PEAK-LOAD MANAGEMENT AND SURGE CAPACITY IN WESTERN CANADIAN GRAIN TRANSPORTATION

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Synopsis

This paper examines the impact of grain transportation demand instability on customer service given Canada's implicit policy of railcar rationing. The Maximum Grain Revenue Entitlement and the Fair Rail for Grain Farmers Act perpetuate inefficiency in the grain supply chain and propagate shipper complaints while doing nothing to buffer the impact of unanticipated surges in the derived demand for grain transportation.

Introduction

Utilization is the key to the economics of network industries that have high fixed costs. The more that the network capacity can be used, the lower the average cost of the services provided. The obstacle to achieving maximum capacity utilization is demand fluctuation. Some network industries, like power utilities have daily peak load demands, while postal networks have weekly demand peaks. Network industries with seasonal demand peaks are also common. The tourist season creates a summer demand peak for the airlines, while the annual grain harvest generates a fall demand peak for railcars. Positioning assets to meet short term peak requirements creates lower levels of capacity utilization during the off-peak period. As a result, demand variability leads directly to higher average costs.

If the demand for service at the peak exceeds the available resources, some method must be used to apportion supply. In unregulated markets this is done by price changes. Those who most want the service pay the going price to receive it. Buyers in a free market may complain about rising prices during the peak period, but no one can complain that the service is unavailable.

The other alternative is to fix prices and ration the available supply amongst the buyers. Rationing, prima facie, must disappoint some buyers because not everyone can access as much as they are willing to pay for at the fixed price. Consequently, rationing systems are subject to chronic customer service complaints.

This paper considers the impact of peak demand on customer service and capacity management of grain transportation in Western Canada. The analysis begins with a discussion of customer service in network industries subject to fluctuating demand peaks. Next, the economics of the railcar allocation system under regulated freight rates are presented, and the alternative methods used to allocate railcar capacity in Western Canada are described. This is followed by a discussion of customer service and Demand Side Management (DSM). The penultimate section addresses the challenges created by unexpected surges in demand. The paper concludes with some thoughts on the need for reform and research to address alternative solutions to unexpected demand surges.

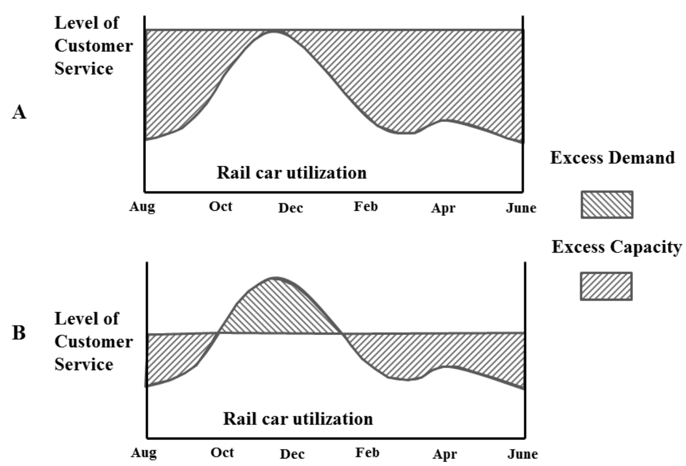
Economics of Peak Load Markets and Customer Service

Grain transportation experiences two sources of demand instability. A peak demand in the seasonal shipping pattern arises each year following the annual grain harvest. Buyers await the arrival of the new crop, and farmers plan to make immediate deliveries. The new crop demand for railway hopper cars peaks between September and January. The second source of instability is unexpected surges in demand that can be caused by harvest variability or export demand fluctuations that follow no established pattern.

Rail car supply is the tangible product that is in scarce supply during the period of peak grain movement, but bottlenecks can occur throughout the entire supply chain. The economic dilemma created by the peak demand is the trade-off between capacity management and customer service. The greater the difference between the peak and the off-peak demand, the more difficult it is to manage the capacity of the supply chain, or deliver consistent levels of customer service.

