Economic Impact Study of Digitization and Automation of Marine Port Terminal Operations in British Columbia

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Executive Summary

The International Longshore and Warehouse Union has retained Prism Economics and Analysis to assess the economic impact associated with digitization and automation of marine port terminals in British Columbia and in three BC communities with the greatest economic dependence on this sector: Prince Rupert, Delta and Vancouver. This report solely focuses on the impact of automation on the container sector, as bulk shipping has yet to be effectively automated. Key findings of the analysis include the following:

- The adoption of automated technology in other ports around the world has caused demand for port related labour including longshoremen and equipment operators to decline. According to the World Maritime University (2019), positions such as crane operators and dockworkers may experience up to 90% task automation by the year 2040.
- Data presented in this report suggests that job loss arising from automation of marine terminal operations places a significant portion of middle-class and high-income employment at risk in communities where marine terminal operations are concentrated.
- Longshore employment in the container sector (i.e. excluding break bulk) accounts for a significant portion of the middle-class and high-income jobs in Delta, Prince Rupert and Vancouver. Based on the 2016 Census, longshore employment accounts for 3% of jobs across sub-districts paying more than $70,000 per year and 6% of jobs across sub-districts paying more than $100,000 per year.
    - Longshore employment accounts for 26% of all jobs paying more than $70,000 in Prince Rupert, 11% in Delta and 2% in Vancouver.
    - Longshore employment accounts for 66% of all jobs paying more than $100,000 in Prince Rupert, 23% in Delta and 3% in Vancouver.
- To assess the economic impact from job loss associated with automation, Prism analyzes two scenarios:
    - A brownfield semi-automated scenario, where labour in targeted occupations is reduced by 50%; and
    - A greenfield fully automated scenario, where labour in targeted occupations is reduced by 90%.
- Brownfield port automation projects involve upgrading existing terminals. In Port Botany, Australia, an existing container terminal was partially automated by Patrick Terminals. In 2014, that port employed 436 workers on site. In 2016, following automation, the terminal employed as few as 213 workers.
- Greenfield projects involve building a new facility, eliminating the need to remodel or demolish existing structures, and are more likely to be fully automated. The Victoria International Container Terminal (VICT) in Melbourne is Australia's first fully automated port and is capable of operating with a workforce of as few as 150 workers, most of whom perform management, administrative or remote computer operations. In comparison, a conventional port such as Prince Rupert operates with a total workforce of 525 workers.
- The impact analysis shows automation and subsequent job loss would have a substantial effect on the local economies and on tax revenue that supports services in those communities:
    - In the Brownfield Scenario, nearly 6,000 jobs provincially, over 2,300 jobs in Delta, more than 2,200 jobs in Vancouver and in excess of 700 jobs in Prince Rupert are at risk
    - In the Greenfield Scenario at risk employment almost doubles: more than 10,780 jobs provincially, 4,100 jobs in Delta, over 4,000 jobs in Vancouver, and over 1,200 jobs in Prince Rupert
    - Total income including wages and salaries and employer contribution to pension and benefit plans is estimated to be reduced by a net value of $628M provincially and over $577M across sub-districts in the Greenfield scenario and by a net value of $349M provincially and over $320M across sub-districts in the Brownfield scenario
    - In the Greenfield Scenario, there is an estimated $66.6M net reduction in federal tax revenue, a $28.9M net reduction in Provincial Revenue; and a $8.3M net reduction in municipal tax revenue
- There is some evidence that anticipated improvements in productivity and profitability are not always realized through port automation. A report conducted by McKinsey & Company (2018) indicates that up-front capital expenditures can be quite high and operational challenges related to automation can be significant. A survey conducted by McKinsey (2018) indicates that while operating expenses may decline following automation, overall productivity may also decline and return on capital invested may be lower than industry norms.

Introduction

The International Longshore and Warehouse Union Canada is undertaking an examination of the economic impact associated with digitization and automation of marine port terminal operations on the Pacific Coast of Canada. To support this work, the Union has engaged Prism Economics and Analysis to conduct a comprehensive regional and local economic impact assessment. The assessment includes the direct, indirect and induced effects of marine terminal automation on employment, incomes and expenditure at an individual, community and provincial level. Unlike some economic impact assessments, this analysis is not solely focused on short-term impacts and therefore does not assume that permanent job loss is offset by temporary construction jobs that might be associated with building a new port or installing new equipment in an existing port.

This report examines the widespread implications of automation and digitization on marine port operations. This report focuses solely on the impact of automation on the container sector, as bulk shipping has not yet been effectively automated. Originating in Europe, the practice of automation has spread to Australia, China, and other industrialized parts of the world. More recently, automation has been adopted by North American port operations. Under pressure to remain competitive, existing terminals in Canada are moving towards automation and digitization as they upgrade their facilities, despite port automation elsewhere producing mixed results. The proposal for a new terminal at Roberts Bank could result in a large and fully automated terminal on the west coast, potentially impacting individual jobs as well as the economic prosperity of surrounding communities. If approved, the construction of the Roberts Bank terminal would take approximately five-and-a-half years.

The first section of this report provides an overview of the relevant literature pertaining to port automation, and also summarizes the stakes for ILWU members and the communities which rely on this sector.

We note that there is literature suggesting that anticipated improvements in productivity and profitability are not always realized. One report by McKinsey & Company indicates that up-front capital expenditures can be quite high and operational challenges related to automation can be significant. A survey conducted by McKinsey (2018) indicates that while operating expenses may decline following automation, overall productivity may also decline and return on capital invested may be lower than industry norms.

The second section includes the economic impact assessment and provides a summary of the impacts in terms of jobs, income, and tax revenues. A detailed description of the methodologies employed to estimate the various impacts can be found in Appendix A.

Section 1: Literature Overview

AUTOMATION

Since the era of containerization, new technology development has enabled the adoption of automated operations and digitized systems. According to Visser and colleagues (2007), between 1985 and 2005, global container transport increased on average by 10% per year, compared to 3.8% per year for general cargo. The increasing number of containers, high volume of trade in Europe and Asia, and increasing desire to remain competitive within the industry has put pressure on port operators to automate.

The concept of the "automated terminal" was first introduced in the Netherlands in 1993, with the launch of the ECT Delta Terminal at the Port of Rotterdam.[1] Following its inception, ports around the world began to automate at least some processes in their container terminals. However, due to the smaller port size, and lower levels of trade and available funds, North American ports have been slower to automate terminals than ports in Europe and Asia.[2]

Similar to containerization, the adoption of automated technology has resulted in a decline in labour demand for port workers. Although automation has been widely adopted around the world, terminals vary in their degree of automation, ranging from semi-automated to fully automated terminals. Semi-automated terminals incorporate some automated technology and equipment; however, there are still workers operating cranes and other equipment. On the other hand, fully automated terminals, which are relatively new, limit human labour to remote monitoring and control of equipment, with minimal human intervention. In 2018, 60 container terminals around the world were either fully or partially automated.[3] The number of automated container terminals is projected to continue to increase, with fully automated terminals becoming more common within the industry.

In addition to various automation types, there are also two different types of projects that can be adopted for terminal automation: brownfield projects and greenfield projects. Brownfield projects require the modification or upgrading of existing terminals, whereas greenfield projects consist of new development on unused land, eliminating the need to remodel or demolish an existing structure. Greenfield projects are more likely to be associated with fully automated terminals, due to the high cost and difficulty associated with fully automating an existing terminal. For example, the Victoria International Container Terminal (VICT) at the port of Melbourne is a fully automated greenfield container terminal, requiring the manpower of only 150 workers, most of whom perform management, administrative or remote computer operations. In comparison, the container terminal at Port Botany in Sydney is only partially automated, requiring a larger workforce of 213 employees.[4] Conventional terminals require a significantly larger workforce than both partially and fully automated terminals. For example, the container terminal at the port of Prince Rupert employs 525 workers, despite both the Prince Rupert Terminal and VICT having an annual container capacity of slightly over 1 million Twenty-Foot Equivalent Units (TEUs). Over the next five years, it is projected that at least half of greenfield port projects will be either semi or fully automated. McKinsey and Company forecast at least half of existing ports will develop plans to update their current equipment over the next five years.[5]

1 Martín-Soberón, Ana María, Arturo Monfort, Rafael Sapiña, Noemí Monterde, and David Calduch, "Automation in Port Container Terminals," (2014): 195-204.

2 Ryan Petersen, "A Tale of Two Ports: Automation at Oakland vs Rotterdam," September 22, 2015.

3 Jens-Uwe Schröder-Hinrichs, Dong-Wook Song, Tiago Fonseca, Khanssa Lagdami, Xiaoning Shi, "Transport 2040: Automation, Technology, Employment - The Future of Work." World Maritime University, Malmö (2019).

4 Victor Gekara and Vi-Xuan Nguyen, "New Technologies and the Transformation of Work and Skills: A Study of Computerization and Automation of Australian Container Terminals," (2018):219-233.

5 Chu Fox, Sven Gailus, Lisa Liu and Liumin Ni, "The Future of Automated Ports." McKinsey & Company, (2018).

IMPACT OF AUTOMATION ON EMPLOYMENT

Automated terminals have taken on a new meaning over the last decade. Advancements in automation have enabled container terminals to operate with a limited number of workers, not only reducing the number of jobs, but also altering the skillset required of workers. Traditionally, longshore workers have worked in large groups which required the physical strength of workers to move cargo. Due to automation, many of the tasks they performed have been mechanized, requiring a fraction of the workforce as well as an increase in the skill level required to perform essential duties.[6]

According to the World Maritime University (2019) the highest potential for automation is in manual labour jobs, which require predictable and repetitive tasks. A recent report by the World Maritime University (2019) highlights the impact of technological change on the future employment of maritime workers. According to the report, dockworker and crane operator jobs will not exist in their current form by the year 2040, as they are projected to experience task automation of up to 90 percent.

