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A short term outlook model for Canadian grain transportation requirements

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1. Introduction

The objective of this paper is to outline a potential framework for estimating grain tonnage through marine export corridors given an estimate for near term crop production. This methodology represents the first iteration of a short term predictive model for grain transport. The intent is to produce a monitoring tool that will provide forward looking guidance as to near term transport demand for grain. Near term is defined as the four quarters of an upcoming crop year. The end goal of the framework would be to provide an alert mechanism which will identify situations where the grain export supply chain is not performing according to its normal historical operating parameters.

Regional differences in crop varieties and distance to port influence the directional flow of grain tonnage. It is shown in this paper that investigating the statistical relationship between grain production and rail car unloads at marine ports at the most granular level provides value in increasing the within sample predictive capability of the model.

The analysis focuses on the three major source provinces for Western grain: Saskatchewan, Alberta and Manitoba; and the three major grain export port terminals: Port Metro Vancouver (PMV), Prince Rupert (PR) and Thunder Bay (TB)[ii]. The analysis does not include domestic consumption, exports to the United States, or grain volume destined for ports more eastern than Thunder Bay.

This paper is organized as follows. It first outlines the data source used for the analysis then outlines the geographic and commodity composition of grain supply. It then provides an overview of the corridor specific characteristics of rail tonnage to export port. Next, the correlation between grain supply and rail transport to port is determined and a statistical regression framework methodology is outlined. This is followed by a discussion on a hierarchical aggregation process. The analysis then demonstrates the results of the estimation process and compares among modelling approaches. Next it outlines the estimates for the 2015/2016 crop year and proposes a seasonal attribution method in order to utilize the statistical parameters in a quarterly predictive model. It then outlines the potential use as a monitoring tool and finally concludes with areas for further research.

2. Data Source

This analysis uses publically available data, sourcing from data files provided by Quorum Corporation under the mandate of the Grain Monitoring[iii] program. Time series data for annual crop supply and rail car grain unloads at the major marine export ports for crop years 1999/2000 to 2014/2015 are used to estimate the parameters of a predictive model. These parameters are then used to create predictions for rail tonnage at the port and are compared against data for the first crop quarter of the 2015/2016 crop year. The data for the analysis is sourced from the December excel file acquired from the Grain monitors' website.

Annual crop production and carry-over[iv] tonnages by grain type for the three major provinces are combined to produce estimates for *total grain supply*. Annual rail unload tonnage by grain, destination port and origin province are used as the measure of *rail volume* for the initial part of this analysis[v]. The later part of the analysis utilizes the rail unload data at a quarterly frequency.

Total crop supply represents the amount of production in the current crop year as well as the amount carried-over from the previous year. The previous year's carry-over typically represents roughly 10-15% of the total tonnage supplied for a given crop year. Table 1 presents an overview of annual production, carry-forward and total supply tonnage for Western province grain for the last 17 years.

Crop Year	Production	Carry Forward	Total Supply	Y/Y % Change
1999	54,556	7,347	61,903	
2000	53,478	9,688	63,166	2.0%
2001	41,940	8,693	50,633	-19.8%
2002	30,802	6,025	36,827	-27.3%
2003	46,675	5,453	52,128	41.5%
2004	53,090	6,600	59,690	14.5%
2005	55,482	10,724	66,206	10.9%
2006	48,483	12,378	60,861	-8.1%
2007	47,580	7,416	54,996	-9.6%
2008	59,444	5,612	65,056	18.3%
2009	55,226	9,499	64,725	-0.5%
2010	49,015	11,174	60,189	-7.0%
2011	52,352	8,610	60,962	1.3%
2012	54,978	5,677	60,655	-0.5%
2013	74,136	4,878	79,014	30.3%
2014	60,500	13,152	73,652	-6.8%
2015	60,620	8,243	68,863	-6.5%
1999-2015 Avg.	**52,844**	**8,304**	**61,148**	
1999-2015 STD	**9,155**	**2,520**	**9,414**	
2011-2015 Avg.	**60,517**	**8,112**	**68,629**	

Table 1 Western Province Grain Supply, 1999-2015 (000's tonnes)

Total grain supply averaged roughly 61 million tonnes over the 17 year analysis period, though with relatively large crops recently the average over the last 5 years has increased to almost 69 million tonnes. This includes a large "bumper" crop in 2013/2014 that realized a 30% increase in tonnage over the previous year. Also of note was a low production period in the 2002/2003 crop year.

