403	48,895	23.0%
4164	Social policy researchers, consultants and program officers	16.5%	\$ 56,671	27,055	14.5%
4165	Health policy researchers, consultants and program officers	16.5%	\$ 55,144	28,470	14.5%
4166	Education policy researchers, consultants and program officers	16.5%	\$ 54,553	24,070	14.5%
4167	Recreation, sports and fitness policy researchers, consultants and program officers	16.5%	\$ 38,877	10,790	14.5%
4168	Program officers unique to government	18.0%	\$ 40,582	18,370	23.0%
4169	Other professional occupations in social science, n.e.c.	15.0%	\$ 48,049	6,545	5.9%
4211	Paralegal and related occupations	69.0%	\$ 43,955	25,950	94.0%
4212	Social and community service workers	13.0%	\$ 33,659	128,665	1.2%
4214	Early childhood educators and assistants	7.0%	\$ 20,233	187,750	0.7%
4215	Instructors of persons with disabilities	7.4%	\$ 35,340	20,945	1.2%
4216	Other instructors	13.0%	\$ 18,266	25,830	1.0%
4217	Other religious occupations	0.0%	\$ 25,587	7,355	2.5%
4311	Police officers (except commissioned)	19.0%	\$ 82,189	80,675	9.8%
4312	Firefighters	40.0%	\$ 77,105	31,825	17.0%
4411	Home child care providers	19.0%	\$ 13,405	62,605	8.4%
4412	Home support workers, housekeepers and related occupations	17.0%	\$ 21,191	92,575	63.0%
4413	Elementary and secondary school teacher assistants	9.0%	\$ 22,613	107,985	56.0%
4421	Sheriffs and bailiffs	33.5%	\$ 54,101	2,805	22.9%

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NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
4422	Correctional service officers	41.0%	\$ 60,742	22,495	60.0%
4423	By-law enforcement and other regulatory officers, n.e.c.	25.0%	\$ 49,442	8,180	37.7%
5111	Librarians	43.0%	\$ 49,130	13,115	65.0%
5112	Conservators and curators	42.5%	\$ 40,135	1,790	29.8%
5113	Archivists	7.0%	\$ 41,499	2,430	76.0%
5121	Authors and writers	13.0%	\$ 35,643	24,355	3.8%
5122	Editors	9.0%	\$ 40,118	17,445	5.5%
5123	Journalists	15.0%	\$ 46,621	13,280	11.0%
5125	Translators, terminologists and interpreters	16.0%	\$ 37,732	16,870	38.0%
5131	Producers, directors, choreographers and related occupations	12.0%	\$ 50,240	21,655	2.2%
5132	Conductors, composers and arrangers	0.0%	\$ 27,603	3,215	1.5%
5133	Musicians and singers		\$ 16,778	32,290	7.4%
5134	Dancers		\$ 13,460	7,730	13.0%
5135	Actors and comedians		\$ 18,778	7,805	37.0%
5136	Painters, sculptors and other visual artists	24.0%	\$ 16,140	15,135	4.2%
5211	Library and public archive technicians	59.0%	\$ 34,286	10,725	99.0%
5212	Technical occupations related to museums and art galleries	59.0%	\$ 18,407	4,890	59.0%
5221	Photographers	27.0%	\$ 21,584	14,825	2.1%
5222	Film and video camera operators	42.0%	\$ 40,627	4,140	60.0%
5223	Graphic arts technicians	6.0%	\$ 36,030	9,830	4.9%
5224	Broadcast technicians	62.0%	\$ 51,035	2,950	74.0%
5225	Audio and video recording technicians	36.0%	\$ 35,936	12,540	55.0%
5226	Other technical and coordinating occupations in motion pictures, broadcasting and the performing arts	62.5%	\$ 36,920	8,770	61.0%
5227	Support occupations in motion pictures, broadcasting, photography and the performing arts	62.2%	\$ 31,464	6,270	67.4%