The Port of Rotterdam was the first to open a fully automated container terminal. The automated APMT Maasvlakte 2 terminal was projected to reduce container sector jobs by 22 percent; however, the full effect of automation on employment has not been realized at this port as the Union and employer have reached an agreement ensuring that all dockworkers who had full-time contracts on Jan.1, 2015 would be guaranteed jobs until 2020.[7] The fully automated container terminal at the Qingdao Port in China is another prime example of the potential impact of task automation on employment. The terminal is projected to reduce container terminal labour by 85 percent, the majority of which will be longshore jobs as the new equipment enables the port to operate in complete darkness.[8]

Several ports in Los Angeles, California further illustrate the impact of automation on employment. Automated technology was first implemented in the Port of Los Angeles and Long Beach in the late 2000s. Following the increase in automated technology, there was an evident decline in the available work for contingent workers.[9] In 2014, the port of Los Angeles automated approximately one third of their existing Trapac terminal, resulting in a labour reduction of 40 to 50 percent. More recently, the port of Long Beach developed a fully automated greenfield container terminal. The automated terminal resulted in a workforce reduction of between 70 to 75 percent of longshore labour. Although there was a slight increase in maintenance and repair labour stemming from automation, the jobs created were unable to offset the high number of longshore jobs lost.[10]

Australia has also seen significant workforce reductions across the continent due to automation. In 2014, Patrick's Sydney container terminal at Port Botany had a total of 436 workers on site, including administration and support staff. In 2016, following automation, the number of workers at the terminal stood at 213, a workforce reduction of nearly 50 percent. However, the Patrick's Sydney terminal only underwent partial automation, as cranes were still operated by workers but machines called 'autostrads' moved containers from the dock to the truck without the assistance of human labour. The VICT in Melbourne is an example of a more intense approach to automation. In 2017, the port of Melbourne opened Australia's first fully automated container terminal. VICT is capable of operating with a workforce of as few as 150, a much smaller workforce than other terminals of comparable size. Further, most of the remaining jobs are primarily comprised of managerial, administrative and remote operator positions, which are located in a control room, removed from the terminal operation.[11] According to the Maritime Union of Australia (2018), the port operator is attempting to further reduce labour at the terminal by outsourcing the remaining remote operator jobs to the Philippines.

Despite differences in workforce size, there is not a significant difference between the annual container handling capacity of the two Australian ports. Port Botany's container terminal has an annual handling capacity of 1.6 million TEUs,[12] while VICT has an annual handling capacity of slightly over 1 million TEUs.[13] VICT would have required a significantly greater capital investment for a fully automated greenfield terminal. While VICT may benefit from lower labour costs stemming from automation, the annual handling capacity is relatively equal to the semi-automated brownfield terminal at Port Botany. Therefore, there is a question as to whether the high capital investment of a fully automated greenfield container terminal provides a significant competitive advantage over semi-automated ports.

A report by the Australian Competition & Consumer Commission (2018) revealed that automation will mean VICT typically incurs lower labour costs compared to its competitors; however, the stevedore's property costs in Melbourne are at a substantial premium compared to its competitors.

6 Ville Hinkka, Jenni Eckhardt, Antti Permala, and Heikki Mantsinen, "Changing Training Needs of Port Workers Due to Future Trends," (2016): 219-233.
7 Bill Mongelluzzo, "Deal Soothes Union Fears of Rotterdam Port Automation," July 6, 2017, JOC.com.
8 Marc Prosser, "Chinese Port Goes Full Robot with Autonomous Trucks and Cranes," May 17, 2018, SingularityHub.
9 Andrew O'Reilly, "Automation of Port Terminals Threatens Thousands of Lucrative Dock Worker Jobs," March 27, 2017, Fox News.
10 Ray Familathe, Personal Communication.
11 Gekara and Nguyen (n 4)
12 Patrick Terminals, "Operations," http://www.patrick.com.au/index.htm.
13 Victoria International Container Terminal, "How We Operate," https://www.vict.com.au/.

IS AUTOMATION WORTH IT?

The new development of a fully automated terminal requires high up-front capital, costing over half a billion dollars to implement.[14] Despite claims to increase safety and reduce environmental impacts, the ultimate goal of port automation is to increase productivity while reducing the amount of human involvement in port operations. However, there is research to suggest that the high cost and operational challenges associated with automation impede the expected benefits.

A survey conducted by McKinsey & Company (2018) canvassed leading practitioners, global suppliers of automation equipment and software, academic experts, and shipping companies, to determine the current status and future outlook of container terminal automation in the port sector. McKinsey & Co. estimated that in order to receive a return on the up-front capital investment, operating expenses of an automated greenfield terminal would have to be 25 percent lower than conventional ports, or alternatively, productivity would have to rise by 30 percent while operating expenses fell by 10 percent. Despite respondents' optimistic outlook, operating expenses were reported to fall by only 15 to 35 percent following automation. Further, there has been an evident decline in overall productivity following the implementation of port automation. On average, the gross moves per hour (a key indicator for productivity) for automated equipment was significantly lower than conventional terminals. Based on the ports' low productivity and higher than expected operating costs, the return on invested capital of assets is below the industry norm, particularly for fully automated terminals.

Olivera and Varela (2017) provide evidence that the reduction in operating costs may not be as high as industry stakeholders have projected. ABB, a leading crane operator in the port industry, has advertised a 45 to 55 percent reduction of labour time per crane due to automation. Olivera and Varela conducted a direct analysis of the costs and benefits of crane automation to determine the reduction in labour time. Results from the analysis show the labour cost saving to be 33 percent, more than 10 percent lower than ABB's advertised savings.

McKinsey & Co. highlighted a shortage of capabilities as one of the main barriers impeding successful container terminal automation. Port employers are struggling to fill the specialized technical positions required to operate an automated terminal. This challenge has been underestimated by many ports, especially due to the long duration for training specific occupations such as experienced engineers. Following automation, the existing workforce is no longer qualified to perform the operations and tasks associated with an automated terminal. Gekara and Nguyen (2018) interviewed human resources professionals at Australian ports following terminal automation. According to an HR manager, recruitment at the port is typically conducted internally, such that lower level workers are retrained to occupy higher skilled positions. However, in the face of automation there has been an increase in external recruitment from the open labour market as the appropriate skills can no longer be harnessed from within.

SUMMARY

Based on the above literature, it is clear that the digitization and automation of container terminals has the potential to negatively impact longshore and related marine employment. In the case of semi-automation of existing terminal facilities, there is evidence that as much as 50% of longshore jobs may be at risk. In the case of fully automated newly built facilities, there is evidence that as much as 90% of longshore employment may be at risk. In response to claims of job creation from multiple port authorities, the literature provides insight into the types of jobs that are likely to be created by automation, such as maintenance and repair positions. However, the jobs created from automated equipment are unable to offset the high number of longshore jobs lost as a result of automation. Finally, the literature casts doubt on the advertised benefits of container automation, highlighting the challenges associated with fully automated terminals.

14 Petersen (n 2)

What is at stake for the communities in which Longshore workers live and work?

In 2018, there were a total of 6,428 longshore workers employed by the BC Maritime Employers Association (BCMEA). Full-time members represented 2,502 of those employed and casual workers represented the remaining 3,926 workers. Foremen comprised an additional 629 workers, bringing the total number of employees to 7,057. The majority of longshore hours are concentrated in the container sector and have been steadily increasing over the past four years. In 2018, the container sector accounted for two-thirds of longshore employment hours.

On average, longshore workers (including full-time, welfare casual and casual) earn $87,931 per year; however, the annual earnings for full-time employees are significantly higher, averaging $118,988 per year. Due to the fewer number of hours worked, casual employees earn significantly less on average than both full-time and welfare casual employees.

The following tables illustrate the importance of longshore employment to the local communities where marine operations are concentrated. A report by the BCMEA (2018) provided a breakdown of the annual income for longshore workers. There were 2,881 longshore workers identified who earned more than $70,000 per year and 2,070 longshore workers identified who earn more than $100,000 per year. Longshore workers were compared to the overall labour force earning above the thresholds of $70,000 and $100,000 per year in order to account for the broad range of workers that could be classified as either middle-class or high-income earners. Assumptions were made on the distribution of income across sub-districts based on the employment distribution provided by the Union. The following tables only account for longshore workers concentrated in the container sector.

Data presented below suggests that job loss arising from automation of marine terminal operations places a significant portion of middle-class and high-income employment at risk in the communities where marine terminal operations are concentrated.

Anticipated longshore employment loss would have a devastating impact in Prince Rupert, eliminating a significant number of middle-class and high-income jobs. Longshore employment accounts for 26% of jobs paying over $70,000 per year and two-thirds of high-income jobs paying more than $100,000 per year.

The community of Delta would also experience a significant economic shock from anticipated longshore employment loss. This community relies on marine longshore employment for 11% of jobs paying more than $70,000 per year and and 23% of its high-income jobs paying more than $100,000 per year.

Vancouver's middle-class and high-income cohort is less reliant on longshore employment; however longshore employment still accounts for 2% of jobs paying more than $70,000 and 3% of jobs paying more than $100,000. Therefore, BC's largest city would not be unscathed by significant job loss in this sector.

