STRENGTHENING ALL LINKS: BUILDING MORE RESILIENT, FLUID SUPPLY CHAINS IN CANADA

Railway Association of Canada

CONTENTS

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INTRODUCTION

In recent years, complex global supply chains have been disrupted by many factors, including a global pandemic, the war in Ukraine, extreme weather events, labour disruptions and shortages, and economic uncertainty, to name a few. Supply chain players have demonstrated remarkable resiliency through it all, working tirelessly through unprecedented disruption to keep Canadian supply chains moving.

In this paper, we examine two supply chains that are of critical importance to the Canadian economy, exporters, and consumers. The main objective of this paper is to provide deeper understanding of complex supply chains – including information on transit times and variability of each link – to broad audiences including supply chain players, government, and the public. Through a better understanding of how these supply chains work and what affects their performance, Canadian businesses, governments and consumers will be better prepared to navigate future disruptions. Given the sheer numbers of variable at play in modern supply chains, disruptions are expected to become more frequent, less predictable, and more widely felt. As a trading nation, strong, efficient, high performing, and cost-effective supply chains are critical to Canada's prosperity. Evidence-based responses to future disruptions will be critical.

RECENT DISRUPTIONS AND CHALLENGES

Over the past three years, supply chain performance has been tested globally. The COVID-19 pandemic wrought myriad supply chain disruptions. No country was spared. The pandemic's health impacts and ensuing policies (e.g., vaccine mandates, travel restrictions, China's COVID-zero policy, etc.) caused recurring labour disruptions in Canada and around the world. These disruptions negatively affected both the production and transportation of goods. While this shook the supply-side of the economy, consumer demand also changed radically. Consumers shifted their consumption patterns, demanding more goods and fewer services, exacerbating the mismatch between supply and demand.

Labour disruptions and shortages are not just temporary; Canadian businesses are facing structural workforce challenges as well. Population aging and the retirements of older, specialized skilled workers are creating gaps that need to be filled, but labour markets are tight.[I]

In transportation, the trucking sector is facing the most significant shortages, which may negatively impact end-to-end supply chain performance. Across the first three quarters of 2022, the 8.9% job vacancy rate in the trucking sector was the highest among all transportation and warehousing industries, which averaged 5.6%.[II] Over half of all vacancies for truck drivers were 90 days or more; in 2019, less than 15% of vacancies had such a duration.[III] Over the past three years, the labour shortages have contributed to a 14% increase in offered wages in trucking, compared to a 9% increase for the total transportation and warehousing sector.[IV]

The story for rail is different. Railways have had some success at replacing retiring workers with newly trained ones through active recruitment campaigns and generous compensation offerings.[V] From 2021-Q4 to 2022-Q4, CN and CP each increased employment by 900 workers;[VI] and Canadian Census data show that between 2016 and 2021, the age distribution of workers in the rail sector became younger.[VII]

In 2021, extreme weather events impacted supply chains in Canada. British Columbia wildfires in July 2021 and historic rains in November 2021 disrupted the flow of goods, as key transportation corridors were blocked. When these weather events hit, railways took immediate action, working 24/7 to restore service as quickly as possible and keep goods moving.

Severe drought conditions in the Prairies in Summer 2021 resulted in a small harvest and low shipments of grain in the 2021-2022 crop year (28.4 MMT vs 52.3 MMT in the previous year).[VIII] Fortunately, the crop rebounded in 2022. Multiple grain shipment records have been broken in the 2022-2023 crop year to-date.[IX]

Over the past few years, consumers and businesses have been dealing with generationally high inflation, especially rising fuel costs. In response to ongoing inflationary pressures, the Bank of Canada raised its policy interest rate at eight consecutive decision dates, increasing the rate from 0.25% in January 2022 to 4.5% in January 2023. These higher rates increase the cost of borrowing and holding inventory, and put pressure on supply chains to improve efficiency and visibility. Lastly, one cannot ignore the forecasts for weak economic growth in 2023.[X]

KEY CONCEPTS

Before getting into our case studies, let us establish a baseline understanding of a few key supply chain concepts.

Supply Chain Visibility:

The ability to track goods as they move through each link in the supply chain. Transportation providers may use technology to provide visibility to one another and their customers. In terms of data visibility and public reporting, there is substantial insight into rail and port operations (through voluntary and regulatory reporting), but less information is available on other links in the supply chain, including grain terminals, marine, warehousing, and trucking.

End-to-End:

The total transit time from origin to destination, including transit and dwell times for each mode of transportation involved in the supply chain. Transport Canada's fluidity indicator uses end-to-end transit times. Total transportation system analysis, with consideration of all links, helps to identify links that take the longest, are more variable or at risk, and may be the cause of supply chain slowdowns.

Variability:

High variability indicates greater dispersion of the average monthly transit and dwell times across the 48 months in the study (less consistent supply chain performance). In this paper, monthly data are used for transit and dwell times, and variability is expressed using both standard deviation and range (spread between the month with the shortest average time and the month with the longest average time).

