An Economic Analysis of Western Canadian Grain Export Capacity

Final Report

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Executive Summary

Gray (2015) estimated the cost of limited export capacity in 2013-14 and 2014-15 crop years to Western Canadian grain producers. The purpose of this report is to follow up on this research and systematically estimate the need for additional grain export capacity in Western Canada. We begin with a description of the economic framework and report the economic impact of limited export capacity during the 2013-14 and 2014-15 crop years. After quantifying the economic impact of limited grain handling and transportation capacity, we assess the need for future export capacity using a forecast of exportable supplies for the 2016-25 period. Using a spatial equilibrium transport model, we simulate additional export capacity and show that 10 million tonnes of additional annual export capacity is worth several billion dollars to Prairie grain producers.

The analysis of past export basis levels begins with a literature review and employs framework developed by Gray (2015) to analyze export basis levels since the 2012 removal of the CWB single desk system. The reported export basis levels remained comparable to long run averages during the 2012-13 crop year, when there was adequate export capacity to move the crop. This situation changed dramatically following the record 2013 crop. In the 2013-14 and 2014-15 crop years, access to the limited grain export capacity was rationed. This resulted in much higher export basis levels. These higher basis levels and lower cash bids came at a substantial cost of at least $5 billion to prairie grain producers. While export basis levels have returned to normal in the 2015/16 crop year, this costly past experience provokes two important questions:

- Were the elevated export basis levels an anomaly, or can we expect similar situations in the future?
- If limited export capacity is likely to result in additional costs to producers in the future, how effectively will investments in capacity reduce these costs?

In order to address these questions, we forecast future grain production levels and use an economic model to calculate the effect of limited export capacity on future expected basis levels. Production forecasts, which are estimated using a vector auto regressive (VAR) model, along with probability density functions (PDFs), are used to calculate future expected basis levels and farmers' expected loss from limited export capacity in a linear programming model.

The Linear Programing (LP) model simulates a competitive market by minimizing the cost of transporting the exportable supplies of cereals, oilseeds, and pulses from Alberta (AB), Western Saskatchewan (West SK), Eastern Saskatchewan (East SK), and Manitoba (MB) to the export markets through the West, East, and South ports. We assume that when export capacity is limited relative to exportable supply, grain can be stored at a cost.

The methodology developed in this study is unique in the sense that it uses production forecasts, their corresponding probability distributions, and rational expectations to estimate farmers' expected storage cost. The per unit expected storage cost is then incorporated in the LP model to minimize total transportation and storage costs. Shadow values, which represent the effect of limited export capacity on expected basis, are then used to calculate farmers' expected loss from limited capacity. Thus, expected storage cost is the key driver of shadow values and, thereby, expected loss.

The VAR forecasts developed in this study indicate that Western Canadian production has an upward trend that increases by approximately 450 thousand tonnes a year. Given this production trend, the probability of running into the "limited grain export capacity" problem increases over time. Our results indicate that the probability of producing over 65 MMT increases from 10 percent in 2016 to 23 percent in 2025.

The increase in expected production also results in an increase in average expected basis over time. With random fluctuations with respect to these upward trends, the excess basis will occasionally reach $120/tonne, which is the equivalent of the cost of storage for two consecutive years. As presented in the following summary table (under the Base Scenario), the production forecasts without increases in rail and port capacity will lead to an expected loss for farmers, as they will be expected to pay approximately $10.8 billion at a 5 percent discount rate for the 2016-25 period as a result of above normal basis. This is very large cost, suggesting that producers have a very significant economic interest in increasing export capacity.

Three scenarios are considered for export capacity improvement (Scenarios 2 to 4 are in the following summary table). Scenario 2 finds the cost-saving benefits of improving rail capacity without any improvement in the West Coast capacity. Results show that increasing rail capacity by 5 million tonnes per year, even without increasing West Coast Capacity, will reduce the cost of excess basis by $3.5 Billion. The cost savings increase to $5.2 billion over the 2016-25 period if annual rail capacity is increased by 10 million tonnes.

Table i. Summary of Main Results at 5 percent Discount Rate, 2016-26.

Scenarios		**Expected Loss** (billion $)	**Cost-Saving Benefits** (billion $)
1. Base		10.8	-
2. Rail Capacity Improvement	5MMT	7.3	3.5
	10MMT	5.6	5.2
3. West Coast Capacity Improvement	5MMT	8.6	2.2
	10MMT	7.6	3.1
4. Rail and West Coast Capacity Improvement	5MMT	4.7	6.1
	10MMT	1.6	9.1

Scenario 3 estimates the cost-saving benefits of improving West Coast capacity without any improvement in rail capacity. Increasing West Coast capacity by 5 and 10 MMT will result in $2.2 and $3.1 billion in cost-saving benefits for producers, respectively. It is worth noting that increasing the West Coast capacity will provide an incentive for the railways to move more grain to the West Coast as they either invest in their capacity, allocate more resources to west movements, or both. In other words, increasing the West Coast capacity might be a necessary condition to improve overall export capacity.

Scenario 4 examines the combined effect of rail and West Coast capacity improvement. A 5 MMT increase in both rail and West Coast capacity reduces the total expected losses from $10.8 billion to $4.7 billion, saving Western Canadian farmers $6.1 billion at a 5 percent discount rate over the next ten years. A 10 MMT improvement in both rail and West Coast capacity lowers the total expected loss to $1.6 with $9.1 billion in cost-saving benefits for the producers. The cost-saving benefits of improving both rail and West Coast capacity simultaneously are significantly higher than improving either one individually.

Results also indicate that under the MRE regulation, the railways can increase their revenue by moving more grain. Removing the MRE, however, will create a perverse incentive for the railways where they can increase their revenues by moving less grain and charging more for their services. Without MRE regulation the railways could maximize their profits by reducing their grain transportation services to 25 MMTs, which is the revenue-maximizing level for normal production years. This means, in most years there would be a shortage of rail capacity and high export basis levels. In the 2013-14 crop year, basis rents exceeded $3.7 billion, and accrued largely to grain companies. In the absence of an MRE, the grain companies would bid for cars and transfer most these large rents to the railways. If the railways had been prepared to only move 25 MMT, the impact on basis levels and producers' welfare would have been greater.

Although estimating the cost to improve export capacity is beyond the scope of this study, cost estimates are borrowed from some grain companies' news reports to provide the reader with a comparison of the benefits and costs of improving export capacity. Richardson considered a $120 million budget to add 80 thousand tonnes of storage capacity, which will result in increasing their export capacity by 2 MMTs, which equates to $60 per tonne of annual export capacity. Global Grain Group (G3) has announced a $500 million investment to create 180 thousand tonnes of storage capacity that will result in at least 4.5 MMTs of export capacity. This equates to $110 per tonnes of annual export capacity.

Using these estimates, it will require approximately $1 billion to add 10 MMT of capacity ($100/tonne) at the West Coast. The estimates of this study show that increasing West Coast capacity without any improvements in rail capacity will result in $3.1 billion of cost-saving benefits for farmers. This implies a benefit–to-cost ratio of 3.1/1. If the West Coast expansion is accompanied by a similar increase in rail capacity, a 10 MMT increase in West Coast capacity will create $9.1 billion of cost-saving benefits. This implies a benefit-to-cost ratio of 9.1/1. These high benefit-to-cost ratios highlight the importance of improving the export capacity throughout the West Coast.

Notably, investing in physical infrastructure is not the sole method to increase West Coast export capacity; policy is also important. Providing additional economic incentives for investment in rail capacity might, at least to some extent, be realized by refining the Maximum Revenue Entitlement (MRE) regulation. Port capacity improvement includes but also goes beyond the physical assets at the port terminals. Increased coordination including the development of viable cash and futures markets, could improve coordination among marketers, would speed up the movement of grain, prevent backlogs, and reduce demurrage costs.

Achieving these desirable outcomes will be a difficult task requiring further research, consultations with various players in the supply chain, and ultimately new institutions. Nevertheless, all of these solutions should be considered as necessary, but not necessarily sufficient components, of a long-run plan to resolve a multi-billion dollar problem in Western Canadian agriculture.

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1. Introduction

In the 2013 crop year, record production levels combined with slow early season grain movements, created a grain transportation crisis in Western Canada. Despite high international prices, grain stocks were very large on the prairies as line-up of boats waited for port delivery. As grain companies lowered their cash bids to ration available capacity, export basis levels increased significantly, peaking up to three times above normal levels. In March 2014, the federal government responded with a regulation to require minimum weekly grain rail movement for both railways. It took until July 2015 for ending stocks export basis levels to return to normal. Two years of elevated basis levels came at a large cost to prairie farmers.

One might argue that the transportation crisis created by record 2013 crop yield was an isolated incident that may not be repeated again and, therefore, any efforts to improve the export capacity are unnecessary. However, this is an empirical question governed by future export demand, and future grain movement capacity.

In this study we use an economic framework that incorporates the derived demand for grain exports within a spatial model, involving four production regions and four export points. This framework is developed by Gray (2015). Using price and quantity data for the 2012-13, 2013-14, and 2014-15 crop years, Gray (2015) estimates *ex post* impacts of limited rail and West Coast export capacity[1]. Looking forward, the *ex ante* component of our study addresses the need for future grain export capacity, which begins with production forecasting over the 2016-2026 period. As a benchmark, we estimate farmers' potential loss with the assumption that there will be no improvements in the grain export capacity in the next 10 years. We then examine how these costs can be reduced with additional rail movement capacity and by increasing specifically West Coast export capacity.

The remainder of this study is organized as follows: Section 2 provides a theoretical background on demand for grain handling and transportation (GH&T). Sections 3 and 4

[1] This study defines export capacity as overall GH&T system export capacity.

present the *ex post* and the *ex ante* analyses, respectively. Sections 2 and 3 are borrowed from Gray (2015) and presented in this study to provide the necessary theoretical and empirical background for the reader. Sections 5 and 6 provide a conclusion of the study and some policy solutions to the limited export capacity issue, respectively.

2. Theoretical Background: Derived Demand for GH&T and Role of Arbitrage

The *export basis* is defined as the difference between the cash prices paid to farmers and the export price received free on board (FOB) Vancouver[2]. Export basis is an approximate measure of the per (metric) tonne (MMT) revenue or gross margin earned by grain companies to purchase grain from producers in Saskatchewan and place it on board a vessel in Vancouver. To earn this gross margin, the grain companies must incur the cost of primary elevation, cleaning and storage, rail freights costs, terminal elevation and fobbing costs. The opportunity for profitable arbitrage occurs when the price paid to producers plus all costs incurred to handle and transport the grain to a FOB position is less than the FOB price paid by the buyer.

Grain companies have to compete with one another to purchase grain from producers. Typically, grain producers have more than one company to purchase their grain, and will deliver to the firm paying the highest net farm-gate price. When there is adequate GH&T capacity to move the available farm supply, the export basis will closely reflect the handling and transportation costs, as any export basis over costs will be an attractive transaction for grain marketing firms.

Given the large investments and fixed costs involved in grain handling, it is not easy to directly observe the costs for each component of the GH&T system. However, the industry does file the maximum tariffs charged to third parties for specific services, including primary elevation, removal of dockage, terminal elevation, etc. Both railways also file freight rates. These filed tariffs include variable costs plus a contribution to fixed

[2] Basis can refer to the difference between any two prices. As the largest volume port, Vancouver FOB, minus the elevator bid prices representative measure of the "export" basis for grains in Western Canada.

costs, which means that when the export basis is equal to the filed grain handling and transportation tariffs, the firms settle all costs and earn a profit for shareholders.

To examine the impact of an export capacity constraint, it is useful to place the grain handling and transportation services in a *derived demand* framework, illustrated in Figure 1. The derived demand for GH&T is derived from the difference between the FOB Vancouver demand (shown in Panel A) and the producer supply curve (shown in Panel C). The derived demand represents the maximum willingness that a broker would pay to have grain handled and transported from producer delivery points to FOB Vancouver position. The FOB Vancouver demand has very little slope, reflecting the fact that Canada produces approximately 4 percent of the world grains and therefore is largely a price taker in the world market. The producer supply curve (shown in Panel C) is the price at which farmers in aggregate are willing to sell any specific quantity of grain to elevators in Saskatchewan for export. The price intercept of the supply curve indicates the cash price that the most desperate producer would accept if the exports were limited to one tonne for the region. As the quantity purchased for export increases, the producers' offer price would also increase. As the quantity purchased for export approaches the total grain available, the producers' supply curve will be become vertical as higher prices cannot attract additional deliveries. The derived demand for GH&T services is the difference between the FOB Vancouver price and the producers' sale price. Graphing this relationship, the vertical subtraction of the upward sloping producer supply curve from the relatively flat FOB demand curve creates the downward sloping derived demand curve for GH&T shown in Panel B.

The supply GH&T services is shown in panel B. The price intercept of the supply curve point represents the minimum basis charge by any grain handling firm to export the first tonne offered. The long and nearly horizontal portion of the GH&T supply curve represents the quantity that will move at posted tariff rates. As the quantity moved approaches GH&T export capacity, the GH&T supply curve slopes upward as the exporter must incur additional costs to secure additional export capacity. The GH&T export supply curve becomes nearly vertical as the short term options to increase export capacity are exhausted.

The price of GH&T or basis charges for GH&T will be determined in the market for GH&T where the demand curve for GH&T intersects with the GH&T supply curve. As illustrated in Panel B of Figure 1, if this intersection occurs where capacity constraints are not binding, the basis charges will be close to the published maximum tariff rates. In this case, bid prices in Saskatchewan will be the Vancouver FOB price minus published tariff rates, so that grain companies will earn normal profits from exporting grain.

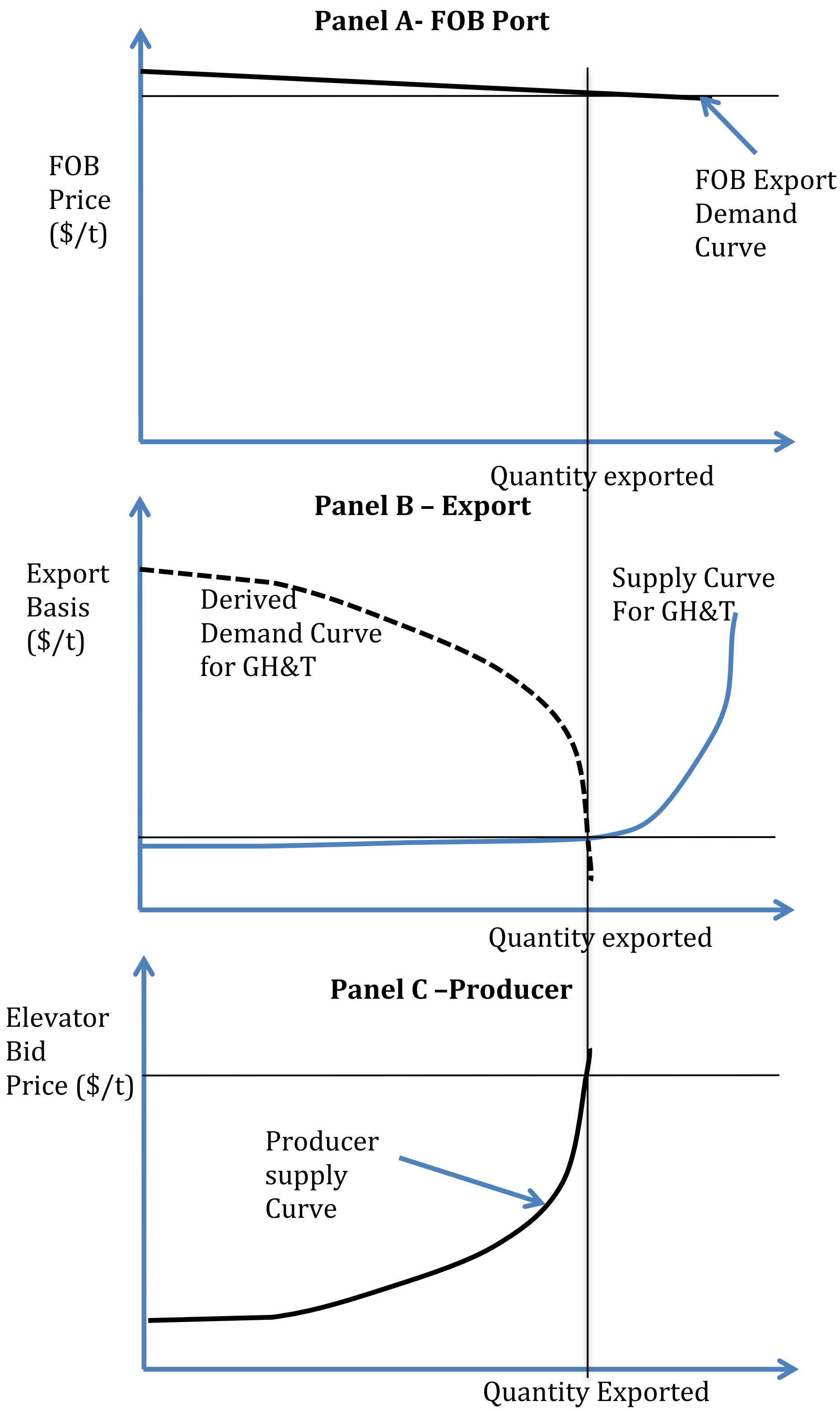

Figure 1: Export Basis and Price Impacts without a binding Capacity Constraint.