FIGURE 1 - LONGSHORE HOURS BY SECTOR

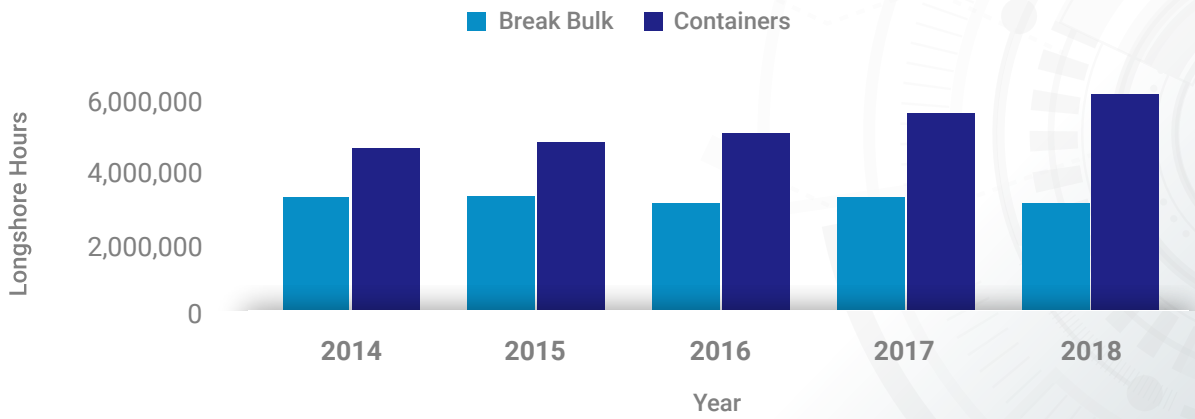


TABLE 1 – NUMBER OF ILWU MEMBERS IN THE CONTAINER SECTOR EARNING ABOVE $70K COMPARED TO THE CENSUS SUB-DISTRICT LABOUR FORCE

Census Sub-District	ILWU Members Earning Above $70K Annually*	Total Labour Force Earning Above $70K Annually**	ILWU Members as a % of Total Labour Force Earning Above $70K Annually
Delta	1,286	11,570	11%
Vancouver	1,234	74,780	2%
Prince Rupert	360	1,360	26%
Total	2,881	87,710	3%

*BCMEA (2018)
**2016 Census

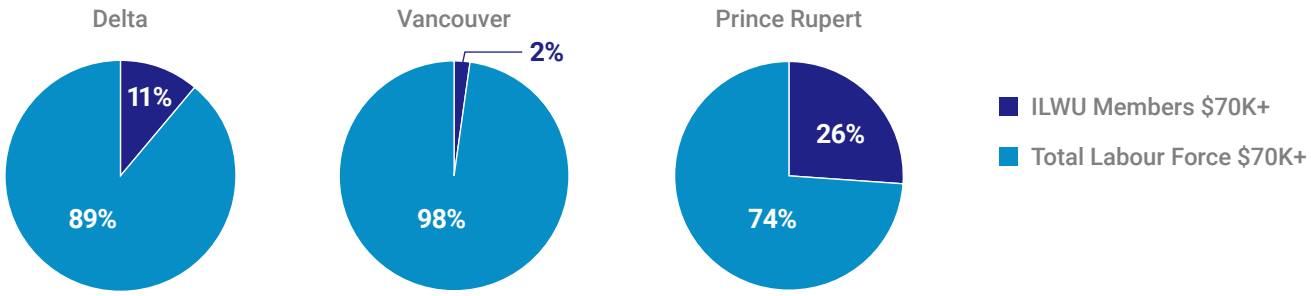
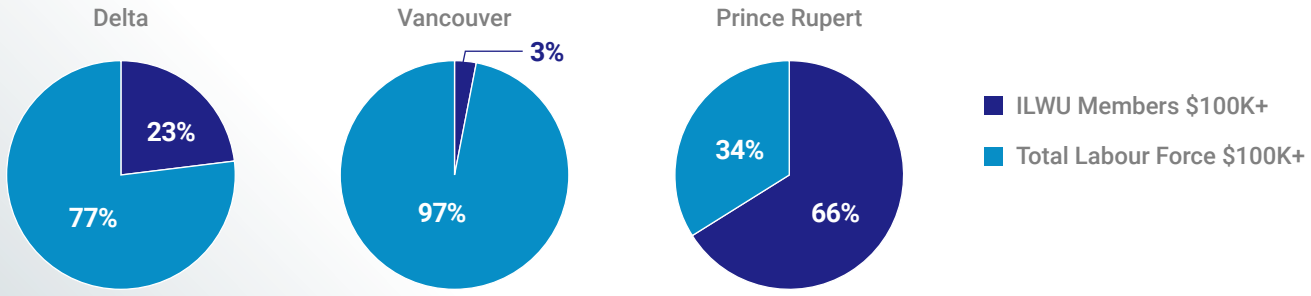


TABLE 2 – NUMBER OF ILWU MEMBERS IN THE CONTAINER SECTOR EARNING ABOVE $100K COMPARED TO THE CENSUS SUB-DISTRICT LABOUR FORCE

Census Sub-District	ILWU Members Earning Above $100K Annually*	Total Labour Force Earning Above $100K Annually**	ILWU Members as a % of Total Labour Force Earning Above $100K Annually
Delta	924	3,970	23%
Vancouver	887	29,795	3%
Prince Rupert	259	395	66%
Total	2,070	34,160	6%

*BCMEA (2018)
**2016 Census



WHAT IS AT STAKE FOR THE COMMUNITIES IN WHICH LONGSHORE WORKERS LIVE AND WORK continued

Longshore workers in the container sector comprise a significant amount of the total workforce earning more than $70,000 a year. Further, longshore employment in the container sector accounts for two-thirds of the total workforce earning above $100,000 per year in Prince Rupert. The loss of jobs stemming from container automation would have a significant impact on the communities where longshore workers live. In the face of automation, there would likely be a reduction in consumer spending as well as an increase in out-migration as longshore workers leave the community in pursuit of new employment opportunities.

In addition to the loss of wages, job loss would impact employer contributions to ILWU pension plans and group benefit plans. The ILWU pension plans are reasonably well funded, so pension credits earned to date may not be at risk, but ILWU members that lose their jobs will not accrue any additional pension benefits, and the loss of employer contributions to group benefit plans put future benefits at risk. According to the BCMEA annual report, employer contribution to the Longshore Health and Benefit Plan and the Foremen Health and Benefit Plan exceeded $34 million in 2018. According to Waterfront Industry Pension Plan advisors, employer contributions to that pension plan based on earnings or hours worked exceeded $57 million in that same year. Accordingly, it is not just lost wages that impact the ILWU membership and their communities if there are layoffs, lost employer contributions to pension plans and benefits will impact them materially as well.

Section 2: Economic Impact Assessment

RESEARCH OBJECTIVE

The objective of this economic impact assessment is to present detailed data on a narrow question: what are the ongoing costs to the larger economy following a shift to automated and digitized port terminals? The impact on individual workers and the broader economy may not be considered prior to the construction of new port terminals or the overhaul of existing terminals. Based on the findings in Gekara and Nguyen's (2018) study, there are two scenarios that will be examined for the impact analysis:

- a brownfield semi-automated scenario, where labour in targeted occupations is reduced by 50%; and
- a greenfield fully-automated scenario, where labour in targeted occupations is reduced by 90%.

The targeted occupations included in the analysis were identified in Gekara and Ngygen's (2018) study and in a report by the World Maritime University (2019) as occupations that have been replaced, or are at risk for being replaced, in automated port facilities. The analysis also considers the expansion of maintenance and repair workers, resulting from an increased reliance on equipment. The key targeted occupations for ILWU members included in the analysis are as follows:

NOC Code	Occupation
1215	Supervisors, supply chain, tracking and scheduling co-ordination occupations
7302	Contractors and supervisors, heavy equipment operator crews
7371	Crane operators
7451	Longshore workers
7452	Material handlers
7511	Transport truck drivers
7521	Heavy equipment operators (except crane)

ECONOMIC IMPACTS OF AUTOMATION ON MARINE PORT TERMINALS

Brownfield Scenario

The Brownfield Scenario is one where automation of some tasks is undertaken in an existing port facility – workers continue to operate in the dock area and cranes are directly manned by operators. Based on automation implemented at Patrick's Port Botany container terminal, the Brownfield Scenario assumes a 50% reduction of container workers in targeted occupations. Only container shipping is included in this analysis, since bulk shipping has not yet been effectively automated. Therefore, the Brownfield Scenario only assumes a 50% reduction of longshore jobs concentrated in the container sector, which accounts for two-thirds of ILWU employment. The output tables from the I-O Model containing a more detailed account of the analysis can be found in Appendix C.

EMPLOYMENT

Brownfield automation is estimated to result in a net provincial workforce reduction of 5,196 core and supporting jobs. Automation is estimated to directly impact 4,736 jobs, 2,106 of which are core jobs within the union. Supporting jobs (indirect and Induced) are estimated to account for an additional loss of 1,254 workers provincially. Table 3 provides a breakdown of the expected job loss relative to potential jobs created from the maintenance and repair of automated equipment. Potential layoffs of core and supporting jobs are estimated to account for 5,990 lost jobs, while new employment created as a result of automation is limited to 794 jobs.

A brownfield, semi-automated terminal is estimated to result in a net workforce reduction of 4,859 core and supporting jobs across the three most impacted census sub-districts. Figure 2 provides a breakdown of job loss and illustrates the disparity between expected job loss relative to potential jobs created from maintenance and repair of automated equipment. Delta is estimated to experience the largest workforce reduction of 2,332, accounting for 924 core jobs. Vancouver closely follows Delta,

Brownfield Scenario continued

with a workforce reduction of 2,256, accounting for 920 core jobs. Compared to the other two sub-districts, Prince Rupert appears to be least impacted by automation. However, due to the small population of the sub-district, Prince Rupert is actually estimated to experience the largest impact, as total job loss accounts for nearly 10 percent of the district's total labour force. Core job loss in Delta, Vancouver and Prince Rupert accounts for 2 percent of total jobs paying above $70,000 per year. Table 4 provides a summary of the total jobs lost as a percentage of the total labour force for each sub-district. Potential layoffs of core and supporting positions account for 5,307 lost jobs, while new employment created as a result of automation is limited to 448 jobs.

