North Superior Workforce Planning Board

Local Employment Planning Council
Conseil local de planification en matière de l'emploi

NORTHERN POLICY INSTITUTE | INSTITUT DES POLITIQUES DU NORD

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# Are Robots Coming for Our Jobs? The Economic Impact of Automation on Northern Ontario's Economy

By Dr. Bakhtiar Moazzami

# About North Superior Workforce Planning Board , your Local Employment Planning Council

The North Superior Workforce Planning Board (NSWPB) is one of twenty-six Workforce Planning zones across Ontario, mandated through the Ministry of Advanced Education and Skills Development to identify, assess and prioritize the skills and knowledge needs of community, employers and individual participants/learners in the local labour market through a collaborative, local labour market planning process.

Our vision is to ensure that our human resource pool will be strategically aligned, competitively positioned and progressively developed to meet future social and economic demands across Northwestern Ontario. Our mission is to connect community partners to improve the quality of life in our communities through workforce development

NSWPB is the Local Employment Planning Council for the Thunder Bay area. The Local Employment Planning Council (LEPC) is one of the eight pilot project sites funded in part by the Government of Canada and the Government of Ontario. The LEPC will be working with 35 local communities to develop labour market information that is relevant to Northern stakeholders such as businesses, employers, employees and employment and training service providers. We will be working to develop and strengthen partnerships, foster integrated planning and coordinate services.

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Ontario

This project is funded in part by the Government of Canada and the Government of Ontario

# About Northern Policy Institute

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Author's calculations are based on data available at the time of publication and are therefore subject to change.

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Dr. Moazzami has taught Economics and Econometrics at Lakehead University since 1988. He is well known for his research activities particularly related to Northern Ontario.

He has written many reports on Northern Ontario's economic development challenges and opportunities. He was commissioned by the Ministry of Northern Development and Mines to undertake a comprehensive study of Northern Ontario's economy as a part of the research conducted for the Growth Plan for Northern Ontario. Included in the study were the identification of growing, declining and emerging industrial clusters in the region.

Professor Moazzami has also written extensively on Northern Ontario's Indigenous people and Northern Indigenous economy. Dr. Moazzami's expertise and influence reaches beyond Lakehead University and Northern Ontario. He has been a regular guest speaker at the University of Waterloo's Economic Development Program.

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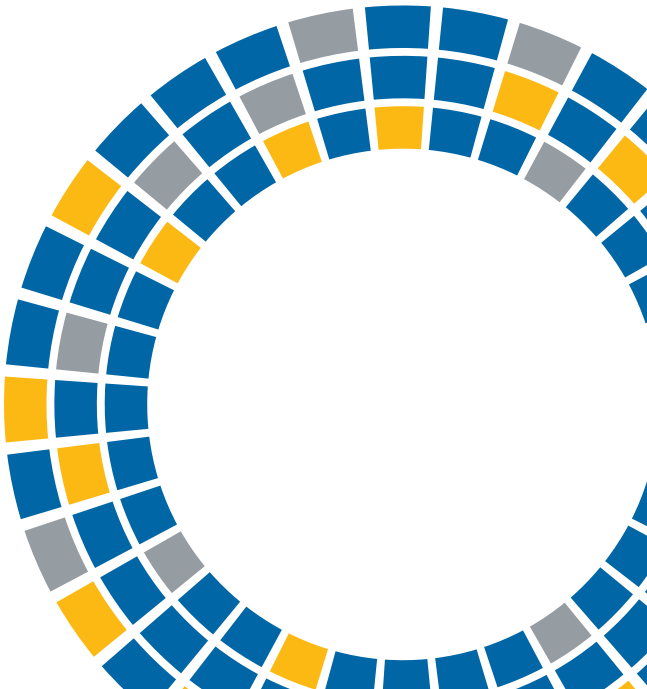


# Executive Summary:

Automation can have both positive and negative effects on economies. Some say that automation can lead to rising productivity, income, and standard of living. On the other hand, concerns include the fact that new technologies could accelerate the pace of change and bring unprecedented occupational disruption and unemployment.

This report examines the impact of automation on industries, jobs, income, income distribution, and communities in Northern Ontario. While examining employment trends in Canada, Ontario, and Northern Ontario during the past 25 years, the study finds that the automation process has not been unique to Northern Ontario. The paper also examines job polarization in industries that have traditionally been the engines of economic growth in Northern Ontario, namely logging and forestry, mining, forest-based manufacturing, health care and social services, and education services industries. To assess occupations which are most and least susceptible to automation, occupations are categorized as follows: non-routine cognitive and analytical, routine cognitive or routine manual, and non-routine manual jobs.

# Key Findings:

- Real earnings growth in Northern Ontario among men has mainly occurred among high earners. On the other hand, women fared better than men as they experienced earnings growth in all segments of income distribution;
- Few occupations are projected to be fully automated but many positions will be significantly transformed due to new technology;
- In general, the share of employment in non-routine cognitive and analytical occupations in Northern Ontario has increased while the share of routine cognitive and routine manual jobs has declined significantly;
- A major shift has happened in women's distribution of employment in Northern Ontario. The share of women working in non-routine cognitive and non-routine manual jobs has increased significantly while the opposite has happened for the share of women working in routine cognitive and routine manual jobs;
- 74.0 per cent of employment in Northeastern Ontario and 76.2 per cent in Northwestern Ontario are in sectors with relatively low potential for automation;
- Approximately 32.2 per cent and 37.2 per cent of jobs in Northeastern and Northwestern Ontario respectively are in education, health care, and public administration, which have very low potential for automation.

# Definitions:

**Skill:** An ability, whether learned or inherent, that facilitates the learning, acquisition, and application of knowledge. Certain skills require learned procedures; others are abstract. Skills that can be acquired through learned procedure are easier to automate, as human procedures can be translated into computational ones.

**Task:** The application of skill and knowledge to complete a goal. If a task requires only skills that are procedural, the task is routine. If a task requires skills that are abstract, the task is non-routine, as the procedure will vary in some abstract way in the course of completing the goal.

**Occupation:** A set of tasks that can be performed either by a human, by technology, or (in almost all cases) a combination of both. For this discussion, we classify occupations consistent with the National Occupational Classification used by Statistics Canada for labour market information. An occupation can be automated only if substantively all tasks required to perform it can be completed without a human. Automating technologies can only perform tasks that consist of skills that are sufficiently procedural as to be facilitated by computers, robots, or tools.

**Automation:** A process of substituting machines or computers for human labour. Automation can be partial or complete. Partial automation is the automation of certain tasks within an occupation. On the other hand, complete automation occurs when a new technology makes an older technology and its associated capabilities obsolete.

**Job Classification:**

Non-routine cognitive and analytical jobs:
These are jobs that involve critical thinking, creativity, problem solving, and interpersonal interaction, and are usually complemented by technology. They require a higher level of education and usually pay more than other positions available to the labour force. Examples of these occupations include managerial, professional, and technical professions in the applied sciences. These jobs are less susceptible to automation.

Routine cognitive or routine manual jobs:
These jobs consist primarily of routine and repetitive tasks, like accounting or data entry. These jobs can be easily performed by machines programmed to follow certain routines. They are generally middle wage and require a lower level of interpersonal interaction. They can be further classified into two groups: routine manual and routine cognitive jobs. Examples of routine manual jobs include assembly line manufacturing, transportation, and equipment operations. Examples of routine cognitive jobs include accounting, bookkeeping, clerical, and some sales roles.

Non-routine manual jobs:
These jobs involve manual and interactive work in an unstructured environment. In general, they require lower levels of education and higher levels of interpersonal skills. They include both low-paying jobs, such as food and beverage servers, and high-paying jobs, such as plumbers and electricians. These jobs are less susceptible to automation.

# Part I. Introduction and Summary

Global competition, changing consumer demand, and rapid technological change force firms to incorporate automation in order to maintain their competitiveness. Automation is the process of substituting human labour with machines and computers. It typically results in increased productivity and competitiveness and its impact on employment, income, and income distribution can be profound. It changes the nature of work and demand for skills, and it benefits some workers while putting others at risk. It leads to occupational change and labour substitution, and often contributes to income inequality.[1] A recent report by the International Monetary Fund (IMF) shows that automation accounts for approximately half of the overall decline in the labour share of income across advanced economies.[2] The occupational and geographical impacts of automation on jobs vary from community to community. There are industries and occupations that are more impacted because of the nature of the tasks performed and others that are more difficult to automate. In general, technology both creates and destroys work. This is the process an Austrian economist, Joseph Schumpeter, referred to as a "gale of creative destruction." However, the dilemma many smaller communities face is the fact that new jobs created by technology may be more centralized in major metropolitan areas. As robots and other computer-assisted technologies take over tasks previously performed by labour, there is increasing concern about the future of jobs and wages.[3]

The objective of this report is to examine the impact of automation on industries, jobs, income, income distribution, and communities in Northern Ontario. For this, we use detailed data between 1991 and 2016 from Statistics Canada.

We examine occupational and employment trends in Canada, Ontario, Northwestern Ontario, and Northeastern Ontario during the past 25 years. In doing so, the provincial and national economic data make it clear that the automation process has not been unique to Northern Ontario. We examine the distribution of risks and benefits for different people and communities in Northern Ontario. We also investigate the impact on employment, employment income, and income distribution in the region.

The report is organized into eight parts. Part II reviews some of the relevant literature on the impact of technology and automation on jobs and income. In general, the existing research and perspectives on the impact of technological change and automation are polarized. Research suggests that very few occupations will be fully automated in the near or medium term. On the other hand, many will undergo significant transformation as a result of new technologies. Part II also reviews various estimates of the share of jobs and occupations that are likely to be automated in Europe, the United States, Canada, and Ontario, as well as the implication of automation on the government's fiscal position and ability to maintain its social supports.

Part III examines employment trends in Canada, Ontario, and Northern Ontario between 1986 and 2016. This part shows that the distribution of employment has shifted from goods-producing industries that were traditionally the base sectors of Northern Ontario's economy to service-producing industries. The industries that experienced growth in all regions under study are professional, scientific and technical services, health care and social assistance, education, and foodservices. Part III argues that health care and education services are financed from outside the region and therefore act like export industries. Similarly, professional services, scientific and technical services, and foodservices often rely on external demand and in that capacity act similar to the base industries. The growth of these quasi-base sectors has, to a large extent, compensated for the decline of the goods-producing sectors.

[1] Krugman, Paul. 2013. "Sympathy for the Luddites." The New York Times, June 14.

[2] Dao, M.C., M. Das, Z. Koczan, and W. Lian. 2017. "Why Is Labour Receiving a Smaller Share of Global Income? Theory and Empirical Evidence." IMF Working Paper 17, 169, July 24, P. 11.

[3] Substitution of jobs by robots also raises concern about government's ability to collect taxes.

Part IV examines occupational trends in Canada, Ontario, and Northern Ontario. In order to examine the impact of technology on jobs and occupations, part IV classifies various occupations into three categories based on the composition of tasks involved: non-routine cognitive and analytical, routine cognitive or routine manual, and non-routine manual jobs. Based on the above classification, part IV finds that the distribution of employment by occupation has changed in all regions. In general, the share of employment in non-routine cognitive and analytical occupations has increased while the share of routine cognitive and routine manual jobs has declined significantly. We also find that a major shift has happened in women's distribution of employment. The share of women working in non-routine cognitive and non-routine manual jobs has increased significantly while the opposite has happened in the share of women working in routine cognitive and routine manual jobs. This part also examines return to education as a proxy for skills and finds that the earnings premium for people with a high school diploma declined over time due to automation of many of the jobs that require such a diploma.

Part V examines job and wage polarization and income inequality in Canada, Ontario, and Northern Ontario. This part investigates the implications of the shift away from routine jobs that were traditionally middle-income jobs to non-routine cognitive jobs for income distribution in various regions. Research on the United States' labour market suggests that middle-income jobs have declined relative to both low- and high-wage jobs. Part V examines whether the same trend has happened in various Canadian regions. Focusing on the 10th, 50th, and 90th percentiles of wage distribution, part V finds that the real earnings growth among men has mainly occurred among high earners. On the other hand, women fared better than men as they experienced earnings growth in all segments of income distribution.

Part VI examines the impact of automation on Northern Ontario's base and quasi-base industries. This part also examines job polarization in industries that have traditionally been the engines of economic growth in Northern Ontario, namely logging and forestry, mining, forest-based manufacturing, health care and social services, and education services industries. We find that the substitution of routine tasks by machines has been happening steadily in the logging and forestry sector. The advent of skidders, mechanical harvesting, and remote chipping has modernized bush operations. GIS, telemetry, and satellite imagery have also optimized harvest planning and access development. Remote sensing of harvesters can grade, sort, and scale product in one operation. These technologies have led to a significant reduction in employment in the logging and forestry industry.

Most of the labour-saving technology in the mining industries relates to the underground and delivery phases of production. Mines have progressed to electric-driven underground vehicles remotely controlled. Thus, the operators can be in a major urban setting without living at the mine site. We also find that the shift from routine tasks to non-routine cognitive tasks has been accompanied by the rising employment of women in Northern Ontario's mining sector.

Wood and pulp and paper industries have traditionally been the main vehicle of economic development in Northern Ontario. Globalization, shifting demand, and automation have impacted these industries significantly. Employment in forest-based manufacturing sectors declined significantly between 1991 and 2016. Most job losses happened in the routine job categories.

Health care and social services has been a growing sector of Northern Ontario's economy. An aging population has increased demand for health-care services. Employment in health care and social services in Northern Ontario has risen significantly between 1991 and 2016. Most employees are women. Most employment growth has happened in the non-routine cognitive categories.

Similar to the health care sector, the education services industries have been an important component of the economic base of many northern communities. However, aging population and declining enrolment have impacted the growth of these industries. We find that approximately 90.0 per cent of employment in the education services sector is in non-routine task categories and thus is not susceptible to automation.

Part VII investigates how vulnerable Northern Ontario is to automation. In order to estimate the percentage of jobs that are potentially at risk of automation, we classify employment into low- and high-risk categories depending on the share of tasks that can or cannot potentially be automated. We find that 74.0 per cent of employment in Northeastern Ontario and 76.2 per cent in Northwestern Ontario are in sectors with relatively low potential for automation. More important, approximately 32.2 per cent and 37.2 per cent of jobs in Northeastern and Northwestern Ontario respectively are in education, health care, and public administration, which have very low potential for automation.

Part VIII looks at the future, which inevitably involves technological change and loss of occupations involving routine tasks as well as the creation of other occupations that tend to require highly skilled workers who are more difficult to replace with robots. The challenge is to ensure that our workforce is trained for the future working environment.

# Part II: Evidence of the Impact of Automation on Jobs

## 2.1 National and International Studies

Although automation is not new, the concern is that new technologies will accelerate the pace of change and bring unprecedented occupational disruption and unemployment. The existing research and perspectives on the impact of technological change and automation tend to be polarized. Some say automation would lead to rising productivity, income, and standard of living; others view it as disruptive, leading to unemployment and joblessness. Even those who believe automation would negatively impact jobs vary substantially in their estimates depending on whether they follow an occupation-based approach or task-based approach.

Technological progress has been a constant feature of economic growth as entrepreneurs have endeavoured to enhance productivity and income. Many researchers, using the experiences of past periods of industrial change, argue that automation and innovation are desirable as they contribute to increased productivity and higher incomes through economic growth.[4] They state that with technology, production requires fewer workers, who can then be employed elsewhere in the economy, resulting in the total level of production and employment to increase.[5] However, this conventional view might not hold in the age of globalization when work can be offshored. Moreover, taking a macro view of the impact of automation on jobs masks the potential geographical redistribution of jobs and work.

Taking the conventional view, Autor and Solomon argue that automation replaces workers who perform certain job tasks but complements other workers, improves productivity, and ultimately creates jobs. Increased productivity results in rising income and consumption that ultimately increases employment.[6] A recent study by C.D. Howe Institute examined changes in robot use in manufacturing industries in several industrialized countries from 1993 to 2007. It finds that the increased use of robots had no significant impact on employment in advanced economies.[7] Graetz and Michael examined the economic impact of industrial robots on employment in 17 countries from 1993 to 2007. They found that increased robot use raised the countries' average growth rates by approximately 0.37 percentage points. They also found that the use of robots increased both wages and total factor productivity. Although robots had no significant effect on total hours worked, there was some evidence that they reduced the hours of both low-skilled and middle-skilled workers.[8]

A recent U.S. study examined the effect of the increase in industrial robot usage between 1990 and 2007 on U.S. local labour markets. Using a model in which robots compete against human labour in the performance of different tasks, the study finds that there are large and robust negative effects of robots on employment and wages. It estimates that one more robot per one thousand workers reduces the employment to population ratio by approximately 0.18 to 0.34 percentage points and wages by 0.25 per cent to 0.5 per cent. This translates to between 360,000 and 670,000 lost jobs due to robots. These impacts were primarily evident for routine manual workers in manufacturing (assembly and related occupations), and for workers with less than a college education.[9]

[4] Miller, Ben, and Robert D. Atkinson. 2013. "Are Robots Taking Our Jobs, or Making Them?" Washington, DC: Information Technology and Innovation Foundation.

[5] Autor, David H. 2015. "Why are there still so many jobs? The history and future of workplace automation." Journal of Economic Perspectives 29, No. 3: 3-30.

[6] Autor, David, and Anna Solomons. 2018. "Is automation labour-displacing? Productivity growth, employment, and the labour share." Brookings Papers on Economic Activity, BPEA Conference Drafts, March 9-9.

[7] Oschinski, Matthias, and Rosalie Wyonch. 2017. "Future Shock? The Impact of Automation on Canada's Labour Market." C.D. Howe Institute, Commentary No. 472.

[8] Graetz, George, and Guy Michaels. 2015. "Robots at Work." Centre for Economic Performance, CEP Discussion Paper No. 1335: 1.

[9] Acemoglu, Daron, and Pascual Restrepo. 2017. "Robots and Jobs: Evidence from US Labor Markets." NBER Working Paper No. 23285.

Duernecker examined the impact of technology adoption in the Organization for Economic Co-operation and Development (OECD) countries during the 1970s. He finds that the unemployment rate rose in Europe while it remained constant in the United States. He argues that, in general, the impact of automation on unemployment is small in countries with high technology adoption rates but large in those with low technology adoption rates. He concludes that the impact of automation on the unemployment rate depends on whether employees have already acquired the skills required to work with the new technology.[10]

An important branch of the research on automation focuses on how susceptible jobs, tasks, or occupations are to computerization. Several studies have attempted to estimate the likelihood of automation and labour substitution of various tasks and occupations. For example, Frey and Osborne estimated 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 these occupations to correspond to the 702 U.S Standard Occupation Classification (SOC) codes. The primary objective was to estimate the number of jobs at risk and the relationship between an occupation's probability of computerization and its wages and educational attainment. According to their estimates, approximately 47 per cent of total U.S. employment is at risk. They also found evidence that wages and educational attainment exhibit a strong negative relationship with an occupation's probability of computerization.[11]

A 2015 study by McKinsey & Company analyzed automation from a task perspective rather than an occupation perspective. The study argues that very few occupations will be fully automated in the near or medium term. On the other hand, many will undergo significant transformation as a result of new technologies. The study examined the percentage of work activities that could be automated using existing technologies. It analyzed 2,000 detailed work activities for 800 U.S. occupations. It then assessed these activities against 18 identified capabilities that it determined could be automated. The study found that 45 per cent of work activities that people are paid for in the U.S. could be automated today using existing technology. However, it also found that fewer than five per cent of occupations can be entirely automated.[12]

A recent study by Brookfield Institute finds that, "nearly 42 percent of the Canadian labour force is at a high risk (70 percent or higher probability) of being affected by automation in the next decade or two."[13] The study finds that occupations with the highest risk of being affected tend to be more routine, administrative, and service oriented. The study suggests that approximately 42 per cent of work activities that Canadians are paid for can be automated using existing technologies.[14] It further suggests that technology has the potential to result in major occupational restructuring relatively soon. The study also estimates the impact of automation on various occupations in Canada, identifying the following as the top five high-risk occupations:

1. Retail salespersons: 92 per cent probability of automation; more than 656,000 employees.
2. Administrative assistants: 96 per cent probability of automation; nearly 329,000 employees.
3. Food counter attendants and kitchen staff and kitchen helpers: 91.5 per cent probability of automation; nearly 313,000 employees.
4. Cashiers: 97 per cent probability of automation; 309,000 employees.
5. Transport truck drivers: 79 per cent probability of automation; nearly 262,000 employees.

Similarly, the bottom five low-risk occupations are:

1. Retail and wholesale trade managers: 20.5 per cent probability of automation; more than 363,000 employees.
2. Registered nurses (psychiatric included): 0.9 per cent probability of automation; more than 291,000 employees.
3. Elementary and kindergarten teachers: 0.4 per cent probability of automation; more than 271,000 employees.
4. Early childhood educators and assistants: 0.7 per cent probability of automation; nearly 188,000 employees.
5. Secondary school teachers: 0.8 per cent probability of automation; nearly 174,000 employees.

[10] Duernecker, George. 2014. "Technology Adoption, Turbulence, and the Dynamics of Unemployment." Journal of the European Economic Association 12, No. 3, Pages 724-754.

[11] Frey, Carl Benedikt, and Michael A. Osborne. 2013. "The Future of Employment: How Susceptible Are Jobs to Computerization?" University of Oxford

[12] Chui, M., J. Manyika, and M. Miremadi. 2015. "Four Fundamentals of Workplace Automation." McKinsey & Company.

[13] Lamb, Creig. 2016. "The Talented Mr. Robot: The Impact of Automation on Canada's Workforce." Brookfield Institute for Innovation and Entrepreneurship. P. 3.

[14] Ibid, p. 5.

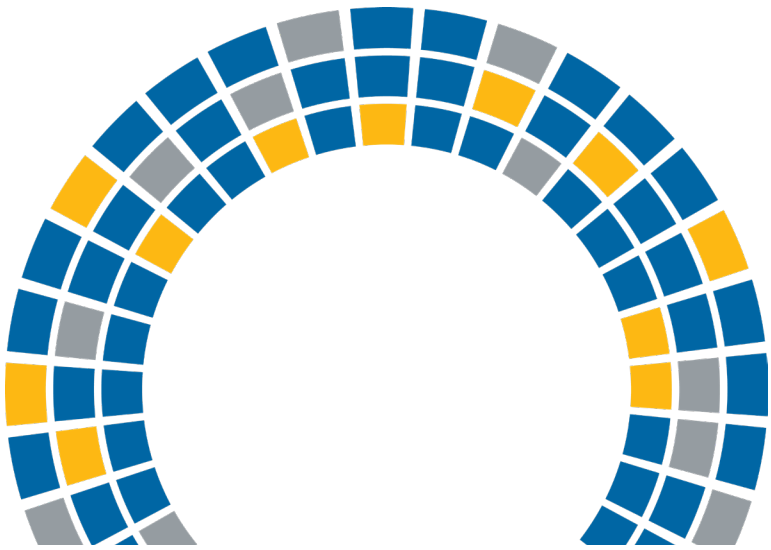
The study notes that although automation appears to primarily impact occupations that involve mostly routine tasks, it can also happen in those involving non-routine tasks in the future. The research by Brookfield Institute applied Frey and Osborne and McKinsey & Company methodologies to the Canadian data. Results are summarized in Table 2.1.