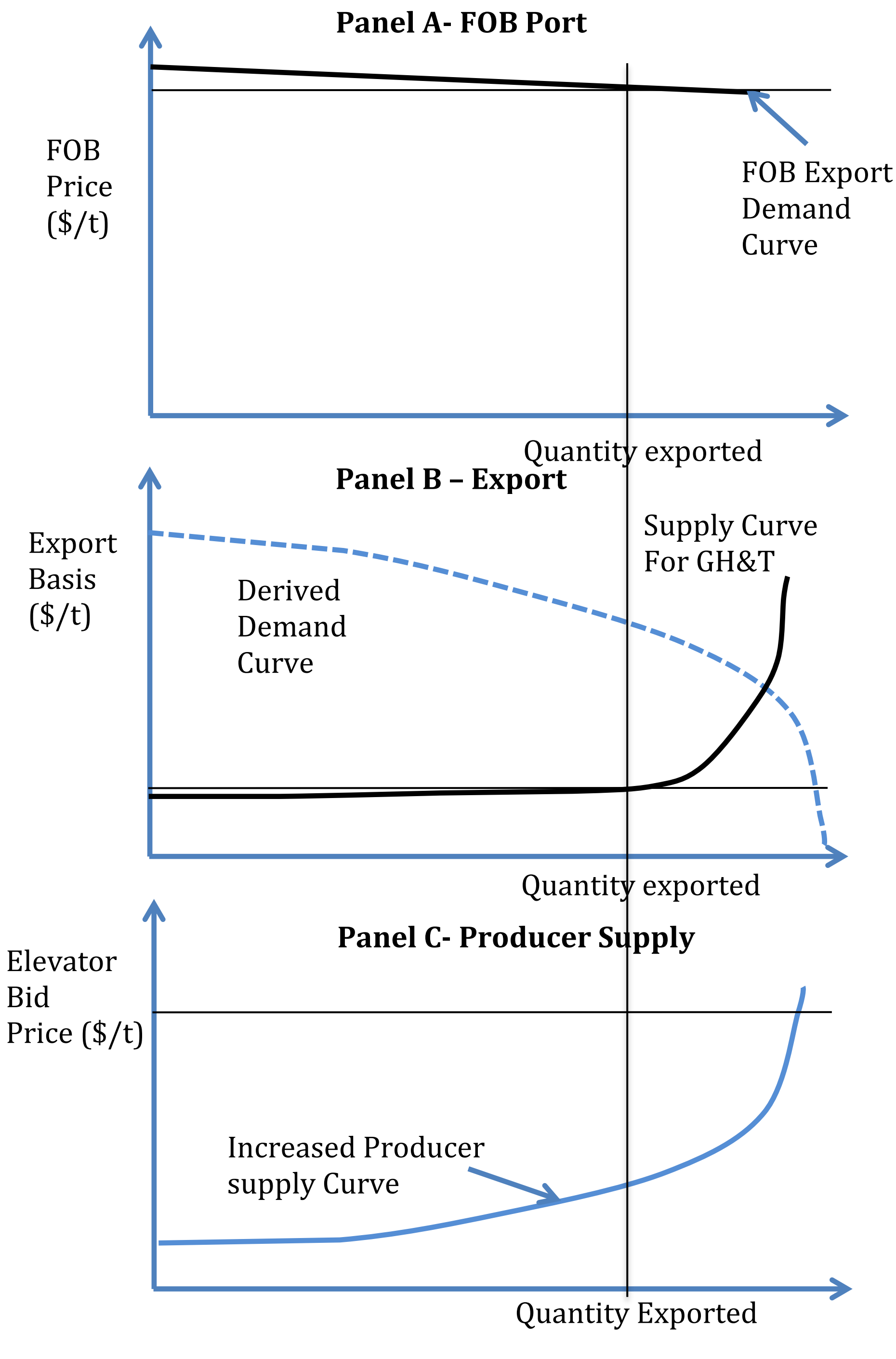

Figure 2: The Impact of Large Capacity Constrained Supply on Basis Levels and Producer Prices.

When GH&T capacity constraints become binding and there is a large producer supply, the situation changes dramatically, as illustrated in Figure 2. In this case, the intersection of derived demand and the supply of GH&T occurs in the more vertical portion of the GH&T supply curve. In this case, the GH&T export basis will be far higher than tariff rates, and the cash bids will be reduced relative to Vancouver FOB prices.

The GH&T rents, which are the differences between the average cost of GH&T and the basis charges, will accrue to the grain companies or contract holders that have secured access at lower tariff-based rates. Railways, whose average freight rates are constrained by the Maximum Revenue Entitlement (MRE), cannot capture additional revenue by increasing freight rates.[3] Producers who face lower prices for the grain they export or sell locally will incur a cost equal to the increase in basis multiplied by the quantity of their sales.

There are a number of forms of arbitrage related to the *law of one price* that will contribute to higher export basis impacts across markets. First, as long as some product is exported at elevated basis levels, the price at which producers are willing to sell to local processors will also reflect the same lower cash bids. Second, grain companies also have a choice as to which grades and commodities to purchase. They have an incentive to purchase and move those grain types with higher basis levels. This grain company arbitrage occurs until all grades and commodities earn similar basis rents per tonne. Finally, producers have a choice between selling grain at the current basis versus storing and selling grain at some future date, with the expected return from current and future sales differing by storage costs. When basis levels increase, both current and future contract prices will be impacted.

Given these various forms of arbitrage in efficient markets, the impacts of an increased basis tends to be pervasive and impacts nearly all sales within the export area similarly. The exceptions to this general rule are those producers able to avoid the impact of lower cash bids by contracting prior to basis level increases or those that find alternative markets for delivery that have not been impacted by an increased basis. For example, in the 2013-14 crop year, some producers near the US border were able to limit the impact of a higher than normal basis by trucking their grain to US shipping points that were less

[3] This differs from the United States, the railways capture most of the rents from a capacity constraint by raising their rates or auctioning off rail car shipments to the highest bidder.

congested. Notably, while some of these forms of arbitrage did take place, CGC delivery statistics suggest that the vast majority of grain was delivered to local grain elevators for export shipment (CGC, 2015).

As well, it is worth noting that capacity constraints can also create significant logistical issues for grain customers at FOB port locations. Customers often calibrate their purchases to create a steady flow of grain to their processing facilities. The GH&T capacity issues in 2013 resulted in a delay in shipment for many customers. While these customers were partially compensated for their losses through demurrage payments, many were forced to take other actions to secure a timely product supply. This additional delivery risk can be reflected in the Canadian FOB offer prices, relative to price offered to other sellers. In this case the FOB demand curve shifts downward to reflect a reduced willingness to pay for risky Canadian grain supply.

The established theory presented in this section is used as the primary framework to measure the impacts of GH&T capacity constraints. To further illustrate this theory, the next section calculates the export basis levels and farmers' foregone revenues over the past three crop years.

3. *Ex post* Analysis: The Foregone Revenue[4]

Excess basis levels are used to approximate the income impact on Western Canadian grain producers as shown in Table 2. Losses to producers are calculated based on the deliveries of grain in Western Canada during the periods of August 1 to December 31, January 1 to March 31, and April to July 1 for the 2013-14 and the current 2014-15 crop year.[5] Wheat, barley, canola, peas and oats are included. Other grains produced in the region are not.

Farmer deliveries are multiplied by the estimates of excess basis levels reported earlier to quantify the overall impact. In the first calculation, the basis levels that exist at

[4] This analysis was initially reported by Gray (2015)

[5] These periods are used because Statistics Canada does surveys of farm stocks providing more accurate estimates of farm sales during these intervals.

the time of delivery are assumed to apply to all grain delivered during the period. This should be considered as an upper bound of any estimate, as many producers forward-price and forward-contract deliveries.

In the second calculation, it is assumed that all grain delivered reflects the basis that existed 12 weeks earlier. While this is an extreme amount of forward contracting, it illustrates the idea that the basis impact is only slightly smaller in total when forward contracting is taken into account. In this case, the estimated income loss to Western grain producers is $6.3 billion.

In a third calculation, reported in the last two rows of Table 2, it is assumed that 20 percent of all the grain deliveries reported were able to escape any impact of higher export basis. All of the sales had their basis is set three months in advance. Even in this extremely conservative case, the losses to grain producers exceed $5.05 billion dollars.

The figures reported in Table 2 are based on several simplifying assumptions, primarily because the data does not exist. First, it assumes that the excess basis reported in Table 1 represents the additional export basis due to a lack of export capacity. Given the clear comparison to the $72 basis that existed in the post CWB 2012-13 crop year, when there was adequate export capacity, the excess over $72 can be reasonably attributed to the lack of export capacity relative to supply. The return towards a more normal basis levels in June 2015, as delivery pressures decreases, also provides support for this assumption.

Second, the reported basis calculations assume that the relationship between the average cash elevator bids and the actual prices received by producers do not change from one crop year to the next. For instance, if producers were able to (on average) receive a $5/tonne delivery premium over the cash bids in 2012, they were also able to do so in 2013. This assumption in the calculation could underestimate the excess basis in 2013 and 2014 if these delivery premiums were reduced as the system became congested.

Table 1: Estimated Vancouver FOB – Saskatchewan Cash bid Export Basis ($/T).

	Crop Year			
Shipping month	2012-13	2013-14	2014-15	2002-2012 (average)
Aug	72.25	83.88	142.89	72.25
Sept	78.95	87.96	134.77	72.25
Oct	85.61	113.06	129.62	72.25
Nov	76.87	125.73	127.50	72.25
Dec	72.44	162.04	115.51	72.25
Jan	65.77	245.24	135.30	72.25
Feb	57.86	252.37	103.83	72.25
March	71.12	199.81	118.61	72.25
April	73.80	199.81	125.08	72.25
May	58.37	168.50	136.15	72.25
June	67.40	157.02	117.99	72.25
July	40.46	145.44	93.00	72.25
Average	68.41	161.74	123.60	72.25

Source: As calculated from Industry, AAFC, CGC, and Saskatchewan Ministry of Agriculture reported prices.

Table 2: Estimated Grain Producer Income Impact of Congestion Related Excess Export Basis Western Canada 2013-14 and 2014-15.

	2013-2014 Crop year			2014-2015 Crop year			
	Aug-Dec	Jan-Mar	Apr-Jul	Aug-Dec	Jan-Mar	Apr-Jul	Total
Farm Deliveries (000T) *	21.80	11.86	18.92	22.85	12.72	15.00	103.15
All Sold at Prevailing Basis**							
Ave Excess Basis($/T)	$51.49	$143.53	$77.67	48.63	59.97	34.94	64.88
Producer Losses ($Million**)**	$1,123	$1,702	$1,470	$1,111	$763	$524	**$6,692**
All sold at basis 12 weeks prior^							
Excess Basis (t -12weeks)($/T)	$6.02	$75.78	$130.82	58.62	48.48	56.82	61.21
Producer Losses ($Million)	$131	$899	$2,475	$1,339	$617	$852	**$6,314**
80% sold at basis 12 weeks prior^^							
Excess Basis (t -12weeks)($/T)	$6.02	$75.78	$130.82	$58.62	$48.48	$56.82	0.75
Producer Losses ($Million)	$105	$719	$1,980	$1,071	$493	$682	**$5,051**

Source: Authors Calculation, Table 1, and CANSIM Table 0010043.
* Farm Deliveries of wheat, oats, barley, Canola, peas, Western Canada.
**Excess basis is estimated to be Vancouver FOB – Sask. Cash bids for wheat - $72/tonne see Table 1 for calculation and sources.
^Excess basis reported for 12 weeks prior to delivery is used to estimate impact.
^^This lower bound estimate assumes that only 80 percent of producer deliveries are impacted and all basis is priced 12 weeks prior to delivery.

Finally, these calculations assume that the wheat export basis is also reflected in the basis levels of the other grains (barley, canola, oats and peas). From an arbitrage perspective, this is a reasonable assumption, as grain companies must allocate limited export capacity among the various grains they buy. As mentioned previously, if the basis level on another grain was significantly higher than wheat, a company would move more of that product until the basis was equal among grains. Similarly, if the basis was lower on some other grain, the company would be better off using their capacity to ship wheat.

4. *Ex ante* Analysis:

The objective of the *ex ante* analysis is to first estimate prairie farmers' potential loss from limited export capacity, and then to estimate the cost-saving benefits of improving the export capacity. For this purpose, a linear programming (LP) model is developed. The model allows for the (on-farm) storage of crops by farmers at a cost when exportable supplies are larger than export capacity, and calculates expected basis and loss as well as the cost-saving benefits to improve the export capacity through rail and port facilities.

4.1. Methodology

In order to find the effect of limited export capacity on basis levels and farmers' revenue, we first forecast future production. This, however, does not provide the likelihood of various production levels occurring in the future. To resolve this issue, this study also generates probability distribution functions (PDFs) for future production levels. Production forecasts, along with their PDFs, are then used to calculate future expected basis levels and farmers' expected loss from limited export capacity in a LP model. The expected basis levels are calculated based on expected storage costs. The next section presents the methodology corresponding to these steps.

4.1.1. Future Production

This study uses historical data to forecast future crop production in Western Canada. Production level data from 1976 to 2014 have been obtained from Statistics

Canada (2015a). Crops used in this study include spring wheat, winter wheat, durum wheat, barley, canola, soybeans, oats, rye, flaxseed, chick peas, lentils, and dry peas. Production data are presented in Figure 3.

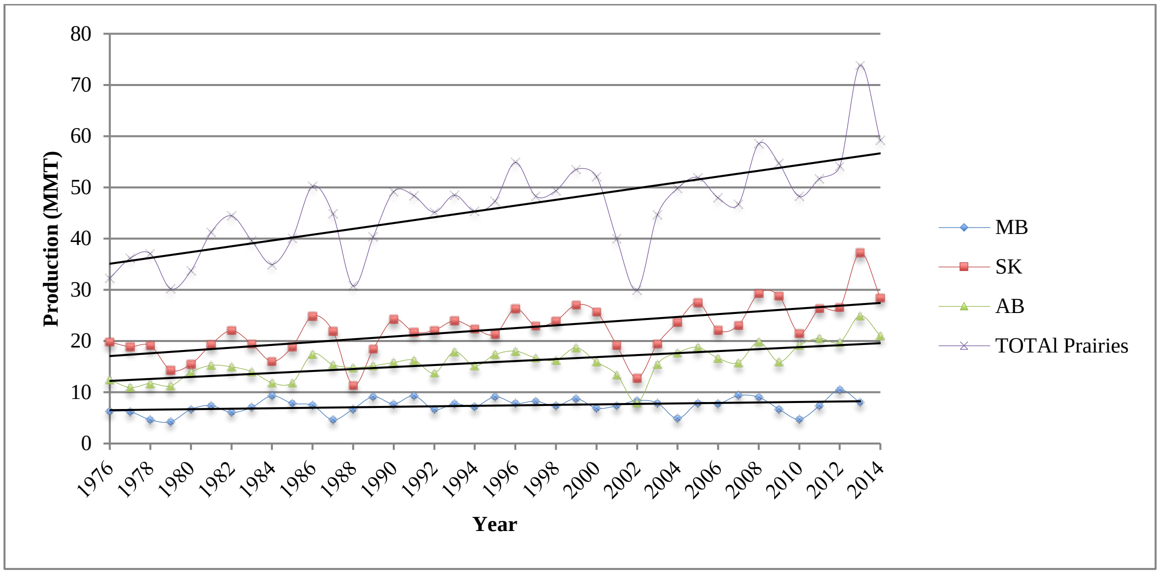

Figure 3. Production of Cereals, Oilseeds, and Pulses in Manitoba (MB), Saskatchewan (SK) and Alberta (AB), 1976-2014.
Source: Statistics Canada (2015a).

As presented in Figure 3, production levels in the three provinces are highly correlated. Therefore, the aggregate data regarding Alberta, Saskatchewan, and Manitoba are applied to forecast future production.

A Vector Auto-Regressive (VAR) model has been applied to estimate the magnitude and length of autocorrelation, and the importance of a time trend in a crop production time series (Greene, 2002; Chapter 19). The VAR model takes the following functional form:

(1) $$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 T + \beta_4 D_{1988} + \beta_5 D_{2002} + \beta_6 D_{2013} + \epsilon_t$$

where Y_t, Y_{t-1}, and Y_{t-2} are the current, first lag, and second lag of production levels, respectively; T represents time trend; D_{1988}, D_{2002}, and D_{2013} are dummy variables for years with significantly lower or higher than average production levels; and ϵ_t represents the error term.

The intuition behind the autocorrelation terms (i.e. Y_{t-1} and Y_{t-2}) in the regression model is quite interesting. As can be seen in the above figure, good crop years are usually followed by another relatively good crop year. Similarly, bad crop years are usually followed by another relatively bad crop year. While weather cycles may last more than one year, moisture stored in the soil can positively impact the subsequent crop. Similarly, a drought can leave less soil moisture for the next crop. This explains the intuition behind the first lag (i.e. Y_{t-1}). The second lag (i.e. Y_{t-2}) reflects the fact that the production level regresses to its average. Therefore, β_2 is expected to have a negative sign.

The time trend variable, *T*, is critical for estimating the rate of yield improvement over time. In order to ensure that abnormally high or low production levels do not affect the parameter on the time trend variable, dummy variables are incorporated for 1988, 2002, and 2013. Production levels in these years can be seen in the above Figure 3.

4.1.2. Probability Distribution Functions (PDFs)

A simulation model has been used to produce probability distributions for current and future production of cereals, oilseeds, and pulses. These probability distributions (Billingsley, 1979) take into account the autocorrelation and the time trend estimated in Equation 1. Production levels are assumed to have Normal Distributions. The probability distribution for production in each year is calculated in the following manner:

A. Calculate the parameters (i.e. mean and variance) of a Normal distribution for the de-trended historical production data from 1977 to 2014.
B. Produce random draws within the Normal distribution with the parameters calculated in *A*.
C. Add the first lag parameter, β_1, estimated in Equation 1 to the random draws calculated in *B*.
D. Add the second lag parameter, β_2, estimated from Equation 1 to the result of *C*.
E. Add the time trend variable parameter, β_3, estimated in Equation 1 to the result of *D*.

4.1.3. Expected Storage Cost and Expected Basis with Rational Expectations

The objective of this section is to describe how expected basis levels are calculated based on expected storage costs, given the limited total export capacity and rational expectations. The next section describes how expected storage costs are used in the LP model to find the movements of grain and storage levels.

