Bringing in the Sheaves: Changes in Canada's Grain Supply Chain Through the Post Canadian Wheat Board Era

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Vast distances in the Canadian grain handling system means that the supply chain is highly reliant on rail transportation. After years of relative stability, the grain supply chain has recently undergone many significant changes, including deregulation in grain handling. However, the consequences emerging from some of these changes were unexpected. In this paper, we explore the evolving behavior of participants in the increasingly liberalized Canadian grain handling supply chain. The changes seem to be creating new winners and losers in the system. To this end, we find that while current railroad regulations in Canada have led to efficiencies, deregulation of grain handling seems to have generated gains for grain companies at the expense of farmers.

INTRODUCTION

Canada's grain production is concentrated in the northern prairie region of North America. Distances in the Canadian grain supply chain are extreme, meaning that the system is very reliant on rail for transportation of grain. And the industry moves a considerable amount of grain. For example, Canada is expected to export about 40 million metric tonnes of grain in the 2016/17 crop year (AAFC 2016).

In Canada, grain farmers pay for transportation. So by industry definition, the difference between the export grain price at port position and an average prairie grain elevator price is referred to in Canada as the export basis, or simply "basis." As calculated, the basis is used by industry to estimate how much farmers pay to move their grain to port. The lower the basis offered by grain companies, the more farmers are incentivized to move grain into the system, while a high basis does just the opposite. The basis estimates serve as a broad metric of how the system is operating and is critical to farm level decision making. Export basis for both wheat and canola is currently estimated by Quorum Corporation, a private company currently serving as a data monitor for the grain handling system.

The 2012/13 crop year was the first crop year after the cessation of the historically important single desk marketing function of the Canadian Wheat Board (CWB) in Canada. Quorum Corp reported that the export basis for wheat was around $54/t (Quorum 2015). But by 2013/14 and a record grain crop being harvested, the Canadian export wheat basis eventually grew to $133/t, a level never before seen in Canada. This situation and its consequences regarding the overall viability of the grain supply chain prompted a review by the Canadian government. This review led to temporary new regulations in the system, including short-term car spot requirements for railways, as well as modified regulations designed to promote more inter-railroad competition for the movement of grain (Nolan and Peterson 2015).

The Canadian grain supply chain remains in major transition. We explore the past, present, and future viability of participants in the Canadian grain handling sector. To this end, a recent study suggested a nearly competitive outcome was achieved by the system over that 2012/13 crop year, but subsequently the system transitioned to a near cartel by 2013/14 (Brewin 2016). Why did this happen? Who did it affect? We analyze these markets by modeling explicit grain supply

and demand relationships. Subsequently, we develop some game theoretic constructs that may be applicable to help understand the system and its subsequent evolution, and then we highlight the implications of our findings for the long run.

THE CANADIAN GRAIN SUPPLY CHAIN

The major participants in Canada's grain supply chain are farmers, elevator companies, railways, and terminal port operators (where the latter are mostly the same set of firms who buy and process grain on the prairies), all marketing 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). Wheat and canola are by far the largest share of agricultural exports (76%) from the prairie region (AAFC 2016). Due to growing demand for grains and oilseeds from Asia, much of this crop moves into export position through the West Coast port of Vancouver.

For exposition, Table 1 lists the shares of interior primary elevator capacity in Canada, as well as port terminal capacity in the port of Vancouver. On the ground, about 70,000 Canadian farms earn at least some of their income from grain and oilseed sales (Statistics Canada 2016a), while recent data show that in Alberta, Saskatchewan, and Manitoba, average farm size is 473, 675, and 460 hectares, respectively (Statistics Canada 2016b). For example, a typical Manitoba grain farm has variable costs of about $496 and $635 per hectare for wheat and canola, respectively, with average yields of about 3.7 and 2.2 tonnes per hectare (MAFRD 2016). 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, once sold, is later moved (by truck) from the farm to the elevator system.

Three large companies - Viterra, Cargill, and Richardson/Pioneer - dominate Canada's primary grain elevation as well as port terminal grain elevation in Vancouver. The largest of the three, Viterra, emerged from several decades of mergers and acquisitions among Canada's once dominant farmer-owned grain cooperatives (Brewin 2014). But changes in the industry are still in process. Viterra was in turn recently purchased by the international commodity trader Glencore in 2013 (Brewin 2016).

