CONSEIL DE L'INFORMATION SUR LE MARCHÉ DU TRAVAIL

LMiCiMT

LABOUR MARKET INFORMATION COUNCIL

Annotated Bibliography | Future of Work

Version 2.6 - February 2020

LMIC-CIMT.CA | @LMIC_eng @CIMT_fra | /company/lmic-cimt

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 studies. To ensure relevance, LMIC focuses 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 information sector. For more information on LMIC's work, please consult LMIC's Strategic Plan at lmic-cimt.ca.

Note: Highlighted entries indicate new or updated entries since version 2.5.

Table of Contents

Accenture. (2018). Inclusive Future of Work: A Call to Action. [Added 2018-10]

[HTML] [PDF]

This report provides an overview of the type of workers that are most vulnerable to technological disruption and discusses different workforce interventions to help these individuals navigate their career transitions. The report notes of the 1,200 employers surveyed 60% think that less than 25% of their workforce is ready to leverage these new technologies. A framework of four workplace interventions to support workers in their career transition is developed from a combination of worker and staff interviews, cross-country workforce surveys and workshops. The four interventions are defined as envision, expand, experience and empower. Each of these focuses on working with employees to discover translatable skills, relevant training and hands-on experience to develop work history and credentials for their next career endeavour. These intervention efforts are even more important for younger and entry-level workers as they face additional challenges to career transitioning such as a limited financial safety net, lower job security, lower proficiency in high-demand skills and unequal access to training.

Acemoglu, D., & Restrepo, P. (2018). The Race between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment. *American Economic Review*, 108: 1488–1542 [Added 2019-02]

[HTML] [PDF]

This paper discusses the extent to which technology can both replace workers and generate new opportunities for labour. The authors introduce a new conceptual framework in which technology automates some tasks while also creating new, complex tasks in which labour has a comparative advantage. To validate their task-creation framework, the authors note that about 60% of the approximately 50 million jobs added to the US economy during the past 35 years are associated with new job titles. The authors assume that new job titles reflect changes in the underlying tasks that workers perform and therefore use the emergence of new job titles as a proxy for new tasks.

The authors embed their framework into a dynamic model that endogenizes both automation and the creation of new tasks. At the long-run equilibrium, the authors focus on two possible scenarios: 1) the economy displays stable growth of both automation and complex tasks; or 2) automation outpaces the creation of complex tasks at a level that leads to a full-automation environment.

Advisory Council on Economic Growth. (2017). Learning Nation: Equipping Canada's Workforce with Skills for the Future. Government of Canada. [Added 2018-08]

[PDF-EN] [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. [Added 2018-08]

[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.

Anani, Namir. (2018). "Paving the Way for the Future of Work." Canadian Public Policy. November. 44(S1): 1–10. [Added 2019-04]

[HTML] [PDF]

[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

This article argues that the world of work is undergoing a structural transformation as evidenced by the rise in non-traditional working environments, the decline in long-term careers, and the increasing number of workers with mobile and on-demand employment structures. It follows that Canadian workers, educators and policy makers should be aware of forthcoming technological changes that may disrupt labour markets. To that end, the author examines key technologies that are expected to boost innovation, fuel economic growth and alter the landscape of work in Canada – namely, 3D printing, augmented and virtual reality, artificial intelligence, 5G wireless and blockchain. The applications of these technologies are far reaching and cut across several key industries in Canada, including manufacturing, health care, finance, retail and transportation. To ensure the Canadian workforce is prepared for the future, the article emphasizes the need for a renewed focus on work-integrated learning, as well as greater collaboration between industry and academia. This requires a pan-Canadian discussion on how to revamp the educational system in order to strengthen the supply of digitally skilled workers.

AON Hewitt and Business Council of Canada. (2016). Developing Canada's future workforce: a survey of large private-sector employers. March. [Added 2018-08]

[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. (2019). Digitalization and the future of work: Macroeconomic consequences. *ZEW Discussion Papers*, 19-024. [Added 2019-10]

[HTML] [PDF]

Advances in machine learning, increased computer power, and the availability of big data have enabled the automation of non-routine and cognitively complex tasks, spurring much debate over the impact of these new technologies on the labour market. Quantifying the total impact of automation on jobs is the challenge undertaken in this report. Previous studies, such as Frey and Osborn (2013), have attempted to measure job losses stemming from automation using binary occupation-level approaches (i.e., either a job is automated, or it is not). Such studies often overestimate job losses, however, because in many jobs only certain tasks have been automated.

Three factors help explain why a high degree of task automation does not necessarily translate into actual or expected job loss. First, there is the gap between available technology and its implementation (called “technological diffusion”). For example, Artificial Intelligence (AI) is a General Purpose Technology, which typically requires a long time to be widely implemented throughout the economy. Second, the impact of AI (or any technology) on employment depends on whether workers adjust to the new demands of their job (called “worker flexibility”). Workers who develop skills that complement those tasks replaced by technology may not experience job loss. For example, ATMs created the need for bank tellers with a more focused skill set, rather than replacing them altogether. Finally, technological change also induces job creation by making firms more productive, raising the demand for production and hence labour. As a result, the net effect of automation on employment is ambiguous, ultimately remaining an empirical question.

To address this empirical question, the authors run model simulations using German labour market data. The simulations yield five key results: (1) investment in automation and digitalization technologies will have a small positive effect on employment; (2) the German labour market will see large structural shifts as a result; (3) high-wage, high-skilled occupations will increase relative to middle- and low-skilled occupations; (4) worker mobility will increase; and (5) related productivity gains will induce greater demand for goods from firms adopting these new technologies, resulting in job creation. These results suggest that policy makers should promote new technologies, address skills shortages, and increase worker mobility between labour market segments to counteract employment and wage inequality.

Arntz, M., Gregory, T. & Zierahn, U. (2017). "Revisiting the risk of automation." *Economic Letters*. 159. July: 157-160. [Added 2018-08]

[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. [Added 2018-08]

[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.