TABLE 3 – PROVINCIAL IMPACT OF BROWNFIELD AUTOMATION ON TOTAL JOBS

	Core Jobs (ILWU)	Non-Core Jobs (Non-ILWU)	Indirect Jobs	Induced Jobs	Total
Reduced Employment	-2,106	-2,630	0	-1,254	-5,990
Jobs Created (Maintenance/Repair)	110	216	311	157	794
Total	-1,996	-2,414	311	-1,097	-5,196

FIGURE 2 – IMPACT OF BROWNFIELD AUTOMATION ON TOTAL JOBS, BY CENSUS SUB-DISTRICT

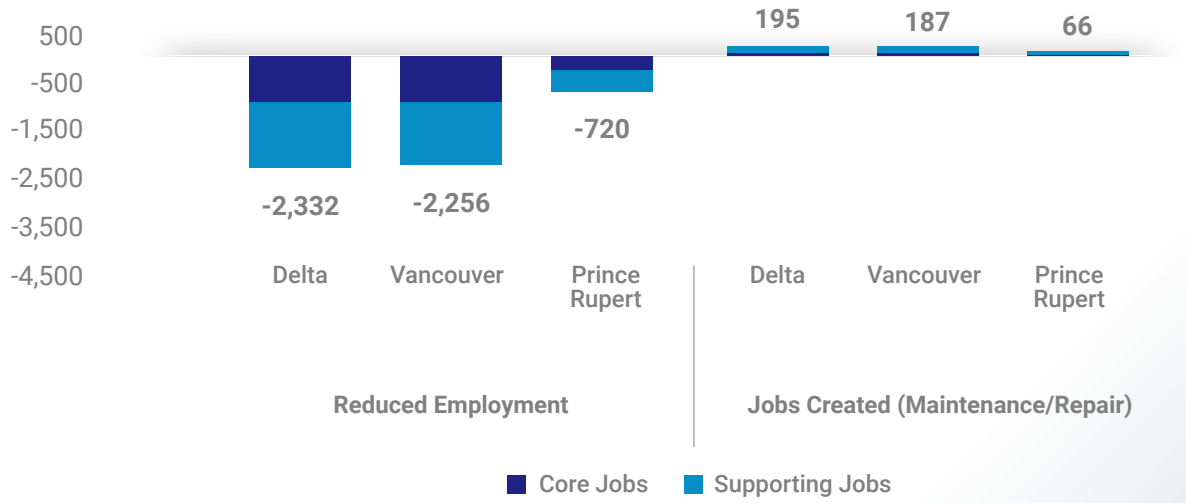


TABLE 4 – NET REDUCTION OF JOBS AS A PERCENTAGE OF THE TOTAL LABOUR FORCE (CSD) AND AS A PERCENTAGE OF THE TOTAL LABOUR FORCE EARNING ABOVE $70,000 ANNUALLY

Census Sub-District	Total Labour Force	Net Reduction in Jobs	Job Loss as a % of Total Labour Force	ILWU Core Job Loss as a % of Total Labour Force Earning Above $70K Annually*
Delta	54,370	2,137	3.9%	8%
Vancouver	370,955	2,068	0.6%	1%
Prince Rupert	6,650	654	9.8%	19%
Total	431,975	4,859	1.1%	2%

*Core job loss, with members averaging $87,791, expressed as a percentage of regional income earners with income in excess of $70,000 annually

IMPACT OF BROWNFIELD AUTOMATION ON INCOME

Within this analysis, 'core jobs' refer to ILWU members and 'non-core jobs' refer to jobs outside of the union that are directly impacted by container automation. 'Indirect jobs' and 'induced jobs' consist of the supporting jobs impacted by container automation. Brownfield automation is estimated to significantly reduce employee compensation for both core and supporting jobs. The loss in employee compensation stemming from brownfield automation, including loss to wages and salaries and employer contribution to pension and benefit plans, is estimated to result in a net reduction of $349M. The net reduction in terms of wages and salaries is particularly significant, accounting for $294M of employee compensation. Table 5 provides a summary of the estimated reduction in employment income relative to the increase in income expected from jobs created by maintenance and repair of automated equipment.

TABLE 5 – PROVINCIAL IMPACT OF BROWNFIELD AUTOMATION ON EMPLOYMENT INCOME (1000S)*

	Reduced Employment Income ($)				Increased Employment Income ($) (Maintenance/Repair)				Net Reduction
	Core Jobs	Non-Core Jobs	Indirect Jobs	Induced Jobs	Core Jobs	Non-Core Jobs	Indirect Jobs	Induced Jobs	
Wages and Salaries	-185,183	-101,845	0	-48,590	9,629	10,155	15,815	6,061	-293,514
Employer Contribution (Pension/Benefits	-24,514	-30,611	0	-6,298	1,275	2,524	2,037	787	-54,800
Total	-209,697	-132,456	0	-54,888	10,904	12,679	17,852	6,848	-348,758

* Employer contribution to pension and benefits for the marine transport industry, sourced from Statistics Canada.

Brownfield Scenario continued

The following figures present the impact of core and supporting job loss at the sub-district level for the two main components of employee compensation: wages and salaries and employer contribution to pension and benefit plans. A more detailed table outlining the impact of automation on employment income, including the effects on labour income of the unincorporated sector, can be found in Appendix C.

Figure 3 illustrates the reduction in wages and salaries stemming from brownfield automation. The total reduction in wages and salaries from the loss of core jobs is $185M across the three census sub-districts. The loss of wages and salaries from supporting jobs account for an additional $123M, for a total of $309M. Delta is expected to experience the largest decline in wages and salaries compensation, with an estimated loss of $136M.

The wages and salaries stemming from an increase in maintenance and repair employment is not comparable to the employment income expected to be lost as a result of automation.

In addition to the expected loss of wages and salaries, automation is estimated to significantly impact employer contribution to pension and benefit plans. A brownfield, semi-automated terminal is estimated to reduce employer contributions by $40M across the three sub-districts, considering both core and supporting job loss. Employer's contribution stemming from expected increased maintenance and repair jobs are unable to offset the large decline in employer contributions for core and supporting jobs (see Figure 4).

FIGURE 3 – IMPACT OF BROWNFIELD AUTOMATION ON WAGES AND SALARIES, BY CENSUS SUB-DISTRICT (1000S)

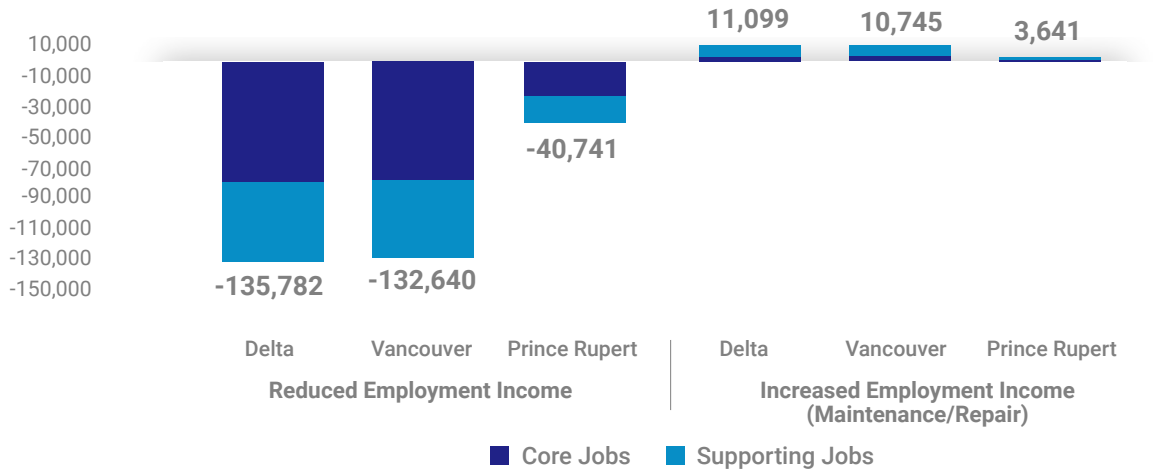
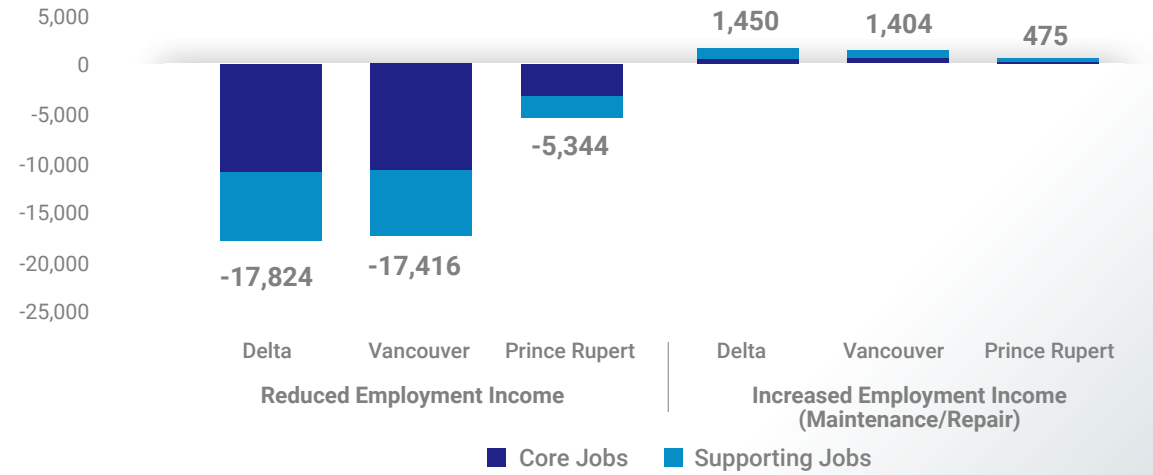


FIGURE 4 – IMPACT OF BROWNFIELD AUTOMATION ON EMPLOYER CONTRIBUTION TO PENSION AND BENEFIT PLANS, BY CENSUS SUB-DISTRICT (1000S)

