



AUTOMATION AND LABOUR IN BRITISH COLUMBIA



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ACKNOWLEDGEMENTS

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BC Federation of Labour
5118 Joyce Street
Vancouver, BC V5R 4H1
t: 604.430.1421
bcfed.ca

The BC Federation of Labour represents more than 500,000 members of affiliated unions, working in every sector of the economy and every corner of the province.

The BCFED has a long and proud history of fighting for the rights of all working people.

The goals of the BCFED are best exemplified by the slogan: *"What we desire for ourselves, we wish for all."*

The BC Federation of Labour office is located on unceded xʷməθkʷəy̓əm (Musqueam), səliłwətaʔ (Tsleil-Waututh), Skwxwú7mesh (Squamish) territories.

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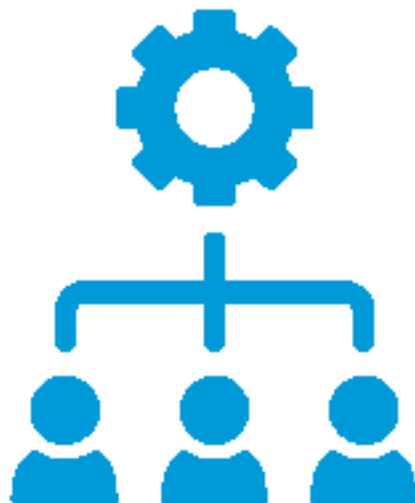
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Executive Summary

UNDERSTANDING THE IMPACT OF AUTOMATION ON WORKERS, their livelihoods, and their well-being is one of the key public policy challenges of our time. Today, automated systems are taking up increasingly complex tasks, and corporations are integrating these systems throughout their work processes.

How these forces are playing out in BC, and what impact they are having on the nature, quality and quantity of jobs, is a key concern for BC's labour movement and indeed for employers and governments. Does automation contribute to the displacement or creation of jobs? How, and in what sectors? Is it effecting trends in inequality and precarious work? How are worker rights and the institutions and laws that protect them being impacted?

This report provides historical context to help explain what automation is and isn't, and what it means for workers in BC. Using Statistics Canada data on the BC labour force, it draws specific insights into job and wage polarization in the BC labour market; in other words, it looks at how jobs are shifting between sectors, and how that may be impacting the incomes of workers. The report also considers the likelihood of near-term automation of work throughout the province. Finally, a case study into BC's ports demonstrate the negative impact employer-controlled automation is having here, and now, on workers and communities in British Columbia.



This report looks at how jobs are shifting between sectors, and how that may be impacting the incomes of workers.



KEY FINDINGS

- Automation threatens to increase the degree to which workers across BC struggle with precarious employment.
- 60% of the BC labour force faces either a high or medium likelihood of having their job impacted by automation in the next twenty years.
- BC has already seen a shift toward the care and service and technical employment categories.
- Good-paying industrial jobs are declining in labour share, directly attacking the gains unionization in those sectors has produced for all workers.
- The growing gap between the average and the median wage in every employment category in BC contributes to increasing inequality.
- This shift disproportionately impacts women, people of colour, and immigrants.
- The impact of automation in BC is significant for workers, as the decreasing costs and increasing sophistication of automated systems has the potential to displace workers and eliminate jobs across the labour market to greater degree than before.

While polarization in the labour market has been seen before, in BC and beyond, the shift away from industrial work *accompanied by* increasing potential for automation in both the care and service and technical categories is a new development, and a worrying one for workers in BC. It bears profound implications for the well-being of workers, their livelihoods, and the communities that depend on them. The report concludes with considerations for how unions and government can respond in ways that minimize the negative impacts on workers and enhance worker control.

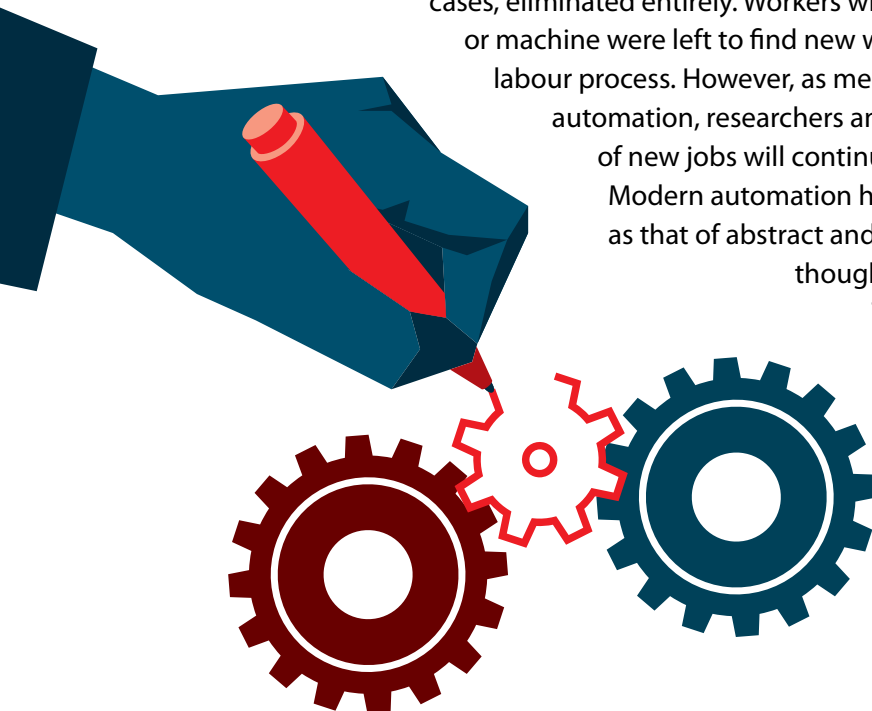
Introduction

THE MECHANIZATION OF LABOUR TASKS has presented concerns for workers and labour organizations for centuries. As far back as 1589, Queen Elizabeth I responded to William Lee's invention of the stocking-frame knitting machine by raising its potential impacts on the employment security and well-being of hand-knitting workers and their artisan guilds.¹ Historically, mechanization of labour tasks displaced great numbers of workers — think of the introduction of industrial machinery in sectors such as agriculture, manufacturing, the automotive industry, and more. While employer-led mechanization has incurred significant opposition in the past — with the early 19th-century Luddite movement being a high-profile example — it has remained a constant in the labour environment nonetheless.²

If a new tool or machine is introduced into a labour process, the process changes. If the tool or machine is significant enough, the labour process is reorganized around its introduction. In the past, when those reorganizations were on a large-enough scale, workers' jobs were redefined — and in many

cases, eliminated entirely. Workers wholly displaced by the entrance of that tool or machine were left to find new work, often in jobs created by the reshaped labour process. However, as mechanization has given way to digitization and automation, researchers and observers have questioned if the creation of new jobs will continue at-pace with the elimination of old ones. Modern automation has penetrated new spheres of labour — such as that of abstract and analytical work — which were previously thought to be securely reserved for human workers.

Today, automated systems are taking up increasingly complex and intricate tasks, and corporations are moving toward both integrating automated systems into their work processes and designing the spaces in which work occurs to be better suited to these systems.



The Future of Workers



TECHNOLOGICAL ADVANCEMENT has consistently brought about structural changes to the labour environment. As a foundational instance of mechanization, the Industrial Revolution produced a separation and distillation of labour tasks that reduced the breadth of skills individual workers regularly applied in their labour.³ In the US, the advance of agricultural machinery through the 19th century mechanized a great share of agricultural labour tasks that had previously been handled by workers and animals under their direction, and so shifted a great share of the workforce out of agricultural jobs and related employment such as blacksmithing and equestrian industries.⁴ In a more contemporary case, the invention of the Automated Teller Machine (ATM) significantly impacted human bank tellers by both digitizing and automating a significant portion of their tasks.⁵

These examples raise distinct processes which replace human labour: (1) mechanization, (2) digitization, and (3) automation. **Mechanization** refers to the process by which a machine or mechanical system is invented which carries out tasks that were previously manually provided — primarily by human workers, and in some cases by animals under the direction of human workers. **Digitization** refers to the process by which computer systems and programs are developed which carry out tasks previously done by human workers. **Automation** refers to automated mechanization and/or digitization — that is, when mechanized or digitized processes are programmed so that they occur automatically, independent of constant human direction or required human intervention.

The distinction between digitization and automation is an important one. For example, a calculator is a relatively simple form of digitization, in which a machine has been programmed with specific functions, receiving numerical inputs from a human user and carrying out the functions as directed. From this perspective, the calculator could be considered a digitized form of an abacus, which is itself a mechanized form of manual-cognitive calculation. In neither the case of the abacus nor the calculator, can the tool make independent decisions about which functions should be applied to the numerical inputs, nor can it be programmed to comprehend the purpose of its calculations — if indeed any machine can be said to be capable of comprehension. Automation is a step beyond either of these — it strives to introduce machines and systems which can make independent decisions about how labour tasks should be accomplished.