Figure 1 presents a model of two levels of customer service and capacity utilization. These diagrams illustrate the seasonal demand pattern for the crop year that begins in August and terminates in July. In model A, capacity is established so that customer service is maximized and consistent throughout the year. However, this also maximizes the cost. The more equipment and crews that are dedicated to serve the peak demand, the more idle equipment and crews remain under-utilized during the balance of the year. The cost of this unused capacity must be financed year-round.

Figure 1 Customer Service and Capacity Management given a Seasonal Demand Pattern



The need for high utilization is sometimes referred to as "sweating the assets". In model B, the capacity is designed to meet a "high average demand"[i]. During the peak period some shippers receive a lower level of customer service than is experienced by off-peak shippers. However, spreading the peak out also lowers the cost of providing the service. “Sweating the assets” means that much less excess capacity has to be maintained during the off-peak period.

The quality of customer service that shippers are willing to pay for and the level of customer service that carriers can afford to offer is found by the interaction of supply and demand. Typically, the customer service target is set to serve a “high average demand” rather than the maximum possible peak demand because shippers are prepared to trade-off a lower level of customer service for a lower price.

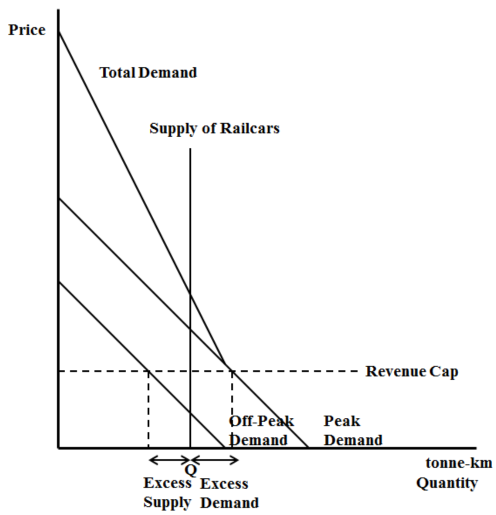
Regulation of Western Canadian Grain Transportation

Several regulatory approaches can be employed to govern the prices charged and the quality of service provided. In the case of Western Canadian grain transportation the Maximum Grain Revenue Entitlement (Revenue Cap)[ii] is used to limit the maximum payment that the railways can receive for hauling grain. Technically the Revenue Cap formula gives the railways pricing flexibility, but effectively it creates a maximum average rate per tonne-kilometre. The level of customer service (in quantity terms) is specified by a second regulation, created in 2014 by Fair Rail for Grain Farmers Act. It amends the Canada Transportation Act to require a minimum volume of grain to be transported per week by the two Class I railways[iii].

The regulation of both the price and the quantity of service provided creates inefficiency and accentuates the chronic nature of customer service complaints. Excess demand occurs because the regulators fail to recognize the basic economic impact of price caps on markets subject to peak load demands. An economic model of the current system in Western Canada is illustrated in Figure 2.

Two demand curves are drawn to represent the peak demand period (September to December) and the off-peak demand period (January to August). The two periods combined sum to yield the annual total demand (the peak and off-peak demands are added vertically). The supply of rail service is represented by the number of railcars that are available at any one time. The Revenue Cap freight rate is represented by a horizontal line. This is the average maximum freight rate that the railways can earn under the regulatory formula. At this freight rate, the market experiences an excess supply of railcars during the off-peak period. This is evidenced by the miles of empty covered rail hopper cars that are parked on unused Prairie branchlines every summer. During the peak demand period, more railcars are wanted at the Revenue Cap rate than are available. The excess demand must be rationed by some administered supply allocation method.

Figure 2 Operations of a Revenue Cap in Western Grain Transportation



The railcar rationing system dates back to the prior period of Statutory Rates, more commonly known as the “Crow Rate”. At this time, the Canadian Wheat Board (CWB) allocated railcars for the shipment of grain to domestic and export markets. In 1979, a government agency, the Grain Transportation Authority (GTA), assumed responsibility for apportioning the railcar fleets when the “Crow Rate” was replaced by the Western Grain Transportation Act (WGTA). The GTA allocated the majority of the cars to the CWB that distributed their supply amongst its agents (grain companies) to move Board grains[iv] and the rest of the railcars were allocated to non-Board grain shippers based their relative sales positions.