Vessel Schedule Reliability or On-time Performance:

The percentage of vessels that arrive at port on schedule, within a specified window (e.g., +24 hours of scheduled berth window start). According to the supply chain advisory firm *Sea-Intelligence*, global vessel schedule reliability decreased from 78.0% in 2019 to 35.8% in 2021 (using the on-time definition of +/- one day from scheduled arrival).[XI]

Velocity:

Measured as the distance equipment travels per unit of time (e.g., average rail car mileage per day). Velocity is affected by both dwell time and train speed. Higher velocity, whether generated from shorter dwell times or higher train speeds, is a cost-effective way to increase supply chain fluidity, capacity, and reduce end-to-end transit times. Velocity is affected by factors such as weather (cold temperatures, snow clearing, etc.); rules on maximum train speeds; loading/unloading efficiency, and congestion at port terminals.

Take-or-Pay:

Take-or-pay is a type of commercial contract in which a shipper reserves capacity (e.g., rail capacity) and must pay regardless of whether they choose to use the service. Such contracts provide traffic certainty for transportation providers, improving supply chain efficiency and reducing variability.

Resilience:

The ability of supply chains to prepare for, respond to, and recover from disruptions; restoring capacity in a timely manner. Disruptions may include, but are not limited to, pandemics, inclement and extreme weather, and labour disruptions. It can take several days to fully recoup losses from a single day of lost productivity.

Policy Controllable Factors:

Many of the factors that deeply affect supply chains in Canada are beyond the direct control of Canadian governments. For example, in recent years, factors have included high container prices and shortages, China's COVID-zero policy, and the poor on-time performance of international marine carriers.

With the context set and these key supply chain concepts in mind, we now turn analyze these concepts through two case studies.

CASE STUDIES

This section analyzes two supply chain case studies using entirely publicly available data.

1. Import of containerized consumer goods from Shanghai, China to retail shelves in Ontario & Quebec, Canada
2. Export of Western Canadian grain from Saskatchewan, Canada to Chinese ports

There are many different supply chains that could be analyzed, but the two case studies presented in this section were chosen for several important reasons.

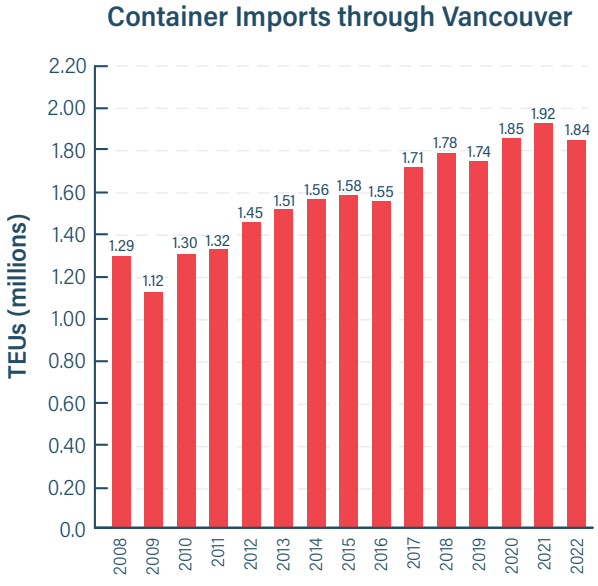
First, these supply chains are of great significance to the Canadian economy, exporters, and consumers. As a trading nation, Canada is a large exporter of grain from the Prairies through West Coast Ports, with the highest volumes moving through the Port of Vancouver. On the import side, a high variety and volume of consumer goods (e.g., things everyday consumers purchase at Costco, Canadian Tire, Home Depot, or any other retailer) are brought in from Asia via container.

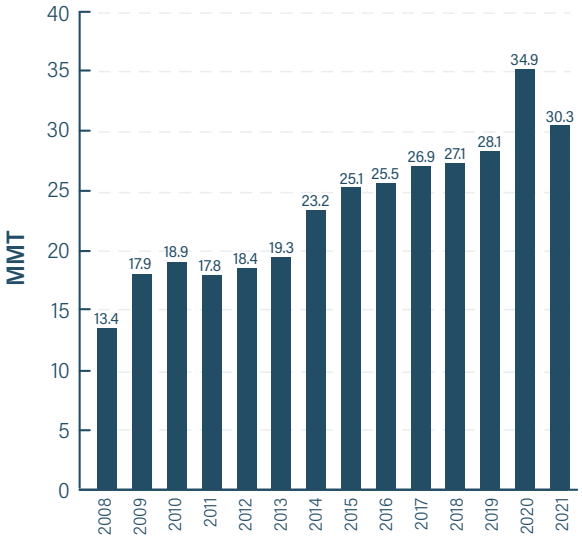
Second, the commodity categories represent the highest volume lines of business for Canadian Class 1 railways (Grains & Fertilizers and Intermodal).[XII]

Third, while not complete, data are publicly available for the total end-to-end transit times and many of the transportation links within these supply chains (while estimates are needed in some instances).

The graphs below show the significant growth of both these key Canadian supply chains since 2008.

SUPPLY CHAIN GROWTH, 2008-2022





Source: Port of Vancouver, *Statistics*.

Note: As of March 14, 2023, 2022 data for grain (Grain, Specialty Crops & Feed) exports were not available.