The province of Saskatchewan is the largest producer of grain, supplying roughly 50% of the grain tonnage in 2015/2016, while Alberta produced 35% and Manitoba produced 15%. Wheat represents the largest tonnage supplied (34.6%), followed by Canola (27.4%) and Barley (12.7%). See table 2 for an overview of the grain supply tonnage for the 2015/2016 crop year.

	Grain	Alberta	Manitoba	Saskatchewan	Total
Tonnes (000's)	Barley	4,913	672	3,192	**8,777**
	Canola	6,082	2,988	9,800	**18,870**
	Dry Peas	1,422	84	2,081	**3,587**
	Durum	850	0	5,102	**5,952**
	Flaxseed	91	83	849	**1,022**
	Oats	568	687	2,266	**3,521**
	Other	326	189	2,577	**3,092**
	Rye	42	87	75	**203**
	Wheat	8,834	4,678	10,327	**23,839**
	Total	23,128	9,467	36,268	**68,863**
Percent of 2015 Total	Barley	7.1%	1.0%	4.6%	**12.7%**
	Canola	8.8%	4.3%	14.2%	**27.4%**
	Dry Peas	2.1%	0.1%	3.0%	**5.2%**
	Durum	1.2%	0.0%	7.4%	**8.6%**
	Flaxseed	0.1%	0.1%	1.2%	**1.5%**
	Oats	0.8%	1.0%	3.3%	**5.1%**
	Other	0.5%	0.3%	3.7%	**4.5%**
	Rye	0.1%	0.1%	0.1%	**0.3%**
	Wheat	12.8%	6.8%	15.0%	**34.6%**
	Total	**33.6%**	**13.7%**	**52.7%**	**100.0%**

Table 2 2015/2016 Grain Supply by Province and Grain Type

The distance to a port from each province and the commodity composition of regional grain production interact to influence corridor and grain-specific rail transport volume characteristics. Alberta, being the most western province, sends the majority of its grain exports through the British Columbia ports, while Manitoba sends the majority of its marine export tonnage through Thunder Bay. Saskatchewan splits tonnage between Thunder Bay and the western ports on average 35/65. Table 3 provides an overview of the province-port pair characteristics.

		Destination Port					
	Origin	Port Metro Vancouver	Prince Rupert	Thunder Bay	Total	2014/2015 Supply	% Exported
Tonnes (000's)	Alberta	10,492	3,322	128	13,942	23,128	60.3%
	Manitoba	537	60	3,316	3,914	9,467	41.3%
	Saskatchewan	11,181	2,689	4,773	18,643	36,268	51.4%
	Total	**22,210**	**6,071**	**8,217**	**36,499**	**68,863**	**53.0%**
Percent of total	Alberta	28.7%	9.1%	0.4%	38.2%		
	Manitoba	1.5%	0.2%	9.1%	10.7%		
	Saskatchewan	30.6%	7.4%	13.1%	51.1%		
	Total	**60.9%**	**16.6%**	**22.5%**	**100.0%**		

Table 3 2014/2015 Rail Unloads by Province and Destination Port

Aside from distance to port the type of grain also influences the direction of the export movement. For example, in 2014/2015 Saskatchewan rail tonnage to port for canola and durum wheat were almost equal at 3.8 and 3.3 million tonnes, respectively. Of these rail tonnage totals, Saskatchewan sent 68% of its canola to west coast ports, while sending 64% of its durum tonnage through the eastern corridor. Thus, it is important to segment the grain type and source province when trying to determine the relationship between grain production and corridor specific rail volume.

3. Methodology

First, it is instructive to determine if there is a statistical relationship between total crop supply tonnage and total rail unloads of grain at port and how strong that relationship may be. The results of a simple correlation analysis between the two variables for the 1999-2014 time periods estimate a pearson correlation coefficient of 0.9144 and is statistically significant (p-value < 0.0001). Therefore, there is a strong positive relationship between crop supply and rail unloads at the three export ports.

