CONSEIL DE L'INFORMATION SUR LE MARCHÉ DU TRAVAIL

LMICIMT

LABOUR MARKET INFORMATION COUNCIL

Annotated Bibliography

Future of Work

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The following is an annotated bibliography of reports on the future of work, produced by the Labour Market Information Council (LMIC). The annotated reports are from a variety of sources, with an emphasis on Canadian reports.
To ensure relevance, LMIC focused on reports that were produced within the last decade, with some exceptions where warranted.

LMIC is pleased to share this contribution with stakeholders and partners in the Canadian labour market sector. For more information on LMIC's work, please consult LMIC's Strategic Plan at lmic-cimt.ca.

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Advisory Council on Economic Growth. (2017). *Learning Nation: Equipping Canada's Workforce with Skills for the Future*. Government of Canada.

[PDF-ENG] [PDF-FR]

The report assesses 18 sectors and calculates the percentage of work activities that could be automated by 2030 and the percentage that can be automated at present in each sector. Using data from ESDC, they list the 10 fastest growing[1] and 10 fastest declining occupations[2] for the period 2015-2024. Further, by 2030 automation and technology-related changes in existing occupations will account for more than 10% of Canadian job losses. Canada's labour training schemes are not sufficiently robust to withstand the expected disruptions of technological change.

It is further argued that annual expenditure on training and post-secondary education for working Canadians will need to increase by approximately $15 billion to ensure Canadians benefit from new opportunities created by technological advancements. The report calls for a new federally-governed Canada Lifelong Learning Fund (CLLF) to help reduce the financial barriers to continuing training for adults and transforming the government's employment centres into hubs of hands-on career guidance not only for the unemployed but also for working adults and employers.

Alexander, C. (2016). *Job One is Jobs: Workers Need Better Policy Support and Stronger Skills*. C.D. Howe Institute. 2 February.

[PDF]

The report suggests that between 2000 and 2015 Canada experienced a noticeable increase in precarious employment. Moreover, long-term has unemployment increased from 6.9% in 2008 to 13.4% in 2014. It argues that these twin problems can be eased by reducing inefficiencies in the labour market through 4 policy measures: (1) better support for displaced workers; (2) an increase in detailed and accessible labour market data; (3) upskilling of workers; and, (4) removal of barriers to labour market entry for newly landed immigrants though increased investments in language-training programmes. Specifically, EI should be reformed. The report proposes uniform, Canada-wide rules of EI access and that any region-specific adjustments should be implemented by provincial governments.

[1] Specialist physicians, Database analysts and data administrators, General practitioners and family physicians, Chefs, Computer and information systems managers, Nursing co-ordinators and supervisors, Physiotherapists, Information systems analysts and consultants, Computer engineers (except software engineers), Social and community service workers

[2] Printing equipment operators, Papermaking and processing machine operators, Managers in communication, Other sales related occupations, Industrial sewing machine operators, Printing press operators, Electronic service technicians, Service station attendants, Administrative assistants, Fishing vessel masters and fishermen

AON Hewitt and Business Council of Canada. (2016). *Developing Canada's future workforce: a survey of large private-sector employers*. March.

[PDF]

Ninety of the top private employers in Canada were asked to complete an online survey. Participants include only key HR personnel such as chief HR officers, HR vice presidents, directors of HR and HR managers. Respondents came from across Canada and from different industries that collectively have more than 800,000 employees. The survey focused on key areas such as critical skills, skills shortages, and partnerships between private organizations and post-secondary institutions. The main finding is that firms are recruiting candidates with soft skills because these non-cognitive skills are crucial to identify future leaders. The surveyed firms report that although post-secondary graduates are sufficiently equipped to enter the labour market, expectations are changing fast for graduates. The report argues that more collaboration is required between the private sector and post-secondary institutions. Most respondents believe that their firms are well-equipped to manage the effects of an ageing population.

Arntz, M., Gregory, T. & Zierahn, U. (2017). "Revisiting the risk of automation." *Economic Letters*. 159. July: 157-160.

[HTML]

Arntz et al. (2017) argue that current methods to calculate the share of automatable jobs yield results that overestimate the true figure because they do not account for the heterogeneity of tasks within occupations nor the adaptability of jobs in the digital transformation. They suggest an alternative task-based approach using data from the Survey of Adult Skills. Correcting for heterogeneity across workplaces in the US labour market, the authors find that the risk of automatability drops from 38% to 9%. Furthermore, they determine that occupations that are predominantly based on the exchange of information or those that are hands-on, will be impacted most.

Arntz, M., Gregory T. & Zierahn, U. (2016). "The Risk of Automation for Jobs in OECD Countries", *OECD Social, Employment, and Migration Working Papers*, no. 189.

[PDF]

This report applies a task-based approach to estimate the automatability of jobs in 21 OECD countries. Previous attempts to assess the risk of automatability equated risk with occupational loss; however, this need not be the case. Even high-risk jobs, for example, have some tasks that cannot be automated. To account for this, this paper instead focuses on assessing the automatability of tasks within an occupation. Accordingly, only 9% of jobs on average are determined to be highly automatable, which is significantly less than the 47% that has been estimated via the occupation-based approach (e.g., Frey and Osborne, 2013). The report concludes that automation and digitalisation will not result in large job losses for two main reasons. First, the introduction of technology in the workplace is a slow process; there are legal, social, and economic obligations that must first be met. Second, technology can create new job opportunities as well.

