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Containerization of Grain: Emergence of a New Supply Chain Market

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Abstract

The containerized shipment of freight continues to grow rapidly. This development can be traced to a transformation of bulk and break-bulk service to containerization. Demand has been driven by opportunities to broaden logistical options as well as advantageous freight rates. Logisticians and policy makers are unsure how much more bulk traffic can be converted to containerization, but the trends are evident. Of particular interest is grain. Bulk grain handlers have successfully resisted the conversion of grain shipping to containerization, except on the North American-Asian traffic lanes and the Australian-Asian traffic lanes where growth has been significant. This paper reviews the theoretical case for grain containerization from a logistics perspective, followed by an examination of the current trends in the United States and Canada. Subsequently, the analysis considers the restrictions and resistance to the conversion of grain from bulk shipping to containerization.

Keywords

Containerization, Grain, Agricultural Logistics, Transportation

1. Introduction

The containerized shipment of freight has grown rapidly in recent years. A portion of this growth can be traced to the containerization of products that previously moved to export markets in bulk or in break-bulk transport. Containers offer opportunities to lower logistics costs and to broaden marketing options. As a result, increasing volumes of grain are being shipped in containers. This raises a fundamental question in the minds of logisticians and policy makers alike: how much more conversion of bulk grain traffic to containers is possible?

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The purpose of this article is to examine where current trends in containerization of grain are leading. The first section of this paper sets out the logistical concepts that support the hypothesis for the modal shift of grain from bulk transport to intermodal ISO containers. This is followed by an examination of current practices in the United States and in Canada. The third section considers the restrictions and resistance to "container conversion" associated with the physical loading constraints of container vessels, the impact on railway efficiency, utilization of port facilities and regulations. The penultimate section compares the theoretical rationale and the practice. The conclusion offers some cautious thoughts on the further conversion of grain from bulk to container movement.

2. Logistics and Economic Theory

Logistics and economics concepts can be used to guide whether or not changes in the organization of supply chains are likely to lead to improved efficiency. In this case, the conventional bulk handling system for grain is compared to the emerging containerized system of grain handling.

Mixed systems are superior to pure systems: The benefits of a mixed system become more obvious the greater the fluctuation in the volumes handled. This leads to the added cost of service required to meet the peak demand. In the Northern Hemisphere, the volume of grain entering the bulk handling system surges as the harvest commences and peaks at the end of the fall months. Volumes then decline, with a few bumps, until the next harvest. While the annual pattern of fluctuation is predictable, the maximum peak demand depends on prices and weather conditions.

The problem for a pure system, like bulk handling, is to be able to serve the peak demand profitably. The more equipment and staff that are allocated to serve the peak, the more capacity is likely to remain idle during the off-peak season. **Figure 1** presents two cases, of (a) a normal peak and (b) an exceptionally larger (bumper) crop year. The economic model illustrates the allocation of railcars under a free market pricing scenario.

The bulk handling system for grain can be characterized as a high fixed-cost, network industry subject to peak load demand. The bulk handling network of railcars, collection points and transfer systems cannot be adjusted quickly to accommodate changes in harvest demand. In **Figure 1(a)**, the peak load demand is accommodated by letting prices rise to allocate the available supply. During the off-peak, prices fall to the point where freight rates cover only short run marginal costs. However, demand may be insufficient to utilize all the available capacity. Consequently, a number of the railcars will sit empty and unused during the off-peak season.

Figure 1(b) illustrates the case when an unusually large crop creates a demand surge. The bid prices for railcars rise much higher, but the demand cannot be satisfied in excess of what the existing infrastructure can accommodate. In this circumstance, some of the peak demand is transferred to the off-peak demand that also shifts

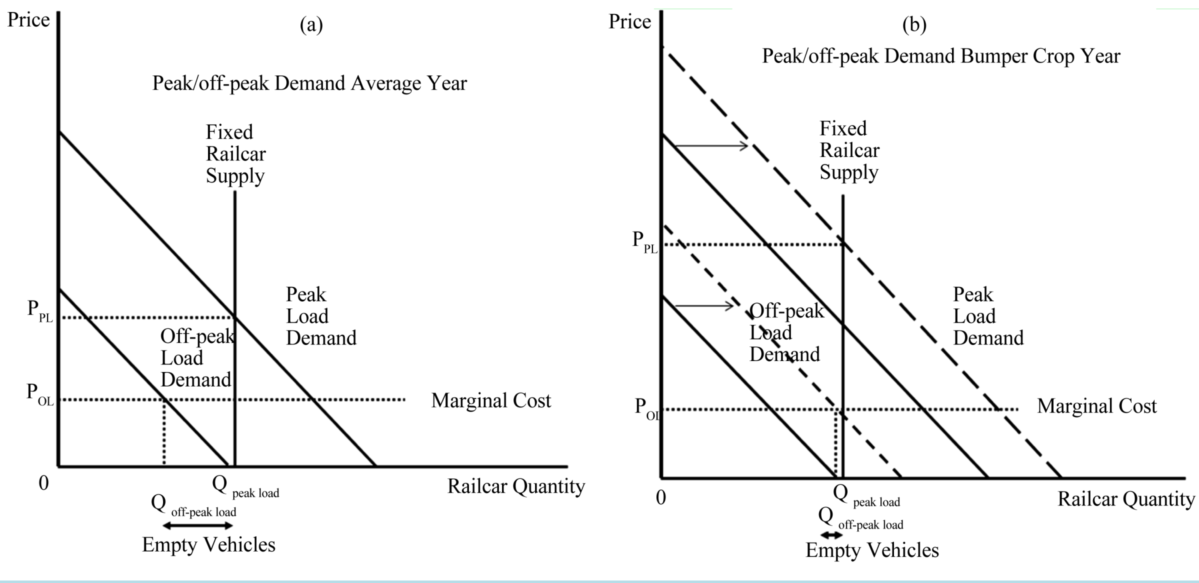


Figure 1. Peak-load demand for covered grain hopper cars.

to the right. Fewer railcars remain empty during the off-peak, but for some shippers the market opportunity may be lost by the time affordable railcars become available.

