CONTAINERIZATION OF BULK PRODUCTS: THE CASE OF GRAIN IN CANADA

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Introduction

The containerized shipment of freight both into and out of Canada has grown rapidly in recent years. A portion of this growth can be traced to the conversion of some export products that previously moved in bulk or break-bulk service. Driven by an opportunity to broaden logistical options as well as advantageous freight rates, this has raised a fundamental question in the minds of logisticians and policy makers alike: how much more conversion of bulk traffic to container is possible?

Many view the availability of empty containers across the country as a lost opportunity for the movement of bulk commodities. This premise is chiefly founded on the belief that using existing empty container capacity in a backhaul move is economically preferable to the forgoing of that opportunity. In fact, the logistical realities inherent in re-tasking such empty container movements are not always economically advantageous, nor do these considerations necessarily enhance the operational effectiveness of the logistics chain itself.

This paper contends that the "container convertible" portion of Canada's existing bulk-product movement is more limited than many of its advocates suggest. This is primarily due to the physical loading constraints of container vessels themselves. Yet there are other factors as well, including: the impact on railway efficiency; the efficient utilization of port facilities; and the burden imposed on the overall logistics system by the large-scale conversion of bulk commodities to container movement. This paper endeavours to identify the potential challenges inherent in containerizing a portion of Canada's current bulk exports. However, owing to the need for brevity, no attempt is made to extend this analysis towards identifying either the optimal or maximum volume involved.

This subject matter was originally addressed as part of a report submitted to the Government of Canada on the movement of grain in containers.[1] This paper expands on that discussion with a continued focus on the movement of grain for illustrative purposes. With an appropriate acknowledgement, the author also draws on his role as the federal government's Grain Monitor to bring forward the views of the broader stakeholder community.

The first topic of discussion will be the events and drivers that led up to the more recent modal conversions to container movement, and the subsequent market changes that influenced those conversions. This is complemented by consideration of the various factors that could both promote and inhibit the containerization of bulk commodities in the future.

Containerization of Freight

Conceptually, the containerized movement of freight represents a relatively new approach to logistics, and one that quickly found a constructive role in the global trade of consumer and industrial products. Once a high-cost option, events over the past decade-and-a-half have strengthened the economic viability of this shipping alternative. Today, containers are almost universally employed in importing just about any product imaginable to North America. Likewise, North American shippers seeking to move their products to the container's originating point can often gain access to low-cost back-haul capacity inherent in its repositioning. Shippers can now potentially arbitrage and lower their freight costs while providing an alternative logistics scenario to their buyers.

The importation of consumer goods from Asia and Europe has been the primary driver in North America's container supply. As these regions increased their production of higher quality goods, North American consumption also increased. This led to an exponential increase in inbound container movements as well as a burgeoning supply of empty containers aiming to return home for reloading. Such imbalances are the underpinnings of what are widely referred to within the transportation industry as head-haul and back-haul rates.

The defining feature of head-haul and back-haul movements is that one has a higher market demand, which distinguishes the dominant flow of traffic. It will, therefore, also command a higher freight rate. The back-haul movement repositions the container back to its origin, typically commanding a lower freight rate. In the context of Canadian export products, this opens the opportunity for lower-cost movements, often to Asia-Pacific countries, by utilizing the capacity made available. Consequently, the growth of imported containerized consumer and manufactured goods into North American markets over the past 10 years has also created a large pool of low-cost, empty containers for use in back-haul export movements.

Shipping lines price these containers aggressively to provide revenue on their back-haul movements to Asia and Europe. By way of example, these prices fell well below those for competing break-bulk ocean freight on exported forest products in the early part of the last decade. Break-bulk carriers subsequently removed capacity from the North American market as pulp, lumber, and panel products shifted largely to containerized movements, and away from the break-bulk movements that had dominated over a decade ago.

This was noted by many in the grain industry who saw the opportunity in using containers to serve small-lot markets, and offer "just-in-time" delivery to specialized, value-added processors in the export marketplace. Between 2003 and 2008, as bulk rates surged ever higher, movement by container became an increasingly more economical logistical choice.