After the WGTA was repealed in 1995, the Car Allocation Policy Group (CAPG) replaced the GTA. CAPG determined the percentage of the fleet to be allocated between the Board and non-Board grains. With the amendments to the Canada Transportation Act in 2000, CAPG was eliminated and the railways became responsible for allocating the railcars.

> "Since that time [2000], the railways have used a variety of methods to apportion cars to grain shippers – historical percentages, terminal authorizations, advance products (some involving monetary bids), order books, etc. The car allocation processes used by the railways during periods of rationing have been of a more dynamic nature than was the case under the previous administered system. (Quorum, 2011: p.43)

No method of rationing the railcars has quelled customer service complaints. Grain shippers complain that the timeliness of the service is wanting, the allocation system is unfair, and they are powerless to get their desired share. Blame for poor customer service to grain shippers has been shifted over the past 50 years from the CWB to the GTA, to CAPG, and now to the railways. In all cases, the source of the chronic complaints is the same, and rests with the fixed freight rates that do not respect the large, and somewhat unpredictable, fluctuations in demand that occur each peak shipping period.

Fixed rates are also impervious to any disruptions in the supply of railcars. The number of railcars available at any one time can be reduced by unexpected weather events, accidents or labour disputes. Exceptionally cold winters, blizzards, floods or landslides can increase railcar cycle times (the time for a railcar to make a roundtrip). The reduction in supply is best illustrated by an example. Assuming that the railways were moving 700 railcars per day and the car cycle was 10 days, the service could be provided by a fleet of

7,000 railcars. If some disruption extended the car cycle to 12 days, these 7,000 railcars would lose utilization such that only 580 cars could be provided per day. Railcar supply disruptions can affect customer service negatively, and especially during the peak demand period, but no market signal is translated back to shippers to cause them to alter their service expectations[v].

Depending on the rationing method, other problems and complaints can arise. Whether the apportionment is done on the basis of "first-come, first-served", "historic market shares", or "administrative discretion" disappointed buyers may charge that there is favouritism, bias, or even corruption affecting their ability to receive service.

Another common problem with rationing systems is "phantom orders". Some shippers will seek to gain advantage by gaming the system so that they obtain a disproportionate share of the rationed supply. For example, if buyers realize that all orders are likely to get reduced *pro rata,* they will over-order in an attempt to obtain the number of railcars that they really need. This can create unfairness, but it also exaggerates the validity of customer service complaints and distorts the true capacity needs of the system.

Customer Service and Demand Side Management (DSM)

Customer service quality is difficult to define in logistics. Any consumer can appreciate when they have received poor customer service, but it is more difficult to define what constitutes good customer service. Buyers and sellers often view the concept quite differently. For example, a buyer may put great stock in service reliability, while the seller is focused on such elements as order processing, invoicing and service accuracy. In general, the quality of customer service lies in the eyes of the beholder.

Consumers in market-based economies recognize that the level of customer service they receive is a function of the price they are charged. No one expects to receive "white tablecloth" service at McDonald's restaurant prices. Markets are divided into segments based on customer service demands that vary from discount level service to premium quality service. At one extreme, buyers trade off customer service for lower prices and at the other end of the spectrum, buyers knowingly pay more for the product to receive a superior level of customer service. Businesses understand this phenomenon and they use customer service to differentiate themselves from the competition, and to defend their market share.