It is assumed that total export capacity is constrained by the current rail capacity of 40MMT. Therefore, exportable supply levels that are higher than export capacity result in storage. The existence of storage costs, which are incurred by farmers, creates an opportunity for grain companies to increase basis levels. In Year *t*, farmers have no choice but to either accept the cash price P_t^f or to pay a storage cost τ_t^s and sell the crop next year at the price of P_{t+1}^f. Therefore, in year *t*, farmers are indifferent between P_t^f and P_{t+1}^f- τ_t^s. Therefore, farm price (i.e. farmers' received price) in year *t* can be found from the following condition:

(2) $$P_t^f = P_{t+1}^f - \tau_t^s$$

Equation 2 links farm price in year *t* to farm price in year *t+1* and is valid if and only if there is storage in year *t*. However, farm price in year *t+1* depends on farm price in year *t+2* and storage cost in year *t+1*. That is, in year *t+1* farmers are indifferent between P_{t+1}^f and P_{t+2}^f- τ_{t+1}^s. Therefore, farm price in year *t+1* can be found from the following condition:

(3) $$P_{t+1}^f = P_{t+2}^f - \tau_{t+1}^s$$

Assuming storage continuously occurs for *n* consecutive years, price in year *n* can be found as follows:

(4) $$P_{t+n}^f = P_{t+n+1}^f - \tau_{t+n}^s$$

Therefore, equation 2 can be rewritten as follows:

(5) $P_t^f = P_{t+n+1}^f - \sum_{i=t}^{t+n} \tau_i^s$

Given that the cash price in any year is equal to a constant world price, P^W minus basis, and assuming that the basis level returns to the normal level after *n* years, equation 5 can be rearranged as follows:

(6) $P^W - B_t = P^W - \bar{B} - \sum_{i=t}^{t+n} \tau_i^s$

where B_t is the basis level in year *t* and $\bar{B}$ is the normal basis level. Equation 6 can be rewritten to find the basis level in year *t*:

(7) $B_t = \bar{B} + \sum_{i=t}^{t+n} \tau_i^s$

Equation 7 states that the basis level in any given year is equal to the normal basis plus all storage costs that farmers incur for the crop produced in that year. However, farmers are not certain about how many consecutive years there will be positive storage from the crop produced in year *t* (i.e. farmers are uncertain about *n*). The number of years that there will be positive storage from crops produced in year *t* depends on future production levels. Therefore, farmers form rational expectations regarding future storage cost (Muth, 1961). To incorporate these rational expectations, equation 6 can be rewritten as follows:

(8) $E[B_t] = \bar{B} + \sum_{i=t}^{t+E[n]} \tau_i^s = \bar{B} + E[\sum_{i=t}^{t+n} \tau_i^s]$

These expectations are based on the probability distributions of future production.

This study assumes basis levels return to normal level after a maximum of two years. Therefore, we use a reduced from of equation 8 as follows:

(9) $E[B_t] = \bar{B} + E[\sum_{i=1}^{2} \tau_i^s]$

Note that the expectations still play a critical role even in the case of only two years. This is because, as mentioned previously, a good crop year is likely to be followed by another relatively good crop year. Therefore, the probability of having to store grain for more than one year is higher in good crop years. Given the fact that farmers have no choice but to either accept the cash price or pay for storage, one can expect the basis levels to increase as the probability of having to store grain increases. This is the foundation of *expected basis* calculations in this study.

Given the theoretical background provided above, we can now describe how the expected basis is calculated when it is assumed that storage can occur for a maximum of two years. Assuming *EC* is export capacity, *DU* is domestic consumption, and subscript *t* represents time, expected basis can be calculated as described in Table 3.

Table 3. Expected Basis Calculations.

Production Level in year *t* (Y_t)	**Expected Basis Level in year *t* ($E[B_t]$)**
Zero to (EC_t+DU_t)	Normal Basis ($\bar{B}$)
Over (EC_t+DU_t)	Normal Basis ($\bar{B}$) + Expected Storage Cost ($E[\sum_{i=1}^{2}\tau_i^s]$)

Basis is determined by the most "desperate to sell" farmers. Therefore, if there is positive storage, regardless of the amount, basis will increase by the expected storage cost. Even if the probability of having to store grain for more than one year is zero, expected storage cost will still be equal to storage costs for one year. That is, expected basis will be equal to normal basis plus the storage cost for one year. However, as the amount of storage increases, the probability of having to store for more than one year increases. This increases the expected storage cost. Therefore, expected storage costs can be formulated as follows:

(10) $$E[\sum_{i=1}^{2} SC_i] = \tau_1^s + P.\tau_2^s$$

where τ_1^s and τ_2^s are storage costs in year 1 and 2, respectively, and *P* is the probability of having to store grain for more than one year (i.e. probability of having to store grain in year 2). It is worth noting that because of the spatial *law of one price,* the expected storage cost, or the increase in basis level, will not be confined to the area in which storage occurs. Instead, it will apply to the entire market.

The probability of having to store grain for more than one year (i.e. the probability of having to store grain in year 2 or more generally year *t+1*) is calculated as follows:

(11) $$\mathrm{P}(Y_{t+1} > EC_{t+1} + DU_{t+1} - S_t) = 1 - F_{Y_{t+1}}(EC_{t+1} + DU_{t+1} - S_t)$$

$$= 1 - \int_{-\infty}^{EC_{t+1}+DU_{t+1}-S_t} f_{Y_{t+1}} dY_{t+1}$$

where is Y_{t+1}, EC_{t+1}, and DU_{t+1} are production level, export constraint, and domestic use in year $t + 1$, and S_t is storage level in year *t*. *F* and *f* represent PDF and cumulative distribution function (CDF), respectively. The PDF has a Normal distribution as follows:

(12) $f_{Y_{t+1}} \sim N(\mu_{t+1}, \sigma^2)$

where μ_{t+1} and σ^2 are expected production level and variance in year *t+1*. In order to calculate the probability in equation 11, we need the expected value and the variance of the PDF for production levels in year *t+1*. The expected value is the "expected production" level for year *t+1*. However, as mentioned previously, good crop years are usually followed by another relatively good crop year. Usually, basis becomes an issue when there are significant carry-over stocks from one good year to another relatively good year. Farmers are aware of this fact and take into account of it when forming their expectation of future production. This is reflected in the VAR model through the first lag. If the production level in year *t* is above the mean, then β_1 (percent) of the difference from the mean is added to the expected production in year *t+1*. To incorporate this in the calculation of farmers' expectations, expected production in year *t+1* is calculated as follows:

(13) $\mu_{t+1} = \bar{Y}_{t+1} + \beta_1(Y_t - \bar{Y}_t)$

where $\bar{Y}_t$ and $\bar{Y}_{t+1}$ are estimates of average production in years *t* and *t+1*, respectively. Y_t is the production level in year *t*, and β_1 is the autocorrelation coefficient obtained from the VAR model.

A simple example provides a better understanding of the basis calculation. Assume export capacity is 40 MMT and domestic consumption is 20 MMT. If production level in a particular year is 70 MMT (a good crop year), pipeline stocks will be full and farmers will have to pay storage costs for at least one year. There will also be 10 MMT of carry-over stocks from this year to the next year. Therefore, any production level above 50 MMT next year results in at least two years of storage for this year's carry-over stocks.

Consequently, the limit for the next year of production is 50 MMT. The PDFs help find the probability of producing over the limit next year. Assuming the PDFs suggests that the probability of producing over 50 MMT next year is 80 percent, the normal basis is \$50/MMT, and the storage cost is \$60/MMT, the expected basis level for this year's crop will be equal to:

50+60+60*0.80 = \$158/MMT

Farmers' expected losses from limited export capacity is calculated as the weighted average of above normal basis levels, with probabilities of the occurrence of various expected basis levels as weights.

4.1.4. The Linear Programing Model

The objective of this section is to quantify farmers' expected loss from limited grain export capacity as well as cost-saving benefits of improving rail and West Coast capacity constraint. For this purpose, a LP model is designed.

In the LP model it is assumed that cereals, oilseeds, and pulses are transported from Alberta (AB), Western Saskatchewan (West SK), Eastern Saskatchewan (East SK), and Manitoba (MB) to the export markets through the West, East, and South ports. Origins and destinations are presented in Table 4.

Table 4. Origins and Destinations of Crops in the LP model.

Origins	Destinations
Alberta	West-Vancouver and Prince Rupert
West Saskatchewan	East- Thunder Bay
East Saskatchewan	South-Minneapolis
Manitoba	South- Pacific Northwest (through Minneapolis)

The LP model minimizes the cost of transporting deliveries of cereals, oilseeds, and pulses from Western Canada origins to the West, East, and South ports. However, if export capacity is limited, then grain must be stored for at least one year.

The critical element of the LP model is the expected storage cost. This is because it's indeed the expected storage cost that determines the shadow value of each constraint. When grain cannot be exported it must be stored at the expected storage cost. Therefore, it's the expected storage cost that determines how much extra cost farmers will have to incur for an extra tonne of exportable supplies (*i.e.* shadow value). Shadow values, in turn, are used to calculate farmers' expected loss from limited capacity. Thus, expected storage cost is the key driver of shadow values and, thereby, expected loss.

The LP model that incorporates both transportation and storage can be formulated as follows:

(14) $Min\ TC = \sum_i \sum_j \left[\tau_{ij} X_{ij}\right] + \sum_i \left[\tau^s S_i\right]$

Subject to:

(14-a) Production Constraint: $\sum_j \left[X_{ij}\right] + S_i = \bar{X}_i$; $\forall\ i$

(14-b) Port Constraint: $\sum_i \left[X_{ij}\right] \leq \bar{X}_j$; $\forall\ j$

(14-c) Rail Constraint: $\sum_i \left[\square_{ik}\right] \leq \bar{R}$; $\forall\ k$

(14-d) Non-negativity Constraint: $X_{ij}, S_i \geq 0$

Where

i represents origins and includes AB, West SK, East SK, and MB;

j represents destination ports and includes West, East, PNW, and Minneapolis;

k represents destination ports that require rail transportation (i.e. West and East);

X_{ij} represents the amount of grain transported from origin *i* to destination *j*;

X_{ik} represents the amount of grain transported from origin *i* to destination *k* by rail;

τ_{ij} represents the cost of transporting grain from origin *i* to destination *j*;

S_i represents the amount of grain stored at origin *i*;

τ^s represents the cost of storing grain and is identical for all four origins;

$\bar{X}_i$ represents the amount of grain produced at origin *i*;

$\bar{X}_j$ represents the capacity of port *j*;

$\bar{R}$ represents the rail capacity.

The corresponding Lagrangian can be formed as follows:

(15) $Z = \sum_i \sum_j [\tau_{ij} X_{ij}] + \sum_i [\tau^s S_i] + \lambda_i [\bar{X}_i - \sum_j [X_{ij}] - S_i] + \lambda_j [\bar{X}_j - \sum_i [X_{ij}]] + \lambda_k [\bar{R} - \sum_i [X_{ik}]]$

The Kuhn-Tucker Conditions are as follows:

(15-a) $\frac{\partial Z}{\partial X_{ij}} \geq 0$, $X_{ij} \geq 0$, and $X_{ij} \frac{\partial Z}{\partial X_{ij}} = 0$;

(15-b) $\frac{\partial Z}{\partial S_i} \geq 0$, $S_i \geq 0$, and $S_i \frac{\partial Z}{\partial S_i} = 0$;

(15-c) $\frac{\partial Z}{\partial \lambda_i} \leq 0$, $\lambda_i \geq 0$, and $\lambda_i \frac{\partial Z}{\partial \lambda_i} = 0$;

(15-d) $\frac{\partial Z}{\partial \lambda_j} \geq 0$, $\lambda_j \leq 0$, and $\lambda_j \frac{\partial Z}{\partial \lambda_j} = 0$;

(15-e) $\frac{\partial Z}{\partial \lambda_k} \geq 0$, $\lambda_k \leq 0$, and $\lambda_k \frac{\partial Z}{\partial \lambda_k} = 0$.

In the LP model, rail, West Coast, PNW, and Minneapolis capacity levels are constrained at the 2013-14 record level. Shadow value of each constraint represents the per tonne cost to farmers from limited capacity or the expected basis increase. These Shadow values are calculated for various production levels within the PDFs. Estimated shadow values along with the PDFs of production levels are used to calculate the expected loss of limited rail and West Coast export capacity. Then capacity limits for rail and West coast are increased individually and simultaneously to find the cost-saving benefits of capacity improvement at 5 and 10 MMT levels.

Shadow values of the rail capacity constraint are used to calculate the railways' revenues without the MRE regulation. The shadow values are calculated at several rail capacity levels to analyze the railways' incentives for moving grain with and without the MRE regulation in place.

4.2. Data and Assumptions

Tables 5 and 6 present the data used in expected basis calculations. Total domestic use of cereals, oilseeds, and pulses has been obtained from Agriculture and Agri-Food Canada (AAFC). Exportable supplies are calculated as total production minus total domestic use in Western and Eastern Saskatchewan, Alberta, and Manitoba. Exportable supplies for each of the four regions have been calculated based on their historical share in total production. To be consistent, both domestic use and production data are calculated for Saskatchewan, Alberta, and Manitoba.

Port and rail capacities are assumed to be the record high 2013-14 movement levels. One may argue that the GH&T system may be capable of exporting greater volumes than the 2013-14 levels. However, since this has never occurred in practice, this study assumes the capacity limits are the 2013-14 movement levels. Data on movements from each port and rail movements have been obtained from Canadian Grain Commission (CGC) (see Table 5).

Table 5. Export, Rail and Domestic Use Capacity for the 3 Provinces.

	Capacity (MMT)
Export-West Coast- Vancouver and Prince Rupert	27
Export-East Coast	11.25 (non-constrained)
Export-South-Minneapolis	1
Export- South-PNW (through Minneapolis)	3.75
Rail Capacity	40
Domestic Use (MMT)	20

Source: CGC (2015), AAFC (2015), Quorum Corporation (2015), Statistics Canada (2015b), Authors' Calculations.

As reported in Table 5, total west, east, and south port export capacities add up to 43 MMT, whereas total rail capacity is 40 MMT. Also, average domestic consumption of cereals, oilseeds, and pulses is estimated to be approximately 20 MMT per year in Western Canada. It is assumed that trucking is used to export grain to the south. Therefore, total export capacity is limited to 40 MMT via rail and 4.75 MMT via trucking. Production levels above 64.75 (i.e. exportable supply levels above 44.75) must be stored.

Cost of storage is assumed to be 15 percent of the value of the crop. This can be attributed to physical storage cost, interest rate on farmers' debt, potential degradation of stored crops, etc. Given the average value of crops at approximately $400 per tonne, the storage cost is assumed to be $60 per tonne per year (see Table 6).

Current rail freight rates for west and east movements have been obtained from Quorum Corporation (2015). A $30 seaway shipping cost has been added to east moving freight rates. Freight rates for South movements to Minneapolis have been obtained from

Gray (1995) and inflated by 1 percent per year. Rail freight rates are presented in Table 6. Freight rates to Pacific Northwest (PNW) includes a $16/MMT for 100 miles trucking from Canadian origins to Minneapolis, obtained from Quorum (2015), and a $55/MMT rail freight for Minneapolis to PNW ports, obtained from US Wheat Associates (2014).

Table 6. Freight Rates and Storage Cost Data

Region From	Freight Rates ($/t) to destination						One-Year Storage Cost ($)
	West Coast (Vancouver)	East Coast (Thunder Bay)	Seaway Shipping Cost	Total East Coast	South (Minneapolis)	South (PNW)	
AB	34	46	30	76	84	71	60
West SK	40	41	30	71	54	71	60
East SK	48	31	30	61	55	71	60
MB	51	25	30	55	41	71	60

Source: Authors' Calculations, Quorum Corporation (2015), Gray (1995).

4.3. Results

4.3.1. Future Production

Table 7 presents the results of the VAR model. In addition to the lagged dependent variables and the time trend, three dummy variables are included in the model. These dummies take into account exceptionally low production levels in 1988 and 2002, and exceptionally high production level in 2013.

All independent variables are statistically significant and have plausible signs. The model also has a relatively high explanatory power of 82 percent. The Schwarz Criterion[6] has been used to verify the optimal lag length (Greene, 2002; page 565). Both the intuition described in section 4.1.1 and the Schwarz Criterion suggest two lags.

The estimated coefficients for the lagged dependent variables show that production levels are positively and negatively correlated with their first and second lag, respectively. The estimated coefficients for the time trend variable shows that, on average, production level in the three provinces have increased by 449,267 tonnes a year, *ceteris paribus*.

[6] This is an "information criterion" used for selecting among formal econometric models. Particularly, it is used for choosing the optimal lag length in models with lagged dependent variables.

The estimated coefficients for the lagged dependent variables and the time trend variable are used in the calculations for probability distributions.

Table 7. VAR Regression Results Prairie Grain Production, 1977- 2014

Provinces:	Alberta, Saskatchewan, Manitoba	
Dependent Variable:	Aggregate Production	
Estimation Method:	VAR	
Independent Variables	Coefficient	Standard Error
Constant (β_0)	-8.50E+08	2.0E+08***
Aggregate Production (Lag 1) (β_1)	0.3015	0.12**
Aggregate Production (Lag 2) (β_2)	-0.2985	0.14**
Time Trend (β_3)	449267	171809***
Dummy for 1988 (β_4)	-10434793	4435866***
Dummy for 2002 (β_5)	-15525738	4491011***
Dummy for 2013 (β_6)	19024762	4392162***
R-squared	0.82	
Adjusted R-squared	0.78	
F-Statistic	21.46***	
Observations after adjustment:	36	

Note: Asterisks denote significance at the10% (*), 5%(**), and 1%(***) levels.
Source: Authors' estimation.

4.3.2. PDFs

Using the results of the VAR model and the approach described in section 4.1.2, future production is forecasted. Results are presented in Table 8. Given the 449,267 tonne time-trend parameter, average production increases from approximately from 38 MMT in 1977 (see Figure 3) to approximately 55 MMT in 2016 and approximately 60 million tonnes (MMT) in 2025 (see Table 8).

Table 8. Prairie Production Forecast 2016 -2025

Year (t)	**Mean ($\bar{Y}_t$) (MMT)**	**Variance (σ^2) (MMT)**
2016	55.47	7.23
2017	55.92	7.23
2018	56.37	7.23
2019	56.82	7.23
2020	57.27	7.23
2021	57.72	7.23
2022	58.17	7.23
2023	58.61	7.23
2024	59.06	7.23
2025	59.51	7.23

Source: Authors' estimation.

Probability distributions are calculated for 1977 to 2026, although results from the initial years are not reliable as there are no lag data available for 1977 and 1978. Figures 4 and 5 depict the PDF and the CDF for 100 future production levels in 2015 and 2025.