It's important to note that these are not novel processes. As noted above, technological change has spurred mass transformations in the labour environment for two hundred years. In the U.S., for example, while just 10% of manufacturing power was electrified in 1905, that number jumped to 50% by 1925.⁶ This same period saw the mass proliferation of items as presently common as aluminum, the radio, the refrigerator, and aircraft. There is compelling evidence that the technological advancements of the Industrial Revolution dwarf those that we are experiencing today. Accordingly, one may surmise that the labour-displacing impacts of modern technological change have been overstated. From this perspective, labour-force changes are less the result of employer-driven changes spurred by advancing automation; rather, they reflect the macroeconomic impacts of factors such as the character of capital inputs into industrial processes, access to education and 'upskilling' by workers, and changes in the ratio of capital stock to wage-earning workers.⁷

There is weight to this argument, but it misses some important aspects about modern technological change. Though mechanization, digitization, and automation are not new processes, their capacity in the modern age is. Historically, when these processes displaced workers from particular tasks,



Automation is a step beyond digitization and automation — it strives to introduce machines and systems which can make independent decisions about how labour tasks should be accomplished.

those workers often took up new tasks or occupations which were supported by the technological advancements made. Digitization, for example, can allow workers to focus on abstract tasks and specialize further, including decreasing time spent on acquiring and documenting information while increasing time spent on analyzing and interpreting it.⁸ When human bank tellers were displaced from a significant amount of their tasks due to the introduction of ATMs, many of those tellers moved into roles involving greater adaptability, creativity, and problem-solving.⁹ The wide-scale introduction of ATMs also created work in manufacturing, repairing, and maintaining those machines. Today, however, the increasing sophistication of automated systems has the potential to displace workers in greater degree than before, if they are accompanied by decreasing opportunity for those workers to find tasks or employment elsewhere.¹⁰ This shift is evident in the cited case of bank tellers impacted by the introduction of ATMs. While many of those tellers shifted into sales roles, eventually, those sales roles were themselves reduced, and banks began cutting staff and closing branches.¹¹ Though it is still the case that automation of tasks is not synonymous with elimination of jobs, automated systems are now capable of carrying out tasks that, until recently, it was difficult to imagine computer systems managing independently.

In the past, automation was primarily focused on tasks involving a set order of activities which were comparatively easy to describe in programming code.¹² With the introduction of machine learning, 'Big Data' mining, artificial intelligence, and mobile robotics, automated systems are rapidly developing the ability to undertake new and increasingly complex tasks — both manual and cognitive ones.¹³ Automated systems are now employed in the realms of fraud detection, health care diagnoses, pre-trial legal research, call centres, education, human resources, monitoring of municipal infrastructure such as water systems, and more.¹⁴ Researchers have argued that agricultural equipment, forklifts, cargo-handling vehicles, and mining equipment are "imminently" automatable, and noted the increasing use of robots in hospitals (delivering food, samples, and prescriptions), trucking and logistics, and 'non-routine, manual' tasks such as wind turbine maintenance, medical surgery, and operation of automobiles.¹⁵ Recent estimates cite that the costs of automating labour tasks are declining by 10% annually, and the rate of cost-decline is projected to increase in the near future.¹⁶ With the purchase of industrial robots increasing year-by-year, some researchers have suggested that the primary obstacles to employer-led automation are upfront capital costs and questions of engineering — that is, it can be challenging to automate tasks that rely upon creativity, social intelligence, or intricate perception and manipulation, or tasks that are difficult to distill into an explicit set of rules which can be described easily in code.¹⁷

Some researchers have cautioned against categorical predictions, arguing that it's unlikely such displacement could occur across the entire labour environment. Even if the most aggressive automation occurs, human labour would still be required to develop and maintain automated systems for the foreseeable future. As well, caring for children, seniors, and people otherwise in need will remain essential work that cannot be meaningfully carried out by machines.¹⁸ In fact, a noted deceleration of productivity growth could indicate that the incorporation of labour-displacing technology is actually *not* accelerating.¹⁹ It's worth noting that mechanization and automation of labour tasks can and has yielded broad societal benefits. Both processes can increase total amount, predictability, and consistency of output — especially in production — while reducing errors and inefficiencies. They can also reduce costs for producers, reductions which can in turn be captured as reduced expenses by purchasers.

Even with these cautions, however, the social context in which these changes occur remains a critical factor.²⁰ Widespread automation need not eliminate jobs entirely for it to create a circumstance in which workers compete for increasingly menial and precarious jobs with grossly insufficient wages, deplorable working conditions, and absolutely no benefits or security. In fact, technological advances such as computerization — that is, work mediated through digital platforms — have already yielded these forms of work. Research of Amazon’s Mechanical Turk platform found that, across 3.8 million tasks performed by 2,676 workers, the median wage was roughly \$2 an hour.²¹ Uber, which was recently granted license to operate in British Columbia, frequently makes the legal argument that it is a technology company, not a transportation company, and that drivers are not a part of its core business.²² Even acknowledging the benefits that automation and artificial intelligence can yield for workers — namely, increased labour demand for non-automated tasks through increased productivity, improvements to tools and machinery, and the creation of new labour tasks — these effects have been found to be outweighed by the labour-suppressing impacts of advanced automation, with long-term reductions in labour’s share of total income.²³ In other words, an apparent long-term trend of automation is fewer jobs and a smaller share of pay for workers.

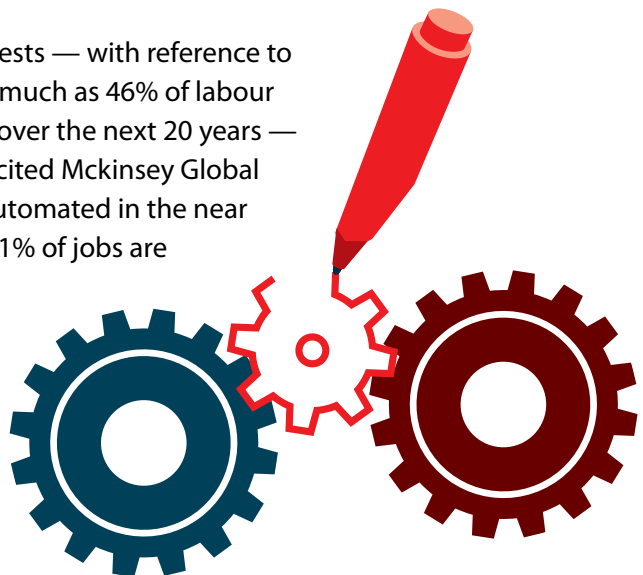


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Automation in British Columbia

RESEARCH CONDUCTED BY THE Brookfield Institute suggests that 42% of work in Canada — that is, 42% of labour tasks, rather than entire jobs — is susceptible to automation over the next two decades.²⁴ The report finds that highly-susceptible jobs tend to be in the industries of trades, transportation and equipment operation, natural resources and agriculture, sales and services, manufacturing and utilities, and technical occupations in health, natural, and applied sciences.²⁵ Throughout these sectors, the highest-susceptibility jobs include occupations such as retail sales person, administrative assistant, food counter attendants and certain kitchen staff, cashiers, and transport truck, drivers.²⁶ By their account, occupations bearing the lowest-susceptibility to automation include registered nurses, elementary school and kindergarten teachers, secondary school educators, early childhood educators and their assistants, and retail and wholesale trade managers.²⁷ The Brookfield Institute also found that the average incomes for occupations highly susceptible to automation are nearly 50% lower than the average incomes for occupations found to be least-susceptible to automation.²⁸ Regarding education and employment growth across sectors, the report found that workers in jobs least-susceptible to automation tend to require more education, and that projected employment growth for these occupations is markedly higher than for those more susceptible to automation in the short and medium term.²⁹

In a subsequent report, the Brookfield Institute suggests — with reference to the 2011 National Household Survey data — that as much as 46% of labour tasks in Canada have the potential to be automated over the next 20 years — the equivalent of 7.7 million jobs.³⁰ The same report cited McKinsey Global Institute data that less than 5% of jobs can be *fully* automated in the near future.³¹ The report argues that, in Canada, less than 1% of jobs are presently *fully* automatable.³² Federal documents retrieved by the Canadian Press through the *Access to Information Act* describe government officials' findings that 11 per cent of jobs in Canada could be automated over the next 15 to 20 years, with an additional 29 percent likely to experience significant change.³³ The documents retrieved



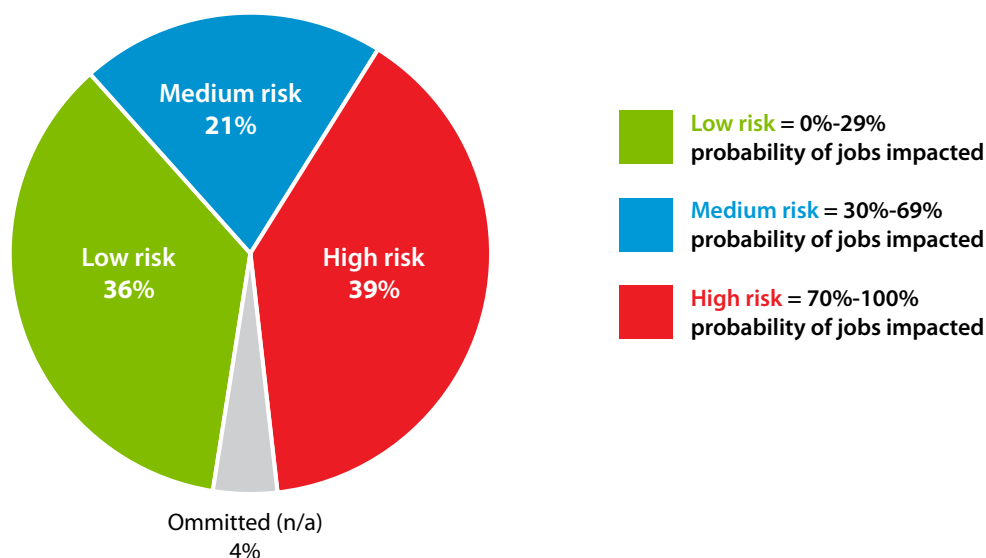
by the Canadian Press are not publicly available in full, and thus their analysis cannot be reviewed or replicated in this report.