**Table 2.1: Impact of Automation on Various Occupations**

| Job | Transport Truck Drivers | Retail Sales-persons | Senior Managers | Specialist Physicians |
|---|---|---|---|---|
| Probability of automation in the next 10 to 20 years (Frey & Osborne) | 79% | 92% | 9% | 0.40% |
| Probability of tasks that can be automated (McKinsey & Company) | 60% | 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% |

The Brookfield Institute study focuses on specific occupations to illustrate the impact of automation. Table 2.1 shows that truck drivers and retail salespersons both have a high probability of being affected by automation over the next 10 to 20 years. It also shows that a large percentage of tasks for which individuals in these occupations are currently paid 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 render many tasks associated with these occupations obsolete.[15]

On the other hand, senior managers and specialist physicians are at a low risk of having their occupations affected by automation in the future even though a large portion of what they do can be automated using current technology. In general, people in these low-risk occupations are more educated and earn more than those in other occupations.



[15] Lamb, Creig. 2016. "The Talented Mr. Robot: The Impact of Automation on Canada's Workforce." Brookfield Institute for Innovation and Entrepreneurship. P 18.

## 2.2 Studies Focused on Ontario Labour Market

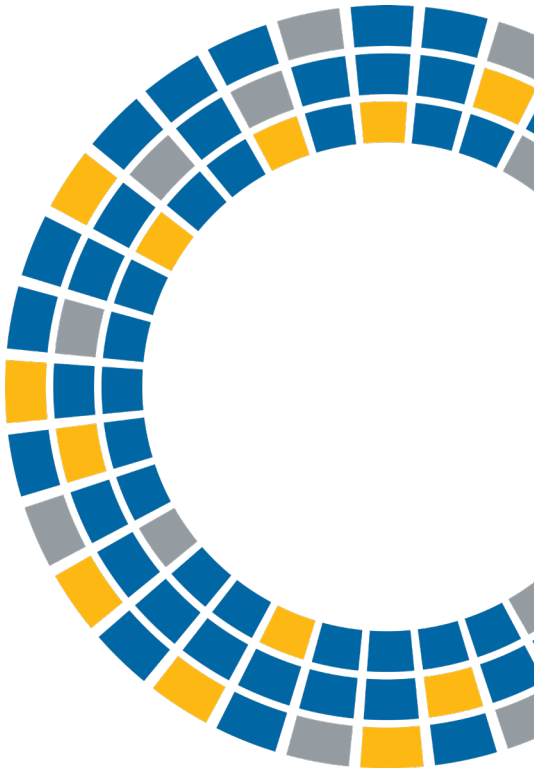
A recent study by the Institute for Competitiveness and Prosperity examined the impact of automation on Ontario's labour market and the role of employers in the skills training ecosystem.[16] Following the existing research in this area, they classify jobs tasks into three categories:

1. Non-routine cognitive and analytical: These are jobs that require a higher level of education and often pay more than other occupations. They are primarily comprised of tasks that involve critical thinking, creativity, problem solving, and interpersonal interaction. Jobs in this category are usually complemented by technology that helps improve worker productivity. These professions typically require interpersonal interaction. Examples of these occupations are managers and professional and technical occupations in the applied sciences.

2. Routine cognitive or routine manual: These jobs consist mostly of routine tasks, such as accounting or data entry, where the outputs are repetitive. These tasks can be followed by explicit, programmed rules. They are typically middle wage and require a lower level of interpersonal interaction. In these jobs, technology can easily substitute for labour, since routine tasks are easily codifiable (i.e., computerized). These jobs are broken down into two categories: routine manual and routine cognitive. Examples of occupations that are routine manual include assembly line manufacturing, transportation, and equipment operators. Routine cognitive ones include accounting, bookkeeping, clerical, and some sales roles.

3. Non-routine manual: These jobs involve manual and interactive work in an unstructured environment. These jobs are less complemented or substituted by technology. They generally require lower levels of education and higher levels of interpersonal skills. There is a wide range of wages within these jobs. For example, plumbers often make a high wage, while food and beverage servers earn a much lower one. Examples of these occupations include child-care workers, cleaners, security, foodservice, home health care professionals, personal care workers, chefs, and cooks.

The study finds that the number of jobs that consist mainly of routine cognitive and routine manual tasks have declined between 2001 and 2015 while those that consist mainly of non-routine cognitive and non-routine manual tasks have experienced growth during the same period. The same trend was observed for wages. Median hourly real wages in routine cognitive occupations declined by five per cent and have experienced a strong downward trajectory since 2012. On the other hand, median wages for non-routine manual occupations increased by eight per cent, partly related to rising minimum wages during the above period. This rising job and wage polarization is related to the claims regarding the disappearing middle-income groups and the middle class. The study examines the future trends in Ontario's labour market. It estimates that during the next 10 to 20 years, 38 per cent of jobs in Ontario have a low probability (0 to 29 per cent) of automation, 20.6 per cent have a medium probability (30 per cent to 69 per cent) of automation and 41.1 per cent are at high risk (70 per cent to 100 per cent) of automation. Table 2.2 shows the top 10 occupations at risk of automation in Ontario.



[16] Institute for Competitiveness and Prosperity. 2017. "The Labour Market Shift: Training a highly skilled and resilient workforce in Ontario." Working Paper 29.

[17] Ibid, page 15.

**Table 2.2: Top 10 Occupations Most at Risk of Automation in Ontario in 2011**

| Occupations | Probability of Automation (%) | Proportion of Occupations with a University Degree (%) | Median Employment Income ($) | Number of Workers in 2011 |
|---|---|---|---|---|
| Retail salespersons | 92 | 14 | 13,400 | 251,000 |
| Food counter attendants, kitchen helpers, & related occupations | 92 | 7 | 8,300 | 124,400 |
| Cashiers | 97 | 8 | 8,600 | 111,300 |
| Administrative assistants | 96 | 18 | 34,600 | 104,900 |
| Administrative officers | 96 | 29 | 41,700 | 93,700 |
| Transport truck drivers | 79 | 6 | 38,700 | 92,000 |
| General office support workers | 96 | 18 | 30,000 | 87,300 |
| Financial auditors & accountants | 94 | 67 | 58,400 | 78,800 |
| Material handlers | 85 | 7 | 29,400 | 65,900 |
| Cooks | 83 | 6 | 13,700 | 59,200 |

Source: Institute for Competitiveness and Prosperity. 2017. "The Labour Market Shift: Training a highly skilled and resilient workforce in Ontario." Working Paper 29: 17.

The Brookfield Institute for Innovation and Entrepreneurship examined the impact of technological change on Ontario's workforce.[18] In general, the impact of automation on Ontario's workforce depends on whether firms invest in automation technologies. The study finds that, "between 2008 and 2014, the gap between Canadian and US ICT investment grew from 31.6 percent to 43.7 percent. While the gap between Ontario and the United States is not quite as large, it is substantial and has grown in recent years. In 2015, Ontario firms' annual ICT investment was 2.39 percent as a share of GDP versus 3.15 percent for the United States and 2.16 percent for Canada as a whole. Only a portion of this gap is the result of industrial mix and lower income per capita; the vast majority can be explained by industry-specific differences in ICT investment."[19] Based on the above information, the report suggests that large-scale disruption caused by automation may not yet be around the corner for Ontario. The Brookfield Institute found that employment growth in Ontario from 1987 to 2017 has occurred in non-routine jobs. More specifically, from 1987 to 2017, management, professional, and scientific occupations grew by 95 per cent, adding 1,437,800 jobs. Sales and service occupations – that are typically non-routine manual occupations – grew by 58 per cent. During the same period, Ontario has experienced no growth in middle-earning, routine occupations where automation can substitute workers.[20] The Brookfield Institute also examined whether Ontario regions, firms, and workers face a potential future of disruptive automation. Using McKinsey & Company's task-based methodology, it estimates the proportion of jobs in high-risk industries in various Ontario regions (Table 2.3) as follows:

**Table 2.3: Proportion of Jobs in High-risk Industries in Ontario Regions**

| Region | Percentage of Jobs at Risk (%) |
|---|---|
| Eastern | 36.5 |
| Central | 37.4 |
| GTA | 33.3 |
| Southwestern | 40.3 |
| Northern | 38.0 |

In general, the Brookfield Institute finds that census metropolitan areas and census agglomerations that are most susceptible to automation are small manufacturing cities. It argues that the cities least susceptible to automation are those with a high proportion of employment in health care and education services.[21]

Additional research on the impact of automation on workers in Ontario was undertaken by researchers at the University of Toronto's Mowat Centre in 2018.[22] Rather than focusing on the impact of automation on employment, they focus on the implication of technological change for governments. How would changes in the nature of work affect the tax base and the governments' ability to maintain social supports? They argue that, "Ontario and many other jurisdictions could face a fiscal squeeze as traditional approaches to taxation and revenue generation — based primarily on residency — lose relevance in a borderless world of digital transactions, virtual work and AI."[23] They further contend that without taking appropriate actions, Ontario could find itself facing plunging tax revenues at the very moment that an aging population consigns it to a slow-growth trajectory and technological change results in unprecedented claims being made on its social safety net.[24] Comparing real wages for different occupations, they show that management and professional occupations have experienced significant wage growth while lower-skilled workers saw their wages grow much more slowly, if at all. In other words, they highlight rising income inequality as a direct consequence of automation. Based on the Ministry of Finance data, they state that, "The number of Ontarians with incomes below the low-income measure (LIM) has continued to increase over the years – from 5.9 per cent in 1996 to 9.0 per cent (or 644,000 people) in 2014."[25]

[18] Brookfield Institute for Innovation and Entrepreneurship. 2018. "The Impact of Technological Change on Ontario's Economy." Draft report.

[19] Ibid, page 25. ICT investment is defined as the acquisition of equipment and computer software that is used to enhance productivity. It has three components: information technology equipment (computers and related hardware); communications equipment; and software.

[20] Ibid, page 27.

[21] Ibid, page 30

[22] Johal, S., J. Thirgood, M. C. Urban, K. Alwani, and M. Dubrovinsky. 2018. "Robots, Revenues & Responses: Ontario and the Future of Work." Mowat Centre. Research No. 167.

[23] Ibid, Page 1.

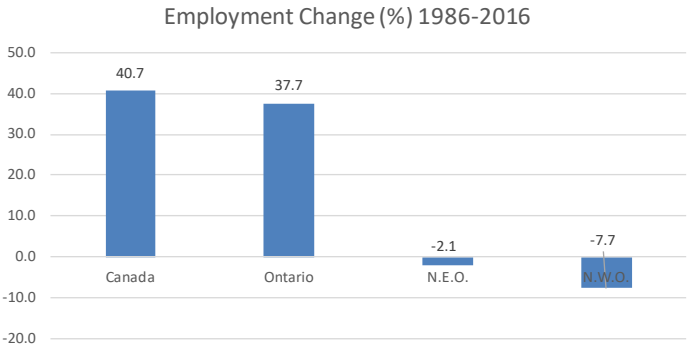
[24] Ibid, p. 1.

[25] Ibid, p. 7.

# Part III: Employment Trends in Canada, Ontario, and Northern Ontario

The Canadian economy has experienced significant employment growth during the past three decades. Total employment in Canada and Ontario grew from 11,702,220 and 4,585,150 respectively in 1986 to 16,467,425 and 6,311,590 respectively in 2016. This represents a growth rate of approximately 40.7 per cent and 37.7 per cent respectively during that period (Figure 3.1). On the other hand, total employment in Northeastern and Northwestern Ontario declined from 236,350 and 106,255 respectively in 1986 to 231,305 and 98,070 respectively in 2016. This represents a decline of approximately 2.1 per cent and 7.7 per cent respectively during that period. The aggregate employment figures do not reveal major industrial and occupational changes that have been happening at the national, provincial, and regional levels.

**Figure 3.1: Percentage Change in Employment During the Past Three Decades**




Source: Author's calculations based on Statistics Canada's various censuses.

Examination of the data reveals that total national and provincial employment in the goods-producing industries that include agriculture, forestry, mining, manufacturing, construction, and utilities declined from 3,573,055 and 1,502,640 respectively in 1986 to 3,338,450 and 1,210,285 respectively in 2016. This represents a decline of approximately 6.6 per cent for Canada and 19.5 per cent for Ontario during that period. Northeastern and Northwestern Ontario's goods-producing sectors experienced much greater declines during that time: 32.6 per cent and 42.2 per cent respectively.[26] The major reason for the greater employment decline in Northern Ontario is that forestry and forest-based manufacturing industries comprised approximately 26.6 per cent and 58.1 per cent respectively of the total employment of the goods-producing sector in Northeastern and Northwestern Ontario in 1986. Employment in these industries declined by 62.6 per cent in Northeastern Ontario and 74.3 per cent in Northwestern Ontario between 1986 and 2016 (Figure 3.2). The only goods-producing industries that experienced significant employment growth were construction and support activities for mining industries. Construction industry employment rose by 79.8 per cent in Canada, 64.6 per cent in Ontario, 32.9 per cent in Northeastern Ontario, and 37.1 per cent in Northwestern Ontario. Employment in the support services for mining and oil and gas rose by 174.1 per cent in Canada, 145.6 per cent in Ontario, 115.0 per cent in Northeastern Ontario, and 58.7 per cent in Northwestern Ontario. Total mining employment in Northeastern Ontario declined from 17,180 in 1986 to 10,360 in 2006 but rose to 14,260 in 2016. Total employment in the mining sector of Northwestern Ontario has been cyclical, rising from 2,750 in 1986 to 2,990 in 1996, declining to 2,500 in 2006, and rising to 3,020 in 2016. In general, the goods-producing industries have been the economic base sectors of Northern Ontario's economy. Their decline impacts total regional employment in the intermediate and long-term unless other base or quasi-base sectors fill the gap. This appears to have happened in the quasi-base sectors of education and health and social services in Northern Ontario. As we will discuss in this report, employment growth has happened in the occupations that involve either non-routine cognitive or non-routine manual tasks in almost all sectors including health care and education. These occupations are less susceptible to automation.

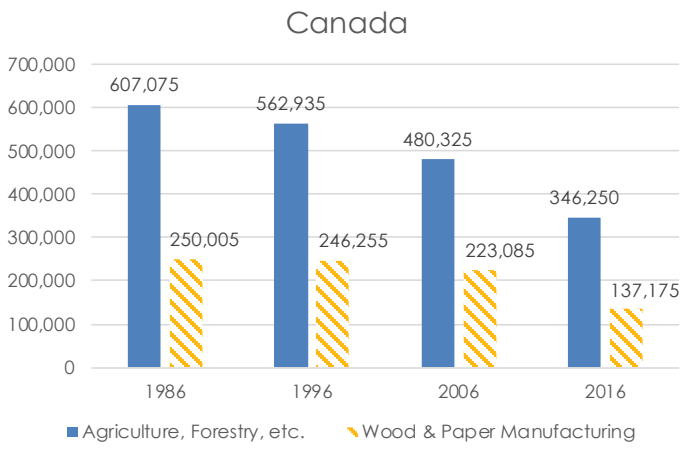
Declining employment in the goods-producing industries has resulted in a decline in their share of total employment in various regions (Figure 3.3). Figure 3.3 shows that the share of employment in the goods-producing industries declined nationally, provincially, and regionally from 1986 to 2016. During the same period, total employment in the service-producing industries grew by 61.5 per cent in Canada, 65.5 per cent in Ontario, 12.5 per cent in Northeastern Ontario, and 7.2 per cent in Northwestern Ontario (Figure 3.4). The industries that experienced growth in all regions under study are professional, scientific and technical services, health care and social assistance, education, and foodservices (Figure 3.5). These are industries that are often referred to as the quasi-base sectors. For example, Northern Ontario's health and education services are financed from outside the region and therefore act like export industries. Similarly, professional services,

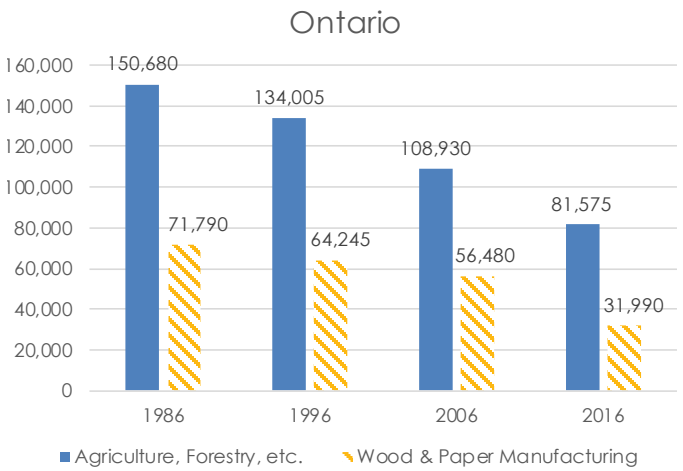
[26] *Total employment in the goods-producing industries in Northeastern and Northwestern Ontario declined from 76,560 and 32,085 respectively in 1986 to 51,600 and 18,540 respectively in 2016.*

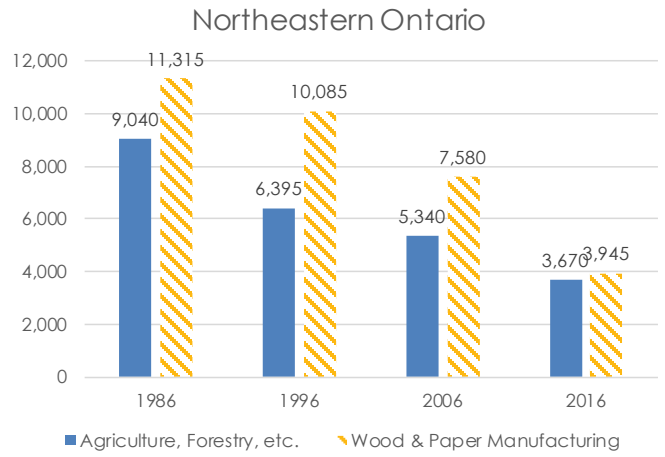
scientific and technical services, and foodservices often rely on external demand and, in that capacity, act like base industries. The only sector within the service-producing industries that experienced decline in all regions under study is the accommodation sector (Figure 3.5). Other sectors such as wholesale trade, retail trade, transportation and warehousing, and public administration experienced employment growth in Canada and Ontario but declined in Northern Ontario.

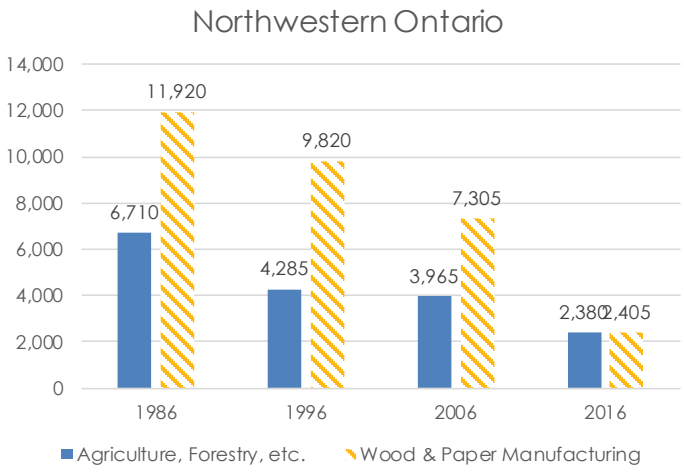
Changes in the industrial distribution of jobs reflect what is commonly referred to as job polarization. Polarization means that the labour market has experienced a shift away from its typically medium-skilled occupations that require routine tasks to be performed. The next part of the study examines job polarization. For this, we must analyze occupational trends in various regions.

**Figure 3.2: Employment Trends in Selected Goods-Producing Industries**



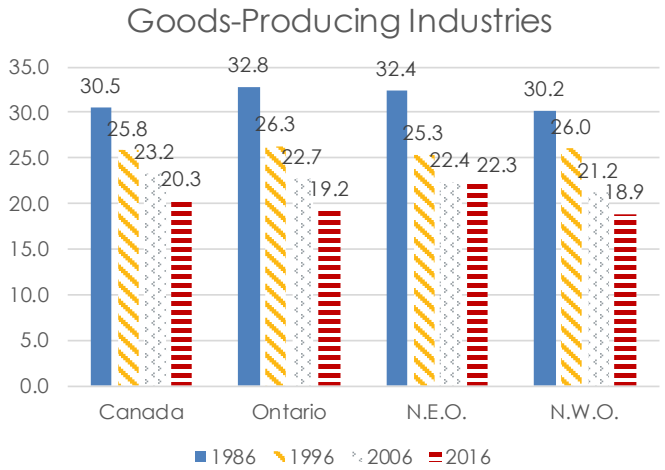




Source: Author's calculations based on Statistics Canada's various censuses.

**Figure 3.3: Percentage Share of Employment in Goods-Producing Industries**




Source: Author's calculations based on Statistics Canada's various censuses.

**Figure 3.4: Employment Trends in Service-Producing Industries**

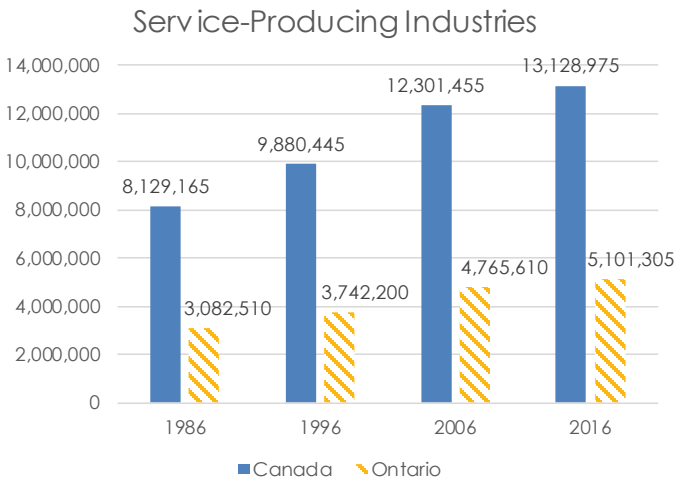
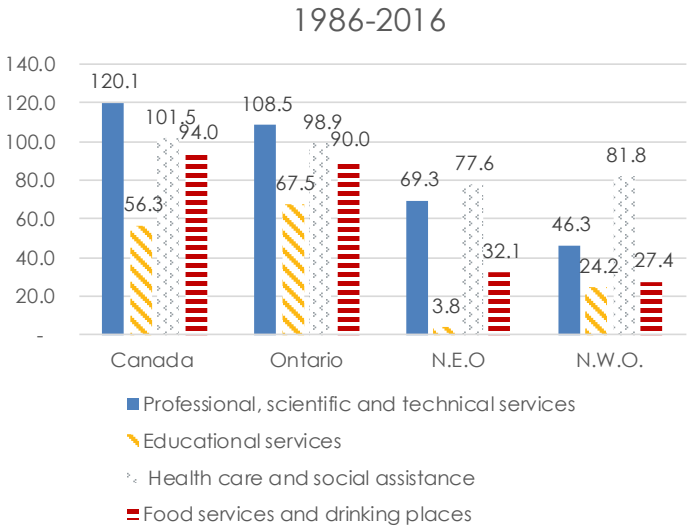
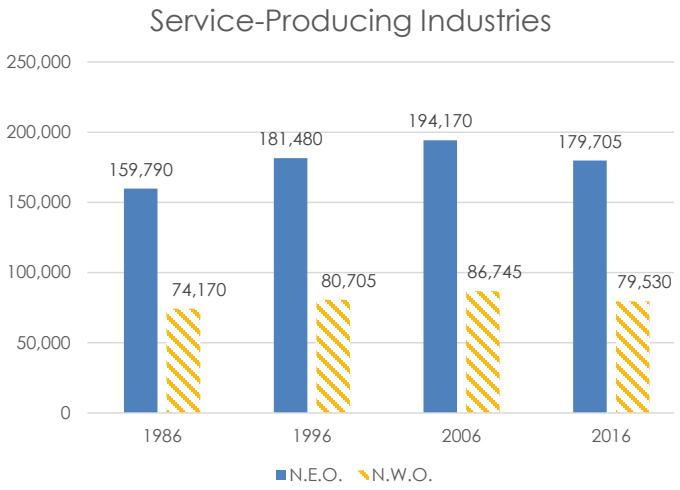
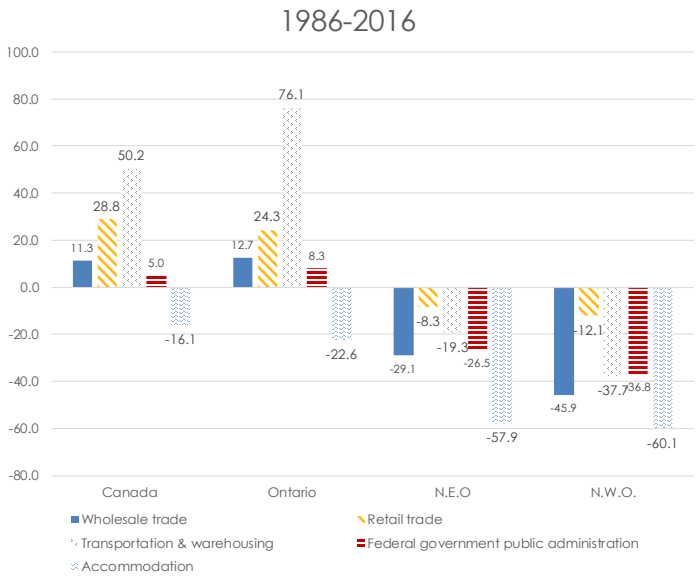



**Figure 3.5: Growing and Declining Service-Producing Industries**




Source: Author's calculations based on Statistics Canada's various censuses.




