Canada's Grain Handling and Transportation System: A GIS-based Evaluation of Potential Policy Changes
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Canada's Grain Handling and Transportation System: A GIS-based Evaluation of Potential Policy Changes

by Savannah Gleim and James Nolan

This research re-examines both transportation allocation and infrastructure capacity problems associated with moving grain from the Western Canada to export position. The analysis is conducted with geographic information system software using grain industry data. In contrast with historical grain industry logistics methods, the analysis and simulation framework allows us to re-examine logistic solutions in this vast supply chain in the interest of improving overall delivery efficiency. In addition, we find that rail network capacity should not constrain any major expansion of grain movement in the system over the foreseeable future.

INTRODUCTION

While rooted in Canada's history, the transportation of Prairie wheat from grain elevators across Western Canada continues to be an issue of contention for Canadian agriculture. Recent changes in the sector have only deepened this concern. In August 2012, the Canadian Wheat Board (CWB), an organization that was the sole international marketer of Canadian wheat, barley, and durum since 1935 was stripped of this function. This event also transferred grain logistics oversight over to grain handling firms operating in Canada. Since Western Canada is a major exporter of grain, the handling system will continue to rely on efficient logistics to move these commodities for export. Now that the CWB no longer controls the allocation and marketing of these grains, significant changes have and will continue to occur within the future logistics and allocation system for Western Canadian grain.

Up until the federal government's decision to stop the marketing function of the CWB, it was the largest marketer of wheat and barley in the world (Canadian Wheat Board 2011). Marketing grain to over 70 countries meant that the CWB played a major role in the Canadian grain sector. For example, in the 2011/12 crop year, the CWB exported approximately 21.3 million metric tonnes (MMT) of grain (Canadian Grain Commission 2012). Of those exports, wheat was the largest export grain, with 15.4 MMT moved through Western Canada. With the CWB policy change, the export of Canadian grain will necessitate an updated and possibly quite different grain logistics system. The vastness of the grain sector means that transition is unlikely to be smooth.

As Western Canada's grain handlers absorb more grains into their new supply chains, their individual and collective transportation problems will shift and become more complex. We expect that novel logistics solutions will need to be identified in order to efficiently move primary export grains across the three Prairie provinces, using the two Class 1 Canadian railways to connect to the four major Western Canadian export points (Vancouver, Prince Rupert, Thunder Bay, and Churchill). Considering the collectivist goals of the CWB, future grain transportation solutions will necessarily shift emphasis away from a farmer profitability focus over to the profitability of grain handling firms themselves.

Currently, it is not well understood how any such changes in Canadian grain logistics will affect overall grain movement and system efficiency. To this end, a spatially oriented optimization analysis is developed in an attempt to literally map out potential evolution of the new grain handling and transportation system in Western Canada. Thus, the primary contribution of this research is to simulate a likely future grain handling logistics system whereby multiple grain companies are responsible for transporting Canadian grain.

GRAIN LOGISTICS IN CANADA

To begin this research, it is useful to understand how grain logistics were conducted under the former CWB. One major point worth highlighting is that CWB grain logistics were based solely on minimizing system transportation costs, in the form of rail freight rates paid by each individual farmer. As a collectivist solution imposed by a monopoly grain marketer, CWB optimization objectives will likely contrast with the new competitive marketing environment for grain in Canada. Due to this, our model is designed at the outset to better align with the objectives of individual grain handling firms as they seek to maximize profit in the new system. On this point, our model assumes that time (as an opportunity cost) is the critical factor governing the movement of grain within the transportation system.

The CWB was created by the federal government in Canada as a means to maximize returns to grain producers through single-desk marketing of grain purchases, sales, and exports (Schmitz and Furtan 2000). In 1995, the CWB changed its grain logistics system to more formally reflect the value of grain at each grain delivery location across the region. The CWB did this by computing a hypothetical shadow price known for delivered grain. This algorithm was called the freight adjustment factor, or FAF.

Mostly based on forecasted demand data, the FAF was a rate adjustment that signalled to every farmer in the region the lowest cost direction to move their grain. Each year, a system-wide FAF was computed to capture not only the flow of grain trade for that year, but also to reflect any other export capacity constraints (Gray 1996). As a single optimization problem that was applied to the entire region altogether, the CWB's logistics system under FAF effectively minimized the collective costs of grain freight for all producers simultaneously.