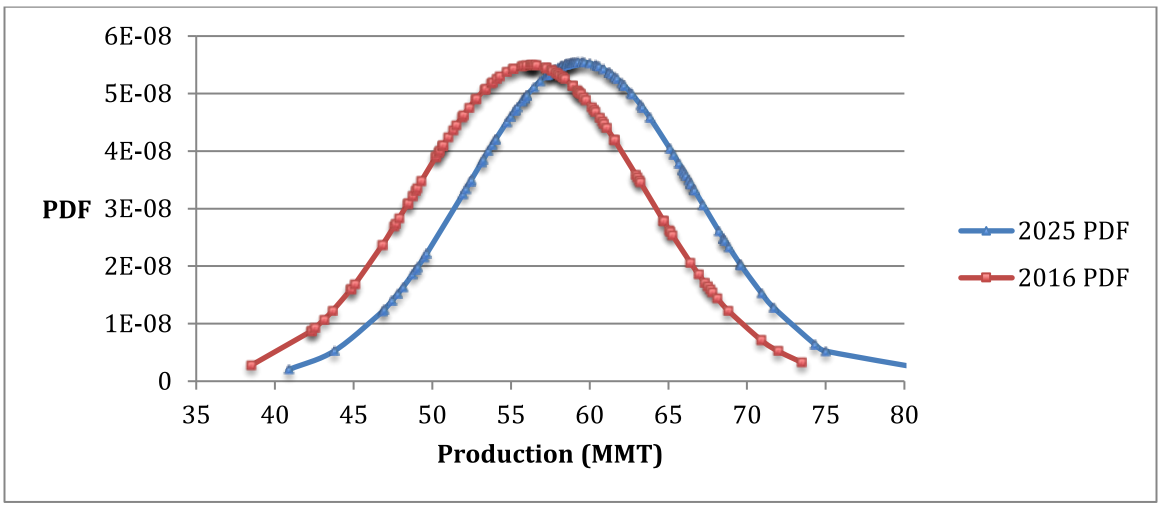

Figure 4. PDF of Forecast Production Levels in 2015 and 2025.
Source: Authors' estimation.

As shown in Figures 4 and 5, probability distributions move to the right over time. This is due to yield improvements of 449,267 tonnes a year. Probability distributions for future production levels allow researchers to calculate the probability of any production level, and therefore any basis level, that occur in the future.

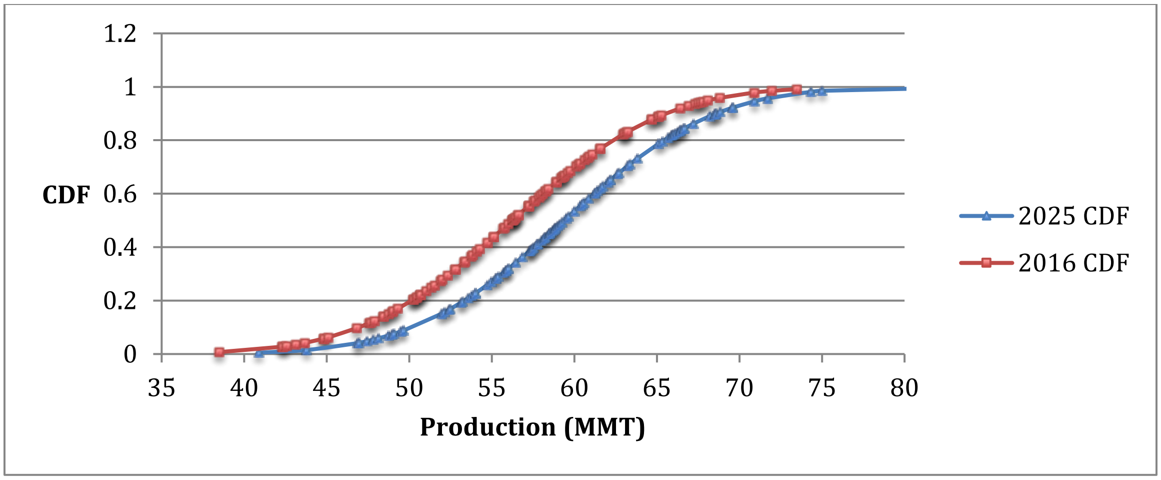

Figure 5. CDF of Forecast Production Levels in 2015 and 2025.
Source: Authors' estimation.

4.3.3. Expected Loss and Cost-Saving Benefits of Capacity Improvement

This section first estimates farmers' expected loss from limited rail and West Coast export capacity. This is the Base Case or Scenario 1. Then, the cost-saving benefits of capacity improvement are calculated under three different scenarios. In Scenario 2 it is assumed that only rail capacity is improved and there are no improvements in West Coast capacity. In Scenario 3 it is assumed that only West Coast capacity is improved there are no improvements in West Coast capacity. In Scenario 4 it is assumed that both rail and West Coast capacity are improved simultaneously.[7] In all cases, when exportable supplies exceed the rail capacity, grain is stored.

4.3.3.1. Scenario 1 (Base Case): Farmers' expected loss when both rail and West Coast capacity are constrained

Table 9 describes the calculation of expected basis levels for various production levels. Current rail capacity and domestic use add up to approximately 60 MMT. An additional 4.75 MMT can be exported to the US via trucking at a higher transportation cost.

[7] Two other cases are explored in the Appendix. In the first case it is assumed that only total rail capacity is constrained and there are no West or East port capacity constraints. In the second case it is assumed that only West Coast capacity is limited and there are no rail or East Coast capacity constraints.

As presented in Table 9, expected basis for production levels under 60 MMT is equal to the normal basis[8]. Production levels over 64.75 MMT must be stored for at least one year.

Therefore, expected basis for production levels over 64.75 MMT also include the storage cost for another year multiplied by the probability of producing over export and domestic use limit in the next crop year.

Table 9. Expected Basis Calculations.

Production Level	Expected Basis Level
0 to 60 MMT	Normal Basis
60 to 64.75 MMT	Freight to South
Over 64.75 MMT	Normal Basis + Expected Storage Cost

Since production levels increase over time, the probability of having to store grain for more than one year increases as well. This results in an increase in average expected basis over time. Figure 6 shows the increase in probability of producing over 64.75 MMT from 10 percent in 2016 to 23 percent in 2025.

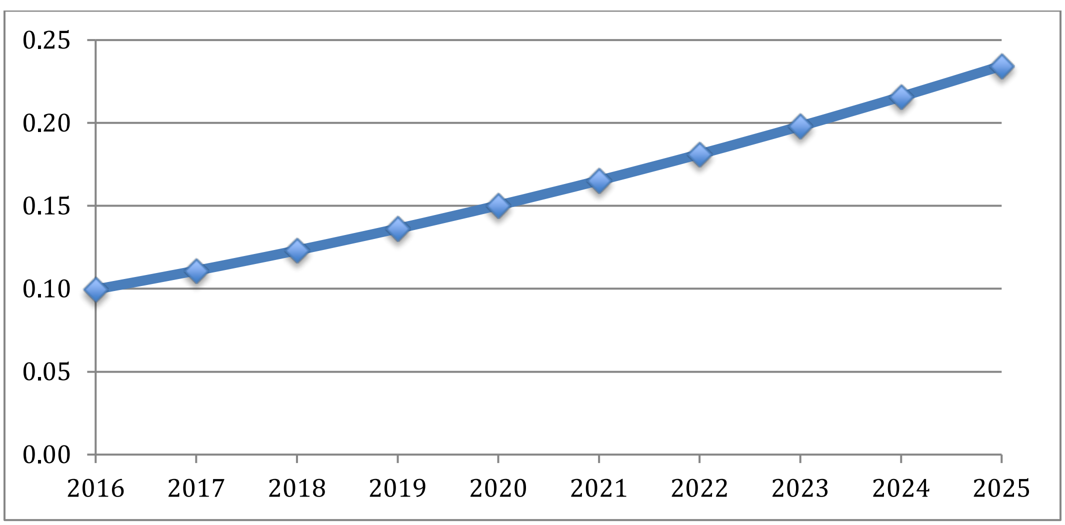

Figure 6. Increase in Probability of Producing over Limit over Time.
Source: Authors' estimation.

The effect of export capacity constraint on expected excess basis levels and expected loss levels are reported in Table 10. At current capacity levels, expected excess

[8] In this study normal basis is defined as the rail freight rate not including the handling cost.

basis increases from $10.5/tonne to $25/tonne in the 2016-25 period.[9] Following the expected excess basis levels, farmers' expected loss increases from over a billion dollars in 2016 to approximately 2 billion dollars in 2025. Given the net present values, one can expect farmers' to lose approximately $10.8 billion at 5 percent discount rate (or $8.3 billion at 10 percent discount rate) over the next ten years.

Table 10. Effect of Rail and West Cast Capacity Constraints on Expected Excess Basis and Farmers' Expected Loss in Western Canada, 2016-25.

Year	Expected Excess Basis Effect ($/MT)	Expected Loss (million $)
2016	10.47	1,001
2017	11.68	1,083
2018	12.99	1,170
2019	14.40	1,262
2020	15.90	1,360
2021	17.51	1,464
2022	19.23	1,573
2023	21.04	1,688
2024	22.95	1,809
2025	24.96	1,935
NPV Total*	-	8,325
NPV Total**	-	10,757

* and ** Net Present Value (NPV) is calculated assuming a 10% and 5% discount rates, respectively.
Source: Authors' estimation.

The next three sections explore the effect of capacity improvement on expected excess basis and expected loss levels.

4.3.3.2. Scenario 2: Cost-Saving Benefits of Rail Capacity Improvement

This section considers a case where both rail and West Coast are constrained but improvements are only made in rail capacity. The effects of a rail capacity constraint on expected excess basis levels (i.e. shadow values of rail capacity constraint) are reported in Table 11. Numbers presented in Table 11 do not include the effect of a West Coast capacity constraint on expected excess basis (i.e. shadow values of the West Coast capacity constraint). This is to solely focus on the rail capacity constraint, and the impact of reducing it, on farmers' total loss.

[9] More detailed calculations of expected excess basis levels for each year are presented in the Appendix.

Table 11. Effect of Rail Capacity Constraint on Expected Excess Basis in Western Canada under Current, and 5 and 10 MMT Improvements in Rail Capacity in existence of both Rail and West Coast Capacity Constraints, 2016-25.

Year	Expected Excess Basis Effect ($/MT)		
	Current Capacity (Base)	5 MMT Improvement	10 MMT Improvement
2016	10.47	2.58	0.24
2017	11.68	3.00	0.30
2018	12.99	3.47	0.36
2019	14.40	4.01	0.43
2020	15.90	4.61	0.52
2021	17.51	5.28	0.62
2022	19.23	6.02	0.74
2023	21.04	6.84	0.89
2024	22.95	7.74	1.05
2025	24.96	8.74	1.24

Source: Authors' estimation.

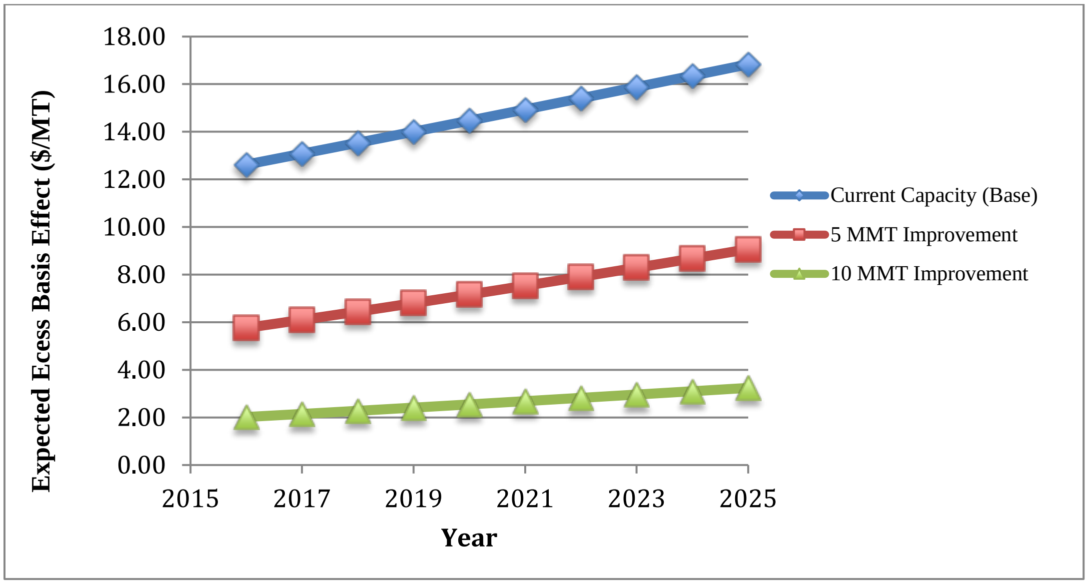

Figure 7. Effect of Rail Capacity Constraint on Expected Excess Basis in Western Canada under Current, and 5 and 10 MMT Improvements in Rail Capacity in existence of both Rail and West Coast Capacity Constraints, 2016-25.
Source: Authors' estimation.

As can be seen in Table 11, rail capacity improvement seems to have a great impact on expected excess basis levels. For example, in 2025 a 5 MMT increase in rail capacity reduces the effect of this constraint on expected excess basis from $24.96/tonne to $8.74/tonne, and a 10 MMT improvement in capacity reduces the effect of this constraint to $1.24/tonne.

Expected loss levels are reported in Table 12 and Figure 8. As mentioned previously, in this section both rail and West Coast capacity constraints are set at the current capacity levels (40 MMT and 27 MMT, respectively). Therefore, the expected loss levels reported under the base case present the closest estimates of the effect of limited grain export capacity on farmers' revenue in reality.

Table 12. Expected Loss Effect of Rail Capacity Constraint in Western Canada under Current, and 5 and 10 MMT Improvements in Rail Capacity in existence of both Rail and West Coast Capacity Constraints, 2016-25.

Year	Expected Loss (million $)		
	Current Capacity (Base)	5 MMT Improvement	10 MMT Improvement
2016	1,001	703	583
2017	1,083	753	613
2018	1,170	806	645
2019	1,262	862	678
2020	1,360	923	712
2021	1,464	987	748
2022	1,573	1,056	784
2023	1,688	1,130	823
2024	1,809	1,208	862
2025	1,935	1,291	904
NPV Total*	8,325	5,665	4,349
NPV of Loss from Rail Capacity Constraint*	4,709	1,511	195
NPV Total**	10,757	7,304	5,568
NPV of Loss from Rail Capacity Constraint**	6,143	1,999	263

* and ** Net Present Value (NPV) is calculated assuming a 10% and 5% discount rates, respectively.
Source: Authors' estimation.

As can be seen in Table 12, at current capacity levels, one can expect farmers' to lose approximately $10.8 billion at a 5 percent discount rate (or $8.3 billion at 10 percent discount rate) over the next ten years. Approximately 57 percent of this loss can be attributed to limited rail capacity. However, a 5 MMT increase in rail capacity can reduce farmers' total loss by approximately $2.7 billion at a 10 percent discount rate and $4 billion at a 5 percent discount rate. A 10 MMT increase in rail capacity alone can reduce farmers' expected loss by 48 percent from $10.8 to $5.6 billion at a 5 percent discount rate (or from $8.3 to $4.3 billion at a 10 percent discount rate).

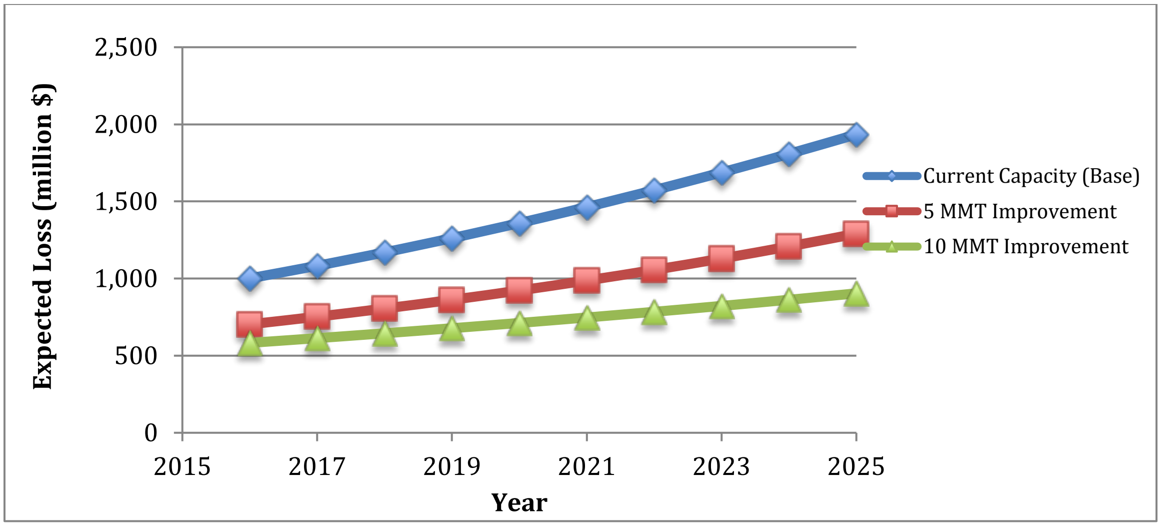

Figure 8. Expected Loss Effect of Rail Capacity Constraint in Western Canada under Current, and 5 and 10 MMT Improvements in Rail Capacity in existence of both Rail and West Coast Capacity Constraints, 2016-25.
Source: Authors' estimation.

4.3.3.3. Scenario 3: Cost-Saving Benefits of West Coast Capacity Improvement

In this section it is assumed that both rail and West Coast capacity are constrained but improvements are only made in West Coast capacity. Table 13 and Figure 9 present the effect of West Coast capacity constraint on expected excess basis levels (i.e. shadow values of West Coast capacity constraint). To specifically focus on the West Coast capacity constraint and the effect of improving it on farmers' total loss, numbers presented only include the effect of a West Coast capacity constraint on expected excess basis.

Comparisons of Table 11 and 13 reveal that the effect of a West Coast capacity constraint on expected excess basis grows at a slower rate than that of a rail capacity constraint. From 2016 to 2025, the effect of a West Coast capacity constraint on expected excess basis increases from $12.62/tonne to $16.83/tonne. Over the same period, the effect of a rail capacity constraint on expected excess basis increases from $10.47/tonne to $24.96/tonne. This comparison has important policy implications. Given the assumptions of the model, if a West Coast capacity constraint is binding, grain can still be moved east at a higher freight rate. However, if a rail capacity constraint is binding, then grain must be stored at a much higher cost. This is why the effect of rail capacity constraint on expected excess basis grows at a higher rate than that of West Coast capacity constraint, as production increases over time. From a policy perspective, as production increases over time, the relative importance of rail capacity increases as well. This argument, of course, is only valid under the assumption of non-constrained East Coast capacity.

Table 13. Effect of West Coast Capacity Constraint on Expected Excess Basis in Western Canada under Current, and 5 and 10 MMT Improvements in West Coast Capacity in existence of both Rail and West Coast Constraints, 2016-25.