Autor et al. (2017). "The Fall of the Labor Share and the Rise of Superstar Firms". NBER Working Paper No. 23396. [Added 2019-02]

[HTML] [PDF]

This paper discusses the reasons for the fall in labour's share of GDP in the US and other countries, starting in the early 1990s and continuing to the present. The authors introduce the "superstar firm" model, based on the notion that industries are increasingly dominated by a small number of highly productive firms with very large market shares (e.g., Google, Apple, and Amazon). Since, by definition, more productive firms require fewer workers for a given production level, a market shift towards these superstar firms causes the aggregate labour share of income to decrease, despite the fact that the average firm's labour share doesn't experience much change. The authors use microeconomic census data on US firms for six major economic sectors to examine the issue. They find that in all sectors the share of sales

going to a small number of firms has increased since the 1980s. They also find that the industries where concentration has increased the most have had the sharpest fall in labour share — further confirming the qualitative results from the model.

Balliester, T., and Elsheikhi, A. (2018). Future of Work: A Literature Review. International Labour Organisation. Working Paper no. 29.. [Added 2018-08]

[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). [Added 2018-08]

[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%.

Brookings Institution. (2019). *Automation and artificial intelligence: How machines are affecting people and places*. [Added 2019-10]

[HTML] [PDF]

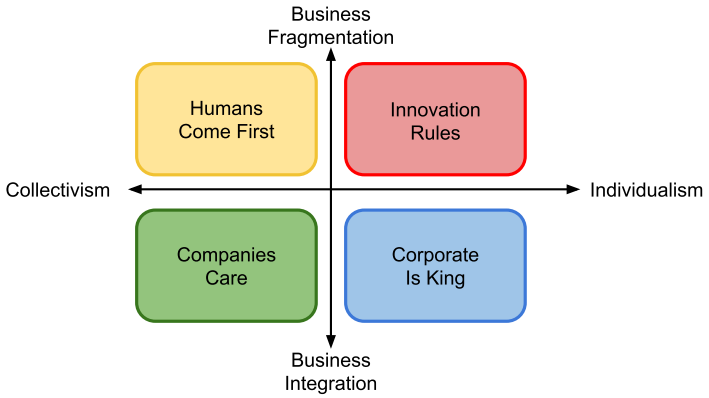
This report documents the effects of technological change on the future of work, focusing on both backward-looking and forward-looking analyses. Backward-looking analysis evaluates the degree to which occupations were automated from 1970 to 2016. Similarly, forward-looking analysis focuses on the risk of automation for occupations by the year 2030. The authors use several US datasets, such as the Census and American Community Survey (ACS), to examine changes in the labour force by occupation and geography. To estimate future automation rates, the authors use McKinsey's estimates of the likelihood of an occupation being replaced by an automated process by 2030. These estimates rank each occupation on a scale from 0 to 100, with 100 representing certainty that the occupation will be lost to automation.

In the backward-looking analysis, the report finds that employment has grown overall, but with a net loss of middle-income occupations to automation, resulting in a "hollowed out" labour market. In other words, the increase in employment has been greatest at the high and low ends of wage distribution. Not surprisingly, middle-wage jobs in decline are typically those most closely associated with routine tasks. In terms of the forward-looking analysis, the report finds that while automation will affect tasks in most occupations, it will have a muted effect on total employment. This is due, in part, to new machines and software that will complement tasks in existing occupations, rather than substituting the entire set of tasks that constitute the job. Importantly, the authors mention several limitations associated with their analysis. For example, they make an important distinction between technological possibilities and the adoption of new technology, which is very difficult to model. Second, they cannot predict what new jobs or tasks might be created by new technologies. Finally, the authors note potential policy initiatives to help smooth labour market transitions, including promoting a constant learning mindset towards re-skilling, and improving safety nets for workers struggling with changes in their jobs.

Brown, J., Gosling, T., Sethi, B., Sheppard, B., Stubbings, C., Sviokla, J., … Zarubina, D. (2018): *Workforce of the future: The competing forces shaping 2030*. PricewaterhouseCoopers (PwC). London, United Kingdom. [Added 2019-08]

[PDF] [HTML]

This publication presents four different scenarios in an attempt to better understand how the labour market and corporate landscape could change by 2030. These scenarios are informed by the results of a survey of 10,000 people from China, India, Germany, the UK, and the US. The scenarios are imagined as responses to the political conflict between individualism and collectivism[3] and the economic struggle between business fragmentation and corporate consolidation[4] (see figure).



The four scenarios are described as follows:

- **Innovation rules (individualism and fragmentation):** In this scenario, only the firms that can implement or commercialize innovations the fastest can compete in the globalized market. Products and services evolve at breakneck speed, and regulators frequently fail to keep up with innovation. Large firms that cannot adapt break up into smaller units. In this scenario, digital platforms match employers with potential job candidates, and contract and freelance work is the norm.
- **Corporate is king (individualism and consolidation):** Consolidation is the name of the game in this setting. The pressure on workers to perform is omnipresent. Many workers are willing to use augmenting technologies, medications, and implants to increase their productivity and reap the benefits of a corporate job. Inequality increases as those without corporate jobs fall further and further behind.
- **Companies care (collectivism and consolidation):** In this scenario, only the companies that fulfill their social responsibilities can compete. Responsible business practices, such as minimizing environmental damage and providing humane work conditions, become integral to companies' branding strategies. Workers are increasingly

[3] Individualism is defined here as a political ideology "focus[ed] on individual wants," whereas collectivism is defined as a political ideology where "[t]he common good prevails over personal preference[s]."
[4] Business fragmentation is defined as the economic process through which "large businesses lose their dominance as customers seek relevance and organizations find scale a burden," whereas corporate consolidation or integration is defined as the economic process through which firms "get bigger and more influential" and conglomerates dominate markets.

loyal to socially responsible firms, with many working for the same company their entire lives.

- **Humans come first (collectivism and fragmentation):** Here, workers are fully mobile across firms and markets, and use new technologies to connect with employers. Start-ups have access to global markets, capital, and talent thanks to new information technologies. Unions are replaced by guilds as workers organize based on members' education, experience, and fields of interest instead of the industry or the organization they work for.