FAF priced away any inherent locational advantages among farmers, particularly those located along the hypothetical boundary of the major Prairie grain catchment area. In fact, the CWB effectively divided Prairie farmers in West and East catchments, so defined by the lesser cost of FAF plus freight to Thunder Bay, or the freight rate to Vancouver. As the CWB possessed complete logistical control over almost all Western Canadian grains, the FAF shadow price signal allocated yearly grain movement either to the East (Thunder Bay) or West (Vancouver/Price Rupert) as needed, subject to the constraints inherent in the supporting rail system. In summary, CWB logistics at the time of their elimination from this function was designed to minimize collective (not individual) freight rate payouts across all farmers in the region.

In some contrast to the collectively driven logistics methods used by the CWB, in this research the transportation problem for grain movement in a new era of multiple competing grain marketers will be studied using explicit spatial analysis. The scale of the Canadian grain transportation problem is enormous, spanning four provinces with numerous delivery points (elevators) and a few distant port locations. Fortunately, geographic information systems (GIS) software can be programmed to solve as well as map out complex spatial transportation solutions. Here, ArcGIS software is programmed to use a standard vehicle routing problem (VRP) toolkit. In our model, the solution identifies the least costly (based on time transported) set of grain transportation routes that allocate (monthly) wheat supplies from across the Prairie elevator system to meet particular (monthly) export demands at each port.

In a competitive grain transportation market, grain handlers incur both the benefits and costs associated with delivering grain to port within a particular time frame. For instance, if a grain handling firm can deliver grain to port before a set date, it receives what is known as a dispatch payment. However, if grain is not delivered within the time frame of the contract, in Canada a demurrage fee (on FOB contracts) is charged to the grain handling firm and is often passed onto farmers (Wilson et al. 2004). In order to get a better sense of the importance of delivery reliability, for the 2009/10 crop year, grain handling firms were paid C$6.0 million in dispatch, whereas for 2010/11, they incurred a net of C$40.6 million in demurrage fees (Quorum Corp 2012). It is for these reasons that the movement of grain across the Prairies in the post CWB era will very likely focus on reducing the risks of incurring additional delivery costs and maintaining reliability, rather than simply focusing on reducing the collective farmer costs of grain transportation.

METHODOLOGY

The scale of the problem to be solved here is large and is accomplished using appropriate software, which reduces the time and complexity of finding optimal solutions. Since this particular logistics problem occurs over a large region, our spatial data interface uses GIS software. Essentially, GIS develops an interactive transportation network map that allows the researcher to create both a visual and numerical solution for the programmed transportation problem. What follows is a basic description of the analysis and data used here, but the interested reader is referred to Gleim (2014) for additional details.

Spatial analysis begins with GIS software interpreting the relationships between spatial data layers. Layers of points, lines, or polygons, which all share the same physical coordinates are virtually stacked on top of one another and then linked together through their geographic coordinates. As information is overlaid, the map begins to take shape and various relationships can form between the different elements or properties of the layers (Scurry 1998).

One of the most widely used GIS software packages in North America is ArcGIS. The analytic portion of this research is conducted using ArcGIS optimization tools. The Network Analyst (NA) toolkit in ArcGIS solves network data problems comprising either of the fastest, shortest, closest, best routes or locations within a specified geographic region. Examples include routing vehicles to a nearest facility, identifying a particular service area for a region, or routing a set of vehicles for the delivery of goods. The transportation problem developed in this research requires a tool to optimize grain routings and minimize time costs of transport, both of which are within the capabilities of the vehicle routing problem (VRP) tool in NA.

DATA STRUCTURES

To perform a VRP within ArcGIS, data describing the transportation network and its associated constraints are needed. These data should possess three key attributes: cost, descriptors, and restrictions (ESRI 2012a). Cost attribute data are values associated with the edges and lines of the network dataset. The VRP requires a minimum of one cost attribute to solve the problem. Descriptors are information attributes that do not contain actual measurements, but other classes and properties use this information to select data for calculations. Descriptor examples are the number of lanes within a segment of highway, direction of traffic, or whether a transportation path permits a certain mode. Finally, restriction data are used to prohibit movements along a network. For example, there could be restrictions for movements around a construction site, restrictions on left turns, and limits for one-way streets. (ESRI 2012b).

