THE CANADIAN GRAIN HANDLING SUPPLY CHAIN IN THE POST CANADIAN WHEAT BOARD ERA

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ABSTRACT

We explore firm behavior in the evolving Canadian grain handling sector. The current grain supply chain for grain is characterized by regulatory shifts in one portion (rail) and full deregulation in another portion (grain handling). Using several models of market structure, we offer that the current system is likely hovering near a tipping point in market power for the grain companies. This situation is in part driven by the potential for future deregulation of the railways, along with recent severe production shocks in the supply chain.

INTRODUCTION

Canada's grain production is concentrated in the northern prairie region of North America. Distances in the Canadian grain supply chain are extreme, so it is very reliant on rail for transportation. The grain industry in Canada moves a considerable amount of grain. Canada is expected to export about 39.7 million metric tonnes (mmt) of grain for the 2016/17 crop year (1).

The difference between the export price at port position and an average Prairie grain elevator price (i.e. the "spread") is known in Canada as the (export) basis. Basis measures how much producers pay to get grain to port; the lower the basis, the better for farmers. Export bases for both wheat and canola in Canada are estimated by the Quorum Corporation, acting as a monitor of the grain handling system serving the Federal government.

At the end of the 2012/13 crop year, Quorum reported that the export basis for wheat was around $54/t (2). However, by 2013/14 with a record grain crop being harvested, the wheat basis ultimately increased to $133/t, a level never before seen. This basis level and the consequences of it on the viability of the system led to a snap review by the Canadian government. This led to temporary regulations in the system as overseen by the Minister of Agriculture and Agri-Food, including short term car spot requirements as well as adjusted regulations to encourage rail competition for grain moves (3).

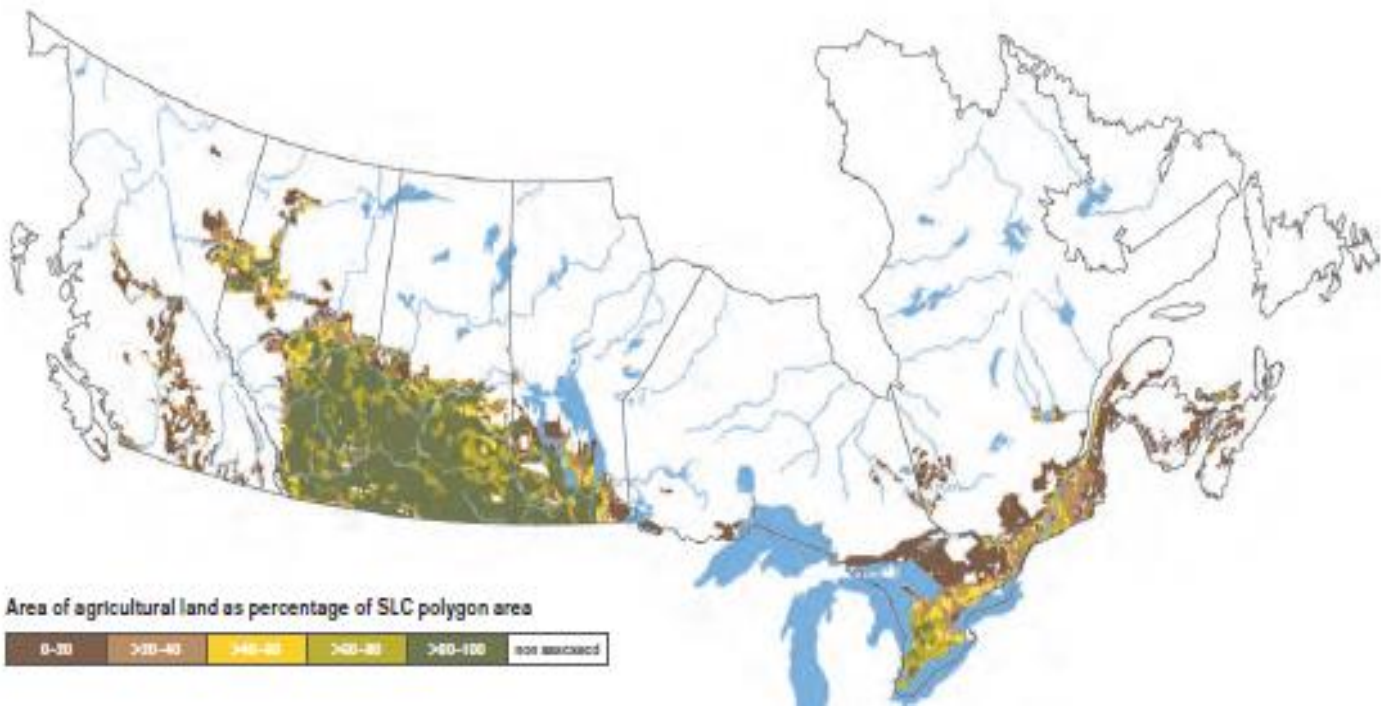
The Canadian grain supply chain remains in major transition. A recent study suggested a competitive outcome was achieved in the system over the transitional 2012/13 crop year, but subsequently the system transitioned to a near cartel by 2013/14 (4). We analyze these markets by modeling grain supply and demand relationships. Then we assess some game theoretic constructs that could be applicable to the system, discussing these implications in the long run.