Source: Author's calculations based on Statistics Canada's various censuses

# Part IV: Occupational Trends in Canada, Ontario, and Northern Ontario

Technological advancements impact the composition of jobs by shifting demand for occupations that can be automated to those that are less susceptible to automation. Changing composition of the labour force, in turn, impacts wages, income distribution, and sectoral distribution of the workforce. As we saw above, during the past three decades, sectoral composition of the employed workforce shifted from goods-producing industries to service-producing sectors. In addition to influencing the sectoral composition of the employed workforce, automation also impacts jobs and occupations within each sector. Jobs requiring routine tasks can be automated while those requiring non-routine tasks are less susceptible to automation. Job polarization reflects the labour market experience of hollowing out its typically medium-skilled, routine cognitive and routine manual occupations that are often identified as the middle-class occupations. As demand for non-routine tasks rises, wages and earnings of those employed in those occupations increase as well. Therefore, job polarization is often accompanied by wage polarization.

Researching task types within different occupations produced insights into the changing labour market as some tasks are easier to automate than others. In general, to quantify the impact of automation on jobs, we first need to distinguish between occupations consisting of predominantly routine tasks that are codifiable and thus more susceptible to automation and those that involve non-routine tasks, complex problem solving, and interpersonal interactions that are more difficult to automate. Occupations that consist of mostly non-routine, manual labour, such as personal care, generally require lower qualifications, involve interpersonal interaction, and are more difficult to automate. Jobs that consist mostly of routine tasks, like business administration, are generally middle wage and require more education than non-routine manual jobs, but little interpersonal interaction.

To examine the impact of technology on jobs, we need to classify various occupations based on the composition of tasks involved in them. For this, we follow earlier research in this field and classify jobs into three categories, namely non-routine cognitive and analytical jobs, routine cognitive or routine manual jobs, and non-routine manual jobs.[25] Appendix I shows task breakdown by National Occupational Classification (NOC).

Using the classification detailed in Appendix I, Figures 4.1 and 4.2 apply the above classification to labour markets in Canada and Ontario.[28] Total employment in Canada rose from 12.7 million in 1991 to 16.5 million in 2016—a growth rate of approximately 30.0 per cent. This amounts to a growth rate of approximately 1.2 per cent per year during that period. Employment in non-routine cognitive and analytical jobs rose from 4.4 million in 1991 to 7.5 million in 2016—a growth rate of approximately 70.8 per cent, or 2.8 per cent per year. Employment in routine cognitive and routine manual jobs rose from 5.8 million in 1991 to 6.6 million in 2016—a growth rate of approximately 12.4 per cent, or 0.5 per cent per year. Finally, employment in non-routine manual jobs rose from 2.5 million in 1991 to 3.4 million in 2016—a growth rate of approximately 34.0 per cent, or 1.4 per cent per year. Examination of the data shows that employment in non-routine cognitive and analytical jobs and non-routine manual jobs has outpaced job growth in routine occupations in Canada. It appears that employment shares have shifted in the workforce from routine to non-routine occupations.

As a result, the distribution of employment by occupation has changed in Canada. The share of employment in non-routine cognitive and analytical occupations has increased from 34.2 per cent in 1991 to 42.8 per cent in 2016. On the other hand, the share of routine cognitive and routine manual jobs has declined from 45.8 per cent in 1991 to 37.6 per cent in 2016. The non-routine manual jobs have maintained their relative share at approximately 20 per cent. The shift in the distribution of employment among men has been less pronounced than women. Approximately 35.4 per cent of employed men were in non-routine cognitive and analytical jobs in 1991. This share has risen slightly to 38.5 per cent in 2016. On the other hand, 45.3 per cent of men were employed in routine cognitive and routine manual jobs in 1991. That share has declined slightly to 41.6 per cent in 2016. The employment share of men in non-routine manual employment has stayed relatively unchanged at approximately 20 per cent.

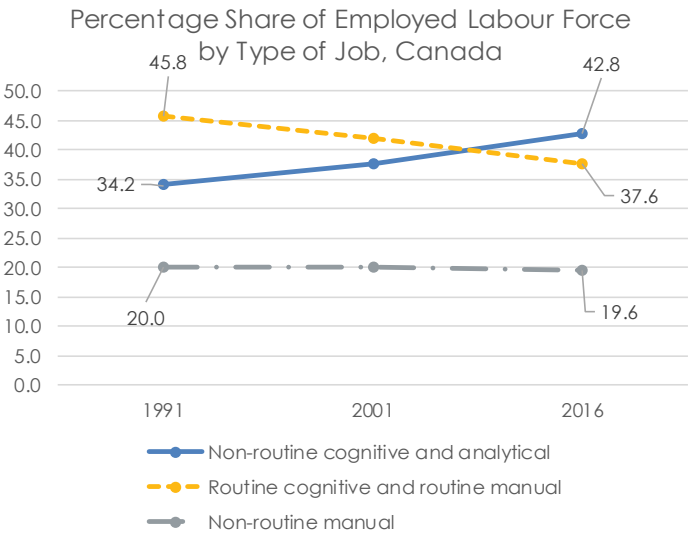
A major shift has happened in the women's distribution of employment. The share of women working in non-routine cognitive and non-routine manual jobs has increased significantly from 32.8 per cent in 1991 to 46.5 per cent in 2016. During the same period, the percentage of women working in routine cognitive and routine manual jobs has declined from 46.3 per cent to 32.7 per cent. The share of women working in non-routine manual jobs has stayed constant at 20.8 per cent. Similar trends have happened in Ontario as well (Figure 4.2).

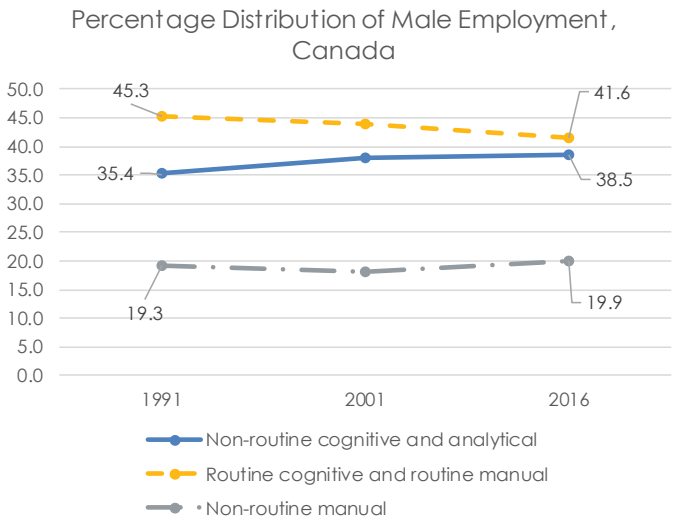
[27] Oschinski, Matthias, and Rosalie Wyonch. 2017. "Future Shock? The impact of automation on Canada's labour market." C.D. Howe Institute.; Autor, David, Frank Levy, and Richard J. Murnane. 2003. "The Skill Content of Recent Technological Change: An Empirical Exploration." The Quarterly Journal of Economics 118, no. 4: 1279-1333.

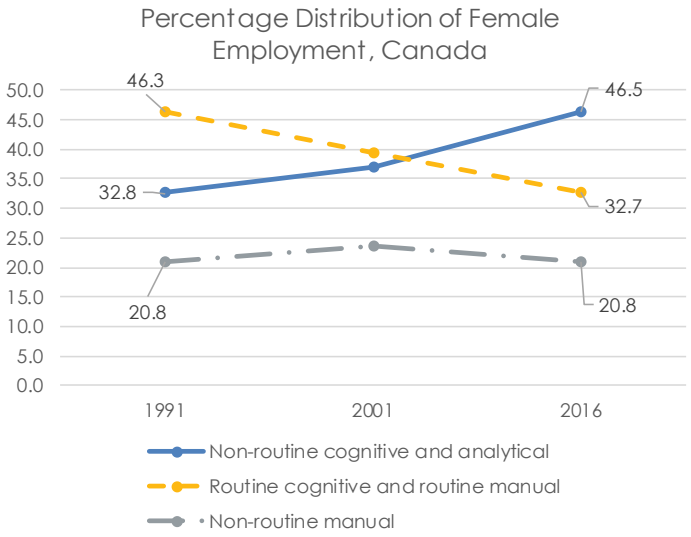
[28] Distribution of total employed workforce by various occupational categories are given in Appendix II.

Employment growth in the non-routine cognitive and analytical job category has been largely dependent on growth in managerial, professional, and technical occupations. Between 1991 and 2016, national employment in managerial occupations grew by 26.5 per cent among men and 92.3 per cent among women. During the same period, national employment in professional and technical occupations rose by 58.6 per cent among men and 80.3 per cent among women (Figure 4.3). Employment also rose by 84.0 per cent in health and 46.5 per cent in education among women compared to 64.0 per cent and 4.2 per cent respectively among men. Employment decline in routing jobs has been largely influenced by a decrease in clerical occupations, which experienced a decline of 69.5 per cent among men and 40.1 per cent among women in Canada between 1991 and 2016. Similarly, employment declined nationally in the processing and manufacturing occupations by 13.1 per cent among men and 13.4 per cent among women during the above period. In the non-routine manual job category, employment grew in sales and service occupations by 36.4 per cent among men and 37.5 per cent among women. A similar trend occurred in skilled trades. Employment trends in Ontario have been similar to those in Canada (Figure 4.4).

**Figure 4.1: Percentage Share of Employment by Occupation Type in Canada**



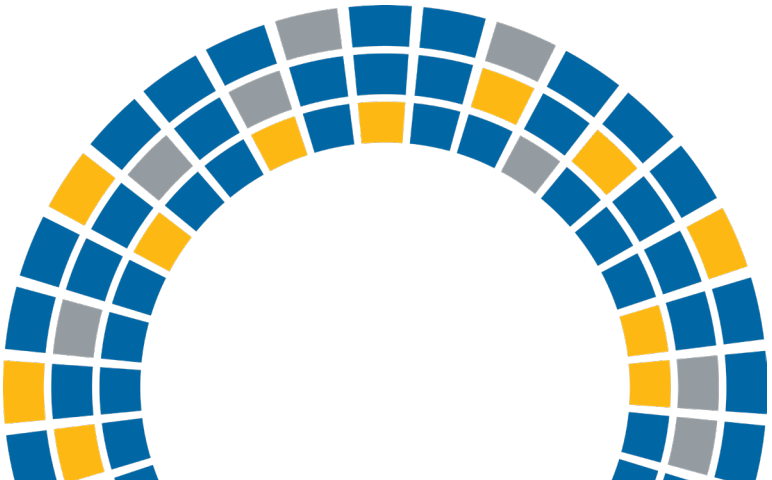
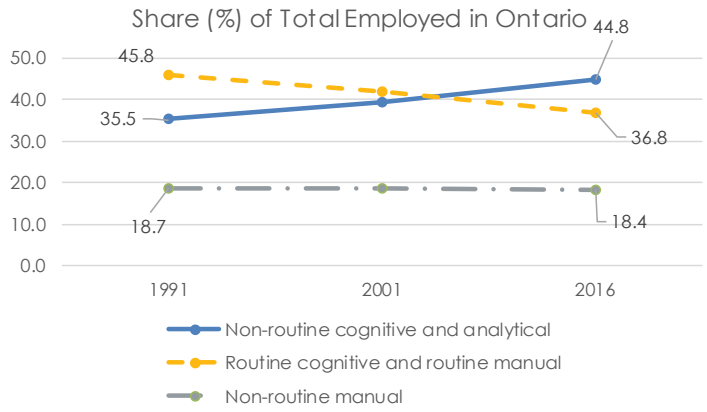
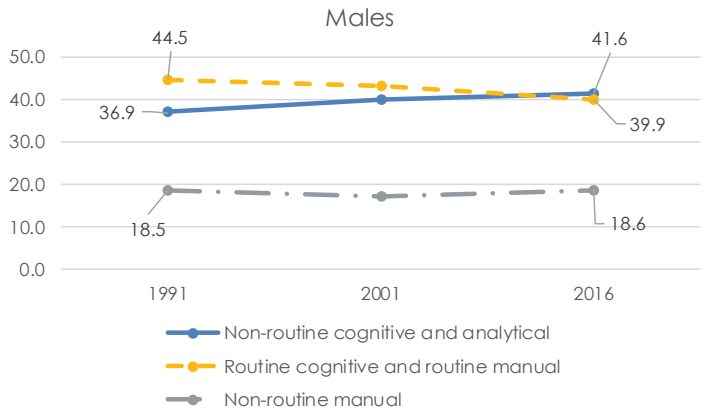



**Figure 4.2 Percentage Share of Employment by Occupation Type in Ontario**



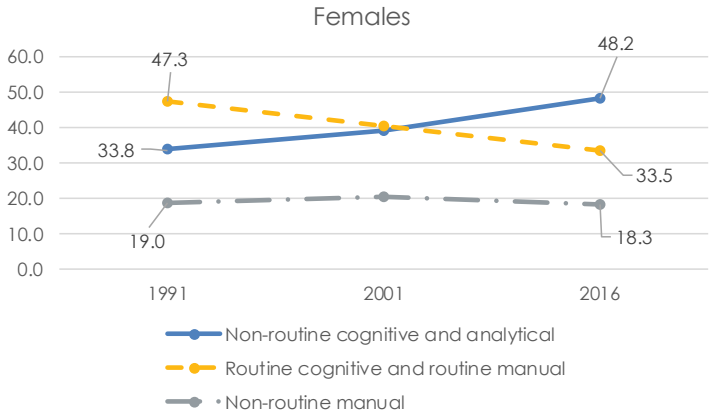
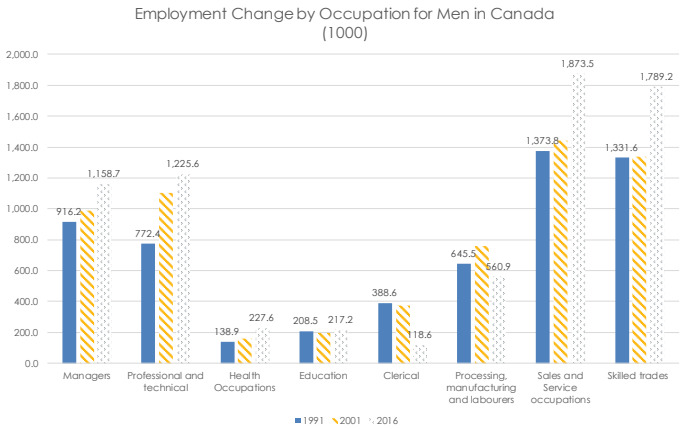




**Figure 4.3**



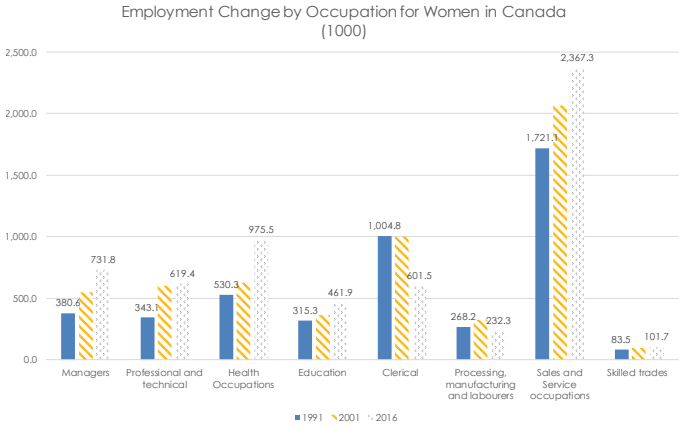
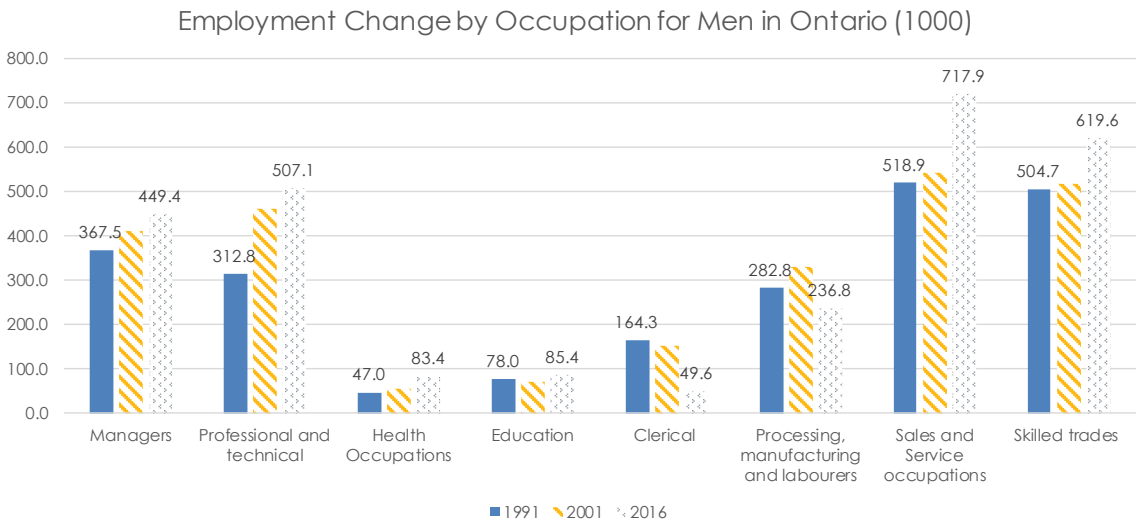
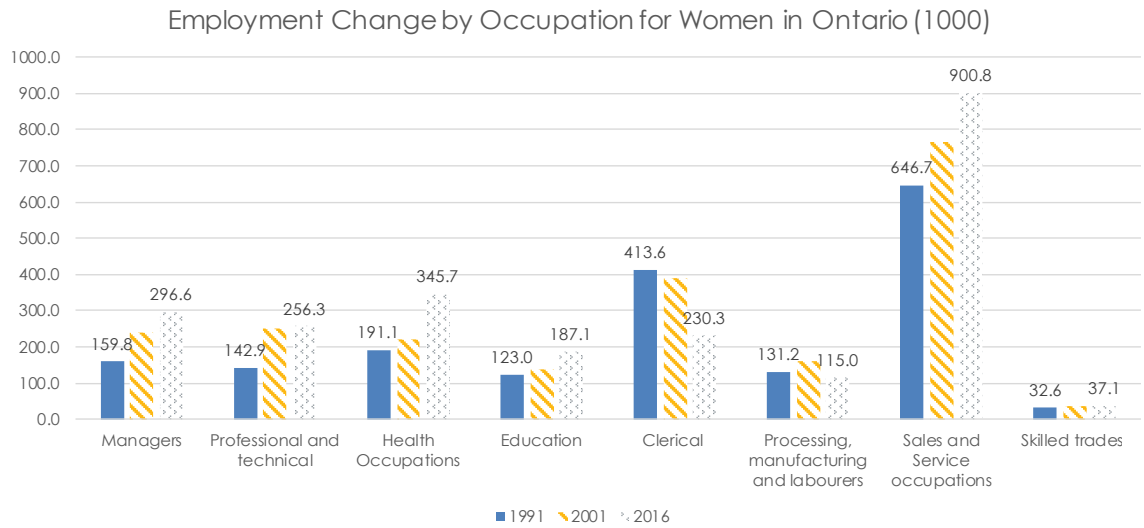



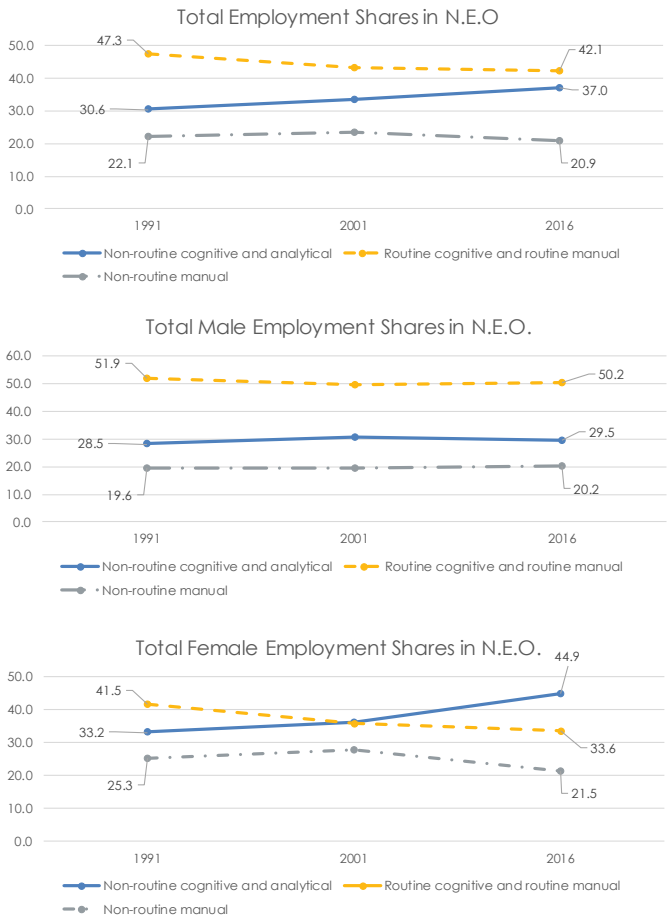

**Figure 4.4**




Between 1991 and 2016, total employment increased in both Canada and Ontario. This has not been the case in Northern Ontario. Focusing on Northeastern Ontario, total regional employment declined from 236,350 in 1986 to 231,305 in 2016—approximately 2.1 per cent. Total employment in non-routine cognitive and analytical jobs rose by 19.8 per cent while employment in routine cognitive and routine manual occupations declined by 12.1 per cent. Non-routine manual jobs also experienced a decline of approximately 6.9 per cent between 1991 and 2016. The share of men employed in non-routine cognitive and analytical jobs rose from 28.5 per cent in 1991 to 29.5 per cent in 2016 (Figure 4.5). The opposite happened to their share in routine cognitive and routine manual jobs. The number of employed men declined from 140,320 in 1991 to 127,355 in 2016. Male employment declined in both non-routine cognitive and routine jobs. On the other hand, employment among men in non-routine manual jobs rose slightly between 1991 and 2016. Meanwhile, total female employment in Northeastern Ontario rose from 111,695 in 1991 to 121,695 in 2016. The percentage of women employed in non-routine cognitive and analytical jobs rose from 33.2 per cent in 1991 to 44.9 per cent in 2016. During the same period, the share of women working in routine cognitive, routine manual, and non-routine manual jobs declined.