All of these scenarios anticipate that individuals will shoulder the brunt of the weight of adapting to changing skill demands—and that as a result, the search for the best employees will intensify. Contractual work is poised to become more common, but to varying degrees across the scenarios.

Boyd, J. A. & Huettinger, M. (2019). "Smithian insights on automation and the future of work." *Futures*, *111*, 104—115. [Added 2019-08]

[HTML]

This report discusses the work of economist Adam Smith in the context of current discussions of how technological changes may affect employment. Many recent publications have discussed this issue. Sometimes referred to as Future of Work Studies (FoWS), they tend to share the same methodological goal: to assess the risk of jobs being lost to automation. Many suffer from the same two shortcomings: a failure to acknowledge the drivers of technological progress and a disregard for the opportunities that automation may bring for improving jobs. As a result, they propagate the message that the impact of automation is largely inevitable, and they present a false dichotomy whereby societies are forced to choose between economic growth and employment.

However, discussions about the impact of technological change on employment and the labour market are not new. Economists have been debating such issues since they were first raised by Smith in the late 18th century. In fact, the particular shortcomings present in these FoWS can be addressed by comparing them with Smith's works, discussed in this report. Specifically, Smith expressed a view that innovation through technological change requires insight and creativity—in other words, that technology does not advance for its own sake, but rather is the result of some underlying human motivation. As a result, it is also not unavoidable. Likewise, Smith conveyed a normative perspective about the benefits of technological progress through the "opulence" (high consumption) it delivers, which, according to Smith, should diffuse itself throughout the different ranks of society. As such, economic growth is valuable insofar as it helps all members of a society achieve equitable livelihoods of with minimal effort. Bringing Smith into the current debate around automation and new technologies compels researchers to probe the issues more deeply: to ask not only which jobs could be automated but which *should* be automated. It also highlights the fact that automation has the ability to free workers from the more mundane tasks of their occupations, freeing them to pursue more fulfilling work.

Citi and Oxford Martin School. (2016). "Technology at Work v2.0: The Future Is Not What It Used to Be", Citi GPS: Global Perspectives and Solutions, January. [Added 2018-12]

[HTML] [PDF]

This report compiles several analyses on job automation and its repercussion. It highlights work from the World Bank that applies the Frey and Osborne methodology for estimating occupations' likelihood of being lost to computerization across the globe. The study shows that a substantial share of the global workforce is at high risk of automation. For example, the world's two most populous countries, China and India, face, respectively, an estimated 77% and 69 % of jobs being lost to automation. The OECD average, on the other hand, is 57%. The high rate of job loss due to automation in emerging and developing countries is somewhat surprising given these economies' relatively lower labour costs. However, the report notes that the degree of automation in manufacturing industries are converging rapidly across the world, which is puts an even greater number of jobs at risk of being lost. A further risk to emerging and developing economies is that technological advancements (e.g., automated manufacturing processes) could alter global production networks and allowing firms to bring production closer to consumer markets. Such 'on-shoring' of production might be welcomed in many Western countries, but it will not come with the high employment levels associated with manufacturing in the past. The authors conclude that, while the potential impact of automation should affect developing countries later than emerging or advanced economies, it is likely to be more disruptive in less advanced economies and could even slow down income convergence. To be better prepare for this future disruption, emerging economies should to invest in up-skilling workers and work to boost domestic demand.

Cutean, A. (2017). *Autonomous Vehicles and the Future of Work in Canada*. Ottawa, ON: Information and Communications Technology Council (ICTC). [Added 2019-06]

[PDF-EN] [PDF-FR]

Autonomous vehicles (AVs) are set to be the next major technological breakthrough of the 21st century. The AV industry in Canada will create 34,700 new jobs between 2017 and 2021. However, Canada lags behind major automobile manufacturing countries such as the US, Japan, and Germany. The extent to which Canada can harness the positive impacts on employment in high-tech sectors from autonomous vehicles (e.g., automotive engineering, ICT in general) will depend crucially on the role Canada plays in the development of this new technology.

Furthermore, the adoption of autonomous vehicle technology will generate new opportunities for inclusivity and economic participation for underrepresented groups — such as individuals with disabilities, Indigenous peoples, and people living in rural or remote areas — as long-distance travel becomes more manageable. AV adoption will also require a comprehensive retrofitting of our road infrastructure and changes to our traffic laws. Such changes will boost demand for civil engineers, urban and land use planners, consultants, and policy analysts.

On the other side of the ledger, most driving jobs will be phased out as the technology improves. How fast this will happen depends on how efficiently various driving occupations can be automated. Although drivers make up only 0.5% of the Canadian labour force, they have, on average, the lowest level of education among workers affected by AV technology. Supporting these workers through a difficult period of transition should therefore be a social and economic priority. In addition to drivers, mechanics and other workers will need re-training, either to adapt to the changing skill demand of their occupation or to transition into other fields.

Culbertson, D. (2017). Canadian Millennials Less Interested in Jobs at Threat from Automation Indeed.com Blog. [Added 2018-08]

[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.

DeCanio, Stephen J. (2016). "Robots and humans—complements or substitutes? Journal of Macroeconomics. 49: 280-291. [Added 2018-12]

[PDF] ($)

In this paper, DeCanio estimates the elasticity of substitution between robotic and human labour using a multi-factor production function. The goal is to determine under what conditions increased use of robots increases or decreases wages. Given the rapid technological changes occurring in the field of Artificial Intelligence (AI), especially those involving cognition, there is mounting uncertainty how such changes may affect employment and wages. Although historic trends support Schumpeter's (1950) "creative destruction" thesis (technical change leads to job loss in the short-term but to increases in productivity and employment in the longer-term), the historic positive correlation between employment, wages, and technical growth may not continue into the future. Therefore, DeCanio uses a theoretical approach to determine whether this trend is expected to continue.