Table 1: The Canadian Grain Handling Sector

| 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*

Source: Brewin 2016

Rail Regulation and Grain Rates

The two Canadian Class 1 railways (CN and CP) dominate transportation in the Canadian grain supply chain, with a number of short line railways still serving the region (Nolan 2007). Both

of the Class 1 railways have major hubs in Winnipeg, where they can move grain into the Great Lakes port of Thunder Bay (Figure 2). This eastbound grain is moved though the Saint Lawrence Seaway and often is transshipped through the port of Montreal for movement across the Atlantic Ocean. While both CN and CP have access into the port of Vancouver, CN has sole access to the other Pacific freight handling port at Prince Rupert, a slightly more remote location where terminal capacity is jointly owned by the major grain companies.

Figure 1: Agricultural Land in Canada (Eilers et al. 2010)
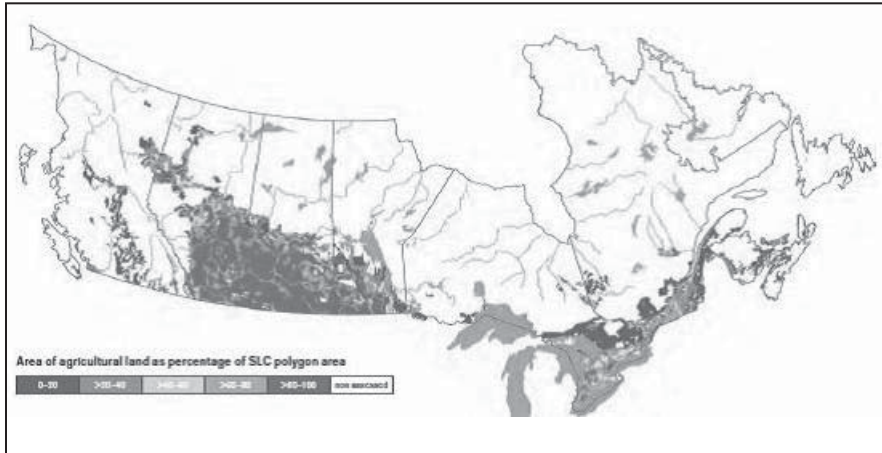
Figure 2: Railway Network, Western Canada (Government of Alberta 2016)

To further encourage individuals to settle western Canada in the late 1800s, a regulated "Crow Rate" was negotiated between the private Canadian Pacific Railway and the Federal Government of Canada (Nolan 2007). This legislation fixed low rates for grain and settlers' goods in exchange for mineral rights in the Rocky Mountains. Eventually, the Crow Rates were made statutory and were applicable for all Canadian railways by 1925. The statutory rates were gradually adjusted through successive regulatory reforms, with major reforms occurring in 1985 (the Western Grain Transportation Act), 1987 (the National Transportation Act), 1996 (Canadian Transportation Act) and finally again in 1999 (as an amendment to the Canadian Transportation Act).

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. The review recommended removal of the extant rate cap policy, to be replaced instead with regulation on railway revenues

from grain movement. In effect, the resulting Bill C-34 replaced rate regulation with the maximum revenue entitlement (MRE) policy for grain. The MRE was intended to mitigate railway market power in grain movement, but also to give the railways more rate flexibility than existed under the former rate cap.

The MRE is still a somewhat unique regulatory policy in the transportation sector. It is effectively a cap on average railway revenue per tonne for all grain movement in a crop year, allowing for some degree of price discrimination by the railway. The novelty of the MRE meant that it took some time for the Canadian railways to fully understand how to make it work to their advantage (Riegle 2001). Since it was focused on revenues, what became clear to the railways under the MRE was the need to constantly seek cost reductions over grain movements to sustain or increase profitability. Under the MRE, Canadian railways have developed new mechanisms to create cost efficiencies and generate increasing profits.

One method for generating cost savings in the MRE era has been the growth of shipper incentives for larger train movements. If a shipper can assemble large volumes of grain, this will result in a highly cost efficient use of locomotives and crew. This engineering-based cost saving is the reason why the railways in Canada under the MRE began to offer reduced freight rates for 50- and 100-car blocks of grain. In addition, both major Canadian railways have at various times offered "shuttle" discounts for long grain trains that move from a single delivery point to export position and back again. All of these discounts typically fall somewhere between 5% to 20 % of a reference standard single car quoted rate.