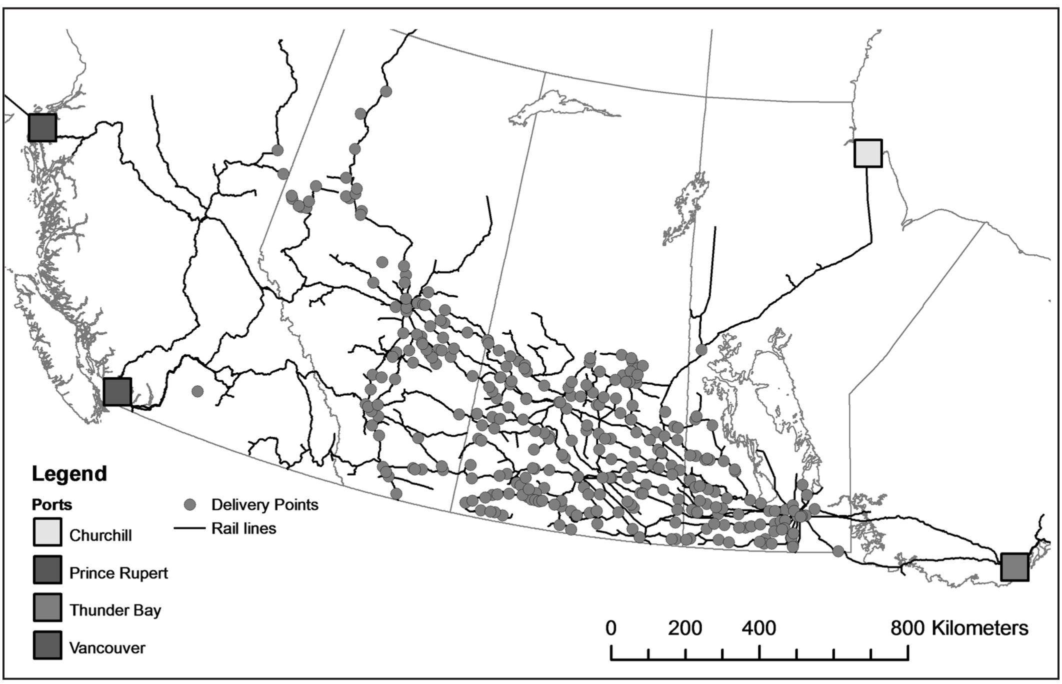
Within all GIS programs, input data layers are required and output data layers are created. In ArcGIS, the VRP can use up to 13 classes of data layers. In this research, just four layers are necessary. These are 1) orders, 2) depots, 3) routes, and 4) route zones. And from each VRP emerge a number of key outputs. These are added to the order, depot, and route layers. These solutions are descriptive results, including items like the route name to which an order point is assigned along with the sequence in which orders were picked up. Cost data are also recorded, such as the time and distance travelled between order points and the total costs of routings. By virtue of the software, these VRP results are readily converted into new visual or mapping representations to display the set of optimized solutions (ESRI 2012c).

Once the network dataset, classes, and parameters have been input, the objective function associated with the VRP can be solved. While the ArcGIS VRP algorithm is proprietary, the VRP used here observes time windows and relies on a modified travelling salesman problem (TSP) to fit the constraints of the set VRP. This means the VRP solver works in two parts. First the origin-destination (OD) matrix shortest path for cost is solved. Within ArcGIS, these paths are identified using Dijkstra's algorithm (ESRI 2013). Next, a Tabu Search (TS) is used to find an improved sequence of routes. Thus, the VRP algorithm within ArcGIS uses a combination of Dijsktra's algorithm to generate an initial low-cost feasible solution, which is subsequently checked and improved upon through iterations of Tabu search to further minimize transportation costs in order to optimize the solution of the VRP.

To construct a spatial VRP of western grain transportation, data representing demands, supplies, and networks serving grain movement are needed. The data used to build our base model were collected from a time prior to the August 2012 removal of the CWB's primary marketing function. We used monthly data from the crop years 2009/10 through 2010/11. By choosing two consecutive crop years near the end of CWB influence on logistics, our base VRP model should closely match actual patterns of supply and demand in the grain handling system. For these years, approximately 12-13 MMT tonnes of wheat alone were exported from Western Canada, which is a level close to average for the last decade (Canadian Grain Commission 2012).

Since the scale of this research problem is large and the relevant base model data and analysis covers 24 consecutive months, only essential data classes and their properties are used in order to reduce the degree of difficulty in VRP estimation. Thus, our model is built over four data classes: order points (elevator delivery points), depots (port facilities), the network dataset (railway network), and routes. We assume there are multiple order points for each month representing primary producer deliveries across Western Canada, while the four port locations receive goods over the two Class 1 railway networks. The base grain handling configuration is shown in Figure 1.

Figure 1: Model Classes and Scale



Maps were created using data from the following sources (Canadian Grain Commission, 2012b; Oak Ridge National Laboratory, 2012; DMTI Spatial, 2012; Canadian Wheat Board, 2011).