The problem illustrated by **Figure 1** is that pure systems are negatively affected by instability. In a normal year, the carriers are burdened with excess capacity, while in the event of a large crop shippers face much higher prices during the peak demand period. A mixed system with a containerized option could lower total cost and address the demand surge that occurs immediately after the harvest [1]. Containers would enable the bulk system to achieve higher utilization over the course of the year because when not needed for grain, the containers would be used in other carriage. Containers could also enable the bulk handling system to move large volumes of grain in fewer separations during the peak demand by removing small segregations from the system. In addition, the container mode offers the ability for small lot buyers to source at origin, thereby eliminating in-transit storage and handling costs as well as the overheads and profits taken by mid-stream brokers and grain dealers.

Variety exacts a price: Containerization of grain is not expected to replace the bulk handling system for lower value or generic products. Oilseeds and feed grains do not require segregation to maintain purity because they are going to be further processed in systems that have broad quality tolerances. The principal concern of oilseed crushing plants and cattle feedlots is handling cost. In cases where a bulk handling system can achieve acceptable quality consistency and economies of size, it will continue to dominate.

As buyer sophistication increases and the varietal differences provided by crop breeders expand, the number of products entering the grain handling system is amplified. An example of export crop diversification is the special crops (peas, beans, lentils, etc.) that have emerged. Their shipment size and handling requirements make containers an ideal shipping method.

The bulk handling system begins to lose its cost advantage when segregation becomes important. Increased crop varieties multiply the number of bins required to maintain product integrity. This is illustrated in **Figure 2**. The vertical axis represents the cost of grain bins. The horizontal axis presents the number of grain separations. In terms of volume, economies of size make bulk storage bins less expensive than containers. Bulk grain is transferred and stored at the ports in bins that are approximately 40 feet in diameter, and upwards of 80 feet tall. However, the more that bulk storage is divided up to create separate bins, the more its average cost increases. Bulk storage cost function is depicted as a series of incremental steps, while the average costs of containers are constant regardless of the number employed.

Bulk shipping suffers diseconomies of scope with respect to handling small quantities of crops with specific attributes. Containers assure that specialized products, like pulses and organic wheat, can move with their specific identity intact.

Variety separation presents another case in which a mixed system is better than a pure system. Other agricultural markets operate with "bulk sales" of generic quality at low prices, and segregated sales of precise quality at very high prices. The beverage market (wine and whiskey) operates this way, but this is less common in the grain market. Some notable exceptions are organic wheat, and soybeans for the Japanese noodle production. In these cases the product is containerized. The ability to differentiate the product allows producers to obtain higher prices.