MOTIVATION AND INDUSTRY BACKGROUND

The dominant participants in Canada's grain supply chain are farmers, grain companies, railways, and finally grain companies (normally the same set of firms who buy grain on the Prairies) who market Canadian grain to export buyers. About 82% of Canada's crop land is located in the three prairie provinces of Alberta, Saskatchewan and Manitoba (see Figure 1). By far the largest share of agricultural exports (76%) come from wheat and canola grown on the Prairies (1). Large demand for grains and oilseeds from Asia means much of the crop moves into export position through the port of Vancouver. Table 1 lists the shares of interior primary elevator capacity in Canada, as well as port terminal capacity in the primary port of Vancouver.

About 70,000 farms earn at least some of their income from grain and oilseed sales (6). Recent data show that in Alberta, Saskatchewan and Manitoba, the average farm size is about 473, 675 and 460 hectares respectively (7). For example, a typical (Manitoba) grain farm has variable costs of about $496 per hectare for wheat, with average yields of about 3.7 tonnes per hectare (8). Farmers plant seed and fertilize in the spring, control weeds and irrigate (if available) in the summer and harvest grain in the fall. Most of the grain harvested goes into on farm storage and is later moved (by truck) once sold from the farm to the elevator.

Figure 1. Agricultural Land in Canada (5).



Three large grain companies (Viterra, Cargill and Pioneer) dominate Canada's primary grain elevation, as well as terminal elevation in the port of Vancouver. As the largest grain company in Canada, Viterra has emerged from several decades of mergers and acquisitions among Canada's former farmer owned grain cooperatives (9).

Table 1. The Canadian Grain Handling Sector (4)

Canadian Grain Exporters	Primary Elevator Capacity (000 t)	Vancouver Terminal Capacity (000 t)
Cargill	681.8	237
Louis Dreyfus	377.6	0
P & H	548.2	25*
Patterson	544.5	25*
Pioneer (RI)	1449.7	108 and 71**
Viterra	1812.0	136 and 212**
All Others	1050.5	50*

Two Class 1 railways (Canadian National, CN and Canadian Pacific, CP) operate within the grain supply chain, with just a few short line railways still in the region (10). See Figure 2. Both railways also have major hubs in Winnipeg, Manitoba to move grain into the Great Lakes port of Thunder Bay. This latter grain is moved though the Saint Lawrence Seaway and often transships through the port of Montreal for movement into the Atlantic Ocean. While both CN and CP have access into the port of Vancouver, CN has sole access to the port of Prince Rupert, a more remote Western grain terminal that is jointly owned by major grain companies.

Figure 2. Railway Network of Western Canada (11).