Balliester, T., and Elsheikhi, A. (2018). *Future of Work: A Literature Review.* International Labour Organisation. Working Paper no. 29.

[PDF]

This report conducts a systematic review of 254 studies on the future of work. 33% of the studies were from intergovernmental organizations or government agencies, 19% from think tanks, 32% academics, 8% from both private institutions and media. Of the 254 studies, 48% focused on developed countries, 13.6% on only developing countries and 38.4% focused on both developed and developing countries. In addition to the impact of technology (such as artificial intelligence and robotics) on the labour market, the review highlights broader economic factors that influence labour outcomes for the future of work and include socio-economic, geopolitical and demographic drivers.

The report finds both developed and developing countries are at risk of job losses due to automation. Many studies suggest that there is expected to be job gains in engineering, computer and mathematics driven largely by the IT, healthcare and the renewable energy sectors. However, other research finds that the impact of technological advancement in AI, genetics and robotics will have only a marginal beneficial effects on the labour market.

Emerging business models indicate that there is likely to be an increase in temporary and flexible employment, reduction in wages, greater prevalence of job insecurity and a reduction in social safety net protections. Although there is a rise in non-standard employment, this also creates an opportunity for marginalized workers to enter the labour force.

The future of work literature only loosely addresses wage growth,but highlights that increasing inequality can be attributed to superstar firms and globalization. Wage distribution for developed countries, job polarization, decreases in unionisation, income inequality, online platforms and de-globalization could have negative effects on wage distribution.

Bélanger, A., & Bastien, N. (2013). "The Future Composition of the Canadian Labor Force: A Microsimulation Projection". *Population and Development Review*. 39(3).

[HTML]

Using micro simulation projection model, the labour force is projected up to 2031 based on five scenarios assessing labour shortage concerns, ethno-cultural and educational composition of the labour force and participation rates. The demographic mechanisms which will affect the size and composition of the labour are assessed in detail along with the impact on labour force growth and participation rates based on varying levels of immigration.

Three alternative assumptions are made regarding future participation rates:

1. Extrapolation of trends observed between 1999-2008;
2. Age and education-specific activity remains constant at 2010 levels ("constant participation rate"); and,
3. No differentials in labour force participation rates between immigrants and ethno-cultural groups.

Based on these three assumptions, five scenarios are generated. The first three scenarios adopt the first assumption and allow the overall population growth rate to vary (high, low, and medium growth).

The fourth and fifth scenarios use the medium population growth assumption, and apply the second and third assumptions listed above, respectively.

Immigration is found to be the main growth driver of the working-age population over the projected period. Other demographic drivers had impact on labour force size but little impact on labour force participation rates. The projected labour force will be older, with higher number of foreign born and visible minority workers, and expansion of Canadian-born workers. In terms of education, the share of degree-holders in the labour force will double between 2006 and 2031, from 22% to 44%.

Culbertson, D. (2017). *Canadian Millennials Less Interested in Jobs at Threat from Automation* Indeed.com Blog.

[HTML]

This article investigates the difference of occupational preferences among Baby Boomers (ages 53-71), Generation X (ages 37-52), and Millennials (ages 20-36 in 2017) in Canada. It finds that Millennials have the least interest in routine manual occupations and the most interest in higher-skilled and non-routine occupations that are least susceptible to automation. On the contrary, the older generations show greater interests in routine-based jobs that will face a higher risk of being replaced by automation. To arrive at these conclusions the author uses data from September 2016 to March 2017 of job seekers' use of Indeed.com postings. Job seeker interest is measured as a share of the volume of clicks on job postings for a particular occupation. The analysis is based on four occupational classifications: non-routine cognitive, routine cognitive, non-routine manual, and routine manual occupations.

Deloitte. (2017). *The Intelligence Revolution: Future-proofing Canada's workforce*.

[PDF-ENG] [PDF-FR]

The study reports that the intelligence Revolution will be driven by three factors: (1) exponential change in machine learning, (2) free data storage and (3) increasing computational power. These changes will lead to job losses but the effect may be more limited than is often feared. The report concludes that "the amount of work will increase but the capabilities needed to perform it will change." The report posits eight archetypes defined by their "future-proofed" skills. Within each archetype category fall multiple occupations – some of which are at high-risk and others low-risk of being lost to automation. The typology is summarized in the table below.

