Re-engineering Grain Logistics: Bulk Handling versus Containerization

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Introduction

A logistics process is a sequence of value-adding activities that puts the right product in the right place at the right time. The best logistics process is the one that achieves this mission at the least total cost, and maximum customer value. Any logistical process that has been in place for some time is a likely candidate for re-engineering.

Re-engineering a logistical process involves radical redesign and the use of technology to achieve a quantum improvement in supply chain performance. This paper explores the opportunity to re-engineer the logistics of the grain handling system. The first section sets out the historic development of the current bulk handling system. This is followed by a discussion of the economic advantages and disadvantages of bulk handling, and the role of the grading system. Subsequently, the analysis examines five principals of logistics that make the containerization of grain a competitive alternative. The paper concludes with a discussion of a new institutional framework (electronic markets) that would facilitate the re-engineering of the grain trade.

Re-engineering Grain Handling in the 19th Century

Before 1850, most grain was marketed in sacks and depended almost entirely on water transport. Sacks had certain advantages given the logistics of the period. Sacks of grain could fit into the awkward spaces of the river boats and could be carried on a man's shoulder across gang planks, down a set of stairs and along narrow corridors. The disadvantages of sacks were equally compelling. Handling was very labour-intensive and consequently expensive. There were few opportunities for economies of size and the water routes were circuitous and slow.

Marketing grain in sacks incurred high transactions costs. No buyer would purchase grain sight unseen. This meant that each lot of sacks had to be kept separately, with a corresponding paper trail. All risk of physical loss, as well as the risk of a price change, was borne by the shipper. Consequently, freight insurance was a major cost associated with handling grain in sacks (Cronon, 1991).

Re-engineering of grain handling in the 1850s was caused by technological and institutional changes that accompanied the invention of the telegraph (1844) and the expansion of the railway. The speed of oncoming trains had to be very slow with a manual system to signal an approaching train. The speed of the telegraph signals enabled the trains to run faster and safer (Yates, 1989; Lubrano, 1997). This encouraged the building of rail lines over longer distances and increased their competitiveness for freight. Only 2,800 miles of railway track had been built by 1840. The railway network expanded to 9,000 miles within six years of Samuel Morse's invention.

A method of handling grain in bulk was demonstrated by Joseph Dart at Buffalo, NY, in 1842. The railways were early promoters of bulk handling[1] because it reduced their labour costs and sped up the loading of railcars. Lack of an accepted grading system impeded bulk handling of grain. As long as ownership and value were distinguished by individual lots of grain, commingling was impossible. The first grading system for grain was introduced in 1856 by the Chicago Board of Trade. The ability to mix lots into a fungible commodity eliminated the need for buyers and sellers to be in physical proximity to the product, or to each other, when conducting their transactions.

The superior speed and lower cost of the railway would have increased bulk transport in any case, but the impact of the telegraph on transactions costs, sealed the fate of traditional grain handling. Information about prices, quality and quantity moved at the same speed as the transport of goods prior to the telegraph. The advent of "electronic" communications linked prices between surplus and deficit regions. This greatly reduced the marketing risk of shippers and enabled buyers to purchase when price was most advantageous.

Bulk handling, grading standards and the telegraph were the prerequisites for a commodity futures exchange. The futures market came into being over the period 1853-65. Once established, traders could make transaction decisions in remote markets based on telegraph quotes of price and grade. Telegraph-enabled buyers and sellers could hedge their transactions risk by committing to firm prices for future delivery.

The grain handling system in North America was well on its way to being completely re-engineered by the end of the American Civil War. Sacks were still used (especially for the movement from farm to country elevator) but the superiority of bulk movements was evident. The costs of trading and transporting grain from the interior of the continent fell dramatically and the volume of trade[1] increased exponentially. This opened the settlement of the great plains, and ultimately, the prairies of western Canada.

Economics of Bulk Handling Systems for Grain

The cost advantages of bulk handling stem from automation and economies of size. Mechanizing grain loading and unloading has continued to increase labour productivity with every new generation of elevator. Economies of country elevator size are determined by the costs of collecting grain from more distant farms, the density of production and the number of competing facilities.