In BC specifically, the Brookfield Institute's research suggests that regions like Quesnel, Williams Lake, Port Alberni, Fort St. John, and Abbotsford-Mission bear a good chance of seeing significant automation of labour tasks in the coming years.³⁴ This is in-part because these areas have above-average rates of employment in agriculture, fishing, hunting, and manufacturing.³⁵

Overall, however, the Brookfield Institute report suggests roughly 43.1% of the BC workforce holds employment that is highly-susceptible to automation over the next two decades, with roughly 20.6% holding 'medium-risk' employment, and 36.1% holding 'low-risk' employment.³⁶ In fact, according to the Brookfield Institute, between 41% and 45% of every province's labour force is at high risk of being affected by automation in the next 20 years.³⁷

The Brookfield Institute report's analysis categorizes jobs into the 'low risk', 'medium risk', and 'high risk' buckets by applying the same 'susceptibility to automation in the near future' measure developed by Frey and Osborne.³⁸ In their analysis, the respective levels of 'risk' refer to the probability that different jobs will be impacted by automation in the next 20 years. We applied these same measures to BC labour force data from the 2016 census. Figure 1 depicts the respective shares.

Figure 1: BC Labour Force, by Susceptibility to Automation in the Next 20 Years



In 2016, 36% of the BC labour force held employment considered to have 'low risk' of being impacted by automation in the next 20 years, 21% held 'medium-risk' employment, and 39% held 'high-risk' employment.³⁹ These numbers show that the most significant change from Brookfield's analysis of 2011 labour force figures is that the share of BC workers in jobs which are highly susceptible to being impacted by automation in the next twenty years has reduced slightly. This change cannot be considered more closely without further data and analysis.

Shifting Nature of Work in BC



ONE METRIC USED to indicate the impact of automation on workers in various jurisdictions is that of job/employment polarization. Job polarization refers to the trend by which a growing share of workers across the labour force shift over time into technical, abstract-analytical occupations or interpersonal, manual and socially interactive occupations, while an increasing amount of industrial labour tasks are taken up by automated systems.⁴⁰ In more practical terms, this means a shift from more industrial jobs (eg. factory work, forestry, farming and agriculture) into jobs in the care and service category, such as nursing, childcare, and service-industry work.

Broadly speaking, the three occupational categories are; (1) protective service, food or cleaning service, and personal care occupations, (2) sales, office and administrative support, production, craft and repair, and operator, fabricator, and labourer occupations, and (3) managerial, professional, and technical occupations.⁴¹ For ease of reference, the first category will henceforth be referred to as the 'care and service' category, the second will be referred to as the 'industrial' category, and the third will be referred to as the 'technical' category. As a potential indicator of the impacts of increasingly sophisticated automation on the labour force, searching for evidence of polarization can be helpful in conducting high-level analysis of the circumstances in BC.

Average incomes across the occupational categories are also important to consider. Many food or cleaning service workers in the care and service category deal with incomes that fall below a living wage in BC. Many workers in this category also face long-term precarious employment. As well, jobs in the care and service category are disproportionately occupied by women, people of colour, and immigrants.⁴² Automation in grocery store chains, fast food restaurants and other workplaces in the care and service category makes these workers' positions even less secure.⁴³ While a significant number of admin and office workers in the industrial category also deal with below-living wages and precarious employment, that category also hosts many middle-class jobs, especially in sectors with deep histories of worker organizing and activism. Notably, however, because automation enables employers to take an increasing number of tasks out of workers' hands, it increases the degree to which workers across all occupational categories struggle with precarious employment.

Statistics Canada (StatsCan) reports that in 1987 there were roughly 1,377,700 workers throughout British Columbia. In 2018, StatsCan reports 2,493,600 workers in the province. We used StatsCan's National Occupation Codes (NOCs) to track the total number of workers in a comprehensive list of

sectors in British Columbia from 1987 to 2018.⁴⁴ NOCs capture all workers aged 15 or older, including those who provide unpaid family labour, and workers who had a job but were not actively working in the reference week due to illness, disability, personal or family responsibility, or labour dispute.⁴⁵ We divided these NOCs into the three aforementioned employment categories (see Appendix 1 for a complete list of how each NOC was categorized).

The year 1987 is the earliest date for which Statistics Canada Labour Force data is readily available. This supports the analysis conducted in this report, as much of the literature on this topic contends that job polarization accelerated through 1970 to 2010.⁴⁶ However, the use of 1987 as a starting point indeed supports valuable analysis, as a much-cited work within the literature of job polarization surveys 16 EU countries between the years 1993 to 2010 — a time period included within our analysis.⁴⁷ In this report, two-digit NOCs are used to maintain consistency between the job polarization and wage polarization analyses — the latter of which is discussed below (see Appendix 2 for a fuller description of our research methodology).

With the NOCs categorized and the totals for 1987 and 2018 calculated, we can look at the change in the number of workers by occupational category and look for evidence of job polarization in the BC labour market.

Figure 2: Change in Total Number of Workers, by Occupational Category

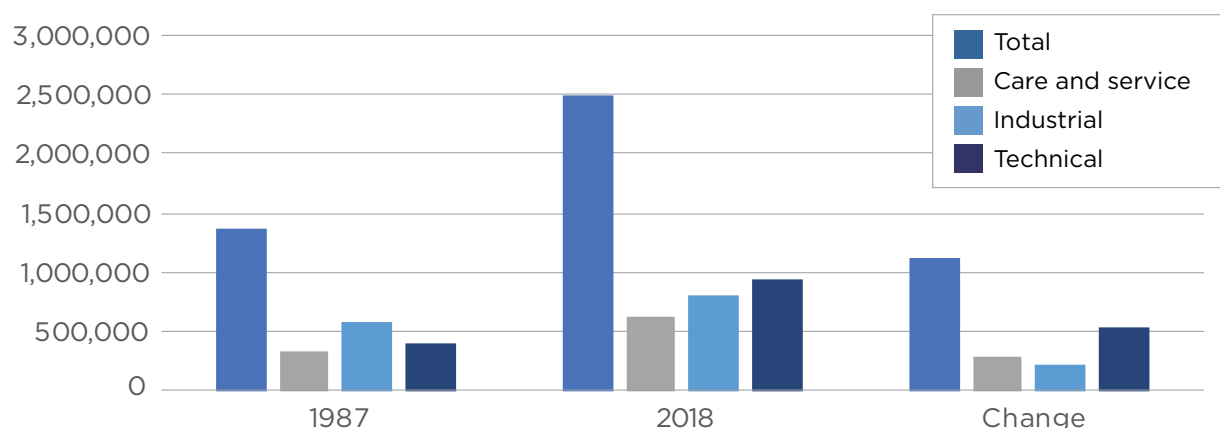
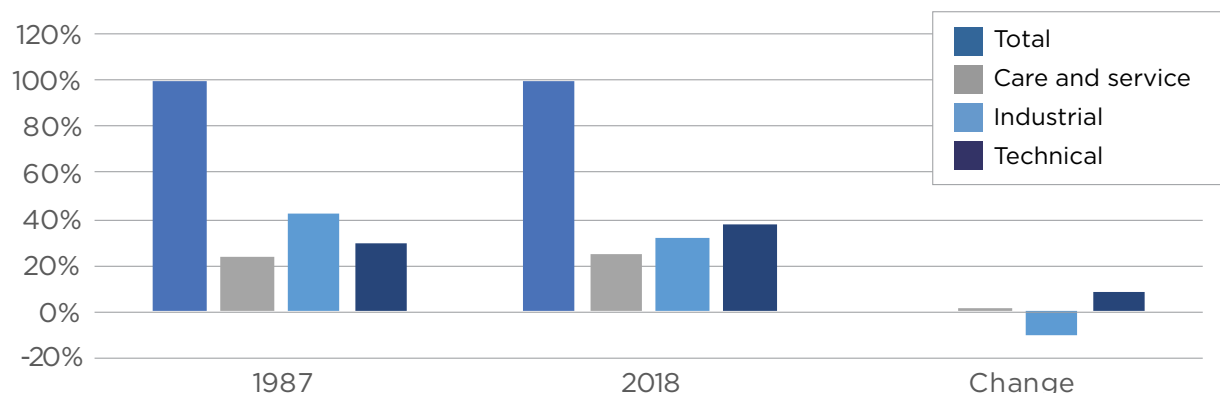


Figure 3: Percentage Change in Labour Market Share, by Occupational Category



Figures 2 and 3 demonstrate that the technical category of employment had the greatest increase on labour share between 1987 and 2018. This category rose from 29.8% of provincial labour share in 1987 to 37.8% of labour share in 2018; an increase of 8.1 %. The care and service category saw a modest increase of 0.8% of the provincial labour share, rising from 24.2% to 25%. Especially notable in this analysis is that the industrial category saw the greatest (and only) drop in labour share of the three groups, decreasing by 9.6% from 41.9% of labour share to 32.3%. This is a significant drop, with implications reaching beyond just industrial workers themselves. Figures 4 and 5 present the above changes year-by-year, demonstrating that trends indicate the reduction in labour share of the industrial category is a long-term trend which is likely to continue.