Archetype	Future-proofed capabilities	High risk of automation	Low risk of automation	Potential job growth
Protector	Social awareness and judgment.	Medical laboratory assistant, security guards and pharmacists.	Police officer, family doctor and speech/language pathologist.	Geronto-kinesiologist, tele-nurse and end-of-life therapist.
Innovator	Competitive edge, judgment and execution.	none	Aerospace engineer, AI designer, University professor and Game developer.	Startup specialist,

				Continuous improvement agent and Mechatronics engineer.
Influencer	Influence, inspirational leadership and competitive edge.	Administrative service managers.	Leader in financial technology, coach and politician.	Online community manager and incubator relationship manager.
Integrator	Collaboration, judgment and creativity	Executive assistant, Real estate agent and Railway traffic controller.	Journalist, Executive chef, Retail buyer and Teacher.	Networking specialist, Company culture ambassador and Simplicity expert.
Scorekeeper	Judgement, competitive edge and social awareness.	Paralegal, Auto Insurance brokers and Accountants.	Lawyer, Actuaries and Employment.	Curriculum standards manager, Big Data scientist and Cybersecurity analyst.
Performer	Creativity, Execution and Social Awareness.	Sports referee	Musician, Film producer, Professional athlete and Broadcaster.	Enhanced reality game/film producer, Vlogger (multi-media blogger) and Personal brand strategist.
Builder	Judgment and execution.	Line cook, Carpenter, Transport, Truck driver and Drycleaner	Car mechanic, Financial analyst and Oil field worker.	Urban farmer, AI developer, Auto-transport analyst and Robotics programmer.
Curator	Customer insight, Creativity and Social awareness.	Hotel front desk clerk, Travel guide and Customer service cashier.	Hairstylist/barber, Advertising manager, Outdoor sports and recreational guide.	Customer service psychologist and Customer experience strategist.

Engineers Canada. (2015). *Engineering Labour Market in Canada: Projections to 2025*. June.

[PDF-ENG] [PDF-FR]

The study provides supply and demand projections for 14 engineering occupations. It highlights a large and growing need to replace retiring engineers as they exit the workforce. This is particularly relevant for civil, mechanical, electrical and electronic engineers as well as computer engineers. In most of the occupations, international in-migration is expected to be high over the next five years. The report provides projections for supply and demand of 14 engineering occupations (by 4-digit NOC code) based on a workforce requirements approach. The study first tracks engineering graduates in each of the 14 fields for each province from 2000 to 2013 and then looks at two aggregate employment projections for each engineering occupation in each province over the 2015-19 and 2020-22 periods.

A labour market tightness ranking is generated for each occupation to give an overview of the relative risk across occupations for obtaining their estimated supply requirements. Rank 1 corresponds to excess supply and 2 represents normal market situation whereby employers can fulfill their employment needs through normal methods whereas rank 3 corresponds to excess demand during which employers need to make special efforts to attract normal workers.

The results suggest that most provinces will experience normal labour market tightness for the engineering occupations assessed in the future (i.e., rank 2 for civil engineers, mechanical engineers, electrical and electronic engineers, chemical engineers, industrial and manufacturing engineers, metallurgical and materials engineers, mining engineers, geological engineers, petroleum engineers, aerospace engineers, computer engineering, other engineers, engineering managers, and software engineers). Only a small number of provinces are expected to experience excess demand in certain years over the medium term.

ESDC (2018). *Canadian Occupational Projection System 2017 Projections: Industrial Summaries 2017-2026*.

[PDF-ENG] [PDF-FR]

This report presents a comprehensive analysis of the historical and future trends for all 42 industries defined in the Canadian Occupational Projection System (COPS). It includes analysis of challenges and opportunities, such as the impacts of new technologies, and a 10-year outlook for real GDP, employment and productivity.

The report covers occupational outcomes over the past ten years (2007-2016) and discusses the COPS projections for the next 10 years (2017-2026). Canada's employment growth rate declined sharply over 2007-2016, largely induced by rapid adoption of technology and lower demand for commodities following the economic downturn between 2006 and 2009. Although the employment growth rates of most industries are still declining, the rate of decline is slowing compared to the 2007-16 rates. It can also be observed that industries requiring low-wage workers such as food and accommodation services will face difficulties in attracting workers as they will have to compete with other higher-wage industries.

Further, there is a declining growth rate of labour supply which is causing a tightening in the labour market (demand greater than supply) in low-wage sectors. This will likely create challenges for these industries when competing with other employers to attract workers. As a result, these sectors will

face additional pressure to increase their productivity level by implementing, for example, new labour-saving technologies.

Fields, A., Uppal, S., & LaRochelle-Cote, S. (2017). *The impact of aging on labour market participation rates*. Statistics Canada. 14 June.

[PDF-ENG] [PDF-FR]

The study uses the Labour Force Survey to assess the extent to which an aging population has contributed to gradual decline in labour force participation rates in recent years in Canada. The authors use the Oaxaca-Blinder decomposition technique to analyze the joint impact of several compositional effects on the participation rate.

The main hypothesis is that an older workforce may lead to "extended periods of slow growth" as an older population requires more government support and leads to a shrinking tax base, fewer work hours, health problems and labour shortages. The findings show that fewer people are entering the labour force than exiting. The ratio of youths aged 15 to 24 to the 55-64 age group is 0.9 in 2016 which is below replacement. As illustrated by projections, this trend will continue over the next two decades.

The study specifically finds that the labour force participation rate among the age group 55 and over has increased from 1996 to 2016 (36% of the labour force belongs to the age group 55 and over in 2016). The factors leading to this increase are also explored in the study. The employment share of the age group 55 and over is expected to increase to 40% by 2026. Conversely, proportion of core-age workers (ages 25-54) is expected to decline to 46% by 2026.

Frey, C. B., and Osborne, M. A. (2013). *The Future of Employment: How Susceptible are Jobs to Computerisation?* 17 September.