The economies of size in movement are associated with equipment utilization and labour savings. Covered hopper cars, which are faster to load and unload, decrease car turn around time and improve railway asset utilization. The efficiency of bulk rail handling can be further improved by increasing the number of hopper cars assembled at bulk loading sites. The ultimate efficiency in bulk handling is a unit train (104 cars) that has one pickup and one delivery. Ocean transport is subject to similar economic considerations. Larger ships with lower per-unit at-sea operating costs dominate marine transport except where port access limits service[1].

Savings in packaging costs is a further important advantage of bulk handling. No packages are needed in bulk shipments because the product takes the shape of the shipping vehicle. Hence, a double benefit: avoidance of the costs of packaging and the cost of shipping the package.

The disadvantages of bulk handling are related to quality and inventory costs. Handling grain repeatedly damages its inherent quality. Physical handling splits some kernels and abrades the seed coat. It also creates the potential for dangerous dust explosions. The necessary dust control measures at warehousing and loading facilities add to the cost of bulk handling.

Commingling grain creates an average quality product based on the lowest common denominator specified in the grading system. This leaves no incentive for quality improvement. If the grading standard calls for one percent foreign matter, no less will be provided. In fact, grain companies add back dockage to meet the maximum grade allowance.

Bulk handling systems tend to have empty backhauls. The specialized design of bulk handling equipment makes it difficult to move products in both directions. Terminal elevators are designed to load grain to export, not to receive imports. Most grain hopper cars return empty to the country elevators. The bulk ships often arrive at the port in ballast. All the transportation and handling costs of the bulk system must be paid by the fronthaul shipper. Moreover, all the operating costs must be paid by the single commodity. If the shipping pattern is subject to seasonal fluctuation, the commodity shippers will have to cover the costs of idle capacity during the “off-season”.

The lower unit costs of bulk transportation are traded off against the higher costs of financing and storing large pipeline inventories. A 45,000 tonne grain ship needs at least this quantity of the correct grade(s) assembled at the port. Any delay in assembling sufficient inventories can lead to large demurrage charges.

The cost of financing pipeline inventories depends on the velocity of marketing. The slower the inventory turnover, the higher the holding costs. Risk of physical loss due to spoilage and pests increases the longer grain sits in the pipeline.

The advantages of bulk movements stem from the economies of size in handling and transportation. These savings are traded-off against the losses in product quality and higher costs for inventory and storage. The direct, or "visible" costs of bulk handling have determined its dominance. The indirect, or intangible cost trade-offs, however, are becoming increasingly important. The negative impacts on marketing are subtle. The key to these impacts is the grading system.

Economics of Grading Systems for Grain

The grading system was developed when information was expensive to collect and costly to transmit. The information pertaining to the quality attributes of grain could be reduced to a single code (e.g.1CRSW). Grade classifications lowered transactions costs when telegraph messages were charged by the word[1].

The grading system created a fungible commodity that reduced clerical work. There was no need to keep paper records of each lot, with multiple carbon copies filed and stored. A simple warehouse receipt with a grade specification was all the paper documentation needed to claim and exchange ownership. Grading reduced the effort and increased the speed of order processing.

The communication benefits of grade classification has evaporated now that voluminous information can be stored electronically and transmitted at negligible cost. The Internet makes it as cheap to send the contents of an encyclopedia across the ocean as it is to mail a letter across the street.

The clerical benefits of grading have also diminished as computer technology has advanced. Electronic Data Interchange (EDI) and bar codes have revolutionized information processing. Customs have electronic clearance procedures in which no paper documents are required. Just-in-time manufacturers use EDI to issue orders, receive and process purchases and make financial settlement without human intervention. Bar codes are used to sort and track millions of individual courier envelopes on a global scale. The difference in processing cost between one large order and a thousand small orders has become inconsequential.

Grading systems have opportunity costs. Market prices of grain adjust to the lowest common quality dominator. Blending better quality grain with lower quality product is a commonly accepted practice. This may raise the value of the lower quality grain, but it denies the benefit to the producer of higher quality grain. The benefits of superior quality are lost through commingling, or captured by grain handlers.

Consistent quality has become more important as food processors have become more sophisticated. The quality attributes identified in grading systems are becoming less relevant. Millers observe that grain varieties of the same grade react differently. Processors are required to adjust their formulas continuously to compensate to differences in the "average" quality. The benefits of "consistent" quality are lost through commingling varieties. Some buyers are beginning to request specific grain varieties to minimize the variances in the grade classification.