CASE STUDY #1: IMPORT OF CONTAINERIZED CONSUMER GOODS

Origin: Shanghai, China **Destination: Retail shelves in Ontario & Quebec, Canada**

Dwell, loading, and unloading | Transit

		MONTHLY AVERAGE TIME (DAYS)			VARIABILITY* (DAYS)			
		2019	2022	2019-2022	Std. Dev.	Range	Min.	Max.
MARINE VESSEL	Loaded Vessel at the Port of Shanghai	*Not measured*			*Not measured*			
	Marine Vessel: Shanghai-Vancouver							
PORT OF VANCOUVER	Port of Vancouver: Vessel Waiting in Port	16.6	27.7	22.0	4.9	20.0	15.3	35.3
	Port of Vancouver: Vessel Unloading							
	Port of Vancouver: Terminal Dwell & Train Loading	3.0	5.6	4.1	1.4	6.1	2.0	8.1
RAIL	Train: Port of Vancouver to Lower Mainland Yard	Estimated at 0.1**			n.a.			
	Train: Lower Mainland Yard Dwell	0.6	0.5	0.6	0.1	0.7	0.4	1.1
	Train: Lower Mainland to Toronto & Montreal Yards	5.2	5.3	5.2	0.3	1.3	4.8	6.1
	Toronto & Montreal Yards: Unload from rail and load onto trucks	0.8	0.9	0.8	0.1	0.4	0.7	1.1
LAST-MILE	Trucking: From yards to distribution centres, retailers and consumers	*Not measured*			*Not measured*			
	END-TO-END***	26.3	40.0	32.8	6.2	26.2	24.1	50.3

*Variability is calculated based on 48 data points (monthly average time) from January 2019 through December 2022.

**Data are unavailable and assumed to be no more than 0.1 days (2.4 hours), based on known distances and train speeds.

***End-to-end transit times are for the measured portion of the supply chain and excludes unmeasured first- and last-mile links.

Sources: Port of Vancouver, *Supply Chain Performance*; Transport Canada; *Transportation supply chain performance*; CN, *Key Weekly Metrics*; CP, *Weekly Key Metrics*; Railway Association of Canada, *Canadian Rail Atlas*.

Notes: The infographic is a linear visualization of average monthly transit and dwell times. The data are not generated from tracking a single good from end-to-end. Some activities may occur simultaneously. End-to-end transit times are set equal to Transport Canada's end-to-end transit times (Shanghai to Toronto), with a minor adjustment for the inclusion of Montreal as an additional destination. Rail yard dwell times for the Lower Mainland, Toronto, and Montreal are calculated as the simple average dwell times at CN and CP's major yards: CP Vancouver & CP Thornton; CP Toronto and CN Thornton; and CP Montreal and CN Taschereau. Train transit time is calculated as the simple average of CN and CP's estimated transit times from Lower Mainland yards to yards in Toronto and Montreal – which are calculated based on average monthly intermodal train speeds and measured track distances. The total time for marine vessel transit, vessel waiting in port, and vessel unloading is calculated as a residual, to satisfy the already-determined total end-to-end transit time (as described earlier). Figures may not add up to totals due to rounding.

This case study illustrates the likely path that a consumer good takes before arriving on retail shelves in Ontario and Quebec. It includes information on each link in the transportation supply chain, including average monthly times and statistics on variability. Within the scope of our analysis, the transportation supply chain begins with the consumer goods loaded in a container on a vessel ready to depart the Port of Shanghai – the largest container port in the world (handling 47.3 million TEUs in 2022).[XIII] In the 2019 to 2022 period, end-to-end transit time averaged 32.8 days, with 67% of this time spent on a marine vessel.

MARINE VESSEL

To begin, the loaded marine vessel travels across the Pacific Ocean, and before arriving at the Port of Vancouver, will make one or more ports of call at other West Coast ports (e.g., Tacoma, Seattle, Prince Rupert) – adding to total transit time and variability. Upon arrival at the Port of Vancouver, the vessel may be required to wait prior to berth and unload (poor vessel on-time performance and port congestion are contributing factors). From 2019 to 2022, the average time it took for the above-mentioned steps increased from 16.6 days to 27.7 days (+11.1 days or 67%). These times reached as high as 35.3 days in January 2022. In the 48-month period from January 2019 through December 2022, total time averaged 22.0 days with a standard deviation of 4.9 days.

PORT OF VANCOUVER

Once the containers are unloaded at the Port of Vancouver, they are then moved and sorted into blocks based on their destination (a very small share of containers undergo a CBSA inspection as well). Terminal operators communicate with railways and when ready, the railcars come into the terminal, where terminal operators load the railcars with containers full of consumer goods. From 2019 to 2022, the average monthly import container dwell time (which includes railcar loading) at the Port of Vancouver increased from 3.0 days to 5.6 days (+2.6 days or 87%). Monthly dwell times were highly variable, ranging from as low as 2.0 days in April 2019 to as high as 8.1 days in December 2021.

RAIL ACTIVITY

Next, some of the railcars that are loaded at the Port of Vancouver head directly to Central Canada and the U.S. Midwest; however, most (approximately 75%) first head to a railyard in the Lower Mainland[XIV] – as is the case in our study. The rail transit times between the Port of Vancouver and Lower Mainland railyard are not available but are assumed to be no more than 0.1 days (2.4 hours), based on known distances and train speeds.

Upon arrival at the yard, the various consumer goods are shifted among containers and intermodal trains are built. Monthly dwell at CN and CP's lower mainland yards averaged 0.6 days from 2019 through 2022, with very low variability (standard deviation of 0.1 days).