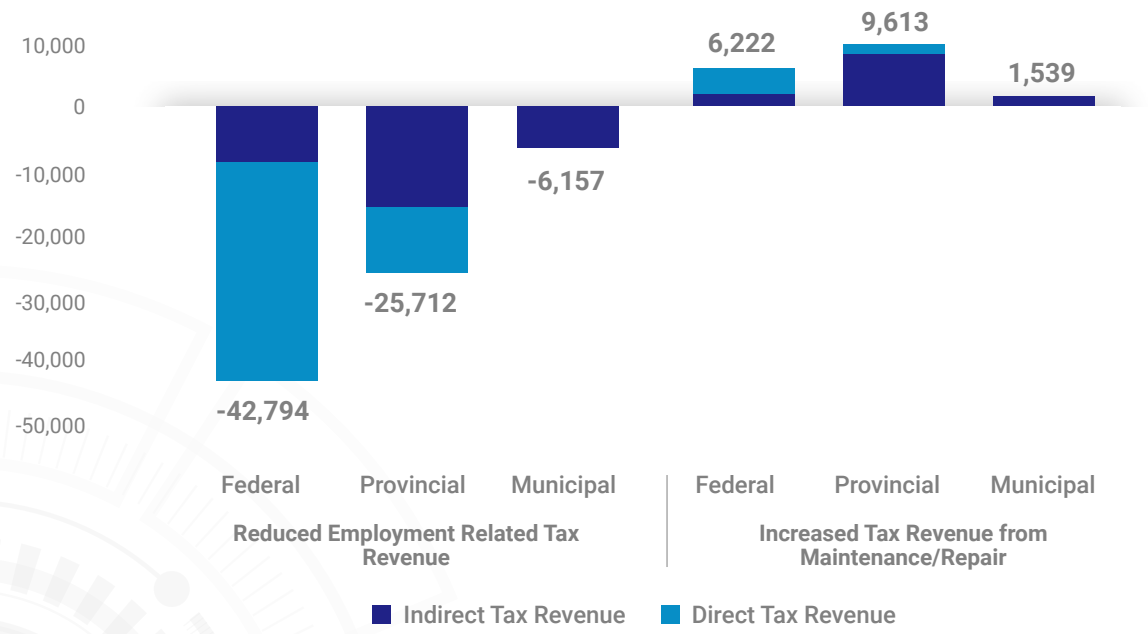


* Employer contribution to pension and benefits for the marine transport industry, sourced from Statistics Canada.

IMPACT OF BROWNFIELD AUTOMATION ON ANNUAL TAX REVENUE

The impact of brownfield automation on tax revenues is expected to result in a net reduction of $36.5M in federal tax revenue, $16M in revenue for the British Columbia government, and $4.6M for municipalities in British Columbia. The largest decline in tax revenue is projected for the Federal level, with direct tax revenue yielding the largest effect as it incorporates both payroll tax and income tax (see Figure 5). Data were unavailable at the census sub-district level for this section of the analysis.

FIGURE 5 – PROVINCIAL IMPACT OF BROWNFIELD AUTOMATION ON ANNUAL TAX REVENUE (1000S)



Greenfield Scenario

The Greenfield Scenario is one where a new facility is purpose-built, allowing for full automation and significant reductions in the overall workforce. All operators are removed from the shipping area and equipment is operated remotely. Based on the automation implemented at VICT in Melbourne, the Greenfield Scenario assumes a 90% reduction of container workers in targeted occupations. Based on the literature, the majority of remaining staff are projected to consist of managers and administration. As previously mentioned, only container shipping is included in this analysis, since bulk shipping has not yet been effectively automated. Therefore, the Greenfield Scenario assumes a 90% reduction of longshoremen concentrated in the container sector only, which accounts for two-thirds of ILWU employment. The output tables from the I-O Model containing a more detailed account of the analysis can be found in Appendix C.

EMPLOYMENT

Greenfield automation is estimated to result in a net provincial workforce reduction of 9,270 core and supporting jobs. Automation is estimated to directly impact 8,524 jobs, 3,791 of which are core jobs within the union. Supporting jobs (indirect and Induced) are estimated to account for an additional loss of 2,259 workers provincially. Table 6 provides a breakdown of the expected job loss relative to the potential jobs created from maintenance and repair of automated equipment. Potential layoffs of core and supporting jobs are estimated to account for 10,783 lost jobs, while new employment created as a result of automation is limited to 1,513 jobs.

A greenfield, fully automated terminal is estimated to result in a net workforce reduction of 8,747 core and supporting jobs across the three most impacted census sub-districts. Figure 6 provides a breakdown of expected job loss and illustrates the disparity between expected job loss relative to potential jobs created from maintenance and repair of automated equipment. Delta is estimated to experience the largest workforce reduction of 4,198, accounting for 1,663 core jobs. Vancouver closely follows Delta, with a workforce reduction of 4,060, accounting for 1,657 core jobs. Compared to the other two sub-districts, Prince Rupert appears to be least impacted by automation. However, due to the small population of the sub-district, Prince Rupert is actually forecast to experience the largest impact, as the total jobs loss accounts for nearly 18 percent of the district's total labour force. Core job loss in Delta, Vancouver and Prince Rupert accounts for 4 percent of total jobs paying above $70,000 per year. Table 7 provides a summary of the total jobs lost as a percentage of the total labour force for each sub-district. Potential layoffs of core and supporting positions account for 9,553 lost jobs, while new employment expected to be created as a result of automation is limited to 807 jobs.

TABLE 6 – PROVINCIAL IMPACT OF GREENFIELD AUTOMATION ON TOTAL JOBS

	Core Jobs (ILWU)	Non-Core Jobs (Non-ILWU)	Indirect Jobs	Induced Jobs	Total
Reduced Employment	-3,791	-4,733	0	-2,259	-10,783
Jobs Created (Maintenance/Repair)	391	559	282	281	1,513
Total	-3,400	-4,174	282	-1,978	-9,270

Greenfield Scenario continued

FIGURE 6 - IMPACT OF GREENFIELD AUTOMATION ON TOTAL JOBS, BY CENSUS SUB-DISTRICT

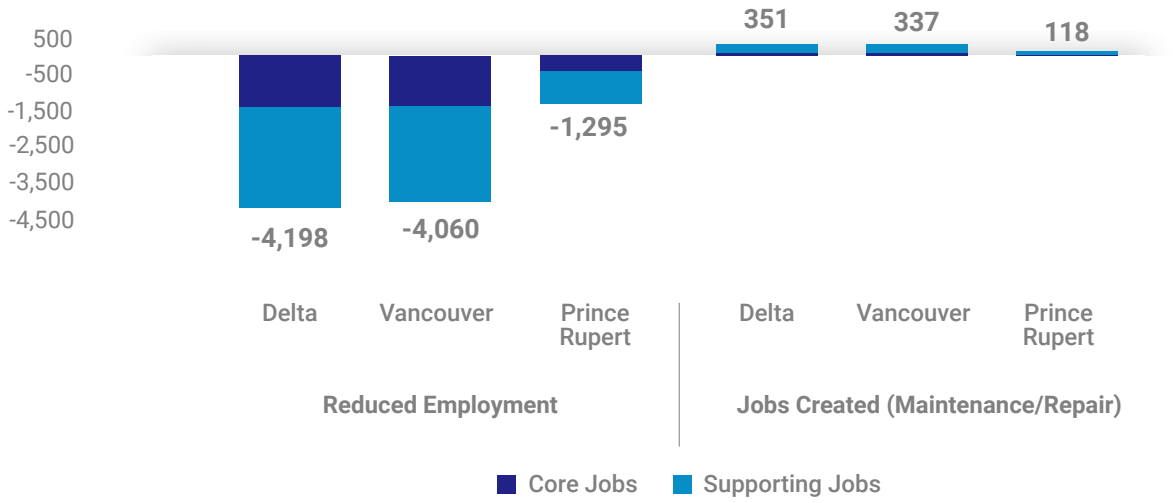


TABLE 7 – NET REDUCTION OF JOBS AS A PERCENTAGE OF THE TOTAL LABOUR FORCE (CSD) AND AS A PERCENTAGE OF THE TOTAL LABOUR FORCE EARNING ABOVE $70,000 ANNUALLY

Census Sub-District	Total Labour Force	Net Reduction in Jobs	Job Loss as a % of Total Labour Force	ILWU Core Job Loss as a % of Total Labour Force Earning Above $70K Annually*
Delta	54,370	3,847	7.1%	14%
Vancouver	370,955	3,723	1.0%	2%
Prince Rupert	6,650	1,177	17.7%	35%
Total	431,975	8,747	2.0%	4%

*Core job loss, with members averaging $87,931, expressed as a percentage of regional income earners with income in excess of $70,000 annually

IMPACT OF GREENFIELD AUTOMATION ON INCOME

Within this analysis, 'core jobs' refer to ILWU members and 'non-core jobs' refer to jobs outside of the union that are directly impacted by container automation. 'Indirect jobs' and 'induced jobs' consist of the supporting jobs impacted by container automation. Greenfield automation is estimated to significantly reduce employee compensation for both core and supporting jobs. The loss in employee compensation stemming from greenfield automation, including loss to wages and salaries and employer contribution to pension and benefit plans, is estimated to result in a net reduction of $627M. The net reduction in wages and salaries is particularly significant, accounting for $529M. Table 8 provides a summary of the estimated reduction in employment income relative to the increase in income expected from jobs created by maintenance and repair of automated equipment.

The following figures present the impact of expected core and supporting job loss across sub-districts for the two main components of employee compensation: wages and salaries and employer contribution to pension and benefit plans. A more detailed table outlining the expected impact of automation on employment income, including the effects on labour income of the unincorporated sector, can be found in Appendix C.

Figure 7 illustrates the expected reduction in wages and salaries stemming from greenfield automation. The total reduction in wages and salaries from the loss of core jobs is $333M across the three census sub-districts. The loss of wages and salaries from supporting jobs account for an additional $223M, for a total of $556M. Delta is expected to experience the largest decline in wages and salaries compensation, with an estimated loss of $244M. The wages and salaries stemming from an increase in maintenance and repair jobs is not comparable to the employee compensation lost in the face of automation.

In addition to the loss of wages and salaries, automation is estimated to significantly impact employer contribution to pension and benefit plans. A greenfield, fully automated terminal is estimated to reduce employer contributions by $73M across the three sub-districts, considering both core and supporting job loss. Employer contribution stemming from increased maintenance and repair jobs are unable to offset the large decline in employer contributions for core and supporting jobs (see Figure 8).