The locations reported by the CWB data become the order locations for the VRP. The data are further aggregated into a total available supply of deliveries per location. The total monthly supplies of wheat (in tonnes) for each order location account for all the wheat reported as transported by rail to the ports. Together, the CWB data and total grain tonnes reported by the CGC are combined to form the order supply location list for the VRP. Then to incorporate the deliveries of grain producers from order points, map coordinates are used to represent physical proximity to the railway network and distance from port. As constructed, the final order point data are then used by the ArcGIS VRP to solve for new routings for the 12.6 (2009/2010) and 10.9 (2010/2011) MMTs of wheat actually delivered each year in the Western Canadian handling system.

Port facilities demand wheat to fill their monthly export orders, so the ports are represented in the VRP as depots, and are the aggregated volume demanded by each port over each railway network. To account for port export demands in the VRP in ArcGIS, the same monthly CGC data on the volume of wheat moved from Prairie origins to port for export are used. As an example, in August of 2009, the CGC reported 283,384 tonnes of wheat moved by railway from Prairies to Vancouver. Thus, the export demand for Vancouver over the month of August 2009 is set at 283,384 tonnes.

The railway data used here combines the Oak Ridge National Laboratory North American railway network and CanMap railway data. The ORNL railway network has multiple link attributes for each segment of railway, including distance, track ownership, access, main line class, access control (Peterson 2003), and track type (ORNL 2012). The data from CanMAP are added to fill any gaps within the ORNL railway network (DMTI Spatial 2012). Together, the two railway data sources generate over 27,291 km of track operated in the region by Class 1 railways and 3,440 km by short line rail. The network dataset also constrains access to each track by its owner. Since the VRP utilizes time as the optimization criterion, the code was set to allow only one train to travel over a segment of rail network at a time (ESRI 2013).

In this manner, we develop a formal transportation problem that maps out modern logistics solutions in the Canadian grain handling system. Using appropriate data about the rail network and grain elevator system, we formulate a VRP and use ArcGIS and its software capability. The objective function of our new VRP for grain is to minimize the total travel time of rail routings subject to the constraints of supplies, demands, routes, network access, speeds, and space in the network. In essence, the VRP solved here minimizes the sum of commodity travel times while maximizing demand throughput.

BASE RESULTS

Considering post CWB grain logistics, we focus on developing a more reasonable, modern, and market driven grain transportation solution. With recent problems in the Canadian grain handling system, we plan to generate grain routings that no longer minimize collective freight rates (as was the case under the CWB), but instead optimize route times. Foremost, this objective seems reasonable since it will necessarily reduce risk of unreliable wheat deliveries in the system and associated charges for port demurrage. Given the existing institutions and relationships among the players in the Canadian grain supply chain, this switch of objective focus for the grain system optimization problem is more compatible with the objectives of independent profit-seeking grain companies, and also represents a move away from the collectivist farmer perspective of the CWB logistics function. In addition, since wheat is generally a comparatively low value commodity, greater benefits will likely be generated by improving system capacity utilization rather than reducing inventory costs for grain handlers and railways (Quorum Corporation 2012). The most important metric for a supply chain in this sense is whether it can provide consistent and timely delivery.

Our base model is solved using historical industry data in order to re-optimize routings and travel times for monthly grain movement. We then examine our base model results in order to determine what factors have most affected grain logistics, including identifying any constraints leading to bottlenecks and delays. This in turn will lead us to the subsequent analysis where some of these constraints are relaxed in order to re-optimize logistics in the grain transportation system.

Simulation Results and Mapping

Over the time-frame re-analyzed and simulated here, each month's grain allocations resulted in a spatial overlapping of routes to ports. The occurrence of overlapping routes results from the limited number of railway lines available and the clustering of delivery points along the Prairies. In addition, there appears to be no visible spatial allocation trend that stays consistent from one month to the next, suggesting that each monthly VRP is unique. As one final point, we find that CWB's East-West grain catchments in these months do not emerge from the optimization criterion used here. While not entirely surprising, it does show that a new grain handling system will likely generate vastly different grain logistics allocations as compared with the old CWB monopoly marketing regime.

Figure 2 is a set of maps comparing two of our new VRP solutions using minimized time travelled. While the maps are mostly similar between the two sample months in spite of the time separating the data used, we note any differences between the respective VRP allocations stem from how they treat grain located near the center of the region, a region very near to the East-West catchment demarcation enforced by the CWB. The maps generated by the VRP simulation are all very similar to these and, not surprisingly, most often vary within the central portion of the Prairies.