REGULATORY ISSUES IN THE CANADIAN GRAIN HANDLING SYSTEM

As part of the set of incentives to encourage individuals to settle western Canada in the late 1800's, a guaranteed "Crow Rate" was negotiated between the new Canadian Pacific Railway and the Federal Government of Canada (10). This fixed low rates for grain and settlers' goods in exchange for mineral rights in the Crow's Nest Pass in the Rocky Mountains. The Canadian National railway was formed by the government as a crown corporation in 1917. CN also had to offer low rates for grain movement, so the Crow's Nest Pass rates were made statutory, by 1925 applying to all Canadian railways. These statutory rates were gradually eliminated through regulatory reforms in 1985 (the Western Grain Transportation Act); 1987 (the National Transportation Act); 1995 (Canadian Transportation Act) and finally again in 1999 (as an amendment to the Canadian Transportation Act).

A rate cap for grain movement was applied as part of the 1996 Act for grain grown in Western Canada. Under the rate cap, the maximum allowable rates for export-bound grain were prescribed according to distance. While the cap was structured such that freight rates could theoretically be set freely below the cap, upwards of 90% of rates under the rate cap regime were set at the maximum allowable level (12). The major impact of this regulatory regime was that an average grain haul cost shippers more than twice as much as under the former Crow regime.

In June 2000, Bill C-34 became law. This was a modification of the extant Canada Transportation Act, stemming directly from an extensive system review process. Recommendation 7 from that review recommended removal of the rate cap policy to be replaced with some form of regulation on railway grain revenues. In effect, Bill C-34 replaced rate regulation with a policy known as the maximum revenue entitlement (MRE). As designed, the MRE policy was intended to offset railway market power but also give the railways more pricing flexibility than under the rate cap.

The MRE is a novel regulatory policy in transportation. It is effectively a cap on average revenue per tonne for grain movement while allowing some price discrimination. The novelty of MRE meant that it took some time for railways to fully understand how to make it work to their advantage (13). But foremost, what was clear to the railways under MRE was the need to continually identify cost reductions in grain movement in order to sustain or grow profitability. Under the MRE regime, Canadian railways turned to new mechanisms to create cost efficiencies and generate greater profits.

One of the first such mechanisms was the development of grain car bidding programs, similar to the Advance Ordering Systems or AOS developed in the US (13, 14). However until very recently and for several reasons, grain bid car schemes have been put on the backburner in Canada. Bid car programs are still used extensively for grain movement in the US, but with no revenue regulation.

Another method for generating cost savings in the MRE era has been the development of unit trains for grain movement. If a shipper can assemble large volumes of grain, this can result in a very cost efficient use of locomotives and crew. This engineering-based cost saving is why railways began to offer reduced freight rates for 50 and 100 car blocks of grain cars. In addition, both major Canadian railways continue to offer "shuttle" discounts, defined as long trains that move as a unit from a single delivery point to export position and back again. All of these discounts typically fall somewhere between 5 to 20 percent of what would be charged on a reference standard single car quoted rate.

Rate discounts represent some sharing with shippers of cost efficiencies associated with assembling a unit train. However, because under the MRE average freight rates for a given year do not change, smaller shippers delivering fewer grain cars often pay higher rates, effectively offsetting lower rates to larger shippers who can deliver more grain cars. Judging by their continued use, under MRE large unit train incentives remain important to rail operations and grain transportation planning.

No matter how long the MRE remains in place, it has forced the railways to seek additional cost economies, generating incentives to assemble large unit grain trains. What is not well established at present is the total amount of logistics and transportation cost savings a railway obtains from by moving unit trains, and by extension, what portion of this total cost saving is passed on to other participants in the supply chain.

Another major regulatory intervention in Canada's grain supply chain was the Canadian Wheat Board (CWB). The CWB was created in 1935 to coordinate wheat and barley marketing/movement for Canada (9). From 1943 to 2012 the CWB was the 'single desk' marker of Canadian wheat and barley for export or domestic human use. The CWB was never allowed to curtail farm production and operated as a non-profit, and some of the justification for the CWB came from its ability to price discriminate to major buyers of Canadian wheat.