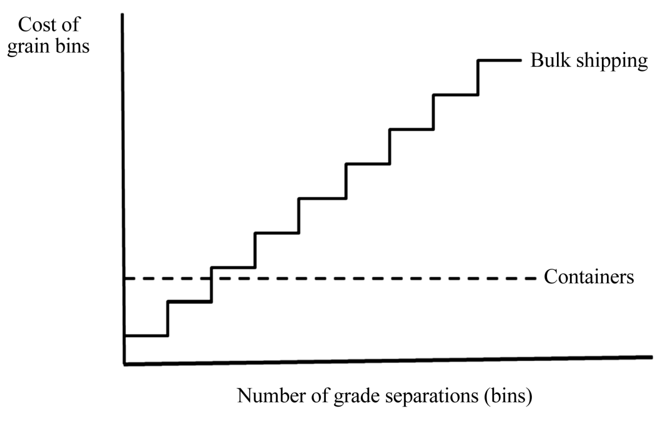


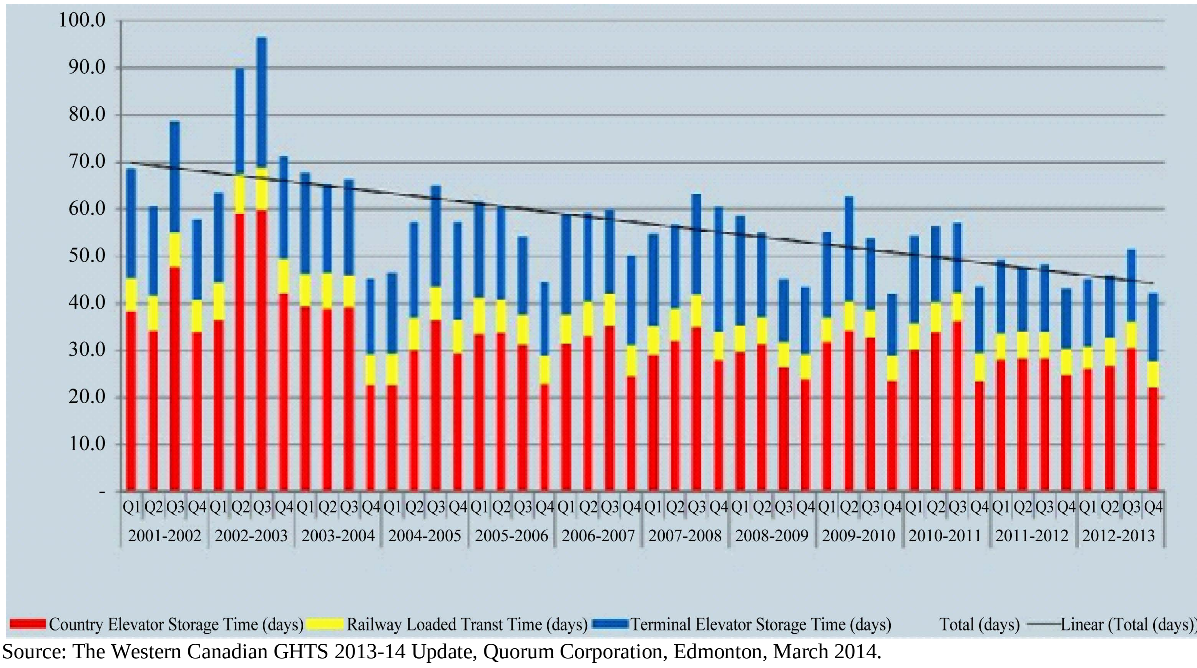
Figure 2. Economies of scope in the handling of multiple grain segregations.

Delayed commitment: Profits can be maximized by shipping products as far as possible before committing to the final product form [2]. This is done in many industries, the most famous being paint that is all shipped white, and tinted after the customer has made a decision to purchase. In the case of grain, the ability to obtain particular milling attributes is lost as soon as the commodity enters the bulk handling system. While it is true that Canadian wheat has a reputation for high average quality, this sometimes comes at the sacrifice of blending very high quality with lesser quality. Some foreign millers might be happier to buy the very best wheat and blend it with their local product to obtain the desired flour quality.

Total costs matter: Many logistical systems fall into the trap of sub-optimization in which too much focus is placed on one cost component at the expense of the total movement cost. For example, shippers that compare only the costs of bulk shipping to containers could easily conclude that the latter can never compete, except perhaps in backhaul traffic lanes. However, the costs of storage, handling, inventory carrying costs and product damage associated with bulk handling need to be considered as part of the total logistics package. This is especially true for small lot buyers that have to go through intermediaries or purchase storage for larger quantities than they wish. With containers, small lot purchasers have the opportunity to buy at source as opposed to a local broker where the broker's storage, overhead and profits get added to the price.

Lean thinking: The recognition that inventory in excess of immediate needs is a waste, led to Just-in-time logistics systems. Bulk handling systems have large pipeline inventories because these quantities are required to load unit trains and bulk ships. In Canada and the US, grain storage at country elevators and port terminals duplicates storage that exists on farms. Moreover grain can be held in these commercial storages for relatively long periods. **Figure 3** presents data for the Canadian bulk handling system. While the system has improved over this 12 year period, grain remains in commercial storage and transit for up to 50 days before export. Containers move more quickly through the logistical system meaning that less inventory in-transit needs to be financed [3]. The 10 days that bulk grain is in transit by rail is likely greater than the total time for a container shipment from farms to the port.

Quality Counts: Given two options in which one method risks the reduction in quality of the shipment, the higher quality transport will generally earn a premium. For certain commodities such as peas and lentils, the bulk handling system has indirect costs that containerization avoids. Continuous handling causes breakage that opens the commodity to quality deterioration and insect damage. Delicate products require handling on "flat belts" or in bags. Containerization eliminates damage that significantly reduces the products value or makes it potentially unsalable.



Source: The Western Canadian GHTS 2013-14 Update, Quorum Corporation, Edmonton, March 2014.

Figure 3. Average days spent in-transit by grain in the Canadian bulk handling system by quarter 2001-2 to 2012-13.

Taken more broadly, the reduction of risk can also mean avoidance of inadvertent blending. As the ability to detect small percentages of genetic attributes improves, the risk of detecting cargo cross-contamination increases. Although the numbers of refused cargoes because of GMOs or other variety mixing is small, containers guarantee that the product is traceable from origin to destination.

3. Containerization in Practice

Containerization of freight is the favored means of logistics for 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. When the containerization of grain was discussed 15 years ago, the largest container ship was in the 4500 TEU range. Such ships now seem mid-sized, 8000 TEU vessels are common, and ships as large as 18,000 TEUs are entering service.

Economies of size in ocean shipping depend on vessel utilization. A downturn in economic growth since 2009, combined with an increasing amount of capacity from newly built vessels has left the shipping lines with excess slots to fill. Consequently, 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 overseas buyers [4].

The examination of grain containerization practice is divided between the United States and Canada. Although the rail and port facilities are comparable in the two countries, differences in crop production, container traffic patterns and economic regulation affect the containerized grain supply chain (CGSC).

3.1. United States CGSC

Prior to 2003, containers were mainly restricted to specialty crops, which would not fill a hold in a ship, and feed ingredients like corn gluten meal, bone and meat meal The containerization of grain in the US began to pick up significantly in 2004 because of the spread that emerged between backhaul container rates and bulk shipping. The rates for bulk shipping increased because of the strong demand for scrap metal.