DeCanio shows that under a simple two-factor production function (i.e., Cobb-Douglas) wages and increases in the capital stock will always be positively correlated. Extending the model to three factors (i.e., labour, robots, and regular capital), however, opens the possibility for wages to either increase or decrease relative to changes in capital. As there are empirical challenges to estimating elasticities of substitution, the author employs a numerical simplification approach (the "Houthakker method"), enabling him to circumvent the need for impractical or unlikely

assumptions about the measurement of capital and to avoid issues associated with aggregation. Using data from the US Bureau of Labour Statistics to estimate the change in wages with respect to robotic labour, DeCanio finds that wages will fall as more robots are used in production if the elasticity of substitution between human and robotic labour is in the range of 1.7 to 2.1 or more. To contextualize these values, he notes that the elasticities between college graduates and non-college workers, was 1.6 from 1963 to 1987, and 2.9 between 1963 and 2008.

Deloitte. (2017). The Intelligence Revolution: Future-proofing Canada's workforce. [Added 2018-08]

[PDF-EN] [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. [Added 2018-08]

[PDF-EN] [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.

Deloitte (2019). The path to prosperity: Why the future of work is human. [Added 2019-08]

[HMTL]

This report discusses how, rather than replacing our jobs, technology will change the way we work. The authors highlight that these changes mean employment will continue to grow in the occupations that are most difficult to automate. The authors focus on the effects technology is likely to have on job replacement, the rate of transition between jobs, and the gig economy for the Australian job market.

The findings highlight that even though technological change is accelerating, unemployment rates are currently low in Australia and other developed countries, such as the US and EU member states. This suggests that so far, technological change is not replacing workers in large numbers, on net. Furthermore, when new technologies start taking effect, they will create more jobs than they replace. With respect to changing jobs and the gig economy, the authors find that 45% of workers in Australia have been with their current employers for more than five years, and that casual jobs currently represent a smaller share of all jobs than they did in the preceding two decades.

Finally, the report focuses on the types of jobs that are likely to be created in the future, predicting that by 2030, 36% of new jobs will be knowledge-based. The report also predicts that most of these jobs will be in the business services, health, education, or engineering sectors. The authors conclude by highlighting the importance of on-the-job learning as a remedy for changes in skill requirements, which are increasingly job-specific.

Ernest & Young. (2018). *Will you wait for the future to happen, or take a hand in shaping it? The future of work*. [Added 2019-10]

[PDF]

This Australian report focuses on expected labour market shifts associated with technological advances and advocates a five-component approach: organizational design, leaders, technology, jobs, and people.

A technology-driven organizational design can create significant opportunities. Redesigning organizations in this way involves eliminating traditional boundaries of hierarchy and role descriptions to foster collaboration among workers, which allows leaders to receive input from all employees and be responsive even during periods of rapid change. For their part, leaders will need to be effective at managing virtual, diverse, and geographically distributed teams. Further, leaders should develop a data-informed view of the organization's outlook to support effective planning and reduce anxiety arising from uncertainty.

Technology and jobs will interact and change together in the coming years. It will therefore be important to conduct labour market impact assessments on how new technologies will change worker roles over multi-year horizons. Such assessments can support short- and long-term planning, particularly in identifying skills requirements and training investments. Finally, organizations are advised to build employee awareness of future outlooks so that expectations stay ahead of any changes.

ESDC (2018). Canadian Occupational Projection System 2017 Projections: Industrial Summaries 2017-2026. [Added 2018-08]

[PDF-EN] [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. [Added 2018-08]

[PDF-EN] [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. [Added 2018-08]

[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. [Added 2018-08]

[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[5] 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. [Added 2018-08]

[PDF-EN] [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

[5] “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).

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 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.

Horton (2017): The effects of algorithmic labor market recommendations: Evidence from a field experiment. *Journal of Labor Economics,* 35(2): 345-385 [Added 2019-04]

[HTML $] [PDF – link to working paper]

This article investigates the impact of recruitment costs on job creation using data from the freelancing platform oDesk (now Upwork). The platform's algorithm recommends candidates to employers who post new job openings. A random set of employers who posted job openings on the platform for the first time were selected to receive up to six recommended candidates (the treatment group). The employer could then decide to invite these candidates to apply to the opening, as well as search for additional candidates to invite. The control group consisted of other employers new to the platform, who had to search for candidates on their own.

The experiment found that the share of new employers inviting candidates to apply increased by 40% when candidates were recommended. Further, the probability that the test group employers would hire someone through the platform for a technical position rose by 20%, but there was no significant impact on recruitment for nontechnical positions. According to the author, this is due to the much larger number of freelancers who apply to nontechnical job positions without being invited by the employer. This suggests that the use of algorithms to match employers and workers would have an impact only in occupations with a small pool of available workers. In these cases, the lower search costs associated with algorithmically-assisted recruitment may positively impact job creation.

Hull, J. (2009). Aboriginal Youth, Education, and Labour Market Outcomes. Aboriginal Policy Research Consortium International (APRCi). [Added 2018-08]

[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.

Institute for the Future. (2017). The Next Era of Human–Machine Partnerships. [Added 2019-02]

[HTML] [PDF]

For this report, 20 experts were surveyed to better understand how the relationship between humans and machines will change by 2030. The overwhelming response was that the expectations for work and how businesses operate will be reset. Participants expect that 85% of the jobs that today's learners will be doing in 2030 do not exist yet. Online platforms are expected to transform the nature of the workplace and how organizations hire new talent. The rapid pace at which skills become outdated and the introduction of new technologies (e.g., augmented reality) will decrease the value of prior knowledge and acquired skills, while increasing the value of aptitudes such as the capacity to learn on the job and digital literacy. The report makes recommendations to workers on how to succeed through the technological transformation that will occur in the next decade, including developing personal brands and adopting a more entrepreneurial mindset. They recommend that organizations should focus on cyber-security and incentivize workers to think creatively and find innovative solutions to problems.

International Labour Organization. (2018). World Employment and Social Outlook 2018: Greening with jobs. [Added 2018-08]

[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 regressions and input–output models are 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. (2017). "The rise of technological unemployment and its implications on the future macroeconomic landscape". Futures. March, 87: 1-9. [Added 2018-08]

[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. (2017) 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.