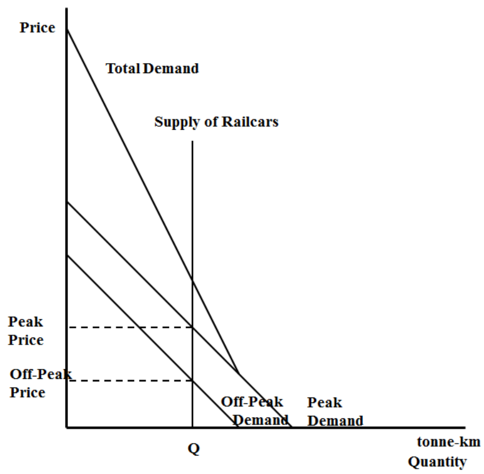
Sellers may view customer service as an activity, as a performance measure or as a philosophy (Coyle, Bardi and Langley, 2003). In the case of grain transportation, customer service is more likely to be viewed as an activity, or maybe a performance measure, but hardly a philosophy. Customer service under a regulated system that sets price and rations output is more likely to resemble that found in the old command economies of the former Soviet Bloc countries where everything was rationed.

In unregulated markets, prices rise during the “high season” and fall when demand is low. Those who want the service most express their interest by offering the highest bid. Similarly, if there is excess supply, prices fall to clear the market. This is known as demand side management (DSM).

DSM has two important roles in markets that are subject to seasonal demand fluctuations. Companies need to charge more during the peak to be able to bear the fixed cost of unused equipment during the off-peak. The total cost of providing the service is based on annual utilization of the assets. Second, rising prices ration the available space amongst those who have the highest demand during the peak period. Those who wish to avoid the high prices can choose to delay consumption until the off-peak. DSM helps to reduce the demand variation by flattening the peak and shifting some of this demand to the off-peak period.

Figure 3 presents the same economic model for the peak/off-peak demand for railcars as illustrated in Figure 2 with two exceptions. If freight rates were allowed to fluctuate with demand, they could be somewhat higher than the Revenue Cap during the peak and below the Revenue Cap during the off-peak. The other difference is the extremes between the peak and the off-peak demands. When buyers are faced with rising prices, some will shift their demand to a later date. This is how DSM reduces (flattens) the peak demand and increases the off-peak demand.

Figure 3 Operations of Western Grain Transportation with unregulated prices



Brunefreeft (2000) has undertaken an in depth analysis of price caps in network industries with peak load demand patterns. He considers the arguments of social welfare, price discrimination, predation and income distribution. None of these arguments support the use of a price cap if the seasonal demands differ strongly. Brunefreeft does not address issues of customer service, but on the basis of these measures alone he concludes that price flexibility is much preferred.

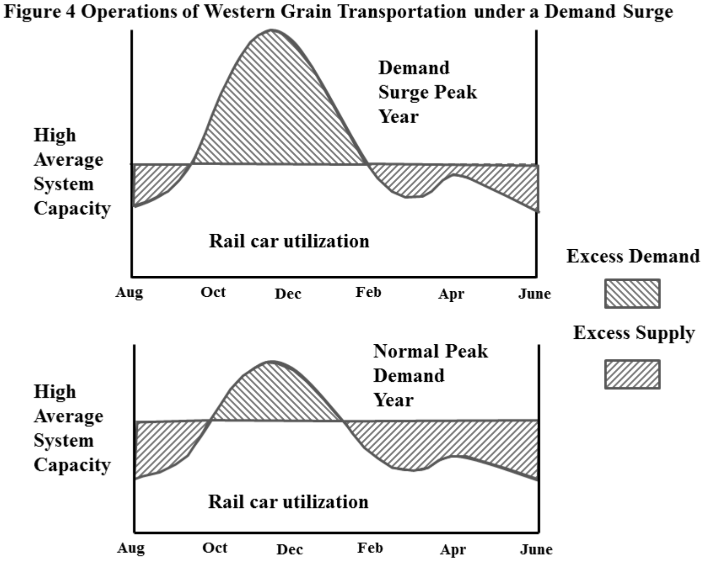
> "… if the regulatory alternative is uniform pricing (i.e. no peak-load structure), then the results of a flexible price cap always seem preferable. …. Especially so for the shifting-peak case, where the common capacity costs should be allocated to the different periods according to demand (rather than to costs). It may be expected that the profit-driven firm will be better informed than the regulator, which

makes a strong case for allowing the firm the pricing flexibility.” (p.26)

Unexpected Demand Surges

Weather is an unpredictable source of demand instability in grain transportation because the size of the harvest can change from year to year. Figure 4 compares the peaks in a normal year with one that experiences a demand surge. Both extremes of instability are detrimental. If the weather is unfavourable and the harvest is less than average, the supply chain is burdened with the cost of excess capacity. If the weather is very favourable and the harvest is well above average, then the peak is exaggerated. A small crop can leave the supply chain with too little revenue to cover its fixed costs, while a surge in supply of grain can lead a massive increase in excess demand and complaints of inadequate customer service.