[PDF]

The paper adopts a novel methodology to estimate the probability of the computerization for 702 occupations. The authors evaluate the potential impact of computerization on the labour market focusing on the number of jobs at risk, an occupations' likelihood of computerisation, and the relationship between wages and level of education. The study shows that recent developments in machine learning can put a significant proportion of occupations at risk of computerization in the next 10-20 years (about 47% of total US employment). The authors expect a technology plateau, as a slower pace of substituting computers for human labour which is caused by some engineering bottlenecks to computerization. They also provide some evidence that there is a strong negative relationship between the educational attainment and occupations' likelihood of computerization.

Green, D. A., and Sand, B. (2013). *Has the Canadian Labour Market Polarized?* November.

[PDF]

The paper uses Canadian Census and Labour Force Survey (LFS) data over the 1971-2012 period to investigate the impact of technological change on labour market polarization[3] in Canada. Since the discussion of polarization has been built mostly around US employment patterns, this study uses US Census data as a benchmark for the Canadian patterns. They analysed the nature of changes in employment by defining jobs in a comparable way across Census years. Then they rank occupations based on the average weekly wage of full-time workers.

The study proposes that the standard technological change model of job polarization for the US does not fit with the Canadian data. They show that job polarization exists in Canada but only in specific jurisdictions and it can mostly be attributed to the resource boom, not to technological change. The report highlights that although job polarization did occur in the 1980s and 1990s, and high- and low-paying occupations had higher employment growth relative to the middle-paying ones, the unbalanced employment growth has subsided since 2000. There is also evidence of increasing inequality as wages decreased for low-paying occupations relative to middle-paying occupations and for middle-paying occupations relative to high-paying occupations.

Hirshorn, R. (2011). *Impacts of Structural Changes in the Canadian Economy*. Industry Canada. Working Paper 2011-04.

[PDF-ENG] [PDF-FR]

This report examines structural changes in the Canadian labour market since mid-1970s, its relationship to changes in productivity, and the impact on jobs and labour compensation. Structural changes in the Canadian labour market can be clearly identified by looking at changes in labour shares in manufacturing and service industries. More specifically, over the 1976-79 to 2001-05 period labour use has significantly declined in the manufacturing industries, while it has increased in service industries. Given rapid productivity growth in the manufacturing sector, these labour shifts out of manufacturing raise concerns regarding labour compensation and improvement in standard of living.

Taking a closer look at changes in labour productivity using “shift-share" analysis suggests that most of the increase in labour productivity during the analyzed time period can be attributed to productivity growth within individual industries. Structural changes had a small but significant negative impact on productivity growth that was due to differences not in productivity levels but in productivity growth rates between industries that were gaining and losing labour share. The weak performance of the service sector was the primary drag on productivity growth, reducing "within industry" productivity growth and being the main factor behind the negative contribution of structural change to productivity growth. This has potentially serious implications for the Canadian economy which seems to have a dominant sector with a weak capacity for innovation and productivity growth.

Service sector jobs which have increased in importance differ in some significant respects from traditional manufacturing jobs. Service industries have a higher incidence of part-time and temporary

[3] “Job polarization occurs when the shares of employment accounted for by high-skill and low-skill jobs grow faster than the employment share accounted for by middle-skill jobs" (p. 2).

workers and make greater use of flexible work arrangements. The proportion of workers with at least a university degree is, on average, higher in services than in manufacturing.

In terms of labour compensation, the relatively weaker productivity growth in the service sector has also contributed to slower growth of real wages in this sector. However, similar to productivity results discussed above, structural changes do not seem have a significant negative impact on real wage growth rate, which confirms results found by other studies.

Hull, J. (2009). *Aboriginal Youth, Education, and Labour Market Outcomes*. Aboriginal Policy Research Consortium International (APRCi).

[PDF]

This report explores the potential of aboriginal populations in Canada in meeting future labour force challenges especially with respect to concerns surrounding population ageing as a policy alternative to immigration and retention of older workers. The aboriginal labour force is projected to grow much more rapidly than the general Canadian labour force with the former groups' 15-64 years age group increasing by 48% as opposed to the latter's increasing only by 18%.

By 2026, younger aboriginal population will be 37% larger than in 2001, whereas general Canadian younger population will be 6% larger. Around 125,000 aboriginal children are turning 15 every five years with more than 600,000 reaching working age in the 2001-2026 period. Although the proportion of aboriginal people in the national labour market is projected to be 5% in 2026, they hold significant shares in certain provincial labour markets namely Manitoba, Saskatchewan and Northern Canada.

Looking at the projected labour force growth, the Atlantic region and Saskatchewan would see the largest growth in the aboriginal share of the labour force. In fact, Saskatchewan would experience a decline in its labour force in the absence of the aboriginal population. There is a strong positive relationship between educational attainment and labour force participation of aboriginals which could have strong impacts on closing the employment gap between aboriginals and general Canadians.

International Labour Organization. (2018). *World Employment and Social Outlook 2018: Greening with jobs*.

[PDF-EN] [PDF-FR] *(résumé analytique)*

The long-term goal of the 2015 Paris Agreement is for the global mean temperature to be kept less than 2°C above pre-industrial levels. This ILO report estimates the net effects of this long-term goal on the number of jobs. Globally, adoption of sustainable practices toward a green economy will lead to 6 million job losses and the creation of 24 million jobs – a large net positive effect. This report includes five separate papers on the green economy, each using different datasets. The report discusses how the damage associated with climate change will destabilize working conditions. So that adoption of some health measures and social protection policies will help workers adapt to the changing environment.