King, Lewis, and Jeroen C. J. M. van den Bergh. (2017). "Worktime Reduction as a Solution to Climate Change: Five Scenarios Compared for the UK." Ecological Economics. 132: 124–34. [Added 2018-10]

[HTML]

An annual reduction of 20% in working hours could translate to a 16% decline in greenhouse gas (GHG) emissions in the United Kingdom and elsewhere. Using UK data, Lewis et al. (2017) consider 5 scenarios to reduce working hours: (i) a 3-day weekend; (ii) free Wednesdays; (iii) shorter workdays; (iv) more holiday entitlement; and, (v) labour force reduction. They separately evaluate the impact of reduced work hours on business and employee activities. It further balances changes in workers' CO2 consumption due to 'income effects' (e.g., less money to purchase things) and 'time effects' (e.g., more leisure time). The former typically lessens GHG emissions, whereas the latter will increase them.

The paper finds a three-day weekend, free Wednesday and workforce minimization are the most effective policies to reduce carbon emissions. Shorter workdays and more holiday entitlement are found to be the least effective. The most effective policy, a three-day weekend, is expected to reduce CO2 emissions by a total 14.21 tons of CO2-equivalents, or 2.2% of 2016 total emissions. A shorter working day, which was the least effective, will reduce emissions by only 0.2%. The authors note there would be aggregate long-term effects of these policies that have uncertain consequences on carbon emissions but highlight the importance of these types of analyses for estimating the impact of various policy options.

Kostyshyna and Luu (2019). "The Size and Characteristics of Informal ("Gig") Work in Canada". *Bank of Canada*, Staff Analytical Note, 2019-6. [Added 2019-04]

[PDF]

New technologies have led to a significant increase in the share of Canadians involved in non-standard or informal work arrangements, particularly among those who are less than 25 years of age. Official labour market statistics in Canada do not fully reflect this new trend, suggesting that employment and wage growth figures may be biased downwards. The authors estimate that taking these new forms of work into account would increase the labour force participation rate by approximately 3 percentage points overall, and by 8 percentage points for youth. Further, using the Canadian Survey of Consumer Expectations, the authors find that participation rates in informal jobs are strongly correlated with weak labour market conditions. For instance, informal job participation is higher in provinces where the unemployment level is high and wage growth is weak. Supporting this correlation, the authors note that 15% of people with informal jobs stated they could not find a standard work position and 37% said they wanted to earn extra money to compensate for negative labour market conditions such as job loss, reduced hours, reduced pay, and/or stagnant wages. Informal work participation rates are also higher among those who fear losing their main job in the coming year and those who work part-time because they cannot find a full-time position. More than half of these informal workers would prefer to have a regular, formal job.

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. [Added 2018-08]

[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. [Added 2018-08]

[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). [Added 2018-08]

[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. (2017). Future-proof: Preparing young Canadians for the future of work. Brookfield Institute for Innovation + Entrepreneurship (BII+E). [Added 2018-08]

[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. (2017). Automation Across the Nation: Understanding the potential impacts of technological trends across Canada. Brookfield Institute for Innovation + Entrepreneurship (BII+E). [Added 2018-08]

[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., Munro, D. and Vu, V. (2018). Better, Faster, Stronger: Maximizing the benefits of automation for Ontario's firms and people. Brookfield Institute for Innovation + Entrepreneurship (BII+E). [Added 2018-08]

[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.

Lane, J. & Murray, T.S. (2018). Literacy lost: Canada's basic skills shortfall. Canada West Foundation, Human Capital Centre. [Added 2019-04]

[HTML] [PDF]

From 2003 to 2011, literacy rates in Canada fell by seven percentage points, according to the International Adult Literacy and Life Skills Survey and the Program for the Assessment of International Adult Competencies Survey, respectively. To explain the data, the authors cite three underlying causes: a failure in the educational system, a high proportion of low-skilled workers in the labour force with a lack of opportunity for up-skilling, and skill loss due to disuse. They argue that the decline in literacy impacts Canadians and the economy at three levels. First, illiteracy makes one more vulnerable to job loss and can make finding new work even more challenging. Second, and related, Employment and Social Development Canada's (ESDC) Essential Skills Profiles show that most occupations require workers to possess minimum literacy scores of 3 out of 5 to be fully productive at their job. Yet, in comparing the assessments of individual Canadians in 2011, Lane and Murray show that the supply of workers with this minimum literacy level has not kept pace with demand. Finally, declining literacy rates and levels can drag down both GDP and worker productivity.

To address declining literacy rates, the authors suggest that Canada improve the literacy skills of students in K-12 and post-secondary education, invest in understanding the skill needs of employers, embed literacy training in all aspects of workforce training, encourage literacy use at work in order to halt loss due to disuse, and mandate the new Future Skills Centre to include cognitive skills in its research.

Lent, R.W. (September 2018). Future of work in the digital world: Preparing for instability and opportunity. *The Career Development Quarterly*, 66, 205-219. [Added 2019-04]

[HTML]

This article asserts that the literature concerning the future of work is inconsistent, which makes taking informed career-related decisions difficult. While some research predicts large-scale job loss and labour disruptions, other research emphasizes the emergence of new, meaningful work opportunities. Given such conflicting reports, only one thing is certain: the world of work is changing; how and to what extent it is changing, remains unclear. Lent seeks to help career counselors and vocational psychologists understand their role amid this uncertainty. He advocates for career development professionals to shift from a career-matching paradigm, which has been the dominant approach in career counseling, to a career-life preparedness approach that encourages clients to accept change as a normal part of individual career paths and teaches planning and coping strategies.

Massé, P., Roy, R., and Gingras, Y. (1998). The Changing Skill Structure of Employment in Canada. Human Resources Development Canada. R-99-7E. November. [Added 2018-08]

[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.