**Figure 4.5: Percentage Share of Employment by Occupation Type in N.E.O.**




Similar to the national trend, employment growth in the non-routine job category in Northeastern Ontario has been largely dependent on growth in managerial, professional, and technical occupations (Figure 4.6). Total employment in managerial occupations grew by 3.5 per cent between 1991 and 2016. Employment in professional and technical occupations also grew by 11.0 per cent during the above period. Employment in health occupations rose by 65.6 per cent among women compared to 44.7 per cent among men. Employment in education services declined by 34.6 per cent among men and 9.6 per cent among women.

Employment decline in routine jobs has largely been influenced by a decrease in clerical occupations, which experienced a decline of 72.4 per cent among men and 43.6 per cent among women in Northeastern Ontario between 1991 and 2016. Similarly, employment declined in the processing and manufacturing occupations by 42.2 per cent men and remained stable women during the above period. In the non-routine manual job categories, employment stayed relatively constant among men but declined among women. Skilled trades employment declined among both men and women between 1991 and 2016 (Figure 4.6).

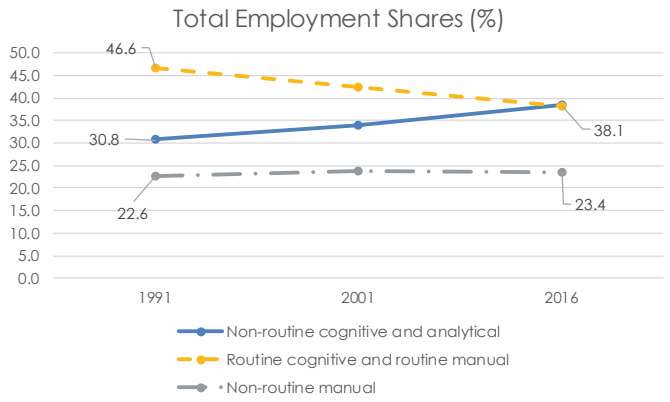
**Figure 4.6: Employment by Occupation in Northeastern Ontario**

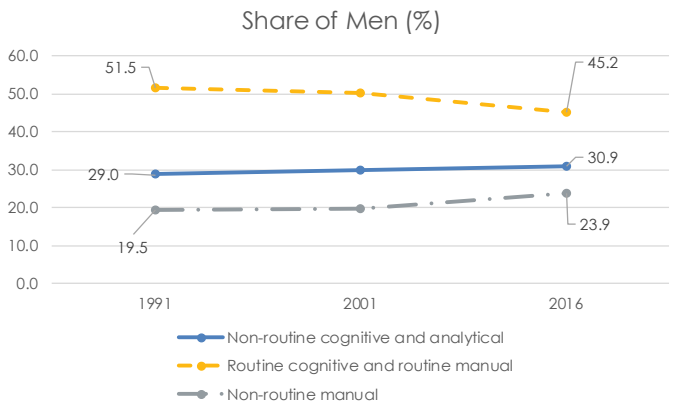

Northwestern Ontario also experienced a decline in its total employed workforce. Total regional employment declined from 106,255 in 1986 to 98,070 in 2016—a decline of approximately 0.25 per cent per year. Employment in non-routine cognitive and analytical jobs rose from 34,165 in 1991 to 40,500 in 2016. During that same period, total employment in routine jobs declined significantly from 51,590 to 40,120. Meanwhile, employment in non-routine manual jobs declined slightly from 25,010 in 1991 to 24,605 in 2016. As a result, the share of employment in non-routine cognitive and analytical jobs rose from 30.8 per cent in 1991 to 38.5 per cent in 2016 while the share of those working in routine cognitive and routine manual jobs declined from 46.6 per cent to 38.1 per cent during that period. The share of employed workers in non-routine manual jobs rose slightly during the above period. The number of men employed declined from 61,670 in 1991 to 53,380 in 2016. Men experienced employment declines in both non-routine cognitive and routine job categories. Their employment in non-routine manual jobs rose slightly during the above period.

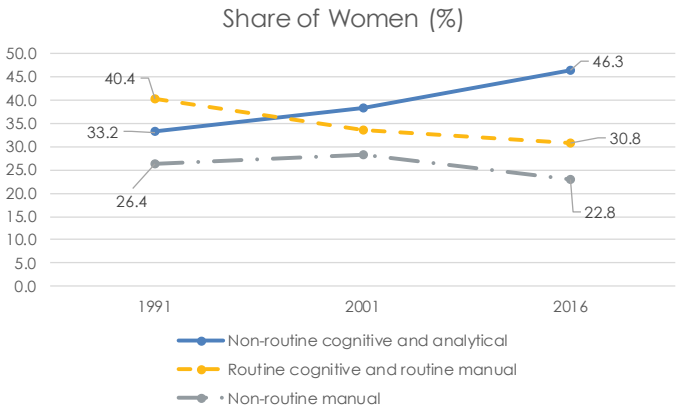
The share of men working in non-routine cognitive and analytical jobs stayed relatively constant while the share working in routine jobs declined from 51.5 per cent in 1991 to 45.2 per cent in 2016. Meanwhile, the share of men working in non-routine manual jobs rose from 19.5 per cent to 23.9 per cent during this period. Unlike employment trends among men, women's

employment rose from 49,090 in 1991 to 51,840 in 2016. Their employment in non-routine cognitive and analytical occupations rose from 16,305 to 24,015 during this period. As a result, the share of women working in non-routine cognitive jobs rose from 33.2 per cent to 46.3 per cent between 1991 and 2016. The share of women working in routine and non-routine manual jobs declined during the above period.

**Figure 4.7: Percentage Share of Employment by Occupation Type in N.W.O.**



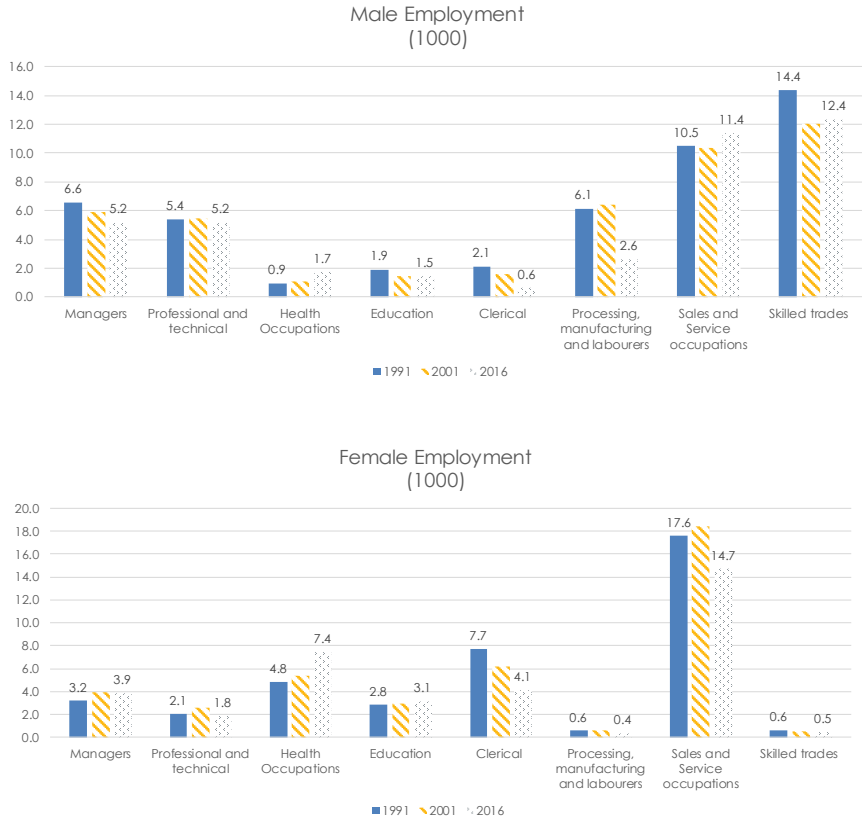




Employment growth in the non-routine cognitive job category In Northwestern Ontario has been largely dependent on growth in health occupations (Figure 4.8). Employment in these occupations grew by 84.9 per cent among men and by 54.6 per cent among women between 1991 and 2016. Total employment in managerial occupations declined by 21 per cent among men but rose by 21 per cent among women during this period. Meanwhile, employment in education-related occupations declined by 24.1 per cent among men but rose by 11.7 per cent among women. As a result, total employment in education-related occupations declined by 2.6 per cent in Northwestern Ontario between 1991 and 2016.

Employment decline in the routine jobs category has been largely influenced by a decrease in clerical occupations, which experienced a decline of 70.8 per cent among men and 46.6 per cent among women in Northwestern Ontario between 1991 and 2016. Similarly, employment declined in the processing and manufacturing occupations by 57 per cent among men and 36.5 per cent among women during this period. In the non-routine manual job category, employment in sales and service-related occupations rose by 8 per cent among men but declined by 16.2 per cent among women. Skilled trades employment declined among both men and women between 1991 and 2016 (Figure 4.8).

**Figure 4.8: Employment by Occupation Category in Northwestern Ontario**




The above figures show that there has been a shift away from routine occupations towards non-routine jobs. This trend indicates a change in skill requirements that is driven in part by technological change. A significant trend is the rising employment of women in both traditional and non-traditional sectors. Rising women's employment in non-routine cognitive jobs is directly related to their rising level of educational achievement between 1991 and 2016. Statistics Canada reports that, "Women have sustained a long-term trend toward higher education by increasingly completing post-secondary qualifications. The proportion of women aged 25 to 64 with a university certificate or degree grew at a faster pace than that of men, more than doubling between 1991 and 2015 from 15% to 35%. The proportion of men with a university certificate or degree also grew during that time period, but to a slightly lesser degree than women (19% in 1991 and 30% in 2015). In 1991, 14% of women had a college diploma compared with 26% in 2015. The percentage of men with a college diploma was 9% in 1991, increasing to 19% in 2015. As women have increasingly completed their college and university education, the percentage of women with a high school diploma as their highest completed educational credential has decreased from 31% in 1991 to 23% in 2015. The proportion of men whose highest level of education is a high school diploma remained largely unchanged during the same period (26% in 1991 to 25% in 2015). Finally, the proportion of women with no formal education credentials (no certificate, diploma or degree) showed a large decline from 31% in 1991 to less than 9% in 2015. The percentage of men with no certificate, diploma or degree showed a similar decline (from 31% to 11%)." [29]

The observed national shift from routine middle-income jobs with an average of $55,999 in full-time and full-year earnings in 2015 to non-routine cognitive jobs with an average of $78,807 in earnings implies that demand for skills has changed over time. Using the level of educational achievement as a proxy for skills, one can ask whether return to education as a proxy for skills has also shifted and to what extent?

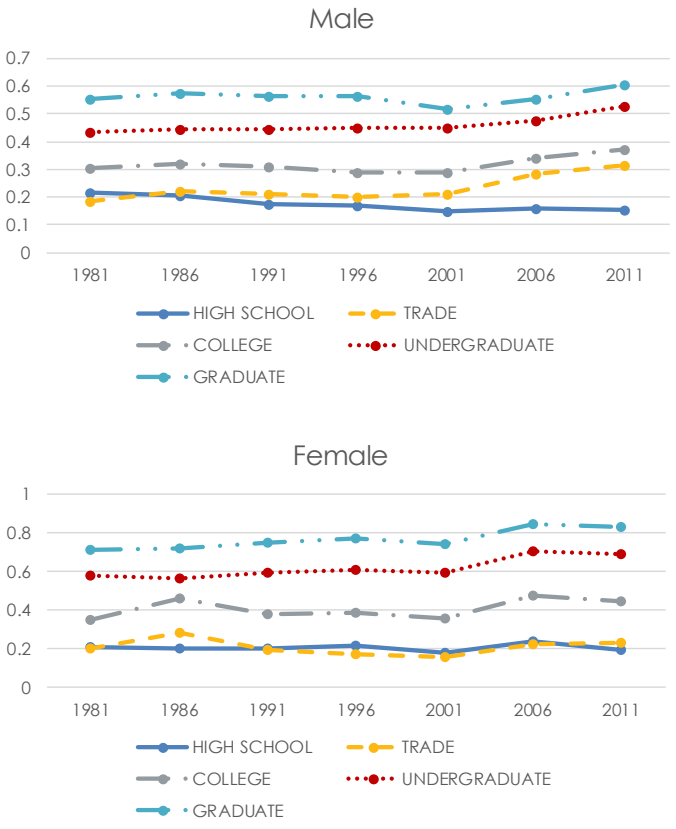
Using the Canadian Census Public Use Microdata Files (PUMFs) from census years 1981 to 2006 and the National Household Survey (NHS) for 2011, we estimated earning functions for men and women in every census year and calculated return to various levels of education.[30] Individuals without a high school diploma are used as a benchmark group against whom the return to achieving higher levels of education are compared. The estimated education premium for those who worked part-time or full-time and those who worked full-time and full-year are shown in Figures 4.9 and 4.10.[31] The return to education is measured on the vertical axis. For example, a numerical value of 0.2 should be interpreted as a 20 per cent greater return compared to those without a high school diploma.

[29] *Ferguson, Sarah Jane. 2016. "Women and Education: Qualifications, Skills and Technology." Statistics Canada. Cat. No. 89-503-X: 3.*

[30] *The PUMFs and NHS microdata files contain samples of anonymous responses to the census questionnaire, which represent 2.7 per cent of the Canadian population. The difference between NHS and the census is that the census is mandatory and NHS is voluntary.*

[31] *Estimates are taken from Zhang, Chunmei. 2018. "Impact of Technological Advances on return to Skills, Income Distribution and Job Polarization in Canada." Graduate major paper, Department of Economics, Lakehead University.*

**Figure 4.9: Education Premium by Schooling Level in Canada (Employed Workforce)**



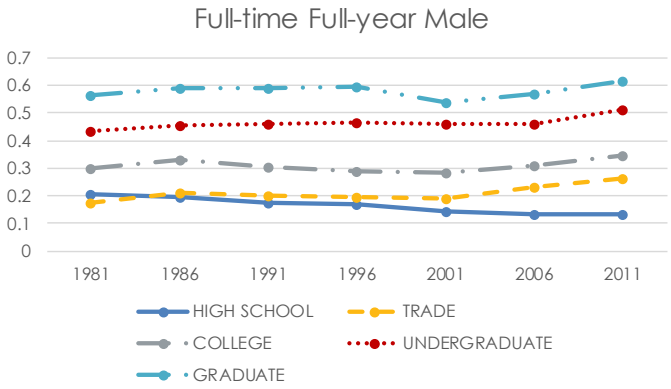


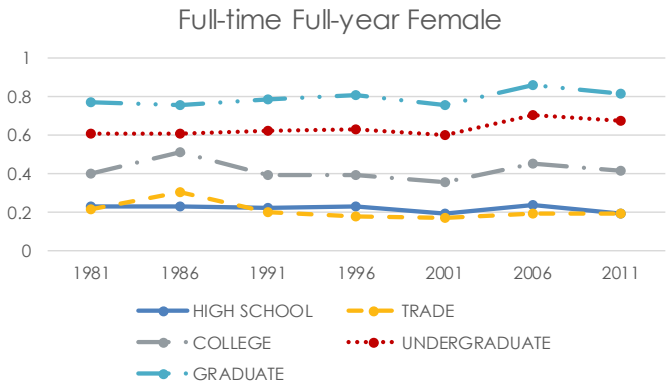


The above figures show that the earnings premium for a male with a high school diploma declined over time. The earnings premium for a trade certificate was lower than a high school diploma in 1981 but eclipsed it in later years. Figure 4.9 shows that the earnings gap between men with a high school diploma and those with trade certificates widened after 2001. It is likely that many of the jobs that required a high school diploma were automated and thus the return to high school diploma declined over time. Also, there does not appear to have been any significant advantage or earnings premium for females with a trade certificate compared to a high school diploma. This is likely due to the concentration of women in trades linked to personal services that can be performed by individuals with a high school diploma.

The estimated results suggest that the earnings premium or returns to investment in education are much higher for women than men as compared to the reference group who are those without a high school diploma.[32] There was a small decline in return to education for each group in 2001 compared to the benchmark group. This could be caused by higher earnings of the benchmark group in Ontario due to rising minimum wage.

**Figure 4.10: Education Premium by Schooling Level in Canada (Employed Full-Time and Full-Year)**



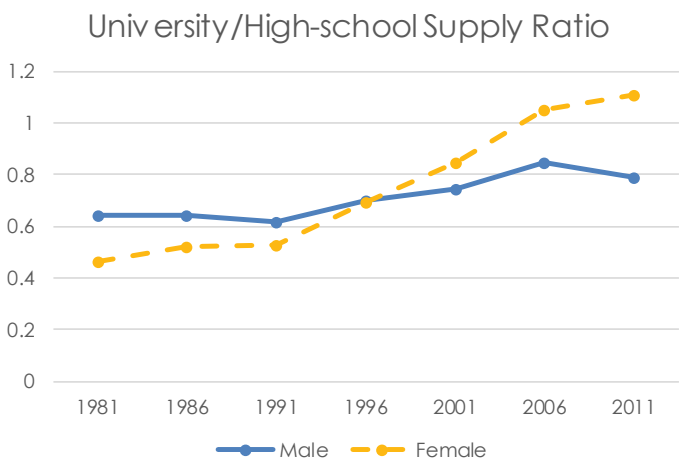

Returns to schooling rise as the level of educational achievement increases. Alternatively, the labour market was willing to pay more to high-skilled workers. The premium gap between workers with a high school diploma and those with a university degree was 23.2 per cent among men and 37.8 per cent among women in 1981. The gap increased to 37.7 per cent among men and 48.6 per cent among women in 2011. In other words, women benefited more from a higher level of educational achievement than men. The differential return was much higher among women compared to men.

To further examine the earnings gap between different levels of educational achievement as proxies for skills, it is useful to consider two classes of workers: skilled and unskilled. We define skilled workers as those with a university degree and unskilled ones as those with a high school diploma. Using this classification, the university premium— the relative wage of university versus high school educated workers—can be viewed as a summary measure of the market's valuation or price of skills.

[32] *This can be read from the numbers on the vertical axis. For example, a numerical value of 0.2 on the vertical axis suggests a return of 20 per cent above the benchmark.*

The university premium is affected by, among other things, the relative supply of skills. Figure 4.11 shows the evolution of the relative supply of university versus high school educated workers.[33] From the 1980s, the relative supply of female workers with university credentials rose robustly and steadily. Moreover, the increasing relative supply of female workers with a university degree accelerated in the early 1990s. However, the rate of growth of university educated male workers declined during the 1980s and it declined further after 2006. After 1996, the relative supply of university educated male workers was surpassed by females. The possible reason accounting for the relative deceleration of university credentials for men since 2006 is that the university premium rose much slower for men compared to women. This gap as well as lower returns to university education likely discouraged some high school men from enrolling in university. In the meantime, the female university completion rate increased sevenfold from 1981 to 2011 while the male university completion rate only tripled. Cumulatively, these trends inverted the male-to-female gap in college completion among young adults. This gap stood at a positive 18 percentage points in 1981 and a negative 32 percentage points in 2011.

**Figure 4.11: University/High School Log Relative Supply, 1981-2011**




Boudarbat et al. (2010) examined the evolution of the returns to education in Canada during the 1980 to 2005 period. Their study, which used high school as a benchmark, found that the economic returns to education had been increasing for both male and female, but the gains for women were considerably larger. Their results are similar to those found in the present report.

[33] *Estimates are based on Zhang (2018)*

# Part V: Job and Wage Polarization and Income Inequality in Canada, Ontario, and Northern Ontario

What are the implications of the observed shift away from routine jobs that were traditionally middle-income jobs to non-routine cognitive jobs? Research on the United States' labour market suggests that middle-income jobs have declined relative to both low- and high-wage jobs.[34] To see if this wage polarization has happened in Canadian regions, one needs to examine the earnings distribution of employed workers in different regions.

**Trends in Income Distribution in Canada[35]**

Our discussion has so far found that labour demand, supply, and earnings have changed over time. However, the above picture does not convey the full set of changes that have occurred in the wage distribution of employed workers. There remains substantial wage dispersion within as well as between skill groups. To examine wage inequality, we need to summarize changes throughout the entire earnings distribution. Thus, we examine trends in real wages by earnings percentile, focusing on the 10th, 50th, and 90th percentiles of the wage distribution in Canada.

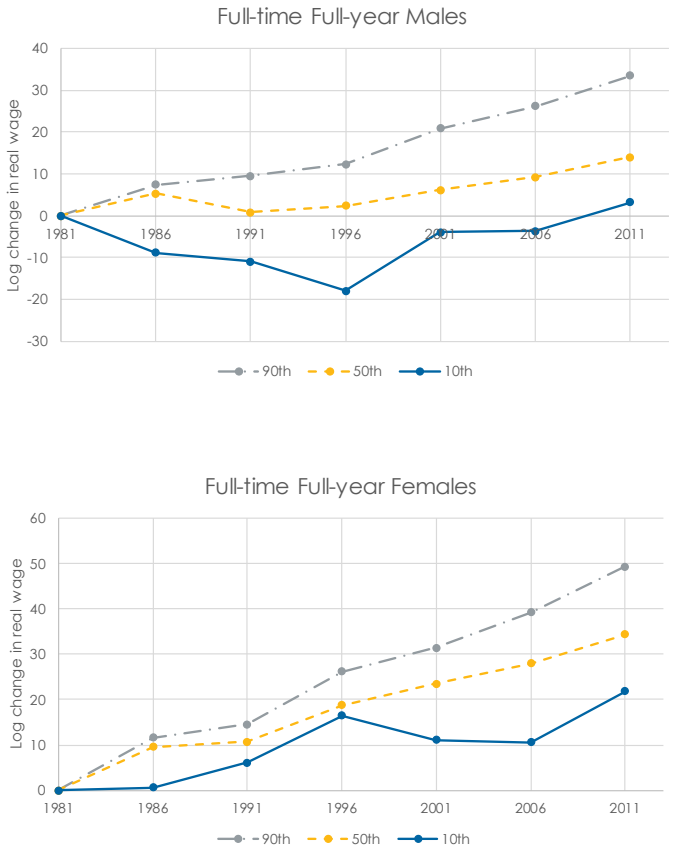
Using various census microdata files, we impose a minimum and maximum wage range restriction of $4,000 to $500,000 in 2015 dollars. This restriction was necessary since the PUMF and census samples are likely to provide inaccurate measures of earnings at the highest and lowest percentiles. High percentiles are unreliable both because high earnings values are truncated in public use samples and, more important, because non-response and under-reporting are particularly severe among high-income households. Conversely, wage earnings in the lower percentiles imply levels of consumption that lie substantially below observed levels.[36] This disparity reflects a combination of measurement error, underreporting, and transfer income among low-wage individuals.

Figure 5.1 plots the evolution of real log weekly wages of full-time, full-year workers at the 10th, 50th, and 90th percentiles of the earnings distribution from 1981 through 2011 in Canada. In each panel, the value of the 90th, 50th, and 10th percentiles are normalized to zero in the start year of 1981, with subsequent data points measuring log changes from this initial level.

Figure 5.1 shows that the real earnings growth among males has mainly occurred among high earners. This is most evident by comparing the male 90th percentile with the median. The 90th percentile rose steeply and monotonically between 1981 and 2011.

By contrast, the male median only increased marginally during this period. At the opposite end of the wage spectrum, the male 10th percentile fell sharply between 1981 and 1996. In other words, their real earnings declined during that period. When the male median began to rise during the early 1990s, the male 10th percentile lagged by approximately five years.