After determining that there is a relationship that can be utilized we move on to estimate the parameters of a statistical model to quantify the effect of grain supply on grain transport to port. The methodology employed for this analysis utilizes a simple linear regression framework at the most granular level of the data and then aggregates the predicted estimates to a desired level in a hierarchy. The traditional notation for the linear model is utilized:

$$\hat{y} = \beta_0 + \beta_1 x + \mu \qquad (1)$$

where $\hat{y}$ is the estimated tonnage of grain rail cars at port, β_0 is the intercept coefficient, β_1 is the slope coefficient, x is the total supply tonnage of grain and μ is the error term.

Figure 1 depicts the results of the regression and shows a statistically significant relationship between total supply and total rail unloads at port. The r-square value of 0.8361 implies that 83% of the variation in grain unloads at port can be explained by the variation in the total grain supply, while the 0.55858 value for the total supply coefficient implies that a 1 tonne increase in total supply increases unloads at port by 0.55 tonnes. The Durbin-Watson D statistic value of 1.19 is above the lower limit of 1.1, implying the test for autocorrelation of the errors is inconclusive; therefore no correction is made to this particular data.

The preceding analysis looked at the relationship between total grain supply and total unloads at the three export ports. As outlined earlier, the source data allows a higher granularity of analysis. There are many potential ways to structure the data but this analysis puts forward a four level descending hierarchy to organize the data. The hierarchy for the analysis is as follows: 1) total grain unloads at port; 2) port-specific grain unloads at port; 3) port-specific and origin-province-specific rail unloads at ports; 4) port-specific, origin-province-specific and grain-specific unloads at ports.

Dependent Variable	Rail Unloads at Ports (000's)
Number of Observations Read	16

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	422716898	422716898	71.43	<.0001
Error	14	82848770	5917769		
Corrected Total	15	505565668			
Root MSE	2432.64656	R-Square	0.8361		
Dependent Mean	24406	Adj R-Sq	0.8244		
Coeff Var	9.96724				

Parameter Estimates						
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	-9480.3349	4055.305	-2.34	0.0348
Supply_Tonnes	Total Supply (000's Tonnes)	1	0.55858	0.06609	8.45	<.0001

Durbin-Watson D	1.191
Pr < DW	0.0291
Pr > DW	0.9709
1st Order Autocorrelation	0.273

Figure 1 OLS Regression output: Rail Unloads at Port

As outlined, at the most granular level of the data (level 4) the regression methodology estimates the relationship between the production of specific grain types in a specific province and the tonnage unloaded of that specific grain at a specific export port. This can be formulated with the following model:

$$\hat{y}_{ijk} = \beta_0 + \beta_1 x_{jk} \qquad (2)$$

Where *i* indexes the destination port, *j* indexes the source province and *k* indexes the grain type.

Given that there are three supply provinces, three destination ports and nine distinct grain types and omitting a few extraneous models[vi], 76 regression models were estimated. The model fit measured by the r-square statistic ranged from 0.98 (PMV-Alberta-Dry Peas) to 0 (MAN-PMV-Flaxseed, for example).

The estimated model parameters for the 76 models are provided in the appendix section. Note that positive autocorrelation of the errors was identified in several of the granular models. For those with identified autocorrelation an autoregressive model of order 1 was fit, utilizing maximum likelihood estimates for the predicted values. This attempts to correct the violation of the independent error assumption for the ordinary least square regression formulation. The regression model then becomes:

$$\hat{y}_{ijkt} = \beta_0 + \beta_1 x_{jkt} + V_t$$

$$V_t = -\theta V_{t-1} \qquad (3)$$

where θ represents the autoregressive error model parameter[vii].

With the level 4 granular models estimated, various time series of predicted rail unload tonnages at the higher levels of the hierarchy can be created. For example, to develop the port specific unloads (level 2) the predicted tonnages in the level 4 of the hierarchy can be aggregated up. To estimate the total tonnage unloaded at a port, we take the sum of the predicted grain specific tonnages from the various source provinces. This aggregation process can be seen with equation 4 below:

$$\hat{y}_i = \sum_{j=1,k=1}^{n} \hat{y}_{ijk} \qquad (4)$$

4. Results

The preceding analysis has demonstrated two potential methods to predict total unloads at port, one by estimating predictions at the most granular level and aggregating those to produce totals (the "granular approach"), and the other based on the already aggregated granular data (the "aggregated approach"). To determine the value added of the granular approach we can compare the prediction accuracy between the two using the mean absolute percentage error[viii] (MAPE). Over the 1999 to 2014 period the MAPE for the granular approach was 5.4% and 7.1% for the aggregated approach. Thus, it can be said that performing several regressions on the base level components of the hierarchy and aggregating the results can lead to better predictive content, then simply regressing against the already aggregated values. This makes intuitive sense as the nuances of the subcomponents of the data can be better captured at the granular level.