The North American consumer demand for imported Asia Pacific manufactured goods also surged between 2003 and 2008. Consequently, freight rates for containers on the westbound traffic lanes fell as the volume of empty containers returning to Asia became excessive. During this period, grain could be shipped in containers from Chicago at $35/40 per ton, while bulk rates for grain at the Gulf of Mexico were $60/70 per ton. This provided the incentive for commercial bulk grain shippers to beginarbitraging the freight and movinggrain exports in containers.

The Baltic Exchange Panamax Index (BPI), shown in **Figure 4**, is a standard indicator of bulk shipping rates worldwide. Driven by the comparative shortage of bulk vessels in the face of the growing demands imposed by a vibrant Chinese economy, prices shot to all-time highs. From late 2003 through to the autumn of 2008, bulk ocean shipping rates, as represented by the BPI, climbed by over 400%. 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.

The current state of grain containerization in the United States is observed in the USDA AMS report: "In 2013, containers were used to transport 10 percent of total US waterborne grain exports, up 2 percentage points from 2012. Approximately 61 percent of US waterborne grain exports in 2013 went to Asia, of which 16 percent were moved in containers. Asia is the top destination for US containerized grain exports—97 percent in 2013." [5] This growth continued in 2014, although reduced by congestion and labor disruption on the US west coast. There has also been a GMO-related dispute between China and the US regarding a corn variety, but this has now ended. China, Taiwan, Vietnam and Indonesia account for about two-thirds of these shipments, but their individual shares vary by month.

Grain is transloaded into containers on the east and west coasts of the United States and at a few interior collection points where excess empty containers accumulate. A site visit to Chicago in 2012 revealed that three facilities accept truckloads of corn, soybeans and dry distillers grains (DDG—derived from ethanol plants) for trans-loading into containers. Two of the transloaders are located adjacent to the CenterPoint Intermodal Centre container port, while the third is located at the CN container yard.

DDGs account for about half the grain exported in containers from the United States. This is explained by the

Figure 4. Baltic Exchange Panamax Index: December 2000-January 2015.

surplus of DDG production arising from the ethanol fuel mandate and the difficulty of shipping DDG in bulk. Soybeans are the next largest containerized export at 24 percent. The balance of containerized grain exports in 2014 were corn (8 percent), animal feed (6 percent), residues of starch manufacturing (4 percent), and other crops (8 percent) [5].

Aside from the movement of identity preserved products, like soybeans for Japan and some special crops, containerization is treated as a substitute for bulk shipping. DDG, corn and soybeans are transloaded into containers without liners, and shipped. Some concern is expressed about the potential for cross-contamination from prior shipments in the containers, but when the end use is livestock feed, and the amount of potential contamination is small in any case, the risk is considered to be minimal.

The motive for using containers is almost universally identified as improved logistical economics. During the boom years prior to the recession of 2009, the gap between available backhaul container rates and bulk shipping attracted increasing volumes. Since 2009, bulk shipping rates have collapsed and the container lines have become more alert to any price differences. Grain in containers must compete with waste paper, scrap metal and on the west coast lumber and logs. Grain may be more valuable, but these other commodities can be forced to pay more because they have no competition from bulk shipping.

When asked whether foreign receivers are willing to pay a premium for higher quality received in containers, the answer of the transloaders is "generally no". Buyers acknowledge that quality is better, and they like this aspect of containers. They are willing to pay a small premium for containers of certain products (e.g. Number 1 Soybeans), but not for ordinary grain.

The places where containerization works best, in terms of source-loading inland, is at gateway locations where surplus empty backhaul containers accumulate, notably Chicago, but containers also compete with conventional bulk at Memphis and Kansas City. Most grain transloaders are located at the ports. Inland shippers away from the gateways that would like to source a container have to pay a premium price for repositioning containers to their locations.

Inbound merchandise transloading practices encourage the loading of grain in containers at the ports. Asian import logistics costs can be reduced by transloading sea containers into 53-foot domestic containers, or 53-foot tractor-trailers, at the North American Pacific coast for shipment to inland distribution warehouses. The ratios are significant because the lading from three forty-foot or six twenty-foot containers can be moved in two 53 foot domestic units (subject to product density). As a result, more sea containers remain at the coast. This reinforces the logic of moving grain in bulk to the coast for transloading into containers.

In 2012, the Union Pacific (UP) railroad initiated a new "Plant-to-Port" transload service for grain and grain products at a facility in Yermo, California. A unit train of grain is moved to the transloading facility where it is met with a unit train of empty containers from the Port of Los Angeles. After transloading, the containers are returned to the port for export shipment. Rates include rail shipment, transloading to a 40-foot container, intermodal loading and transport to the Ports of Los Angeles or Long Beach. In the case of the DDGs, rates also include USDA inspection. However, shipments must be made in unit train quantities of 80 or 100 carloads with a maximum average loading weight of 96 tons per covered hopper car.

The competition between source-loading at Chicago, or sending unit trains to the UP facility is a question of backhaul rates. The Chicago transloaders retained a rate advantage in 2013 because container backhaul rates are lower than the equivalent hopper car tariff. Smaller lot shippers would also favor source loading of containers at Chicago.