In the act that created the single desk regime in Canada, the stated purpose of the CWB was 'orderly marketing' (9). The CWB was given wide powers within the supply chain including managing public owned rail cars, calling grain into specific train corridors and negotiating elevation and rail rates with grain companies and railways. For an overview of the latter, as well as an examination of the broad role of the CWB in rail service negotiations and movements, see (15).

The summer of 2012 was a fortuitous time to remove the CWB from the supply chain. The relatively small 2012 grain and oilseed crop led to real competition between grain companies and railways for services. So at that time, the export basis was narrow, meaning high export prices and farmers being offered near record prices for grain.

THE EVOLVING CANADIAN GRAIN SUPPLY CHAIN

Previous academic work on the CWB and the grain supply chain often focused on the value of price discrimination by the CWB among the buyers of Canadian wheat and barley. While some researchers found evidence of market power exercised by the CWB (16, 17, 18, 19), others found no evidence of any gains, with possibly increased costs to the sector stemming from the actions of the CWB (20, 21).

Regarding grain supply chain logistics in Canada, there are few published studies describing the role the CWB played in bargaining for transportation services with grain companies and railways. Some unpublished work (22) modeled this bargaining process but with an assumption of deregulated railways, while others have modeled the Canadian grain sector as an oligopoly (23). All of these papers assumed the CWB single desk was active or used data collected prior to its dissolution. Research on bargaining in this supply chain most often used a competitive model without allowance for significant market power. One recent study has modeled the sector without the CWB in the supply chain (24). The latter argues that under reasonable conditions, considerable market power would always be exercised by the railways in the supply chain.

To link our analysis of the effects of regulation in one sector (rail and the MRE) with deregulation in another sector (grain handling), we note that some theoretical work assessed the usefulness of an average revenue cap as a regulatory policy, mostly within utility deregulation discourse in the UK through the 1980s (25). This discourse offered mixed reviews of the effectiveness of average revenue regulation over other forms of utility regulation, like price caps.

As regulation on grain transportation in Canada, the MRE calculation is made each year and tied to the revenues actually earned on grains and oilseeds movements by Canada's two major railways. As an index style calculation, MRE uses a base year, with adjustments made for the average distance grain is actually transported as well as changes in rail costs. MRE is computed using the following formula:

$$m_{ti} = \left[\frac{a_i}{b_i} + (g_{ti} - d_i) \times k\right] \times e_{ti} \times f_t \qquad [1]$$

Where: m_{ti} is the maximum revenue entitlement for firm *i* for crop year *t*; a_i and b_i are the base revenues and tonnes hauled for firm *i* in 1999/2000; g_{ti} and d_i are current year *t* and base average

distance hauled for firm *i*; k is a constant derived from base costs of transporting grain longer average distances; e_{ti} is the number of tonnes moved in year *t* by firm *i*; and f_t is a cost adjustment factor for the current year *t* that accounts for price changes across a range of major inputs used by the railways.

According to (26), average grain haul distance has not changed significantly since the implementation of the MRE, so we conclude there have been no systematic changes to move grain longer or shorter distances on average. There have been significant adjustments to the cost factor in the calculation, but this part of the calculation is beyond the control of the railways. For these reasons let us ignore the terms g_{ti}, d_i, k and f_t in the following discussion. To operationalize the MRE as a constraint to a monopoly railway, m_{ti} can be interpreted as a constraint on the profit maximizing firm. We will assume only two grain companies supply the railway and they generate different costs. In the base year, average rates to move grain were fixed by the federal government and the volume moved by the grain companies were part of car allocation schemes managed at that time by the CWB. Thus the individual railways profit maximization can be described as choosing optimal amounts sourced from either of two shippers (grain companies 1 and 2) with different cost structures:

$$\begin{aligned} L_{ti} \quad &= \frac{p_{1t}q_{1t} + p_{2t}q_{2t}}{q_{1t} + q_{2t}} - c_1 q_{1t} - c_2 q_{2t} \\ &+ \lambda_m \left(\frac{p_0 q_{10} + p_0 q_{20}}{q_{10} + q_{20}} - \frac{p_{1t}q_{1t} + p_{2t}q_{2t}}{q_{1t} + q_{2t}} \right) + \lambda_q \left(\bar{q} - q_{1t} - q_{2t} \right) \end{aligned} \qquad [2]$$

Where: L_{ti} is the Lagrange value function for firm *i* for crop year *t*; p_{jt} and q_{jt} are the prices and quantities for the grain shipper *j* in crop year *t* and base year is equal to 0, λ_m and λ_q are the shadow values of the revenue cap and the fixed supply of grain to haul ($\bar{q}$) and c_j is the cost to the railway of shipping from grain company *j*.

