

# **Using Derivatives to Manage Risk for Western Canadian Agriculture**

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**A Thesis Submitted to the Faculty of Graduate Studies of**

**The University of Manitoba**

**in Partial Fulfillment of the Requirement**

**for the Degree of**

**DOCTOR OF PHILOSOPHY**

**Individual Interdisciplinary Studies**

**Warren Centre for Actuarial Studies and Research and**

**Department of Agribusiness and Agricultural Economics**

**University of Manitoba**

**Winnipeg, Manitoba, Canada**

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## ABSTRACT

Canadian agriculture faces considerable price risk. This thesis is composed of three essays investigating the effectiveness of using derivatives to manage risk in the Western Canadian grain industry.

The objective of the first essay is to examine the use of grain price futures and options for reducing net indemnities paid by crop insurers on yield loss insurance. Data includes premiums and indemnities paid for canola in Manitoba and canola futures prices. Results show canola futures and options hedges were not effective in reducing net indemnities paid, while a spread position incorporating soybean oil futures showed some effectiveness. This analysis is applicable to crop insurers considering additional risk management methods.

The objective of the second essay is to examine the use of futures contracts to manage price risk for Canadian wheat producers, using futures contracts based in the United States. Wheat in Canada is unique in that it has only recently traded on an ‘open market’ in Western Canada since 2012. Mean square error is used to examine hedging effectiveness. Downside risk measures are also considered. Data includes Manitoba and North Dakota hard red spring wheat prices and Minneapolis futures prices. Results show hedging to be effective for Manitoba farms, although less effective than in North Dakota.

The objective of the third essay is to examine managing price risk across an entire grain farm in Western Canada. Hedging with futures can be a useful for reducing price risk, although basis risk, including foreign exchange risk, may impact hedging effectiveness for Canadian producers for most contracts. Many farms also grow multiple crops and benefit from diversification. Mean square error is used to determine hedge effectiveness, with data including Manitoba prices for hard red spring wheat, canola, corn and soybeans and their respective futures prices. Results show diversification reduces variability and downside risk over individual crop returns, and hedging is found to be more effective than simple diversification.

Keywords: risk management, hedging, futures and options markets, crop insurance.

## ACKNOWLEDGMENTS

I would like to express my greatest gratitude to my advisors, Dr. Milton Boyd and Dr. Lysa Porth. Your expertise, patience, and guidance made my graduate experience enriching and enjoyable. The learning experience has gone beyond the insights, knowledge and perspective on my research topic, and have included mentorship on submitting papers for journals and conferences and on engaging in research outside of my specific thesis topic. Your flexibility in allowing me to manage my studies within the demands of family, work and other commitments that come with being a more ‘mature’ student went above and beyond. It truly would not have been possible for me to get to this point without your support.

As well, I would like to extend my appreciation to the other members of my committee, Dr. Barry Coyle and Dr. Ken Seng Tan. Your valuable comments have greatly contributed to the quality of this thesis. A special thank-you as well to my external examiner, Dr. Dermot Hayes of Iowa State University, whose participation and feedback was an important contribution. I also want to express my appreciation to the I.H. Asper School of Business and the Agribusiness and Agricultural Economics Department at the University of Manitoba for supporting my interdisciplinary research.

I am deeply appreciative of financial support from National Sciences and Research Council (NSERC), the Social Sciences and Humanities Research Council (SSHRC) and Guy Carpenter & Company, LLC. These resources were very helpful in allowing my research and studies to take place.

Finally, I would like to thank my family for their support and encouragement. My wife and three daughters had more evenings and weekends of an ‘absent’ father and husband than they deserved, and yet they were always supportive in helping me to push through. Knowing I had your moral support during late nights and exhausting stretches is a larger contribution to the completion of this work than any ‘technical expertise’ could have provided.

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# **CHAPTER 1**

## **THESIS INTRODUCTION**

The Western Canadian agricultural industry faces considerable risk for both production and price. While government programs can have a role to play in helping to manage agricultural risk, they may not always be suitable to fully meet producers' needs. The ability for producers to effectively use existing methods within the private industry may allow them to more efficiently manage their risk.

Futures and options contracts are often widely available for hedging various crops. But while they are generally viewed as being effective for managing risk, often this is within a 'narrowly traditional' perspective (such as a U.S. producer hedging their crop using a futures contract on a U.S.-based exchange). There is less research on the extent to how effective futures and options can be in managing risk when applied to wider applications. If futures and options can be effectively used more broadly, then these methods can more confidently be incorporated by industry.