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5231	Announcers and other broadcasters	20.0%	\$ 41,577	6,670	10.0%
5232	Other performers, n.e.c.	15.5%	\$ 16,302	3,675	37.1%
5241	Graphic designers and illustrators	10.0%	\$ 36,068	55,190	8.2%
5242	Interior designers and interior decorators	12.0%	\$ 31,418	22,720	2.2%
5243	Theatre, fashion, exhibit and other creative designers	19.5%	\$ 29,553	11,865	1.3%
5244	Artisans and craftspersons	83.6%	\$ 16,744	12,405	75.1%
5245	Patternmakers- textile, leather and fur products	61.0%	\$ 34,666	1,020	0.5%
5251	Athletes	0.0%	\$ 136,996	2,440	28.0%
5252	Coaches	28.0%	\$ 31,076	8,925	1.3%
5253	Sports officials and referees	13.0%	\$ 4,329	3,035	98.0%
5254	Program leaders and instructors in recreation, sport and fitness	11.0%	\$ 11,605	82,480	8.5%
6211	Retail sales supervisors	33.0%	\$ 30,987	61,515	28.0%
6221	Technical sales specialists- wholesale trade	37.0%	\$ 75,271	65,250	25.0%
6222	Retail and wholesale buyers	5.0%	\$ 34,910	33,005	29.0%
6231	Insurance agents and brokers	60.0%	\$ 53,582	66,205	92.0%
6232	Real estate agents and salespersons	27.0%	\$ 50,146	61,700	86.0%
6235	Financial sales representatives	46.0%	\$ 49,948	53,880	1.6%
6311	Food service supervisors	58.0%	\$ 22,695	35,545	63.0%
6312	Executive housekeepers	60.0%	\$ 31,685	3,685	94.0%
6313	Accommodation, travel, tourism and related services supervisors	40.3%	\$ 43,884	6,390	11.4%
6314	Customer and information services supervisors	45.0%	\$ 46,323	14,040	7.6%
6315	Cleaning supervisors	60.0%	\$ 40,669	9,655	94.0%
6316	Other services supervisors	45.0%	\$ 34,183	15,395	7.6%
6321	Chefs	54.0%	\$ 28,898	52,525	10.0%

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6322	Cooks	81.0%	\$ 17,773	192,540	83.0%
6331	Butchers, meat cutters and fishmongers- retail and wholesale	93.0%	\$ 27,076	20,570	93.0%
6332	Bakers	98.0%	\$ 21,740	41,650	89.0%
6341	Hairstylists and barbers	65.0%	\$ 18,124	91,500	11.0%
6342	Tailors, dressmakers, furriers and milliners	96.0%	\$ 18,866	13,325	84.0%
6343	Shoe repairers and shoemakers	83.0%	\$ 19,253	1,460	52.0%
6344	Jewelers, jewelry and watch repairers and related occupations	88.0%	\$ 25,435	5,300	95.0%
6345	Upholsterers	89.0%	\$ 27,275	5,420	39.0%
6346	Funeral directors and embalmers	17.5%	\$ 59,883	4,540	37.0%
6411	Sales and account representatives- wholesale trade (non-technical)	21.0%	\$ 53,848	131,060	85.0%
6421	Retail salespersons	47.0%	\$ 21,113	656,395	92.0%
6511	Maître d'hôtel and hosts/hostesses	65.0%	\$ 8,714	21,915	97.0%
6512	Bartenders	56.0%	\$ 15,575	35,520	77.0%
6513	Food and beverage servers	64.0%	\$ 13,335	180,605	94.0%
6521	Travel counsellors	73.0%	\$ 29,664	24,780	9.9%
6522	Pursers and flight attendants	75.0%	\$ 40,084	13,060	35.0%
6523	Airline ticket and service agents	41.0%	\$ 34,982	12,465	61.0%
6524	Ground and water transport ticket agents, cargo service representatives and related clerks	41.0%	\$ 36,319	2,885	61.0%
6525	Hotel front desk clerks	59.0%	\$ 20,732	22,880	94.0%
6531	Tour and travel guides	45.0%	\$ 13,700	4,355	91.0%
6532	Outdoor sport and recreational guides	31.0%	\$ 20,302	2,400	0.6%
6533	Casino occupations	53.4%	\$ 33,240	12,640	73.4%
6541	Security guards and related security service occupations	39.0%	\$ 27,338	109,625	84.0%
6551	Customer and information services representatives- financial institutions	29.0%	\$ 27,890	88,535	55.0%