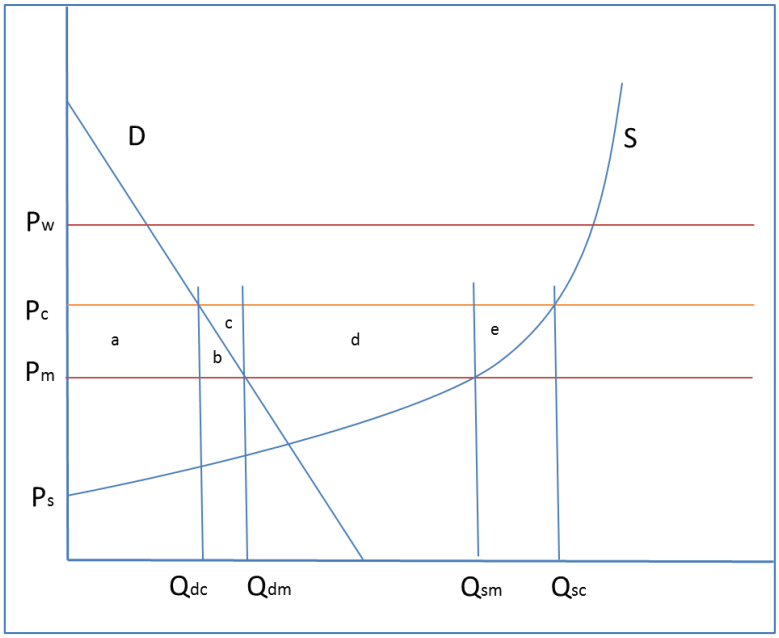
Note that if the costs are fixed for each shipper and $c_1 \succ c_2$, the constrained profit is linear and maximized when all of $\bar{q}$ is shipped to the lower cost shipper (#2), and the price of rail services is the same as the base price p_0.

Given these broad railway incentives associated with the MRE policy, it is important to note that while the role of the former CWB in grain handling and transportation was significant, in fact very little academic research formally analyzed their potential contribution as a "countervail" to both railway and grain company behavior. In this section, we motivate other models to better understand the role played by the CWB in the supply chain.

Grain companies are now playing a more significant role. It has been suggested that grain companies in Canada have now priced their services in the post-CWB era at near cartel levels (4). This situation is illustrated in Figure 3. Pw is the world price available at the port, while Pc is the price offered to domestic producers if the internal market chain is competing or free of regulatory distortions, and is equal to Pw less the cost of moving goods through the chain. Pm is any price offered by handlers that is lower than the world price, less their real costs. The difference between Pc and Pm is a measure of

competition. D accounts for domestic demand and S is driven by the producers supply. In the grain trade, the difference Pw and Pm is the export basis. Any increase in the area d may be a gain to grain companies at a cost to farmers.

Figure 3. A Market with Trade and Imperfect Competition in Intermediary Services



While indicative, other models also offer insight into the current situation. The CWB did sometimes advertise itself as a countervail against the market power of railways (27, 28). Therefore we next evaluate the former CWB's ability to bargain with grain companies and railways in order to mitigate market power over farmers.

Related work on coal markets provides motivation for this extension (29). Wolak and Kolstad argued that interaction over division of market power between states (who charge taxes) and railways (who charge rates) in US coal movement is a rent-seeking game in which each player optimizes their choice of decision variable and extracts the maximum rent from the coal market. This interaction could manifest in a number of state/railway coalitional structures, each of which can be represented by imputations derived from a Shapley value computation.