**Figure 5.1: Cumulative Log Change in Real Earnings at the 90th, 50th, and 10th Wage Percentiles, 1981-2011**




The wage picture for women shows that they fared better than men during the above period. The 10th percentile rose between 1981 and 1996, fell between 1996 and 2006, and rose again between 2006 and 2011. The female 90th and 50th percentiles rose almost continuously from the early 1980s even though the gap between them expanded after 2001.

[24] *Cheremukhin (2014)*

[35] *Estimates in this part are based on Zhang (2018).*

[36] *Meyer and Sullivan (2008)*

Figure 5.1 shows that male income inequality has been more apparent than that among women. The top and middle halves of the distributions experienced a monotone expansion while the bottom half became notably non-monotone during this period. The gap between the 90th percentile and the rest of the distribution had broadened but the log change among the middle and bottom tended to converge. In conclusion, to the degree that automation drives the above results, it appears to have had a more significant impact on women's earnings compared to those of men. Similarly, the distribution of earnings has become more unequal, with the top 90th percentile group experiencing significant earnings growth compared to middle- and low-income groups.

Research by Green and Sand (2013) found that, in Canada, the income inequality between the 90th percentile and the 50th percentile increased from 1971 to 2006 but the inequality relative to the 10th percentile was uncertain. Our results suggest an increasing wage inequality relative to the 10th percentile group. Green and Sand (2013) also found that different provinces showed different income patterns. In general, rising wage inequality over the past several decades is not unique to Canada. Autor, Katz, and Kearney (2008) report that the steady growth in wage dispersion in the upper half of the wage distribution appears to represent a secular trend that has been ongoing since the early 1980s but the sharp growth in wage dispersion in the lower half of the wage distribution during the early to mid-1980s seems to be an episodic event in the U.S.

**Trends in Income Distribution in Ontario and Northern Ontario**

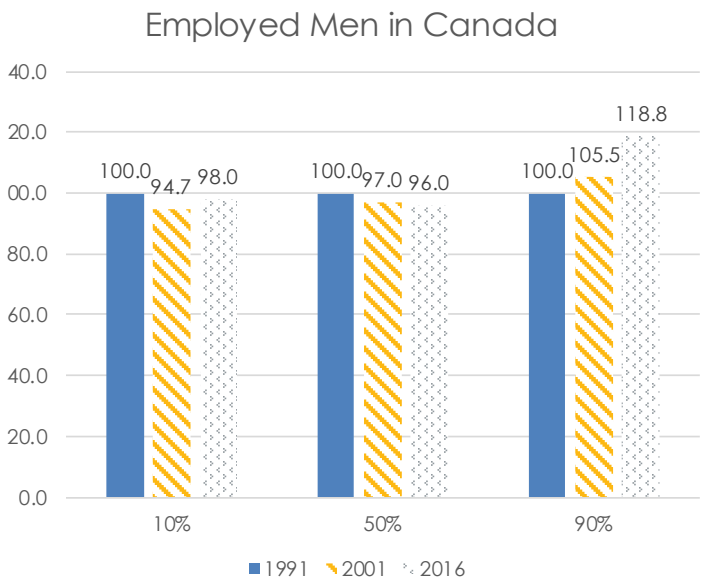
Above, we examined distribution of earnings of those who worked full-time and full-year in Canada. However, focusing on full-time and full-year workers tends to obscure wage developments for the lower tail of the earnings distribution because a larger share of low-income workers are employed part-time or part-year. Using census data from 1991 to 2016, Figure 5.2 shows trends in real earnings of all employed workers in the 10th, 50th, and 90th percentiles in Canada and Ontario. We have set 1991 real earnings equal to 100.

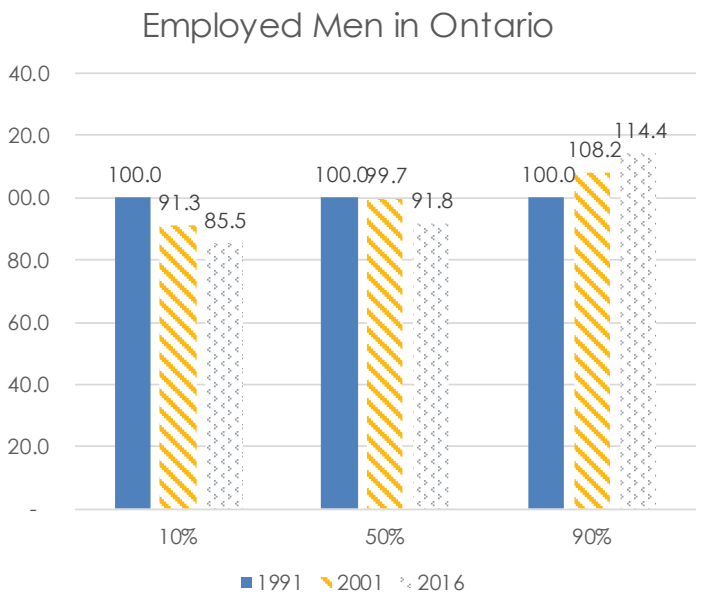
Figure 5.2 shows a downward trend in real earnings of men in the 10th and 50th percentiles in Canada and Ontario throughout the 1991 to 2016 period. On the contrary, women experienced real earnings growth at all segments of the earning distribution between 1991 and 2016. Figure 5.2 also shows that women at the low end of the income distribution in Ontario experienced significant real income growth comparable to or exceeding that at the top of the income distribution for men. One possible explanation is that prior to the 1990s, many women at the lower end of the income distribution worked part-time and/or part-year in the service industry. Job opportunities for women improved significantly as their level of educational achievement increased during the 2000s.

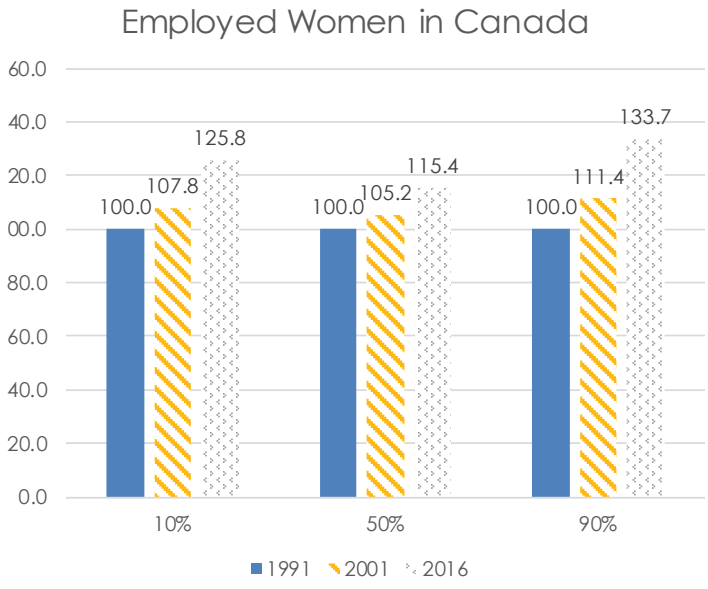
Figure 5.3 shows trends in real earnings of all employed workers in the 10th, 50th, and 90th percentiles in Northern Ontario. Male workers in the 10th and 50th percentiles in Northeastern Ontario experienced a decline in their real earnings between 1991 and 2001 but regained all the losses between 2001 and 2016. On the other hand, men in the 10th and 50th percentiles in Northwestern Ontario experienced declining earnings throughout the period. Meanwhile, men in the top percentile experienced significant wage growth. As for women, they experienced significant real income growth throughout the period. This reflects their higher level of educational achievement as well as changing occupational distribution of their employed workforce. These figures also show that income inequality is more apparent for men than for women.

In conclusion, to the extent that automation drives these results, technological progress appears to have been biased toward high-income groups. In addition, it has improved the women's labour market condition more than it has for men.

**Figure 5.2: Real Earnings Growth of Employed Workers**



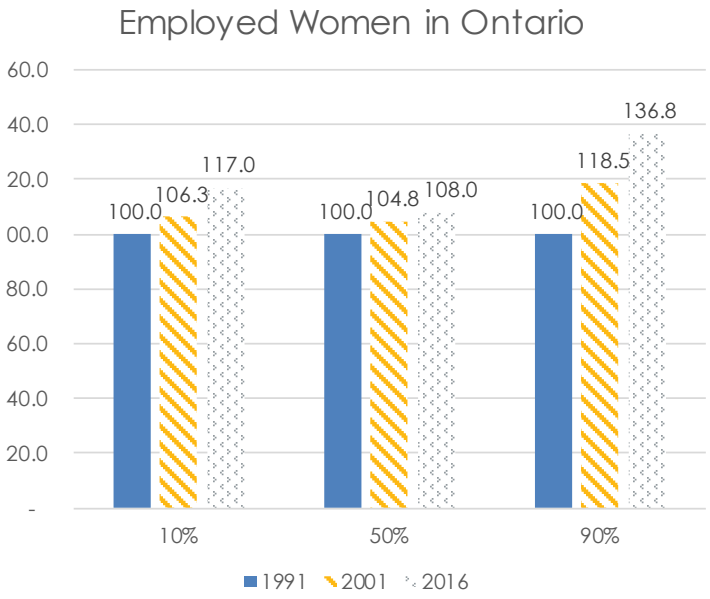
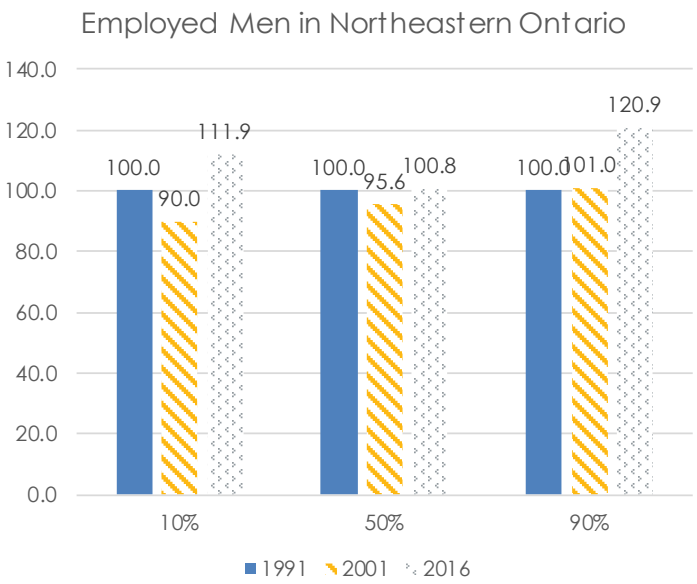
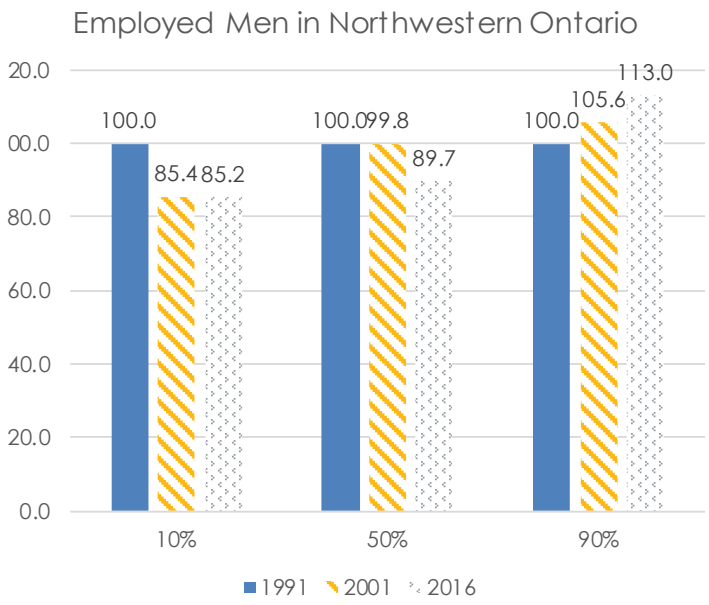
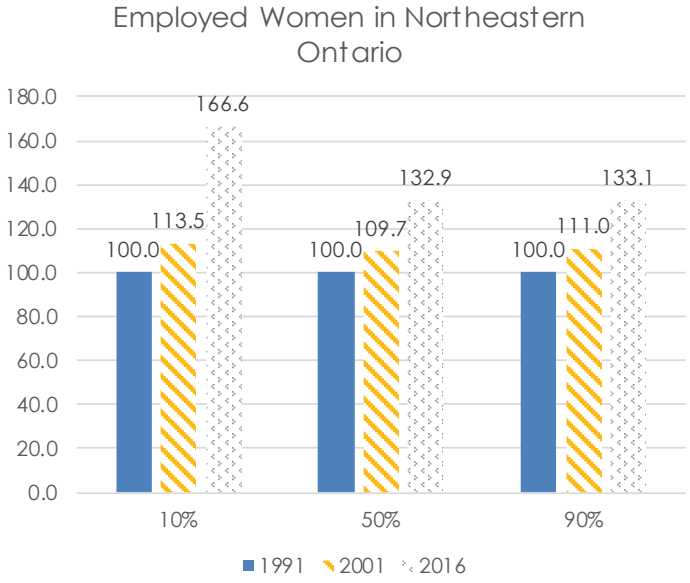
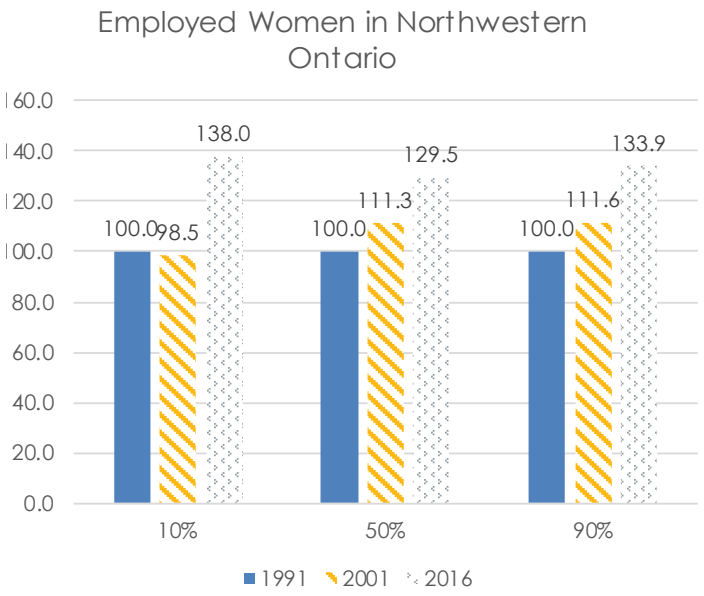



**Figure 5.3: Real Earnings Growth of Employed Workers**



# Part VI: Impact of Automation on Northern Ontario's Base and Quasi-Base Industries

This part of the study examines job polarization in industries that have traditionally been the engines of economic growth in Northern Ontario. These are logging and forestry, mining, forest-based manufacturing, health care and social services, and education services industries.

**Forestry and Logging Industries**

The logging and forestry service industries have traditionally played an important role in Northern Ontario's economic development. They accounted for 3,470 jobs in Northeastern Ontario and 3,340 jobs in Northwestern Ontario in 1991. Employment in those industries declined to 2,730 and 2,965 respectively in Northeastern and Northwestern Ontario in 2001 and to 1,360 and 1,185 respectively in those regions in 2016. The decline reflected global demand, competition, and automation, as well as declining supply and rising cost of production in Northern Ontario.

**Figure 6.1: Trends in Employed Workforce in Logging and Forestry Industries**

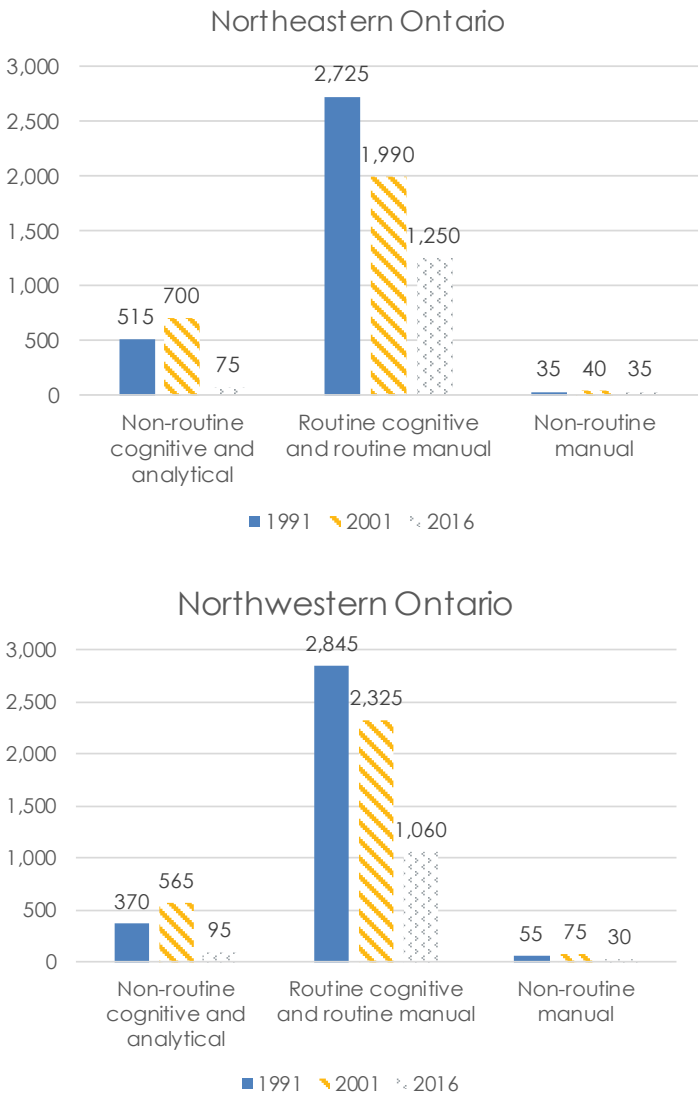



Figure 6.1 shows that the majority of the employed workforce in the logging and forestry industries have been employed in occupations involving routine tasks and therefore those occupations have experienced the largest employment decline as a result of the overall sectoral downturn during the above period. Figure 6.2 shows employment by major occupations in the logging and forestry service industries between 1991 and 2016.

**Figure 6.2: Occupational Distribution of Employment**

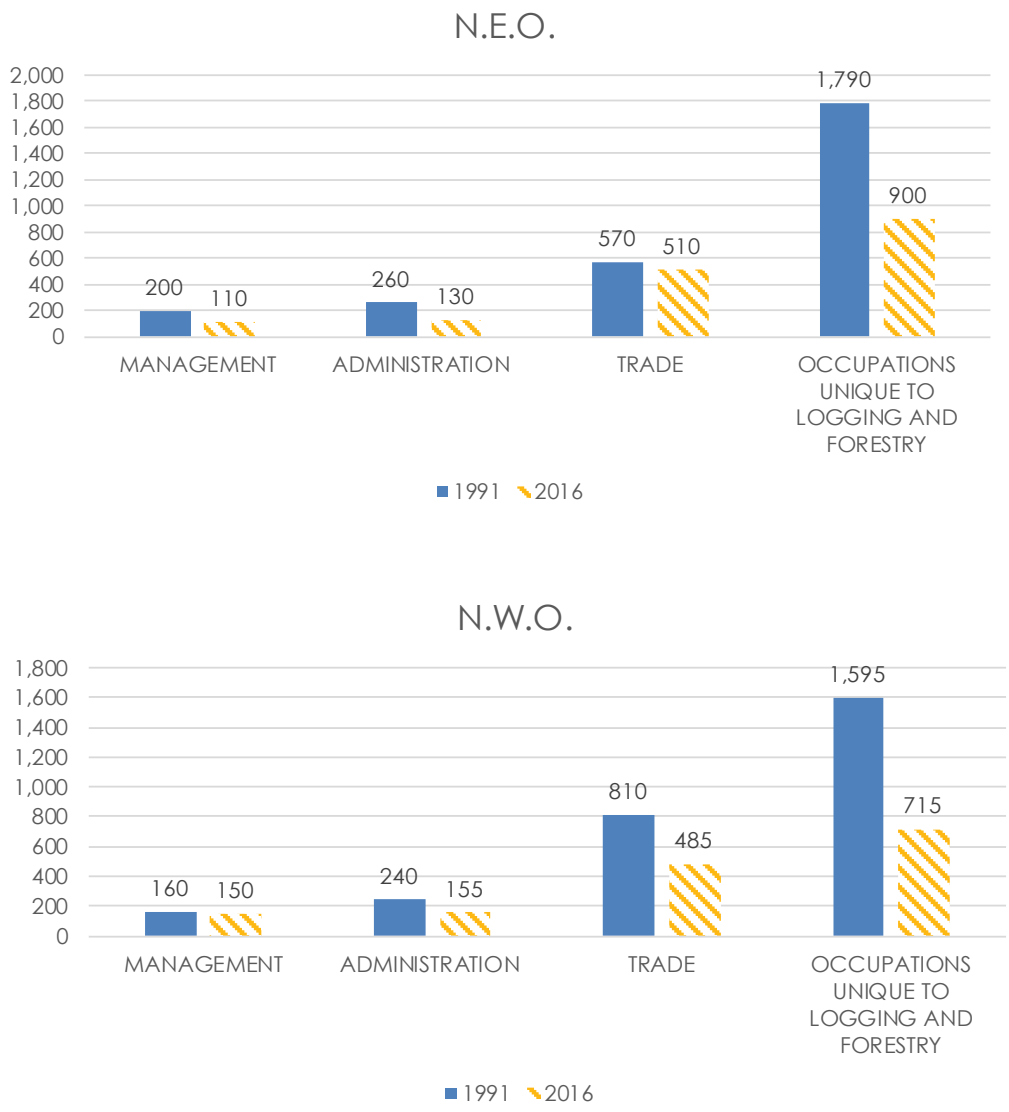



Figure 6.2 shows that most of the job losses have been in occupations unique to logging and forestry services, including logging machine operators, chainsaw and skidder operators, logging and forestry labourers, silviculture and forestry workers, and primary production labourers.

The substitution of routine tasks by machines has been happening steadily in the logging and forestry sector. The advent of skidders, mechanical harvesting, and remote chipping has modernized bush operations. GIS, telemetry, and satellite imagery have also optimized harvest planning and access development. Remote sensing of harvesters can grade, sort, and scale product in one operation. These technologies have led to a significant reduction in employment in the logging and forestry industry.

The ongoing process of automation in the forestry sector implies that most of the remaining jobs in these sectors can also be automated. Therefore, the prospects of increasing employment to the levels experienced in the 1980s and 1990s during the future cyclical uptrend is slim.

**Mining Industries**

Mining and mining services industries employed 16,885 people in Northeastern Ontario in 1991. Total mining employment in Northeastern Ontario declined slightly to 14,260 in 2016. Employment in Northwestern Ontario's mining sector declined from 3,535 in 1991 to 3,020 in 2016. Table 6.1 shows the distribution of employment by occupational grouping between 1991 and 2016.

**Table 6.1: Distribution of Employment by Occupation Category in Mining Industries**

| **Northeastern Ontario** | **1991** | **2001** | **2016** |
|---|---|---|---|
| Non-routine cognitive & analytical | 2,745 | 2,080 | 2,760 |
| Routine cognitive & routine manual | 13,390 | 7,610 | 11,040 |
| Non-routine manual | 750 | 395 | 460 |
| **Total** | **16,885** | **10,085** | **14,260** |
| **Northwestern Ontario** | | | |
| Non-routine cognitive & analytical | 515 | 510 | 600 |
| Routine cognitive & routine manual | 2,805 | 1,920 | 2,185 |
| Non-routine manual | 215 | 135 | 235 |
| **Total** | **3,535** | **2,565** | **3,020** |

Table 6.1 shows the cyclical nature of the mining industry. Total employment declined between 1991 and 2001 but increased between 2001 and 2016. Employment in the non-routine cognitive occupations has, in fact, risen in Northern Ontario even though the total employment has declined during the past three decades. The major job losses have happened in the routine task categories that are easier to automate.