Year	Expected Excess Basis Effect ($/MT)		
	Current Capacity (Base)	5 MMT Improvement	10 MMT Improvement
2016	12.62	5.76	2.02
2017	13.08	6.10	2.15
2018	13.54	6.45	2.28
2019	14.00	6.80	2.41
2020	14.47	7.16	2.55
2021	14.94	7.53	2.68
2022	15.41	7.91	2.82
2023	15.88	8.29	2.96
2024	16.36	8.68	3.10
2025	16.83	9.07	3.24

Source: Authors' estimation.

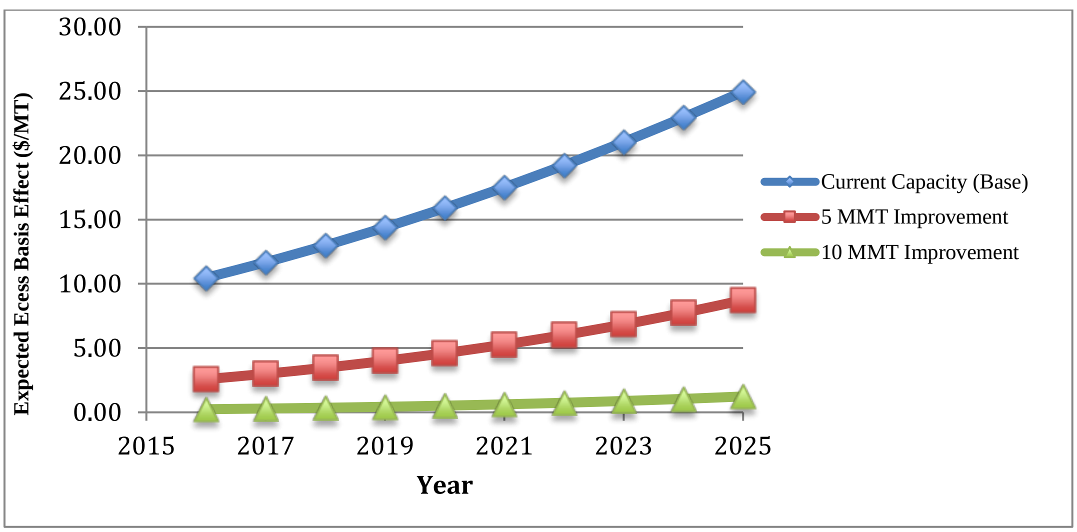

Figure 9. Effect of West Coast Capacity Constraint on Expected Excess Basis in Western Canada under Current, and 5 and 10 MMT Improvements in West Coast Capacity in existence of both Rail and West Coast Constraints, 2016-25.
Source: Authors' estimation.

Improvement in West Coast capacity seems to reduce the effect of the West Coast capacity constraint on expected excess basis significantly. For example, in 2025 a 5 MMT increase in West Coast capacity reduces the effect of this constraint on expected excess basis by 46 percent from $16.83/tonne to $9.07/tonne.

Farmers' expected loss levels are presented in Table 14 and Figure 10. As presented in Table 10, farmers' expected loss in the base case is approximately $10.8 billion at a 5 percent discount rate over the 2016-2015 period. Approximately 44 percent of this 10.8 billion can be attributed to limited West Coast capacity. A 5 MMT and a 10 MMT improvement in West Coast capacity reduces the total expected loss to $8.6 billion and $7.6 billion at a 5 percent discount rate (or $6.6 billion and $5.9 billion at a 10 percent discount rate), respectively. Notice that the expected loss-reducing effect of improvement in West Coast capacity is smaller than that of rail capacity presented in Table 14.

Table 14. Expected Loss Effect of West Coast Capacity Constraint in Western Canada under Current, and 5 and 10 MMT Improvements in West Coast Capacity in existence of both Rail and West Coast Constraints, 2016-25.

Year	Expected Loss (million $)		
	Current Capacity (Base)	5 MMT Improvement	10 MMT Improvement
2016	1,001	744	646
2017	1,083	819	716
2018	1,170	899	791
2019	1,262	985	872
2020	1,360	1,076	959
2021	1,464	1,173	1,051
2022	1,573	1,276	1,148
2023	1,688	1,384	1,249
2024	1,809	1,499	1,360
2025	1,935	1,619	1,474
NPV Total*	8,325	6,593	5,875
NPV of Loss from West Coast Capacity Constraint*	3,616	1,884	672
NPV Total**	10,757	8,561	7,644
NPV of Loss from West Coast Capacity Constraint**	4,615	2,419	863

* and ** Net Present Value (NPV) is calculated assuming a 10% and 5% discount rates, respectively.
Source: Authors' estimation.

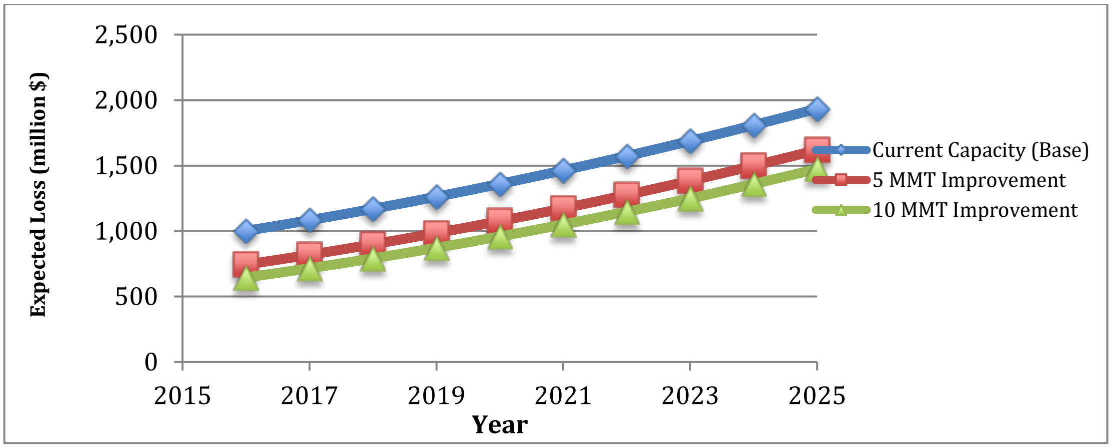

Figure 10. Expected Loss Effect of West Coast Capacity Constraint in Western Canada under Current, and 5 and 10 MMT Improvements in West Coast Capacity in existence of both Rail and West Coast Constraints, 2016-25.
Source: Authors' estimation.

4.3.3.4. Scenario 4: Cost-Saving Benefits of Rail and West Coast Capacity Improvement

The last and perhaps most relevant case is where both rail and West Coast are constrained and improvements are made in both rail West Coast capacity. Table 15 presents the effect of simultaneous improvement of rail and West Coast capacity on expected excess basis. As mentioned previously, these effects grow over time due to increase in production. The effect of limited rail capacity on expected excess basis, for example, increases by 138 percent from $10.47/tonne to $24.96/tonne in 2016-2015 period.

Improvement in rail and West Coast capacity seems to effectively prevent the increase in expected excess basis. Even a 5 MMT simultaneous improvement in both rail and West Coast capacity lowers the effect of these constraints on expected excess basis in 2025 to levels lower than those of 2016.

Table 15. Effect of Rail and West Coast Capacity Constraint on Expected Excess Basis in Western Canada under Current, and 5 and 10 MMT Simultaneous Improvements in both Rail and West Coast Capacity in existence of both Rail and West Coast Constraints, 2016-25.

Year	Effect on Expected Excess Basis					
	Current Capacity (Base)		5 MMT Improvement		10 MMT Improvement	
	West	Rail	West	Rail	West	Rail
2016	12.62	10.47	5.76	3.22	2.63	0.37
2017	13.08	11.68	6.10	3.70	2.83	0.44
2018	13.54	12.99	6.45	4.24	3.04	0.52
2019	14.00	14.40	6.80	4.84	3.26	0.62
2020	14.47	15.90	7.16	5.51	3.49	0.74
2021	14.94	17.51	7.53	6.26	3.72	0.87
2022	15.41	19.23	7.91	7.08	3.97	1.03
2023	15.88	21.04	8.29	7.98	4.22	1.20
2024	16.36	22.95	8.68	8.96	4.48	1.41
2025	16.83	24.96	9.07	10.04	4.75	1.62

Source: Authors' estimation.

Table 16 presents farmers' expected loss from limited export capacity at current capacity levels (base case) and after simultaneous improvement of rail and West Coast by 5 and 10 MMT. A 5 MMT increase in both rail and West Coast capacity reduces the expected loss that can be attributed to limited West Coast capacity from $4.6 billion to $2.4 billion at a 5 percent discount rate (or $3.6 billion to $1.9 billion at a 10 percent discount rate). It also reduces the expected loss that can be attributed to limited rail capacity from $6.1 billion to $2.3 billion at a 5 percent discount rate (or from $4.7 billion to $1.8 billion at a 10 percent discount rate). In total, a 5 MMT increase in both rail and West Coast capacity reduces the total expected loss from $10.8 billion to $4.7 billion at a 5 percent discount rate (or $8.3 billion to $3.6 billion at a 10 percent discount rate). This means, a 5 MMT improvement in both rail and West Coast capacity brings approximately $4.7 to $6.1 billion of cost-saving benefits to Western Canadian farmers.

A 10 MMT improvement in both rail and West Coast capacity lowers the total expected loss to $1.6 billion at a 5 percent discount rate (or $1.2 billion at a 10 percent discount rate). This is an 85 percent reduction in total expected loss and implies $7.1 to $9.1 billion of cost-saving benefits for the producers.

Table 16. Expected Loss Effect of Rail and West Coast Capacity Constraint in Western Canada under Current, and 5 and 10 MMT Simultaneous Improvements in both Rail and West Coast Capacity in existence of both Rail and West Coast Constraints, 2016-25.

Year	Expected Loss (million $)					
	Current Capacity (Base)		5 MMT Improvement		10 MMT Improvement	
	West	Rail	West	Rail	West	Rail
2016	1,001	1,001	243	164	116	20
2017	1,083	1,083	259	189	126	24
2018	1,170	1,170	275	217	136	29
2019	1,262	1,262	292	248	146	35
2020	1,360	1,360	309	283	157	41
2021	1,464	1,464	327	321	168	49
2022	1,573	1,573	346	364	180	57
2023	1,688	1,688	364	411	191	67
2024	1,809	1,809	384	462	205	79
2025	1,935	1,935	404	518	219	91
NPV*	3,616	4,709	1,884	1,768	956	267
NPV Total*	8,325		3,653		1,223	
NPV**	4,615	6,143	2,419	2,333	1,234	357
NPV Total**	10,757		4,752		1,591	

* and ** Net Present Value (NPV) is calculated assuming a 10% and 5% discount rates, respectively.
Source: Authors' estimation.

4.3.4. Removal of the MRE regulations

The main goal of this section is to explore the railways incentives for moving more grain with and without MRE regulations. The effect of removal of the MRE regulation on expected freight rates and distribution of rents within the GH&T system are discussed as well.

In this section we first show that railways have an incentive to cut back services when there is no MRE regulation and increase service level with the MRE regulation in place. Then, graphical analysis is used to illustrate the case of 2013-14 crop year and show the railways' incentives for moving grain with and without the MRE regulation in the 2013-14 crop year. This example also shows the distribution of rents within the GH&T system with and without the MRE regulation.

4.3.4.1. Incentives for Moving Grain with and without the MRE

It is assumed that after the removal of the MRE regulation, the railways are able to increase their freight rates by the amount of the expected shadow value of the rail constraint that is calculated in the LP model. Notice that as a constraint becomes more binding its shadow value increases. Therefore, without the MRE regulation in place, the railways have an incentive to limit their capacity (i.e. move less grain) in order to raise the shadow value of the rail constraint, which is indeed the average freight rate. However, by limiting their capacity, the railways move less grain. Therefore, there is a tradeoff between the movement level and the average freight rate.

Table 17 presents the average excess freight rates and revenues captured by the railways at various capacity levels in a normal production year and no MRE regulation in place. In order to calculate the average excess freight rate levels we first calculate the excess freight rate (i.e. shadow value of the rail constraint) levels for various production levels within the PDF (i.e. 30 to 80 MMT). Then we take the weighted average of the excess freight rate levels corresponding to the various production levels with the probabilities of occurrence of each production level as weights.

The revenue levels are calculated as the sum of the products of the movement levels of each region by the expected freight rate (i.e. normal freight rate plus average excess freight rate) for that region.

As presented in Table 17, average excess freight rate increases as rail capacity decreases. As rail capacity is reduced from 40 to 25 MMT, average expected shadow value (i.e. excess freight rate) increases from $10.5/t to $99.9/t. Although this decrease in capacity reduces the movement levels from 34.5 to 25 MMT, railways' revenue increases from $1.6 to $3.4 billion. Therefore, with no MRE regulation in place, railways may have a perverse incentive to reduce their current capacity service levels in order to increase their average freight rates and, thereby, their revenues.

However, a further attempt to reduce capacity to less than 25 MMT will result in a reduction in railways' revenue. It is easy to see in Table 17 that there is an optimal (i.e.

revenue-maximizing) level of service for railways. If there were no MRE, the railways would plan to provide the revenue-maximizing level of service, which is approximately 25 MMT for normal production levels. As it will be shown in the next section, this will result in a grain transportation crisis in any year with a production level that is significantly higher than normal.

Table 17. Average Excess Basis and Revenues Captured by Railways at Various capacity Levels with No MRE and a Normal Production Level of 55.5 MMT.

Capacity (MMT)	Movements (MMT)	Storage (MMT)	Average Excess Freight Rates ($/t)	Revenue (Billion $)
40	34.5	0	10.5	1.6
35	34.5	0	34.4	2.4
30	30	1	62.4	3.0
26	26	4.7	90.7	3.3
25	**25**	**5.7**	**99.9**	**3.4**
24	24	6.7	100.0	3.3
20	20	10.7	112.3	3.0

Source: Authors' estimation.

Table 18 presents the revenues captured by the railways at various capacity levels in a normal production year and the MRE regulation in place. In this case, freight rates are at their normal levels because the MRE regulation is in place. Therefore, average excess freight rate levels are equal to zero for any capacity level.

The revenue levels are calculated as the sum of the products of the movement levels of each region by the normal freight rate for that region. As illustrated in Table 18, when the MRE regulation is in place, it is in the railways benefit to move all the exportable supplies of grain. In the example provided in Table 18, there are 35.5 MMT of exportable supplies resulting from 55.5 MMT of production. If the railways limit their capacity and movement level to 30 MMT they only earn $1.1 billion of revenues. By increasing their capacity to 35.5 MMT or higher, however, they earn $1.2 billion of revenues.

Table 18. Average Excess Basis and Revenues Captured by Railways at Various capacity Levels with MRE and a Normal Production Level of 55.5 MMT.

Capacity (MMT)	Movements (MMT)	Storage (MMT)	Average Excess Freight Rates ($/t)	Revenue (Billion $)
30	30.0	0.7	0	1.1
40	35.5	0	0	1.2
50	35.5	0	0	1.2

Source: Authors' estimation.

4.3.4.2. The 2013-14 Event

In this section we use graphical analysis to illustrate the case of 2013-14 crop year. The goal of this section is to show the railways' incentives for moving grain as well as the distribution of rents within the GH&T system with and without the MRE regulation in the 2013-14 crop year.

We first consider a factual case that illustrates what occurred in the 2013-14 crop year. We then present two counterfactuals. Counterfactual 1 illustrates what would have happened in the 2013-14 crop year if there were no MRE regulation. Counterfactual 2 discusses the market outcome if the railways moved an additional 9 MMT to bring the carryover stock levels back to normal.

Factual case: Panel *a* of Figure 11 presents the derived demand and average revenue (AR) for GH&T in 2013-14 crop year with 73.8 MMT of production and 53.8 MMT of exportable supplies. Panel *b* illustrates the total revenue curve for the railways with the MRE regulation in place.

In Panel *a*, the area under AR curve and to the left of the 40 MMT rail capacity represents normal rents resulting from normal basis levels in 2013-14 crop year. This area is shared between the railways (the dotted area) and the grain handlers (the shaded area). The LP model estimates the basis levels to exceed the normal levels by $93.6/t. This is due to high demand for transportation in 2013-14. The MRE did not allow the railways to capture any rents beyond their average freight rates (i.e. beyond the dotted area). As a result, the grain handlers were able to capture the additional $3.7B (the shaded area above the AR curve) above and beyond their normal rents (the shaded area under the AR curve).

Railways total revenue is shown in Panel b. Under the MRE regulation, increasing rail capacity and movement levels results in an increase in total revenue for railways as long as there are exportable supplies of grain. In the 2013-14 crop year, the railways' revenue remained at normal level. The revenue levels in Panel *b* are calculated as the sum of the products of the movement levels of each region by the expected freight rate (i.e. normal freight rate plus average excess freight rate) for that region.