Assuming the Canadian grain supply chain evolved as a cooperative game in this economic sense, we will measure relative market power over historical Canadian grain handling and transportation allocations between the CWB and the railways. We compute a set of Shapley values over potential grain industry revenue to measure the relative strength of each player in a cooperative supply chain game.

ASSESSING RELATIVE MARKET POWER IN THE CANADIAN GRAIN SUPPLY CHAIN

Using industry level cost and production data from 2000-2015, we can compute Shapley values for the grain supply chain. These computations help us evaluate whether or not grain companies now act as oligopolists, as well as assessing how much of a role the CWB played in countervailing any market power asserted by the other major players in the supply chain. On a normative level, these

findings will shed light as to whether or not recent policies enacted in the grain handling sector have been appropriate for ensuring that farmers get a "fair" share of rents that accrue to the grain supply chain.

Table 2 lists relative shares of export values from 2000/01 to 2014/15. We are assuming that the CWB is one player in a supply chain game, with the railways and grain companies also attempting to manipulate grain movement and handling services. Note how the MRE era has seen rail rates relatively static over time, while the grain companies have seen their relative value shares grow, especially since the CWB left in 2012. Revenue division in the system changed over time because system participants altered their behaviour over time.

Table 2. Approximate Shares of the Export Price of Wheat, 2000 to 2015[1]

Average rates	Rail Rate	Grain Co	CWB/Farmer
2000-2001	$ 25.8	$ 28.8	$ 154.8
2001-2002	$ 25.3	$ 27.6	$ 167.3
2002-2003	$ 24.5	$ 26.4	$ 198.3
2003-2004	$ 25.7	$ 31.4	$ 160.3
2004-2005	$ 25.9	$ 29.6	$ 152.3
2005-2006	$ 27.9	$ 34.0	$ 141.2
2006-2007	$ 29.8	$ 33.4	$ 156.0
2007-2008	$ 28.2	$ 39.4	$ 314.3
2008-2009	$ 30.9	$ 35.8	$ 253.1
2009-2010	$ 28.8	$ 37.1	$ 181.1
2010-2011	$ 30.6	$ 42.8	$ 286.2
2011-2012	$ 31.4	$ 43.4	$ 268.4
2012-2013	$ 34.0	$ 19.5	$ 275.3
2013-2014	$ 33.6	$ 98.8	$ 194.7
2014-2015	$ 35.3	$ 88.9	$ 199.2

GRAIN INDUSTRY DATA

As evidence of market power exertion, Equation [2] also suggests that under the MRE, the supply chain should ultimately abandon more costly shipping points. Rail line abandonment began under the former WGTA, but shifts in the sector that have occurred between the 1999/2000 crop year and 2014/15 are notable (26). For example, there have been:

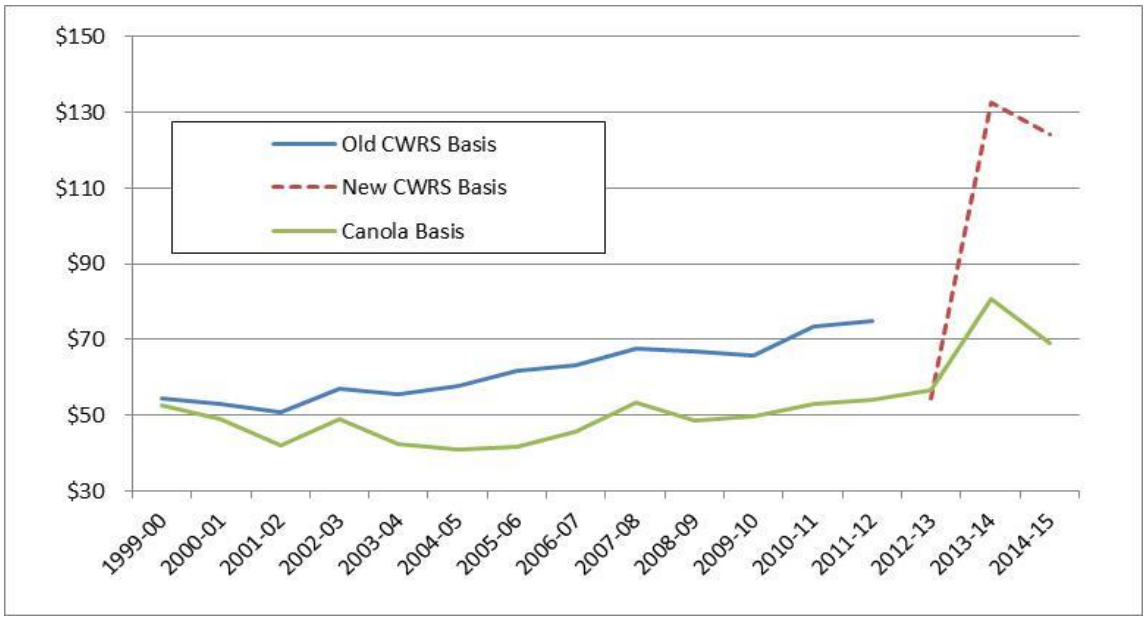
- 67% reduction in primary elevators in Western Canada, from 976 to 326 elevators
- 1% increase in total storage capacity of all elevators, from 1.60 to 1.64 million tonnes
- 38% increase in turnover rate for the primary elevators, from 4.8 to 6.6 turns
- 98% increase in turnover rate for terminals, from 9.1 to 17.1 turns
- 67% increase in share of grain car rail movements in lots over 50 cars, from 50.4% to 84.2%
- 147% increase in total volume moved by rail, from 12.9 to 31.9 million tonnes

[1] Sources: Canadian Transportation Agency revenue cap data (various years), Quorum Corporation reports (various years).

- 111% increase in average incentives for 50 or more car movements, from $3.54 to $7.47/tn.

The base data also provides evidence that the grain supply chain is far more efficient now than before, meaning it must be substantially less costly now to handle and move grain. But who has benefitted from those cost savings? See Figure 4. The export basis has generally increased over time (26), but note that in the first year without the CWB, 2012/13 saw a drop in the wheat basis. However, we note this was also the year whereby the method used for basis calculation (by Quorum) changed. Keeping this in mind, the last two reported years of data generated significant increases in the basis, to the detriment of farmers in the supply chain. Given the grain volumes transported in those years, these changes and shifting revenues amounted to over C$2 billion in 2013/14.

Figure 4. Export Basis for CWRS Wheat and Canola, Western Canada



As is well known, the 2013/14 crop year was a significant challenge to North American grain supply chains, with a record supply of wheat and canola. Total supplies of grains and oilseeds in western Canada increased 34% and ending stocks increased 163%. Some argue this is why the basis increased by 148% over the previous year. But we note that during the CWB era there was a similar record supply shock in 2008, where that year saw a 24% increase in output over the previous year and a 68% increase in ending grain stocks. As shown in Figure 4, the export basis for 2008/09 actually fell for both wheat and canola. But in effect, this comparison is further evidence that the 2013/14 crop year was one characterized by significant rents garnered by the grain companies. To this end (30) has developed a case that grain companies made significant profits that year at the expense of other players in the grain supply chain.

MARKET POWER AND THE SHAPLEY VALUE

To assess the potential for participants to exert market power in the grain handling and transportation system, we compute a Shapley value for our three key participants. The Shapley value yields a “fair” division of a good or outcome based on the marginal contribution of individual players to various sub-coalitions that could be formed from the overall cooperative game among the players (31, 32). In effect, the more value any individual player adds to the payoff of a given coalition, the higher their

relative position within the game and the greater their individual Shapley value. Formally, the Shapley value for an n-player cooperative game is computed in the following way (33, 34);

$$Shap.\ Val. = \Sigma\ \zeta_n(S)[\ \upsilon(S\ U\{i\}) - \upsilon(S)] \quad [3]$$

where $\zeta_n(S)$ is a weighting factor representing the likelihood that one of the players joins existing coalition S and $\upsilon(.)$ is a general value function, defined by the specific game payoffs. The second term in the Shapley computation is the marginal contribution to the value of the coalition which includes the *ith* player to the coalition formerly defined by S (excluding player *i*, by definition). The weighting or probability factor $\zeta_n(S)$ is essentially a combinatorical representation of how an n-player coalition can be formed. This weighting factor is;