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6552	Other customer and information services representatives	29.0%	\$ 30,507	186,830	55.0%
6561	Image, social and other personal consultants	54.4%	\$ 27,936	3,295	42.4%
6562	Estheticians, electrologists and related occupations	54.4%	\$ 17,194	42,340	42.4%
6563	Pet groomers and animal care workers	6.5%	\$ 14,817	16,365	46.0%
6564	Other personal service occupations	32.0%	\$ 17,235	925	27.9%
6611	Cashiers	49.0%	\$ 11,716	308,945	97.0%
6621	Service station attendants	90.0%	\$ 15,484	22,380	91.0%
6622	Store shelf stockers, clerks and order fillers	85.0%	\$ 16,240	150,770	64.0%
6623	Other sales related occupations	41.0%	\$ 17,661	32,255	85.3%
6711	Food counter attendants, kitchen helpers and related support occupations	78.0%	\$ 11,948	312,820	91.5%
6721	Support occupations in accommodation, travel and facilities set-up services	55.0%	\$ 25,966	4,705	84.7%
6722	Operators and attendants in amusement, recreation and support	55.0%	\$ 13,877	24,460	72.0%
6731	Light duty cleaners	18.0%	\$ 18,462	213,515	69.0%
6732	Specialized cleaners	16.0%	\$ 22,617	38,960	37.0%
6733	Janitors, caretakers and building superintendents	22.0%	\$ 28,071	195,540	66.0%
6741	Dry cleaning, laundry and related occupations	89.0%	\$ 22,958	21,160	71.0%
6742	Other service support occupations, n.e.c.	39.0%	\$ 16,112	24,570	65.8%
7201	Contractors and supervisors, machining, metal forming, shaping and erecting trades and related occupations	38.0%	\$ 67,453	14,090	17.0%

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7202	Contractors and supervisors, electrical trades and telecommunications occupations	38.0%	\$ 77,678	12,860	17.0%
7203	Contractors and supervisors, pipefitting trades	38.0%	\$ 81,590	5,455	17.0%
7204	Contractors and supervisors, carpentry trades	38.0%	\$ 54,065	13,370	17.0%
7205	Contractors and supervisors, other construction trades, installers, repairers and servicers	38.0%	\$ 48,933	26,040	17.0%
7231	Machinists and machining and tool inspectors	84.0%	\$ 46,394	42,095	65.0%
7232	Tool and die makers	87.0%	\$ 53,039	12,185	84.0%
7233	Sheet and metal workers	39.0%	\$ 46,843	20,020	82.0%
7234	Boilermakers	46.0%	\$ 66,543	3,630	68.0%
7235	Structural metal and platework fabricators and fitters	92.0%	\$ 47,232	6,045	41.0%
7236	Ironworkers	24.0%	\$ 56,375	14,140	86.5%
7237	Welders and related machine operators	93.0%	\$ 45,726	89,240	94.0%
7241	Electricians	59.0%	\$ 51,544	86,080	15.0%
7242	Industrial electricians	59.0%	\$ 73,846	24,800	15.0%
7243	Power system electrician	59.0%	\$ 77,017	6,120	15.0%
7244	Electrical power line and cable workers	40.0%	\$ 77,574	11,365	9.7%
7245	Telecommunications line and cable workers	36.0%	\$ 51,876	13,510	49.0%
7246	Telecommunications installation and repair workers	40.0%	\$ 50,658	24,835	36.0%
7247	Cable television service and maintenance technicians	88.0%	\$ 46,637	2,260	65.0%
7251	Plumbers	50.0%	\$ 47,019	47,200	35.0%
7252	Steamfitter, pipefitter and sprinkler system installer	50.0%	\$ 64,665	20,305	35.0%
7253	Gas fitter	50.0%	\$ 47,455	6,530	35.0%
7271	Carpenters	72.0%	\$ 33,910	149,395	92.0%