The Baltic Dry Index (BDI), shown in Figure 1, is the standard indicator of bulk shipping rates worldwide. From late 2003 through to the autumn of 2008, bulk ocean shipping rates, as represented by the BDI, climbed by over 400%. Driven by the comparative shortage of bulk vessels in the face of the growing demands imposed by a vibrant Chinese economy, prices surged to an all-time high. As the economic downturn in late 2008 began to grip the global economy, bulk ocean vessel rates soon fell, this time to record low levels, where they continue to languish to this day.

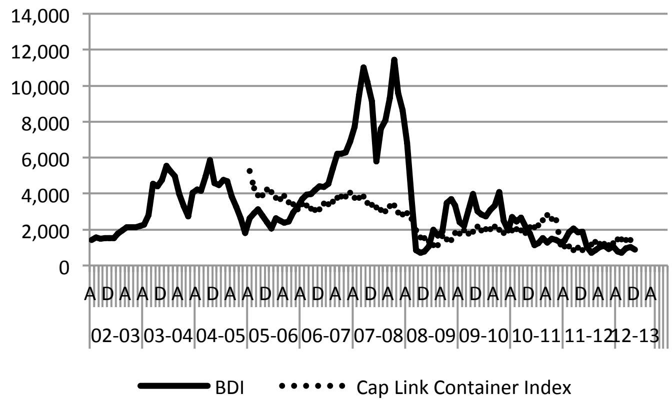

Figure 1. Baltic Dry Index: December 2003–December 2012[2]

While forest products typically employ break-bulk options to reach offshore export markets, grain products – both cereal grains and oilseeds – use bulk freighters to reach the majority of markets to which these products are shipped. Nevertheless, there are niche markets for cereal grains that can be better served by container. Special crops are even more suited to containerized shipment, as these products are typically sold in much smaller lot sizes with receivers accustomed to such movements.

A considerable amount of discussion has been dedicated to the potential conversion of Canada's bulk resource and agricultural exports to containers. It is argued that grain products could readily be converted to containerized freight because the back-haul direction for imported containers (east to west) corresponds to the head-haul direction for export grain moving in hopper cars to port terminals on the west coast. The concept would see grain loaded in the country using the empty containers that are flowing westward instead of in hopper cars, thereby shipping export grain overseas under back-haul rates. It is believed that the conversion of grain from bulk to container will then balance the movement of containers and reduce the requirements for hopper cars, and the return empty movement they incur on each trip.

The proponents of container conversion suggest that if more grain is moved from prairie origins by container, there will be improved railway capacity utilization, as well as an increase in the overall efficiency of the grain handling and transportation system.

The rise in bulk ocean freight rates in the 2005–2009 period also drove the conversion to containerized movement. To illustrate, consider the following model that uses actual rates. The total cost used represents that of the logistics chain components. In the case of bulk grain, it can be expressed as the steps involved in moving grain from the country to a destination port. This approach allows for a comparison to an alternate containerized movement.

Table 1 illustrates the component costs of a bulk movement of grain under three different scenarios. In each, all costs remain constant with the exception of the ocean freight:

- Scenario A portrays ocean freight when the BDI is at a very low point, with rates for a Panamax size vessel (approximately 60,000 tonne capacity) falling in the $8,000-per-day range. This is reflective of current market conditions.
- Scenario B portrays ocean freight when the BDI is at a moderate or ‘normal’ point, with rates for Panamax sized vessels being in the range of $25,000 per day.
- Scenario C portrays ocean freight when the BDI is at a high point, such as what was experienced in the period immediately before the economic crisis of 2008, and vessel rates soared to over $75,000 per day.

As noted above, the period leading up to early 2008 saw the logistical cost of moving grain increase by over 21% from the ‘normal’ level. While this provides some insight into the cost of large-lot movements of 60,000 tonnes or more, the impact on smaller movements was even greater. This led many in the grain industry to look for alternatives, particularly when smaller-lot volumes were being traded.

Table 1. Costs associated with the movement of Canadian grain in bulk freighters

Bulk Freight Mode [3]

	Scenario A	Scenario B	Scenario C
Elevation in Country	14.08	14.08	14.08
Rail to Port	38.56	38.56	38.56
Port Terminal Fees	9.59	9.59	9.59
CGC Fees	0.38	0.38	0.38
Ocean Freight	2.40	7.50	22.50
Cost per Tonne	**65.01**	**70.11**	**85.11**
Ocean Freight Differentials			
Rate/ day	8,000	25,000	75,000
Transit time (days)[4]	18	18	18
Total Freight	144,000	450,000	1,350,000
Tonnes/ vessel	60,000	60,000	60,000
Cost/ Tonne	2.40	7.50	22.50

Table 2 portrays a similar set of cost scenarios for the movements of grain in containers. In this model, both rail and ocean freight rates fluctuate. As depicted in Figure 1, the period between 2005 and 2008 saw container rates fall while bulk rates rose. This figured heavily in the subsequent decisions made by grain logisticians.