Rate discounts effectively represent a degree of sharing with shippers some of the cost efficiencies associated with the assembly of a unit train. Since under the MRE average freight rates within a given year do not change, smaller grain shippers delivering fewer hopper cars often pay relatively higher rates, in effect offsetting lower rates offered to larger shippers who can deliver more grain cars. Under the MRE, large unit train incentives remain important to rail operations and grain transportation planning.

Since the MRE provides the railways with incentives to seek cost economies, it has led to the current dominance of large unit grain trains in the industry. But all parties in the supply chain must coordinate their actions in order to load a large unit train in a timely manner, and this coordination effort can be more costly to some participants. What is not well understood is the total amount of logistics and transportation cost savings that a railway obtains through the assembly and movement of unit grain trains, and by extension little is known about the proportion of this latter cost saving that may or may not be passed on to other participants in the grain supply chain.

The former Canadian Wheat Board (CWB) served as a major regulatory factor in Canada's grain supply chain. The CWB, created in 1935, coordinated wheat and barley marketing for Canada (Brewin 2014). And from 1943 to 2012 the CWB was the "single desk" marketer of Canadian wheat and barley for export or domestic human use. The CWB operated as a non-profit organization and was not designed to curtail farm production. They did, however, manage producer delivery of grains to the commercial system through a series of delivery quotas, and later through contract calls. Due to their position in the industry, the CWB was also able to price discriminate among major buyers of Canadian wheat and barley (e.g., Brooks and Schmitz 1999). The CWB was ultimately given wide powers within the supply chain, including managing publicly owned rail cars, calling grain into specific rail corridors as well as negotiating elevation and unregulated rail rates with grain companies and railways (Nolan and Drew 2002).

Losing the CWB was bound to have profound effects on the grain supply chain. The hope was that opening up marketing and logistics to the grain companies in Canada would ultimately lead to more and competitive choices for all industry participants, including farmers. And in the immediate transition period, this seems to have been the case. Just after the CWB was dissolved in the summer of 2012, the relatively small grain and oilseed crop that year appears to have led to significant price competition between grain companies and railways to the benefit of farmers. With

a high port price and a narrower export basis, farmers were offered near record domestic prices for their grain in 2012. But by the fall of 2013, Canadian farmers were facing their widest export basis in many decades. The next section motivates economic models that will help us assess who gained and who lost in the transition away from the CWB in the Canadian grain supply chain.

A MODEL OF CANADIAN GRAIN TRANSPORTATION REGULATION

Previous research about the Canadian grain supply chain often focused on the level and value of price discrimination practiced by the CWB among buyers of Canadian wheat and barley. Only a few studies examined the effect of the CWB on grain logistics and transportation services for farmers, grain companies, and railways. To start, Fulton et al. (1998) modeled this as a bargaining process but assumed the railways were fully deregulated, while another study peripherally modeled the Canadian grain sector as an oligopoly (Zhang et al. 2007). More recently, Çakir and Nolan (2015) developed a vertical model of the sector (without the CWB) and found that, under a set of reasonable assumptions, considerable market power could be exercised by the railways in the absence of rail regulation.

Prior theoretical work examining revenue based regulatory policies mostly highlights the implementation and potential consequences of a so-called average revenue cap on a monopolist. The latter literature formed part of the extensive utility deregulation discourse that originated in the United Kingdom through the 1980s and early 1990s (Bradley and Price 1988). This discourse offered mixed reviews of the effectiveness of revenue-based regulation over other forms of natural monopoly regulation, such as price or rate caps.

Under the MRE as currently implemented in Canada, allowable revenues on grain and oilseeds movement by each of Canada's two Class 1 railways are calculated every year using the following formula:

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

where: m_{ti} is the maximum revenue entitlement for firm i for crop year t; a_i and b_i are base year revenues and tonnes of grain hauled for railway i as of 1999/2000; g_{ti} and d_i are current year t and base year average distance hauled for railway i; k is a constant used to approximate the costs of transporting grain longer average distances; e_{ti} is the number of tonnes of grain moved in year t by railway i; and f_t is a cost adjustment factor applicable for the current year t that helps account for input price changes across a range of major inputs employed by the railways.