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7272	Cabinetmakers	72.0%	\$ 30,804	21,680	92.0%
7281	Bricklayers	53.0%	\$ 35,372	18,775	82.0%
7282	Concrete finishers	86.0%	\$ 38,759	10,125	94.0%
7283	Tile setters	86.0%	\$ 31,629	8,510	75.0%
7284	Plasterers, drywall installers and finishers and lathers	90.0%	\$ 32,636	29,630	84.0%
7291	Roofers and shinglers	31.0%	\$ 30,281	22,275	90.0%
7292	Glaziers	42.0%	\$ 38,752	11,590	73.0%
7293	Insulators	54.0%	\$ 46,326	8,825	83.0%
7294	Painters and decorators (except interior decorators)	46.0%	\$ 25,012	42,100	92.0%
7295	Floor covering installers	85.3%	\$ 27,842	14,755	80.3%
7301	Contractors and supervisors, mechanic trades	63.0%	\$ 64,415	18,465	67.6%
7302	Contractors and supervisors, heavy equipment operator crews	64.6%	\$ 69,382	32,475	71.9%
7303	Supervisors, printing and related occupations	75.2%	\$ 51,957	4,370	1.6%
7304	Supervisors, railway transport operations	48.5%	\$ 76,938	1,740	71.3%
7305	Supervisors, motor transport and other ground transit operators	52.2%	\$ 63,000	8,290	68.2%
7311	Construction millwrights and industrial mechanics	60.0%	\$ 61,246	68,700	63.0%
7312	Heavy-duty equipment mechanics	41.0%	\$ 60,634	42,985	67.0%
7313	Refrigeration and air conditioning mechanics	31.0%	\$ 53,144	23,940	65.0%
7314	Railway carmen/women	90.5%	\$ 61,748	2,725	73.5%
7315	Aircraft mechanics and aircraft inspectors	85.0%	\$ 60,257	16,520	71.0%
7316	Machine fitters	70.0%	\$ 58,952	4,940	81.0%
7318	Elevator constructors and mechanics	30.0%	\$ 76,714	4,550	39.0%
7321	Automotive service technicians, truck and bus mechanics and mechanical repairers	91.0%	\$ 41,635	137,530	59.0%

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7322	Motor vehicle body repairer	81.0%	\$ 37,751	28,565	73.0%
7331	Oil and solid fuel heating mechanics	31.0%	\$ 41,078	2,800	65.0%
7332	Appliance servicers and repairers	41.0%	\$ 36,515	7,545	72.0%
7333	Electrical mechanics	69.3%	\$ 47,884	8,490	70.7%
7334	Motorcycle, all-terrain and other related mechanics	85.0%	\$ 37,815	4,795	79.0%
7335	Other small engine and small equipment repairers	92.0%	\$ 29,345	3,480	93.0%
7361	Railway and yard locomotive engineers	54.0%	\$ 85,208	5,155	91.0%
7362	Railway conductors and brakemen/women	46.0%	\$ 60,547	5,855	83.0%
7371	Crane operators	85.0%	\$ 64,787	13,325	90.0%
7372	Drillers and blasters-surface mining, quarrying and construction	75.0%	\$ 58,341	3,160	66.5%
7373	Water well drillers	90.0%	\$ 46,707	1,055	84.0%
7381	Printing press operators	86.0%	\$ 44,968	14,390	83.0%
7384	Other trades and related occupations, n.e.c.	54.6%	\$ 40,612	10,230	76.2%
7441	Residential and commercial installers and services	61.6%	\$ 31,068	41,955	66.6%
7442	Waterworks and gas maintenance workers	47.5%	\$ 53,006	5,325	48.5%
7444	Pest controllers and fumigators	36.0%	\$ 34,268	2,920	66.0%
7445	Other repairers and servicers	57.0%	\$ 32,842	12,495	50.0%
7451	Longshore workers	7.0%	\$ 57,905	5,520	85.0%
7452	Material handlers	7.0%	\$ 30,404	158,080	85.0%
7511	Transport truck drivers	69.0%	\$ 40,871	261,775	79.0%
7512	Bus drivers, subway operators and other transit operators	62.7%	\$ 34,121	85,130	80.7%
7513	Taxi and limousine drivers and chauffeurs	58.0%	\$ 19,037	48,545	89.0%
7514	Delivery and courier service drivers	70.0%	\$ 27,762	90,075	69.0%
7521	Heavy equipment operators (except crane)	79.0%	\$ 50,592	78,510	89.2%