Mateos-García, J. (2018). The Complex Economics of Artificial Intelligence. National *Endowment for Science, Technology and the Arts (NESTA). Available at SSRN 3294552* [Added 2019-02]

[HTML]

AI systems are often seen as a neutral and homogenous "General-Purpose Technology" (GPT). This article argues, in contrast, that AI systems are not neutral and that certain trajectories of deploying AI systems can have significant societal benefits. The main difference between AI and other GPTs (e.g., the steam engine, electricity, computers) is the fallibility of AI. AI applications mimic specific human intelligences, making them susceptible to failure in unexpected situations. The article discusses four complexities of AI systems that can derail their adoption — organizational, market, social, and temporal — as well as the ideal scenarios for each complexity.

Type of complexity	Description
Organizational	Uncertainties in how AI might create tensions between different organizations
Market	Widespread informational asymmetries of AI systems can lead to unfavourable applications
Social	Individual deployment of AI systems might have adverse effects, such as worker displacement
Temporal	Once locked-in to a trajectory, it is difficult to change course even if the trajectory is recognized as inferior

The author argues that societies can maximize the benefits of AI deployment by identifying and strengthening favourable AI trajectories, undertaking rigorous research to reduce uncertainties in deploying AI, introducing regulatory and compliance measures to help identify permitted applications of AI, and active monitoring to preserve diversity and prevent premature lock-in into inferior AI trajectories.

McDaniel, S., Wong, L., & Watt, B. (2015). An Aging Workforce and the Future Labour Market in Canada. Canadian Public Policy. 41(2). June. [Added 2018-08]

[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. [Added 2018-08]

[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. [Added 2018-08]

[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. [Added 2018-08]

[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.

Mitchell, C., Young, M., & Popiela, A. (2018, August 29). The Future of Work: Frontline Challenges in an Era of Digital Transformation. *The Conference Board*. [Added 2019-02]

[HTML]

This report presents the findings from *The Future of Work: The Strategic HR Joint Council Meeting* where 250 C-suite and senior level executives from 14 councils on human resources (HR) management discussed the future of HR. The report also lists the skills and aptitudes that will become essential to HR professionals in the near future, such as managing ever-changing operational needs and adopting an experimental approach to program development.

Discussants believe that the field will become increasingly focused on those non-routine tasks necessary to achieve long-term organizational goals. In order to generate greater efficiencies, routine HR tasks will be increasingly automated. For instance, HR will play a pivotal role in improving incentive structures to reward collaboration instead of competition between employees. HR professionals will also be increasingly involved in training staff on teambuilding and new digital skills. It is also expected that the number of freelancers and external consultants used by companies will increase, therefore requiring HR professionals to be at the forefront of workplace restructuring.

Nesta. (2018). The Future of Skills: Employment in 2030. [Added 2018-10]

[HTML] [PDF]

The authors employ a novel mixed-model prediction approach that leverages expert information with machine learning models to focus on the unexplored effects of automation on job creation. They also gather data on major labour market trends to contextualize the interaction of automation with other relevant future of work trends such as globalization, population aging, urbanization and the rise of the green economy. Using a combination of detailed occupational information from the Occupational Information Network (O*Net) and workshop respondent data for both the US and the UK, the paper maps out how jobs are likely to change, and the resulting implications for skills demand.

The authors discuss the likely dynamics of technological change in different labour markets. They find that education, health care and public sector occupations are likely to grow, while low-skilled jobs in fields like construction and agriculture are less likely to suffer poor labour market outcomes. However, because they show heterogenous occupational growth patterns, the authors find that the negative outcomes for lower skilled workers are likely to be less severe than has been previously assumed. The authors conclude that technological change points to opportunities for boosting growth with the caveat that current education and training systems must respond appropriately to these new challenges.

OECD. (2017). Employment Implications of Green Growth: Linking jobs, growth, and green policies. Report for the G7 Environment Ministers. June. [Added 2018-08]

[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.

◆[NEW] OECD. (2020). The Future of Work: Expert Meeting on Collective Bargaining for Own-Account Workers. Paris: OECD. [Added 2020-02]

[HTML] [PDF]

This report presents issues facing the labour market, notably current obstacles for own-account workers. The OECD defines own-account workers as self-employed workers without employees. Workers in such non-standard forms of employment can face poor working conditions. For instance, own-account workers have no access to collective bargaining. Even when they do, they may face practical issues in identifying the relevant bargaining counterpart. They may also face price competition from foreign contractors who do not have to abide by the collective agreement.

Such obstacles impede the possibility of improving working conditions. The OECD advises all countries to follow the best practices implemented by some OECD members. Tailoring labour regulations, for example, to define worker categories thoroughly so that it is clear who is allowed to access bargaining rights is one remedy. Tailoring competition regulations by lifting the ban against collective bargaining for sectors and occupations where own-account workers may face power asymmetry is another possible measure.

Oschinski, M., and Wyonch R. (2017). Future Shock? The Impact of Automation on Canada's Labour Market. C.D. Howe Institute. Commentary no. 472. [Added 2018-08]

[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 Canadian industries where more than three-quarters of the job are at high risk of automation account for only 1.7% of employment. 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.

Policy Horizons Canada. (2018). *The Next Generation of Emerging Global Challenges*. [Added 2019-06]

[HTML-EN] [HTML-FR]

Surveillance is becoming ubiquitous, which could lead to major societal and economic changes, as practical anonymity may no longer exist in future. To prepare for this change, research and public dialogue is required to address privacy issues and to create opportunities for an open and democratic information society. The report describes the key factors expected to lead to greater surveillance, including Artificial Intelligence (AI) and smart cities. Advancement in such technologies will intensify surveillance and thereby pose greater risks to the privacy of individuals and businesses. It is possible to have a surveillance society in which individuals have practical anonymity, but this requires negotiation on the context and definition of privacy in the modern age. New agreements, concepts, and tools may be required to protect privacy boundaries. As institutional surveillance increases, it is likely that citizens will also increase counter-surveillance to monitor the activities and devices that breach privacy.