Figure 2 demonstrates the difference in the fit line between the two regression model approaches. It is apparent that for the most part, the dashed line is closer to the solid line, than the dotted line is. The bars represent the squared residuals, which show the period specific errors in the prediction.

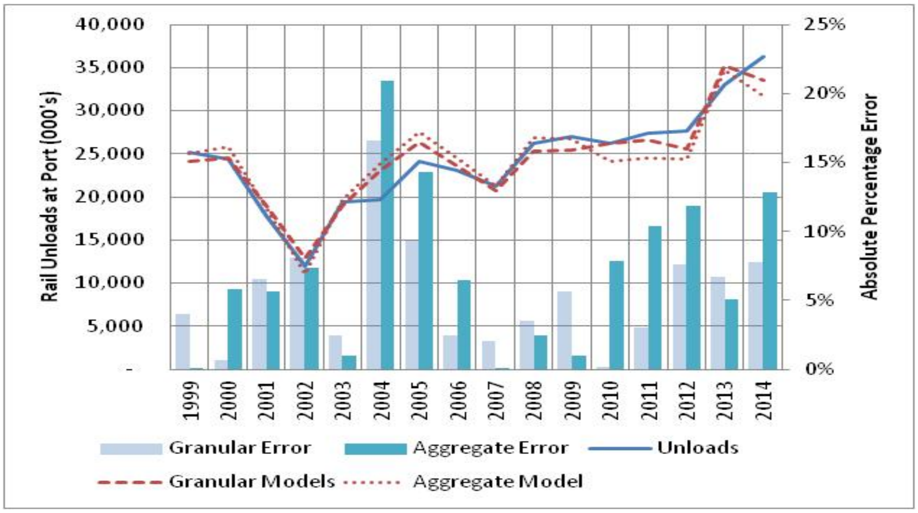

Figure 2 Fit plot for Aggregate vs Granular regression methodology

Utilizing the parameters from the estimated models and the estimate for the 2015/2016 total crop supply we can make predictions for the rail transport required for the current crop year. Again, the granular level 4 data for provincial grain specific production is utilized to estimate the amount of rail transport to each port. These estimates are then aggregated to hierarchy level 2 to estimate the amount of grain to be unloaded this crop year. Table 4 presents an overview of unloads at each of the three ports for the last 2 crop years as well as the predictions for 2015/2016.

With an estimated decrease in total supply from 2014/2015 to 2015/2016 of 6.5%, total grain unloads at the three export ports are expected to decrease by 5.8%. The difference in relative reduction between production and rail unloads at port relates to the composition of the crop supply reduction. As outlined earlier, certain commodities have higher export proportions than others, which are compounded by the regional variances in production interacting with the export port preference. For example, Saskatchewan and Alberta are expected to supply 6.5% and 10.5% less grain than the previous crop year, while Manitoba is expected to supply 6.6% more. Given these nuances, the model predicts that Port Metro Vancouver will receive roughly 5.7% less grain than the 2014/2015 crop year, while Prince Rupert is expected to receive 17.1% less and Thunder Bay 3.7% more.

Year	Port	Predicted	Actual	Actual/ Predicted
2013	PMV	21,378	19,949	-6.7%
	PR	6,229	6,065	-2.6%
	TB	7,571	7,093	-6.3%
2013 Total		**35,178**	**33,106**	-5.9%
2014	PMV	20,346	22,064	8.4%
	PR	6,036	6,140	1.7%
	TB	7,113	8,244	15.9%
2014 Total		**33,495**	**36,449**	8.8%
2015	PMV	19,186		
	PR	5,005		
	TB	7,378		
2015 Total		**31,569**		

Table 4 Predicted vs. Actual Rail Unloads at Port (000's)

5. Quarterly Methodology

Seasonality estimates are utilized to spread the annual tonnage predictions across the quarters of a crop year. The data source used to derive the quarterly seasonality coefficients is the same as previously outlined. Seasonality coefficients are derived using X-12 seasonal decomposition procedures[ix]. It is important to note that a crop year begins in August and ends in July, thus, the first quarter of a crop year runs from August to October, the second runs from November to January and so on.