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7522	Public works maintenance equipment operators and related workers	17.5%	\$ 39,441	18,685	90.0%
7531	Railway yard and track maintenance workers	47.0%	\$ 53,414	5,255	89.5%
7532	Water transport deck and engine room crew	86.5%	\$ 44,894	3,770	86.0%
7533	Boat and cable ferry operators and related occupations	76.0%	\$ 37,706	2,120	27.0%
7534	Air transport ramp attendants	68.0%	\$ 33,333	7,960	99.0%
7535	Other automotive mechanical installers and servicers	91.0%	\$ 29,947	14,555	59.0%
7611	Construction trades helpers and labourers	35.0%	\$ 28,571	134,150	88.0%
7612	Other trades helpers and labourers	35.0%	\$ 27,108	9,585	88.0%
7621	Public works and maintenance labourers	30.8%	\$ 32,761	30,740	89.8%
7622	Railway and motor transport labourers	35.0%	\$ 28,676	4,005	88.0%
8211	Supervisors, logging and forestry	40.0%	\$ 51,248	3,100	57.0%
8221	Supervisors, mining and quarrying	38.0%	\$ 98,984	6,225	17.0%
8222	Contractors and supervisors, oil and gas drilling and services	38.0%	\$ 113,164	13,320	17.0%
8231	Underground production and development miners	71.6%	\$ 71,794	14,365	66.5%
8232	Oil and gas well drillers, servicers, testers and related workers	68.2%	\$ 78,949	11,610	77.2%
8241	Logging machinery operators	100.0%	\$ 43,225	6,815	79.0%
8252	Agricultural service contractors, farm supervisors and specialized livestock workers	40.0%	\$ 28,096	9,825	57.0%
8255	Contractors and supervisors, landscaping, grounds maintenance and horticulture services	36.0%	\$ 32,591	17,500	57.0%
8261	Fishing masters and officers	24.0%	\$ 34,365	2,310	83.0%
8262	Fishermen/women	24.0%	\$ 20,241	16,595	83.0%

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8411	Underground mine service and support workers	27.0%	\$ 49,895	2,195	37.0%
8412	Oil and gas well drilling and related workers and services operators	68.2%	\$ 72,433	7,355	77.2%
8421	Chain saw and skidder operators	64.0%	\$ 25,668	5,275	76.0%
8422	Silviculture and forestry workers	11.0%	\$ 21,464	5,810	0.8%
8431	General farm workers	45.0%	\$ 17,778	82,475	87.0%
8432	Nursery and greenhouse workers	49.0%	\$ 14,551	15,110	87.0%
8441	Fishing vessel deckhands	24.0%	\$ 19,854	3,240	83.0%
8442	Trappers and hunters		\$ 14,825	455	77.0%
8611	Harvesting labourers	49.0%	\$ 12,440	5,650	87.0%
8612	Landscaping and grounds maintenance labourers	9.0%	\$ 16,849	92,655	95.0%
8613	Aquaculture and marine harvest labourers	49.0%	\$ 22,162	1,420	87.0%
8614	Mine labourers	27.0%	\$ 45,462	3,390	37.0%
8615	Oil and gas drilling, servicing and related labourer	27.0%	\$ 46,756	9,925	37.0%
8616	Logging and forestry labourer	33.0%	\$ 21,709	3,660	87.0%
9211	Supervisors, mineral and metal processing	33.0%	\$ 69,548	7,035	1.6%
9212	Supervisors, petroleum, gas and chemical processing and utilities	33.0%	\$ 88,168	13,810	1.6%
9213	Supervisors, food, beverage and associated products processing	33.0%	\$ 50,341	12,945	1.6%
9214	Supervisors, plastic and rubber products manufacturing	33.0%	\$ 49,787	5,730	1.6%
9215	Supervisors, forest products processing	33.0%	\$ 63,835	6,630	1.6%
9217	Supervisors, textile, fabric, fur and leather products processing and manufacturing	33.0%	\$ 41,020	1,965	1.6%
9221	Supervisors, motor vehicle assembling	33.0%	\$ 70,201	5,320	1.6%