$$\zeta_n(S) = [(s!\ (n-s-1)!)/n!] \quad [4]$$

The data from Table 2 are used to compute Shapley values among supply chain participants. We calculated vertical shares of export values in the grain supply chain. We note that in a system where each set of firms relies on the same volume moving through a vertical chain, Shapley values will ultimately collapse into the vertical share of the final price. But knowing this, if we assume that a type of cooperative game is being played among the industry participants over grain export values, our computed share value does indicate the relative coalitional strength of each participant in the supply chain.

Table 3. Vertical Shares of Total Export Values for Wheat (f is for farmers without CWB)

Crop year	CWB	Railways	Gran Co.
2000-2001	0.74	0.12	0.14
2001-2002	0.76	0.11	0.13
2002-2003	0.80	0.10	0.11
2003-2004	0.74	0.12	0.14
2004-2005	0.73	0.12	0.14
2005-2006	0.70	0.14	0.17
2006-2007	0.71	0.14	0.15
2007-2008	0.82	0.07	0.10
2008-2009	0.79	0.10	0.11
2009-2010	0.73	0.12	0.15
2010-2011	0.80	0.09	0.12
2011-2012	0.78	0.09	0.13
2012-2013	0.84f	0.10	0.06
2013-2014	0.60f	0.10	0.30
2014-2015	0.62f	0.11	0.27

Table 3 lists the (normalized) Shapley values as vertical shares of the export price. Some points about these values are of interest. To start, it seems as if the CWB possessed greater coalitional power in this market than any of the other players, during their existence. While it also appears that farmers have retained significant market power over the most recent two years, we also see a significant shift

in coalitional strength from farmers to the grain companies. This finding is even more important noting that farmer share can be further parsed into their input suppliers (often the grain companies). Here, we also note that (8) reports current on farm grain operating costs are about 60% of wheat prices.

Given the goals of the MRE policy, railway market power in the grain supply chain has clearly been limited by the MRE. Railway share values in the supply chain over the interval consistently fall between .08 and 0.14, considerably lower than the other players. We note that the transition away from the CWB appears to have had little impact on the railways in this supply chain. In effect, the major effect of the policy change seems to have been the sharing or division of system rents between farmers and the grain companies.

While it is not clear theoretically what Shapley value is necessary to pass judgment as a dominant player in the supply chain (35), it seems grain companies are at a point where further consolidation will continue to buttress their position in the supply chain, potentially allowing them to garner even more rents from within the system. And prior sections show that what happens with rail regulatory policy will certainly affect their ability to do this. How the supply chain will evolve moving forward remains a major policy question in Canada.

CONCLUSIONS

Several relevant factors have been necessarily left out of this discussion. For example, large increases in the export basis could have been driven by higher storage costs, but with little changes in overall storage capacity on the Prairies, there is historical evidence that the record turnover through the elevators in 2013/14 should have been associated with decreased average costs as occurred in 2008/09. More data on actual firm level costs as incurred by the railways and the grain companies would clearly improve our understanding of the changes occurring in the system.

Our evidence on the relative share of market power exercised by the CWB and railways suggests that the CWB had significant countervailing market power in the supply chain. However, the implication of the CWB's coordinating role in grain movement is less clear. With the rise of canola and other crops, the CWB was involved with a smaller share of all movements in terms of foreign sales but maintained a historical influence on car allocation and elevator returns. Some evidence of this shows up in the very tight export basis of the 2012/13 crop year, suggesting efficiency gains due to removal of the single desk.

The grain companies also seem to have maneuvered so as to shift system rents from farmers since the removal of the CWB. If grain industry consolidation continues, the former coordinating role of the CWB in grain car allocations and foreign shipping logistics might ultimately be assumed by just one or two of the current grain companies. As (36) notes, repeated rent taking from market intermediaries will eventually reduce farmer investments and lead to a supply reduction or may trigger new entrants and erode system rents.

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