Policy Horizons Canada. (2018). *Working in the Digital Economy*. [Added 2019-06]

[HTML-EN] [HTML-FR]

The advancement of information technology has enabled the production network of the service industry to become global in scope. Platforms such as Freelancer and Amazon allow anyone, anywhere in the world to find a virtual worker. These platforms divide traditional jobs into discrete tasks, effectively shifting the labour market away from full-time work towards part-time contract work. While automation and robotics will reduce labour shortages in manual occupations, many people could lose their jobs as a result. Indeed, a 2016 survey by Randstad suggests that 85% of those companies surveyed will move to hiring more contract, temporary, and freelance workers.

A number of labour market policies will require updating in response to these technological changes. Because social insurance programs only protect people with full-time jobs, such policy instruments should be revised in order to deal effectively with workers in non-traditional roles. Similarly, minimum wage laws, labour standards, and tax rules are also not well suited to the changing labour market. Without smart and effective policy changes, digitization will lead to less stable employment and growing income insecurity for many.

Prism Economics & Analysis. (2017). The Future of the Manufacturing Labour Force in Canada. Canadian Manufacturing & Exporters (CM) & Canadian Skills Training & Employment Coalition (CSTEC). January. [Added 2018-08]

[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.

◆[NEW] Radin, J., Hatfield, S., Schwartz, J., & Bordeaux, C. (2020). Closing the employability skills gap: The answer is simpler than you may think. New York: Deloitte. [Added 2020-02]

[HTML] [PDF]

Automation presents an enormous risk to almost 47 percent of US jobs in the next two decades (Frey & Osborn, 2013). Automation, however, is not the only threat to the future of work according to this report. Other disruptive forces include, for instance, the shift to more team-based structures, to virtual or flexible workplaces, and to a more diverse workforce. Business leaders are advised to remodel their business plans in order to implement new technologies, expanded work settings, and find new talent to address these disruptive forces.

Soft skills such as creativity, leadership and critical thinking are becoming increasingly valuable since they are not easily automated. Workers must develop these skills in order to survive the so-called "Fourth Industrial Revolution." In addition to technical skills, the report argues that workers must cultivate such social and emotional capacities as curiosity and empathy.

The report draws on studies such as the 2013 Chronicle of Higher Education survey in which half of companies claimed to have trouble finding applicants with the required communication, adaptability, decision-making and problem-solving skills. A 2015 study by the National Bureau of Economic Research also suggests renewing outdated models of education to develop social and emotional capacity. Regardless of innate talent, some believe that these skills can still be developed in adulthood with the right resources. An MIT study testing this theory found that a one-year workforce training program focused on improving social and emotional skills could significantly impact productivity.

Randstad. (2016). Workforce 2025: the future of the world of work. [Added 2018-08]

[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.[6] 30% of the current workforce is comprised on non-traditional workers,[7] 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. [Added 2018-08]

[PDF]

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

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. 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. [Added 2018-10]

[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.

Thornton, J., Russek, H., O'Neil, T. (2019). *Turn and Face the Strange: Changes impacting the future of employment in Canada*. Brookfield Institute for Innovation + Entrepreneurship (BII+E). [Added 2019-04]

[HTML EN] [PDF EN] [HTML FR] [PDF FR]

This report is the first output of the *Employment in 2030* initiative from the Brookfield Institute. The initiative seeks to forecast skills and occupations in Canada, taking into consideration a number of complex factors, drivers and trends. To spark exploratory and imaginative thinking around the future of work, the report describes 31 trends affecting skills demand in Canada. These trends were identified by a "horizon scan" in which possible signals of change are gathered from academic journals and media sources. The 31 trends are grouped into seven categories: technological change, globalization, demographic change, environmental sustainability, urbanization, increasing inequality, and political uncertainty. An eighth "other" category is also included to capture certain Canada-specific trends including 'entrepreneurial spirit' and the 'cannabis economy'. For each of the 31 trends identified, the report offers an evaluation of the nature of the observable signal (weak, emerging or mature), potential implications for Canadian labour markets, an overview of present studies, sample evidence of change, and an action assessment as to whether the impacts will be immediate or long-term. The report concludes with a snapshot of the potential impact for Canada in 2030 and a call to action.

United Nations. (2017). Frontier Issues: The Impact of the Technological revolution on Labour Markets and Income Distribution. Department of Economic & Social Affairs. 31 July. [Added 2018-08]

[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.

Welse, M.R., Hanson, A.R., Sentz, R., & Saleh, Y. (2018). *Robot ready: Human+ skills for the future of work.* Strada Institute for the Future of Work & Emsi. [Added 2018-12]

[HTML]

The labour market outcomes of liberal arts graduates in the US are quite strong, yet enrollment in these types of programs has been on the decline since the 1970s. Graduates of liberal arts programs are often left to navigate the job market alone, with little guidance on how to map their education to the skills needed in the workplace. Since liberal arts programs are the main pathway by which soft skills are developed, Welse et al. argue that these programs need to do a better job of preparing students to enter the workforce. Hindering this effort, however, are differences in terminology used by labour market experts and educators. Employers, for example, often list in-demand skills such as communication and critical thinking, which are too broad to measure. Schools, on the other hand, often talk about skills in relation to academic subjects, which does not provide employers with a clear way of assessing what the graduates can do with their knowledge. To clarify this point, Welse et al. use a cluster analysis approach to group skills by field, occupation, and job. Combining data from job-postings, applicant resumes and social media profiles, they show how one skill (e.g., communication) maps to several different capabilities and job tasks depending on the field. They also advocate for the inclusion of technical skills into the liberal arts education, a combination they refer to as “human+” skills (e.g., programming + ethics, or AI + emotional intelligence).