Several of the MRE components are relatively static, while others have undergone considerable changes. For example, average grain distance hauled has not changed significantly since the implementation of MRE. But there have been significant adjustments to the cost factor used in the MRE calculation, adjustments that are beyond the control of the railways (Quorum 2016).

If we ignore the terms g_{ti}, d_i, k, and f_t in the subsequent discussion, m_{ti} can essentially be interpreted as a profit maximization constraint. For illustrative purposes, consider the following example in which we assume there are just two grain companies who move grain and that each grain company has a different cost structure. Referring to the base year aspect of the MRE, average rates to move grain were fixed at that time by government, and the volume of grain moved was linked to car allocation schemes managed at that time by the CWB and not the grain companies. Knowing this, the individual railway's profit maximization problem would be to choose optimal quantities sourced from either of two shippers (i.e., grain companies 1 and 2) with different cost structures, thus maximizing the following Lagrangian with respect to variables q₁ₜ, q₂ₜ, λ_m, and λ_q:

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

where: L_{ti} is the Lagrange value function for railway i for crop year t; p_{jt} and q_{jt} are the prices and quantities for grain company j in crop year t (with the base year value here equal to 0), λ_m and λ_q are the shadow values of the MRE and the fixed supply of grain to haul ($\overline{q}$), and c_j is the cost to the railway of shipping from grain company j. Note that if the costs are fixed for each grain company and $c_1 > c_2$, the constrained profit function is linear and maximized when all of $\overline{q}$ is shipped to the lower cost shipper (#2 in this case), and the price of rail services is the same as the base value price p_0.

But understanding the overall effectiveness and need for grain transportation regulation is linked to the active players operating in the supply chain. While many understood that the role of the former CWB in Canadian grain handling and transportation was significant, almost no research exists that formally assessed the role of the CWB as a "countervail" to both railway and grain company market power in the Canadian supply chain. In order to better understand the future of grain supply chain regulation in Canada, we need other perspectives to help assess the role played by the CWB in this regard.

Since late 2012, grain companies in Canada have played a more significant role in grain marketing and logistics. Interestingly, some offer evidence that grain companies in fact priced their services at near cartel levels as early as 2013 (Brewin 2016; Brewin et al. 2017). To clarify what has happened, we illustrate this situation applied to the grain sector through Figure 3. Here, we assume D is the domestic demand curve for grain while S is the domestic supply curve. P_w is assumed to be the world price available at port (for export), while P_c is the price offered to domestic producers if the internal market chain is free of regulatory distortions. The latter is equal to P_w minus the cost of moving goods through the chain. P_m is any price offered by grain handlers that happens to be lower than the world grain price, minus their real costs.

From a supply chain perspective, we offer that the difference between P_c and P_m is a measure of competition in the supply chain. The more competition in the supply chain, the nearer P_m will approach P_c. Note that Q_{dc} and Q_{dm} represent the quantity of domestic grain consumption at P_c and P_m, respectively, while Q_{sc}, and Q_{sm} represent domestic grain supply at P_c and P_m, respectively. Grain exports equal the quantity supplied minus domestic consumption under either price. For the grain trade in Canada, the difference between P_w and P_m is referred to as the "export basis." We can also observe that a drop in the price received by producers from P_c to P_m leads to welfare changes – this translates to a gain of area d for the grain companies, and a gain to domestic consumers of areas a and b, but a loss of areas a,b,c,d and e in producer surplus. Given this lens of analysis, this study represents a very preliminary attempt to measure the scale of welfare changes among participants that have occurred through time in the Canadian grain supply chain.

In its heyday, the CWB advertised itself in the public domain as a countervail against the market power of the railways with respect to grain movement (Fulton, 2006; Schmitz and Furtan 2000). So to paraphrase the contribution of this analysis, we will evaluate the former CWB's success at working alongside both grain companies and railways in order to mitigate their potential for market power exertion over farmers in the Canadian grain supply chain.

To this end, there is a small body of related research that uses the well-known Shapley value (Roth 1988) to compute relative market power measures when applied in context to resource supply chains. For example, recent papers by Hubert et al. (2014, 2015) use Shapley values to evaluate relative market power exertion among participants within European natural gas networks. But most closely related to this work is research assessing relative market power in a major U.S. coal

supply chain (Wolak and Kolstad 1988). In the coal producing Powder River Basin, competition for relative market position was believed to have occurred between states (who can charge taxes to participants) and railroads (who can charge rates to coal shippers). The authors argued that coal movement was in effect a lucrative rent-seeking game in which the participants maneuvered over time so as to extract rent from the coal market. Assuming participant interaction in this supply chain market power/rent extraction game manifested in various state/railroad coalitional structures, the latter's structure and consequences were measured through imputations based on Shapley calculations.