More formally, we need to check how well the simulation allocated actual grain demands. See Figure 3. We found that over all the months simulated, the total volume of cars allocated to port by the model met 92.7% of all wheat export demands at port. But this level of service was somewhat inconsistent. For example, during the 2009/10 crop year, the simulation generated monthly variations for fulfilling port demands ranging from 61.9% to 99.0%, while the 2010/11 crop year narrowed this variation somewhat to between 81.3% and 99.0%. Over the period studied, 18 out of 24 months possessed 90% fulfilled port demand or higher. In 2009/10 and 2010/11, port demands were met on average by between 92.3% and 94.0%. So while this is a complex and large optimization problem, the simulation model is generally able to allocate grain to port demands with a high success rate, in comparison to the actual delivery data.

One reason the model cannot route 100% of port demand in each month is caused by the distribution of supplies along CN and CP VRP solutions and routings. Wheat supplies and associated VRPs within each month are split between CN and CP, as are route demands. In the optimization problem, this process limits a CP delivery point from being picked up by a CN routing. While there are always sufficient supplies to meet the total port demands, individual port demands are distributed between the Class 1 railways (based on regulatory data). As a result of splitting port demands between CN and CP, the model often identifies greater supplies available on the CP network than demanded, while CN's port demands for several of the months are greater than the available CN supplies. In fact, CP routes were able to deliver 98.8% and 97.9% of total demands each crop year while, for example, CN in 2009/10 made only 88.2% of demanded deliveries and 91.6% the next year. We believe that the improvement of CN deliveries during 2010/11 was likely the result of better balance between elevator supply and port demands. This also indicates that improvements can be gained by a better balance of railway provider distribution and supply. The imbalance of supplies along each of the railway networks effectively creates a bottleneck, which reduces the efficiency of the simulated solutions.

Figure 2: Simulated Grain Deliveries to Port, Minimum Time Criterion, May 2010 (top) vs. June 2011 (bottom)

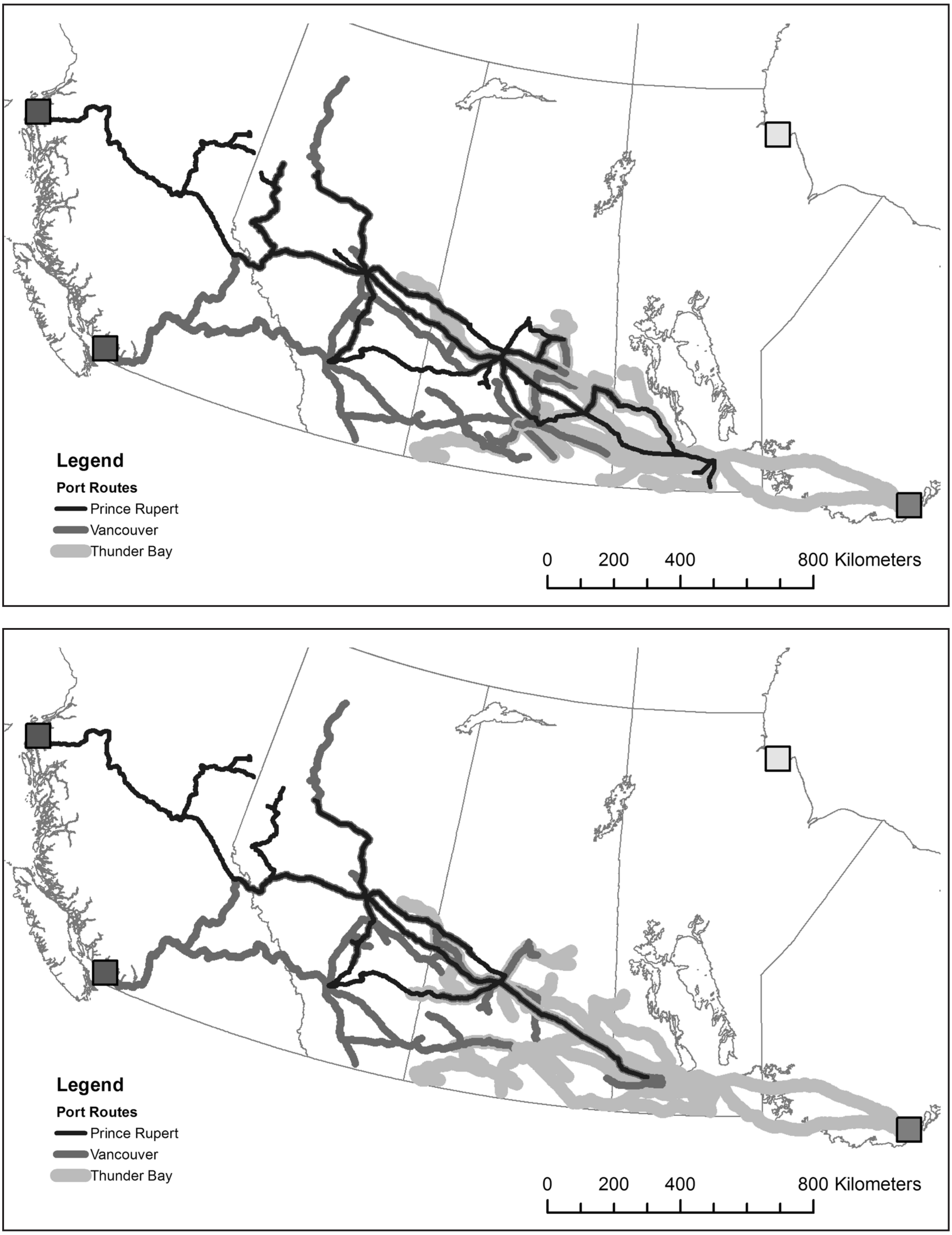
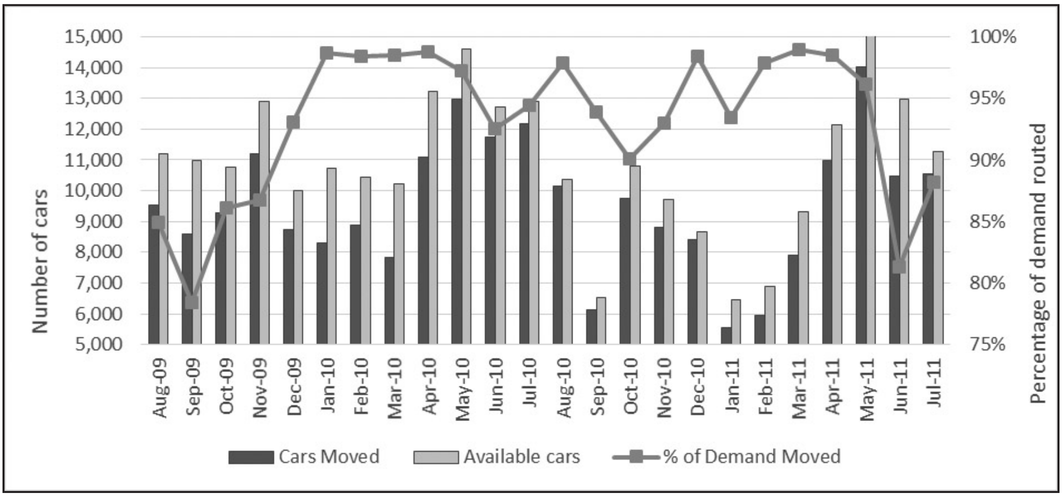