TABLE 8 – PROVINCIAL IMPACT OF GREENFIELD AUTOMATION ON EMPLOYMENT INCOME (1000S)*

	Reduced Employment Income ($)				Increased Employment Income ($) (Maintenance/Repair)				Net Reduction
	Core Jobs	**Non-Core Jobs**	**Indirect Jobs**	**Induced Jobs**	**Core Jobs**	**Non-Core Jobs**	**Indirect Jobs**	**Induced Jobs**	
Wages and Salaries	-333,329	-183,321	0	-87,461	17,333	18,278	28,466	10,912	-529,122
Employer Contribution (Pension/Benefits	-44,125	-55,099	0	-11,338	2,294	4,545	3,666	1,416	-98,641
Total	-377,454	-238,420	0	-98,799	19,627	22,823	32,132	12,328	-627,763

* Employer contribution to pension and benefits for the marine transport industry, sourced from Statistics Canada.

FIGURE 7 – IMPACT OF GREENFIELD AUTOMATION ON WAGES AND SALARIES, BY CENSUS SUB-DISTRICT (1000S)

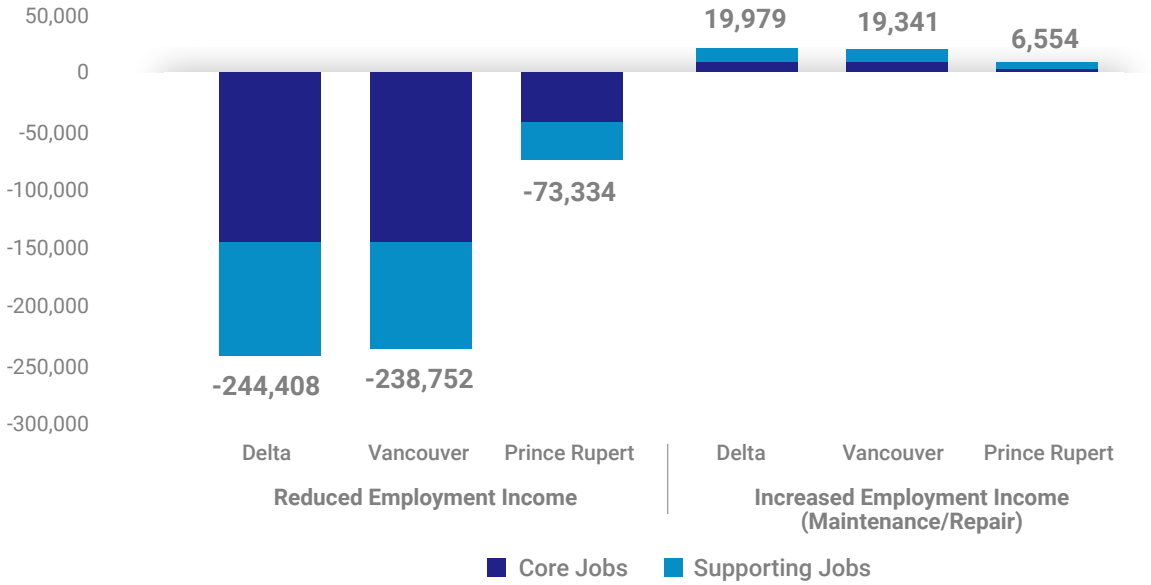
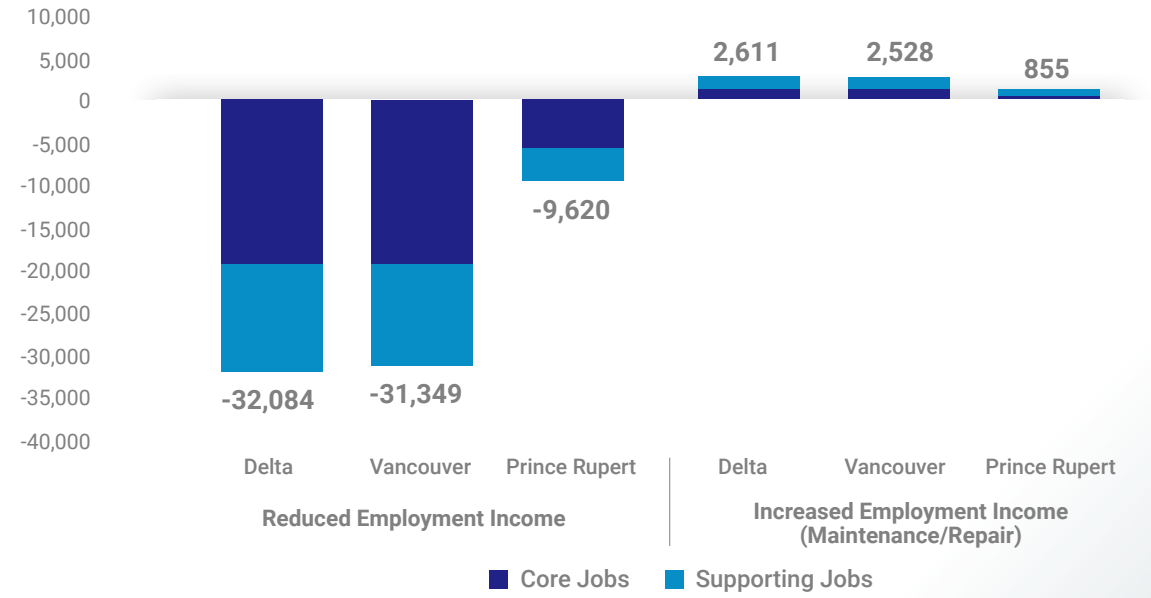


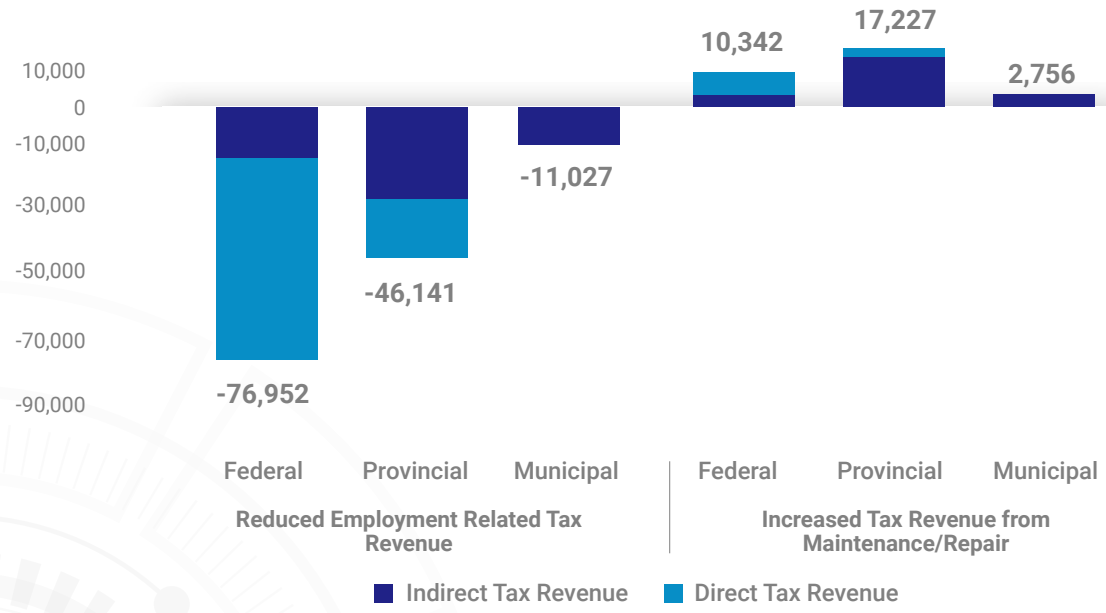
FIGURE 8 – IMPACT OF GREENFIELD AUTOMATION ON EMPLOYER CONTRIBUTION TO PENSION AND BENEFIT PLANS, BY CENSUS SUB-DISTRICT (1000S)*



IMPACT OF GREENFIELD AUTOMATION ON ANNUAL TAX REVENUE

The impact of greenfield automation on tax revenues is expected to result in a net reduction of $66.6M in Federal tax revenue, $28.9M in revenue for the British Columbia government, and $8.3M for municipalities in British Columbia. The largest decline in tax revenue is projected for the Federal level, with direct tax revenue yielding the largest effect as it incorporates both federal payroll tax and federal income tax (see Figure 9). Data was unavailable at the census sub-district level for this section of the analysis.

FIGURE 9 – PROVINCIAL IMPACT OF GREENFIELD AUTOMATION ON ANNUAL TAX REVENUE (1000S)



Conclusion

The impact analysis shows that port automation and digitization would have a substantial effect on local economies. In terms of jobs, the large impact of reduced employment is off-set in a very limited way by increased indirect employment. In the Greenfield Scenario, where ports are automated as fully as the Victoria International Container Terminal in Melbourne, it is estimated that there will be 8,747 fewer jobs across the census sub-districts, with the highest loss evident in the district of Delta. The estimated job loss across the census sub-districts of Delta, Vancouver and Prince Rupert account for 2% of the total labour force of 431,975. Further, core job loss in Delta, Vancouver and Prince Rupert account for 4% of total jobs paying above $70,000 per year. In Prince Rupert the results are particularly felt as the district would have a much larger proportional impact relative to the overall population.

In addition to a loss of jobs, losses in employment income would negatively impact both individuals and the local economy. Not only would there be a significant decline in wages and salaries for core and supporting jobs, but the decrease in consumer spending would negatively impact local economies. Further, the termination of employer contributions to employees' pension and benefit plans would also impact them materially as well. In the most severe case of automation, employment income would decline by a net value of $628M provincially and $577M across census sub-districts, when accounting for the loss in both wages and salaries and loss of employer contribution to pension and benefit plans.

In the Greenfield Scenario, the provincial impact of revenues is expected to result in a net reduction of $66.6M in federal tax revenue, $28.9M in revenue for the British Columbia government, and $8.3M for municipalities in British Columbia. This assumes that automated ports are not levied with additional taxes, and does not include corporate income taxes.