Table 2 also presents three comparative scenarios:

- Scenario D portrays back-haul container and rail rates in the period prior to 2005, when both the railways and container shipping lines priced their services with an eye towards building volumes and establishing the foundations of a potential back-haul container business.
- Scenario E portrays ocean freight in the period after 2008, as both the railways and shipping lines adjusted rates to a level that secured the volumes they could adequately handle. This best reflects the situation being experienced at the time this paper was written.
- Scenario F portrays ocean freight in the period after 2005, as both the railways and shipping lines experienced unusually high volumes and began to look for ways to optimize asset utilization.

These prices also appropriately reflected market demand, as bulk rates had soared between 2005 and 2008.

Table 2. Costs associated with movement of Canadian export grain in containers

	Scenario D	Scenario E	Scenario F
Drayage in Country	240.00	240.00	240.00
Inland Terminal Fee	-	150.00	150.00
Rail to Port	400.00	600.00	600.00
Port Terminal Fee	125.00	125.00	125.00
Ocean Freight	800.00	1,000.00	1,200.00
Cost/ TEU	1,565.00	2,115.00	2,315.00
Cost/ Tonne	**68.04**	**91.96**	**100.65**

The situation in the bulk freight market as seen in Scenario C ($85.11 per tonne) and the container freight market in Scenario D ($68.04/ tonne) represents prices leading up to the summer of 2008. This differential between these rates led many logistics managers in the grain industry to explore and experiment with a conversion of some typically bulk movements to container. When the economic collapse of 2008 pushed bulk freight rates from an all-time high down to abnormally low levels, rates as seen in Scenario A ($65.01/ tonne) became the norm while at the same time container rates rose to that seen in scenario E.

During that period, the predominant area of growth was in special crops, pulses in particular. This new modal choice worked well with global markets looking to purchase Canadian pulse products in small lot volumes.

The cost differentials were short lived, though, and since 2009, bulk rates have fallen. While some traffic reverted back to bulk in response to the lower cost, much continues to move by container, with shippers continuing to take advantage of multi-modal alternatives. The most prominent multi-modal option is characterized by the use of transload facilities at the ports of Montreal and Vancouver, which have created a competitive cost structure by combining inbound hopper-car movements with outbound container movements to final destination. This has contributed to maintaining container volumes.

Despite this, the preponderance of Canadian grain continues to move in bulk, as portrayed in Table 3. This table shows the last five years of grain movements against the volume of grain in containers through the ports of Montreal and Vancouver, where the vast majority of containerized grain flows and compares it to the total volume of grain exported from Canada. Of not, this data demonstrates the rise of container volumes in 2009 following the surge in bulk freight rates, and then the gradual return to bulk movement that corresponds with the decline in bulk freight rates.

Table 3. Bulk export movements of Canadian Grain from Canada compared to container and other modes (tonnes, 000)

	2007	2008	2009	2010	2011
Total Bulk Exports	33,812	31,549	30,409	30,874	30,987
Total container, other	2,924	2,593	3,657	3,591	3,003
% Bulk movements	91%	92%	88%	88%	90%

The Physics of Ocean Container Loading Weights

The most significant driving factor in the loading of bulk commodities into ocean containers is the loading capability of the container vessels themselves. The operational requirements of any transportation service provider dictate the maintenance of balanced equipment flows between a variety of origins and destinations. This is to ensure that adequate amounts of equipment are in position at the locations where the market demand calls for it. The common objective of all container vessel operators have is to make each ocean crossing with as many containers as possible, preferably filling with 100% of the vessel's container slots being used.