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9222	Supervisors, electronics manufacturing	33.0%	\$ 55,702	1,880	1.6%
9223	Supervisors, electrical products manufacturing	33.0%	\$ 55,846	1,045	1.6%
9224	Supervisors, furniture and fixtures manufacturing	33.0%	\$ 45,278	2,860	1.6%
9226	Supervisors, other mechanical and metal products manufacturing	33.0%	\$ 62,855	3,660	1.6%
9227	Supervisors, other products manufacturing and assembly	33.0%	\$ 47,032	2,815	1.6%
9231	Central control and process operators, mineral and metal processing	82.0%	\$ 68,181	2,795	62.0%
9232	Petroleum, gas and chemical process operators	84.7%	\$ 84,661	18,775	78.0%
9235	Pulping, papermaking and coating control operators	100.0%	\$ 66,178	2,595	67.0%
9241	Power engineers and power systems operators	83.5%	\$ 82,084	29,565	90.0%
9243	Water and waste treatment plant operators	70.0%	\$ 53,587	10,855	61.0%
9411	Machine operators, mineral and metal processing	91.3%	\$ 57,047	8,050	88.3%
9412	Foundry workers	100.0%	\$ 45,349	4,180	67.0%
9413	Glass forming and finishing machine operators and glass cutters	89.0%	\$ 31,345	3,380	90.0%
9414	Concrete, clay and stone forming operators	89.0%	\$ 34,562	5,865	90.0%
9415	Inspectors and testers, mineral and metal processing	65.0%	\$ 45,784	2,825	98.0%
9416	Metalworking and forging machine operators	90.9%	\$ 37,979	14,810	85.6%
9417	Machining tool operators	91.4%	\$ 40,117	9,415	87.9%

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9418	Other metal products machine operators	88.6%	\$ 37,407	6,555	89.4%
9421	Chemical plant machine operators	90.0%	\$ 41,372	9,025	76.0%
9422	Plastics processing machine operators	91.2%	\$ 34,645	17,535	90.6%
9423	Rubber processing machine operators and related workers	81.5%	\$ 41,204	6,565	84.8%
9431	Sawmill machine operators	93.0%	\$ 37,193	8,615	86.0%
9432	Pulp mill machine operators	100.0%	\$ 66,428	2,480	67.0%
9433	Papermaking and finishing machine operators	100.0%	\$ 54,826	3,015	67.0%
9434	Other wood processing machine operators	94.0%	\$ 40,873	4,395	97.0%
9435	Paper converting machine operators	100.0%	\$ 41,689	7,545	67.0%
9436	Lumber graders and other wood processing inspectors and graders	74.0%	\$ 42,090	3,900	97.0%
9437	Woodworking machine operators	94.0%	\$ 29,597	4,795	97.0%
9441	Textile fiber and yarn, hide and pelt processing machine operators and workers	86.0%	\$ 28,378	2,870	95.0%
9442	Weavers, knitters and other fabric making occupations	80.0%	\$ 26,229	3,510	73.0%
9445	Fabric, fur and leather cutters	86.0%	\$ 23,413	2,720	95.0%
9446	Industrial sewing machine operators	100.0%	\$ 19,185	19,760	89.0%
9447	Inspectors and graders, textile, fabric, fur and leather products manufacturing	65.0%	\$ 27,015	3,295	98.0%
9461	Process control and machine operators, food, beverage and associated products processing	92.8%	\$ 37,344	30,735	77.5%
9462	Industrial butchers and meat cutters, poultry preparers and related workers	93.0%	\$ 31,133	12,310	93.0%
9463	Fish and seafood plant workers	92.0%	\$ 13,978	7,670	73.0%