This thesis is composed of three essays investigating applications of using futures and options to manage risk in the Western Canadian grain industry. The first essay considers the effectiveness of using futures and options to reduce losses for crop yield insurers. The second essay considers the effectiveness of using futures contracts to manage price risk for a Manitoba wheat producer. The third essay considers the role of futures contracts to manage price risk within the 'portfolio' of crops grown on a typical Manitoba farm. Effectiveness will be considered both in terms of reducing the variability of returns as well as downside risk, reflecting the fact that some industry participants may be more concerned about avoiding deep losses.

Testing the Effectiveness of Futures and Options for Reducing Risk for Crop Insurers:  
The Case for Canola in Manitoba

The objective of chapter two is to investigate the use of futures and options in reducing the net indemnities paid by crop insurers on yield loss insurance. Crop insurance premiums are based on expected losses over a period of time. Premiums are set and policies taken out by producers prior to planting time, with losses determined during the period between planting and harvest. Moderate declines in yield below insured levels would not likely result in significant losses for insurers. However, widespread damage across many farms in a region could potentially lead to catastrophic loss, which would cause more difficulty for the insurer. In cases where there are significant crop losses and large insurance claims, there is also a reduction in the supply of that crop, which may cause a price response in the market.

One measure of the severity of crop insurance losses is the Loss Cost Ratio (LCR). The LCR is calculated as:

$$\text{LCR} = \text{Total indemnities paid} \div \text{Total liabilities}$$

and is often expressed as a percentage (Josephson, Lord, and Mitchell, 2000). On average, the LCR for crop yield insurance is approximately 8-12 percent, depending on the region, and years in which the LCR is above 25 percent are considered a disaster (Porth, Pai and Boyd, 2014). The effectiveness of hedging will be determined by the impact of the net hedging gains or losses on the LCR, with hedging gains reducing the net indemnities paid, while hedging losses would increase the net indemnities paid. The data includes premiums and liabilities for Manitoba from 1980 to 2018 and futures prices from ICE Canada Futures for canola and the Chicago Board of Trade for soybean oil.

If hedging in the futures market by insurers is effective in managing crop yield insurance exposure it could be a beneficial risk management strategy, particularly given the flexibility of those instruments.

## Hedging Effectiveness for Canadian Wheat Producers

The objective of chapter three is to examine the effectiveness of using futures contracts to manage price risk for Western Canadian wheat producers. Most hedging research assumes that the producer operates in the same country in which the hedging instrument is based (for example, a corn producer in Illinois using a corn futures contract that trades on the Chicago Board of Trade). However, for Canadian producers, using a U.S. futures contract in U.S. dollars has the potential to increase basis risk, possibly reducing its effectiveness to hedge prices.

The basis risk is not just in the currency, as this could also theoretically be hedged. When the cash market exposure is in a different country than the delivery location of the futures contract there is also the potential for additional variability between cash and futures market price behavior due to factors such as government policy, logistics, and trade flows that might affect prices differently in one country than the other. Aside from canola, Canadian producers may use futures contracts that are based in another country, which potentially increases risk through higher basis risk, including foreign exchange risk. Previous work on futures hedging in Canadian agricultural markets showed mixed results (Carter and Loyns, 1985; Braga, 1990; Novak and Unterschultz, 1996).

Wheat is particularly unique since, aside from being one of the most important crops grown in Canada, it has most recently traded on an ‘open market’ in Western Canada since 2012. This means that only recently has hedging effectiveness been able to be statistically evaluated based on actual cash prices in more recent years, rather than using inferred values from other price series.

Data includes average elevator hard red spring wheat prices for Manitoba and North Dakota from 2013 to 2019 and hard red spring wheat futures prices from the Minneapolis Grain Exchange. Hedging effectiveness for wheat is analyzed using mean square error, which measures the difference in actual returns relative to expected returns. Downside risk measures of semivariance and value-at-risk are also considered in assessing hedging effectiveness.

This chapter also considers the effectiveness of hedging for a Manitoba producer relative to a North Dakota producer. Essentially the only thing that separates a Manitoba farm and a North Dakota farm is the international border. If the Minneapolis futures contract is considerably more effective at reducing price risk for North Dakota producers, this may create a competitive advantage for the U.S. producer.

Managing Price Risk for Western Canadian Grain Producers: How Much Does Simple Diversification Reduce Risk and is Hedging Effective in a Portfolio Context?

The objective of chapter four is to examine managing price risk across an entire grain farm for Western Canadian producers. Western Canadian grain producers face considerable risk for both production and price. There are various ways that producers can manage risk in their operation. This includes both government programs (such as crop yield insurance or the AgriStability program, which is a federally administered margin insurance program) and private methods (private margin insurance contracts, price risk management contracts done directly with grain buyers or hedging on futures exchanges). Aside from traditional crop yield insurance, government risk management programs in Canada have had relatively low participation from producers. This means that, outside of crop insurance, Canadian producers largely relied on private methods of managing risk.