Most of the labour-saving technology relates to the underground and delivery phases of production. Mines have progressed to electric-driven underground vehicles remotely controlled. Thus, the operators can be in a major urban setting, without living at the mine site. Remote operation with electric vehicles will improve ventilation and heating costs significantly. Job losses would occur in fuel handling and camp services with fewer people on-site. Automation will improve safety, reduce cash cost per unit of production, and potentially reduce the cutoff grade, maximizing resource utilization. The jobs that are preserved are in the technical and professional fields with low probability of automation.

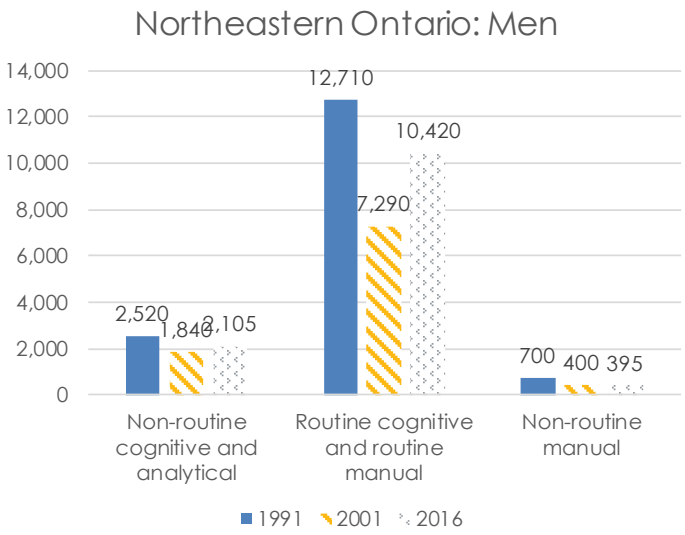
As a result, the share of non-routine cognitive jobs rose from 16.3 per cent in Northeastern Ontario and 14.6 per cent in Northwestern Ontario in 1991 to 19.4 per cent and 19.9 per cent respectively in 2016. On the other hand, the share of routine jobs declined from 79.3 per cent in Northeastern and Northwestern Ontario in 1991 to 77.4 per cent and 72.4 per cent respectively in 2016.

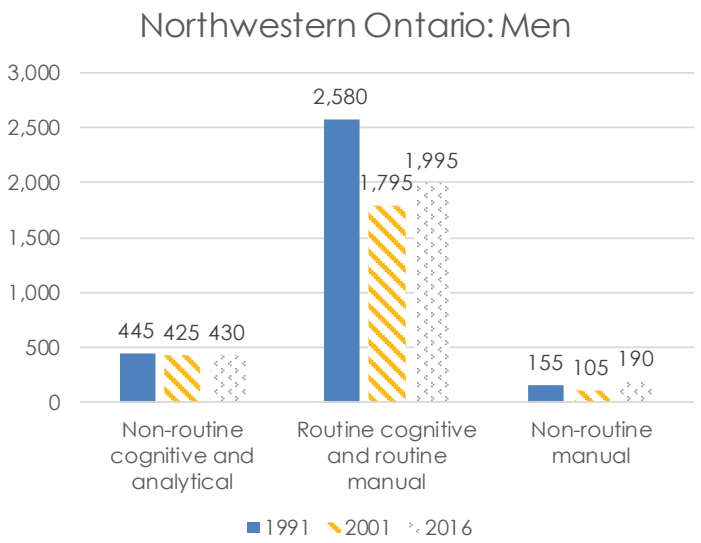
The shift from routine tasks to non-routine cognitive tasks has been accompanied by rising employment of women in Northern Ontario's mining sector. Figure 6.1 shows employment trends in Northeastern Ontario's mining sector by gender between 1991 and 2016. Focusing on Northeastern Ontario, the number of men employed declined from 15,930 in 1991 to 12,920 in 2016 while the number of women rose from 810 in 1991 to 1,340 in 2016. The major change has been in the rising employment of women in the non-routine cognitive jobs category. Table 6.2 shows the percentage distribution of women in Northeastern Ontario's mining industry by occupational category. The same trend is observed in Northwestern Ontario's mining sector.

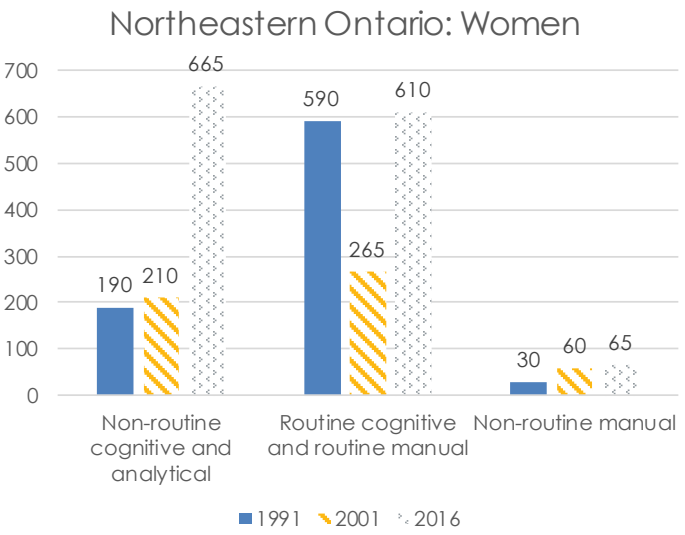
The fact that more than 70.0 per cent of jobs in Northern Ontario's mining sector are in routine task categories implies that a significant share of employment in this industry is susceptible to automation. The Brookfield Institute estimates that 52 per cent of jobs in the mining sector in Canada have the potential of being automated.[37]

*[37] Lamb, C., Lo, M. 2017. "Automation Across the Nation: Understanding the potential impacts of technological trends across Canada" The Brookfield Institute for Innovation and Entrepreneurship. June 8.*

**Figure 6.3: Mining Employment by Gender in Northern Ontario**



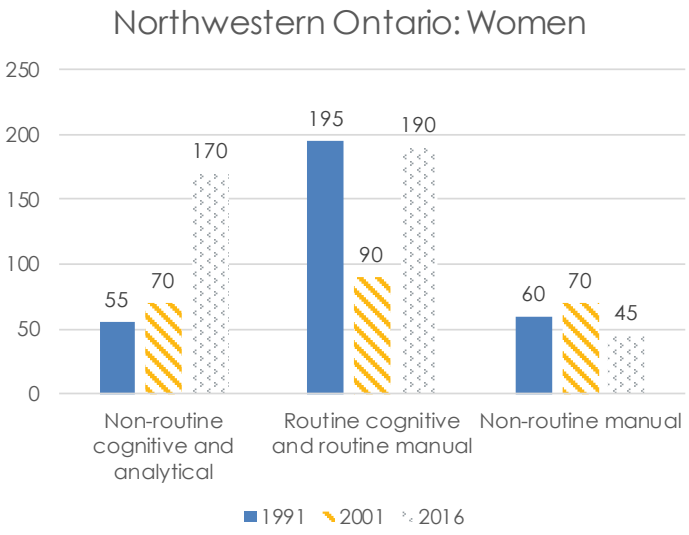
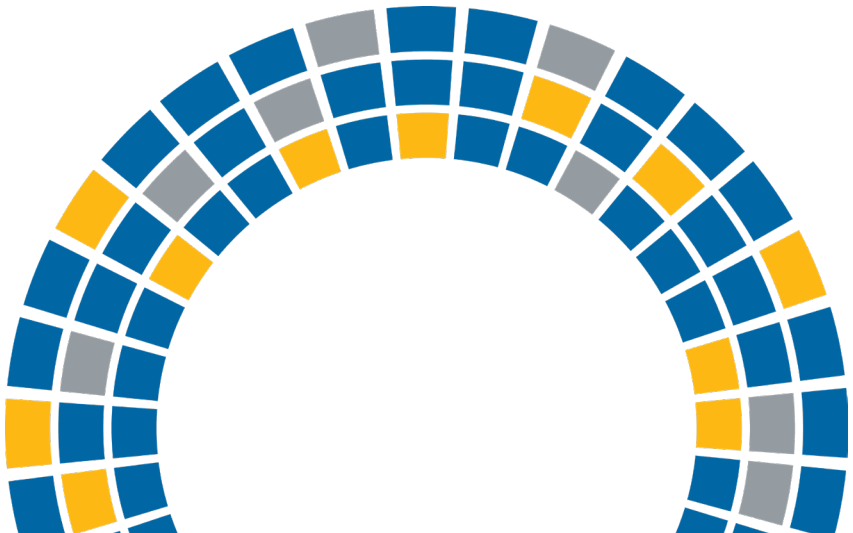



**Table 6.2: Percentage Distribution of Employed Women in Northeastern Ontario (Mining Industry)**

| Occupational Distribution of Women in mining | Percentage Employed (2016) |
|---|---|
| Designers & craftspersons | 1.50 |
| Senior management | 1.50 |
| Retail sales supervisors | 2.26 |
| Professional occupations in health | 6.02 |
| Policy researchers | 6.77 |
| Specialized management | 10.53 |
| Professional occupations in business & finance | 16.54 |
| Technical occupations related to natural & applied sciences (geologists, chemical technologists, etc.) | 26.32 |
| Professional occupations in natural & applied sciences (physicists, geoscientists, etc.) | 27.07 |
| Total | 100 |

On the positive side, development of the Ring of Fire, which is expected to happen in the next five to 10 years, will generate a significant number of jobs and will continue to be a source of stimulation to Northern Ontario's economy. Indigenous residents of the area will be able to participate in the development and initial phase of the operation, which will consist of open pit operations. However, to receive long-term benefits, we need to enable our workforce to perform tasks that require a higher level of expertise and education.



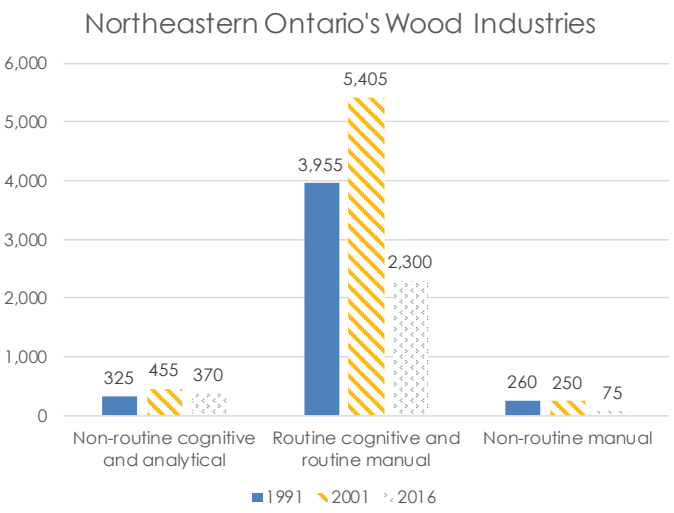
**Forest-Based Manufacturing Industries**

Wood and pulp and paper industries have traditionally been the main vehicle of economic development in Northern Ontario. Approximately 4,540 people were employed in the wood manufacturing sector and 4,945 were employed in the pulp and paper sector in Northeastern Ontario in 1991. That same year, approximately 1,445 people were employed in wood manufacturing and 8,235 in pulp and paper in Northwestern Ontario. Globalization, shifting demand, and automation have impacted these industries significantly. In 2016, there were only 2,745 people employed in wood manufacturing and 1,195 in pulp and paper in Northeastern Ontario. Similarly, only 1,075 people were employed in wood manufacturing and 1,345 were employed in pulp and paper in Northwestern Ontario that same year. Figure 6.4 shows employment trends by occupational grouping in Northeastern Ontario.

Total employment in wood manufacturing industries in Northeastern Ontario rose between 1991 and 2001 but declined thereafter. Employment in the pulp and paper sector experienced a downturn throughout the period. The share of non-routine cognitive jobs rose from 7.2 per cent to 13.5 per cent in the wood industries between 1991 and 2016. The majority of job losses occurred in the routine task category, which declined by 57.5 per cent between 2001 and 2016. The share of employment in that category declined from 87.1 per cent in 1991 to 83.8 per cent in 2016.

In 2016, total employment in the pulp and paper sector in Northeastern Ontario was less than a quarter of its 1991 level. Again, the majority of job losses happened in the routine task category, which lost approximately 76.1 per cent of its employed workforce between 1991 and 2016.

**Figure 6.4: Employment by Occupational Grouping in Northeastern Ontario**



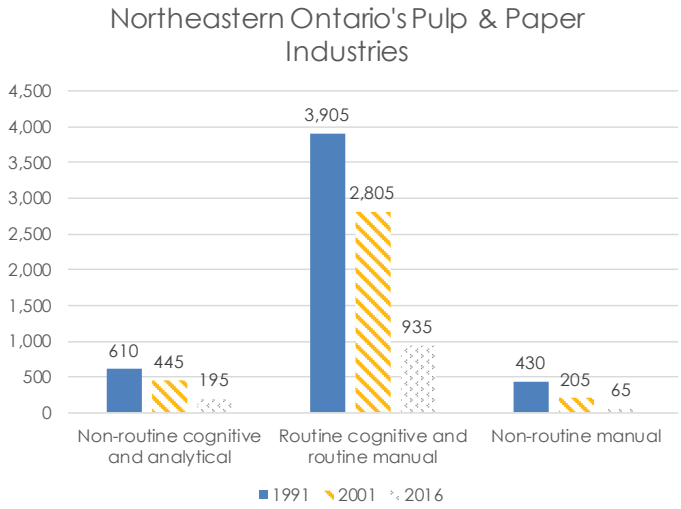



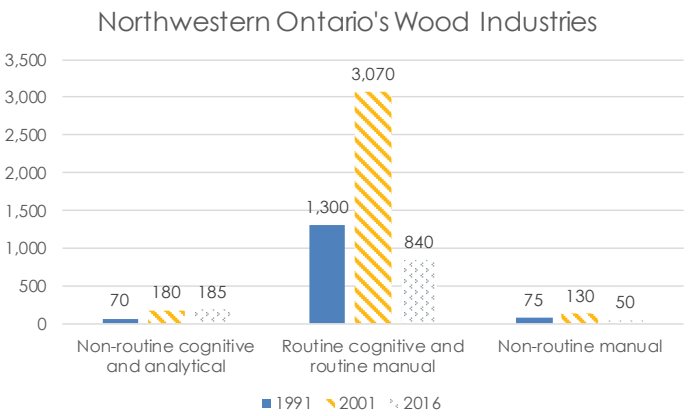

Figure 6.5 shows employment trends in the forest-based manufacturing industries of Northwestern Ontario. Total employment in the wood manufacturing sector rose between 1991 and 2001 but followed a downward trend afterward. The rising employment in the wood sector between 1991 and 2001 is related to the development of products such as engineering wood and other value-added products. The above figures show that employment trends in wood and pulp and paper industries are similar as they use each other's byproducts.

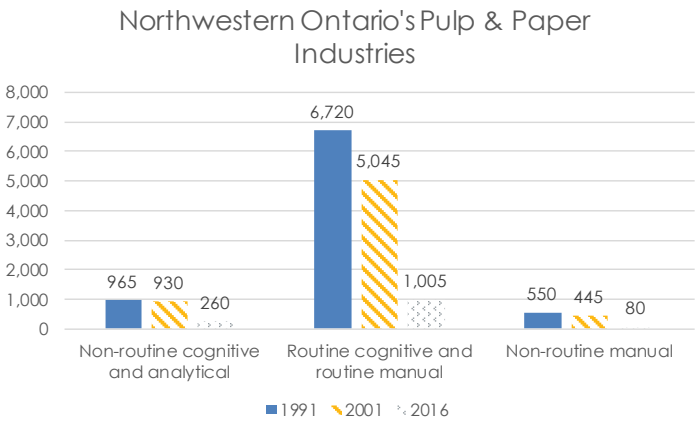
Overall, employment in wood industries in Northwestern Ontario declined by approximately 25.6 per cent between 1991 and 2016. The majority of job losses happened in the routine job category, which experienced a decline of approximately 35.4 per cent during the above period. Employment in the non-routine cognitive jobs category rose from 70 in 1991 to 185 in 2016. Similar to trends in Northeastern Ontario, the pulp and paper sector experienced a decline throughout the period. In 2016, total employment in that sector was approximately 16.3 per cent of its 1991 level. The majority of job losses happened in the routine task category. In 2016, employment in that category equaled 14.9 per cent of its level in 1991. The routine task share of total employment in the pulp and paper sector declined from 81.6 per cent in 1991 to 74.7 per cent in 2016.

In general, the majority of jobs in the manufacturing sector require routine tasks that can be automated. As we saw above, wood and pulp and paper sectors are no exception. In fact, the Brookfield Institute estimates that 61 per cent of jobs in the manufacturing industries of Canada have the potential of being automated.[38]

[38] *Lamb, C., Lo, M. 2017. "Automation Across the Nation: Understanding the potential impacts of technological trends across Canada" The Brookfield Institute for Innovation and Entrepreneurship. June 8.*

**Figure 6.5: Employment by Occupational Grouping in Northwestern Ontario**




**Health care and social services**

Health care and social services is one of the growing sectors of Northern Ontario's economy. An aging population has increased demand for health-care services. According to our estimates, demand for health care will increase by 30 to 40 per cent during the next two decades.[29] This sector also has a relatively low probability of automation. Brookfield Institute estimates that approximately 32 per cent of jobs in the health care sector in Canada have the potential of being automated.[40]

Employment in the health care and social services sector in Northeastern Ontario rose from 26,185 in 1991 to 37,070 in 2016—an increase of approximately 41.6 per cent. In Northwestern Ontario, employment in health care and social services rose from 12,135 to 17,770 during that period—an increase of approximately 46.4 per cent. Figure 6.6 shows the distribution of employment by task type and gender in Northern Ontario. Focusing on Northeastern Ontario, employment in non-routine cognitive occupations rose by 83.8 per cent between 1991 and 2016. The percentage of men employed in non-routine cognitive occupations rose from 67.6 per cent in 1991 to 74.4 per cent in 2016. Similarly, the share of women in the non-routine cognitive category rose from 51.4 per cent to 69.4 per cent during that period.

Routine occupations also experienced a growth rate of approximately 17.3 per cent but non-routine manual occupations experienced a decline of approximately 23.0 per cent. The majority of employees in the health care and social services sector in Northeastern Ontario are women. In fact, between 1991 and 2016, women's employment rose by 44.6 per cent compared to 30.9 per cent among men. The number of women employed in non-routine cognitive occupations rose by 94.9 per cent compared to 44.0 per cent among men. On the other hand, men's employment experienced a growth rate of 28.2 per cent in the routine occupation category compared to 16.3 per cent among women. The number of women employed in non-routine manual jobs declined by 25.2 per cent compared to 6.0 per cent among men. The share of men and women working in routine and non-routine manual occupations declined between 1991 and 2016.

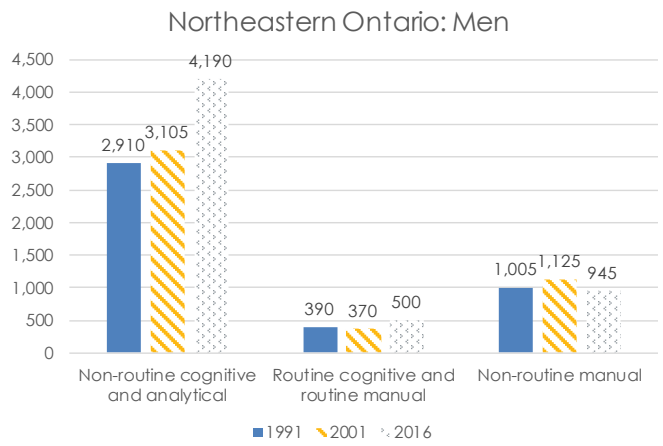
Focusing on Northwestern Ontario, employment in non-routine cognitive occupations rose by 95.2 per cent between 1991 and 2016. During that time, the share of men employed in non-routine cognitive occupations rose from 66.4 per cent to 72.8 per cent while the share of women in this category rose from 51.4 per cent to 70.9 per cent.

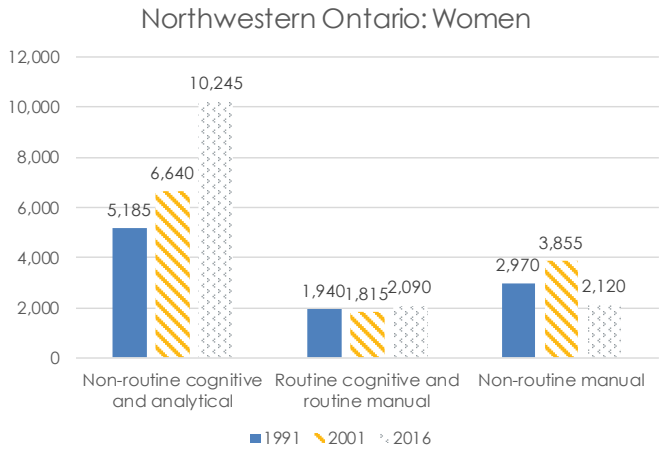
Routine occupations grew slightly by approximately 10.3 per cent and non-routine manual occupations experienced a decline of approximately 19.2 per cent. Between 1991 and 2016, women's employment rose by 43.2 per cent compared to 74.5 per cent among men. The number of women employed in non-routine cognitive occupations rose by 97.6 per cent compared to 91.4 per cent among men. On the other hand, men's employment experienced a growth rate of 35.0 per cent in the routine occupation category compared to 7.7 per cent among women. The number of women employed in non-routine manual jobs declined by 28.6 per cent while male employment rose by 43.8 per cent. The share of men and women working in routine and non-routine manual occupations declined between 1991 and 2016.