A typical 5,000 TEU container vessel will have a maximum gross carrying capacity of approximately 49,000 tonnes, or approximately 9.8–10.5 tonnes per TEU. This is a function of a vessel's buoyancy and a vessel's carrying capability, and. This was confirmed in a review of the 10 largest container vessels in the global fleet.[5,6] A bulk carrier of roughly equal size and dimensions would carry in excess of 65,000 tonnes. Much of the reason for this relates to the carrying-capacity lost to the structure within a container vessel that is required to hold containers in a fixed position, sometimes referred to as ‘slots’. Based on the dimensions of a standard 20-foot container, these ships can accommodate a maximum per-cubic-foot loading of approximately 14.3 pounds per cubic foot.

The challenge with loading Canadian bulk commodities into containers is that their densities are typically high-density weight, which is much greater than the average lading threshold capability of 14.3 lbs. So much so, in fact, that a typical ocean container ship’s optimal utilization can only accommodate a portion of the total containers it was physically designed to handle. To use industry vernacular, the ship would ‘weigh-out’ before it ‘cubed-out’.

Table 4 shows the density weights of typical bulk exports from Canada:

Table 4. Average densities of typical Canadian bulk commodities

	Lbs. per cubic foot	% of typical container capacity
Coal	52	28%
Wheat	48	30%
Barley	38	38%
Sulphur	82	17%
Potash	80	18%

In each case, the density of the commodity exceeds the practical limit per available cubic foot by a factor of at least two. This means that a container ship would be unable to take on a full complement of containers uniformly loaded with such heavy commodities. More than half of the allotment would necessarily have to be left behind to await another ship.

A standard 20 foot container will typically accommodate somewhere in the area of 21 tonnes of grain, often filling much of the available cargo space. At the higher end of this range is wheat, which normally weighs in at an average of 23 tonnes per container. If it is assumed that a 5,000-TEU container ship is available to load, then the weight profile of these loaded containers would only permit 2,140 to be taken aboard – a load factor of just under 43%. Although the remainder of the ship's container slots could be used to move empty containers, its ability to take on additional loaded containers had effectively been reached. Ultimately, 1.34 empty TEUs would accompany every TEU loaded with wheat. The calculations being as follows for a typical 5,000-TEU Vessel:

Given:	Vessel's Net Tonnage:	NT = 49,226 tonnes
	Vessel's Container Capacity (TEUs):	T = 5,000 TEUs
	Standard lading per TEU:	SL = 9.84 tonnes
	Wheat lading per TEU:	WL = 23 tonnes/TEU

a) The maximum number of loaded wheat containers that could be borne by a container vessel:

$$MC = (NT / WL) = (49{,}226 \text{ tonnes} / 23 \text{ tonnes}) = 2{,}140 \text{ loaded wheat containers}$$

b) Load factor per container ship:

$$LF = (MC / T) = (2{,}140 / 5{,}000) = 0.428$$

c) Empty-to-loaded container ratio:

$$ELR = ((T-MC) / MC) = ((5{,}000-2{,}140) / 2{,}140) = (2{,}860 / 2{,}140) = 1.336$$

A review of actual inbound and outbound container weights was undertaken using Port Metro Vancouver statistics. These are shown in Table 5.

The movements depicted in Table 5 provide an indication of the actual operating and loading practices of container lines, and show that outbound movements are typically 66% heavier than those on the inbound side, and loaded to about 76% of the maximum allowable weight. While the companion movement of less dense products or commodities can help mitigate the operational issues that arise from moving high-density traffic in containers, a significant increase in volumes of the latter would greatly diminish the number of slots a vessel could make available for back-haul movements.

Table 5. Actual container traffic – Port Metro Vancouver (2009–2011)

	2009	2010	2011	*3 Yr Avg.*
Inbound				
Tonnes	7,111,796	8,695,938	8,782,564	*8,196,766*
TEU's	1,122,849	1,296,946	1,320,610	*1,246,802*
Tonnes/ TEU	6.33	6.70	6.65	*6.56*
Outbound				
Tonnes	12,166,641	12,232,135	12,892,052	*12,430,276*
TEU's	1,029,613	1,217,363	1,186,422	*1,144,466*
Tonnes/ TEU	11.82	10.05	10.87	*10.91*
Total				
Tonnes	19,278,437	20,928,073	21,674,616	*20,627,042*
TEU's	2,152,462	2,514,309	2,507,032	*2,391,268*
Tonnes/ TEU	8.96	8.32	8.65	*8.64*

Discussions with container terminal personnel indicated that, in practice, container lines will balance the heavier loaded containers with empty or lighter loaded ones, leaving heavier traffic behind in order to ensure a proper balance of movement, and a safely loaded vessel. The traffic left behind would place increased pressure on the storage capacity of port terminals that are already constrained, as well as adding additional costs in the form of storage and rebilling fees.