Hedging with futures and options may be effective for a number of producers. For Canadian producers, basis risk, including foreign exchange risk, can reduce their effectiveness since the futures markets for many crops are listed on U.S.-based exchanges. Portfolio theory also points to reduced variability through a diversified collection of assets. Most farms grow more than one crop, which means there is a certain amount of variance reduction that could happen through diversification. This could significantly alter the extent to how futures contracts would be efficiently used by Canadian producers. This study considers how diversification of the crop mix reduces price risk at the farm level, and the extent to which (if) an efficiently hedged portfolio can further manage risk at the whole enterprise level for a Canadian grain farm.

The study will specifically look at revenue per acre for a Manitoba farm that grows an equal area of canola, hard red spring wheat, corn, and soybeans, which would act as a reasonable proxy for a crop rotation in the province. Data includes Manitoba cash prices for corn, canola, hard red spring wheat and soybeans are from the 2013/14 to 2019/20 marketing years (7 seasons). Average elevator prices for Manitoba are used for each crop. Canola futures prices are used from ICE Futures Canada (formerly the Winnipeg Commodity Exchange), hard red spring wheat futures from the Minneapolis Grain Exchange, and corn and soybean futures from the Chicago Board of Trade. Yield data is from Statistics Canada.

Mean square error (MSE) is the measure by which actual returns vary from projected returns. Comparisons are made for the portfolio of crops relative to each crop on an individual basis for positions that are unhedged, using a naïve hedge, using hedge ratios calculated on an individual crop basis, and using a hedge ratio calculated based on the portfolio of crops.

In some cases producers may be more concerned about adverse outcomes rather than minimizing the variance of returns. For this reason downside risk measures are also considered for the portfolio, including semivariance and value-at-risk (VaR).

The analysis should be of interest for producers and policy makers. For Canadian policy makers, knowing that hedging with futures contracts is an effective method of managing price risk would give them the confidence that existing private sector methods are in place and can be considered for some farmers. Conversely, if futures contracts are not effective in reducing price risk then other policies may need to be considered.

## **CHAPTER 2**

# **TESTING THE EFFECTIVENESS OF FUTURES AND OPTIONS FOR REDUCING RISK FOR CROP INSURERS: THE CASE OF CANOLA IN MANITOBA**

### **Introduction**

Adverse weather is the major cause of large crop production losses, and these weather events are typically infrequent, yet severe, and correlated across geographic regions. This presents a challenge for crop insurers, as losses cannot be easily pooled and diversified (Porth, Pai, and Boyd, 2014). Crop insurance premiums are based on expected losses, or average loss over a period of time, typically during planting and through to harvest. Moderate declines in yield below insured levels would not likely result in significant losses for insurers. However, widespread damage across many farms in a region could potentially lead to catastrophic loss, which would cause more difficulty for the insurer. Miranda and Glauber (1997) estimated that the spatially correlated nature of crop insurance losses increases the risk to insurers by between 20 and 50 times compared to if yields were independent.

Another challenge for insurers is that the ability to manage the risk of losses is limited once premiums are set. Rates are determined in the period prior to planting the crop, leaving a window of time where producers still have some ability to adjust their planting decisions. Decisions could change in response to factors such as fluctuating crop prices or weather conditions that occurred after insurance rates were calculated. This further adds to the risk for crop insurance organizations relative to other types of insurance and the need for additional methods to manage risk. Any additional instruments or methods that enhance the ability for insurers to reduce their risk between when premiums are set and when final yields are determined can further help to manage potential losses.

In Canada it is the provincial government that is the seller and underwriter of crop insurance to producers. There is a multi-layered risk-sharing framework to help manage crop insurance losses, as each province can elect to participate in a deficit financing

program, called the Federal-Provincial Reinsurance Fund. This national reinsurance fund is back-stopped by the federal government, and provincial reinsurance funds are back-stopped by participating provincial governments. If the balance in the provincial insurance or reinsurer funds is insufficient, the provincial government insurance corporation may access the reserves in the “federal reinsurance fund” and in their “provincial reinsurance fund.” In addition to the Federal-Provincial Reinsurance Fund, individual provinces may also purchase reinsurance from the private market to protect against significant losses. However, even with the risk-sharing framework, each provincial crop insurance corporation acts as an independent entity.