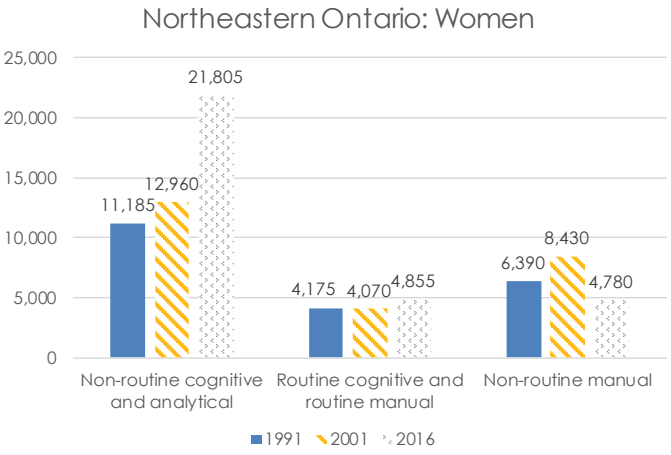
[39] *See Northern Projections, Human Capital Series district reports for Northern Policy Institute.*

[40] *Lamb, C., Lo, M. 2017. "Automation Across the Nation: Understanding the potential impacts of technological trends across Canada" The Brookfield Institute for Innovation and Entrepreneurship. June 8.*

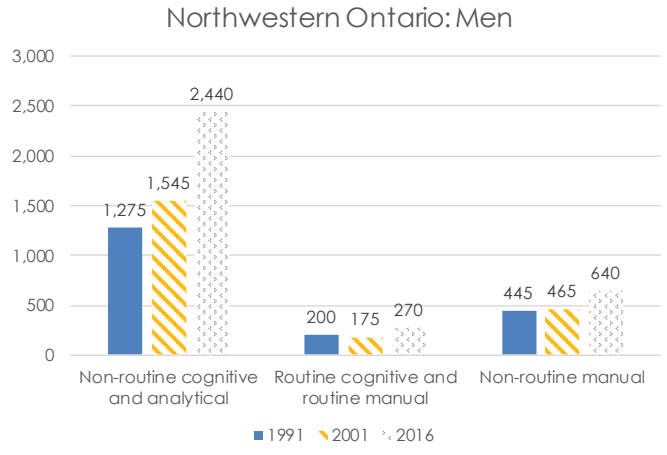
**Figure 6.6: Employment by Task Type in Health Care & Social Services Industries**

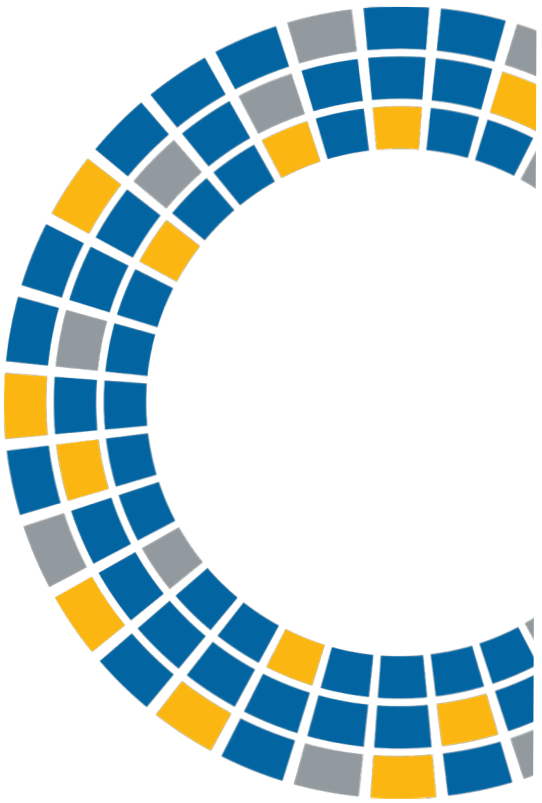



The above figures show that more than 84.8 per cent of health care and social services jobs are either in non-routine cognitive or non-routine manual occupations that are less susceptible to automation. In other words, employment in these industries can only grow as the population ages in the coming decades. Since these industries are financed from outside Northern Ontario, they act as export sectors and, in that capacity, they compensate for the loss of jobs in the primary and manufacturing industries.



**Education Services Industries**

Education services industries have been an important component of the economic base of many northern communities. However, aging population and declining enrolment have impacted the growth of these industries. In Northeastern Ontario, approximately 21,185 people were employed in education services industries in 1991. Total employment declined slightly to 19,470 in 2016. Table 6.3 shows the distribution of employment by teaching and non-teaching staff in Northeastern Ontario.

**Table 6.3: Employment in Education Services Sector in Northeastern Ontario**

| Employees (N.E.O.) | 1991 | 2001 | 2016 |
|---|---|---|---|
| Teachers, instructors, & professors | 11,685 | 10,460 | 9,555 |
| Other employees | 9,500 | 10,090 | 9,915 |
| Total employed | 21,185 | 20,550 | 19,470 |

Secondary and elementary school teachers and counsellors comprise the majority of employees in these industries. Their total employment in Northeastern Ontario declined from 9,865 in 1991 to 7,750 in 2016. The number of postsecondary instructors rose from 1,815 in 1991 to 1,845 in 2001 but declined to 1,805 in 2016.

Total employment in Northwestern Ontario rose from 8,520 in 1991 to 9,465 in 2016 (Table 6.4).

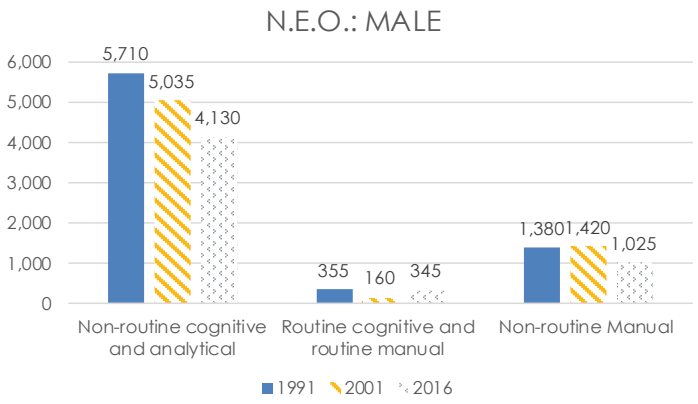
**Table 6.4: Employment in Education Services Sector in Northwestern Ontario**

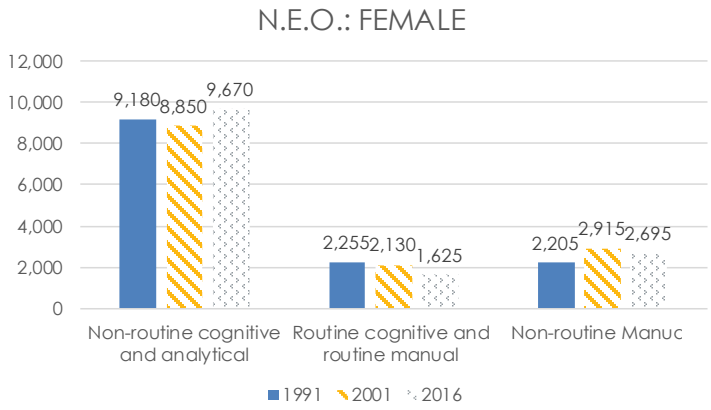
| Employees (N.W.O.) | 1991 | 2001 | 2016 |
|---|---|---|---|
| Teachers, instructors, & professors | 4,445 | 4,265 | 4,290 |
| Other employees | 4,075 | 4,945 | 5,175 |
| Total employed | 8,520 | 9,210 | 9,465 |

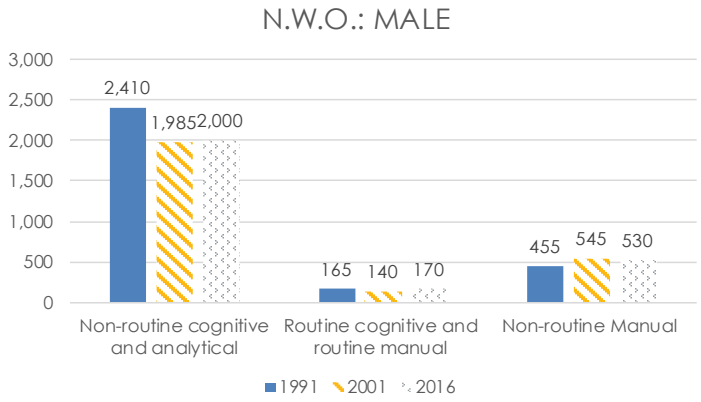
The number of secondary and elementary school teachers and counsellors declined from 3,665 in 1991 to 3,510 in 2016. The number of postsecondary instructors declined from 780 in 1991 to 670 in 2001 but rose to 780 in 2016.

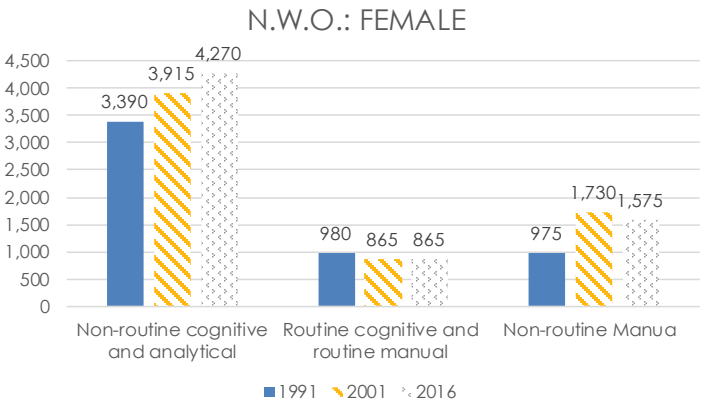
Figure 6.7 shows the distribution of employment by task type in education services sectors of Northern Ontario's economy.

**Figure 6.7: Distribution of Employment by Task Type in education services in Northern Ontario**




Total employment in non-routine cognitive occupations declined in Northeastern Ontario by 7.3 per cent, reflecting the decline in the teaching staff. The number of men employed in non-routine cognitive occupations declined by 27.7 per cent while the number of women rose by 5.3 per cent. Employment in the routine task category declined for men and women. Employment in non-routine manual occupations that primarily consist of elementary and secondary school teacher assistants (approximately 62 per cent) and cleaners (approximately 32 per cent) declined for men but rose for women.

Employment in the non-routine cognitive occupations in Northwestern Ontario rose by 8.1 per cent. The number of men employed in those occupations declined by 17.0 per cent between 1991 and 2016 while the number of women employed rose by 26.0 per cent. Employment of men in routine occupations stayed relatively constant while the rate declined by 11.7 per cent among women. The number of men employed in non-routine manual occupations rose by 16.5 per cent while the number of women rose by 61.5 per cent.

It is important to note that approximately 88.6 per cent of employment in the education services sector is in non-routine task categories and thus is not susceptible to automation. Brookfield Institute estimates that the potential for automation in the education services sector of the Canadian economy is approximately 30 per cent, which is considered low.[41]

[41] *Lamb, C., Lo, M. 2017. "Automation Across the Nation: Understanding the potential impacts of technological trends across Canada" The Brookfield Institute for Innovation and Entrepreneurship. June 8.*

# Part VII: How Vulnerable is Northern Ontario to Automation?

Table 7.1 shows total employment in various sectors of Northern Ontario's economy in 2016. In order to estimate the percentage of jobs that are potentially at risk of automation in Northern Ontario, we have to classify employment into low- and high-risk categories depending on the share of tasks that can or cannot potentially be automated.

**Table 7.1: Employment by Industry in Northern Ontario in 2016**

| All Industry Categories | N.E.O. | N.W.O. |
|---|---|---|
| 11 Agriculture, forestry, fishing, & hunting | 3,670 | 2,380 |
| 21 Mining, quarrying, & oil & gas extraction | 14,260 | 3,020 |
| 22 Utilities | 2,340 | 1,175 |
| 23 Construction | 16,425 | 6,805 |
| 31-33 Manufacturing | 14,905 | 5,160 |
| 41 Wholesale trade | 5,485 | 1,965 |
| 44-45 Retail trade | 29,460 | 11,635 |
| 48-49 Transportation & warehousing | 10,410 | 5,225 |
| 51 Information & cultural industries | 2,935 | 1,565 |
| 52 Finance & insurance | 5,710 | 2,075 |
| 53 Real estate & rental & leasing | 2,970 | 1,025 |
| 54 Professional, scientific, & technical services | 8,920 | 3,840 |
| 55 Management of companies & enterprises | 110 | 30 |
| 56 Administrative & support, waste management, & remediation services | 8,940 | 2,625 |
| 61 Educational services | 19,490 | 9,455 |
| 62 Health care & social assistance | 37,075 | 17,785 |
| 71 Arts, entertainment, & recreation | 3,920 | 1,450 |
| 72 Accommodation & foodservices | 16,910 | 7,545 |
| 81 Other services (except public administration) | 9,480 | 4,040 |
| 91 Public administration | 17,905 | 9,280 |
| **Total employment** | **231,310** | **98,075** |

Using the Brookfield Institute's estimates of the probability of automation in each industry, Table 7.2 shows total employment in Northern Ontario in sectors with a low risk of automation. We define low risk if the potential for automation is less than 50 per cent.

Table 7.2 shows that 74.0 per cent of employment in Northeastern Ontario and 76.2 per cent in Northwestern Ontario are in sectors with relatively low potential for automation. More important, approximately 32.2 per cent and 37.2 per cent of jobs respectively in Northeastern and Northwestern Ontario are in education, health care, and public administration, which have very low potential for automation. As we saw above, the majority of jobs in education and health care sectors are in non-routine cognitive occupations that cannot be easily automated.

**Table 7.2: Employment in Industries with Low Potential for Automation**

| Low-risk Industries | N.E.O. | N.W.O. |
|---|---|---|
| 22 Utilities | 2,340 | 1,175 |
| 23 Construction | 16,425 | 6,805 |
| 41 Wholesale trade | 5,485 | 1,965 |
| 44-45 Retail trade | 29,460 | 11,635 |
| 51 Information & cultural industries | 2,935 | 1,565 |
| 52 Finance & insurance | 5,710 | 2,075 |
| 53 Real estate & rental & leasing | 2,970 | 1,025 |
| 54 Professional, scientific, & technical services | 8,920 | 3,840 |
| 55 Management of companies & enterprises | 110 | 30 |
| 56 Administrative & support, waste management, & remediation services | 8,940 | 2,625 |
| 61 Educational services | 19,490 | 9,455 |
| 62 Health care & social assistance | 37,075 | 17,785 |
| 71 Arts, entertainment, & recreation | 3,920 | 1,450 |
| 81 Other services (except public administration) | 9,480 | 4,040 |
| 91 Public administration | 17,905 | 9,280 |
| **Total employment** | **171,165** | **74,750** |
| **Share of total employment** | **74.0** | **76.2** |

Table 7.3 shows employment in the sectors that have high potential for automation. These industries account for approximately 26.0 per cent and 23.8 per cent respectively of total employment in Northeastern and Northwestern Ontario. Using the probability of automation, we estimate the potential job losses to equal 36,434 in Northeastern Ontario and 14,349 in Northwestern Ontario. This represents approximately 15.0 per cent of total employment in Northern Ontario regions. The majority of job losses are expected in the accommodation and foodservices industries.

**Table 7.3: Employment in Industries with High Potential for Automation**

| High-risk Industries | N.E.O. | N.W.O. |
|---|---|---|
| 11 Agriculture, forestry, fishing, & hunting | 3,670 | 2,380 |
| 21 Mining, quarrying, & oil & gas extraction | 14,260 | 3,020 |
| 31-33 Manufacturing | 14,905 | 5,160 |
| 48-49 Transportation & warehousing | 10,410 | 5,225 |
| 72 Accommodation & foodservices | 16,910 | 7,545 |
| **Total employment** | **60,155** | **23,330** |
| **Share of employment** | **26.0** | **23.8** |

It must be mentioned that the potential for automation does not necessarily mean that those jobs will be automated. In general, it is unlikely that all occupations in the high-risk category will be replaced by smart machines in the near future. Automation is a gradual process and responds to shifting demand from low-skilled to high-skilled tasks and occupations in the economy. Therefore, regions like Northern Ontario can invest in development of skills to moderate the effect of technological change on the level of employment. In other words, there is room for public policy to take advantage of automation rather than falling victim to it. We address some aspects of this in the next part of the study.

# Part VIII: Looking Ahead

The conventional view influenced by the experiences of past industrial revolutions is that automation and technological innovation are desirable as they increase productivity and income and lead to economic growth (Miller and Atkinson 2013). However, automation reduces demand for workers whose tasks can be automated and increases demand for those with higher skills. In the age of globalization, there is no guarantee that the new higher skilled occupations will be generated where job losses have occurred. Some economists worry that the current speed of automation can indeed destroy old jobs faster than new ones can be created.[42] The objective of the present report has been to examine the structure of the employed workforce in Northern Ontario and classify jobs into those that are less susceptible to automation and those that can potentially be automated. The report not only examines the impact of automation on employment but also on income distribution in the region. We examined the effect of technological change on various goods-producing and service-producing sectors of the regional economy and compared those with national and provincial trends. We examined job and earnings polarization in regional and national economies. We found that employment and income in the segment of the population usually identified as the middle class have declined during the past three decades. The middle and lower distributions of earnings experienced no or negative growth while the top percentile experienced significant growth.

The majority of job losses have been in occupations involving routine tasks such as retail salespersons and cashiers that required a lower level of education and skills. Employment in occupations involving non-routine cognitive tasks have indeed increased in all regions. The study finds that approximately 75 per cent of jobs in Northern Ontario are at low risk of automation. We also saw that jobs in the education and health care sectors are mostly in non-routine cognitive categories that are at very low risk of automation.

We saw that the forest-based industries that have traditionally been an important vehicle of economic growth in Northern Ontario have experienced significant job losses. As most of the employment in those sectors has been in routine tasks categories, the prospect of those industries' share of employment rising to the levels seen in the past is very slim. On the other hand, forest resources represent important renewable natural resources in Northern Ontario. However, the state of the industry and market conditions preclude the modernization of pulp and paper facilities. The service sector to the forestry industry has declined significantly since 2008 and will likely atrophy more without a resurgence in market demand.

*[42] See Krugman (2013); Levy and Murnane (2004); and Sirkin, Zinser and Hohner (2011).*

It is unlikely that market share will increase for Northern Ontario in proportion to global demand. Other jurisdictions with vibrant forestry employment will optimize automation and technology advances to the detriment of Northern Ontario. There is a need for public policy to stimulate investment in the region's forest-based industries.

The study shows that the mining sector has significant potential for future job creation as the Ring of Fire is getting closer to operation. Northern Ontario's mineral reserves will play an important role in the region's future economic development as they have the potential to create many high paying jobs. Development of the Ring of Fire will increase demand for skills well above the regional supply as most tradespeople are close to retirement in northern regions.[43] Thus, many migrant workers will be employed at the site. The northern Indigenous population will be the primary beneficiary of jobs in the initial stages of development. However, given the relatively low levels of educational achievement among the northern Indigenous workforce, the prospect of benefiting from later stages of development is slim.[44]

There is a need for educational institutions, including primary, secondary, and technical schools as well as apprenticeship programs, to prepare the regional workforce for the changing employment environment, shifting from routine task training to occupations involving non-routine cognitive tasks. Unfortunately, the current education system appears to be lagging behind the innovations and changing nature of the labour market and demand for skills.[45] The Conference Board of Canada reports that 55 per cent of Canadian adults do not have proficient numeracy skills.[46] Education institutions, including primary and secondary schools, must prepare students with the necessary mathematics and science skills required for the increasingly high-skill job environment. The education system needs to be more responsive to changes in the labour market. At the same time, labour market information must be readily available to students so they can make informed decisions on their paths to the workforce.

*[43] See Northern Projections, Human Capital Series district reports for Northern Policy Institute.*

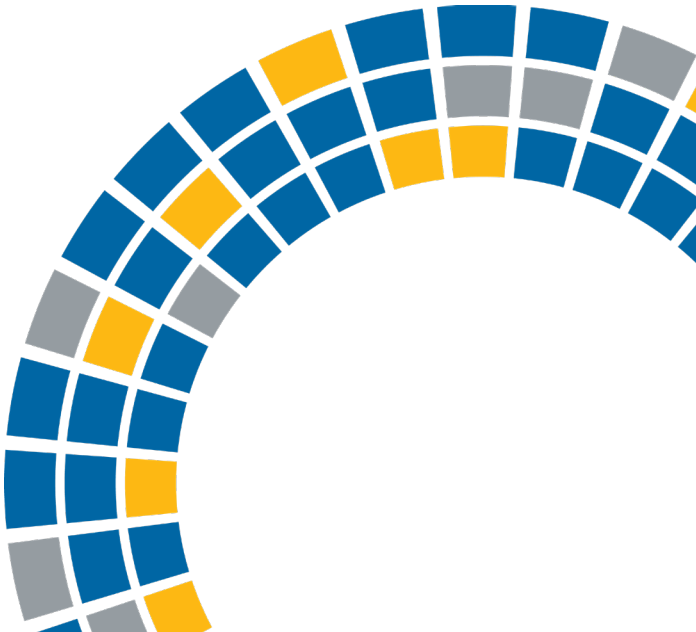
*[44] The low level of educational achievement among the Indigenous population is partly due to the years of underfunding primary and secondary education in Northern Ontario's Indigenous communities. See "Federal Spending on Primary and Secondary Education on First Nations Reserves" Office of the Parliamentary Budget Officer, December 6th, 2016.*

*[45] Michelle Weise's study surveyed youth, education providers, and employers in nine countries. The study reveals that although 72 per cent of higher education institutions believe they prepare their students for the labour market, approximately 50 per cent of students are not sure if their education improves their likelihood of finding employment. There appears to be a disconnect between education providers and the labour market, as only 11 per cent of business leaders strongly agree that students have the vital skills for the labour market.*

The cost of postsecondary education has risen significantly in recent years.[47] On the other hand, the real value of that education is questioned as employers have difficulty finding qualified candidates.[48] There is a need for governments and educational institutions, including primary and secondary schools, to ensure that our youth not only receive the type of skills that are needed in the workplace but also make higher education more affordable.

There is also a role for public policy in preparing employers and employees for an increasingly changing labour market environment. There is a need for policies that encourage employers to improve the skills of their employees. This would happen if employers do not have to bear the full cost of retraining employees. In fact, some policies along those lines already are in place in Canada.[49]

In conclusion, technological change is inevitable and will have a significant impact on the labour market environment in Northern Ontario and Canada. This process will destroy jobs involving routine tasks and generate others that tend to require highly skilled workers who are more difficult to replace with robots. The challenge is to ensure that our students are trained adequately for the future working environment.