Other Issues and Circumstances

A number of additional barriers to a large-scale conversion of grain to containerized movements were identified by industry stakeholders, these broadly include:

Railway efficiency – In comparing the merits of container versus bulk movement, the predominant difference between the two approaches is the volume capability of the different kinds of train service. For comparison purposes, we examined the characteristics of a typical container or bulk grain train with a length of 6,000 ft[7] and found a considerable difference in the amount of lading each is able to carry. A container train will carry approximately 450 TEUs with an average lading weight of approximately 15.9 tonnes each, or a total of 7,800 tonnes per train.[8] On the other hand, a bulk grain train will carry in excess of 10,300 tonnes, some 32% more. This differential implies that the average per-tonne cost for moving grain in containers is higher than that of moving it in bulk, thus rendering it less economically efficient.

Port property utilization – The physical layout of Canada's major ports is such that land on tidewater is always at a premium, and comes at a high cost. It is crucial that the utilization of that space be managed in the most efficient and effective manner possible.

The design of bulk grain terminals sees product transferred and stored at port in bins that are approximately 40 feet in diameter, and upwards of 80 feet tall. The typical grain train carrying 10,300 tonnes will require 4.2 bins, or result in the utilization of slightly less than 5,000 square feet of port tidewater space. Conversely, The 645 TEUs required to carry the same tonnage can be stacked no more than 5 high, and will therefore require more than 20,600 square feet of land, approximately 4 times more than a bulk terminal facility would.

The average storage time for bulk grain at port is likely longer than it would be in the case of a container movement. The average days in store for bulk grain during the 2010-11 crop year was 15.5 days,[9] while it is estimated that a turn time for containers at Vancouver would be approximately 10 days. This 30% reduction in time spent at port in containers would not, however, mitigate the need for additional land.

Country and port terminal asset investments – Grain companies, railways, and the government have made significant capital investments in the country's bulk handling infrastructure, estimated to exceed $5 billion. This includes the country and port terminal network, the hopper car fleet, and the processes that allow them to function. While it would be possible to convert or adapt these facilities to load containers, it would be costly. Further, the location of intermodal terminals in the present rail gathering network would necessitate an increased amount of truck movement in order to position containers at the appropriate inland terminal.

Offshore investment in bulk handling systems – The buyers of Canadian grain have many long-term strategic investments in port- and inland-based bulk handling facilities. Examples include a 1 million metric tonne facility that was recently upgraded in Dalian, China, and the extensive network of port terminal storage facilities throughout Southeast Asia. Viterra has also invested in bulk handling projects in China's Guangxi region through a 49% interest in a canola crushing plant. Globally, the majority of grain is typically traded in lot sizes greater than 25,000 tonnes, an amount most conducive to bulk movement, utilizing the network of bulk grain facilities found in ports around the world.

Volume impact of conversion – Based on current traffic levels, the conversion of bulk grain to containers would likely have an impact on the balance of inbound and outbound flows.

Table 6. Calculation of potential TEUs converted from grain bulk movement

	2010-2011 Actual
Bulk Grain through Vancouver	
Tonnes (000)	14,958
Estimated TEUs (converted)	650,348
All Containers (TEUs)	
Outbound - Loaded	999,725
Outbound - Empty	186,697
Total Outbound Movement	1,186,422
% of Empty Supply	348%
% of Total Movement	55%

Using the bulk grain traffic currently moving through the port of Vancouver (2010–2011 crop year) as an example, the conversion of all bulk grain traffic would require more than 650,000 20-foot containers. Outbound movements from Vancouver that year totaled 1,186,000 TEUs, 186,697 of which were empty. Consequently, based on these actual figures, the demand for grain alone would outstrip the available supply of empty containers by more than 3½ times. If empty containers were brought into Vancouver to meet the additional demand, this would place significantly greater pressure on the port's already strained capacity. Such a change would likely also adversely impact the shipping line's perspective on head-haul and back-haul movements, precipitating a sharp probable rise in what had been lower-cost back-haul ocean freight rates.