Figure 4: Annual Employment Totals, by Occupational Category

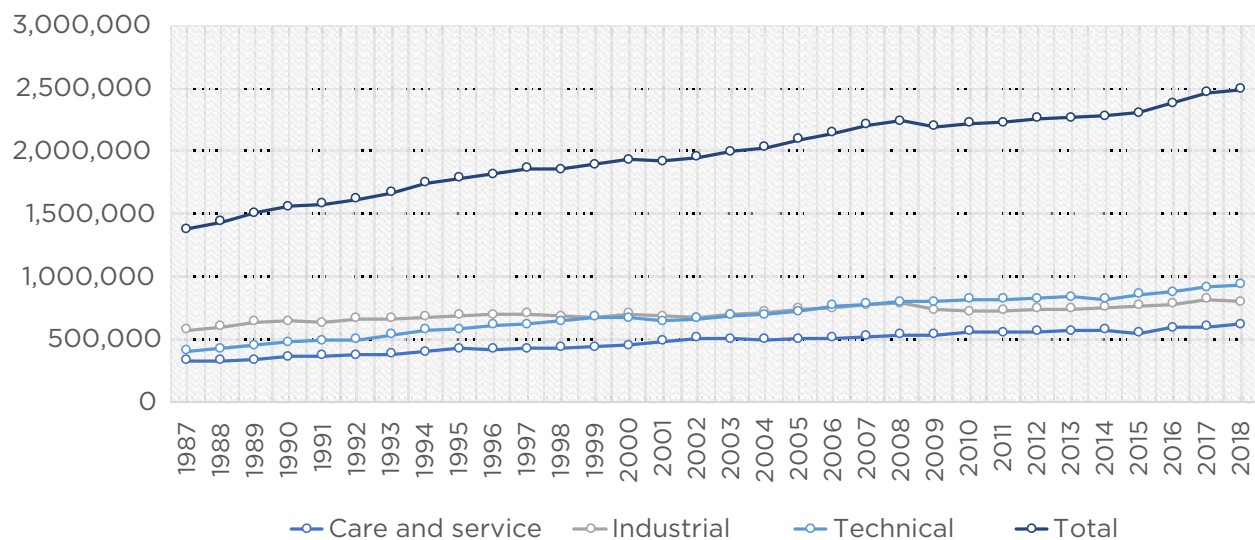
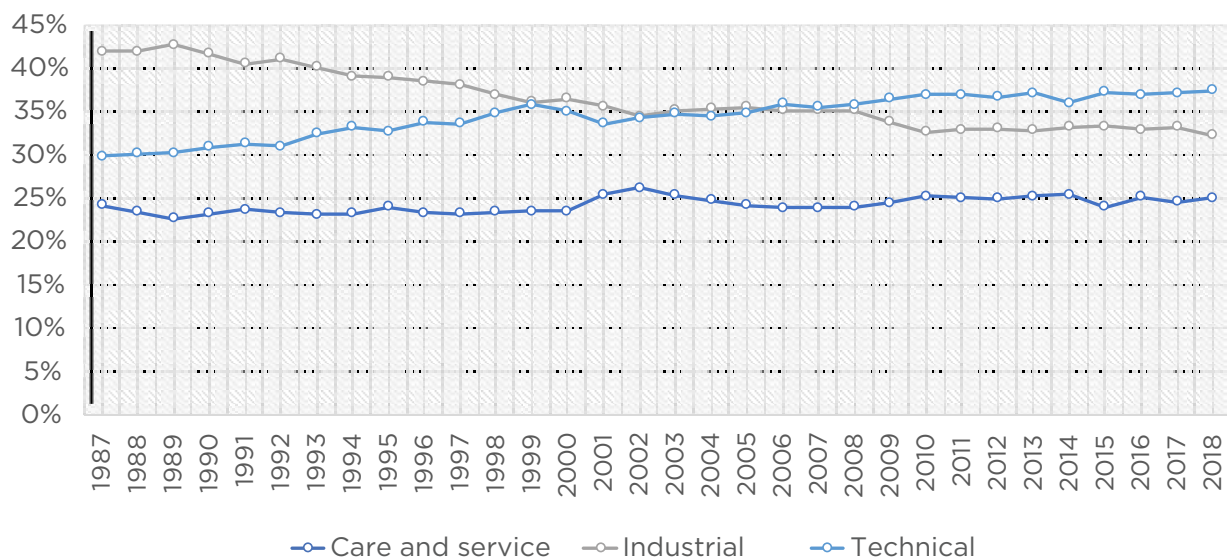


Figure 5: Annual Labour Share, by Occupational Category



These results appear to align with the job polarization of the US, UK, and the EU countries analyzed in the cited literature.⁴⁸ In each the US, Ireland, Belgium, Spain, the UK, Greece, Italy, Austria, Denmark, Sweden, France, Norway, the Netherlands, Germany, and Portugal, researchers note a shift toward the care and service and technical employment categories, while the industrial category reduced in labour share.⁴⁹

This trend is frequently referred to as a 'decline of the middle class.' Though the decline is in *labour share*, rather than in absolute numbers of workers, unionization among industrial workers has been a foundational element in pursuing collective well-being in Canada.⁵⁰ A reduction in labour market share among industrial workers could undercut the gains unionization in those sectors produced for all workers, whether or not they are unionized. Researchers who find this as evidence for automation spurring polarization argue that, if employer-controlled automation displaces workers — especially workers in industrial and labour sectors, and particularly those with long-reaching histories of worker organizing and activism — good-paying and family-supporting jobs will decline in their availability, alongside decreasing opportunities for those workers to find employment elsewhere. This type of polarization also has long roots in the history of labour market transformations, with foundational works identifying polarization as a fundamental element of labour market cycles.⁵¹ Once more, however, it is the advancing capacities of potential labour-saving technological advancements that makes present circumstances significantly more troubling. While polarization in the labour market has been seen before, and labour share changes across occupational categories are not themselves a herald of cataclysm, the polarization away from industrial work *accompanied by* increasing potential for automation in both the care and service and technical categories is a new development, and a worrying one.



As employer-controlled automation displaces workers, good-paying and family-supporting jobs decline in their availability.

Changes in the Wages of BC Workers

IN INVESTIGATING POTENTIAL EVIDENCE for job polarization, some researchers also look for evidence of wage polarization. What this report discusses as wage polarization refers to an increase in the rate of wage growth in the care and service and technical employment categories, accompanied by a decrease in the rate of wage growth of the industrial employment category. This decrease would align with our observations regarding changes in the respective categories' labour share across the BC workforce.

Figure 6: Change in Hourly Wage, by Employment Category

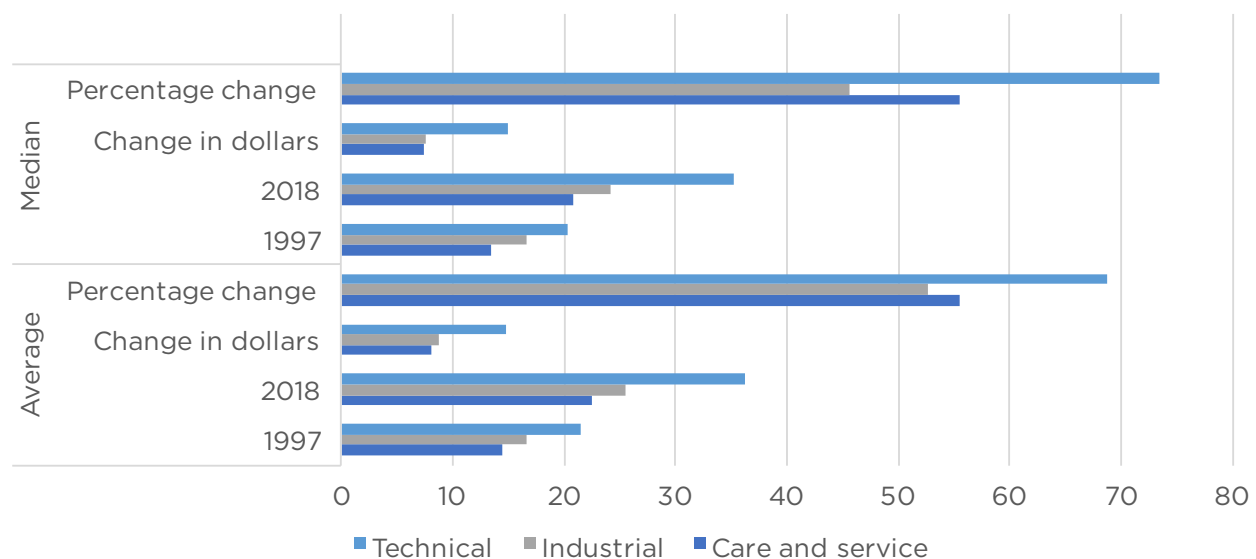
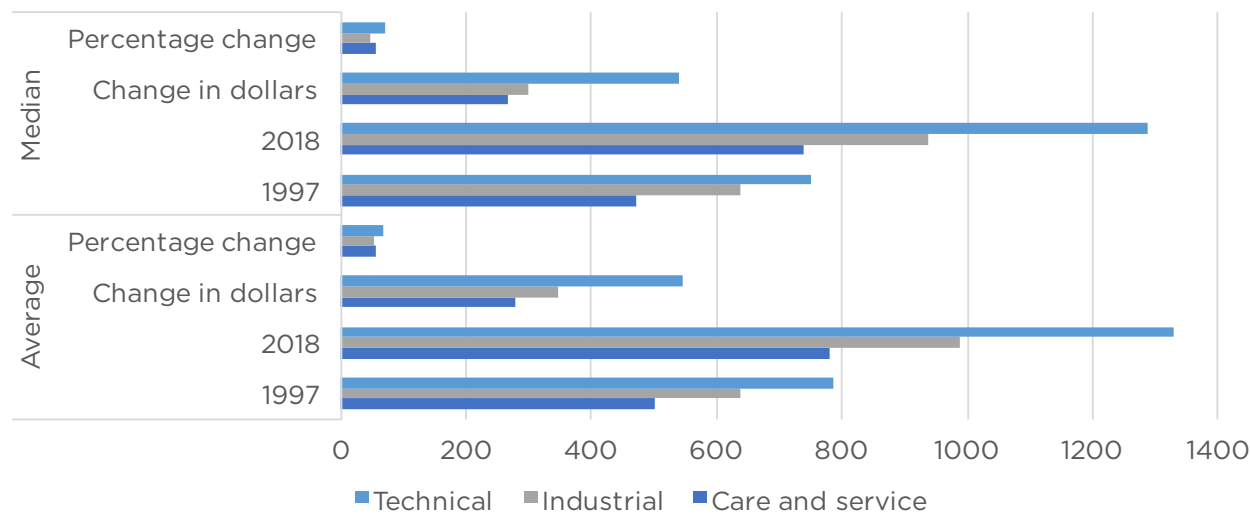


Figure 7: Change in Weekly Wage, by Employment Category



Figures 6 and 7 depict the changes in both hourly and weekly wage level of the three employment categories between 1997 and 2018, as drawn from StatsCan archival data.⁵² These figures show that the technical category has had the largest percentage increase in both average and median wage in the time observed, followed by the care and service category, and then the industrial category. The technical category of employment has seen an increase of 68% in the average hourly wage, and 73% in the median hourly wage, while the care and service category has seen increases of 55% in both average and median hourly wages. The industrial employment category has seen the smallest rate of hourly wage growth in the observed time period, with a 52% for the average hourly wage and 45% increase for the median hourly wage. The industrial category has also seen the highest rate of increase in the gap between the average and median wage.