[46] *Canada 2020. 2017. "Towards an inclusive innovative Canada." Volume 1, Canada 2020.*

[47] *The average tuition in an undergraduate program in Canada rose from approximately $4,400 in 2006-2007 to approximately $6,373 in 2016-2017—an increase of approximately 44.8 per cent, or 4.5 per cent per year. This is significantly greater than the inflation rate during the same period, implying that the real cost of education has also risen during the above period.*

[48] *Author's survey of employers in Northern Ontario shows that many employers have difficulty finding qualified employees. This appears to be the case in the rest of Canada as well.*

[49] *For example, the Canada Job Grant (CJG) program offers financial incentives to employers to provide training (through an eligible third-party trainer) to improve employees' skills. The employers identify the training their workers need and the cost is shared by employer and the public. This policy is being expanded through two new initiatives in Ontario. The first program, Upskill, funds partnerships to develop sector-specific training programs for essential and technical skills. The second program, Customized Training, encourages employers to develop firm-specific training programs in partnership with third-party trainers.*

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# Appendix I: Occupation Group:

**Non-routine cognitive and analytical:**

A0: Senior management occupations

A1: Specialist managers

A2: Managers in retail trade, food, and accommodation services

A3: Other managers

B0: Professional occupations in business and finance

B1: Finance and insurance administration occupations

C0: Professional occupations in natural and applied sciences

C1: Technical occupations related to natural and applied sciences

D0: Professional occupations in health

D1: Nurse supervisors and registered nurses

D2: Technical and related occupations in health

D3: Assisting occupations in support of health services

E0: Judges, lawyers, psychologists, social workers, ministers of religion, and policy and program officers

E1: Teachers and professors

E2: Paralegals, social services workers, and occupations in education and religion

F0: Professional occupations in arts and culture

F1: Technical occupations in arts, culture, recreation, and sport

G0: Sales and service supervisors

G1: Wholesale, technical, insurance, real estate sales specialists, and retail, wholesale and grain buyers

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B2: Secretaries

B3: Administrative and regulatory occupations

B4: Clerical supervisors

B5: Clerical occupations

G2: Retail salespersons and salesclerks

G3: Cashiers

H8: Trades helpers, construction and transportation labourers, and related occupations

I0: Occupations unique to agriculture excluding labourers

I1: Occupations unique to forestry operations, mining, oil and gas extraction, and fishing, excluding labourers

H2: Stationary engineers, power station operators and electrical trades, and telecommunications operations

H3: Machinists, metal forming, shaping, and erecting occupations

H4: Mechanics

H5: Other trades

H6: Heavy equipment and crane operators, including drillers

H7: Transportation equipment operators and related workers, excluding labourers

I2: Primary production labourers

J0: Supervisors in Manufacturing

J1: Machine operators in Manufacturing

J2: Assemblers in manufacturing

J3: Labourers in processing, manufacturing, and utilities

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D3: Assisting occupations in support of health services

G8: Childcare and home support workers

G4: Chefs and cooks

G5: Occupations in food and beverage services

G6: Occupations in protective services

G7: Occupations in travel and accommodation, including attendants in recreation and sport

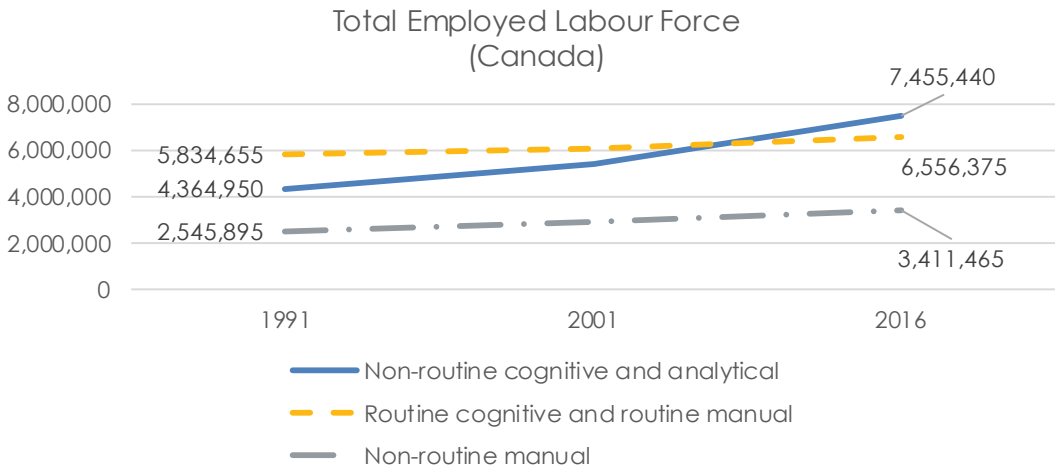
G8: Childcare and home support workers

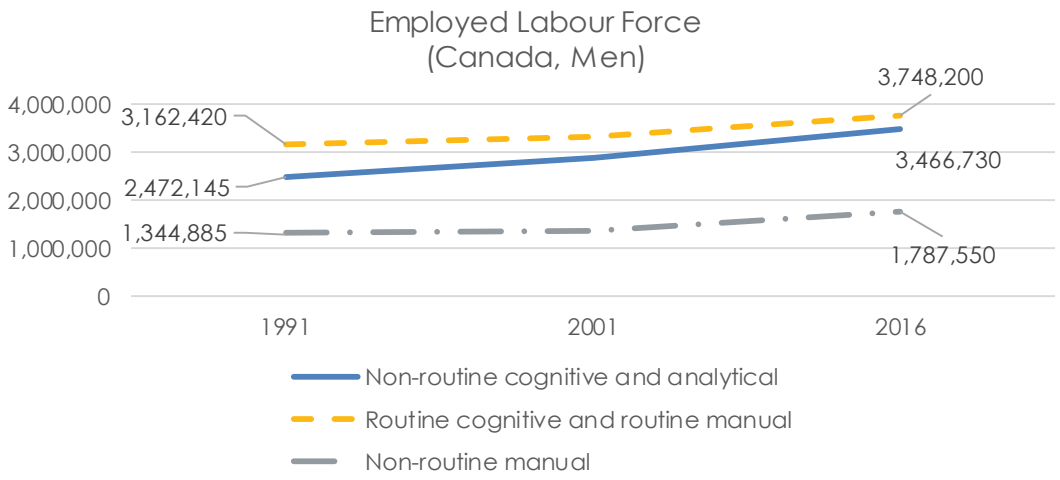
G9: Sales and service occupations

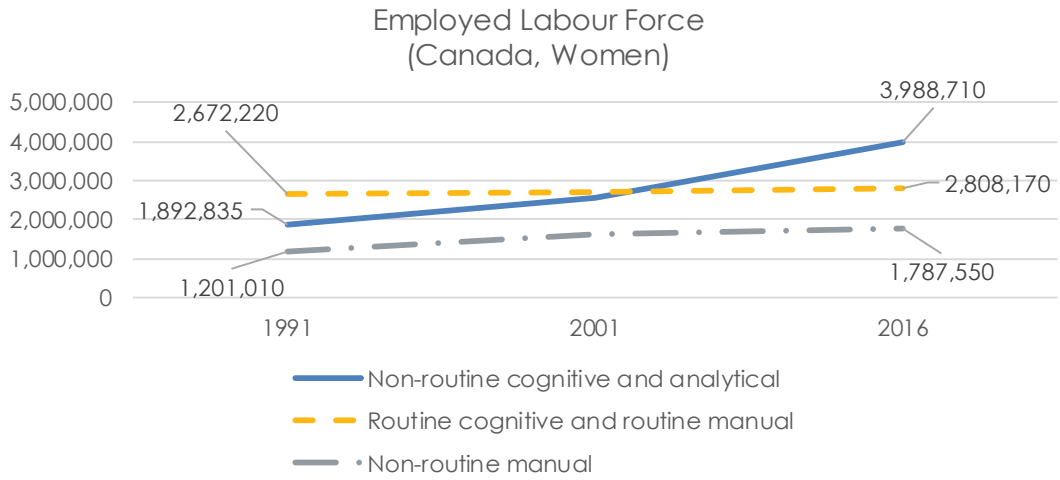
H0: Contractors and supervisors in trades and transportation

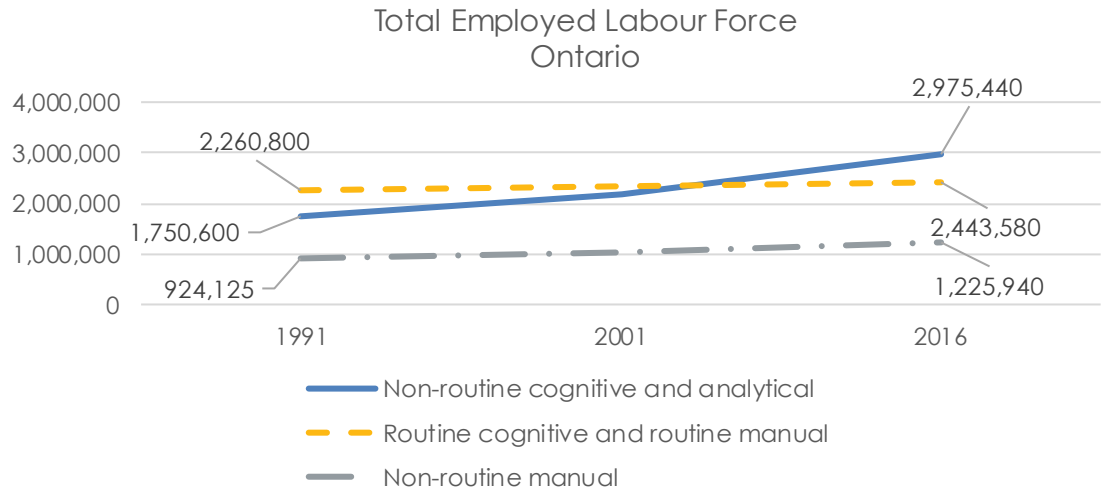
H1: Construction trades

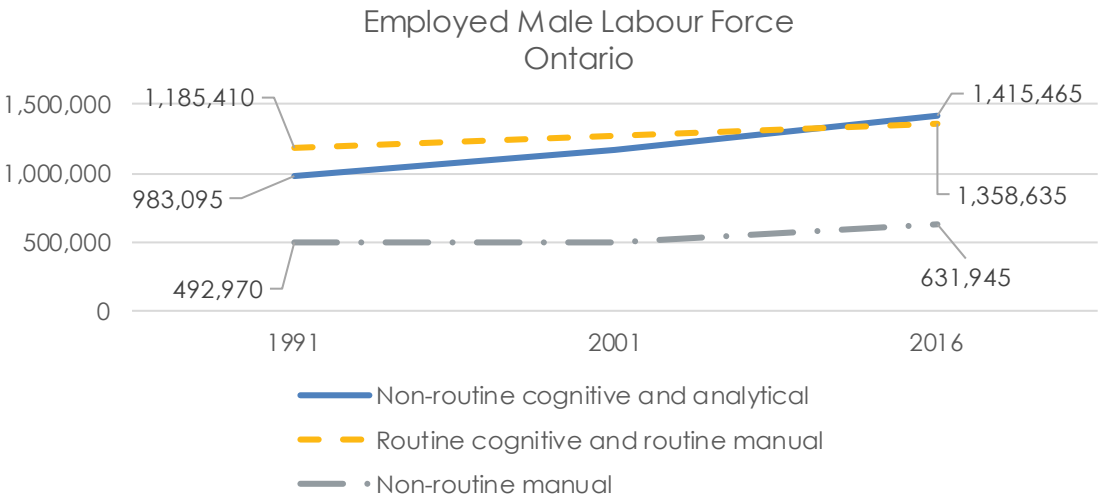
# Appendix II: Total Employment by Occupation Group

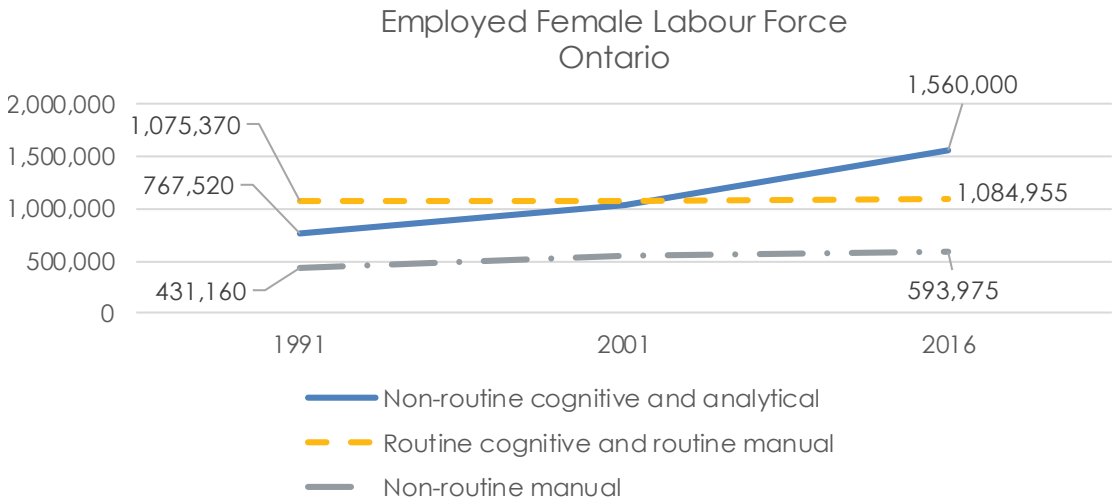


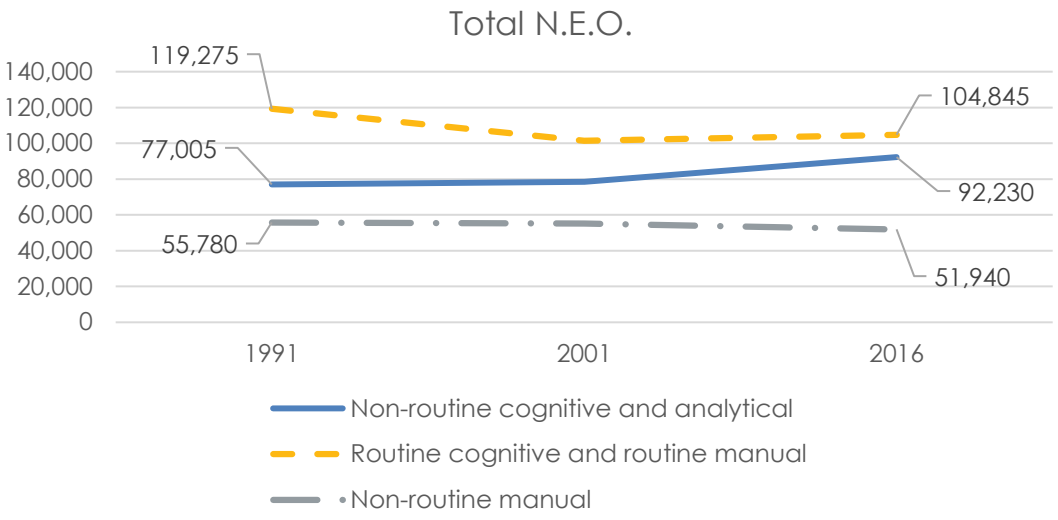



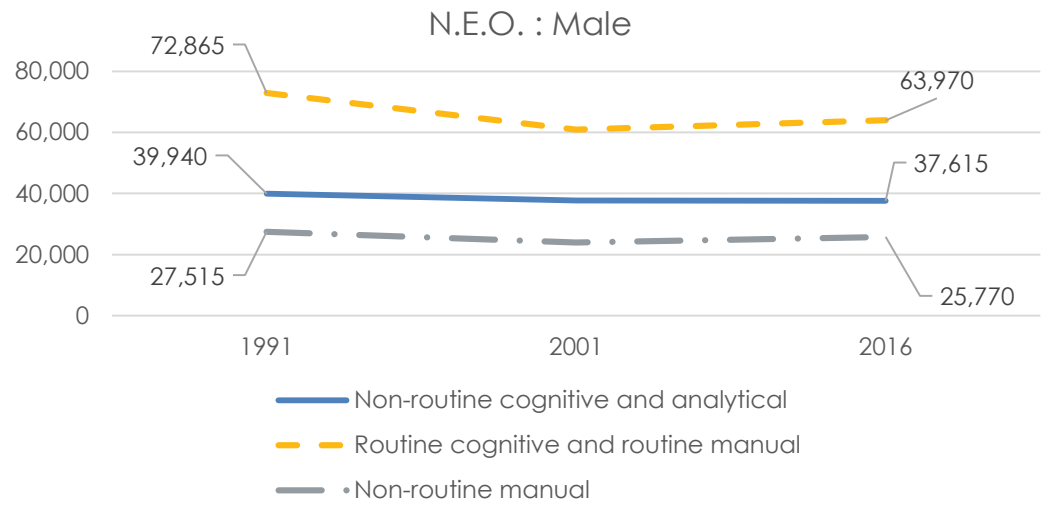



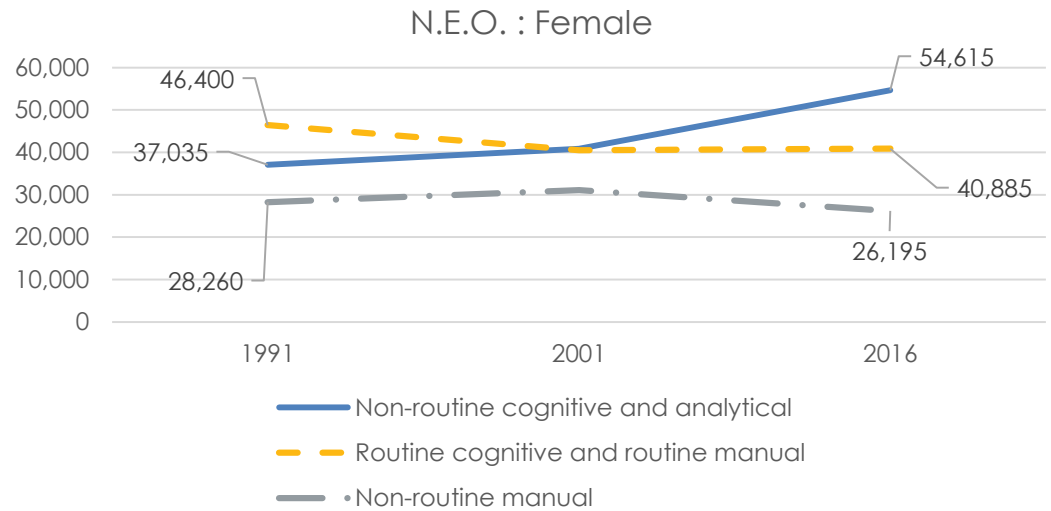

Total Employed Labour Force
Ontario
4,000,000
3,000,000
2,000,000
1,000,000
0
2,260,800
2,975,440
1,750,600
2,443,580
924,125
1,225,940
1991
2001
2016
Non-routine cognitive and analytical
Routine cognitive and routine manual
Non-routine manual

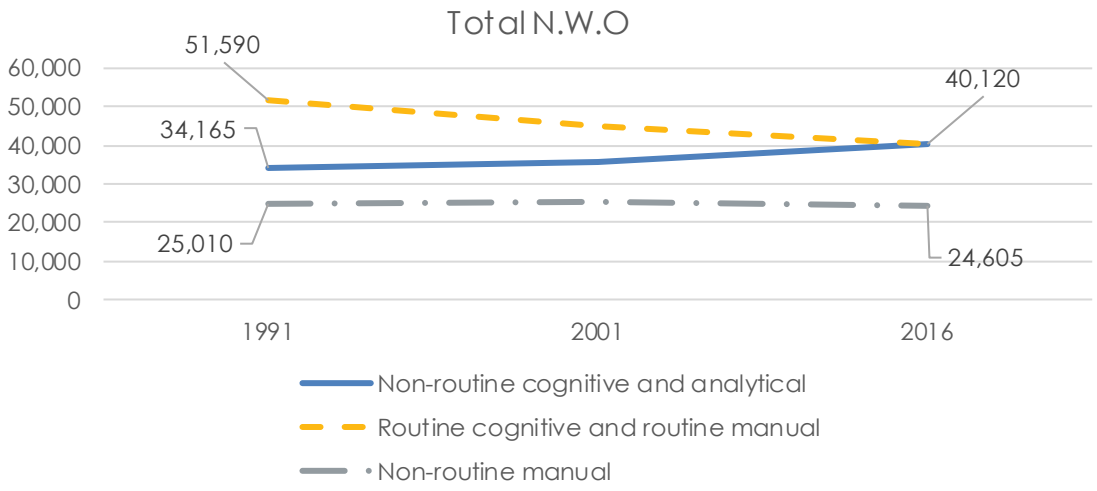

Employed Male Labour Force
Ontario
1,500,000
1,000,000
500,000
0
1,185,410
1,415,465
983,095
1,358,635
492,970
631,945
1991
2001
2016
Non-routine cognitive and analytical
Routine cognitive and routine manual
Non-routine manual

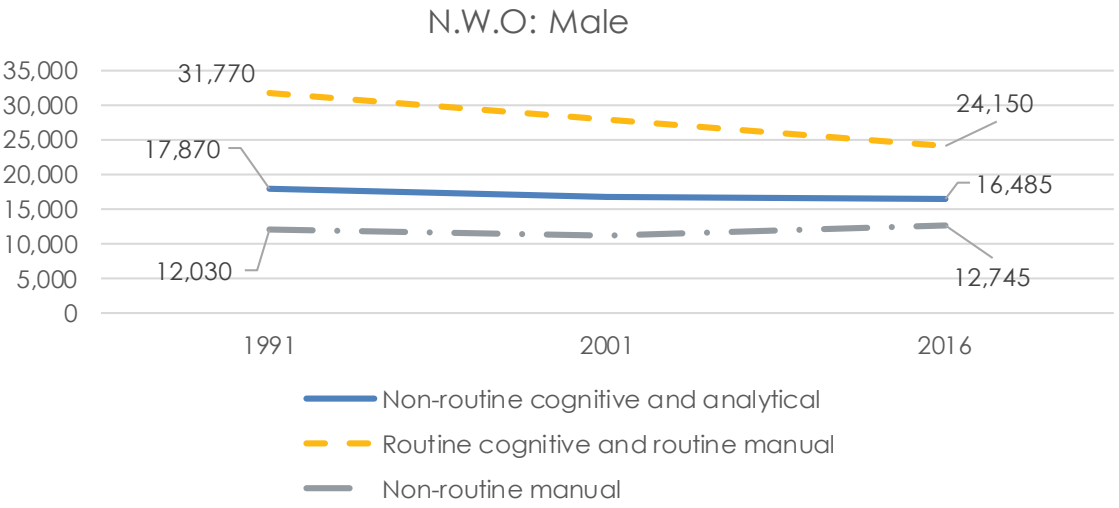

Employed Female Labour Force
Ontario
2,000,000
1,500,000
1,000,000
500,000
0
1,075,370
1,560,000
767,520
1,084,955
431,160
593,975
1991
2001
2016
Non-routine cognitive and analytical
Routine cognitive and routine manual
Non-routine manual

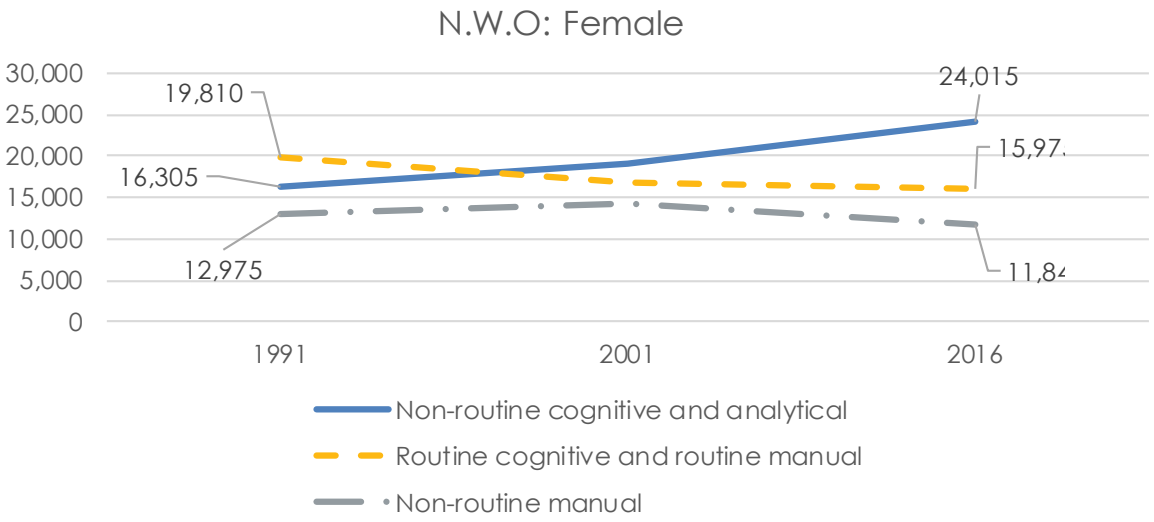

Total N.E.O.
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
119,275
104,845
77,005
92,230
55,780
51,940
1991
2001
2016
Non-routine cognitive and analytical
Routine cognitive and routine manual
Non-routine manual


N.E.O. : Male
80,000
60,000
40,000
20,000
0
72,865
63,970
39,940
37,615
27,515
25,770
1991
2001
2016
Non-routine cognitive and analytical
Routine cognitive and routine manual
Non-routine manual


N.E.O. : Female
60,000
50,000
40,000
30,000
20,000
10,000
0
46,400
54,615
37,035
40,885
28,260
26,195
1991
2001
2016
Non-routine cognitive and analytical
Routine cognitive and routine manual
Non-routine manual


Total N.W.O
51,590
40,120
34,165
25,010
24,605
60,000
50,000
40,000
30,000
20,000
10,000
0
1991
2001
2016
Non-routine cognitive and analytical
Routine cognitive and routine manual
Non-routine manual


N.W.O: Male
31,770
24,150
17,870
16,485
12,030
12,745
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1991
2001
2016
Non-routine cognitive and analytical
Routine cognitive and routine manual
Non-routine manual


N.W.O: Female
19,810
24,015
16,305
15,97.
12,975
11,84
30,000
25,000
20,000
15,000
10,000
5,000
0
1991
2001
2016
Non-routine cognitive and analytical
Routine cognitive and routine manual
Non-routine manual

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