Strategic Concepts of Logistics for Re-engineering

Innovations in transportation and communications create opportunities for developing improved logistical systems. The alternative to handling grain in bulk is to ship grain in ISO containers. Containers can be loaded at the farm, or at a consolidation facility, e.g., a country elevator. Containers can be trucked to double-stack train terminals, and forwarded to marine container ports. Grain in containers moves with other containerized cargo to foreign buyers. As a result, containerized grain faces only the marginal costs of the intermodal shipping system, rather than the full costs of the bulk handling system.

A key problem in re-engineering logistical systems is to escape entrenched ideas. Logistical theory has developed strategic concepts that are useful in assessing the prospects for re-engineering marketing channels (Ballou, 1992). Five strategic concepts of logistics theory are used to argue why the grain handling system should be re-engineered to move grain in containers.

Mixed systems are superior to pure systems.

A mixed system is always superior if the process is subject to fluctuating volumes. The low utilization of the fixed capacity during the off-season can make it less expensive to use an alternative that has variable capacity. This is the argument for using public warehousing to supplement a private warehouse during a peak sales period. It is less expensive to use a small private warehouse at full capacity all year, and hire public warehousing as needed. Rather than incurring the cost of a large private warehouse that is only used at capacity for a very short time, total cost of a mixed system is less.

Congestion cost theory supports the principal that mixed systems are superior. As increasing volumes are forced through any fixed capacity, congestion will lead to diminishing returns. Congestion can be reduced by expanding capacity, or by shifting some activity to an alternative system. The marginal costs of shifting peak volumes to the container system are much lower than adding new capacity to the bulk handling system.

Variety exacts its price.

The greater the variety of products in a logistical system, the higher the inventories necessary to maintain customer service. Product variety increases pipeline inventories. This raises the logistical costs for storage and financing inventories. Greater variety also lowers the average shipment size. Assuming the same volume of demand, dividing the product into more classifications produces smaller shipments.

Variety is the soft underbelly of the bulk handling system for grain (Prentice and Craven, 1980). The more products that the bulk system has to maintain separately, the less efficient that it becomes. The demand for "Identify Preserved Grains" (IPG) is increasing: organic wheat, variety preferences, specific quality attributes, e.g., protein. Advances in genetics and the demands for product differentiation threaten to congest the bulk system with further variety[1]. The bulk system could operate more efficiently if the lower volume, small shipments are moved in containers.

One size does not fit all.

A differentiated distribution strategy may be applied to products, sales volume or customers. Some consumers are willing to pay more for premium service, while others are just interested in the lowest price. A standard level of service dissatisfies the "quality-sensitive" customers, and has attributes for which the "price-sensitive" customer will not pay. Similarly, some products have high margins and are very popular, others may be offered more as a service than a profit centre. Providing the same level of logistics service in both cases is not warranted.

Bulk handling favours a push, rather than a pull system of marketing. Large stockpiles are created and deliveries are made in boatload quantities. If the customer wants lowest cost, average quality and will accept these volumes, the bulk handling system is ideal. Not every customer needs or wants the volumes that are most "economic" for bulk delivery. Some buyers process volumes that could be handled on a Just-in-time (JIT) basis using containers.

Delay commitment to the final product until the last possible moment.

This logistical strategy is used to lower finished inventory costs and increase customer service. The classic example is the distribution of paint. Only untinted paint is shipped to retail outlets. Tints are added after the customer chooses the desired colour. This reduces inventories held at retail and eliminates obsolescence while improving the selection of colours available. The strategy of delaying commitment is now being used in a range of products. For example, assembly plants have been established in the Netherlands to finish the manufacture of Japanese computers and other electronic equipment for the European market.

Bulk handling reduces the foreign miller's opportunity to tailor processed grains to the exact specifications of the buyer. Commitment is made to the quality of the final product, as soon as the grain is commingled at the country elevator. Containerized grain would delay commitment and give the foreign processor a multitude of options. Each container would be bar-coded with information on grain variety and exact quality attributes. The foreign processor could blend grain with different quality attributes from a small inventory of bar-coded containers to fit a wide spectrum of finished product specifications.