Figure 3: Tracking Simulated Rail Car Deliveries to Ports



There are other aspects of the base VRP that require further discussion. To start, the base model VRP also often showed a tendency to route grain to the ports of Vancouver and Thunder Bay over Prince Rupert and Churchill. If there was a high demand for northern (CN served) ports, the tendency of the VRP to route grain trains to Thunder Bay and Vancouver created a bottleneck in the optimization problem. Given these broad findings, there would appear to be improvements available, particularly for grain distribution on the more northern CN rail network. In addition, we allowed each solution to be created using several discrete sizes of trains, approximately corresponding to train sizes used in reality. Not surprisingly, we always found that the system VRP optimization favored larger capacity grain trains over smaller ones. In addition, the southern CP network was often optimized using all available routes, both small and large. This situation was likely due to its more favorable location within the region, meaning that large grain supplies on elevators on the CP network (coupled with smaller trains) could lead to serious inefficiencies with respect to route timing in the supply chain.

ALTERNATIVE GRAIN TRANSPORTATION SCENARIOS

In this section, we examine a couple of interesting alternative simulation scenarios using insights drawn from our base model results. They offer insight as to the future of the grain handling system in the new era in Canada of private grain marketing and logistics. For ease of exposition, each of these additional comparative simulations was only conducted for a few specific but representative months of the complete data set. See also Gleim (2014).

Scenario 1 – Larger Trains

The first counterfactual policy simulated off of the base model is referred to as the *larger trains (LT)* scenario. This is simulated to address bottleneck inefficiencies potentially created by smaller modular train capacities. This scenario alters the base model routes so as to use fewer sizes of small modular trains, and allows us to examine whether policies to increase average modular train capacities could also improve efficiencies in the grain transportation problem.

To test this, whereas the base model assumed six modular train capacities, here these are reduced to three. The three modular train capacities imposed are for 50, 100, and 150 car trains. Routes larger than 150 cars are not permitted, noting that regional siding data did not uncover any extant elevators that possessed the capacity to handle a greater train spot (Informa Economics 2012).