Under the assumption that the Canadian grain supply chain has evolved as a cooperative supply chain game in a similar manner, we estimate relative historical market power in the chain by valuing grain handling coalitions that could be formulated among the participants. Using available industry data, we compute a set of Shapley values over grain industry revenue in order to assess the relative strength of each participant in a stylized grain supply chain game.

THE CURRENT CANADIAN GRAIN SUPPLY CHAIN

With a long history of regulation, grain transportation in Canada at present relies on regulations that incentivize particular behavior. For example, equation (2) means that under the current MRE policy on grain rail revenues, railways should avoid serving high cost shipping points. From a rail perspective, such an incentive eventually translates into service cuts or line abandonment. While rail line abandonment in Canada began in earnest under the former WGTA, important changes in the sector still occurred between the 1999/2000 crop year and up to the 2014/15 crop year (Quorum 2016). Over this time, there has 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
- 111% increase in average incentives for 50-plus car movements, from $3.54 to $7.47/tonne.

These basic measures indicate that, over time, it has gradually become less costly for the system to handle and move grain for export. However, as mentioned, it remains an open question as to who has benefitted from these industry cost savings (Figure 3).

Figure 4 shows that the export basis in Canada has generally increased over time (Quorum, 2016), save for the very first year without the CWB (2012/13). Given the grain volumes moved in those years, some researchers have tried to compute the difference in farm level revenues that can be attributed to the increasing basis. While calculations vary depending on assumptions, the value is significant and typically estimated as somewhere in the single digit billions of dollars ($Canadian) when accrued over the most recent few years. Further, some suggest that any system gains from basis growth accrued mostly to the Canadian grain companies (Torshizi and Gray 2017; Brewin et al. 2017).

In fact, the 2013/14 crop year was a significant challenge to North American grain supply chains because of rail service problems as well as record supplies of wheat and canola. The total supply of grains and oilseeds in western Canada increased by 34%, while ending stocks increased by 163%. Some offer that this situation led to basis increases of up to 148% over the previous year. However, during the CWB era, we noted there was a similar record supply shock (2008/2009) associated with a 24% increase in output over the previous year, coupled with a 68% increase in ending grain stocks. However, we note that the export basis actually fell for both wheat and canola

in that crop year (Figure 4). We conclude that significant basis differences in otherwise similar market situations is further evidence that the recent 2013/14 crop year was one where significant rents were captured by the grain companies.