Longshoremen account for a considerable portion of the labour force earning over $70,000 annually, across sub-districts. Based on the 2016 Census, longshoremen account for 3% of workers across sub-districts earning more than $70,000 per year. Most noteworthy, Prince Rupert accounts for 26% of the labour force earning above $70,000. Further, longshoremen account for 66% of the labour force in Prince Rupert earning over $100,000 per year. Based on this data, it is clear that the loss of jobs stemming from automation will have a significant impact on lost wages for individual workers, but also the communities in which they live.

This analysis is based on the current state of automation technology as it has been implemented in other jurisdictions. It does not consider automation of bulk transport, for example, or for off-shoring of operators for automated facilities which would exacerbate the effects of this technological transition. It also does not consider technologies that substantially reduce shipping costs for consumers; we have not yet seen this in the cases in analogous where automation has been implemented.

Appendix A: Methodology

The purpose of this analysis is to assess the economic impact of container terminal automation at two geographic levels:

- Census Sub-Districts (CSD) where ports are located; namely Delta, Vancouver and Prince Rupert; and
- Province of British Columbia.

Economic impacts are measured on an ongoing basis considering operational, not capital, expenditures. In the short-term capital expenditures would be required to implement large-scale automation and digitization; these would be expected to stimulate local economies. However, the short-term increase in economic activity caused by automation is not included in this analysis because they are short term and will dissipate with time.

The Statistics Canada Input-Output Model ("I-O Model") was used to estimate the economic impact for the following indicators:

- jobs (including both self-employed and employee jobs);
- effects on labour income; and
- tax revenue effects for municipal, provincial and federal governments.

Impacts are modelled as a change in how inputs (labour, equipment, fixed costs) are transformed to provide port services. A report conducted by McKinsey & Company (2018) illustrates that while operating expenses may decline following automation, anticipated improvements in productivity are not always realized. A report by the Australian Competition and Consumer Commission (2018) illustrates substantial reductions in labour costs associated with automation but no substantial increase in overall productivity. Instead, firms are showing higher equipment and fixed costs, reflecting greater amounts of capital and higher capital costs, which offset the reduction in labour costs. In fact, net profits have fallen over the period of study. Therefore, instead of a standard model of technological change, where technology increases total factor productivity, this model is one of stable overall productivity with a shifting distribution of equipment, labour costs, and gross margins. As such, GDP and output effects are not included in this analysis as the output in each scenario is expected to remain the same.

The I-O Model used in this analysis draws from and benefits from a broad array of unsuppressed information collected by Statistics Canada, such as customs records, income tax returns, governments' public accounts, businesses' remittances of HST collections and through more than one hundred economic and social surveys. As a linear model, its outputs can be converted without difficulty into current dollars. Outputs from the I-O Model separately estimate the indirect and induced impacts of higher equipment expenditures and lower labour expenditure on the Provincial economy. Indirect effects are the changes in sales, income or jobs in sectors that supply goods and services to the marine transportation sector. Induced effects are the increased sales from household spending of the income earned in the marine transportation sector. For example, induced effects account for longshoremen employees spending their income on housing, utilities, groceries, etc.

Outputs from the I-O Model were regionalized using an economic base analysis. This used estimated four-digit NAICS to calculate Location Quotients (LQs) for the local geographies under analysis (CSDs). This process defined which industries were areas of local specialization and which were support industries. Base analysis produces multipliers for local specialty industries but these do not distinguish between indirect and induced effects. These multipliers were further adjusted to account for the assumption of stable output in line with the Statistics Canada I-O multipliers for the precise shocks under consideration.

PORT TERMINAL EMPLOYMENT

Patrick's Port Botany terminal in Sydney and the VICT in Melbourne were used as the basis for estimating employment loss for the economic impact assessment. There are several reasons underlying the rationale for this decision. First, there was limited scholarly research which presented numerical values of the impact of automation on container employment. Gekara and Nguyen (2018) was the only scholarly source discovered to provide a concrete example of the impact of automation for both a partially automated, brownfield terminal (50 percent automation) and a fully automated, greenfield terminal (90 percent automation). Second, there are multiple similarities that can be drawn between the container terminals at Port Botany and the Port of Melbourne and the proposed Roberts Bank Terminal at the Port of Vancouver. Finally, Australia and Canada share various economic and geographical components which make them a natural comparator for an economic impact assessment.
Employment within this analysis is limited to target occupations within the container shipping sector, since bulk shipping has not yet been effectively automated. In 2018, the container sector accounted for two-thirds of ILWU's longshoremen's hours. As a result, only two-thirds of ILWU employment is accounted for in this analysis. Further, target occupations included in the analysis were limited to those working in the water transportation support industry, with the exception of longshore workers – which could be drawn from other industries. Total employment growth of 8% was applied to the 2016 census data in order to provide an up-to-date employment estimate.

In addition, effects were calculated using reductions for both ILWU members (core) and non-ILWU workers employed in the industry (non-core). These non-ILWU workers on average earn less than ILWU members due to their hours and occupations but are still employed within the industry and so are considered within direct impacts with respect to I-O estimates and base multiplier effects. In this report, "core" jobs are used to consider the direct effects on ILWU members and "supporting" jobs consider the effects on non-ILWU workers, indirect jobs and jobs arising from induced expenditure.

Reduction in labour costs are based on the following sources:

- Changes in overall employment are based on occupations (NOC Codes) targeted by automation drives seen in other jurisdictions within port-specific industries (NAICS codes) in British Columbia sourced from the 2016 census and supplemented with data from ILWU to provide up-to-date employment growth;
- Wages and benefits are based on reported average wages within target occupations as recorded by the ILWU;
- Equipment expenditures include fuel, repair construction, equipment maintenance, and energy costs. The increase in equipment expenditures is modelled based on the distribution of expenses in existing facilities. If automated facilities use a substantially different mix of costs (for example, patent fees, software, computer equipment, etc.) it may overstate the impact of these expenditure increases because those kinds of commodities and services are more likely to be imported from out of country or province; and
- Gross margins are calculated as the residual of the difference between the fall in labour costs and the rise in equipment costs.

LABOUR INCOME

Compensation paid to employees is comprised of wages and salaries and employer contributions to pension and benefit plans. Wages and salaries are an aggregate of many types of payments made to employees. In addition to regular remuneration, it includes directors' fees, bonuses, commissions, gratuities, income in kind, taxable allowances, retroactive wage payments and stock options. Wages and salaries are estimated on a "gross" basis, that is, prior to deductions for employees' contributions to income tax, employment insurance, pension funds etc. Employer contributions to pensions and benefit plans, defined as payments made by employers for the future benefit of their employees, comprises employer contributions to employee welfare, pensions, workers compensation and employment insurance. Although not typically included in compensation for employees, labour income from the unincorporated sector is also included within the analysis. This represents earnings received by self-employed persons or working owners of unincorporated businesses and is only considered with respect to indirect and induced impacts.

The hours and wages of core employees in targeted occupations at the CSD level were provided by the ILWU. Employer contribution to pensions and benefit plans to the marine transportation industry were sourced from Statistics Canada. For supporting jobs and the unincorporated sector, data for labour income and benefits was sourced from Statistics Canada.

TAX REVENUE

Estimates of tax revenue are produced by the Input-Output Model for each level of government based on the patterns of taxation seen in each industry. The analysis accounts for the impact of both direct and indirect tax. Indirect tax passes through an intermediary before being paid to the government, which include taxes such as harmonized sales tax (HST), goods and sales tax (GST), and provincial sales tax (PST). Direct tax includes income and property tax which is levied on the income or profits of the person who pays it, rather than on goods or services. These estimates do not include corporate taxes, but do provide comprehensive accounts of income and wealth (income tax) and taxes on products and imports and other taxes on production seen in actual transactions for each industry. No indirect tax impacts on products and import taxes are modelled in this analysis because of the assumption of stable output.

Appendix B: Terms and Definitions

Capital (Gross fixed capital formation)
Capital investment, or gross fixed capital formation, is the value of a producer's acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non-produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) realized by the productive activity of institutional units.

Commodity classification
A commodity is defined as a good or service normally intended for sale on the market at a price designed to cover the cost of production. The classification of goods in the Input-Output accounts is based on the Standard Classification of Goods. Given the absence of a standard classification of services, the Input-Output accounts utilize a service classification based on the characteristic products of industries.

Direct impact measures the initial requirements for an extra dollar's worth of output of a given industry. The direct impact on the output of an industry is a one dollar change in output to meet the change of one dollar in final demand. Associated with this change, there will also be direct impacts on GDP, jobs, and imports.

Direct Taxes are paid directly to the government and are levied on the income or profits of the person who pays it, rather than on goods and services. These include tax such as income tax and property tax.

Employer Contributions to Pension and Benefit Plans
Employer contributions to pension and benefit plans, which is defined as payments made by employers for the future benefit of their employees, comprises employer contributions to employee welfare, pensions, workers compensation and employment insurance.

Indirect impact measures the changes due to inter-industry purchases as they respond to the new demands of the directly affected industries. This includes all the chain reaction of output up the production stream since each of the products purchased will require, in turn, the production of various inputs.

Indirect Taxes is a type of tax that passes through an intermediary before being paid to the government. These include taxes such as sales tax.

Induced impact measures the induced impacts arising from shifts in spending on goods and services as a consequence of changes to the payroll of the directly and indirectly affected businesses; expenditures at this level can include food, clothes and cars.

Inputs
Economic resources used in a firm's production process. A distinction is usually drawn between primary inputs (labour and capital) and intermediate inputs (energy and raw materials).

Intermediate inputs
Intermediate inputs consist of the goods and services used by industries in a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital; the goods or services may be either transformed or used up by the production process.

Labour Income of the Unincorporated Sector
Earnings received by self-employed persons or working owners of unincorporated businesses, which are not typically included in compensation of employees.

Twenty-Foot Equivalent Unit (TEU)
A Twenty-foot equivalent unit (TEU) is the standard unit of measurement for shipping containers. One TEU is equivalent to one 20 foot shipping container. One 40 foot shipping container is equivalent to two TEUs.