It's Total Costs that matter.

In traditional supply chain management each participant views the next agent in the marketing channel as the "customer". Great efforts may be made to reduce costs and improve the service to this customer, without considering the impact on the entire supply chain. Only system changes that lower total costs to the end consumer make everyone better off. The principal of the total cost concept is that producers need to be as concerned about their customer's customer as they are with their customer. Some firms have found that getting their immediate customer to bear more costs is possible, if they can lower the total costs to the ultimate customer.

The North American grain handling system is designed as if all the important transportation and handling costs ended at the port of export. Most grain exporters have no idea of the total costs to the processor in the foreign country. Reducing the costs of the domestic portion of the system may shift costs to the foreign buyers. For example, large bulk shipments may be the lowest cost method of moving grain from farm to port, but impose high inventory holding and storage costs on importers. A JIT container system could have higher transportation costs than bulk, but would virtually eliminate the storage, inventory holding and shrinkage costs for the foreign processors.

Intangible costs, such as the reliability, are also important. The greater uncertainty of the bulk handling system adds to costs. Foreign buyers must have contingency plans and additional inventories to guarantee service to their customers. A rough comparison of the shipping time for the bulk handling system and the proposed container system is presented in Figure 1. The comparison is only approximate because no informed opinion could be obtained of the unloading time and storage of grain in foreign import terminals. These data show that the bulk handling pipeline is four times longer than a container system. A 25 percent variation in delivery time of the bulk system would equal the time required for a container movement.

Figure 1 Approximate Shipping Time Comparison for Bulk Handling and Containerization of Canadian Wheat

Bulk Handling System	Days	Container System	Days
Farm Storage		Farm Storage	
Local Delivery	1	Local Delivery	1
Primary Elevator	40	Intermodal Terminal	2
Rail Hopper Cars	11	Double-stack Train	2
Export Terminal	19	Intermodal Port	2
Bulk Shipment	15	Container Ship	11
Import Terminal	10	Intermodal Port	2
Local Delivery	1	Local Delivery	1
Final Customer		Final Customer	
Total	97		21

The costs of the relatively slow bulk system are reminiscent of the sacks grain it replaced. Assuming FOB sales contracts, producers are financing inventories up to 10 times longer in the bulk system, than a containerized system. These costs are generally absorbed in the basis, or in the case of the Canadian Wheat Board final payments to producers.

Cost Trade-offs: Bulk versus Containers

Cost trade-offs are central to the re-engineering of logistics. The scope and design of logistics involve a balance between conflicting activities. Logistical functions can never be eliminated, only the cost of one activity can be traded-off against the cost of another activity. For example, transportation costs can be reduced by opening additional warehouse distribution points, but to maintain the same level of customer service, the inventory holding costs must increase.

Cost of physical handling versus container transfer. Grain is loaded and unloaded at least four times before reaching the final customer. Containerized grain would be handled once and the container transferred three times. The economics of size in bulk handling may not be totally exhausted, but further gains are likely to be marginal. Container systems are experiencing rapid productivity improvements. Computer controlled cranes and robotic trolleys are reducing labour costs and increasing handling speed.

Pipeline storage costs versus use of containers. Farmers already possess most of the storage they require to protect the crop after harvest. The storage provided in the bulk handling pipeline duplicates on-farm storage. The container serves as transportation unit and storage. Farmers could use containers to supplement on-farm grain storage. When the grain was sold, the storage would move into the handling system.

Economics of shipping versus inventory holding costs. The speed of the container system, and the opportunity to use Just-in-time scheduling reduces the costs of financing pipeline inventories. Lower inventories also reduce the risk associated with spoilage and shrinkage due to pests. On the other hand, approximately two tonnes of metal have to be physically moved with each 20 tonne container shipment. Adding 10 percent to the weight of the shipment increases the cost of transport.

Empty backhauls versus tare weight of containers. Containers are the new “boxcars” of the railways. Whereas bulk systems experience empty backhauls, the availability of empty containers would attract a variety of freight. If no backhaul can be obtained however, the container is likely more expensive to return empty than the bulk handling equipment.