Figure 3: Trade and Imperfect Competition in Intermediary Services
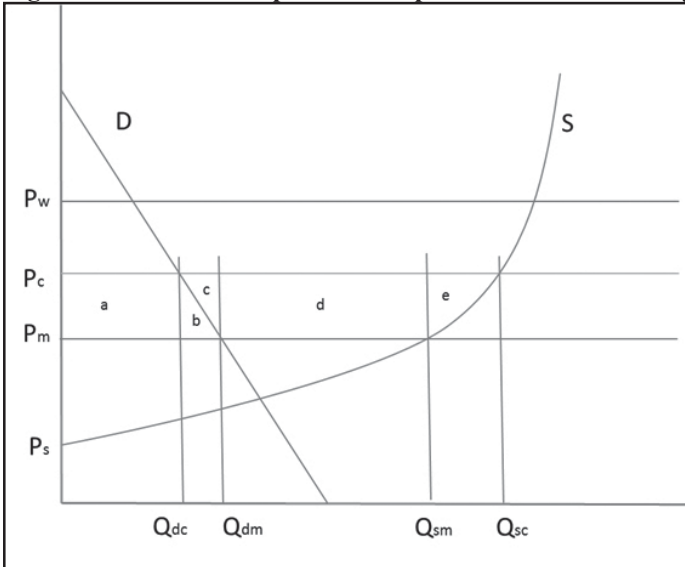
Figure 4: Export Basis (Canada) for CWRS Wheat and Canola, Western Canada
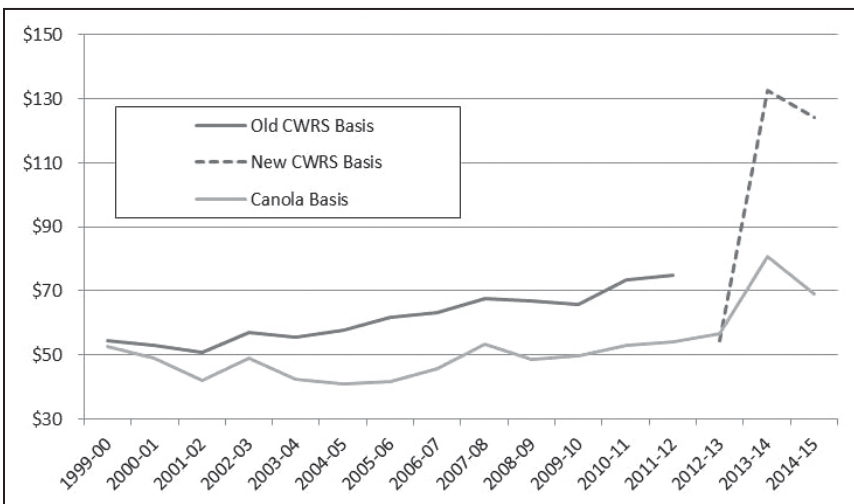
EVALUATING RELATIVE MARKET POWER IN THE GRAIN SUPPLY CHAIN

With industry level cost and production data from the years 2000-2015, we compute Shapley values applicable to the key participants in the Canadian grain supply chain. The Shapley computations will help clarify whether or not participants acted as oligopolists exploiting market power, while the results also provide us with a better sense of the role the CWB may have played in countervailing market power exercised by other participants in the supply chain.

We begin the exercise by referring to the relative shares of grain export values from the years 2000/01 to 2014/15 (all data here fall under the MRE regime) in Table 2. We assume here that the CWB during its existence was a major player in the supply chain, with railroads and grain companies also acting as major participants in the process of grain handling and movement. While the MRE era in Canada has been characterized by rail rates that have remained relatively static over time, grain companies have seen their relative value shares grow, especially so after the CWB was removed from the supply chain in late 2012. Therefore, we speculate that the division of revenues in the grain supply chain must have changed over time because various system participants altered their behavior, reacting to various market and policy changes.

While there are other individual or group contribution measures used in the theory of cooperative games, the Shapley value is popular because it is relatively simple to compute yet generates a relative contribution share measure among participants conducting a collective or cooperative action. Where data are available, they are computed using the assessed contribution of individual participants to various sub-groups or coalitions that could be formed within the full cooperative game situation (Shapley 1953; Young 1991). Effectively, the greater marginal contribution an individual player makes to the value (or payoff) associated with a given coalition, the higher is their relative contribution to the outcome and thus the greater will be their computed Shapley value. Formally, the Shapley value for an n-player cooperative game is computed in the following way (Roth 1988; d'Aspremont and Jacquemin 1985; Intriligator 1972);

(3) *Shapley Value* $= \Sigma\, \zeta_n(S)[\, \upsilon(S \cup \{i\}) - \upsilon(S)]$

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 or payoff function, as defined by the specific game situation. The second term in the Shapley computation represents the marginal contribution to the value of coalition that now includes the *ith* player in a coalition that was formerly defined by S, whereby the latter necessarily excluded player *i* (by definition). The weighting or probability term $\zeta_n(S)$ is essentially a combinatorial representation of how an n-player coalition can be formed in the game. This weighting factor is written as;

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

Using these equations and mapping the situation onto the Canadian grain supply chain, we need to first calculate the vertical shares of export values in the grain supply chain. In a system where each set of firms relies on the same volume moving through a vertical chain, it turns out that the Shapley values ultimately collapse into the vertical share of the final sale price. Considering this, if we assume that a cooperative game is being played among industry participants over grain export revenues, our computed share value measures the relative coalitional strength of each participant in the grain supply chain.

Data from Table 2 are used to compute Shapley values among the Canadian supply chain participants, with normalized Shapley values listed in Table 3. The computed values represent vertical shares of the export price, but under the additional assumption that there is only a single railway participant in the game.