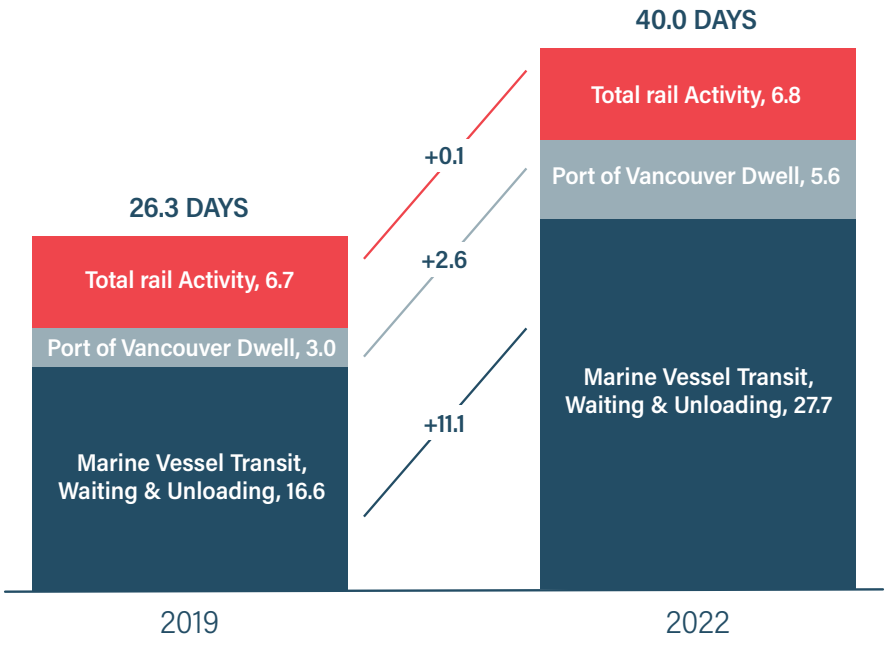
The intermodal train, full of containerized consumer goods, then leaves the yard destined for major yards in the Toronto and Montreal areas. The transit times between Lower Mainland yards and yards in Toronto and Montreal were estimated using data on intermodal train speeds and measured track distances, for both CN and CP.[XV] Rail transit time averaged 5.2 days from 2019 through 2022, with very low variability (standard deviation of 0.3 days and a total range from slowest to fastest month of just 1.3 days).

After arriving in Toronto and Montreal yards, 0.8 days later (+/- 0.1 days standard deviation) the containerized consumer goods leave the yards, loaded on a truck, destined for distribution centres, retailers, and consumers. These efficient, optimized terminal operations are an outcome of investments in training and automated technologies.

TOTAL END-TO-END

The end-to-end transit time, from the loaded vessel in Shanghai to the loaded truck in Toronto or Montreal, increased from an average of 26.3 days in 2019 to 40.0 days in 2022 (+13.8 days or 52%). The 11.1 day increase in marine vessel transportation contributed to 80% of the 13.8 day increase, the increase in dwell at the Port of Vancouver contributed 2.6 days (19%), and rail contributed 0.1 days (1%).

MODAL CONTRIBUTIONS TO END-TO-END TRANSIT TIME



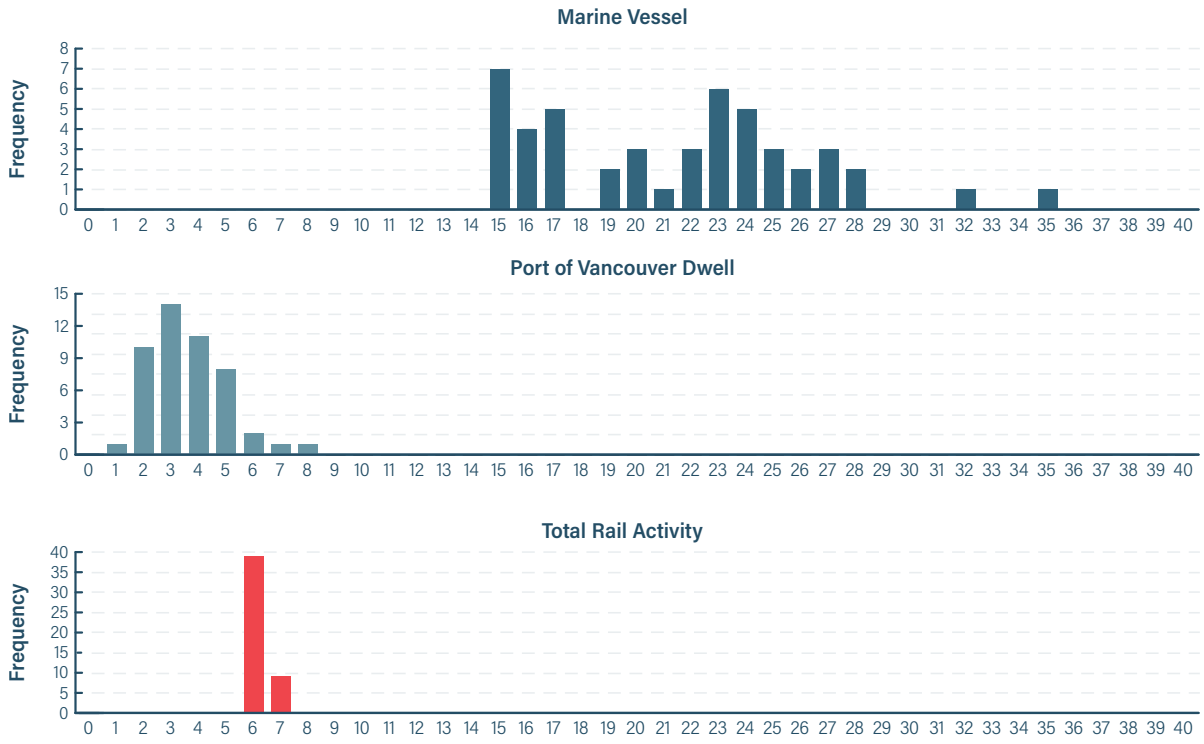
Sources: Port of Vancouver, *Supply Chain Performance*; Transport Canada; *Transportation supply chain performance*; CN, *Key Weekly Metrics*; CP, Weekly Key Metrics; Railway Association of Canada, *Canadian Rail Atlas*.