In fact, Canadian Pacific Railway stated in 2008 that its average grain train was 114 cars long, a level hoped to increase to 168 cars in the future (Vantuono 2011).

Given this, the scenario simulates a policy to increase average capacity of the routes. Further, we assume that 90% of routings have greater than 50-car modular trains, or that 50% of modular train capacities carry 100 cars, 40% carry 150 cars, and 10% carry 50 cars. Here, the average modular train capacity is 115 cars, compared with the base model, which carried 93 cars on average in 2009/10 and 102 cars on average during the 2010/11 simulation.

Two simple criteria allow us to compare the base and alternative LT scenarios. First, comparative route durations are shown in Table 1. Note that the LT scenario dominates the base case, especially in the total hours travelled and total distance covered categories. Overall, we see that the LT scenario delivers grain more efficiently than the base by, on average, moving loaded grain for longer durations and distances per routing.

Table 1: Overall Route Durations

	Base	Larger Trains
Total distance travelled (km)	777,848	644,712
Average distance per route	1,583	1,789
Total hours travelled	14,118	11,356
Average hours per route	28.5	31.4
Average car pick-up (minutes)	22.5	18.1

The next criterion measures the ability of the scenario to meet port demands. Table 2 shows how each scenario performed using this metric. The base scenario was only improved upon by about 0.5% as compared with the LT scenario. But it is worth pointing out that other simulated scenarios performed much worse than LT at meeting demands, compared with the base (Gleim 2014).

Table 2: Model Demand Deliveries Routed

	Base	Larger Trains
Cars Moved	38,001	38,059
Cars Demanded	43,270	43,270
Demands routed (%)	87.8%	88.0%

Scenario 2 – Greater Grain Volumes

This section addresses concerns about future increased grain movements in the system. A very basic grain transportation scenario is developed and optimized consisting of higher supplies and demands than exist in the data. As motivation, recent statements by the government of Saskatchewan concerning the growing issue of food security imply that agronomists expect average grain yields in the province to at least double over current levels by the year 2020.

For the hypothetical scenario, wheat demands and supplies are doubled. In fact, this level approximates the actual volumes moved over the past few months in Canada (2013-2014) with a bumper grain crop. The effects of such higher grain volumes are evaluated using both the base model (HVB – see Figure 4) as well as the large trains policy (HVLR). For tractability, the results of the hypothetical higher volume simulation do not account for any changes that increased supplies or demands of other agricultural commodities may have on the grain transportation problem. The exercise will demonstrate whether there is enough capacity in the rail system in the face of potential increased grain transportation demand.