These results align with Figures 2 and 3, in that the technical employment category has seen both the largest increase in total number of workers since 1987, and the largest increase in labour market share, as well as the largest percentage increase in wages since 1997. Similarly in alignment with the employment data presented in Figures 2 and 3, the industrial employment category has seen the smallest rate of wage growth in the observed time period.



The industrial employment category has seen the smallest rate of hourly wage growth in the observed time period, with a 52% for the average hourly wage and 45% increase for the median hourly wage.

Figure 8: Average Annual Difference Between Average and Median Hourly Wages, by Employment Category

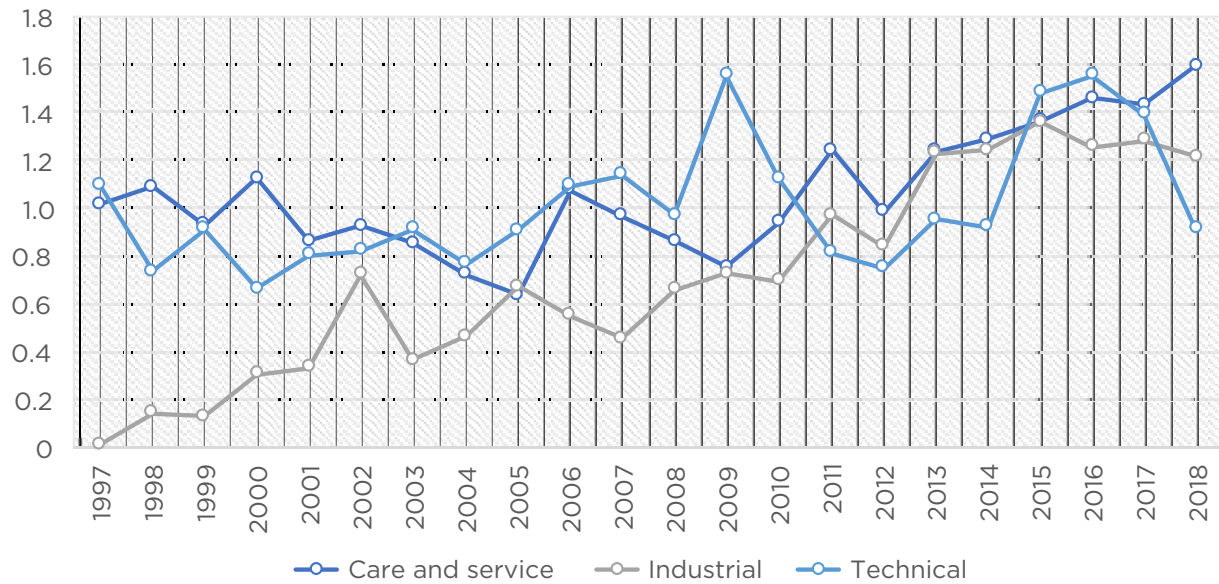
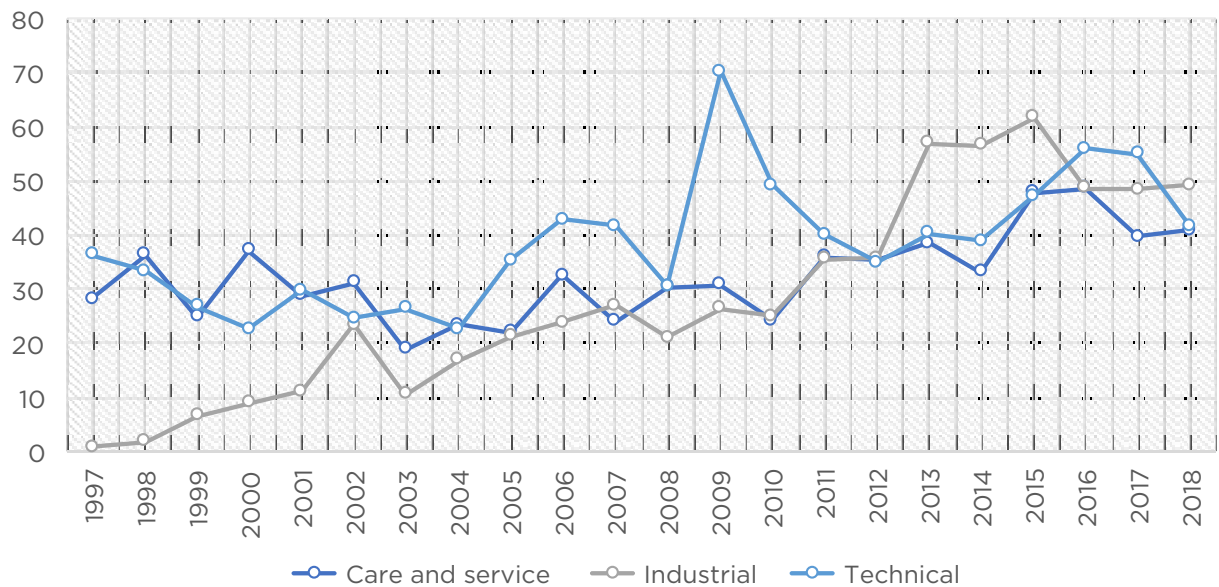


Figure 9: Average Annual Difference Between Average and Median Weekly Wages, by Employment Category



Figures 8 and 9 depict the year-by-year difference between the average and median weekly and hourly wages for the respective employment categories, as a calculated average of the wage rates for each NOC contained in the respective categories (see Appendix 2 for a fuller description of the methodology applied here.) While the data showcases that there is a significant amount of year-by-year fluctuation in the average-median wage discrepancy, they also demonstrate that the gap between the average and the median wage is increasing for every employment category. Notably, the industrial category appears to have the highest rate of increase in discrepancy between the average and median wage. More detailed data would be required to attempt a comprehensive explanation of that phenomenon. Median wages are typically considered to be a more accurate representation of incomes, as average wages can be pushed upward by a relatively small number of high-income earners.⁵³ Therefore, the increasing disparity between average and median incomes may suggest that income inequality is increasing in every employment category.

So, how does this relate to the employment data considered earlier? For the purposes of this report, the average-median wage discrepancy analysis is most useful in indicating that income inequality may be rising across the three employment categories over the same period in which we observe apparent evidence for both job and wage polarization in British Columbia. There is a significant body of research demonstrating that income and wealth inequality are rising within Canada, with British Columbia (and Vancouver in particular) being one of the focal points of this trend.⁵⁴ However, that analysis typically compares incomes *across* the labour force, contrasting incomes in entirely different occupations. The analysis in this report cites potential evidence that income inequality is rising even *within* respective employment categories, raising questions about how young or new workers, precarious workers, and workers who are changing jobs or tasks, are faring economically.



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Case Study — Automation and Labour at BC's Ports



ON MAY 28, 2019, the BC Maritime Employers Association (BCMEA) announced a province-wide lockout of 6,500 workers from all ports along Canada's west coast.⁵⁵ This lockout included the Port of Vancouver, the busiest port in Canada and the third-largest in North America. The Ports of Vancouver and Prince Rupert together account for 67% of all shipping container traffic in Canada. BCMEA's announcement came during an ongoing labour dispute between the association and the International Longshore and Warehouse Union Canada (ILWU Canada).⁵⁶

Bargaining between ILWU Canada and BCMEA had begun nearly 18 months prior, in January 2018, roughly three months before their contract was set to end on March 31, 2018. ILWU Canada had explicitly sought to avoid shutdown of Western Canadian ports despite the ongoing labour dispute. The union organized limited, targeted job actions at the Port of Vancouver's Vanterm and Deltaport container terminals, issuing an overtime ban rather than initiating a strike. Both Vanterm and Deltaport are operated by the Global Container Terminals corporation. The lockout would come to an end just hours after it had been announced, following a deal reached between ILWU Canada and BCMEA. This deal, however, left many issues to be worked out going forward, and highlights an increasingly prominent concern for workers. The central issue which prolonged the bargaining process, and which ILWU Canada fought to make advances on, is the issue of automation.

The dispute between ILWU Canada and the BCMEA highlights the ways in which modern automation presents serious concerns for workers. In basic terms, workers' collective bargaining power comes from employers' dependence on their labour. Job actions such as strikes are impactful because workers leverage this dependence by withholding their labour, thus forcing employers to the bargaining table, where workers argue for better wages and benefits, improved working conditions, and more job security. When controlled by employers for their benefit, modern automation disrupts the dependence upon workers' labour, and so attacks an essential mechanism of leverage in the fight for decent work and well-being for all people. Mechanized processes have already replaced human workers in a wide array of tasks, and the impact of digitization and automation is palpable at ports and container terminals.



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ILWU Canada recently released a report, commissioned from PRISM Economics and Analysis, which vividly demonstrates this reality. The report — entitled ‘Economic Impact Study of Digitization and Automation of Marine Port Terminal Operations in British Columbia’ — notes a global downward trend in port-related labour, citing estimations that crane operators and dockworkers may experience as much as 90% task automation by 2040.⁵⁷ In addition to drastically reducing the workforce, port and container terminal automation also changes the applied skillset of the workers that are retained.⁵⁸ The workforce is reduced to a fraction of prior levels, while the remaining workers are required to take on increasing number of tasks.