Note: Figures may not add up to totals due to rounding.

VARIABILITY BY MODE

The figure below provides a visualization of supply chain variability across the 48 months in the study (January 2019-December 2022), showing the distribution of monthly transit and dwell times for each mode of transportation. The dispersion for marine vessel transit, waiting at port, and unloading is quite wide; Port of Vancouver dwell was usually in the two-to-five-day range, while total rail activity from loaded car at the Port of Vancouver to loaded trucks in Toronto and Montreal was consistently in the six-to-seven-day range.

DISTRIBUTION OF MONTHLY TRANSIT & DWELL TIMES (DAYS)



Sources: Port of Vancouver, *Supply Chain Performance*; Transport Canada; *Transportation supply chain performance*; CN, *Key Weekly Metrics*; CP, *Weekly Key Metrics*; Railway Association of Canada, *Canadian Rail Atlas*.

Note: the x-axis indicates the beginning of the range. For example, 6 represents all values from 6 to 6.99.

CASE STUDY #2: EXPORT OF WESTERN CANADIAN GRAIN

Origin: Saskatchewan, Canada Destination: China

Dwell, loading, and unloading | Transit

	MONTHLY AVERAGE TIME (DAYS)			VARIABILITY* (DAYS)			
	2019	2022	2019-2022	Std. Dev.	Range	Min.	Max.
Trucking Transit: Farm to Prairie Elevator	*Not measured*			*Not measured*			
Train Loading at Elevator	2.5	2.9	2.5	0.7	3.1	1.5	4.6
Train Dwell at Origin & Local Switching	2.2	1.9	2.2	1.2	5.1	0.9	5.9
Train Transit: SK Elevator to Vancouver Rail Yard	5.3	5.0	5.2	0.9	5.5	4.1	9.6
Lower Mainland Dwell & Train Movement	0.7	0.3	0.5	0.2	0.8	0.2	1.0
Train Unloading & Vessel Loading at Port of Vancouver	7.0	6.4	7.1	1.9	9.3	2.9	12.3
Marine Vessel Transit: Vancouver to Chinese Port	24.2	24.2	24.4	2.2	9.2	20.9	30.1
END-TO-END**	41.9	40.7	41.9	4.4	23.7	33.1	56.9

* Variability is calculated based on 48 data points (monthly average time) from January 2019 through December 2022.

**End-to-end transit times are for the measured portion of the supply chain and excludes unmeasured first- and last-mile links.

Sources: Quorum Corporation, *Grain Monitor December 2022 Monthly Report*; Transport Canada; *Transportation supply chain performance*.

Notes: The infographic is a linear visualization of average monthly transit and dwell times. The data are not generated from tracking a single good from end-to-end. Some activities may occur simultaneously. End-to-end transit times are set equal to Transport Canada's end-to-end transit times plus the time for train loading at the Prairie elevator. Data for the rail links are from the Grain Monitor's 5B-1 Table, with an adjustment to account for the slightly longer transit times from Saskatchewan to Vancouver (compared to the Prairie average). Marine vessel transit time is calculated as a residual, to satisfy the already-determined total end-to-end transit time. Figures may not add up to totals due to rounding.

Canada's grain export supply chain is unique compared to other commodities. First, the production of grain is subject to weather variability and other factors, bringing volatility into the export supply chain before it even begins. And second, wheat and barley growers have only recently had choice in whom to sell their product. Until August 2012, farmers of regulated Western Canadian wheat and barley were required to sell their output to the Canadian Wheat Board (CWB). Since the end of the CWB monopsony, the export of grain has become more sophisticated and complex. On-farm storage has increased as farmers have become involved in playing the market – selling grain through regular contracts but also using the spot market. The size and timing of the harvest, as well as the business decisions of the agricultural producers and shippers, affects the consistency of volumes that are shipped each week. Without established weekly commitments through take-or-pay contracts, volatility is introduced into the transportation supply chain at the outset.

Increasing rail capacity is sometimes thought of as an answer to grain export supply chain issues. Yet this is overly simplistic. It only focuses on one link in a very complex supply chain, and overlooks issues such as bottlenecks at ports, closure of the Port of Thunder Bay in the winter, the lack of 24/7 terminal operations, and operational interdictions on loading grain into vessels in the rain in Vancouver (where it rains on average 166 days per year).[XVI] In fall 2022, railways demonstrated the ability to bring cars on line and service record grain shipments. In fact, in October 2022, when both Class 1 railways set all-time monthly records for grain shipments, they also achieved the shortest total rail activity time in the 48 months of this study.