3.2. Canada: GCSC

Canadian experience with the containerization of grain is different than the US in several respects. While cereal grains (wheat and barley) and canola make up almost 80% of the export market, in an effort to diversify, Western Canadian farmers have embraced new field crops like red and green lentils, yellow peas, mustard and canary seed. From small beginnings these "special crops" have grown to represent almost 20% of the crop mix with cleaning and processing plants appearing across the Prairies. This has led to increased agricultural research directed at developing broader varieties with higher production yields. As a result the seeded area of these crops now averages 5 million to 7 million acres annually in Saskatchewan alone.

Institutional arrangements are also different in Canada. Until the 2012/13 crop year, cereal crop exports, which represent over 60% of Canadian production, were under the monopoly control of the Canadian Wheat Board (CWB). The CWB focused on large customers and bulk shipping. While the CWB would deliver in containers on the customer's request, this was not a marketing practice that they actively promoted. The situation was similar in Australia, until 2007 when the power of the Australian Wheat Board (AWB) to license wheat exports in containers as removed. Since 2007, Australian wheat exports in containers have grown from 500,000 tons to 2.7 million tons by 2012 [6].

The rise in bulk ocean freight rates in the 2005-2009 period drove the conversion of bulk grain shipments 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 in Canada under three different scenarios. In each, all costs remain constant with the exception of the ocean freight:

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

Bulk Freight Mode	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	2.4	7.5	22.5
Cost per Tonne	65.01	70.11	85.11
Ocean Freight Differentials			
Rate/Day	8000	25,000	75,000
Transit Time (Days)	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

- Scenario A portrays ocean freight when the Baltic Exchange Panamax Index (BPI) 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 BPI 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 BPI 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 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. Between 2005 and 2008 container rates fell while bulk rates rose. This figured heavily in the subsequent decisions made by grain logisticians.

- 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 is 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.

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, and in particular, pulses. 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.

Figure 5 presents grain export data for Port Metro Vancouver (PVM) by mode of transport from 2000 to 2014. Containerization's share varied between 9 and 19 percent in the first decade. The percentage of grain exports in containers through PMV has varied, but the total volumes have gradually increased. This is consistent

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

	Scenario D	Scenario E	Scenario F
Drayage in Country	240	240	240
Inland Terminal Fee	-	150	150
Rail to Port	400	600	600
Port Terminal Fee	125	125	125
Ocean Freight	800	1000.00	1200.00
Cost/TEU	1565.00	2115.00	2315.00
Cost/Tonne	68.04	91.96	100.65

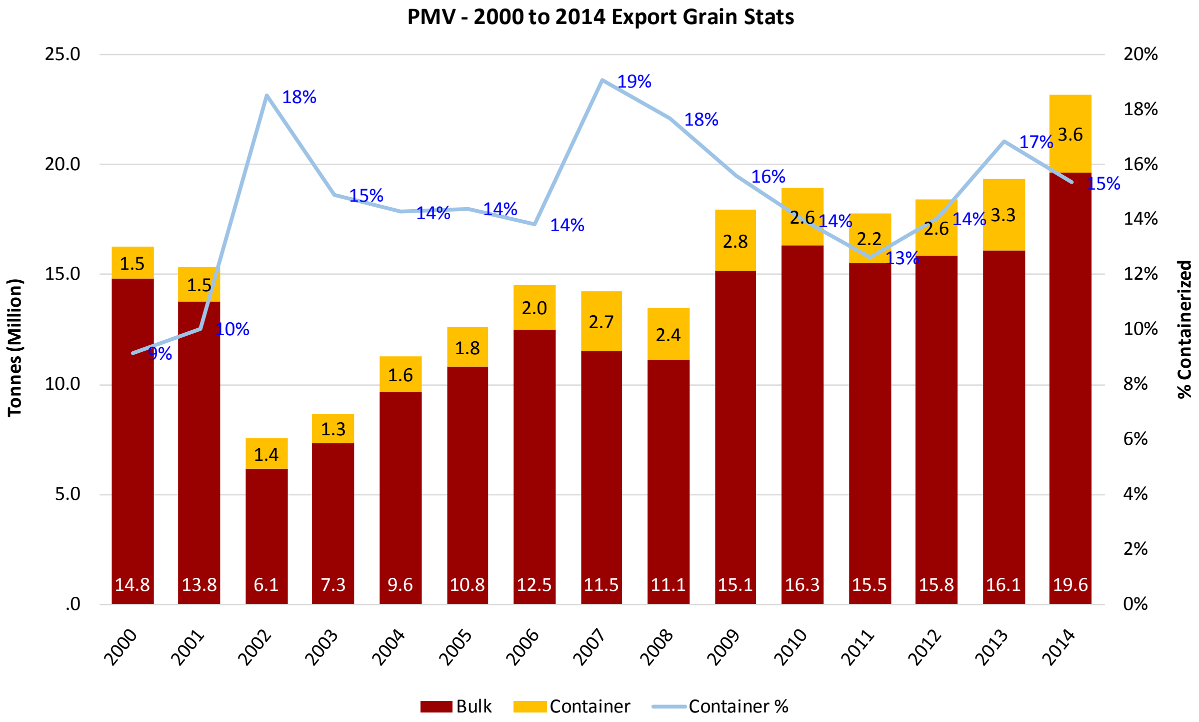


Figure 5. Grain exports via Vancouver, BC: Containerized versus bulk, 2000-2014.

with the comments of transloaders in the United States who observe that the shipping lines now price backhaul container rates for grain with an eye to bulk shipping rates.