The seasonality coefficients are estimated at level 4 of the hierarchy. To aggregate up to higher levels of the hierarchy, level 2 for example, a weighted average of the granular coefficients for each port is calculated. The weights for the average are the unloaded tonnes for each component of level 4 of the hierarchy at a particular port. The intent of this procedure is to incorporate the most granular information for seasonality for each commodity and province pair, but also to aggregate up to port level estimates using a relative weighting for each grain-province-port combination. The seasonal coefficients for the 2015 predictions are a weighted average of the most recent three year periods, crop years 2012/2013 to 2014/2015. Table 5 below outlines the seasonality coefficients used to spread the 2015 annual estimates for unloads at port across the quarters of the crop year.

	Crop Quarter				
Unload Port	**1**	**2**	**3**	**4**	**Total**
Port Metro Vancouver	1.09	0.94	1.02	0.95	4.00
Prince Rupert	0.96	1.04	1.09	0.91	4.00
Thunder Bay	1.29	0.91	0.58	1.23	4.00

Table 5 2015 Crop Year Seasonality Coefficients

The quarterly results for crop year 2013 to the first quarter of 2015 are presented in table 6. It can be seen that for the last nine quarters the model is either over or underestimating unloads at port when compared to the actual values. Specifically, the actual values for Q1 2015 at Port Metro Vancouver are 18% above the predicted, while Prince Rupert is 23% above and Thunder Bay is 7% above.

The magnitude of the variance in the quarterly actual to predicted results imply several points. For example, the model may be missing pertinent information that would aid in predicting the timing that grain will come to market and that there is inherent variability in the year-to-year seasonality coefficients. Also, the main explanatory factor for the model is the crop size estimate, which is based on the carry over and the production tonnage estimates, both of which could be subject to measurement error. The 2015/2016 crop size could actually be larger than what has been estimated and the actual unloads would be reflecting this larger size. If the crop size estimate is considered accurate and the model correctly identified, then the results suggest that grain is coming to market earlier than usual which implies fewer shipments later on in this crop year.

The statistical model uses parameters drawn from historical data in order to estimate future operating performance, in terms of volume shipped. As demonstrated in the preceding section deviations from previous trends can be diagnosed easily by comparing predicted to actual values. Reviewing a longer time series for predicted and actual quarterly rail unloads shows that periods of abnormal supply chain behaviour can be identified.

Figure 3 plots the quarterly predicted versus actual unloads for the three export ports, for the last 17 years. We can see a large increase in the negative residuals beginning in the fourth quarter of the 2012/2013 crop year as rail unloads are less than predicted, especially given the size of the crop harvested in 2013/2014. As mentioned earlier a large increase in production caused total supply to be roughly 30% higher than the previous year. Based on this amount of supply the model predicted a large increase in unloads that was not met by actual unloads. We can also see a large increase in the positive residuals during the last quarter of 2013/2014 and throughout the 2014 crop year. During this time rail carriers were obligated through policy regulation to haul specified volumes of grain during quarters of the year which previously did not have such high volumes[x].

		Port Metro Vancouver			Prince Rupert			Thunder Bay			Total		
Year	Quarter	Predicted	Actual	Actual/ Predicted	Predicted	Actual	Actual/ Predicted	Predicted	Actual	Actual/ Predicted	Predicted	Actual	Actual/ Predicted
2013	1	5,843	4,805	-18%	1,490	1,169	-21%	2,464	1,780	-28%	9,796	7,754	-21%
	2	5,061	4,256	-16%	1,567	1,385	-12%	1,710	1,409	-18%	8,338	7,050	-15%
	3	5,459	5,286	-3%	1,733	1,689	-3%	1,085	816	-25%	8,277	7,792	-6%
	4	5,016	5,603	12%	1,440	1,821	26%	2,312	3,087	34%	8,768	10,511	20%
2014	1	5,601	5,682	1%	1,457	1,605	10%	2,285	2,945	29%	9,343	10,233	10%
	2	4,728	5,094	8%	1,644	1,474	-10%	1,631	1,907	17%	8,003	8,474	6%
	3	5,129	5,692	11%	1,624	1,476	-9%	1,010	1,060	5%	7,763	8,229	6%
	4	4,888	5,596	14%	1,311	1,585	21%	2,188	2,332	7%	8,387	9,513	13%
2015	1	5,245	6,213	18%	1,201	1,481	23%	2,374	2,541	7%	8,820	10,235	16%
	2	4,513			1,301			1,675			7,489		
	3	4,884			1,362			1,064			7,311		
	4	4,544			1,141			2,264			7,950		