System capacity is driven by velocity. For example, grain unit trains, loaded on loop tracks, that take a direct route to Vancouver without unnecessary switching reduces car cycle times by around four days. Increasing capacity through velocity means shorter transit times, less congestion, less variability, and lower costs. Switching, to build manifest trains or interswitching between carriers, increases time and variability.

Returning to our case study, this example illustrates the likely path that grain exports from Saskatchewan take before arriving at Chinese ports. Saskatchewan is the largest grain exporting province[XVII], and China is the largest importer of grain through the Port of Vancouver.[XVIII] The case study includes information on each link in the transportation supply chain, including average monthly times and statistics on variability. Within the scope of our analysis, the transportation supply chain begins at the Prairie elevator in Saskatchewan and ends upon vessel arrival at a Chinese port. In the 2019 to 2022 period, end-to-end transit time averaged 41.9 days, with 17% of this time spent loading vessels in Vancouver and 58% on marine transit across the Pacific.

PRAIRIE GRAIN TERMINAL

To begin, grain companies load railcars with grain at the Prairie elevator in Saskatchewan – taking an average of 2.5 days, with a standard deviation of 0.7 days. Once complete, the loaded cars are released to the railways.

RAIL ACTIVITY

The data on rail activity are from the *Grain Monitor*, which tracks railcars moving in unit trains and manifest trains, of which the latter may take indirect routes and stop at multiple yards. Based on track mileage and average reported speeds of grain unit trains, transit times for grain moving by unit train could be several days shorter than *Grain Monitor averages*.[XIX] The nature of the grain shipment affects rail activity.

Once the railways receive the loaded cars, origin dwell, local switching and train building averaged 2.2 days before heading off to Vancouver. Rail transit time from Saskatchewan to Vancouver rail yards averaged 5.2 days from 2019 through 2022, with a standard deviation of 0.9 days. Transit time may include stops at additional yards and crew changes. Upon arrival at the Vancouver yard, trains may be required to dwell until the terminal is ready to accept the shipment (delays could be due to capacity constraints or rain). Dwell at the railyard plus the Lower Mainland train movement to the terminal averaged half a day.

PORT OF VANCOUVER

At the port terminal, grain is unloaded by the grain terminal operators from the train into the terminal elevator, taking an average of 1.0 day. Since this may occur simultaneously with vessel loading, the 1.0 day does not factor into the total end-to-end transit times.

The marine vessel loading procedure is complex, and averaged 7.1 days through 2019 to 2022, with a standard deviation of 1.9 days and a maximum monthly average of 12.3 days. Large marine vessels may make multiple terminal calls, berthing and unberthing, loading grain from an elevator several times before beginning their voyages across the Pacific.

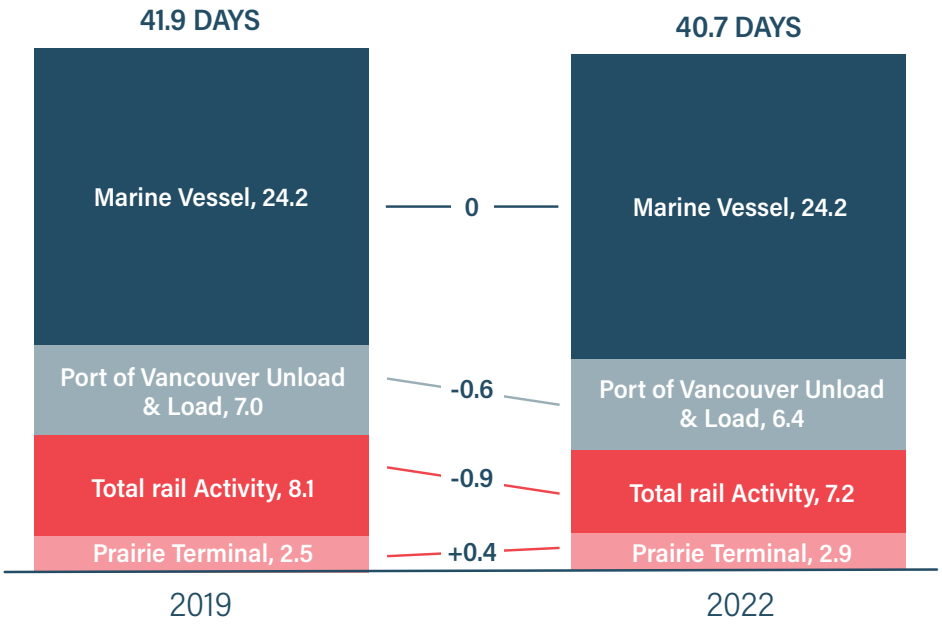
MARINE VESSEL

Once loading is complete, vessels took an average of 24.4 days to travel from Vancouver to Chinese ports, with a standard deviation of 2.2 days and a maximum monthly average of 30.1 days. The transit time of vessels exporting grain have much lower variability than the vessels importing containers. Vessels leaving Vancouver tend to head directly to China, without additional ports of call. Variability observed in transit times may result from slow steaming to reduce fuel consumption and/or meet scheduled arrival times.