Figure 4: High Grain Volumes, Base Model (HVB), May 2010

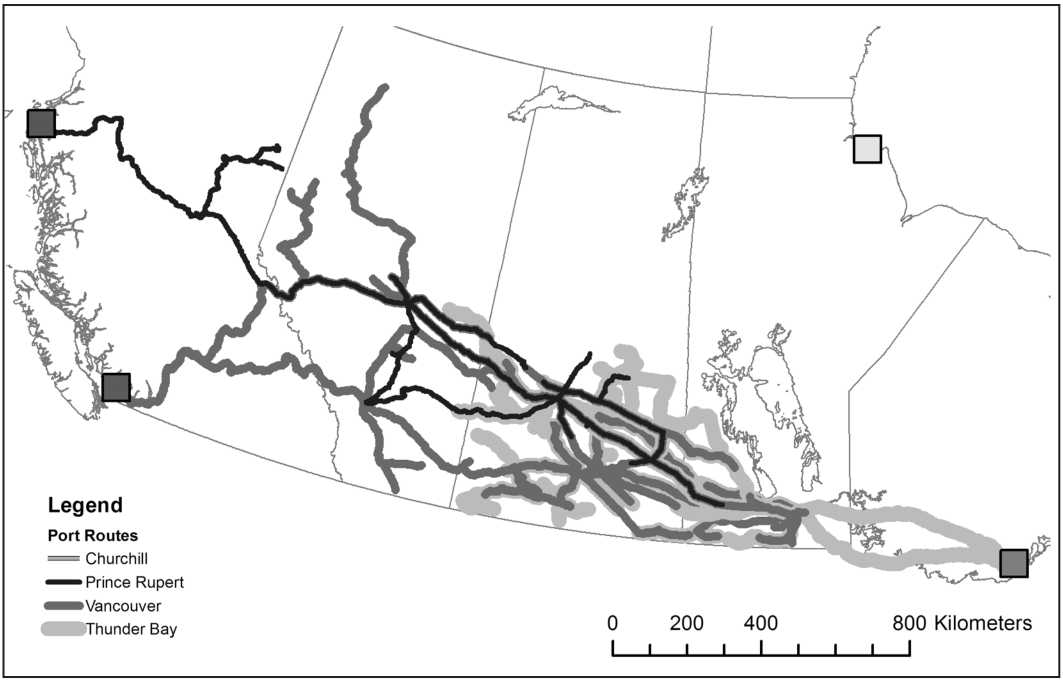


Figure 4 shows grain train routings under the high volume base scenario, and the reader should also compare this to the upper map in Figure 1. Results of specific performance metrics in this scenario are shown in Table 3. Again, note that these simulations were only conducted for a single representative month (May 2010), so the actual metrics listed in the table are somewhat different than those listed in previous tables. We tracked performance metrics under both base and LT scenarios, each simulated with doubled grain volumes over the entire system.

Examining the base scenario in this case, we find that transportation efficiencies are actually improved with greater grain volumes. For example, route capacities are improved to close to 100% efficiency. More importantly, to future agricultural policy considerations, we find that the LT policy under larger volumes (HVLT) does not seem to restrict the efficiencies generated by our logistics solution. Table 3 shows that these scenarios generated shorter, quicker routes under the high volume LT policy. Staying mindful that we did not model other commodity movements in this analysis, we offer that contrary to current public statements by the railways, it appears that the current Canadian grain transportation system is not at capacity and that the system could realistically accommodate additional wheat movement. Finally, we note that the HVLT policy in particular led to greater use of the port of Prince Rupert, extending routes serving Prince Rupert much farther East than under the base scenario. This finding supports a general feeling in the system that Rupert is currently underused relative to its grain handling capacity compared with the other ports.

Table 3: System Efficiency Metrics, Double Grain Volumes Transported

	Base	High Volume Base (HVB)	Larger Trains (LT)	High Volume Larger Trains (HVLT)
Cars routed	12,971	26,116	13,002	26,106
Cars demanded	13,337	26,674	13,337	26,674
Demands routed (%)	97.3%	97.9%	97.5%	97.9%
Efficiency of routed capacity	98.6%	99.5%	99.3%	99.4%
Total KM	228,673	594,633	224,900	447,460
Change (%) [a]	-	106%	-	99.0%
Total hours	5,231	10,228	3,939	7,688
Change (%) [b]	-	95.5%	-	95.2%
Average car pick up (min)	24.2	23.5	18.2	17.7

[a, b] Measures the increased totals as a percentage from the original simulation (base or larger trains).

CONCLUSIONS

The grain handling system in Canada is undergoing significant change. It was the goal of this research to examine the nature of changes that might occur under new organizational structure in grain handling and transportation. Using historical monthly data on wheat supplies and demands through the 2009/10 and 2010/11 crop years, we simulated both base and alternative optimized transportation allocations of wheat across Western Canada. Compared to reality and a very different logistics criterion, the base simulation outcomes were found to be efficient.

The base transportation model simulated novel grain transportation re-allocations using actual grain system data. The nature of the analysis meant that alternative scenarios could be created and simulated as variations on the simulated base solutions. Effectively, these were done to better understand system bottlenecks while potentially improving those solutions generated by the base transportation scenario.

These latter simulations showed that while the base model did a good job finding a good feasible solution for grain logistics, in particular, the larger trains (LT) policy improved system logistics allocations over the base results and also reduced effects of system bottlenecks. In effect, this latter policy resulted in greater hopper car turnover, marginal increases in deliveries, as well as enhanced route capacity efficiencies. Within the current and evolving grain transportation system in Canada, we were able to confirm that larger capacity unit grain trains will certainly improve overall grain logistics efficiency.

The second set of hypothetical simulation results were done to address concerns about future grain transportation volumes to be exported with respect to rail network capacity. In contrast to continued public comments made by the Canadian railways about capacity concerns in their networks, we find that even if double current typical volumes needed to be moved, rail capacity issues should be not a concern with respect to the future movement of grain.

Overall, relying on the assumption that grain handling companies will want to minimize transport time rather than the cost to transport grains, we showed that efficient grain routes over rail will become larger in capacity and move greater distances. Longer routes will occur between locations, which will need to perform quicker loading or handling services for a grain train. Ultimately, our findings confirm that the preference of Canadian Class 1 railroads will be to move grain almost exclusively along their main corridors, forming a so-called "pipeline" model for commodity movement. Not surprisingly, something akin to this situation was observed during the recent (and controversial) 2013 harvest, where limited routes available for grain moved almost exclusively along mainline track of either CN or CP (Cross et al. 2014 and Franz-Warkentin 2014).

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