The objective of this paper is to examine the effectiveness of using grain futures and options contracts to reduce (hedge) crop yield insurance losses for canola (also referred to as rapeseed) in the province of Manitoba, from the perspective of the insurer. For this analysis the impact of the hedge on the loss cost ratio (LCR, which is the ratio of indemnities to liabilities) is used to assess the performance of the hedge. There is little published research that examines the role of grain futures contracts in hedging crop yield losses for insurers. Woodard and Garcia (2008) examine the efficacy of weather derivatives for hedging crop insurance exposures. Tiwari, et al (2017) looked at the effectiveness of using put options to reduce the risk to insurers for crop revenue insurance, and found that considering only put options as a risk management tool was not appropriate. Hayes, Lence and Mason (2003) examined various hedging strategies for their potential to reduce government reinsurance risk. This included yield futures and options and price puts and calls. They found that hedging with only price options was not as effective at reducing risk as yield options. In addition, correlations are based on historical data, and any changes in correlations may reduce the effectiveness of the hedge.

But beyond this no other research has examined the connection between changes in futures prices and the indemnities paid out for yield losses. If hedging in this manner is effective in managing crop yield insurance exposure it could act as an additional risk management strategy for the industry, potentially resulting in reduced losses and more efficient pricing of premiums.

A sharp decline in yields, and resulting decrease in the supply of a commodity, might be expected to result in a price increase, all other things being equal. If the relationship between yields and prices is statistically significant, crop insurers may have the potential to hedge crop insurance losses from widespread yield declines with grain futures markets. Miranda and Glauber (1997) suggest that the hedging potential of grain futures markets is limited because domestic output and futures price movements have become less correlated due to the increased effects of more widespread and integrated international trade. This could be the case in crops such as corn, where U.S. production for the 2019/20 marketing year is approximately 31 percent of the world total and has a market share of approximately 26 percent of world trade, which is down considerably from a decade ago. For wheat, United States has less than 10 percent of world production and 14 percent of world exports. For soybeans, United States production is approximately 29 percent of the total and 28 percent of world exports. For these crops a large portion of production and trade happen in countries outside the United States (USDA Foreign Agricultural Service, 2021). Also, futures contracts are increasingly used by traders as the primary tool to hedge price risk on a global basis. This, in turn, may cause domestic production to have a relatively smaller role in driving futures values than in the past.

However, the ability to use futures and options to hedge the risk of crop insurance losses may be stronger in instances where futures prices are more directly impacted by changes to domestic production. For example, Canada represents just over 30 percent of global production of canola (rapeseed), but accounts for as much as 60 percent or more of world trade. The Intercontinental Exchange (ICE) Canada (formerly the Winnipeg Commodity Exchange) has a canola futures contract. This contract has more volume and open interest than the rapeseed contract listed on the MATIF exchange in Paris, and is considered the primary futures contract for global canola traders. However, Canada's dominant position in global canola trade should also make the ICE contract more sensitive to Western Canadian yield outcomes. While canola prices will be influenced by other vegetable oil prices such as soybean oil or palm oil, Canada's dominant position in global export markets contributes to the ICE Canada canola contract potentially being less influenced by outside forces and more closely linked to changes in

domestic supply, which may tighten the link between Western Canadian yields and futures prices.

This study specifically looks at Manitoba crop insurance losses and canola futures prices. The ability to aggregate indemnities across provinces might be more effective for this type of hedging approach, as opposed to examining the effects within a single province. For example, Vedenov and Barnett (2004) found weather derivatives of limited use as a hedging instrument for crop losses at the farm and individual county level. Woodard and Garcia (2008) found that better hedging opportunities existed for reinsurers using weather derivatives at higher levels of spatial aggregation. While aggregating production exposure across space reduced localized risk in the aggregate portfolio, much of the remaining risk is in the form of systemic weather risk, which may be effectively hedged using weather derivatives. While the impact of yields the province of Manitoba, specifically, on canola prices would be expected to be smaller than if aggregating the effects across all of Western Canada, this province-specific approach to hedging for yield losses reflects the fact that the risk of crop insurance losses lies at the individual provincial level.

One measure of the severity of crop insurance losses is the Loss Cost Ratio (LCR). The LCR is calculated as the total indemnities paid relative to the total liabilities, and is often expressed as a percentage (Josephson, Lord, and Mitchell, 2000). On average, the LCR for crop yield insurance is approximately 8-12 percent, depending on the regions, and years in which the LCR is above 25 percent are considered a disaster (Porth, Pai and Boyd, 2014). The LCR is also approximately the premium ratio on average over time. For example, if a producer's insured value of canola is \$100 per acre, and the long-term average LCR is 10 percent, then the premium would be approximately \$10 per acre.