TOTAL END-TO-END

The end-to-end transit time decreased from an average of 41.9 days in 2019 to 40.7 days in 2022 (-1.1 days or -3%). Throughout the 2019-2022 period, the grain export supply chain also experienced less variability than the intermodal import supply chain (standard deviation of 4.4 vs 6.2 days). The reduction in transit times and low variability are impressive, thanks to all supply chain players, considering the volatility in the size of the grain harvest, extreme weather events, the COVID-19 pandemic and ensuing government policies. Port activities contributed 0.6 days to the 1.1-day reduction and rail contributed 0.9 days.

MODAL CONTRIBUTIONS TO END-TO-END TRANSIT TIME



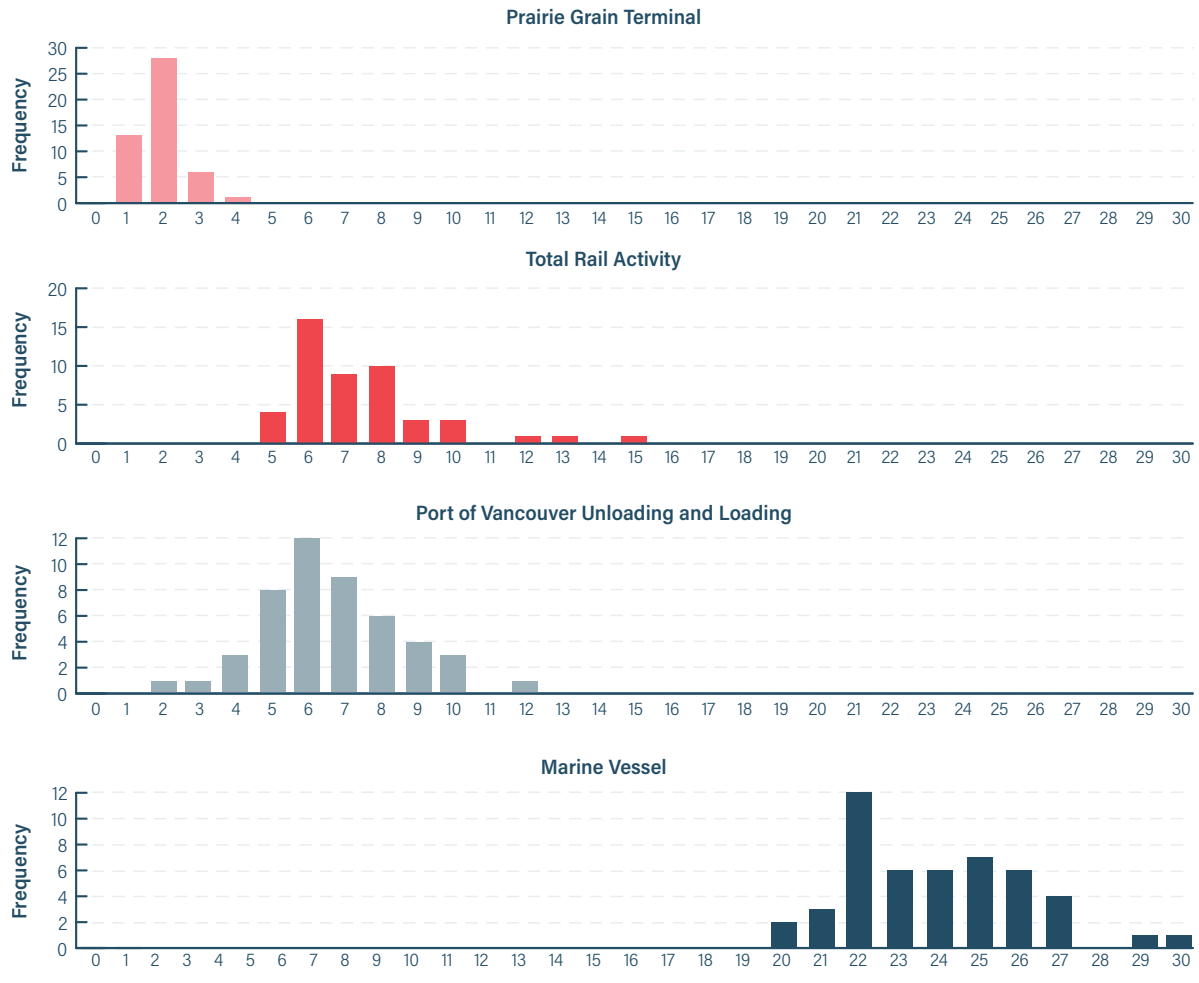
Sources: Quorum Corporation, *Grain Monitor December 2022 Monthly Report*; Transport Canada; *Transportation supply chain performance.*

Note: Figures may not add up to totals due to rounding.

VARIABILITY BY MODE

The figure below provides a visualization of supply chain variability across the 48 months in the study (January 2019-December 2022), showing the distribution of monthly transit and dwell times. Extreme weather events contributed to weaker supply chain performance in certain months. Historic rainfall in British Columbia in November 2021 impacted performance through January 2022. In December 2021, total rail times were 15.6 days and port times were 10.6 days; in January 2022, rail times were 13.3 days and port times were 10.0 days. Wildfires in July 2021 brought total rail times up to 10.3 days and port times to 8.4 days. Performance was relatively consistent across other months.