OLS regression and input–output models have been used in this report. The report looks at the relationship between GDP and GHG emissions growth over 1995–2014 or latest year available by using data for various regions. They also estimate the relationship between total GHG emissions,

materials and resource extraction and land use over 2000–14 or latest year available. Then they investigate decoupling of production and consumption-based emissions in the countries and changes in labour market outcomes for coupled and decoupled countries over 1995–2014 and estimate working hours lost to heat stress under a specific scenario over 1995–2030.

The report also calculates the percentage difference in employment between the sustainable energy scenarios in different sectors and regions and present public employment programme components by region. They simulate the effects of social protection policies for a green economy for developed and developing countries. The GDP growth rate for non-green versus green scenarios are also simulated for selected countries.

Kim, Y., Kim, K., & Lee, S. (2018). "The rise of technological unemployment and its implications on the future macroeconomic landscape". *Futures*. March, 87: 1-9.

[HTML]

This article uses two- and three-state Markov chain models to predict the proportion of jobs that are susceptible to computerization. Expanding on the model used by Frey and Osborne (2003), Kim et al. (2018) incorporate the passage of time to account for the assumption that susceptibility is not fixed; jobs that are non-susceptible today may later become susceptible in the future, and vice versa. Simulations of various future employment situations indicate that the probability of switching between states (susceptible versus non-susceptible) is heavily influenced by external controls, such as government intervention. This suggests that public policy initiatives may be key to managing the effect of computerisation on future employment. Furthermore, it is shown that the rate of computerisation is equal to the difference between the proportion of susceptible jobs that stay susceptible and the non-susceptible jobs that switch. Therefore, policy initiatives should specifically target the latter ratio.

Kühn, S., Milasi, S., & Yoon, S. (2018). "Population Ageing and Future Labour Market Challenges", *World Employment and Social Outlook*, Chapter 4. International Labour Organization. January.

[HTML] [PDF]

This chapter identifies three consequences of a rapidly ageing population on the global labour market: (a) declining labour force growth rates, (b) changing patterns of savings and consumption, and (c) growing pressure on public social expenditures. Since older workers encounter unique problems and barriers to employment, addressing these issues is integral to the creation of favourable market outcomes. Older workers, for example, are less likely to receive on-the-job training, which limits job flexibility and employment options. They are also more prone to work-related physical injury and mental stress, contributing to premature exit from the labour force. These issues might be resolved through targeted efforts to offer continuing education, to improve working conditions, and to encourage a better work-life balance.

Kustec, S. (2012). *The role of migrant labour supply in the Canadian labour market*. Citizenship and Immigration Canada. June.

[PDF-EN] [PDF-FR]

This paper examines the implications of a slowing population growth and an ageing workforce for Canada's labour market. In the next decade, the annual labour force growth rate is estimated to decrease from 1.6% to 0.8%, while the proportion of workers over 55 years of age is expected to increase. Future projections of labour demand suggest a total of 4.4 million job vacancies due to retirements, deaths, and emigrations alone, compared to the 700,000 vacancies from expansion growth. One tool for meeting this predicted demand is through the use of immigrant workers. Currently, landed and non-landed immigrants, such as temporary foreign workers, comprise 22.9% of the total Canadian labour force. Although this figure is expected to increase in the next decade, the gains from Canadian-born workers still outweigh the gains from immigrant labour and is expected to remain so for the foreseeable future.

Lamb, C. (2016). *The Talented Mr. Robot. The impact of automation on Canada's workforce*. Brookfield Institute for Innovation + Entrepreneurship (BII+E).

[PDF]

This report concludes that Canadian jobs involving routine tasks are highly susceptible to automation, but that these jobs may not be eliminated only restructured. It estimates that 42% of the Canadian labour force is at high-risk of being affected by automation within the next 10 to 20 years. In addition, 42% of job tasks currently performed by Canadian workers are already automatable with existing technology. Although this does not imply these jobs will be lost *per se*, it does mean workers will need to acquire new skills to adapt to the changing job requirements. Low-education, low-skilled workers are at most risk of becoming unemployment. On the other hand, 36% of Canada's labour force is employed in high-skilled occupations with low risk of being affected by automation. These occupations are expected to produce 712,000 jobs over the next 2 decades, which provides opportunities for those willing and able to change careers.

Lamb, C., and Doyle, S. (2018). *Future-proof: Preparing young Canadians for the future of work*. Brookfield Institute for Innovation + Entrepreneurship (BII+E).

[PDF]

This report examines ways to help Canada's teenagers prepare for their future career development amidst the growth of automation. Most entry level jobs, which are likely to be replaced by automation, are staffed by younger workers. By equipping them with a wide range of technical and soft skills, such as digital literacy, entrepreneurship and social intelligence, young workers will be better suited to find work in the higher-skilled occupations not replaceable by automation. The report also suggests that employers provide relevant training programs to complement post-secondary education. Some general recommendations offered include the provision of timely labour market information, career planning services, and mentorship programs for youth entering into the labour force.