Fully automated container terminals already exist in the Netherlands (the APMT Maasvlakte 2 terminal at the Port of Rotterdam) and China (at the Qingdao Port), and the automated Qingdao Port container terminal is projected to reduce the labour force by as much as 85%.⁵⁹ Since the year 2000, automation has been increasing at the ports of Los Angeles and Long Beach in California, resulting in labour force reductions of 40-50% and 70-75%, respectively.⁶⁰ Automation at Australia’s Patrick’s Sydney container terminal, located at Port Botany, has led to a 50% reduction in its labour force since just 2014.⁶¹ The Victoria International Container Terminal (VICT), located at the port of Melbourne, was opened in 2017 as Australia’s first fully automated container terminal,

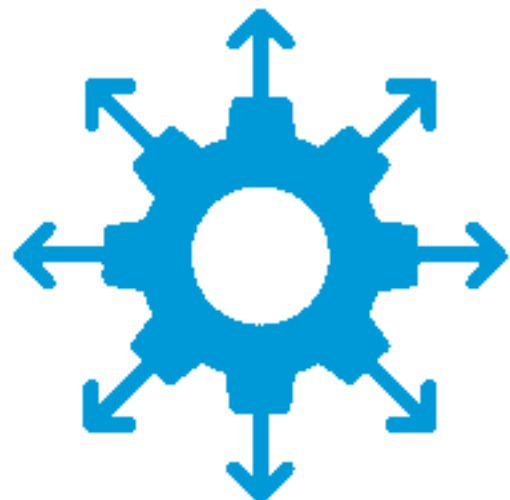
**Crane operators and dockworkers
may experience as much as 90%
task automation by 2040.**

capable of operating with a workforce of just 150 workers of primarily managerial, administrative, and remote operator jobs.⁶² Notably, remote operator jobs can be outsourced across national borders. In the case of the VICT, the terminal operator has attempted to further cut the workforce by outsourcing remote operator jobs to the Philippines.⁶³ The Australian ports have managed to maintain their annual container handling capacity despite the severe cuts in their workforce.

The trends described in this report are directly visible in the case of ILWU Canada. Over the past 10 years, every newly developed container terminal has had some degree of digitization and automation. This has led to reductions in the number of workers at ports that would fall into the industrial category, and creates barriers to entry and job security for new workers. Computer-controlled cranes can be operated from a desk within an office, and even if this office is on-site — as opposed to overseas — employers can task a single crane operator with controlling multiple cranes. As well, increasingly sophisticated cameras and object-recognition software have reduced the number of ‘checkers’ and shipping and receiving clerks working at container terminals, each of whom would also fall into the industrial category. ILWU Canada has noted that, as terminal operators increase automation at BC ports and reduce the number of positions and tasks available to workers, casual workers are hit first, promoting precarity in their employment. The crane operators and dockworkers who face as much as 90% task automation by 2040, as cited in the PRISM study, all fall into the industrial category, reinforcing that this polarization could continue. Given these figures and the PRISM report’s finding, there is cause to believe the negative impacts of employer-controlled automation which have been experienced by workers across the industrialized world are being experienced here, and now, in British Columbia as well.⁶⁴

ILWU Canada and other longshore and port workers are in a distinct position when contending with automation. While terminal operators may shift cargo traffic between terminals to undercut workers, the port itself can’t simply be moved elsewhere. For workers in other industries, employers and operators may relocate their business to undercut workers that achieve gains against employer-controlled automation through collective bargaining, direct action, and organizing. However, as discussed earlier, this also means these workers represent a significant portion of incomes to smaller port communities. Drastic reductions in those workforces raises serious concerns to those communities.

There is cause to believe the negative impacts of employer-controlled automation which have been experienced by workers across the industrialized world are being experienced here, and now, in British Columbia as well.



Following the lockout of ILWU Canada workers by BCMEA — and after intervention from a federal government mediator — ILWU Canada was able to attain language in their new collective agreement mandating that terminal operators consult with the union at least 120 days before operation of a container terminal begins. However, such terminals take years of planning and construction to develop, meaning 120 days is not nearly enough time to facilitate meaningful consultation with workers. Port authorities request operator proposals years before the terminal is to open, and selected terminal operators make their terminal design and equipment-purchasing decisions years in advance, and thus can design their terminals to be primed for automation. Planning for the Deltaport container terminal began in 2016, though the terminal didn't begin operations until late 2018, early 2019.

In fact, terminal operators can even design terminals in which it would be especially dangerous for human workers to be present on-site, such as container terminals that are intended to operate through



PHOTO ILWU.ORG

In British Columbia, port automation threatens more than 10,780 jobs and workers, especially in Delta, Vancouver, and Prince Rupert.

the night, or without enough space for human workers to safely move around. As well, cargo ships and shipping containers have been increasing in size over the past 20 years, and the cranes installed at container terminals are increasing along with them. They've reached a size at which, in some cases, it can be difficult for a human being to operate the cranes on eyesight alone. While there is camera equipment which could be installed to support human operation, employers will often cite any capital investment as reason to move toward automation outright, given its high upfront costs (as much as \$500,000,000).⁶⁵

securing benefits for workers in Stewart, BC, that had been exploited by their employer for nearly 30 years. However, increasing automation remains a significant concern. The 'Roberts Bank Terminal 2 Project: Overview and Rationale' report released by the Vancouver Fraser Port Authority proposes a semiautomated container terminal to be developed at the Port of Vancouver.⁶⁶ The report states that the proposed development would require 12,400 person-years of employment during operation, with 1,550 of these being at the terminal site, while 10,850 would be off-terminal.⁶⁷ There is reason to question these numbers, since the off-terminal person-years of employment would largely consist of trucking and warehousing jobs — two industries that are also being automated by corporations and

ILWU Canada made other gains in bargaining with BCMEA, including the establishment of a committee including representatives of both ILWU Canada and the BCMEA (the union pushed for Local representatives to be prioritized), increasing wages and benefits, and

employers.⁶⁸ Thus, the port authority arguably cannot guarantee that the person-years of employment it presents would actually be retained.

When approaching bargaining at the beginning of 2018, ILWU Canada had to figure out how to contend the issue of automation. For example, ILWU holds jurisdiction over all work related to the movement of cargo at ports and container terminals. To attack this jurisdiction, employers and terminal operators have taken the position that the development of computer systems which facilitate digitization and automation — and, even, the maintenance of equipment operated by those processes — does not fall under the umbrella of work related to the movement of cargo. This represents the employers' effort to exclude new work from the union's jurisdiction and prohibit any new workers from joining the union.

This example also raises how worker displacement impacts communities, as harm done to workers will necessarily cause harm to their communities as well. The PRISM/ILWU report cited earlier notes that this especially threatens communities where longshore and dockworkers live, and in which they frequently represent a significant portion of middle-income and high-income employment. In British Columbia, port automation threatens more than 10,780 jobs and workers, especially in Delta, Vancouver, and Prince Rupert.⁶⁹ In Delta, the terminal operator has already automated the port-adjacent rail system, and acted against the ILWU Local and its workers. Many of the other industries in these communities, such as forestry and fisheries, have already been automated in significant degree, or otherwise seen drastic reductions in their workforces. If the incomes brought in by longshore workers reduce significantly, those communities will experience further harm. The economic activity that those incomes produce will disappear, hurting every sector and business remaining within the community, and so reproducing that income loss repeatedly.⁷⁰

LESSONS LEARNED FROM LONGSHORE

ILWU Canada's engagement with automation shows that unions must be proactive in dealing with technological change. ILWU Canada viewed examples of automation and port-based labour disputes around the world, and planned in advance for how they would address the issue. The union put forward 20 proposals regarding automation that it had developed, and though these proposals weren't won, the joint committee they've established with the BCMEA gives workers direct input into the processes, and the targeted actions they took during the dispute demonstrate their commitment to solidarity in the face of workforce-reducing automation. The union was also successful in recapturing some jobs which had been moved out of its jurisdiction.

The actions of container terminal operators designing their worksites to better facilitate automation shows that employers are taking the long view. Unions must also take a long view, recognizing that modern automation cannot be stopped outright, but it *can* be harnessed to uplift workers, improve labour processes and working conditions, and increase the benefits working people and communities receive from technological advancement.

Conclusion



MECHANIZATION OF LABOUR TASKS has long been a concern for workers and their organizations. Throughout history, mechanization has typically created new tasks or jobs for workers impacted or displaced by the process, including allowing further opportunity to specialize in their field, and to apply creative, analytical, and abstract skills in their work. However, as industrial mechanization has given way to modern digitization and automation, some researchers argue that workers face decreasing opportunity to find new tasks and employment, and that the advance of Big Data, artificial intelligence, sophisticated algorithms, and other innovations may herald a larger-scale and more-permanent displacement of workers.

One of the indicators researchers have used to demonstrate the impact of automation on national labour forces is the presence of both job and wage polarization — that is, the shifting of labour share away from industrial employment and into either care and service work or technical and analytical jobs. This report uses Statistics Canada on the BC labour force to look for potential evidence of job and wage polarization in BC, as well as considers the respective susceptibility to near-term automation of workers throughout the province.

Citing analysis on respective job's likelihood of automation in the near term, we find that roughly 60% of the BC labour force faces either a high or medium likelihood of having their job impacted by automation in the next 20 years. Further, review of BC labour force data reveals potential evidence of job polarization among BC workers. Since 1987, the industrial job category has lost labour share, while

Review of BC wage data finds apparent evidence for wage polarization in BC, with the industrial category of work experiencing the smallest percentage growth in wages since 1997.

both the care and service and technical categories have grown in labour share. Trends suggest that this will continue in the coming years. Finally, review of BC wage data finds apparent evidence for wage polarization in BC, with the industrial category of work experiencing the smallest percentage growth in wages since 1997. BC wage data also reveals an increase in the disparity between average and median wages in every job category since 1997, suggesting that income inequality may be growing *within* respective sectors across the BC labour force.

WHAT DOES THIS MEAN FOR BC WORKERS?