Table 2: Approximate Breakdown of the Export Price of Wheat, 2000 to 2015

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

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

Our computed Shapley values offer some novel insights into the evolution of the Canadian supply chain. To start, we find that during their existence, the CWB appears to have possessed greater coalitional power than any of the other players. Also, we find that at various times, farmers appear to have retained significant market power, even without the CWB. But over time, we also observe a significant shift in coalitional power from farmers to grain companies. Interestingly, this effect is likely compounded as well by the fact that farmers' shares can often be further parsed into their input suppliers (which are often the same grain companies).

The Shapley value evidence also suggests that railway market power in the Canadian grain supply chain has been effectively mitigated through the MRE era. Since the implementation of the MRE in 2000, railway Shapley values have remained relatively small, between .08 and 0.14, values that are considerably lower than other participants. Furthermore, the transition away from the CWB seems to have had little impact on the railways with respect to their computed Shapley value. Given the latter, we conclude that the major consequence of removing the CWB seems to have been a change in the way in which market rents are being divided between farmers and the grain companies.

While it is not theoretically possible to ascertain how high an individual Shapley value must be in order to determine whether or not a player is truly dominant in a cooperative game situation, ceteris paribus our calculations seem to indicate that Canadian grain companies are sitting at a point where any additional consolidation in that industry would only strengthen their position in the grain supply chain. The latter possibility would potentially allow them to capture even more rents from the system in the future (D'Aspremont and Jacquemin 1985).

What this analysis also highlights is that, from a regulatory perspective, grain supply chain participants in Canada can no longer be thought of as truly separate and distinct industries. The international nature of the grain trade means that participants in the grain supply chain are inter-linked now more tightly than ever before. Moreover, any future changes in regulatory policy in the Canadian rail sector will certainly percolate upstream and eventually affect the behavior of the

grain companies. The manner in which the grain supply chain will evolve in the future remains a major policy question in Canada. To this end, we now use the methodology to evaluate relative market power under different potential coalitional structures in the Canadian grain supply chain.

Table 3: Shapley Values, Single Railway Player

Crop year	CWB	Railways	Grain 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

Note: f represents farmers' value without the CWB
Source: Authors' calculations.

Relative Market Power in the Rail Sector

Once again, Table 3 illustrates the relatively weak position of the Canadian railways in the grain supply chain through the MRE era. Although reliable data are not available to compute Shapley values for the privately held grain companies that dominate grain handling, we re-estimate Shapley values applicable to each of the two Class 1 railways, while alternatively assuming the CWB and farmers act as a single player. To perform these modified Shapley calculations, we must further assume there are three major grain handling firms in the market. The latter seems reasonable considering the era during which the CWB was involved in Canadian grain marketing there were several major grain companies operating in Canada.

The next problem we face is finding a defensible valuation for the coalitions, or equivalently the $\upsilon(.)$ in equation (3). With little prior guidance from the literature, we propose that the relative value of our Shapley coalitions possesses an upper limit, defined by that point where the profits of each firm in the current supply chain are added together, and having a lower limit of zero. To wit, the share of revenues for the farmers/CWB with respect to the total tonnes moved would certainly be an overestimate of the value of their coalition. Given this, we will define the value of a coalition as the net gain relative to the lowest revenue shares observed in Table 2. In fact, this means there are potential gains to either party as a result of their potential coalition.

We also assume that any coalition formed between the CWB and the grain companies with either railway can be evaluated only by using the tonnes of grain moved by that railway. But this in turn means that in some years the valuation to either the CWB or a grain company of a coalition

with a railway could actually be negative if rail profits/tonnes are limited and computed on only part of the total tonnes moved. To correct for this, excess profits above the lowest share in Table 2 are used to proxy for the value functions. These data are available, and used to compute valuations over a four player Shapley game, again according to equations (3) and (4). Thus, Table 4 lists the Shapley values for this latter cooperative game that includes individual railways as players.

For these modified Shapley calculations, we acknowledge that treating grain companies as a single player with no CWB in the mix is unrealistic for the years 2012 through 2015. In spite of this, our analysis once again illustrates the relatively weak position of the railways under MRE regulation, as well as the shift in coalitional power away from the CWB/farmer player toward the grain company player. While neither major railway becomes as a significant market power threat to the supply chain over this time frame, we do find that their relative position in the supply chain improves when using the share of export values to compute Shapley values in Table 4.