Total Jobs
A job is defined as an explicit or implicit contract between a person and an institutional unit to perform work in return for compensation for a defined period or until further notice. The institutional unit may be the proprietor of an unincorporated enterprise; in this case the person is described as being self-employed and earns a mixed income.

Supplementary labour income
Supplementary Labour Income are expenditures by employers on their labour account which are regarded as compensation of employees. They include contributions to employment insurance, private and public pension plan contributions, and (beginning in 1990) retirement allowances.

Wages and salaries
Wages and salaries consist of monetary compensation and payments-in-kind (e.g.,board and lodging), to wage earners and salaried persons employed in private, public and non-profit institutions in Canada including domestic servants and baby-sitters. Other forms of compensation included here are commissions, bonuses, tips, directors' fees, taxable allowances, and the values of stock options of corporations. Bonuses, commissions and retroactive wages are recorded in the period paid rather than earned. Wages and salaries are recorded on a gross basis, before deductions for taxes, employees' contributions to employment insurance, and private and public pension plans.

Appendix C: Output Tables

Within the following tables, 'core jobs' refer to ILWU members and 'non-core jobs' refer to jobs outside of the union that are directly impacted by container automation. 'Indirect jobs' and 'induced jobs' consist of the supporting jobs impacted by container automation.

EMPLOYMENT - BROWNFIELD

TABLE 1 – PROVINCIAL IMPACT OF BROWNFIELD AUTOMATION ON TOTAL JOBS

	Core Jobs (ILWU)	Non-Core Jobs (Non-ILWU)	Indirect Jobs	Induced Jobs	Total
Reduced Employment	-2,106	-2,630	0	-1,254	-5,990
Jobs Created (Maintenance/Repair)	110	216	311	157	794
Total	-1,996	-2,414	311	-1,097	-5,196

TABLE 2 – IMPACT OF BROWNFIELD AUTOMATION ON TOTAL JOBS, BY CENSUS SUB-DISTRICT

Census Sub-District	Reduced Employment			Jobs Created (Maintenance/Repair)			Net Reduction
	Core Jobs	Supporting Jobs	Total	Core Jobs	Supporting Jobs	Total	
Delta	-924	-1,408	-2,332	48	147	195	-2,137
Vancouver	-920	-1,335	-2,256	48	140	187	-2,068
Prince Rupert	-262	-458	-720	14	52	66	-654
Total	-2,106	-3,201	-5,307	110	339	448	-4,859

EMPLOYMENT - GREENFIELD

TABLE 3 – PROVINCIAL IMPACT OF GREENFIELD AUTOMATION ON TOTAL JOBS

	Core Jobs (ILWU)	Non-Core Jobs (Non-ILWU)	Indirect Jobs	Induced Jobs	Total
Reduced Employment	-3,791	-4,733	0	-2,259	-10,783
Jobs Created (Maintenance/Repair)	391	559	282	281	1,513
Total	-3,400	-4,174	282	-1,978	-9,270

TABLE 4 – IMPACT OF GREENFIELD AUTOMATION ON TOTAL JOBS, BY CENSUS SUB-DISTRICT

Census Sub-District	Reduced Employment			Jobs Created (Maintenance/Repair)			Net Reduction
	Core Jobs	Supporting Jobs	Total	Core Jobs	Supporting Jobs	Total	
Delta	-1,663	-2,534	-4,198	86	264	351	-3,847
Vancouver	-1,657	-2,404	-4,060	86	251	337	-3,723
Prince Rupert	-471	-825	-1,295	24	94	118	-1,177
Total	-3,791	-5,763	-9,553	197	610	807	-8,747

INCOME - BROWNFIELD

TABLE 5 – PROVINCIAL IMPACT OF BROWNFIELD AUTOMATION ON INCOME (1000S)

	Reduced Employment Income ($)				Increased Employment Income ($) (Maintenance/Repair)				Net Reduction
	Core Jobs	**Non-Core Jobs**	**Indirect Jobs**	**Induced Jobs**	**Core Jobs**	**Non-Core Jobs**	**Indirect Jobs**	**Induced Jobs**	
Wages and Salaries	-185,183	-101,845	0	-48,590	9,629	10,155	15,815	6,061	-293,958
Employer Contribution (Pension/Benefits	-24,514	-30,611	0	-6,298	1,275	2,524	2,037	787	-54,800
Labour Income (Unincorporated Sector)	0	0	0	-3,670	0	0	0	459	-3,211
Total	-209,697	-132,456	0	-58,558	10,904	12,679	17,852	7,307	-351,969

TABLE 6 – IMPACT OF BROWNFIELD AUTOMATION ON INCOME, BY CENSUS SUB-DISTRICT (1000S)

Census Sub-District	Reduced Employment Income ($)			Increased Employment Income ($) (Maintenance/Repair)			Net Reduction
	Core Jobs	**Supporting Jobs**	**Total**	**Core Jobs**	**Supporting Jobs**	**Total**	
WAGES AND SALARIES							
Delta	-81,261	-54,521	-135,782	4,225	6,874	11,099	-124,683
Vancouver	-80,925	-51,716	-132,640	4,208	6,537	10,745	-121,895
Prince Rupert	-22,997	-17,744	-40,741	1,196	2,445	3,641	-37,100
Total	-185,183	-123,981	-309,163	9,629	15,856	25,485	-283,678
EMPLOYER CONTRIBUTION (Pension/Benefits)							
Delta	-10,757	-7,067	-17,824	559	891	1,450	-16,374
Vancouver	-10,712	-6,704	-17,416	557	847	1,404	-16,012
Prince Rupert	-3,044	-2,300	-5,344	158	317	475	-4,869
Total	-24,514	-16,071	-40,585	1,275	2,055	3,330	-37,255
LABOUR INCOME OF UNINCORPORATED SECTOR							
Delta	0	-742	-742	0	261	261	-482
Vancouver	0	-544	-544	0	226	226	-318
Prince Rupert	0	-385	-385	0	128	128	-257
Total	0	-1,672	-1,672	0	615	615	-1,057

INCOME - GREENFIELD

TABLE 7 – PROVINCIAL IMPACT OF GREENFIELD AUTOMATION ON INCOME (1000S)

	Reduced Employment Income ($)				Increased Employment Income ($) (Maintenance/Repair)				Net Reduction
	Core Jobs	**Non-Core Jobs**	**Indirect Jobs**	**Induced Jobs**	**Core Jobs**	**Non-Core Jobs**	**Indirect Jobs**	**Induced Jobs**	
Wages and Salaries	-333,329	-183,321	0	-87,461	17,333	18,278	28,466	10,912	-529,122
Employer Contribution (Pension/Benefits	-44,125	-55,099	0	-11,338	2,294	4,545	3,666	1,416	-98,641
Labour Income (Unincorporated Sector)	0	0	0	-6,606	0	0	0	827	-5,779
Total	-377,454	-238,420	0	-105,405	19,627	22,823	32,132	13,155	-633,542

TABLE 8 – IMPACT OF GREENFIELD AUTOMATION ON INCOME, BY CENSUS SUB-DISTRICT (1000S)

Census Sub-District	Reduced Employment Income ($)			Increased Employment Income ($) (Maintenance/Repair)			Net Reduction
	Core Jobs	**Supporting Jobs**	**Total**	**Core Jobs**	**Supporting Jobs**	**Total**	
WAGES AND SALARIES							
Delta	-146,270	-98,138	-244,408	7,606	12,373	19,979	-224,429
Vancouver	-145,664	-93,088	-238,752	7,574	11,767	19,341	-219,412
Prince Rupert	-41,394	-31,940	-73,334	2,152	4,402	6,554	-66,780
Total	-333,329	-233,166	-556,494	17,333	28,541	45,874	-510,620
EMPLOYER CONTRIBUTION (Pension/Benefits)							
Delta	-19,363	-12,721	-32,084	1,007	1,604	2,611	-29,473
Vancouver	-19,282	-12,066	-31,349	1,003	1,525	2,528	-28,821
Prince Rupert	-5,480	-4,140	-9,620	285	571	855	-8,764
Total	-44,125	-28,928	-73,052	2,294	3,700	5,994	-67,058
LABOUR INCOME OF UNINCORPORATED SECTOR							
Delta	0	-1,336	-1,336	0	469	469	-867
Vancouver	0	-980	-980	0	407	407	-573
Prince Rupert	0	-693	-693	0	230	230	-463
Total	0	-3,009	-3,009	0	1,106	1,106	-1,903

TAX REVENUE - BROWNFIELD

TABLE 9 – PROVINCIAL IMPACT OF BROWNFIELD AUTOMATION ON ANNUAL TAX REVENUE (1000S)

Provincial Tax Impact	Reduced Employment Related Tax Revenue ($)			Increased Tax Revenue from Maintenance/Repair ($)			Net Reduction
	Indirect Tax Revenue	**Direct Tax Revenue**	**Total**	**Indirect Tax Revenue**	**Direct Tax Revenue**	**Total**	
Total Federal	-8,532	-34,261	-42,794	2,125	4,097	6,222	-36,572
Total Provincial	-15,640	-10,072	-25,712	8,477	1,136	9,613	-16,099
Total Municipal	-6,157	0	-6,157	1,539	0	1,539	-4,618

TAX REVENUE - GREENFIELD

TABLE 10 – PROVINCIAL IMPACT OF GREENFIELD AUTOMATION ON ANNUAL TAX REVENUE (1000S)

Provincial Tax Impact	Reduced Employment Related Tax Revenue ($)			Increased Tax Revenue from Maintenance/Repair ($)			Net Reduction
	Indirect Tax Revenue	**Direct Tax Revenue**	**Total**	**Indirect Tax Revenue**	**Direct Tax Revenue**	**Total**	
Total Federal	-15,282	-61,670	-76,952	2,967	7,375	10,342	-66,610
Total Provincial	-28,012	-18,130	-46,141	15,182	2,045	17,227	-28,914
Total Municipal	-11,027	0	-11,027	2,756	0	2,756	-8,270

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