Low freight costs/average quality versus freight premiums/exact quality. The bulk system offers low-cost service but delivers only average quality grain. Containers cost more to transport, but can deliver exact specifications. Some buyers may find the quality benefits more than offset the extra transportation charges. Its worthwhile bearing in mind that the value of grain contained in a loaf of bread, or a bottle of beer, is measured in pennies. A penny more for transportation might be easily extracted as a quality premium for the final product.

Factors Favouring Containerization of Grain

A range of technological and economic factors favour the containerization of grain.

Freight costs

Container rates for grain to Asia Pacific are about 10 to 30 percent higher than the direct costs of bulk handling. Several improvements are likely to narrow this difference. The container fleet has nearly doubled in size since 1985 (Worldwide Container Growth, 1997). In addition, the capacity of the containerships has nearly doubled. In 1980, containerships carried 2,000 to 3,000 TEUs (twenty foot equivalent unit). The new 6,000 TEU containerships operate with the same crew complement and feul consumption of their smaller predecessors. Freight rates for grain are being bid down as steamship lines compete for cargo to fill these new ships.

Container terminals are becoming highly automated. The new *Deltaport* container terminal at Vancouver that opened in June 1997 has capacity to load two double stacked trains simultaneously. The facility is aiming to load 30-35 containers per hour from ship to railcar and to load a unit train within eight hours of starting (Daniels, 1997). A 6,000 TEU ship carries the equivalent of 15 double stack container trains.

The railways are improving their container service. The first double-stacked container train service was introduced by APL in 1984. The Association of American Railways estimates that double stacking lowers line-haul costs by up to 40 percent (Martin, 1996). Container volumes in North America have enjoyed a compound growth rate of 5.7 percent since 1988. Better service and lower costs are anticipated as the railways upgrade their container terminals and add equipment.

Further cost improvements are likely as the container system matures. Steamship lines jealously guard their container fleets. The railways have invested in “domestic” containers that are larger, and do not move overseas. The pooling of container fleets is beginning to gather support. Increasingly, the industry is pointing to “Gray Boxes,” which are owned by third parties, as a method of increasing vehicle utilization.

Communication Costs

The revolution in communications can be summed up with one word: Internet. The information highway may be the most important innovation of this age, but it is still at a primitive state. Proposals to launch a network of satellites that would create real time access to the Internet are planned. Visions of global commerce via the Internet are already taking shape. The impact of the Internet on grain marketing in the 21st Century could be akin to the changes that occurred in the 19th Century when the telegraph was introduced. Just as the telegraph decentralized the physical transaction of grain, the Internet could decentralize the electronic transaction of grain. Information is replacing the need to store large inventories and reducing the economies of size in order processing.

Price/quality Considerations

Bar codes and computer data bases reduce the effort of tracking container shipments. Importer demand for IPG will lead the move to larger container volumes. Quality premiums to farmers are encouraging the production of organically grown crops, specific varieties of mainstream crops, and a variety of "special crops" that range from herbs to pulses. These products cannot move economically through the bulk handling system. As their volume grows more products will be added to the list of containerized grain.

JIT service to foreign grain processors is an advantage of containers that bulk shipment cannot provide. Given the success of JIT in manufacturing, it is only a matter of time before processors begin to demand JIT grain shipments. If the benefits from delayed commitment can be added to the reduction of inventory costs, the volume of container movements will accelerate.

Electronic Markets for Grain

The impact of communications technology and containerization could be far reaching for the grain industry. Electronic markets could shift some functions performed by grain handlers back to the farm. Operationally, farmers could post container loads of products on an Internet site, and field purchase offers via e-mail. Potential buyers could be sent grain samples by FedEx. Transactions could be consummated with container shipments that never touch the current bulk handling system, or use the services of grain handlers. Naturally, some institutional arrangement s would have to be put in place to assure the farmer received payment, and the buyer received the actual quality according to the contract. These institutional arrangements constitute the requirements of an electronic market.

Electronic markets enable traders to buy and sell complicated products without being in physical contact. There are certain institutional prerequisites that must be developed for an electronic market (Prentice and Mulligan, 1996). A computer-supported system must be used to search and negotiate the transaction. There must be membership rules, a method of quality checking and a system for settling transactions. Some elements of an electronic market for containerized grain are in place; the missing pieces present no significant barrier.