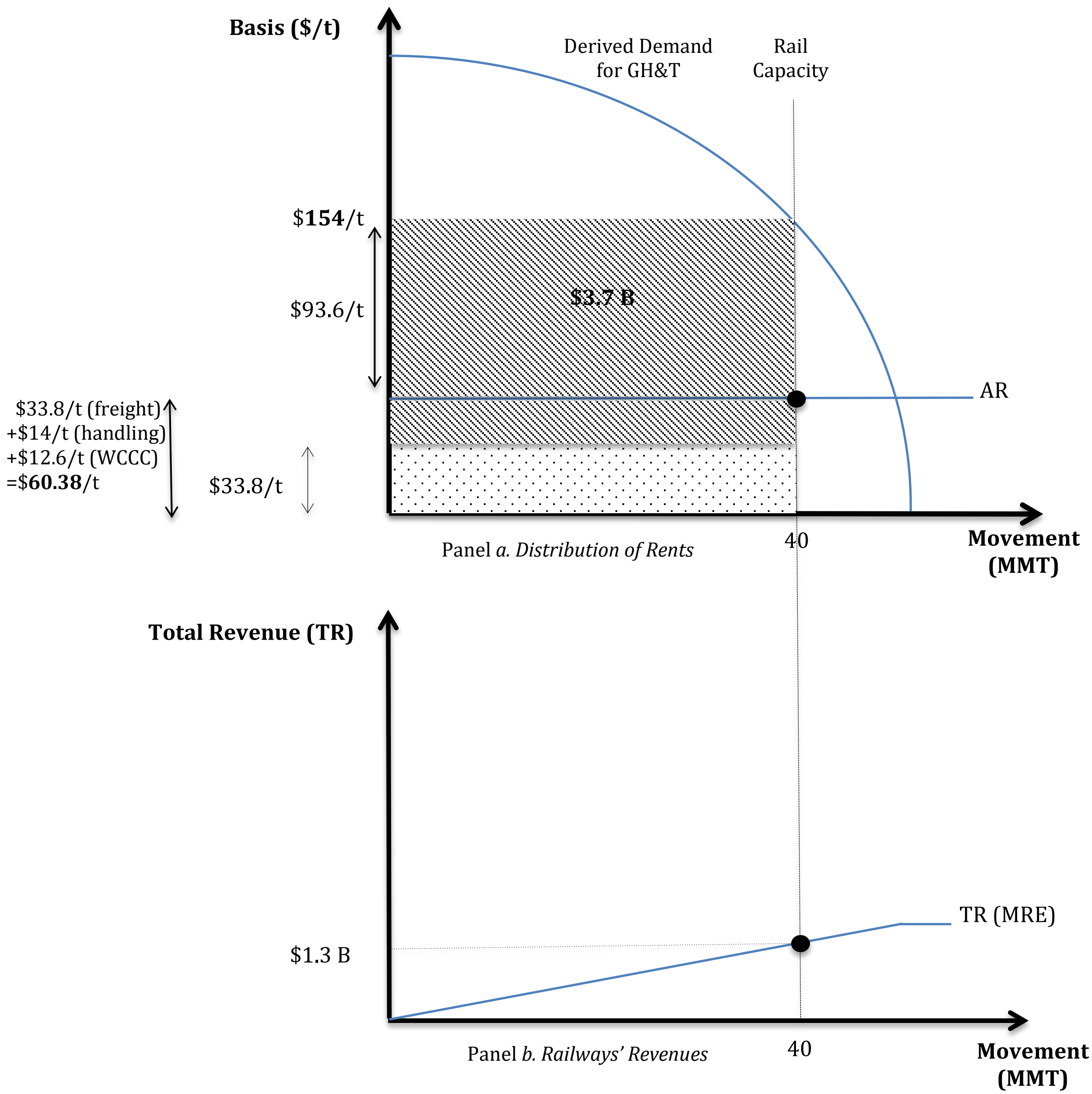

Figure 11. Derived demand for GH&T, Railways' Total Revenue, and Distribution of Rents within the GH&T System in the 2013-14 crop year with the MRE regulation in place.

Counterfactual 1: Figure 12 presents the effect of the removal of the MRE regulation on rail revenues in the 2013-14 crop year. Panel *a* depicts the derived demand and average revenue (AR) for GH&T in the 2013-14 crop year with 73.8 MMT of production and 53.8 MMT of exportable supplies. Panel *b* illustrates the total revenue curve for the railways with and without the MRE regulation in place.

As mentioned before, without the MRE regulation in place, the railways are able to increase their freight rates by the amount of the expected shadow value of the rail constraint that is calculated in the LP model. As the rail constraint becomes more binding, its shadow value increases. As illustrated in Table 17, without the MRE regulation in place, the railways can increase their revenue by limiting their capacity and movement levels. This results in a hill-shaped total revenue curve for the railways, as depicted in Panel *b* of Figure 12. The hill-shaped total revenue curve implies that there is an optimal (i.e. revenue-maximizing) movement level for the railways. This optimal level is different every year depending on the exportable supplies. In Table 18 we have shown that without the MRE regulation, railway revenue would have happened to be maximized at approximately 40 MMT, which is the actual movement level for that year. Although the railways could not capture the above normal revenues under the MRE, they coincidentally provided these revenues to the grain handlers.

Had there been no MRE regulations the grain handlers would have had to bid on rail cars, similar to the U.S. system. Given that the railways offer the most inelastic factor in the GH&T system, they would have captured the $3.7B (the shaded area above the AR curve) above and beyond their normal rents (the dotted area under the AR curve). The difference between the railways' revenue with and without the MRE is also shown in *Panel b*. In this scenario the grain handlers would have only received their normal rents (the shaded area under the AR curve). This means the removal of the MRE does not prevent the events of an above normal basis, but changes the allocation of the pie between the grain handlers and the railways.

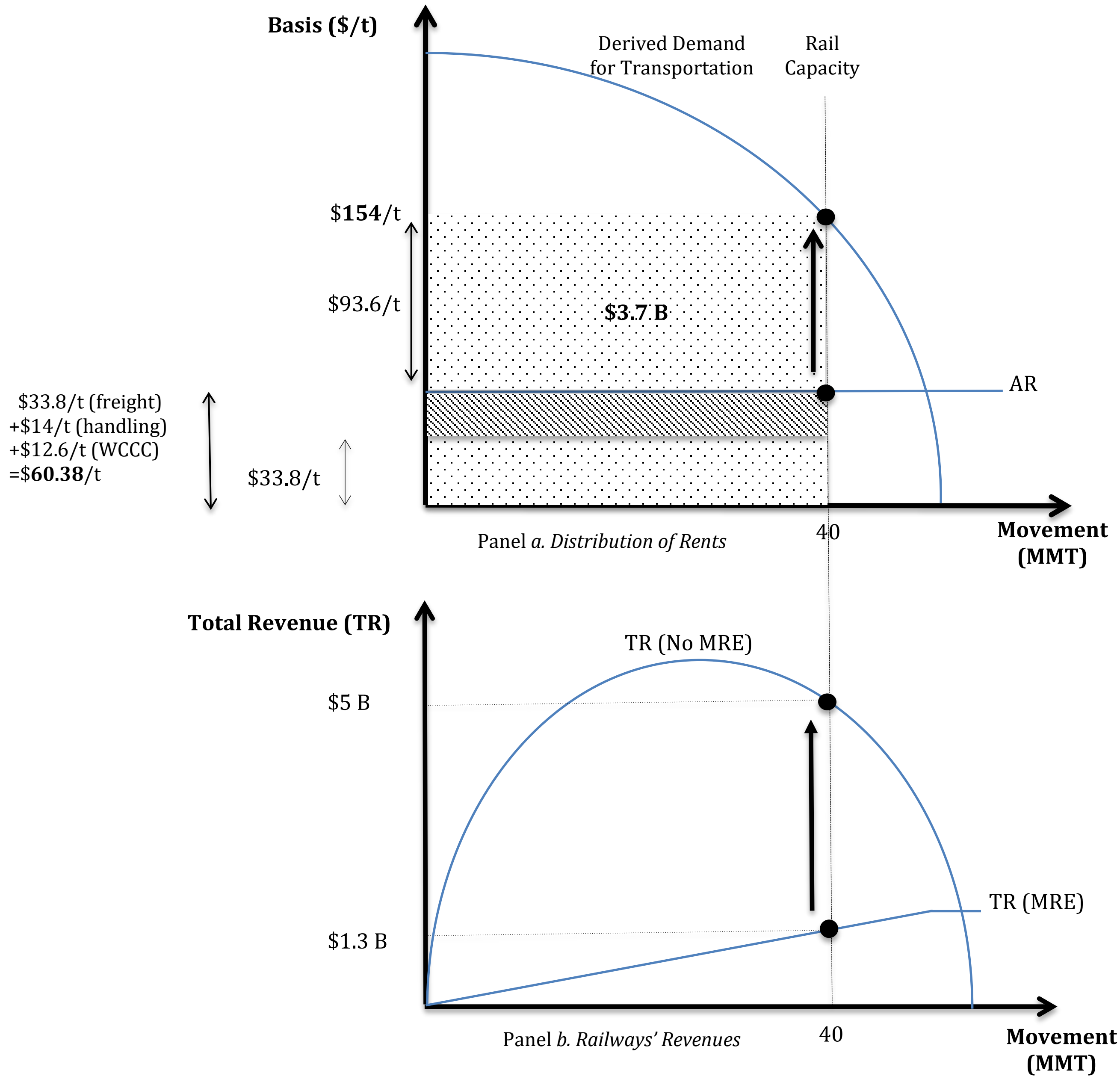

Figure 12. Derived demand for GH&T, Railways' Total Revenue, and Distribution of Rents within the GH&T System in the 2013-14 crop year with and without the MRE regulation in place.

Counterfactual 2: Figure 13 presents the effect of moving an additional 9 MMT of grain in the 2013-14 crop year with the MRE regulation in place. Panel *a* depicts the derived demand and average revenue (AR) for GH&T in the 2013-14 crop year with 73.8 MMT of production and 53.8 MMT of exportable supplies. Panel *b* illustrates the total revenue curve for the railways with the MRE regulation in place.

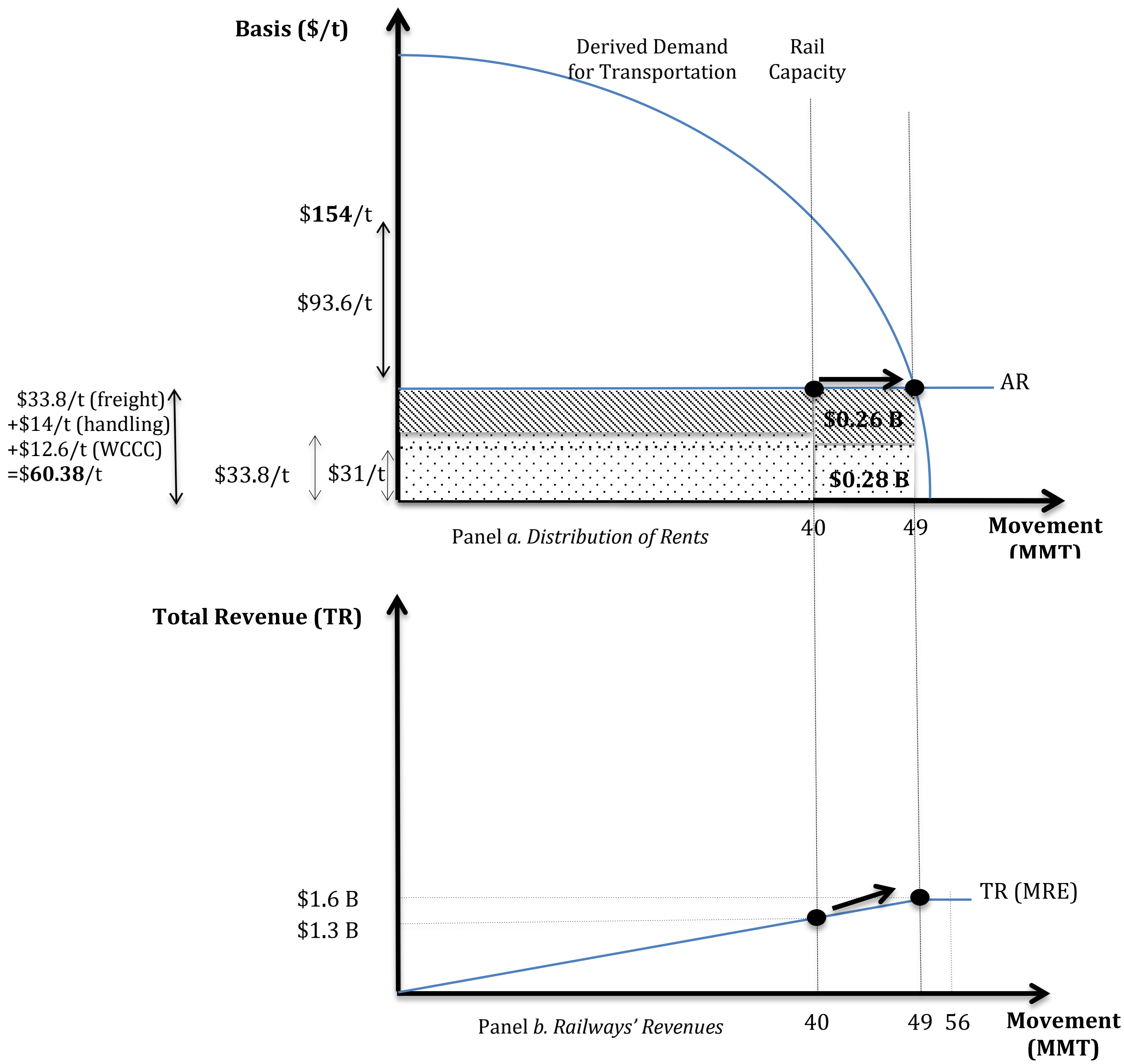

Figure 13. Derived demand for GH&T, Railways' Total Revenue, and Distribution of Rents within the GH&T System in the 2013-14 crop year with the MRE regulation in place.

An additional movement of 9 MMT would have brought the carryover stocks, and subsequently the basis levels, back to normal levels. This would have increased the railways rent compared to the factual case by $0.28 B (the dotted area under the AR curve and to the right of the rail capacity limit, between 40 and 49 MMT in Panel *a*) from $1.3B to $1.6B (see Panel *b*). This would have also resulted in an increase in the grain handlers' rent compared to normal levels by $0.26 billion (the shaded area under the AR curve and to the right of the rail capacity limit, between 40 and 49 MMT).

The 9 MMT additional movement, however, would have eliminated the $3.7 B above-normal rents from the grain handlers' rents (shown in Figure 12). Therefore, it is easy to see that under the MRE regulation the railways have an incentive to move all the exportable supplies, whereas the grain handlers may have substantial benefits in having significant levels of carryover stocks.

Nevertheless, the railways have strong incentives for removing the MRE. Table 19 summarizes all the revenue levels with and without the MRE in 2013-14 crop year. In the 2013-14 crop year, the railways could have earned an additional $3.7 billion if there were no MRE regulation. Also, as illustrated earlier and summarized in Table 19, under the MRE regulation the railways have an incentive to move all the exportable supplies of grain in order to maximize their revenue. Without the MRE regulation, however, the railways may benefit significantly from cutting back their services, especially in high price or crop years when there is high demand for GH&T.

However, as mentioned before, if there is no MRE regulation, the railways are more likely to plan for a level of service that is optimal for normal production levels. This means, there will be a grain transportation crisis every time production level is significantly higher than normal. In 2013-14, the basis levels would have been significantly higher if the railways were prepared to move only 25 MMT, which is their optimal service level in years with a normal production level.

Table 19. Revenues Captured by Railways at Various capacity Levels with MRE and without MRE in 2013-14 crop year with Production Level of 73.8 MMT.

Capacity	Revenue-No MRE	Revenue-MRE	Difference
39	4.6	1.3	3.3
40	**5.1**	**1.4**	**3.7**
41	4.0	1.4	2.6
50	2.9	1.6	1.3
56	1.6	1.6	0

Source: Authors' estimation.

5. Summary of Main Results

The *ex ante* component of this study estimates farmers' potential loss from limited grain export capacity over the next 10 years. The two railways have been able to move a maximum of approximately 40 MMT within the 2013-14 crop year. Given approximately 20 MMT of domestic consumption, and less than 5 MMT of exports to the U.S. via trucking, production levels exceeding 65 MMT result in grain storage, and thereby dramatic increases in basis levels.

Forecasts of this study indicate that production will increase by approximately 450 thousand tonnes a year. As it increases, the probability of stored grain for more than one year will increase. From 2016 to 2025, for example, the probability of producing over 64.75 MMT increases from 10 percent to 23 percent. Given these increasing production trends, the probability of running into a problem regarding limited grain export capacity will increase over time.

This study considers four scenarios. The Base Case (Scenario 1) of this study estimates farmers' expected loss as they pay the excess basis under current export capacity limits of $10.8 ($8.3) billion at a 5 (10) percent discount rate. Scenarios 2 to 4 explore the effect of improvements in rail capacity, West Coast capacity, and then both. Table 17 summarizes the expected losses and cost-saving benefits of all four scenarios at 5 and 10 percent discount rates.

Table 17. Summary of Main Results at 5 percent Discount Rate, 2016-26.

		Expected Losses (billion $)		Cost-Saving Benefits (billion $)	
Discount Rate (%):		10	5	10	5
Scenarios:					
1. Base		8.3	10.8	-	-
2. Rail Capacity Improvement	5MMT	5.7	7.3	2.7	3.5
	10MMT	4.3	5.6	4	5.2
3. West Coast Capacity Improvement	5MMT	6.6	8.6	1.7	2.2
	10MMT	5.9	7.6	2.4	3.1
4. Rail and West Coast Capacity Improvement	5MMT	3.6	4.7	4.7	6.1
	10MMT	1.2	1.6	7.1	9.1

Source: Authors' estimation.

In Scenario 2, it is assumed that only rail capacity is improved while there is no improvement in West Coast capacity. That is, there are exportable supplies above the rail capacity limit that are stored. In this scenario, At a 5 (10) percent discount rate, farmers' expected loss decreases by approximately $3.5 ($2.7) billion when the export capacity constraint is increased by 5 MMT. At a 5 (10) percent discount rate, a 10 MMT increase in the export capacity constraint results in a $5.2 (4$) billion decrease in the expected loss over the 2016-25 period.

In Scenario 3, it is assumed that only West Coast capacity is improved while there is no improvement in rail capacity. At a 5 (10) percent discount rate, a 5 MMT and a 10 MMT increase in West Coast capacity reduces farmers' expected loss by $2.2 ($1.7) and $3.1 ($2.4) billion, respectively.

In Scenario 4, rail and West Coast capacity improve simultaneously. A 5 MMT increase in both rail and West Coast capacity reduces the total expected loss from $10.8 ($8.3) billion to $4.7 ($3.6) billion at a 5 (10) percent discount rate. This saves Western Canadian farmers $6.1 ($4.7) billion at a 5 (10) percent discount rate over the next ten years. A 10 MMT improvement in both rail and West Coast capacity lowers the total expected loss to $1.6 ($1.2) billion at a 5 (10) percent discount rate. This is an 85 percent reduction in total expected loss and implies $7.1 to $9.1 billion of cost-saving benefits for producers.

Results also indicate that without the MRE regulation the railways may benefit significantly from cutting back their services, especially in high price or crop years when there is high demand for GH&T. In the 2013-14 crop year, the railways could have earned an additional $3.7 billion if there were no MRE regulation. Under the MRE regulation, however, the railways have an incentive to move all the exportable supplies of grain in order to maximize their revenue. Removing the MRE will change the distribution of rents in the GH&T system significantly. With no MRE regulations the grain handlers would have to bid on rail cars, similar to the U.S. system. Given that the railways offer the most inelastic factor in the GH&T system, they would capture the above-normal rents that are currently realized by the grain handlers when capacity is limited.

6. Limitations of the Study and Future Research

In order to focus on rail and West Coast capacity constraints, this study has made a few simplifying assumptions. While some of these assumptions are traditional in the literature, some are specific to this study as is the model developed to study the effect of grain export capacity constraint on farmers' revenue. Nevertheless, it is important for the reader to be aware of the technical limitations that these assumptions might create. This section explains the technical limitations created by these assumptions.