Figure 4 Operations of Western Grain Transportation under a Demand Surge

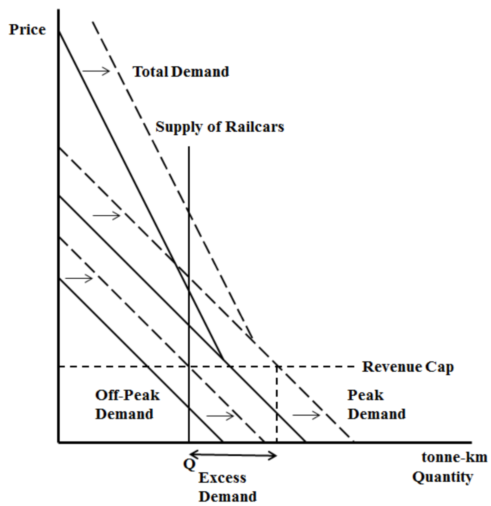


Network industries with high fixed costs, like the railways, have great difficulty adjusting to short run fluctuations in demand because most of their assets are long lived and they have few, if any alternative uses. A decision to invest in a railway capacity increase generally means a commitment to many decades of supply.

The railways also have trouble adjusting quickly to short run demand changes because they are such complex organizations. The railway network comprises four overlapping systems that must be closely coordinated: crews, locomotives, cars and infrastructure (tracks, yards, signal systems). Adding more railcars without corresponding increases in crews and locomotives does not add capacity. Moreover, if the infrastructure is already subject to bottlenecks, adding capacity to the rolling stock may just aggravate the pinch points and create more congestion with little or no increase in output.

Following an unusually large harvest in 2013-14, the super surge in peak load demand created a chorus of shipper complaints about inadequate customer service. Figure 5 presents an economic model of the peak load that illustrates the impact of a demand surge when the Revenue Cap controls freight rates.

Figure 5 Operations of Western Grain Transportation Under a Revenue Cap Fixed Price and a Demand Surge



The demand surge moves both the peak and the off-peak demand curves to the right. The shift to the right of the peak demand curve greatly expands the excess demand. Consequently, even more shippers are disappointed because their apportionment of the fixed railcar fleet is inadequate to move the larger crop.

Although the railways received undeserved blame in 2013/14 for not providing enough railcars to meet the surge in demand, the problems would not have been solved by more railcars. First, there is the complexity mentioned earlier of finding more crews and locomotives, even if the infrastructure capacity were available to move more grain trains. The second problem is the capacity of the other links in the supply chains. The country and terminal elevators are not designed with the ability to handle a 35% increase in demand. Railcars would have simply backed up at the country elevators waiting for loads, and at the terminal elevators waiting to be unloaded.

As the chronic customer service complaints caused by the regulated freight rate became shriller, the government reacted with even more regulations in the vain effort to “do something”. Had prices been free to rise with the surge in demand, shippers would have been presented with more information to decide whether they wanted to proceed at this price, or defer the decision to a subsequent time period, or indeed search for alternatives e.g. domestic markets, truck to the US, or ship in ISO containers.

Unexpected demand surges accentuate the customer problems that are inherent in a regulated system with a strong peak/off-peak character. The solution does not lie in more regulation aimed at setting minimum customer service standards. A high fixed-cost, network industry, like the railways, simply cannot respond in a matter of months, with changes that would take much longer to implement. In addition to repealing the Revenue Cap, other solutions must be found. The ideas presented here all require further research, but suggest a range of policy options for the one in 10-year, or one in 100-year event.