Lamb, C., and Lo, M. (2018). Automation Across the Nation: Understanding the potential impacts of technological trends across Canada. Brookfield Institute for Innovation + Entrepreneurship (BII+E).

[PDF]

Lambo and Lo examine the number of individuals employed in each industry in every Canadian Census Metropolitan Areas (CMAs) and Census Agglomeration (CA) to identify the proportion of work activities most susceptible to automation. They find that job markets in smaller cities and towns that specialize in manufacturing or resource extraction, such as southern Ontario and Quebec, are more likely to be disrupted as a result of automation than smaller cities and towns that specialise in health care assistance, political and educational services, or than larger cities with "diversified economies and a highly skilled labour market."

Lamb, C., and Munro, D. (2018). *Better, Faster, Stronger: Maximizing the benefits of automation for Ontario's firms and people*. Brookfield Institute for Innovation + Entrepreneurship (BII+E).

[PDF]

This report investigates the risks and benefits of automation for employers and companies in Ontario's manufacturing, and finance and insurance sectors. The report points out that Ontario's economy is facing a "dual challenge": (1) to increase productivity through automation and (2) to create more jobs. Ontario firms, however, have been hesitant to incorporate automation over concern for disruption to jobs and workers. This is due, at least in part, to reports that have focused on the association between automation and job loss, but automation also creates new employment opportunities and job tasks. Therefore, taking steps to encourage firms to implement new technological advances, while equipping workers with the skills needed to adapt to the changing world of work is essential to realizing the dual challenge. These steps include investing in technology research and development, creating a culture of lifelong education, promoting flexible training programs, and facilitating collaboration between businesses and post-secondary schools.

Massé, P., Roy, R., and Gingras, Y. (1998). *The Changing Skill Structure of Employment in Canada*. Human Resources Development Canada. R-99-7E. November.

[PDF]

This paper examines the evolution of the demand for skilled labour due to technological change and changing trends in Canada's labour market. Overall change in employment is decomposed into a skill substitution effect, a productivity lag effect, and an output effect. The skill substitution effect is that technological innovation leads to demand for higher-skilled workers; Productivity lag effects suggests that differing growth rates across industries determine the distribution of in-demand skills; and, the output effect refers to the changing demand in skills due to demand for Canadian-produced goods and services. They find that the skill substitution effect dominates the other two effects in driving the structural changes in skills demanded in Canada. Likewise, the substitution effect appears to be gaining in importance over time.

Relatedly, the report demonstrates that knowledge and management occupations have significantly increased leading to increased demand for cognitive and communication skills, which in turn has led to an increase in the demand for higher education and literacy.

Despite the increase in demand for skilled labour, there was no significant evidence of skill shortages in the Canadian economy. The increase in demand for skilled labour has been met by an equal increase in supply of highly skilled workers. Furthermore, there is no significant evidence of job deterioration for low skilled workers.

McDaniel, S., Wong, L., & Watt, B. (2015). *An Aging Workforce and the Future Labour Market in Canada*. Canadian Public Policy. 41(2). June.

[PDF]

The paper explores peer-reviewed research for the period 2000-2013 to determine the effect of Canada's ageing workforce on the labour market. The looming retirement of Canada's "baby-boomers" raises concerns of a potential shortage of replacement labour. The paper argues that such concern may be unwarranted, as the age composition of the labour force is also shifting. Questions also arise as to the usefulness of relying on temporary foreign workers (TFW) as a potential solution; however, policies pertaining to immigration are very recent and their implications are not yet fully understood. Changes made to TFW policy in 2014, for example, require more research to understand how this may affect future labour market conditions. The lack of good data on skills and labour further prevents a complete understanding of current and future labour demand. The paper identifies the need for improved information on current and future provincial and pan-Canadian labour markets in order to better understand skill-needs.

McKinsey Global Institute. (2017). *A Future that Works: Automation, Employment, and Productivity*.

[HTML PDF]

This report analyses the impact of automation on work activities and global productivity. It is shown that automation can boost annual global productivity growth by anywhere from 0.8 to 1.4%. In addition, it is found that approximately 50% of work activities have the potential to be automated by adapting current technology. Nevertheless, this does not equate directly to job-loss as less than 5% of occupations are found to be fully automatable; it does, however, imply a restructuring. Furthermore, it is estimated that those workers who are disrupted will find other employment. To contextualise the effects, the paper compares the situation to the shift away from agriculture in the United States in the 19th and early 20th century: Although some jobs were lost, other jobs were created.

Five factors influencing the pace and form of automation are identified. The first is technical feasibility. It takes time to research, identify, and decide how to incorporate new technology. Second, creating and implementing technical solutions requires capital investment and can be costly. Labour costs from training and losses due to temporary skill mismatches are a third factor that will influence the pace and form of automation. Finally, the economic benefits, and both social and regulatory acceptance must be considered. The public may be opposed to automation if they expect large job-losses, for example, and workplace safety and liability issues must be also address.

McKinsey Global Institute. (2018). Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation.
[HTML] [PDF]

This report highlights the impact of automation on the labour market with respect to the disruption to and creation of jobs by 2030. It is framed around three questions: Will there be enough work in the future to maintain full employment? Which occupations will grow? And, how will skills and wages be affected?