APPENDIX

NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
9465	Testers and graders, food, beverage and associated products processing	65.0%	\$ 32,866	4,095	98.0%
9471	Plateless printing equipment operators	86.0%	\$ 35,722	12,210	97.0%
9472	Camera, platemaking and other prepress occupations	100.0%	\$ 41,218	4,215	99.0%
9473	Binding and finishing machine operators	87.0%	\$ 29,053	7,245	95.0%
9474	Photographic and film processors	97.0%	\$ 23,511	4,850	99.0%
9521	Aircraft assemblers and aircraft assembly inspectors	62.5%	\$ 55,505	6,850	88.5%
9522	Motor vehicle assemblers, inspectors and testers	67.5%	\$ 45,769	59,700	90.0%
9523	Electronics assemblers, fabricators, inspectors and testers	64.5%	\$ 29,665	16,535	96.5%
9524	Assemblers and inspectors, electrical appliance, apparatus and equipment manufacturing	64.5%	\$ 33,022	10,870	96.5%
9525	Assemblers, fabricators and inspectors, industrial electrical motors and transformers	71.0%	\$ 37,213	2,925	97.5%
9526	Mechanical assemblers and inspectors	67.5%	\$ 36,616	7,650	90.0%
9527	Machine operators and inspectors, electrical apparatus manufacturing	64.5%	\$ 36,194	2,140	96.5%
9531	Boat assemblers and inspectors	67.5%	\$ 31,043	2,270	90.0%
9532	Furniture and fixture assemblers and inspectors	68.5%	\$ 26,357	18,245	95.0%
9533	Other wood products assemblers and inspectors	68.5%	\$ 29,926	10,400	95.0%
9534	Furniture finishers and refinishers	90.0%	\$ 29,113	7,430	87.0%
9535	Plastic products assemblers, finishers and inspectors	77.0%	\$ 30,616	8,720	95.5%

APPENDIX

NOC #	Occupation	Proportion of tasks that can be automated (McKinsey & Company)	Average Income, 2011	Employed Canadian Labour Force, 2011	Probability of automation in the next 10-20 years (Frey and Osborne)
9536	Industrial painters, coaters and metal finishing process operators	97.0%	\$ 38,249	13,255	91.0%
9537	Other products assemblers, finishers and inspectors	69.0%	\$ 28,121	19,155	91.5%
9611	Labourers in mineral and metal processing	97.0%	\$ 42,083	8,745	66.0%
9612	Labourers in metal fabrication	97.0%	\$ 32,161	9,815	66.0%
9613	Labourers in chemical products processing and utilities	97.0%	\$ 31,254	9,785	66.0%
9614	Labourers in wood, pulp and paper processing	97.0%	\$ 33,620	19,175	66.0%
9615	Labourers in rubber and plastic products manufacturing	97.0%	\$ 29,400	9,570	66.0%
9616	Labourers in textile processing	97.0%	\$ 26,350	2,155	66.0%
9617	Labourers in food, beverage and associated products processing	97.0%	\$ 25,686	60,425	66.0%
9618	Labourers in fish and seafood processing	97.0%	\$ 12,381	6,150	66.0%
9619	Other labourers in processing, manufacturing and utilities	97.0%	\$ 22,995	61,525	66.0%



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