Modern automation raises critical issues for BC workers. Labour-saving technological advancement is now buoyed by advanced algorithms and ‘Big Data,’ increasingly sophisticated systems such as object-recognition software and off-site operation of computer-controlled equipment, and vast teams of computer programmers. If it is widespread and controlled by employers, automation of labour tasks can threaten the well-being of workers, their communities, and society as a whole. This is a significant issue in BC; Amazon is developing both fulfillment centres and software engineering offices in Metro Vancouver.⁷¹ Amazon is infamous for its abusive labour practices — which use automated systems to govern every second of a workers’ time, causing high rates of injury and automated dismissals — as well as its stupefying tax avoidance.⁷² There are critical questions to engage regarding how automation and digitization interact with rising precarious employment, the costs of education, and the notion of equity and justice in how labour is distributed across the population.⁷³ The capacities and potential of modern automation represent a fundamental restructuring of the labour environment unlike any before it, and we must determine whom this re-structuring will serve.

As noted in the literature, “The balance between job conservation and technological progress, to a large extent, reflects the balance of power in society, and how gains from technological progress are being distributed.”⁷⁴ “Properly deployed and democratically accountable technology has the ability to shorten workweeks and improve workers’ lives and living standards. But we will not get such technology by talking about the Future of Work. We will only get it if we begin to challenge the reigning assumptions that are currently guiding Future of Work discussions.”⁷⁵

If employer-controlled technological change pushes us toward a circumstance in which workers are competing for a decreasing number of available jobs — with more and more of the newly-created positions excluded from existing unions’ contractual jurisdictions — while fewer and fewer people are able to afford pursuing the education that would make them potential applicants for the jobs which do remain, inequality will continue to increase. This would not only critically threaten the well-being of people in this province and country, it would also undercut the democratic nature of our society; as Statistics Canada has reported, the higher someone’s income, the more likely they are to vote.⁷⁶

To avoid this outcome, governments must both support and increase workers’ protections from and control over technological change in their workplaces. As noted in the BC government’s 2018 Labour Market Outlook report, access to post-secondary education, public transportation, affordable housing, and other public services and essential resources are critical in supporting workers in the era of automation.⁷⁷ Thus, governments must invest in those services, while also expanding income supports and advanced skills training programs for workers adversely effected. Governments should also seek to implement rigorous public data-gathering measures. Doing so would give workers access to the information they need for effective collective bargaining across the table from employers who can implement equipment and computer systems which automatically gather data. What’s more, governments must ensure that there are no barriers to unionization in this changing labour environment, while unions will have to contend with employers designing work sites and labour processes to isolate workers and discourage organizing.

As cited throughout this report, there is a significant body of research connecting automation of labour tasks with both job and wage polarization. Critically, broader societal changes have increased the difficulty for workers displaced by technological change to take up new tasks or occupations. The case of ILWU Canada in their labour dispute against the BCMEA demonstrates this potential impact more immediately, showing how workers, their communities, and broader society are threatened by employer-controlled automation.

In response to these issues raised, we argue that workers must have meaningful input in — if not direct control over — the process of automation, both to guard against the critical threat it presents to workers and society, but also to properly capture and the distribute the possible benefits of automation.

Giving workers control over the process of automation in their workplace empowers them to incorporate technological advancements from a labour- and community-focused perspective, rather than a wholly profit-driven one. Workers know the labour processes they carry out better than anyone, including their employers. Supporting worker control of labour processes — through unionization or other means — allows both those processes and the broader economy to benefit from technological advancement without undercutting workers, their families, or their communities.

Evidence suggests that abstract (i.e., creative and adaptable) task-intensive work is responsive — or, ‘elastic’ — in that technological progress which increases output of these tasks also increases demand for them.⁷⁸ Further, despite the rise of Big Data and the degree to which it increases programmers’ ability to automate labour tasks, the evidence does not suggest that automation will categorically displace workers.⁷⁹ If controlled by workers and used in service of the public interest, labour-saving technological change can be used to complement human labour, improve working conditions and increase productivity in ways that increase both labour demand and the comparative advantage of workers’ adaptability and ingenuity.⁸⁰ If the process of automation is controlled by workers, it can be used to benefit them — and through them, benefit all of society.

Governments must also play a role in addressing the issues modern automation of labour tasks can create in society. The apparent job and wage polarization cited above threatens to increase economic inequality in our society — an issue that has already been climbing steadily for years.⁸¹ Herein lies the real threat — without government intervention in support of workers and the public interest, employer-



The capacities and potential of modern automation represent a fundamental restructuring of the labour environment unlike any before it, and we must determine whom this re-structuring will serve.

controlled automation could undercut unions, disempower workers, and create a labour market defined by insecure, low-paying, benefit-less jobs that cycle through workers as quickly as possible.⁸²

Our response must be multi-pronged; we have to ensure steady, secure, good-paying and unionized jobs for all workers; make education and ‘upskilling’ accessible at minimal or zero cost for students and workers; prohibit employers or corporations for extracting labour from workers without honouring their rights by employing misclassification or otherwise non-standard employment structures; invest deeply in public services, income protections, and care-providing institutions; pursue economic and labour policies which center workers and families, rather than profits and investment; establish public control over technological advancement; and — of course — support workers’ rights to unionization and collective bargaining in every sector.⁸³

As the old labour hymn goes, ‘Without our brain and muscle, not a single wheel can turn.’ Employer-controlled automation wishes to turn the wheels without workers’ brain and muscle, despite that it was the workers who built those wheels. Meaningful worker control in the process of automation, and democratic accountability for employers who pursue automation as a method of undercutting workers, are essential if we are to protect and support workers in the coming era.

APPENDIX 1: DATA TABLES

Combined BC Labour Force Employment Totals

- 1987; 1,377,700 workers
- 2018; 2,493,600 workers

Category 1: Protective service, food or cleaning service, and personal care occupations

NOC	NOC description	1987 total (x1000)	2018 total (x1000)
34	Assisting occupations in health services	15.1	49.2
43	Occupations in front-line public protection services	10.4	13.7
44	Care providers and educational, legal, and public protection support services	31.2	40.1
62	Retail sales supervisors and specialized sales occupations	32.6	98.6
63	Service supervisors and specialized service occupations	56.2	94.4
64	Sales representatives and salespersons — wholesale and retail trade	72.1	113.1
66	Sales support occupations	40.2	85.5
67	Service support and other service occupations, n.e.c.	75.5	128.3
Total		333.3	622.9

Category 2: Sales, office and administrative support, production, craft and repair, and operator, fabricator, and labourer occupations

NOC	NOC description	1987 total (x1000)	2018 total (x1000)
12	Administrative and financial supervisors and administrative occupations	80.1	118.1
13	Finance, insurance, and related business administrative occupations	20	43.8
14	Office support occupations	78.9	91.1
15	Distribution, tracking and scheduling co-ordination occupations	30.7	35.2
72	Industrial, electrical and construction trades	75	35.2
73	Maintenance and equipment operation trades	65.9	84.8
74	Other installers, repairers and servicers and material handlers	25.5	43.5
75	Transport and heavy equipment operation and related maintenance occupations	61.7	86.4
76	Trades helpers, construction labourers and related occupations	12.2	20.8

82	Supervisors and technical occupations in natural resources, agriculture and related production	18.2	25.3
84	Workers in natural resources, agriculture and related production	20.1	25.3
86	Harvesting, landscaping and natural resources labourers	11.6	14.7
92	Processing, manufacturing and utilities supervisors and central control operators	12.1	24.6
94	Processing and manufacturing machine operators and related production workers	34	28.5
95	Assemblers in manufacturing	8.5	12.5
96	Labourers in processing, manufacturing utilities	22.8	15.8
Total		577.3	804.4

Category 3: Managerial, professional, and technical occupations

NOC	NOC description	1987 total (x1000)	2018 total (x1000)
00	Senior management occupations	5.6	5.7
01-05	Middle and other management occupations	30.8	59.3
06	Middle and other management occupations	67.3	76.3
07-09	Middle and other management occupations	38	66.5
11	Professional occupations in business and finance	33.8	97.1
21	Professional occupations in natural and applied sciences	31.9	103.8
22	Technical occupations related to natural and applied sciences	33.3	96
30	Professional occupations in nursing	23.1	52.9
31	Professional occupations in health, other than nursing	11.1	38
32	Technical occupations in health	20.6	54.8
40	Professional occupations in education services	40.1	80.8
41	Professional occupations in law and social, community and government services	21.2	68.8
42	Paraprofessional occupations in legal, social, community and education services	22	52.2
51	Professional occupations in art and culture	14.3	30
52	Technical occupations in art, culture, recreation, and sport	17.2	61.5
Total		410.3	943.7

Raw data in Excel format can be downloaded from <https://bcfed.ca/automationreportdata>

APPENDIX 2: METHODOLOGY

Regarding Susceptibility to Automation

The measure of susceptibility to automation (or, computerisation, as it is termed in the paper) refers to the likelihood that respective jobs will be impacted by automation in the timespan projected. It does not refer to the degree to which those jobs will be impacted by automation. In each case, there is a specific portion of the jobs' standard tasks are most-susceptible to automation. However, the methodology of this task-specific analysis as conducted by McKinsey was not considered for this report, and thus the specific numbers of its assessment are not included. The trend of employment polarization does not imply that occupations in the second occupational category will completely disappear — as argued in the literature, some tasks, even if automatable, are too difficult to 'unbundle' from associated tasks without reducing the quality of the task as performed.⁸⁴

To be specific, these occupational categories do not represent the susceptibility to automation of respective occupations based on the tasks those occupations involve. Rather, taking job polarization as an effect of the impact on automation — as described earlier in this report — this analysis seeks to replicate the categorizing of occupations based on that trend, and then seeks to determine whether that trend is evident in changes to the BC labour market.