In all four scenarios, it is assumed that East Coast capacity is not constrained. That is, as long as rail capacity is not binding, exportable supplies can be moved through East Coast facilities. If the East Coast capacity constraint were to become binding at some level of exportable supplies, this would increase the magnitude of expected loss levels estimated in this study.

For simplicity, this study only incorporates four origin regions of crops. Of course, a model that incorporates all loading points will provide a more precise estimate of the total cost of transportation. However, the goal of this study is to calculate the expected basis levels and the loss associated with the expected excess basis levels. Since the premise of expected basis calculations in this study is arbitrage and the *law of one price*, adding more origin locations might not necessarily improve the precision of the estimates significantly.

However, it is worth noting that this study uses the concepts of rational expectations and the *law of one price* to introduce an economic framework to calculate future expected basis levels. Future studies might apply the framework presented in this study to more origin locations.

Given that investment in rail and port capacity will most likely have intergenerational benefits, relatively low discount rates (5 and 10 percent) are used in this study. It is possible for future studies to explore a broader range of discount rates, as well as longer periods of time more consistent with the life of railway and storage assets.

Since the start of this study, some grain companies might have added to their storage capacity at the West Coast. This has not been considered in this study. However, this study is very clear about its assumptions regarding capacity limits. Even if there have been such additions to West Coast capacity, the validity of the estimates are not undermined under the set of assumptions used in this study.

Unfortunately, given time and limited resources we were unable to explore the grain companies' incentives to invest in port terminal storage capacity. This, perhaps, requires a *Game* theoretical model to first lay out the underlying economic incentives for investment in capacity in the grain marketing industry.

7. Policy Options

Gray (2015) and others (see for example OECD-FAO (2015; page 29)) have pointed out that most of the growth in global demand has occurred in Asia. Thus, proximity to these growing markets suggests that investment in West Coast export capacity is necessary. Also, the absence of a Seaway Shipping cost at the West Coast makes this port more attractive than the East Coast to shippers and, therefore, the most reasonable place for investment in capacity improvement.

West Coast export capacity improvement can be achieved through a variety of policy solutions. A principal policy solution is to increase West Coast port capacity followed by rail capacity. It is important to note that increased rail capacity, *per se*, will not resolve the limited export capacity issue unless it is accompanied with an improvement in port capacity and handling coordination, especially at port terminals. A few policy solutions are briefly discussed below.

1. Improved Port Capacity: More research is needed to examine the private and public returns to investment in additional port terminal capacity, which is an important bottleneck in the grain handing and transportation system. Private firms have already made some investments to increasing port terminal capacity and other plans have been announced. This additional capacity can be facilitated with complementary investments in public infrastructure and through timely and efficient regulatory processes.

Notably, improved port capacity is not confined to physical storage infrastructure investment. For example, currently, precipitation can significantly impede port terminals' ability to load ships. Improved ability to load ships in the rain might accelerate the movement of grain and reduce the magnitude of backlogs and demurrage costs. Port capacity improvement goes beyond the physical assets at the port terminals. Although physical port capacity seems to be necessary, it might not be sufficient if it is not accompanied with improved coordination and overall system performance. The next policy solution seeks to shed a light on this issue.

2. Improved Rail Capacity: As shown in the results section, increasing rail capacity alone only by 5 MMT reduces farmers' expected loss over a ten-year period by $2.73.4 billion. The importance of sufficient rail capacity cannot be overemphasized. Without sufficient rail capacity, grain must be stored. As illustrated in this study, storage is the most expensive option.

However, rail capacity cannot be improved simply by increasing the number of cars. As Canadian Pacific Railways (CP, 2015) claims, "capacity comprises of track, bridges, tunnels, crews, locomotives, cars, snowplows, signaling system, etc." Given the capital-intensive and complex nature of rail transportation, improving the rail capacity does not seem to be an easy task. While this study merely explores the issue of grain transportation, the railways must satisfy the needs of multiple groups of customers. Further research is necessary to fully understand the concerns and interests regarding the issue of improvement in capacity for the railways.

While the current MRE regulation provides the railways with strong incentives to make capacity improving investments, the removal of the MRE would eliminate these incentives. The next policy solution provides more insight into how the MRE regulation can be refined to accommodate investment in rail capacity enhancement.

3. Refining the MRE: The MRE regulation caps average revenue per ton-mile of grain moved by the railways. This policy, which manages the market power of the two railways, eliminates the possibility of selling less service at higher prices. The MRE gives railways strong incentives to lower their cost per ton-mile and to move the volume offered to them. Also, railways can earn higher revenue levels by moving greater volumes of grain. It is therefore important that this key aspect of the MRE mechanism be retained.

Nevertheless, the existing MRE can be refined to create incentives to increase rail capacity, including additional incentives for early crop year and winter grain movement. If these additional incentives are developed, it is important that they are done so through negotiation with producers groups and shippers within the MRE structure to avoid the perverse incentives that are created when the railways can drive up service rates by reducing service levels.

Additional research is needed to examine how the MRE formula can be refined to create railway incentives to increase rail capacity and other rail service enhancements including infrastructure and rail access to the United States.

4. Improved Competition: Increasing competition could be a viable solution, from a theoretical perspective. In practice, however, increasing competition in the Western Canadian grain handling and transportation system might be a difficult task. The only mechanism that would appear to mimic a competitive market would be to move to a system of open running rights where multiple operators could run on the existing rail infrastructure. This mechanism was used in the electrical and telephone utilities to deal with the spatial monopoly of local utility companies.

In their recent submission to the Canadian Transportation Act (CTA) review panel, Canadian Pacific Railways (CP) claimed that they face many sources of competition. Some producer groups, however, claim that "the reality of the situation is that grain rail transportation is often constrained by a lack of competition and that will always be the case…" (Producer Groups, 2014). These producer groups recommend the use of "running rights" to improve rail service competition. A "costing review", as recommended by the Producer Groups (2014) might help measure the current level of competition and market power in the system.

5. Improved Coordination and Overall System Performance: Coordination among various parts of the grain supply chain is critical. CP has recently claimed that "by going to a full "365 24-7" grain supply chain in Canada's largest export gateway, Vancouver, an additional 25% or 5.2 MMT could have been moved during the 2013/14 crop year" (CP, 2015). This highlights the importance of coordination, particularly at the port terminals.

Improved coordination can also be attained through increased coordination among marketers. An active cash market that would allow marketers to swap grain stocks might reduce the number of anchor pulls to load a boat. This, in turn, will speed up the movement of grain, prevent backlogs, and reduce demurrage costs. Also, there appears to be a need for third party logistics coordination when the system is backlogged due to unexpected disruptions.

Improved coordination might be the most affordable approach to facilitate the movement of grain. Given that the industry would gain billions of dollars through cost-saving benefits, improved coordination might be a necessary short-run solution. However, in the long run, this may not be sufficient, as it does not increase the amount of assets necessary to transport grain.

In their submission to the CTA review panel, producer groups asked for more market transparency. They claim that market transparency is necessary for overall system performance. For this purpose, the Producer Groups (2014) recommend forming a “rail oversight” group. This group would mainly provide accurate system information to various players, and would serve as a third party that could intervene with predictable rules when an unanticipated system disruption makes existing commercial grain shipping contracts difficult to implement in a timely manner.

8. Conclusion

Limited grain export capacity reduces Western Canadian prices at a substantial cost to growers and the provincial economy, while creating economic opportunities for grain handlers and processors. An *ex post* analysis performed by Gray (2015) estimates that the prairie farmers' loss due to payments of excess basis in 2013-14 and 2014-15 crop years was at least $5 billion.

This study explores an important empirical question: Was the transportation crisis created by record 2013 crop an isolated incident that might not be repeated again? In other words, is it unnecessary to improve grain export capacity? This empirical question is governed by future export demand and future grain movement capacity.

Farmers' expected loss is estimated to be $8.3-10.8 billion assuming 10 and 5 percent discount rates, respectively. Approximately 57 percent of this cost can be attributed to rail constraints while the remaining costs are attributed to the West Coast capacity constraint. A 5 MMT increase in both rail and West Coast capacity saves Western Canadian farmers $4.7-6 billion over the next ten years, assuming 10 and 5 percent discount rates, respectively. A 10 MMT improvement in both rail and West Coast capacity lowers the total expected loss to $1.2 billion at a 10 percent discount rate and to $1.6 billion at a 5 percent discount rate. This is an 85 percent reduction in total expected loss, and implies $7.1-9.2 billion of cost-saving benefits for the producers over the 2016-25 period.

Although estimating the cost of improving export capacity is beyond the scope of this study, cost estimates are borrowed from some grain companies' news reports to provide the reader with a comparison of the benefits and costs of improving export capacity. Richardson has decided upon a $120 million budget to add 80 thousand tonnes of storage capacity, which will result in increasing their export capacity by 2 MMT. This will equate to $60 per tonne of annual export capacity. G3 has announced a $500 million investment to create 180 thousand tonnes of storage capacity that will result in at least 4.5 MMT of export capacity. This equates to $110 per tonne of annual export capacity.

Using these estimates, it will require approximately $1 billion to add 10 MMTs of capacity ($100/tonne) at the West Coast. The estimates of this study show that increasing the West Coast capacity without any improvements in rail capacity will result in $3.1 billion of cost-saving benefits for farmers. This implies a benefit-to-cost ratio of 3.1/1. If the West Coast expansion is accompanied by a similar increase in rail capacity, a 10 MMT increase in West Coast capacity will create $9.1 billion cost-saving benefits. This implies a benefit to cost ratio of 9.1/1. These high benefit-to-cost ratios highlight the importance of improving the export capacity through West Coast.

Results also indicate that under the MRE regulation, the railways can increase their revenue by moving more grain. Removing the MRE, however, will create an incentive for the railways to increase their revenues by moving less grain. In the 2013-14 crop year the railways could have earned an additional $3.7 billion if there were no MRE regulation.

Given the magnitude of the cost-saving benefits, finding appropriate policy solutions to improve West Coast export capacity seems necessary. The following policy solutions are recommended in this study:

1. Improving port capacity;
2. Improving rail capacity;
3. Refining the MRE;
4. Improving coordination and overall system performance;
5. Improving competition.

Improving West Coast port capacity followed by increased rail capacity should be the focus of policy makers.

Implementing some of these policy solutions might be a difficult task, which needs further research and consultation with various players in the supply chain. Nevertheless, all of these solutions should be considered as necessary but not necessarily sufficient components of a long-run plan to resolve a multi-billion dollar problem in Western Canadian agriculture.

9. References

Agriculture and Agri-Food Canada (AAFC). (2015). *Canada: Outlook for Principal Fireld Crops, 2015-06-18.* Retrieved July 03, 2015, from AAFC: http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/crops/crops-market-information-canadian-industry/canada-outlook-for-principal-field-crops/?id=1378743094676

Agriculture and Agri-Food Canada (AAFC). (2014). *Weekly Price Summary.* Retrieved January 27, 2015, from AAFC: http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and- market-information/by-product-sector/crops/crops-market-information-canadian-industry/weekly-price- summary/?id=1378745200250

Billingsley, P. (1979). *Probability and Measure.* New York: John Wiley and Sons.

Canadian Grain Commission (CGC). (1997-2015). *Canadian Grian Exports.* Retrieved January 27, 2015, from CGC: https://www.grainscanada.gc.ca/statistics-statistiques/cge-ecg/cgem-mecg-eng.htm

Canadian Pacific Railways (CP). (2015). *CP Submission to the Canada Tranasportation Act Review Panel.* Retrieved February 15, 2016, from CP Railways: http://www.cpr.ca/en/about-cp-site/Documents/cp-cta-review-submission.pdf

Gray, R. (1995). *Basis Deductions for CWB Deliveries in Western Canada: A Proposal for Basis Calculations.* Winnipeg: Canadian Wheat Board.

Gray, R. (2014). Policy Options to Reduce Basis: Presentation at *Grain Handling and Transportation Summit*. Saskatoon, SK, Canada. March 26, 2014.

Gray, R. (2015). *The Economic Impact of Elevated Export Basis Levels on Western Canadian Grain Producers.* Saskatoon: Saskatchewan Wheat Development Commission.

Greene, W. (2002). *Econometric Analysis, 5th ed.* Upper Saddle River: Pearson Education.

Muth, J. (1961). Rational Expectations and the Theory of Price Movements. *Econometrica*, *29* (3), 315-335.

Northwest Terminals Ltd. . (2014). *Posted Cash Prices.* Retrieved January 27, 2015, from http://www.northwestterminal.com/index.cfm

OECD/Food and Agriculture Organization of the United Nations. (2015). *OECD-FAO Agricultural Outlook 2015*. OECD Publishing, Paris. Retrieved March 31, 2016, from *http://dx.doi.org/10.1787/agr_outlook-2015-en*

Producer Groups (APAS, SWDC, SBDC, SPG). (2014). *Producer Recommendations on the Future of Canada's Transportation Act.* Retrieved February 15, 2016, from Government of Canada: https://www.tc.gc.ca/eng/ctareview2014/pdf/Agricultural%20Producers%20Association%20of%20Saskatchewan%20Submission.pdf

Quroum Corporation. (2015). *2013-14 Annual Report.* Retrieved Augeust 20, 2015, from Quroum Corporation: http://www.quorumcorp.net/reports.html

Saskatchewan Ministry of Agriculture. (2014). *Market Trends.* Retrieved September 2015, from http://www.agriculture.gov.sk.ca/MarketTrends

Statistics Canada. (2015a). *Estimated areas, yield and production of principal field crops by Small Area Data Regions, in metric and imperial units, annual (CANSIM Table 001-0071).* Retrieved June 3, 2015, from Statistics Canada: http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=10071

Statistics Canada. (2015b). *Farm supply and disposition of grains as of March 31, July 31, August 31 (soybeans only) and December 31 (CANSIM Table 001-0043).* Retrieved January 27, 2015, from Statistics Canada: http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=10043

Statistics Canada. (2014a). *Estimated areas, yield, production and average farm price of principal field crops, in metric units (CANSIM Table 001-0010).* Retrieved January 27, 2015, from Statistics Canada: http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=10010

Statistics Canada. (2014b). *Field Crop Reporting Series.* Retrieved January 27, 2015, from Statistics Canada: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3401

United States Department of Agriculture (USDA). (2014). *Portland, Market News Pacific NW Wheat Basis Report.* Retrieved September 2015, from USDA: http://www.ams.usda.gov/mnreports/jo_gr111.txtts

United States Wheat Associates (USWA). (2014). *Weekly Price Report.* Retrieved January 27, 2015, from USWA: http://www.uswheat.org/

10. Appendix A

This Appendix explores two scenarios. In the first case it is assumed that only total rail capacity is constrained and there are no West or East port capacity constraints. In the second case it is assumed that only West Coast capacity is limited and there are no rail or East Coast capacity constraints.

Scenario A1: Farmers' expected loss when only rail capacity is constrained

In this scenario, it is assumed that only rail capacity is constrained and West and East Coast capacity levels are not constrained. In this scenario, when exportable supplies are larger that rail capacity, grain is stored.

Using the shadow values of the rail capacity constraint, expected basis levels for Alberta, West Saskatchewan, East Saskatchewan, and Manitoba are calculated for a range of production levels in 2016 to 2025. Expected basis levels for all years are calculated as described in Table 9. Table A1 presents the detailed results for each production level in each region for 2016. The calculation method is the same for other years. Therefore, to avoid repetition, only the final results for other years are reported (in Table A2).

Table A1 reports average expected basis, average excess or above normal basis, as well as farmers' expected loss. While expected basis levels are calculated for each segment of the distribution, average expected basis and expected loss are calculated for the entire range of the distribution. Average expected basis is the weighted average of basis levels reported for each segment, while the weights are the probabilities of production level within that segment, as reported in column 2.

Expected loss is calculated in a similar fashion; the weighted average of deliveries and their probability levels reported in column 2 are multiplied by the average excess basis.

Table A1: PDF of Forecast Basis Level in 2016.

1	2		4	Expected Basis ($/tonne)			
Production Range (Y_t) (MMT)	Prob. of 1	Deliveries (MMT)	Prob. of over limit production next year	AB	West SK	East SK	MB
33-35	0.001	14	0.29	34	39	48	51
35-37	0.003	16	0.29	34	39	48	51
37-39	0.006	18	0.29	34	39	48	51
39-41	0.011	20	0.29	34	39	48	51
41-43	0.020	22	0.29	34	39	48	51
43-45	0.032	24	0.29	34	39	48	51
45-47	0.047	26	0.29	34	39	48	51
47-49	0.065	28	0.29	34	39	48	51
49-51	0.083	30	0.29	34	39	48	51
51-53	0.098	32	0.29	34	39	48	51
53-55	0.108	34	0.29	34	39	48	51
55-57	0.110	36	0.29	34	39	48	51
57-59	0.104	38	0.31	34	39	48	51
59-61	0.091	40	0.34	34	39	48	51
61-63	0.073	42	0.42	54	59	68	71
63-65	0.055	44	0.56	54	59	68	71
65-67	0.038	46	0.70	139	145	153	157
67-69	0.025	48	0.81	145	151	159	163
69-71	0.015	50	0.89	149	155	163	167
71-73	0.008	52	0.95	152	157	166	169
73-75	0.004	54	0.98	153	158	167	170
75-77	0.002	56	0.99	154	159	168	171
77-79	0.001	58	1.00	154	159	168	171
79-81	0.000	60	1.00	154	159	168	171
Average Expected Basis ($/tonne)				47	52	61	64
Average Excess Basis ($/tonne)				13	13	13	13
Expected Loss ($)		$612,253,621					

Source: Authors' estimation

As shown in Table A1, in 2016 the average expected basis ranges from $47 to $64 per tonne for the three provinces. This implies that a normal or excess basis is more than $13 per tonne, or that there is expected loss of over $612 million for farmers. As presented in Table A3, in 2020 and 2025 the expected loss increases to approximately $921 million and $1.43 billion, respectively.

Figure A1 presents the expected basis increase and the PDF for different production levels ranging from 30 MMT to 80 MMT. Production levels under 60 MMT imply a normal basis. Production levels higher than 60 and lower than 64.74 MMT imply higher basis levels that reflect a minimum $19.85 per tonne premium for transporting grain to the South, rather than the cheapest alternative. As production level increases, expected basis increases as well though with a lower probability. However, it is possible for the excess basis levels to reach $120 per tonne, which is the cost of two years of storage.