An unexpected demand surge creates risk that could be dealt with as an insurance program. If it were desirable for the supply chain to hold 25 percent extra capacity on standby in case of a demand surge, the costs could be assessed, and compensation could be incorporated into handling and freight rates. It is unlikely however that farmers or governments would be prepared to finance these costs given the uncertain benefits.

Another alternative could be to arrange an outlet for surplus Canadian grain through trucking to the US market. However, good harvests in Canada and the US are highly correlated. It is unlikely that surplus production from Canada would be welcome in the US if they are also challenged to move a large crop. But it remains an alternative for some shippers.

New technology could help ameliorate the impact of demand surges. For example, the new generation of covered hopper cars carry about 30% more grain than the older railcars in the government-owned fleet. Of course, nearly all technological solutions that currently exist involve some form of investment. Replacing the existing government fleet of railway cars cannot be achieved without cost. An average freight rate based on historical movement is not the basis for investment to increase future movement capacity. The structure of the regulatory calculation inhibits capacity investment.

Another technological alternative is to consider is the potential to augment the bulk handling supply chain with a container-based grain supply chain. The world supply of containers is very elastic and they can be rented on a short term basis. Importing a large number of containers on a temporary basis would provide immediate storage capacity for a surge in grain production, while any grain that moved in containers would not impact the capacity of the current bulk handling system.

More research is required to assess the container shipping option, but grain is already moving in containers, it would only be a matter of expanding this more flexible outlet (Prentice and Hemmes, 2015). A major barrier to the increased containerization of grain is the Revenue

Cap that does not recognize the higher costs of container shipping. Without adequate compensation the railways have no incentive to pursue grain in containers instead of bulk shipment.

Conclusions

The regulation of grain transportation in Canada is unique. Unlike all other commodities that are subject to freight rate negotiation between shippers and carriers, the government has intervened continuously to manipulate the freight rates for the rail transport of grain. A legacy of this experience is a regulatory system that creates an effective maximum average freight rate for hauling grain, and an administered system for the rationing of railcars to shippers. Supply rationing, by definition, delivers lower customer service and reduces the efficiency of the entire supply chain.

In addition to the transparency of service allocation, a market-based pricing system makes more efficient use of resources. Some unused capacity could still exist during the off-peak season under a flexible pricing system because the freight rate must still cover the opportunity costs of the equipment employed in another use[vi]. However in a regulated price system, no incentive exists to shift demand from the peak to the off-peak, or to lower the freight rates to encourage utilization of the excess supply.

No system is without complaints or compliments. The difference between whether supply is allocated by changing prices or by rationing under a fixed-price system is most obvious at the peak demand. During times of slack demand, all customers can be accommodated, but during the peak demand period not everyone can be served, or satisfied. Buyers may complain about paying higher prices to receive service during the peak in an unregulated system, but the rationing system delivers only one level of customer service that by definition must disappoint some recipients.

Unanticipated surges in demand that place additional strain on the bulk handling system only aggravate customer service complaints. More regulation cannot solve a capacity problem that is inherent in the high-fixed cost nature of this network industry. Other solutions, such as the containerization of grain need to be explored.

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[i] The high average demand could represent the mean expected demand plus one standard deviation.

[ii] See sections 147-152 of the *Canada Transportation Act, 1996. http://laws-lois.justice.gc.ca/eng/acts/c-10.4/page-55.html#docCont*

[iii] "Subject to volume demand and corridor capacity, each company referred to in subsection (1) must move the minimum amount of grain that the Governor in Council specifies or varies by order." *http://lois-laws.justice.gc.ca/eng/acts/C-10.4/page-41.html#h-63* Even if the minimum volume of grain was not prescribed by an Order in Council, regulators can still specify the level of service (in quantity terms) either in the context of a level of service complaint or by service arbitration.

[iv] Wheat, barley and oats were the Board grains, although oats were later removed from the CWB in 1989.

[v] The only signal that producers see is the widening basis on the prices offered at the local grain elevator.

[vi] The opportunity cost refers to the next best use. For example if the locomotives and crews can earn more revenue hauling forest products, the movement of grain cars should pay at least as well.