Table 6 Quarterly Rail Unloads (000's tonnes): Actual vs Predicted by Port

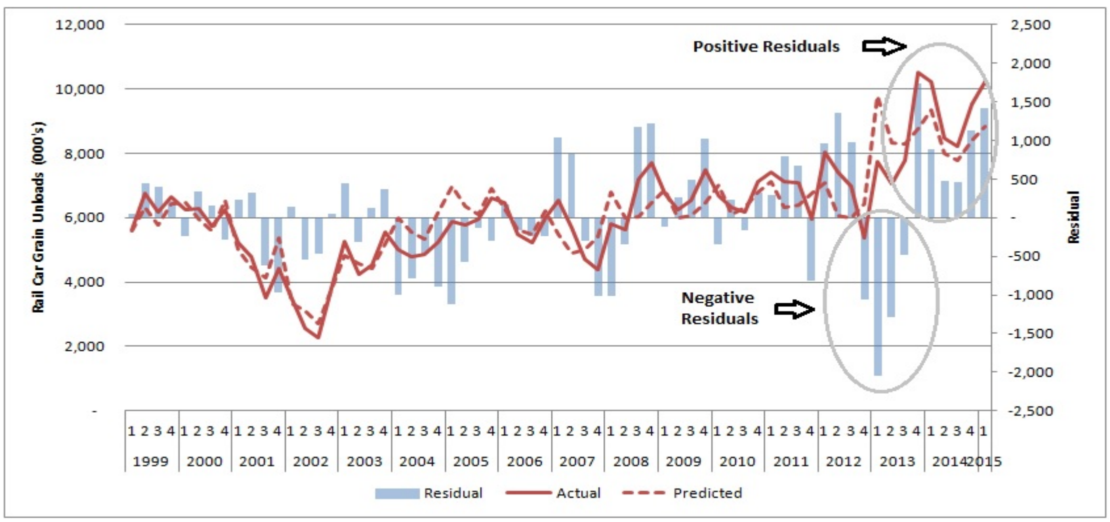

Figure 3 Quarterly Rail Unloads Actual vs Predicted: 1999 to Q1 2015

6. Conclusions and Next Steps

This analysis has presented a statistical modelling framework that estimates the volume of grain unloads at specific export ports based on the total supply of specific grains in the three major production provinces. It presented the relative increase in prediction accuracy given the utilization of a more granular estimation strategy. Using historical examples of the bumper crop period it was demonstrated that the model can identify periods where rail unload volumes at the port are either higher or lower than what is typical for the year and relative to the size of that year's crop. With further refinement this framework could potentially be used as an alert to signal when the grain export supply chain is performing outside of normal operation parameters.

Further research will be dedicated to identifying and incorporating variability in the seasonality coefficients and integrating this methodology into a more granular monthly and weekly monitoring framework. The model results exhibit a fair degree of error when decomposed to the quarterly frequency, especially for the last 9 quarters, and this could be due to factors that are not included in the seasonality attribution method.

To address potential omitted variable bias, a multi-variate model will be investigated to determine the impact that currency exchange rates, specific grain commodity prices and transport freight rates may have on the directionality of exports as well as the timing of grain being brought to market. While, this iteration of the modelling attempts to account for the "supply/push" characteristics of the grain supply chain, future iterations will focus on the "demand/pull" characteristics, which should aid in further identifying the drivers for the directionality of grain exports.