Overall, it is found that automation will boost economic growth and productivity but will significantly alter the distribution of jobs and the demand for skills. Due to the increase in productivity, it is expected that full employment levels may be maintained, provided that people are able to successfully and quickly change careers (within one year). As the share of job tasks become automated, the distribution of occupations and related skills will change. In advanced economies, the demand for physical labour will decrease, while employment for professionals, care providers, and managers/executives is predicted to increase. All workers are advised to focus on building skills that are hard to automate, such as social, emotional, and high-cognitive skills.

The effects of automation on wages will depend on the success of disrupted workers in changing careers. If re-employment is slow, greater than one year for example, frictional unemployment will place downward pressure on wages. For advanced economies, such as the United States, job polarization could be exacerbated, whereas for emerging economies, middle class wages may rise and reduce polarization.

Mertins-Kirkwood, H. (2018). Making decarbonization work for workers: Policies for a just transition to a zero-carbon economy in Canada. Canadian Centre for Policy Alternatives. January 25.

[HTML PDF]

The report argues that there are two sets of policies involved in transiting to a zero-carbon economy: (1) reactive ones which can minimize the negative effects of decarbonization on workers; and, (2) proactive ones which can maximize the positive effects. The zero-carbon economy needs a mix of both policies to ensure an equitable and productive employment outcome for all workers. The study also highlights that workers in the fossil-fuel production and energy-intensive heavy industry sectors are most at risk of these negative effects. However, one of the biggest beneficiaries of a clean economy is the construction sector.

Regarding provincial findings, the report shows that Alberta has the highest number of jobs in the fossil fuel industry at 138,000 jobs and Saskatchewan has the second largest share accounting for nearly a fifth of the province's GDP. Nationally, the fossil fuel industry accounts for just 8% of GDP and 1% of employment.

Nesta. (2018). *The Future of Skills: Employment in 2030*.

[HTML] [PDF]

Two foresight workshops were held with researchers and machine learning experts to identify seven trends (technological change, globalization, demographic change, environmental sustainability, urbanization, increasing inequality, political uncertainty) that will affect future demand for various jobs and the skills needed for each. Machine learning methods were applied to classify the demand of jobs into three categories (increasing, unchanged or declining). Predictions of these labels were generated for all occupations by training a Gaussian classifier. These results were interpreted and transferred into recommendations for education and training systems.

OECD. (2017). Employment Implications of Green Growth: Linking jobs, growth, and green policies. Report for the G7 Environment Ministers. June.

[PDF]

This report uses the OECD data to analyze the impact of green policies (policies that improve environmental quality) by identifying and quantifying concerns surrounding employment losses arising from an economy's transition to green growth for OECD countries. It argues that well-implemented green policies that generate employment in several "green" sectors, will lead to job destruction in environmentally polluting "brown" sectors, whose activities would be replaced by green sectors. The study shows that the transition to green policies will lead workers to shift between sectors. It finds that low-skilled workers will face larger employment shifts to new sectors relative to the shifts made by mid- and high-skilled workers. Thus, it is important to have well-functioning markets to enable smooth transitions across sectors.

Furthermore, the report highlights that government revenues could be efficiently used to mitigate these negative effects through methods such as lowering taxes on wages, and funding education and training programs to generate "positive overall employment outcomes." Well-functioning labour markets are also integral in ensuring the smooth transition and integration of displaced workers.

Oschinski, M., and Wyonch R. (2017). *Future Shock? The Impact of Automation on Canada's Labour Market*. C.D. Howe Institute. Commentary no. 472.

[PDF]

This report evaluates the impact of technological change on the Canadian labour market over the past 30 years and assesses the implications for the future. The report highlights that the Canadian economy is well diversified with only 27.5% of total employment in industries highly susceptible to automation. Based on historical evidence, the report argues that high rates of unemployment stemming from technological progress is unlikely. Furthermore, empirical evidence suggests that the increased use of robots will not directly cause unemployment, because countries with relatively higher robot densities than Canada would have experienced greater job losses.

Prism Economics & Analysis. (2017). *The Future of the Manufacturing Labour Force in Canada*. Canadian Manufacturing & Exporters (CM) & Canadian Skills Training & Employment Coalition (CSTEC). January.

[PDF]

The report provides an analysis of the labour needs of the manufacturing industry in Canada for the next 5 and 10 years, and a baseline projection of the labour requirements of Canadian manufacturing by occupation. The first objective is to generate LMI that is regional, current, and focused on the skills needs of the manufacturing sector. The second is to provide supply and demand forecasts that are rigorous and calibrated to take account of locally generated data. Finally, the results should be used to engage regional employers in a discussion about steps that might be taken to address any skills shortages identified by the LMI.

Of the 15 regions covered, 14 expect a recruitment gap totaling 129,000 workers. This is further complicated by the age of workers, as the average age of workers in the manufacturing sector is higher than the rest of the workforce. This poses additional burden with regard to replacement demand as these workers are expected to retire within the next decade. It is also observed that manufacturing faces substantial competition for workers with other industries. Montreal and the Greater Toronto Area (GTA) are expected to need the greatest number of manufacturing workers by 2025, with a demand of 71,000 and 63,000 workers respectively.

Randstad. (2016). *Workforce 2025: the future of the world of work*.