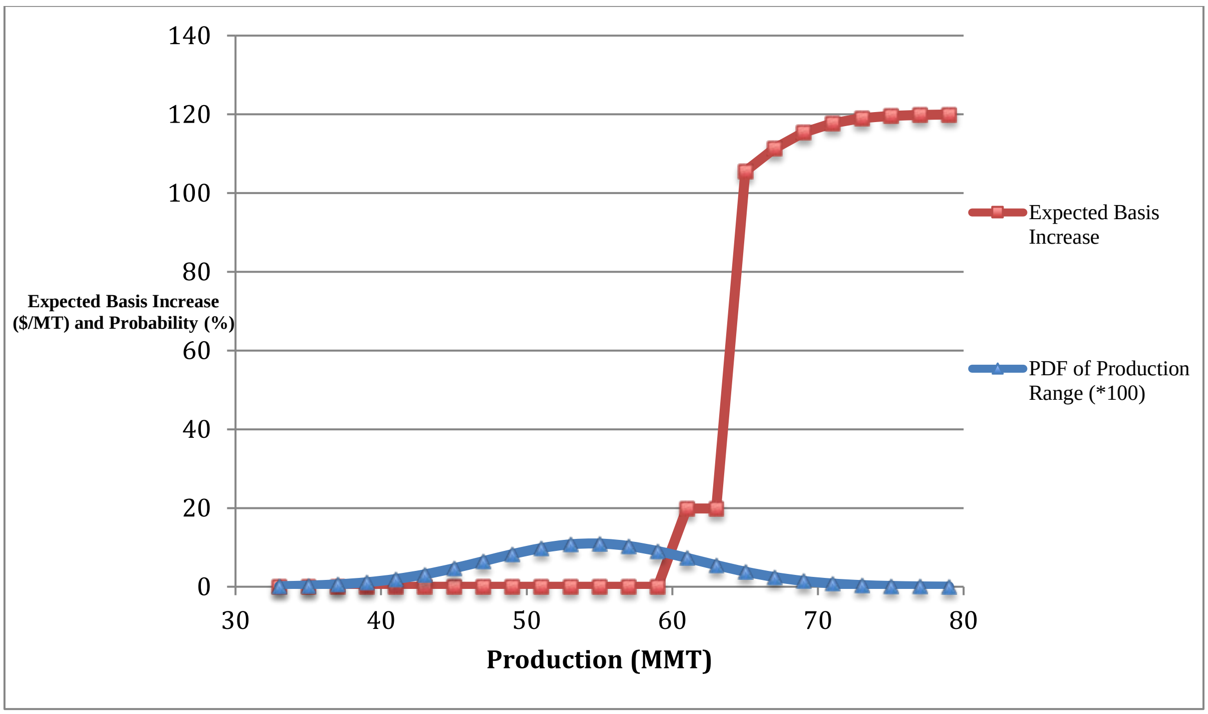

Figure A1. Expected Basis and PDF for Different Production Levels in 2016.

Source: Authors' estimation.

Figure A2 and Table A2 provide a representation of excess basis levels under a current rail capacity limit of 40 MMT and a 5 MMT and a 10 MMT increase in rail capacity. As illustrated in Figure A2, excess basis levels significantly decrease when export capacity is improved by 5 and 10 MMT. At the current capacity levels, excess basis reaches $30/MMT in 2025. With a 10 MMT export capacity improvement, excess basis remains under $3/MMT.

Table A2. Effect of Rail Capacity Constraint on Expected Excess Basis in Western Canada under Current, and 5 and 10 MMT Improvements in Rail Capacity in absence of West Coast Constraint, 2016-25.

	Expected Excess Basis Effect ($/MT)		
Year	Current Capacity (Base)	5 MMT Improvement	10 MMT Improvement
2016	12.93	4.23	0.53
2017	14.24	4.83	0.63
2018	15.88	5.51	0.75
2019	17.52	6.25	0.88
2020	19.27	7.07	1.04
2021	21.14	7.98	1.22
2022	23.11	8.97	1.42
2023	25.18	10.06	1.65
2024	27.37	11.24	1.92
2025	29.65	12.52	2.22

Source: Authors' estimation.

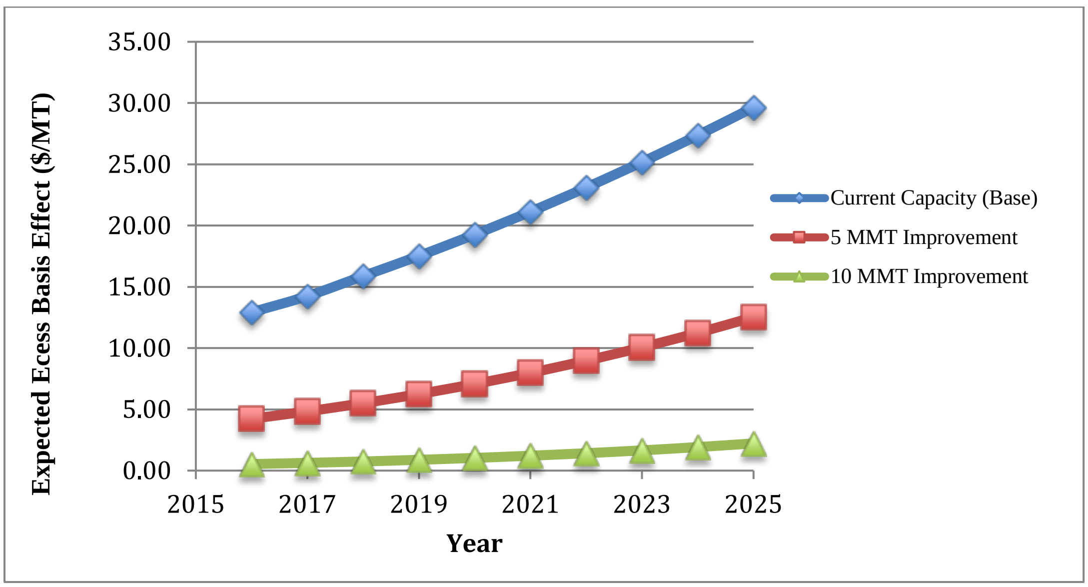

Figure A2. Effect of Rail Capacity Constraint on Expected Excess Basis in Western Canada under Current, and 5 and 10 MMT Improvements in Rail Capacity in absence of West Coast Constraint, 2016-25.
Source: Authors' estimation.

Figure A3 and Table A3 summarize farmers' expected losses for a ten-year period from 2016 to 2025 under the three scenarios. Expected loss levels increase over time. This is due to increase in production and the resulting increase in the probability of paying a higher excess basis. Net present value (NPV) of the expected loss under current export capacity is estimated to be over $5.6 billion (at 10 percent discount rate) and $7.3 billion (at 5 percent discount rate) for the ten-year period. At a 10 percent discount rate, the expected loss decreases by approximately $3.4 billion when the export capacity constraint is increased by 5 MMT. This cost-saving benefit increases to $4.4 billion at a 5 percent discount rate.

A 10 MMT increase in the export capacity constraint results in a $5.3 billion (at a 10 percent discount rate) and $6.8 billion (at a 5 percent discount rate) decrease in the expected loss over the 2016-25 period. Figure 9 provides a comparison of the expected loss under the three scenarios. The area under each curve, when adjusted by the discount rate, represents the NPVs reported in Table A3.

Table A3. Expected Loss Effect of Rail Capacity Constraint in Western Canada under Current, and 5 and 10 MMT Improvements in Rail Capacity in absence of West Coast Constraint, 2016-25.

Year	Expected Loss (million $)		
	Current Capacity (Base)	5 MMT Improvement	10 MMT Improvement
2016	612	213	29
2017	675	244	35
2018	756	279	41
2019	836	317	49
2020	921	359	57
2021	1,012	406	67
2022	1,109	457	79
2023	1,212	514	92
2024	1,319	575	107
2025	1,433	641	123
NPV*	5,643	2,239	369
NPV**	7,351	2,948	492

* and ** Net Present Value (NPV) is calculated assuming a 10% and 5% discount rates, respectively.
Source: Authors' estimation.

It is worth noting that this section does not take into account farmers' potential loss from limited West Coast export capacity. As can be inferred from the freight rates presented in Table 6, West Coast export capacity is a relatively less expensive export point. However, West Coast export capacity is constrained at 27 MMT. This means that exportable supply levels above 27 MMT must be exported through other ports at a higher cost. Therefore, it is important to quantify the cost-saving benefits of an improvement in the West Coast export capacity. In the next section, we specifically focus on West Coast capacity constraint.

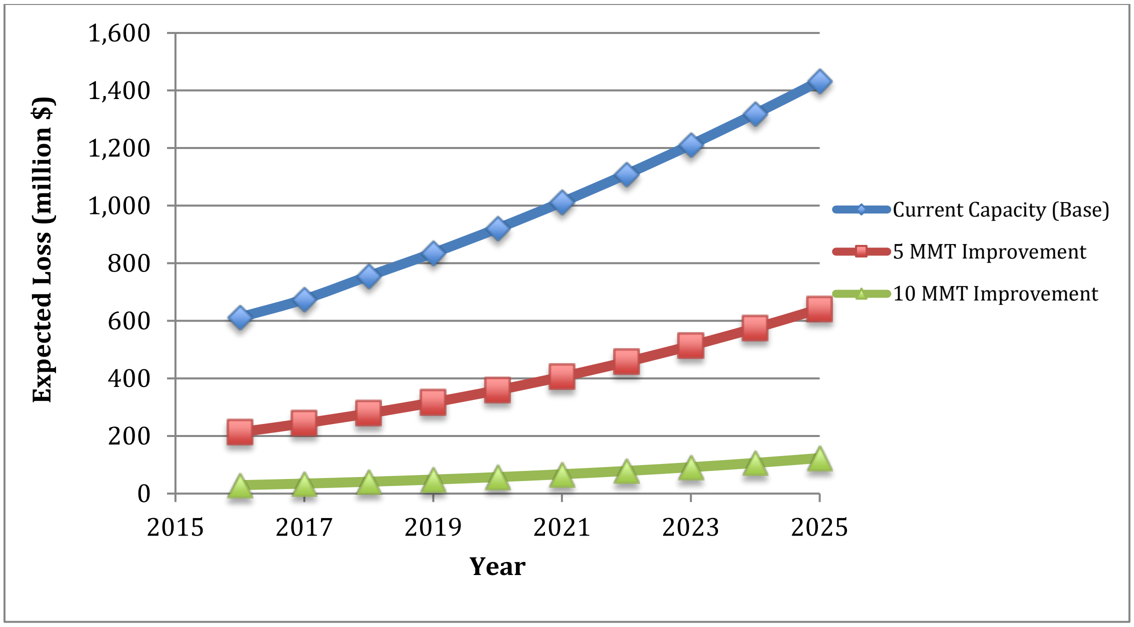

Figure A3. Expected Loss Effect of Rail Capacity Constraint in Western Canada under Current, and 5 and 10 MMT Improvements in Rail Capacity in absence of West Coast Constraint, 2016-25.
Source: Authors' estimation.

Scenario A2: Farmers' expected loss when only West Coast capacity is constrained

In this section it is assumed that only West Coast capacity is constrained at 27 MMT. That is, when the West Coast capacity constraint is binding, exportable supplies can be moved to East Coast by rail. Therefore, there will never be any storage. Nevertheless, expected basis levels could still be higher than normal due to the fact that freight rates for the West Coast are relatively lower than freight rates for East Coast. This means the expected loss that is estimated in this scenario merely reflects the cost of exporting through other, relatively more expensive, ports when the West Coast capacity constraint is binding. The difference in West-East freight rates is reflected in the shadow value of West Coast. Shadow values of the West Coast capacity constraint are used to calculate the expected basis levels for each region.

Expected excess basis levels are reported in Table A4 and Figure A4. Increase in capacity reduces the expected excess basis significantly. The reduction in the expected excess basis seems to have a non-linear relationship with the capacity improvement. Each

5 MMT increase in capacity reduces the expected excess basis by approximately 50 percent.

Table A4. Effect of West Coast Capacity Constraint on Expected Excess Basis in Western Canada under Current, and 5 and 10 MMT Improvements in West Coast Capacity in absence of Rail Constraint, 2016-25.

Year	Expected Excess Basis Effect ($/MT)		
	Current Capacity (Base)	5 MMT Improvement	10 MMT Improvement
2016	13.33	6.01	2.64
2017	13.92	6.38	2.84
2018	14.53	6.76	3.05
2019	15.14	7.16	3.28
2020	15.75	7.57	3.51
2021	16.37	7.99	3.75
2022	16.99	8.42	4.00
2023	17.62	8.87	4.26
2024	18.24	9.32	4.52
2025	18.85	9.79	4.80

Source: Authors' estimation

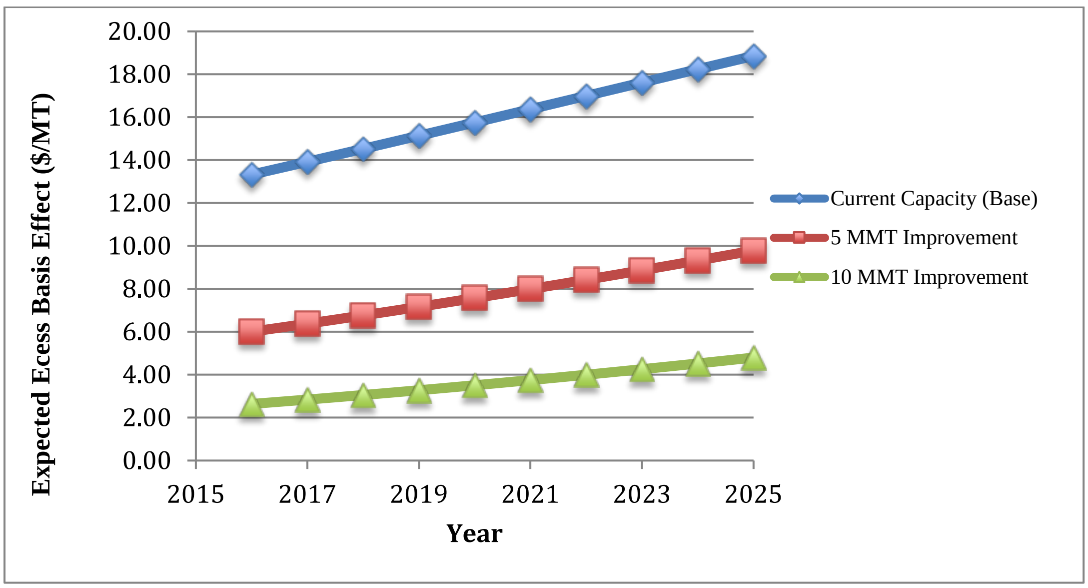

Figure A4. Effect of West Coast Capacity Constraint on Expected Excess Basis in Western Canada under Current, and 5 and 10 MMT Improvements in West Coast Capacity in absence of Rail Constraint, 2016-25.
Source: Authors' estimation.

The expected loss for each year is calculated in the fashion described previously; the weighted average of deliveries and their probability levels are multiplied by the average excess basis. Expected loss in the three scenarios is reported in Table A5. Every 5 MMT increase in capacity reduces farmers' expected loss by approximately 50 percent.

Table A5. Expected Loss Effect of West Coast Capacity Constraint in Western Canada under Current, and 5 and 10 MMT Improvements in West Coast Capacity in absence of Rail Constraint, 2016-25.

Year	Expected Loss(million $)		
	Current Capacity (Base)	5 MMT Improvement	10 MMT Improvement
2016	542	256	117
2017	570	273	126
2018	599	292	136
2019	629	311	147
2020	659	330	158
2021	689	351	170
2022	720	372	182
2023	752	394	195
2024	783	417	208
2025	815	441	222
NPV*	4,008	2,015	966
NPV**	5,124	2,591	1,247

* and ** Net Present Value (NPV) is calculated assuming a 10% and 5% discount rates, respectively.
Source: Authors' estimation.

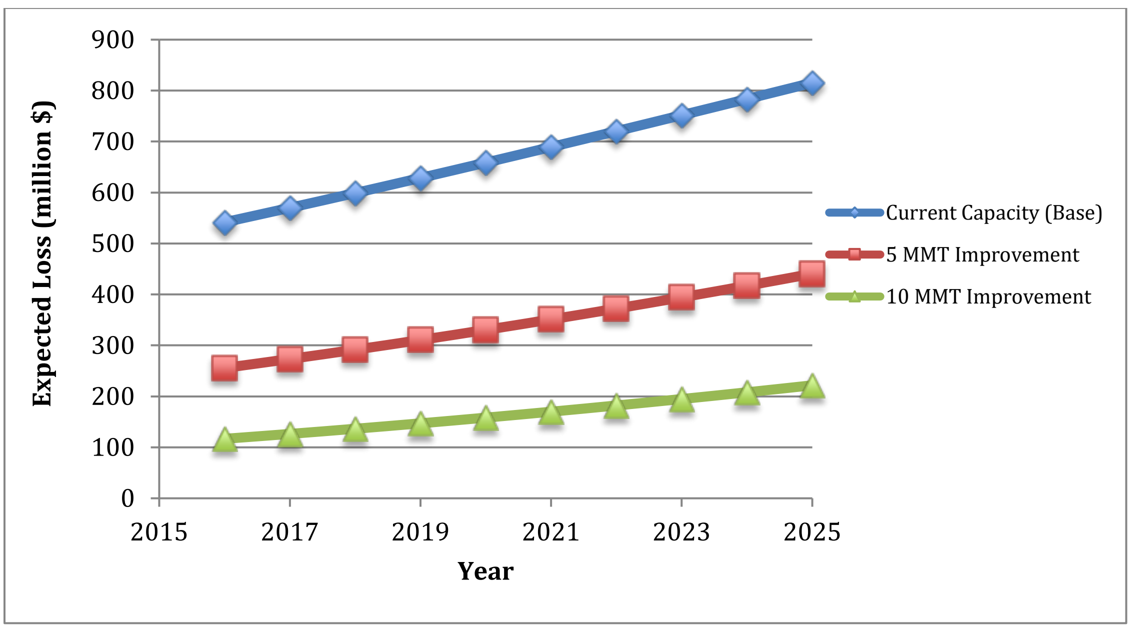

Figure A5. Expected Loss Effect of West Coast Capacity Constraint in Western Canada under Current, and 5 and 10 MMT Improvements in West Coast Capacity in absence of Rail Constraint, 2016-25.
Source: Authors' estimation.