It is therefore important to consider the average value of products being shipped, and their ability to support the cost of freight. Using grain as an example, the average price ranges from $300 to $500 per tonne.[10] This equates to approximately $7,000 to $11,500 per TEU. A shipment of consumer goods can range from $25,000 per TEU for linens and clothing to over $100,000 for electronics. The value of the consumer products being imported can sustainably support head-haul freight rates that exceed $4,000 per TEU. If the directional balance were altered because of export demand for capacity, the container rates on export movements would increase. Grain is traded as any other commodity and the price is determined in the global market. As such, freight cost increases are not carried by the price paid by the buyer, but borne by the supplier, who, in the case of Canadian grain, is ultimately the farmer.

Summary

In conclusion, the writer asserts that the impetus for the conversion from bulk to container was largely initiated by an aberration in bulk shipping rates in the period between 2005 and 2008. This was not necessarily a negative event, as it provided a much needed boost for some commodities, such as pulse crops, to gain a foothold in the global market place.

The largest inhibitor for significant conversion, though, is the density weight of bulk products, including grain, which detracts from the number of loaded containers that can be safely handled aboard a container ship. With a potential load factor of 43%, the adverse impact on vessel productivity would be severe. Further, the relatively low value of these export products are likely not sufficient to support higher freight rates. Based on current actual average weights, there is room for continued growth of containerized bulk products, but it is strictly limited by the amount of capacity made available through imported goods.

While the factors described above will place a ceiling on the growth of containerization for grain, there will be two specific areas that should expect to experience continued growth:

- As markets open in the grain industry for more identity preserved products, there will be a demand for smaller, better controlled logistics solutions, and the most effective means of accommodating this is through containerization.
- The most prevalent area of growth continues to be the special-crops market, pulses in particular, where sales are typically made in lot sizes of less than 10,000 tonnes, and not conducive to bulk shipment.

In discussions with bulk shippers of coal, sulphur, fertilizers, and other commodities, the consensus was that no potential market of significance would demand movement by container. Further, China and other major markets for Canada's bulk commodities have recently invested heavily in bulk-handling facilities, including grain elevators and oilseeds crushing plants. So long as both buyers and sellers of these products continue to invest in logistics infrastructure that focuses on bulk movement, and the economics of bulk movement continues to favor this mode, no large shift to container movement is likely.

Endnotes

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[1] Container Use in Western Canada: Inland Terminals, Container Utilization, Service and Regulatory Issues and the Optimization of Use in Western Canada – Supplemental Study of the Grain Monitor, November 2007

[2] The Baltic Dry Index is drawn from data available from the Baltic Exchange and the Cap Link Container Index is sourced from Capital Link Maritime Transportation Group (http://marine-transportation.capitallink.com/)

[3] Costs have been drawn from Section 4 of the Grain Monitors reports (Annual Report of the Grain Monitor for 2010-2011, Quorum Corporation), from container lines and from the BC Chamber of Shipping weekly reports (weekly average ocean freight report)

[4] Analysis of ocean transit – GMP Supplemental study on the Grain Supply Chain, Spring 2013

[5] This is based on the average of the 10 largest container vessels in the world (Emma Maersk, Gudran Maersk, Xin Los Angeles, CMA CGM Medea, Axel Mærsk, NYK Vega, MSC Pamela, MSC Madeleine, Hannover Bridge)

[6] This is based on the average of the 10 largest container vessels in the world (Emma Maersk, Gudran Maersk, Xin Los Angeles, CMA CGM Medea, Axel Mærsk, NYK Vega, MSC Pamela, MSC Madeleine, Hannover Bridge)

[7] Train lengths for trains will typically run between 6,000 and 12,000 feet depending on the route taken, time of year and traffic demand. A reference to 6,000 foot trains is used for the purpose of comparison only.

[8] The equipment preference of most shippers loading grains into containers is the 20-foot high capacity units as they allow for the heaviest loading at approximately 26 tonnes. These units are not always easily available and therefore, 40-foot units are utilized. Forty-foot units however are restricted to a maximum loading of about 31 tonnes due to their structural capability. The average per TEU on a train is therefore 15.98 tonnes.

[9] 5C-3 Annual Report of the Grain Monitor for 2010-2011, Quorum Corporation, Measure 5C-3

[10] Wheat prices from Western Producer, March 2013; consumer goods prices from NITL resources.

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