[PDF]

This report analyses data from 1,295 surveys of workers and 504 surveys of employers to assess the current and projected state of the Canadian workforce. It finds that approximately 85% of employers expect the workforce to become more agile by 2025.[4] 30% of the current workforce is comprised on non-traditional workers,[5] and that figure is expected to grow in the coming years. It is estimated that the IT sector currently employs the largest number of non-traditional workers at 19.3%, followed by engineering at 11.1%, administrative support services at 10.5%, sales and business development at 9.6%, finance and accounting at 9.2%, and human resources at 8.1%. Employers estimate that by 2025, 35% of workers will be "contingent, contract, or consultant", 32% will be virtual or remote workers, and 25% will be part time consultants. Having a flexible staffing model will lead to reductions in cost for and improved performance by the corporation.

RBC. (2018). *Humans Wanted: How Canadian youth can thrive in the age of disruption*.

[PDF]

300 occupations are grouped according to their essential skills and then evaluated to assess potential for worker mobility. Skill acquirement, skill upgrade, job switching, and ease of career change are analyzed with respect to changing demand for skilled labour in the Canadian economy.

[4] Workforce agility is defined as the ability of employees and organizations to remain steadfast and maintain productivity in the face of change.
[5] Non-traditional worker refers to contingent, consultant, contractual, part-time, freelance and/or virtual workers.

Specific skills investigated include literacy, critical thinking, system analysis, and technology design. It is suggested that certain skills demonstrate high transferability between jobs, implying that one need only focus on a small subset of skills to facilitate job mobility. For example, results indicate that a worker in the "facilitator" group has only to upgrade 4 out of 35 foundational skills to move from a career as a dental assistant to one as a graphic designer.

The report also generates labour market forecasts to identify occupational skill-groups for which demand is expected to increase, as well as those with high susceptibility to automation. Demand for workers with management skills who display strong critical thinking (referred to as "solvers") and for workers with strong analytic abilities ("providers") is expected to increase the most. The weakest demand growth, as well as highest susceptibility to automation, is expected for workers who serve or support others ("facilitators").

Tech Toronto. (2016). *How Technology Is Changing Toronto Employment*.

[PDF]

This report investigates the impact of technological development on the Toronto economy and provides political recommendations to help the technology ecosystem grow and prosper. The tech ecosystem is measured using three types of employment: all tech jobs in the tech industry, all non-tech jobs in tech industries and all tech jobs in non-tech industries. Some policy recommendations include fast-tracking work visas for immigrant "tech talents," improving housing, and allocating more government funds to start-ups.

United Nations. (2017). *Frontier Issues: The Impact of the Technological revolution on Labour Markets and Income Distribution.* Department of Economic & Social Affairs. 31 July.

[HTML] [PDF]

The report explores how recent technological evolutions will change the nature of work, and influence income distribution. Recent evidence suggests that despite rapid technological advances in the last few decades, labour productivity growth in developed countries has been experiencing a downward trend. In addition, sectoral changes in most economies and employment shifts from manufacturing to service sector have contributed to an increasing prevalence of precarious employment conditions, which is associated with reduced worker benefits, welfare protection, and union membership.

Technological progress has also had wide-ranging distributional effects by producing both winners and losers. New technologies often affect how jobs are performed by substituting workers as opposed to eliminating occupations entirely. Recent empirical studies suggest that technological advances have primarily affected jobs that involve routine tasks (i.e. tasks that are based on well-understood procedures) and have contributed to their long-term decline. However, this job-destruction effect has been counterbalanced by a job creation effect. Technological advancements tend to increase demand for more skilled workers by creating new products and by increasing consumer demand for existing products as productivity gains reduce sale prices. Some recent empirical evidence suggests that over the last 150 years technological advancement has created more jobs that it has destroyed.

The combination of routine-biased technical change and offshoring has also led to job polarization across developed countries by shifting from middle-wage jobs to both high-wage and low-wage

jobs. In most cases, this job polarization has been accompanied by rising wage inequality with majority of developed countries experiencing higher levels of wage inequality (measured by the 90:10 ratio) than 40 years ago.

The future of technological progress is expected to introduce substantial changes to the nature of work, causing both job creation and destruction. However, the impact of new technologies is not pre-determined and can be shaped by policies at the national and international level.

Wyonch, R (2018). Risk and Readiness: The Impact of Automation on Provincial Labour Markets. CD Howe Institute. Commentary no. 499.

[PDF]

This report analyses employment growth across Canada for the years 1987 through 2030. Readiness to respond to technological changes and sensitivity to polarization are also assessed at the provincial level. Results indicate that technological advancements will impact the workforce of Canada's provinces asymmetrically. Each province is expected to experience its own unique set of challenges due to differences in industry and labour market structure. Employment trends from past 30 years suggest the process of automation is gradual, granting the labour markets ample time to adjust. Furthermore, it is unlikely that even jobs which are most susceptible to automation will be completely replaced in the next few years.

Highly skilled workers in Ontario, British Columbia, and Alberta face the least risk of job-loss due to automation. These labour markets are also the least likely to experience disruptions and job polarization. Low-skilled workers in Newfoundland and Labrador face the highest risk of job-loss due to automation, with the labour markets of Newfoundland and Saskatchewan the most susceptible to disruptions.