Appendix

Model	Prov	Port	Grain	Root Mean Square Error	Intercept	Supply Tonnes Coefficient	R Square	P_Value	Durbin Watson
1	AB	PMV	Barley	108.07	-218.96	0.09	0.41	0.01	2.48
2	AB	PMV	Canola	296.83	207.67	0.57	0.90	0.00	1.35
3	AB	PMV	DryPeas	46.03	-108.01	0.83	0.98	0.00	2.20
4	AB	PMV	Oats	7.20	-4.87	0.02	0.20	0.08	1.29
5	AB	PMV	Rye	17.17	-0.29	0.18	0.08	0.28	1.98
6	AB	PMV	Wheat	541.03	-30.92	0.38	0.65	0.00	1.54
7	AB	PR	Barley	128.91	198.65	-0.01	0.01	0.70	2.22
8	AB	PR	Canola	231.31	-411.54	0.17	0.59	0.00	1.41
9	AB	PR	DryPeas	2.24	1.87	0.00	0.05	0.40	1.66
10	AB	PR	Durum	35.72	-2.63	0.02	0.01	0.67	2.34
11	AB	PR	Oats	1.03	1.22	0.00	0.04	0.45	2.19
12	AB	PR	Other	3.30	3.55	-0.01	0.04	0.47	1.52
13	AB	PR	Wheat	336.31	-42.35	0.20	0.58	0.00	1.42
14	AB	TB	Canola	20.82	-7.78	0.00	0.07	0.32	1.84
15	AB	TB	Durum	104.38	-17.40	0.26	0.17	0.11	1.46
16	AB	TB	Flaxseed	1.43	3.40	-0.04	0.20	0.08	2.21
17	AB	TB	Oats	2.08	2.08	0.00	0.00	0.93	2.05
18	AB	TB	Rye	0.11	0.04	0.00	0.00	0.99	1.83
19	AB	TB	Wheat	87.68	6.17	0.01	0.03	0.49	1.45
20	MAN	PMV	Barley	24.89	-0.87	0.01	0.03	0.53	2.09
21	MAN	PMV	DryPeas	58.53	66.32	-0.37	0.07	0.32	1.29
22	MAN	PMV	Durum	1.45	-0.27	0.03	0.47	0.00	2.57
23	MAN	PMV	Flaxseed	2.41	1.41	0.00	0.00	0.97	1.66
24	MAN	PMV	Oats	0.29	-0.04	0.00	0.02	0.62	1.19
25	MAN	PMV	Other	30.06	35.08	-0.02	0.00	0.83	2.58
26	MAN	PMV	Rye	2.57	-1.71	0.04	0.16	0.12	1.80
27	MAN	PMV	Wheat	203.00	716.76	-0.09	0.09	0.25	1.56
28	MAN	PR	Barley	6.76	-0.72	0.00	0.02	0.62	2.15
29	MAN	PR	Canola	10.49	-27.88	0.02	0.46	0.00	2.31

Model	Prov	Port	Grain	Root Mean Square Error	Intercept	Supply Tonnes Coefficient	R Square	P_Value	Durbin Watson
30	MAN	PR	DryPeas	0.12	-0.10	0.00	0.15	0.14	2.61
31	MAN	PR	Durum	2.24	0.88	-0.01	0.03	0.49	2.25
32	MAN	PR	Other	0.16	-0.05	0.00	0.06	0.38	2.08
33	MAN	PR	Wheat	151.36	139.02	0.01	0.00	0.92	1.31
34	MAN	TB	Canola	104.97	28.01	0.25	0.64	0.00	1.50
35	MAN	TB	DryPeas	21.64	-4.81	0.29	0.26	0.04	1.41
36	MAN	TB	Durum	9.95	8.13	0.35	0.77	0.00	1.75
37	MAN	TB	Flaxseed	33.04	-28.59	0.61	0.66	0.00	1.13
38	MAN	TB	Oats	8.26	-1.57	0.02	0.26	0.04	2.60
39	MAN	TB	Rye	1.70	0.72	0.00	0.00	0.92	1.89
40	SASK	PMV	Barley	146.74	-146.28	0.15	0.65	0.00	1.25
41	SASK	PMV	Canola	413.02	157.54	0.29	0.73	0.00	1.27
42	SASK	PMV	DryPeas	204.27	-330.09	0.71	0.80	0.00	1.48
43	SASK	PMV	Oats	18.39	-17.80	0.02	0.17	0.11	1.57
44	SASK	PMV	Other	209.28	-193.91	0.51	0.63	0.00	1.68
45	SASK	PMV	Rye	11.79	5.64	0.03	0.02	0.59	1.69
46	SASK	PR	Barley	132.22	99.12	0.00	0.00	0.85	2.37
47	SASK	PR	DryPeas	8.40	13.76	0.00	0.10	0.24	1.65
48	SASK	PR	Durum	58.53	-162.02	0.05	0.30	0.03	1.14
49	SASK	PR	Flaxseed	1.70	1.71	0.00	0.04	0.46	2.18
50	SASK	PR	Oats	8.00	-2.71	0.00	0.02	0.57	1.23
51	SASK	PR	Other	49.74	-43.32	0.04	0.15	0.14	1.38
52	SASK	PR	Rye	1.11	1.10	-0.01	0.06	0.35	2.02
53	SASK	TB	Barley	72.34	31.44	0.03	0.25	0.05	1.35
54	SASK	TB	Durum	219.13	858.83	0.17	0.30	0.03	1.76
55	SASK	TB	Oats	41.87	4.25	0.07	0.41	0.01	1.51
56	SASK	TB	Rye	0.72	0.78	0.00	0.04	0.47	1.56
57	SASK	TB	Wheat	271.19	505.66	0.07	0.25	0.05	1.90