DISTRIBUTION OF MONTHLY TRANSIT & DWELL TIMES (DAYS)



Sources: Port of Vancouver, *Supply Chain Performance*; Transport Canada; *Transportation supply chain performance*; CN, *Key Weekly Metrics*; CP, *Weekly Key Metrics*; Railway Association of Canada, *Canadian Rail Atlas*.

Note: the x-axis indicates the beginning of the range. For example, 6 represents all values from 6 to 6.99.

RECOMMENDATIONS

Before taking action to "fix" supply chains, it is important to first develop a deep understanding of their complexity and how they function in order to determine root causes of supply chain slowdowns. Supply chain performance must be analyzed holistically. Fixes should be evidence-based and lead to tangible improvements. The majority of end-to-end transit times and variability of imports are driven by marine shipping, and Canadian policy makers have very little control in this area. Vancouver is not a first port of call for most marine carriers, which increase total transit times and variability. Globally, vessel on-time performance is very low (averaging 35.8% in 2021), which impacts the performance of Canadian supply chains. On the export side, variability in grain transit times may have a lot to do with variability in harvests and business decisions, which impacts the ability to have consistently strong supply chain performance. On supply chains, the federal government has a role to play in building Canada's international reputation, which has suffered recently.[xx] Policy should focus on enhancing visibility, fluidity, and capacity, while addressing concerns on vulnerabilities related to weather and labour shortages and disruptions.

Enhanced data visibility will contribute to improving supply chain performance. Public data are available from ports (e.g., West Coast Supply Chain Visibility Program) and railways (key weekly metrics posted, grain updates, etc.), but the government can play a role in enhancing visibility across all links in these complex supply chains, including marine carriers, grain terminal operators, warehousing and trucking.

The government can also play a role in helping to ease port congestion, leading stakeholders toward a solution for loading grain in the rain in Vancouver. Through investments, more grain could be loaded during the rain, easing port congestion, reducing cycle times, and improving supply chain performance.

On labour shortages, increasing levels of immigration under Canada's 2023-2025 Immigration Levels Plan is a step in the right direction. Immigration, Refugees and Citizenship Canada's consultation on Express Entry may help address some of the shortages in specialized supply chain occupations and trucking at large.

On the regulatory side, there are two items under consideration by the federal government that run counter the objective of building fluid, resilient supply chains. First, banning the use of replacement workers could deepen the negative impacts felt by work stoppages. Second, expanding the interswitching distance would increase congestion and lengthens car cycle times while reducing fluidity, velocity, and capacity. This could risk undermining the recent investments made to build more efficient grain supply chains.

CONCLUSION

This paper took a close look at two of Canada's most important supply chains. From 2019 to 2022, end-to-end transit times for container imports increased significantly, driven by the poor on-time performance of marine carriers; while end-to-end transit times for the export of grain improved, thanks to strong performances by multiple supply chain players. Moving forward, with a deeper understanding of the complexity of integrated global supply chains and key supply chain concepts, government can focus on what it can influence (e.g., data visibility, labour supply, targeted strategic investments), and work together with all players to improve supply chain performance and Canada's reputation as a reliable trading partner.

ACKNOWLEDGEMENTS

We thank Mr. Louis-Paul Tardif (Principal, L-P Tardif & Associates) for providing his knowledge and expertise to advise us on this paper. We also thank our colleagues at Transport Canada in the Transportation and Economic Analysis directorate and colleagues at the Port of Vancouver for their helpful advice.

ENDNOTES

I Using the economy's job vacancy rate as a measure of labour market tightness. Statistics Canada, Table: 14-10-0326-01.

II Statistics Canada, Table 14-10-0326-01.

III Statistics Canada, Table 14-10-0328-01.

IV Statistics Canada, Table 14-10-0326-01.

V Statistics Canada, Table 14-10-0326-01. Offered wages in rail are the highest among transportation and warehousing industries.

VI CN and CP's 2022 Q4 reports.

VII Statistics Canada, Table 98-10-0455-01; Statistics Canada, Catalogue no. 98-400-X2016364.

VIII Canadian Transportation Agency, Maximum Grain Revenue Entitlements for Crop Year 2021-2022, December 22, 2022.

IX Throughout the first 31 weeks of the 2022-2023 crop year, CN and CP both set all-time monthly records for the movement of grain in October 2022; CP set a record for the month of January; CN and CP each set several weekly records.

X The latest forecasts (as of March 15, 2023) of most major Canadian banks forecast 2023 real GDP growth of less than 1%.

XI https://www.sea-intelligence.com/press-room/190-schedule-reliability-dips-slightly-m-m-in-january-2023

XII Railway Association of Canada, *RAC Quarterly Report 2022-Q4*, February 2023.

XIII https://www.porttechnology.org/news/top-10-ports-in-china-2022/

XIV Transport Canada, Transload Mapping Study

XV Sources: CN and CP's weekly metrics; RAC's Canadian Rail Atlas.

XVI 1998 to 2022 annual average number of days of rain. https://vancouver.weatherstats.ca/charts/count-rain-yearly.html

XVII Grain Monitor data.

XVIII Canadian Grain Commission data.

XIX Estimated train transit time of 2.3 days based on a 1,033-mile distance at an average grain unit train speed of 18.5 mph.

XX According to the World Bank Logistics Performance Indicators, Canada's rank fell from 10th in 2007 to 20th in 2018. The World Bank and S&P Global ranked the Port of Vancouver 368 out of 370 ports in their Container Port Performance Index, 2021.