Regarding Discussion of Job Polarization

Testing for polarization required some subjective decisions regarding how occupations should be grouped. First, certain two-digit NOCs contained different types of employment that could arguably be split between two, or even three different occupational categories. In these instances, we placed that NOC into the bucket we felt best-represented the majority or plurality of the occupations contained therein. This categorization affects the totals for the group, and thus the totals produced in the analysis. We chose to independently sort the NOCs into job categories, rather than directly applying Frey & Osborne's ratings as cited in the Brookfield report, to avoid a pre-determined outcome. If our own analysis produced results in rough alignment with the cited literature — which it did — we felt this would lend further support to our conclusions.

For example, NOC 31 (Assisting occupations in support of Health Services) contained both NOC 3413 (Nurse aides, orderlies, and patient service associates) and NOC 3414 (Other assisting occupations in support of Health Services). While, as a collected group, NOC 31 seems to fit appropriately within the first occupational category, which includes personal care occupations, it could be argued that NOC 3414 would fit well in the second occupational category, which includes office and administrative support occupations. Thus, the research conducted in this report can be furthered by analyzing employment totals for each of the four-digit NOCs. For this report, the employment data for two-digit NOCs were used so that the categories would align with those used for the wage-data analysis. Further research would benefit from considering more granular microdata regarding the BC labour force, including changes in both respective and relative income distribution over time.

A complicating factor in utilizing the NOC classification system is that Statistics Canada updates the system every five years, and at times certain four-digit NOCs are shifted between two-digit groups. Therefore, it is possible that some of these shifts occurred in the time period considered for our analysis. If the StatsCan data is retroactively reorganized, this would not affect our results whatsoever. However, if a four-digit code that is in a particular two-digit group up until 1993, but then shifted to a different two-digit group from 1994 onwards, our analysis would not identify that change nor account for it in our employment totals and calculated median- and average-wage averages. Our analysis also does not discuss how the NOC system relates to the preceding Canadian Classification and Dictionary of Occupations system. However, given that StatsCan makes data available which organizes employment numbers into NOCs even preceding the 1992 introduction of the NOCs classification system, this may suggest that the data has been retroactively re-classified. As it was not determined whether that is the case for the purposes of this report, we used the data as presented.

Additionally, the job-polarization analysis conducted on the UK and 15 EU countries focuses on wages as a method of categorization, as opposed to task-defined categories of employment. While these metrics are correlated in certain aspects, that correlation is not perfect, and is complicated by the relative share of unionized workers in respective occupations. Some contesting literature raises this distinction as a point of contention.⁸⁵ Whether the data included in Figures 2 through 5 can be considered evidence of polarization — and whether it can be tied to automation — is a topic of debate in economic literature.⁸⁶ A recent paper from the National Bureau of Economic Research argues against both assertions, citing as rejoinder that increases in labour share among both high- and low-wage occupations accompanied by a decrease in labour share for middle-wage occupations can be natural products of technological advancement and increases in the levels of education and skills training distributed throughout the workforce, as opposed to being detrimental impacts of worker-displacing automation.⁸⁷ The paper also reflects on the distinction between grouping jobs into categories based on wage and grouping into categories based on employment characteristics.⁸⁸ While acknowledging these caveats in our report, we note that the contesting paper asserts that a rise in the labour share of so-called ‘high-tier’ and ‘low-tier’ employment, accompanied by a fall in the ‘middle-tier’, can fairly be described as polarization.⁸⁹ Ongoing debates notwithstanding, this paper operates with this definition.

This distinction represents another complication when comparing employment and wage trends in the US to a Canadian jurisdiction. The intensity of macroeconomics effects in the US outdistances the Canadian case to some degree, with sharper declines in union density, harsher drops real wages (or declines in the rate of real-wage increases), degree of offshoring of production, and decreasing progressivity of taxation, each being more extreme in the US than in Canada.⁹⁰ Adjacent factors — such as the cost of post-secondary education being higher in the US than in Canada — also influence job polarization trends. These macro-economic factors also influence the disparities between the Canadian and US cases in the time period considered in our analysis — i.e., post-Reagan.

This also raises another necessary caveat — that we are applying a method of analyzing of national labour market trends to the case of a single Canadian province. Conducting this analysis on the entire Canadian labour market will require further data gathering and research collaboration, but, as a review of the potential impact of automation on labour in BC specifically — and applying that analysis to a closely considered case of a single labour dispute — this high-level trend is still valuable in helping us understand how large-scale changes in socio-economic circumstances structuring the labour environment affect us all at a more immediate, tangible level.

Regarding Discussion of Wage Polarization

To review the Statistics Canada data for potential evidence of wage polarization, we collected the year-by-year figures for both the average and median hourly wages and weekly wages for every NOC included in the employment data. These figures were grouped into their respective categories, and then the average of each category was calculated for each available year of data. The outcomes of these calculations are graphed in Figures 6 through 9.

It cannot immediately be said whether this average-median discrepancy data supports or contradicts the apparent evidence of wage polarization found in analyzing the overall change in the respective categories average and median wage levels. For this data to itself present evidence for or against wage polarization, we would have to identify a specific relationship between the rate of growth in the difference between average and median wages across employment categories and wage polarization — a relationship which is not considered in this report. Additional research regarding the stratification of wages within particular jobs, and within employment categories overall could investigate that relationship, and relate it to research on job polarization overall.

ENDNOTES

- 1 Frey and Osborne, pg. 7
- 2 Frey and Osborne, pg. 7
- 3 Frey and Osborne, pg. 9
- 4 Autor, pg. 5-6
- 5 Bátiz-Lazo
- 6 Goldin and Katz, pg. 256
- 7 Goldin and Katz
- 8 Autor, pg. 15
- 9 Bátiz-Lazo; Autor, pg. 5
- 10 Frey and Osborne, pg. 15
- 11 Bátiz-Lazo
- 12 Frey and Osborne, pg. 17
- 13 Frey and Osborne, pg. 17-21
- 14 Frey and Osborne, pg. 19
- 15 Frey and Osborne, pg. 23
- 16 Frey and Osborne, pg. 24
- 17 Frey and Osborne, 25-30
- 18 Stanford [1], pg. 2
- 19 Stanford [1], pg. 3
- 20 Stanford [1], pg. 6-7
- 21 Semuels
- 22 Rosenblatt
- 23 Acemoglu and Restrepo [1]
- 24 Lamb, pg. 3; It is difficult to contextualize these figures historically, as such data is not readily available, and technological change over time prohibits attempting to apply current measures of respective jobs' susceptibility to automation to past distributions of tasks across those jobs.
- 25 Lamb, pg. 10
- 26 Lamb, pg. 12
- 27 Lamb, pg. 12
- 28 Lamb, pg. 14
- 29 Lamb, pg. 15-16
- 30 Lamb and Lo, pg. 4
- 31 Lamb and Lo, pg. 3
- 32 Lamb, pg. 17
- 33 Press
- 34 Lamb and Lo, pg. 16-17
- 35 Lamb and Lo, pg. 16-17; There are caveats; the 2011 National Household Survey data lacks respondents in the North, and low-income workers were less-likely to respond than middle- or high-income workers (Lamb and Lo, pg. 5-6)
- 36 Lamb, pg. 13
- 37 Lamb, pg. 13
- 38 Frey and Osborne, pg. 40-41
- 39 Four percent of jobs were omitted from this analysis.
- 40 Autor, pg. 5
- 41 Autor, pg. 14
- 42 Block and Galabuzi
- 43 CBC News; Choi
- 44 Statistics Canada. Table 14-10-0023-01 Labour force characteristics by industry, annual (x 1,000); Statistics Canada data is known to miss some segments of the population, especially those at the bottom of the economic spectrum.
- 45 Statistics Canada Table 14-10-0023-01 Labour force characteristics by industry, annual (x 1,000)

- 46 Autor; Future research could access earlier data on BC's labour force to identify longer-term trends, as some of the considered literature seeks to do (Autor, pg. 10)
- 47 Autor, pg. 15; Future research could also employ more-detailed NOC data — that is, NOC data which separates the two-digit NOCs into four-digit codes specific to each type of employment contained in the two-digit categories — as well as, the year-by-year employment numbers for each of the four-digit NOCs, to replicate the analysis conducted in this report
- 48 Autor
- 49 Autor, pg. 15
- 50 Brennan
- 51 Goldin and Katz
- 52 Statistics Canada, Table: 14-10-0307-01. Employee Wages by Occupation, Annual
- 53 Hunt and Nunn, pg. 3
- 54 Tencer; Green, et al.; OECD
- 55 Grauer and McKeen
- 56 Grauer and McKeen
- 57 PRISM/ILWU Canada, pg. 3
- 58 PRISM/ILWU Canada, pg. 6
- 59 PRISM/ILWU Canada, pg. 6
- 60 PRISM/ILWU Canada, pg. 6
- 61 PRISM/ILWU Canada, pg. 6
- 62 PRISM/ILWU Canada, pg. 6
- 63 PRISM/ILWU Canada, pg. 6; Shore-based and automated control of ships is also a burgeoning area. (DNV-GL. "ROMAS project completed first phase of remote machinery operation testing." June 6, 2019.)
- 64 Lamb and Lo, pg. 16-17
- 65 PRISM/ILWU Canada, pg. 7
- 66 Vancouver Fraser Port Authority
- 67 Vancouver Fraser Port Authority, pg. 7
- 68 Vancouver Fraser Port Authority, Project Summary 26
- 69 PRISM/ILWU Canada, pg. 3
- 70 PRISM/ILWU Canada, pg. 8-10
- 71 Chan [1]; Chan [2]
- 72 Lecher; Ingraham
- 73 Celentano
- 74 Frey and Osborne, pg. 8
- 75 Gupta, Lerner, and McCartin
- 76 Sharanjit and LaRoche
- 77 BC Government, pg. 25-27
- 78 Autor, pg. 16
- 79 Autor, pg. 22-25; Stanford [1]
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