Table 7 OLS Regression Parameters

Model	Prov	Port	Grain	Estimate of Variance	Sum of Squares Error	Log-Likelihood	Intercept	Supply Tonnes Coefficient	First Order Autoregressive Estimate	Durbin Watson
58	AB	PMV	Durum	32125	417621	-104.34	-12.29	0.41	-0.65	1.00
59	AB	PMV	Flaxseed	64	832	-54.69	-2.74	0.52	-0.72	0.90
60	AB	PMV	Other	8752	113774	-93.95	241.32	0.64	-0.67	0.74
61	AB	TB	Barley	27	354	-47.62	37.45	-0.01	-0.49	0.98
62	AB	TB	DryPeas	3	42	-31.00	2.43	0.00	-0.85	0.60
63	AB	TB	Other	160	2081	-61.83	34.52	-0.11	-0.55	1.03
64	MAN	PMV	Canola	24149	313932	-102.09	-337.63	0.25	-0.68	0.88
65	MAN	TB	Barley	481	6250	-70.77	22.96	0.01	-0.69	0.61
66	MAN	TB	Other	71	921	-55.76	10.08	0.03	-0.85	0.45
67	MAN	TB	Wheat	83590	1086665	-112.17	421.30	0.25	-0.78	1.00
68	SASK	PMV	Durum	56038	728500	-108.95	143.70	0.08	-0.76	1.08
69	SASK	PMV	Flaxseed	7093	92206	-92.21	-51.43	0.24	-0.61	0.94
70	SASK	PMV	Wheat	180400	2345196	-118.04	-874.64	0.29	-0.54	1.07
71	SASK	PR	Canola	18252	237280	-100.37	97.40	0.04	-0.90	0.93
72	SASK	PR	Wheat	141629	1841181	-116.14	-516.57	0.18	-0.58	0.86
73	SASK	TB	Canola	9814	127583	-94.71	-105.33	0.05	-0.48	0.99
74	SASK	TB	DryPeas	12888	167547	-97.63	-208.24	0.19	-0.91	0.77
75	SASK	TB	Flaxseed	4119	53549	-88.12	73.43	0.24	-0.79	0.47
76	SASK	TB	Other	629	8179	-73.28	27.49	0.05	-0.86	0.39

Table 8 Autoregressive model parameters

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i Views expressed in this paper benefited from exchanges between the authors and colleagues from Transport Canada. The authors thank all reviewers of this article for their useful comments. However, the views expressed herein do not necessarily reflect those of Transport Canada.

[ii] Note that British Columbia as a source province and Churchill as a destination port have been excluded from this analysis.

[iii] http://www.quorumcorp.net/index.html

[iv] Tab '1A-1A' & '1A-2A' from 'MonthlyReport201512DataTables.xls'

[v] Tab '2B-5 M' from 'MonthlyReport201512DataTables.xls'

[vi] Flaxseed and Rye were not estimated for AB-PR, MB-PR and Oats were not estimated for MB-PR, therefore 5 models were excluded from the total potential 81 models.

[vii] Newbold, P, Carlson, W & Thorne, B.E.T.T.Y. (2003). *Statistics for Business and Economics*. (5th ed.). New Jersey: Pearson Education Inc.

[viii] https://en.wikipedia.org/wiki/Mean_absolute_percentage_error

[ix] http://support.sas.com/documentation/cdl/en/etsug/67525/HTML/default/viewer.htm#etsug_x12_overview.htm

[x] http://news.gc.ca/web/article-en.do?mthd=advSrch&crtr.page=2&crtr.dpt1D=6695&nid=822889