Many Canadian special crops, e.g. peas, mustard, etc., can go in bulk to the large importers using "soft handling" technology, which refers to the use of flat belts and maximum dropping distances. Special crops shipments through PVM are reported for both bulk and container exports. **Figure 6** presents the data for the years 2000 to 2014. Containerized shipping increased significantly during the years when bulk shipping rates were rising rapidly. Following the recession when bulk shipping rates fell dramatically, the shares in containers and bulk reversed, but appears to on the rise again.

4. Restraints on the Containerization of Grain

A number of additional barriers to a large scale conversion of grain to containerized movements are identified by industry stakeholders.

Inspection and Documentation Costs: Transactions costs are an important advantage for bulk handling. A 10,000 ton shipment requires the same amount of paperwork (letter of credit, B13, ocean bill of lading) as a single container. When the bulk rates are less per ton than shipping in containers, the economics favor large shipments that are split up at destination. When the bulk rates move up, container shipping increases because so many more buyers become accessible.

The increase in the number of buyers intensifies competition. A bulk shipment in a Panamax ship may be handled by 5 or 6 large import buyers, who split up the cargo to supply many smaller domestic buyers. When the product goes in containers, the number of buyers available expands to hundreds. This creates opportunities to establish niche markets and form new loyalties.

Inspection and grading costs, like the costs of transactions, favor conventional bulk handling. Grading is redundant for containerized grain because it is never mixed and can be traced back to its origin. The reason for grading is generally a case of the buyer and seller wishing a third party to adjudicate the quality. Depending on the number of containers, the inspections in Canada cost approximately $100 for 3.5 containers. In the US, the inspection fees are $1.50 to $2 per ton. This is about 10 times more than the equivalent inspection costs for bulk shipping.

Cargo Density Considerations: The most significant driving factor in the loading of bulk commodities into

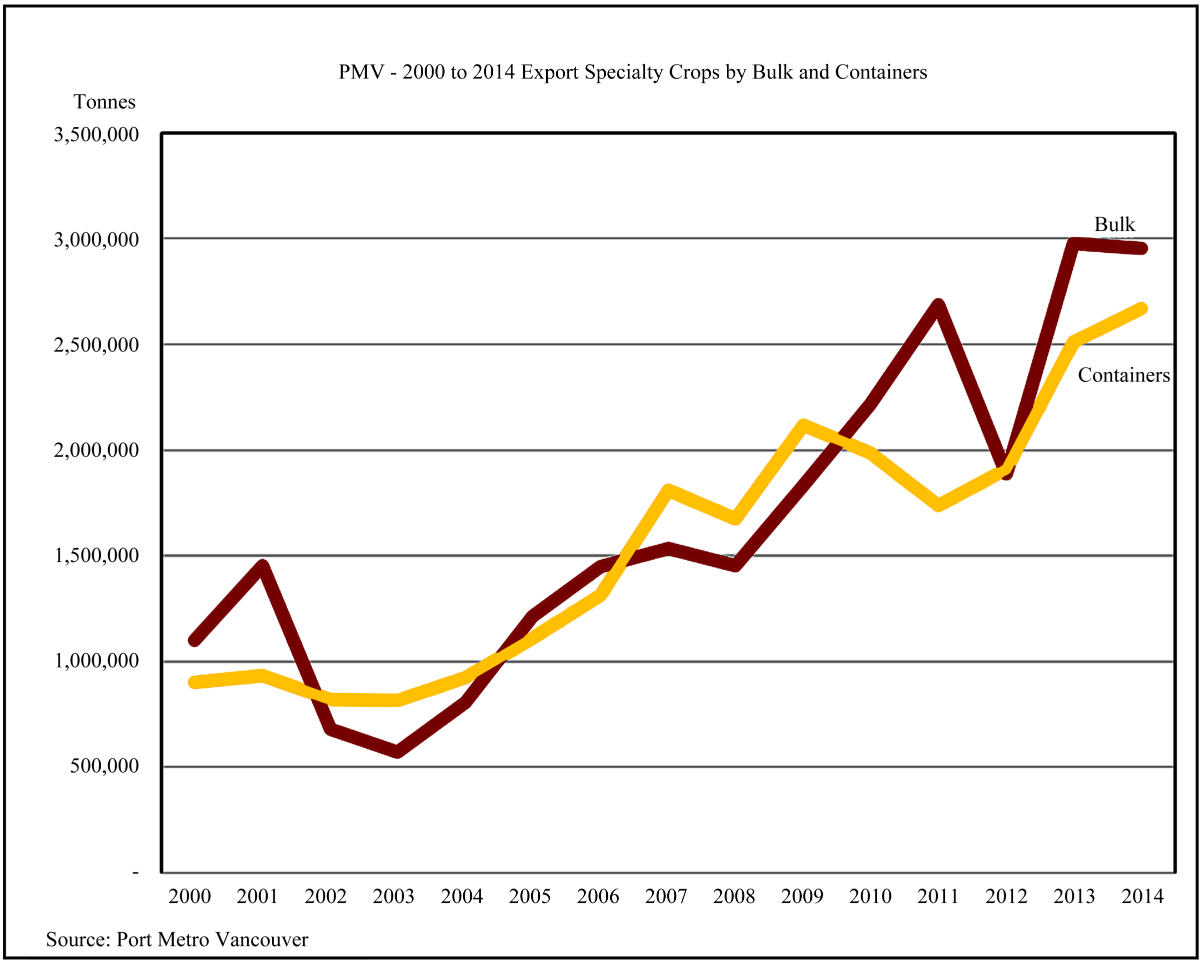


Figure 6. Exports of special crops by container and in bulk, via Vancouver: 2000-2014.

ocean containers is the loading capability of the container vessels themselves. The operational requirements of any transportation service provider dictates 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 container vessel operators is to make each ocean crossing with as many containers as possible, preferably filling 100% of the vessel's container slots.