Finally, we note there are two zero Shapley values in Table 4. One zero value appears for the CWB in 2005-06 and the other is for the grain companies in 2012-13. These Shapley values imply that particular players added zero marginal contribution to their coalitions within the supply chain in that year. The latter findings would seem to emphasize the ongoing positioning among key participants in the Canadian grain supply chain over relative shares of grain system revenues.

Table 4: Shapley Values, Separate Railway Players

	CWB/Farm	**Grain Co.**	**CN**	**CP**
2000-2001	0.425	0.289	0.147	0.138
2001-2002	0.554	0.171	0.140	0.135
2002-2003	0.657	0.079	0.117	0.147
2003-2004	0.443	0.274	0.148	0.134
2004-2005	0.371	0.336	0.152	0.141
2005-2006	0.000	0.628	0.203	0.169
2006-2007	0.341	0.318	0.175	0.167
2007-2008	0.652	0.075	0.136	0.137
2008-2009	0.623	0.090	0.141	0.146
2009-2010	0.488	0.214	0.152	0.146
2010-2011	0.620	0.099	0.150	0.131
2011-2012	0.602	0.113	0.149	0.136
2012-2013	0.699	0.000	0.151	0.149
2013-2014	0.285	0.420	0.151	0.145
2014-2015	0.318	0.379	0.152	0.151

Source: Authors' calculations

CONCLUSIONS

Limitations of the Analysis

While novel, we acknowledge that several relevant factors had to be left out of this preliminary analysis. For example, it is possible that large increases in the Canadian export basis may have in part been driven by higher storage costs (Brewin 2014). But with little change in overall storage capacity on the prairies, there is evidence (from 2008/09) that the record elevator turnover in

2013/14 should have been associated with decreased average costs. More data on actual firm level costs incurred by the railways and the grain companies would vastly improve our understanding about the nature of changes occurring in the supply chain.

The existence of the MRE regulation during the entire time period of study makes it difficult to infer relative market power among the participants in the supply chain in the absence of the MRE. Given historical complaints about railway behavior in Canada under other regulatory regimes, it would be useful to compare railway Shapley values across these regimes.

Finally, we offer that some of the value shocks observed in the years after the removal of the CWB could also be evidence of learning economies in the grain sector. In effect, grain companies may have gradually learned how to better manage foreign sales as well as their domestic logistics processes, while still also possibly engaging in novel cooperative games in the supply chain.

Implications of the Analysis

The evidence presented here about the relative share of market power as exercised by the CWB and railroads suggests that at least during the MRE era, the CWB possessed significant (countervailing) market power in the grain supply chain. However, the consequences associated with the CWB's coordinating role in grain movement are less clear. With the rise of canola and other crops in the region, the CWB gradually became involved with a smaller share of all agricultural rail movements in terms of foreign sales, but it always maintained considerable influence over car allocation and elevator returns. The tight export basis seen in the 2012/13 crop suggests that removal of the CWB may have resulted in initial efficiency gains, but as listed here, there are other factors that likely contributed to the tight export basis in that year.

Since the removal of the CWB in Canada, the evidence shows that grain companies seem to have positioned themselves in such a way as to shift system rents away from farmers. If grain industry consolidation continues, the former farmer-focused coordinating role of the CWB in grain car allocation and foreign shipping logistics might eventually be run by a grain company oligopoly. As Sexton (2013) notes, this may create a difficult situation for this supply chain. Repeated rent taking from market intermediaries will eventually reduce farmer investments and could lead to supply reductions, or it may trigger new entrants and erode system rents. Furthermore, Sexton argues that agricultural oligopolies may realize a benefit to sharing more gains with farmers in order to encourage reliable long-run supply from that link in the supply chain.

Recent concerns voiced by a Canadian federal government review about suspected system inefficiencies attributed to the MRE (Emerson 2016) are not supported by our findings. While the system seems to have remained relatively stable or improved somewhat with respect to efficiency, we do find that MRE regulation seems to have accomplished what it was initially designed to do: control the potential for exertion of market power in grain transportation by Canada's two Class 1 railways. But our findings also indicate that more work is needed both to understand how the Canadian grain supply chain continues to evolve and identify a set of regulatory mechanisms that will best support improved overall supply chain efficiency moving forward.

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