***World Bank. 2019*. “The Changing Nature of Work”. Chapter 1. *World Development Report 2019*: The *Changing Nature of Work*. [Added 2018-12]**

[HTML] [PDF]

This first chapter of the 2019 World Development Report provides a general overview of how technological progress has changed the landscape for workers over the past decades. The chapter focuses on three main areas of transformation: (i) the effects of automation; (ii) changes in skills demanded; and, (iii) the rise of the gig economy. The authors note the difficulty in estimating the percentage of jobs at risk for automation. For example, in the US alone, the estimated number of jobs at risk of being lost to automation range from 7% to 47%. Further, such estimates typically do not accurately include the rate of technology absorption into the economy and its use by firms. The report argues that a better pathway for future research is to focus on the demand for skills. Today, the most in-demand skills are those that are non-routine,

cognitive and socio-behavioural. Finally, the report briefly discusses the rise of gig-workers, which account for approximately 3% of the global labour force. Even though gig workers do not constitute a large proportion of the workforce, gig jobs have changed the way work is traditionally performed, allowing for more flexibility and greater labour market access.

World Economic Forum. (2018). The Future of Jobs Report. [Added 2018-10]

[HTML] [PDF]

This report considers the risks of automation to employment and its potential to improve the quality of existing jobs and create new high-quality jobs. The WEF surveyed 313 global companies from a variety of industry sectors representing a total of 15 million employees. The survey probes corporate leaders' views on the future of work, new in-demand skills and strategies for upskilling the workforce over the 2018-2022 period. Nearly 50% of companies expect that technological advancement will lead to a reduction in their full-time workforce by 2022. This is in part driven by the fact that firms expect machines to perform 58% of all tasks by 2022, up from 29% in 2018. Further, depending on their industry, between 23 and 37% of firms plan major investments in robots over the next 5 years. Finally, half of all companies report that they expect technological change to modify their geography of production, distribution and value chains.

Despite the seemingly dire warnings of automation, the report finds a net positive outlook for job creation. It estimates a decline of 0.98 million jobs and a gain of 1.74 million jobs across all industries. Further, human skills that remain in-demand are expected to increase in value. Soft skills such as creativity, persuasion, negotiation, emotional intelligence, and leadership are highlighted as the most likely to increase in value. However, much of the growth in jobs is likely to be non-standard: Between 33% and 50% of businesses are likely to hire external contractors, temporary staff and freelancers to fill their new demand for skills.

World Economic Forum. (2019). *AI Governance: A Holistic Approach to Implement Ethics into AI*. White paper. [Added 2019-06]

[HTML] [PDF]

This report explores different policy mechanisms that would facilitate a human-centric AI society. The authors first discuss the respective advantages and disadvantages of AI applications to society. Advantages include the reduction of economic inefficiencies and labour costs as AI allows firms to gain better understanding of customer needs. On the other hand, the increased use of AI may lead to the displacement of worker tasks and significant job losses. The lack of transparency of AI and the loss of privacy stemming from personal data being collected and fed into AI systems are also issues.

The authors discuss several ethical approaches, such as top-down mechanisms where ethical principles are programmed directly into AI systems. They also discuss casuistic and dogmatic approaches to ethical debates. The casuistic approach would see machines react in a situation-specific way when making an ethical decision. Alternatively, the dogmatic approach would program a particular school of thought into an AI system, so that all decisions would be made accordingly.

Despite these different approaches, the authors conclude by discussing the difficulty of implementing any ethical system, proposing a plurality of policymaking instruments, such as international resolutions and treaties to address these and other societal implications of AI.

World Economic Forum. (2019). *Strategies for the New Economy: Skills as the Currency of the Labour Market*. White paper. [Added 2019-06]

[HTML] [PDF]

The future of work is expected to be characterized by two significant problems: job loss and growing skills shortages. Experts have long called for improved clarity regarding the definition and measurement of skills, and their relation to the job market. There is an inherent challenge to accurately measuring and evaluating skills as they are not directly observable. The traditional solution has been to use proxies for skills, such as educational qualifications, program quality, and even the social networks of potential job applicants.

Beyond being poor measures of actual skills held by individuals, the use of proxies contributes to labour market inefficiencies and social inequalities. Education-based skills proxies, for example, are premised on a linear “learn, do, retire” life model that does not reflect changing skills requirements and reinforces the social stratification associated with high performance in secondary and tertiary education. To address these inefficiencies, the authors suggest shifting to a skills-based system, in which skills are the core currency of the labour market. They outline ten strategies to accomplish this:

1. Build, adapt, and certify foundational skills;
2. Build, adapt and certify advanced skills;
3. Build, adapt and certify skills among the adult workforce;

4. Realize the potential of educational technology and personalized learning;
5. Map the skills content of jobs;
6. Design coherent and portable certifications;
7. Rethink organization and talent management processes;
8. Drive momentum around the concept of skills;
9. Align skills taxonomies; and,
10. Shape culture, mindsets and mechanisms for lifelong learning.

The report concludes with a series of case studies describing emerging initiatives exemplifying these ten strategies.

◆[NEW] World Economic Forum. (2020). Jobs of tomorrow: Mapping opportunity in the new economy; Part 1: Opportunity in the emerging labour market. Cologny, Switzerland: WEF. [Added 2020-02]

[HTML] [PDF]

The Fourth Industrial Revolution is expected to create many new jobs and opportunities in future. In order to recognize which skillsets workers will require in order to leverage those opportunities, the World Economic Forum analyzed labour market metrics with the collaboration of Burning Glass Technologies, Coursera and LinkedIn.

The report finds seven emerging professional groups adopting new technologies: data and AI; engineering; cloud computing; marketing; sales and content; people and culture; and product development. AI specialists and data scientists have the highest growth rate among professions. However, human interaction remains a critical aspect of the new economy. The demand for such professionals as customer support specialists, social media assistants and green marketers is expected to rise.

Moreover, this report groups skills into five clusters: business skills; specialized industry skills; general and soft skills; tech baseline skills; and tech disruptive skills. Business skills include those needed to start or operate an enterprise, while specialized industry skills are specific to the field in question. General and soft skills — known as cross-functional skills — are typically the non-cognitive capabilities needed across all professions. Tech baseline skills span basic computer literacy while tech disruptive skills allow for using and designing the technologies set to impact business models.

Wyonch, R (2018). Risk and Readiness: The Impact of Automation on Provincial Labour Markets. CD Howe Institute. Commentary no. 499. [Added 2018-08]

[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.