A typical 5000 TEU container vessel has a maximum gross carrying capacity of approximately 49,000 tonnes, or approximately 9.8 - 10.5 tonnes per TEU. This is a function of the vessel's buoyancy and carrying capability. This was confirmed in a review of the ten largest container vessels in the global fleet. 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 (pcf).

The challenge with loading bulk commodities into containers is that their densities are greater than the average lading threshold capability of 14.3 pcf. To use industry vernacular, a container ship of grain would "weigh-out" before it "cubed-out".

A standard twenty foot container typically accommodates about 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 5000-TEU container ship is available to load, then the weight profile of these loaded containers would only permit 2140 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 5000-TEU Vessel:

Vessel's Net Tonnage: NT = 49,226 tonnes

Vessel's Container Capacity (TEUs): T = 5000 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 tonnes/23 tonnes) = 2140 loaded wheat containers

b) Load factor per container ship:

LF = (MC/T) = (2140/5000) = 0.428

c) Empty-to-loaded container ratio:

ELR = ((T − MC)/MC) = ((5000 − 2140)/2140) = (2860/2140) = 1.336

A review of actual inbound and outbound container weights was undertaken using Port Metro Vancouver statistics. The movements depicted in **Table 3** 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, an increase in volumes of the latter would diminish the number of slots a vessel could make available for back-haul movements of grain.

Discussions with container terminal personnel indicated that, in practice, container lines 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 places 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.

Country and port terminal asset investments: 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. Grain companies, railways, and the government have made significant capital investments in bulk handling infrastructure, estimated to exceed $5 billion in Canada. This includes the country and port terminal network, the hopper car fleet, and the processes that allow them to function.

It is crucial that the utilization of that space be managed in the most efficient and effective manner possible [7]. While it could be possible to convert or adapt these facilities to load containers, it could reduce their utilization for bulk movements. Certainly, thesunk investment in bulk handling facilities could be the largest single financial barrier to the conversion of exports into containers.

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, a typical container or bulk grain train with a length of 6000 feet has a considerable difference in the amount of lading each is able to carry. A container train could carry approximately 450 TEUs with an average lading weight of approximately 15.9 tonnes each, or a total of 7800 tonnes per train. A bulk grain train can carry in excess of 10,300 tonnes, some 32% more. This differential implies that the average per-tonne cost for

Table 3. Actual container traffic—Port Metro Vancouver (2009-2011).

	2010	2011	2012	3 Yr Avg.
Inbound				
Tonnes	8,695,938	8,782,564	9,626,431	9,034,978
TEU's	1,296,946	1,320,610	1,451,309	1,356,288
Tonnes/TEU	6.70	6.65	6.63	6.66
Outbound				
Tonnes	12,232,135	12,892,052	13,396,225	12,840,137
TEU's	1,217,363	1,186,422	1,261,852	1,221,879
Tonnes/TEU	10.05	10.87	10.62	10.51

moving grain in containers is higher than that of moving it in bulk, but of course this does not consider the railways round-trip revenues. All covered hopper cars return empty to the inland origin, while containers are more likely to carry freight in both directions.

Source-loading of containers in Western Canada is more expensive than transloading at the port of Vancouver because of the empty container repositioning charges. Although shippers prefer to load at source because of greater control over damage, security, etc. the costs are unfavorable [8]. This is explained mainly by freight rate regulations that discourage containerization.

Canadian Transportation Regulations: The Government of Canada has interceded in the rail transport of grain since the Crow's Nest Pass freight rates came into effect in 1897. In 1926, these fixed rates per ton-mile were extended to all rail carriers and made statutory. After 50 years, the Statutory Freight Rates were deemed non-compensatory and railways were faced with the significant challenge of renewing plant and resources. Consequently, the rate structure was replaced by a subsidized maximum freight rate under the *Western Grain Transportation Act* in 1984 [9]. Finally the grain transportation subsidy was abolished in 1995, and for five years farmers paid a regulated maximum freight rate. In 2001, the Maximum Grain Revenue Entitlement (MRE) [10] was introduced for Canadian National (CN) and Canadian Pacific (CP) railways to replace maximum freight rate regulation. Under the MRE formula, the railways are allowed flexibility in pricing, with a limitation on total revenues. The MRE is subject to an annual increase in the average rate per tonne through the calculation of an index of input price changes that relates specifically to the rail industry.

When the MRE was established in 2001, railway revenues were based on a costing review completed in 1992 when no grain was moving in containers. This original cost base was adjusted in 1999 in anticipation of the implementation of the MRE in 2001. The revenues and volumes of grain moved in containers are included with the bulk grain volumes and revenues.

The situation is confusing, and data are not publically available to determine the degree that the MRE may discriminate against containerization in favor of bulk shipping. The railways' costs are higher for container movements so the rates charged for container movements must be higher, too. As a consequence, this could have an impact on how the railways choose to price movements in containers and allocate equipment to this type of movement.