The need for containers could create a second electronic market for farmer-owned "Gray boxes". Essentially, producers would purchase containers and form a leasing pool. While the containers were at the farm, the producer would receive no payment. When the grain was sold, the container would enter a leasing pool that would return a payment to the farmers. In the next harvest season, the producer could request the delivery of a container, and the cycle would begin again. Containers last about seven years. Farmers would not necessarily receive the container they purchased, but would receive "rights" to a container for seven years. Container leases could be traded electronically, with bids and offers entered by producers, grain handlers, carriers and buyers. This would encourage utilization of equipment and maximize producer returns.

Conclusions

Complacency in business is always risky, but it is particularly dangerous during periods of economic transition. Rapid changes in global trade are being spurred and reoriented by growing world populations and rising incomes. Competitive advantage is being sought through technological advances in computers, genetics, robotics, telecommunications, and transportation. Governments are intensifying competition with policies of deregulation, "free" trade, and privatization. The drivers of structural change have seldom been more diverse, or more profound. To survive, businesses are being forced to re-engineer their manufacturing and logistical processes to lower costs and increase quality.

After 150 years of growth and development, most grain exports are marketed through grain elevators, rail hopper cars and bulk carriers. The bulk handling system is so ubiquitous and entrenched as to be uncontested. No doubt it appeared the same to the handlers of bagged grain when the bulk method was first introduced. There have been many refinements and productivity improvements in the bulk handling system, but the basic concept remains unchanged. The economic rational for the creation of bulk handling of grain have changed. Technological advances in information collection and transmission now make container shipment a rival for the bulk handling of grain.

The motto of the Industrial Age (1850-1975) can be summed up with the expression: *"If it ain't broke, don't fix it!"*. In the modern era, which some have termed the Information Age, this expression could be changed to *"If it still works, it's probably obsolete!"* Rapid changes because of new information technology are forcing many systems to be overhauled. These changes spare no sector of the economy, least of all the grain handling industry.

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Endnotes

1. The Canadian Pacific Railway offered free lease sites on sidings to companies willing to build "standard" elevators of not less than 25,000 bushels. "This offer was accompanied by an undertaking by the railway not to allow competitive loading from flat warehouses or from farmers' wagons at points where elevators were located." (Wilson, 1978).

2. Re-engineering a logistical system is trade creating. Kindleberger (1962) has described the effect of innovations in transportation and communications as having a double impetus for trade. Innovations that lower the cost of logistics increase profits for the producer while it lowers prices

for the consumer. The incentive to buyers combined with the incentive to sellers creates the double impetus to expand trade.

3. "In 1995, 50 percent of all ocean shipments of grain were carried by Handysize vessels. In addition, about 87 per cent of grain exports from Australia and 68 per cent of African grain imports were carried in vessels of less than 50,000 dwt [dead weight tonnage]." (Agriculture and Agri-food Canada, 1997) In contrast, most coal and iron ore shipments are carried in Capesize vessels of 120,000 dwt.

4. The standard telegram of six words was sufficient to execute a transaction: buy/sell, commodity, grade, price, place, date.

5. The $20 per tonne (1996) quality premium that Warburton's, a British bakery, is willing to pay for three specific varieties of wheat is a well known example of IPG. The contracts are regionally specific as well as being variety-specific (Rance, 1997).

Chiefâ€™s staff of engineers are dedicated to continually seeking ways to increase the capacity, efficiency and longevity of our material handling systems. To assure ease of installation, Chief trunking systems are precision-aligned and test-fit at our factory. Behind every Chief material handling system is our longstanding tradition of excellence in engineering, manufacturing and customer service. Material Handling. Chief elevators and conveyors are built to last and are easy to maintain. Learn More. Catwalk and towers. Structural support, easy assembly, and engineered for safety and dependabil The terminals handled 7.7 mn tons, up 28% year-on-year. According to the company, the growth was due to record volumes of container traffic and grain exports. Container traffic via NUTEP increased 30% to 304,000 TEU. Tonnage-wise, the volume was up 36%. KSK handled 4.2 mn tons of grain, up 27% compared to 2016 due to record harvest volumes. General cargo traffic decreased 30% while ro-ro cargo was down 53% as a result of containerization of imports. In unit equivalent, ro-ro traffic decreased just 5%. Bunkering fuel sales surged 101% compared to 2016.