5. Reconciling Theory and Practice

Total Costs Matter according to theory, but in practice it appears that only the differential of costs between bulk and container shipping rates is necessary to shift grain from one mode to the other. Quality is appreciated, but the driver is price. With the world population at 7 billion, *One Size Fits All* is apparently the case for the majority of the international grain trade. Better quality is nice, but the marketplace may not be willing to pay higher logistical costs for the sake of quality.

The impetus for the conversion from bulk to containerization was largely initiated by an aberration in bulk shipping rates in the period between 2005 and 2008. This was not necessarily a negative event, because it provided a much needed boost for some commodities, such as pulse crops, to gain a foothold in the global market place. If the containerization of grain has passed a "tipping point", then its share could grow could again grow at the expense of conventional bulk, once bulk ocean shipping rates recover again.

To the extent that premiums for quality are available, the driver is risk. US grain shippers note that they can receive 10 to 20 percent price premiums over Brazilian soybeans because the grading and inspection system guarantees better quality perception. High food grade soybeans put through the conventional bulk system can be mixed with lower grade soybeans. Consequently, food grade soybeans are shipped in containers. This same scenario can be seen with the marketing of Canadian wheat, which is recognized for its superior milling quality.

Delayed Commitment can forge new traffic patterns. In China, the containerization of feed is a means of addressing two problems. Space for intensive livestock production is becoming scarce at the coastal provinces. This is increasing the desire to move inland. At the same time, Chinese manufacturers want to move production to the interior provinces where labor is less expensive. The manufacturers need empty containers to ship out exports and the inbound delivery of feed in containers solves their repositioning problem. This could make feed a backhaul shipment all the way from the interior of North America to the interior of China.

Variety exacts its price, but the documentation and inspection costs are more for containers than the conventional bulk supply chain. This may also apply to traceability. In Canada, the system of Kernel Visual Distinguishability for wheat has been replaced by a certificate system. The certificate system seems to be operationally successful in the bulk system. For bagged products, and small volume shipments like organic wheat however, containers offer lower overall logistics costs. This also applies to feed ingredients. DDGs are described as dusty, smelly and in volumes too small to fill a ship's hold. Ultimately it is the buyers' terms and level of risk tolerance that will determine the value these systems will derive from the market.

While the factors described above will place a ceiling on the growth of containerization for grain, there are 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.

Mixed systems are superior to pure systems. The availability of empty backhaul containers presents an opportunity to lower the total cost of moving grain to some export markets as well as gaining access to smaller, niche markets. Where empty containers are in surplus at inland locations, they are used, even if they just substitute for conventional bulk shipments of corn and soybeans. Where containers are available for backhaul loads at the ports, the railways move bulk hopper cars of grain to the coasts for transloading in containers. At this point, neither the buyers, nor the sellers may be maximizing the full benefits of containerization, but they are certainly seizing the opportunities to save money.

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.

6. Future of Grain Containerization

A considerable amount of discussion has been dedicated to the potential conversion of bulk resource and agricultural exports to containers. It is argued that grain products could be readily 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 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 empty return movement they incur on each trip.

Has the containerization of grain reached a point of maturity and will now be characterized by slow growth, or is a rise to a new level of container use only waiting for the next cycle of high bulk shipping rates to trigger increasing volumes?

No definitive answer is possible at this time. The success of grain containerization is highly dependent on backhaul freight rates, which is why shipments to Asia account for most of the volume. Container shipments to Europe, South America and Africa are generally only made for special crops that require higher quality handling. However the direct substitution of conventional bulk for bulk in containers suggests that only the differential in shipping rates restricts the use of more containers.

The conventional bulk handling system is very mature. While some extra efficiency might yet be found, it is difficult to improve on unit trains and existing material handling systems. To the extent that improvements are possible in the bulk handling system, the capital barriers are significant. In contrast, the barrier to entry for transloading containers is low. The technology is simple and an efficient scale is easily reached. Any significant profit incentive is going to attract new entrants and more locations for transloading containers.

There has been a significant shift away from the break bulk shipping practices of old in favor of containers and more recently, bulk shippers are viewing containers as an option to meet certain logistical demands and efficiencies. The average size of container ships is continuing to grow and the absolute size may not yet have been reached. While bulk freighters enjoy economies of size, the diseconomies of inventory holding may auger against larger shipments in some markets. The availability of low cost communications and lean logistics practices favor the just-in-time inventory management strategies that containerization offers. At the present time, the higher unit costs of transactions and inspections of containerized grain give the bulk handling system some protection. It seems only a matter of time however, before a new transaction system is developed for containerized grain that reduces these costs.

Traceability and identity preservation are desirable marketing features that are difficult for bulk handling systems to guarantee. Containerization provides a form of quality assurance at only a marginally higher cost and the product is not re-handled until it reaches the import buyer. This makes milling wheat a desirable commodity for containerization when the buyer is looking for certain quality attributes such as seed variety, gluten and protein content. It is noted that Australia saw an upsurge in the volume of wheat moving in containers shortly after the removal of their monopoly marketing board as smaller niche markets became open to them. It is conceivable that Canadian wheat exports could follow a similar path now that the monopoly powers of the CWB have been removed.

As global demands place increased importance on traceability and security of the entire food chain, the necessity for guarding and preserving the identity of grain used in the human food chain may become critical. Containerization of grain products from North American markets can provide the kind of protection within the supply chain that global buyers of the future will strive for and will likely result in an increased demand for the use of this mode.

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