The remainder of this chapter is organized as follows. The next section reviews the literature that examines hedging and crop insurance. The next section discusses data, followed by the methodology section, after which an examination the potential role of hedging crop insurance losses with grain price futures contracts is discussed. Results are presented next, including the outcome of hedging using three different strategies, followed by a summary section.

## Literature Review

While there is a large range of literature that examines the role of derivatives (future and options) to hedge the commodity price risk for a firm, the research that looks at hedging potential losses for crop insurers is more limited. Coble, Heifner and Zuniga (2000) studied optimal hedge ratios for futures and put options in the presence of yield, price and revenue risk management markets for a risk-averse corn producer. They found that, in general, revenue insurance tends to result in lower hedging demand than would occur given the same level of yield insurance coverage. And to the extent that producers would switch from yield insurance to revenue insurance, there would be a decline in the demand for hedging. Mahul (2003) examined the demand for hedging against price uncertainty in the presence of crop yield and revenue insurance contracts for French wheat farms. Results showed that futures and crop yield insurance were complements, whereas futures and crop revenue insurance were shown to be substitutes.

There has also been research examining crop risk using yield insurance futures and options. Vukina, Li and Holthausen (1996) studied crop yield futures and options contracts for corn shortly after first being listed on the Chicago Board of Trade in 1995. They stated that a risk-minimizing firm can reduce its variance of profit by hedging in both crop yield futures and price futures markets compared to hedging in price futures only. Mahul and Vermersch (2000) analyzed the optimal hedging decisions for risk-averse producers facing crop risk, assuming crop yield futures and options are available. They found that hedging instruments such as crop yield insurance futures and options are usually more effective to reduce farm yield variability than individual yield contracts for producers, while also providing a way of spreading the large systemic component of crop risk through the financial markets.

Trading volume of the crop yield futures contract (e.g. corn) was low, perhaps due to the relative attractiveness of subsidized government reinsurance (Tweeten and Thompson, 2002). The yield futures contracts were eventually delisted from the CBOT, following their introduction in 1995.

There has also been research in the livestock sector of the agriculture industry. Neyhard, Tauer and Gloy (2013) looked at futures and options contracts on milk and feed to determine the effect on a dairy farm's cash flow requirements and variance on net income. They found that the risk management activities did not result in a significant change on the level or variance of income. Burdine, Mosheim, Blayney and Maynard (2014) found that the Livestock Gross Margin – Dairy Insurance program in the United States is more flexible in terms of coverage for protecting gross margin on a dairy farm than other risk management methods, including hedging in futures and options markets.

Outside of agricultural markets, Cox and Schwebach (1992) studied the Chicago Board of Trade's proposal to offer insurance futures contracts designed to allow the insurance industry to hedge business results. The contracts under consideration were health, homeowners and catastrophic property damage. The insurance futures contract would be based on a pool of qualifying policies representing a national cross-section, with contract settlement done on the basis of actual claims and premiums. While the concept was viewed as having some merit, there were some strong reasons why insurers may choose not to use insurance futures and options. For example, 'reinsurance' obtained through a futures put option is on the market portfolio rather than on the buyer's own portfolio. Also, the potential for manipulation and fraud may be greater with futures and options than it is with traditional reinsurance.

Given the limited work on the use of hedging from an insurer's perspective in the agriculture industry, more research is needed in order to determine if hedging crop insurance losses using price futures and options contracts is effective.

## **Data**

This study uses Statistics Canada data for seeded area, yield and final production figures for canola in Manitoba from 1980 to 2018. Seeded area is combined with the predicted long-term regression yield to estimate the production that would be expected ahead of the actual growing season for each year. The actual yield and production figures are compared to what would have been expected if a trend yield was achieved.

Canola futures prices for the November contract from 1980 to 2018 are from ICE Canada (formerly the Winnipeg Commodity Exchange). The period from April 1 to October 15 is chosen as this represents the period between when premiums are established and crop insurance policies are taken out by producers, and the insurers' exposure is defined, and when final production can be estimated with reasonable confidence as harvest is in its final stages. This is also a window of time when markets are particularly attentive to weather and overall growing conditions.

It should be noted that final official Statistics Canada estimates on production for each year only gets released in early December, and is subject to revisions in future reports. An earlier estimate is typically released in October during the observation period, although the producer survey that produces the results is conducted before harvest is fully completed.

The reason for not using futures prices after October 15 is because the liquidity of the November canola futures contract starts to decline as the open interest decreases in the final trading sessions leading up to the first notice day for delivery. Declining liquidity leaves the potential for erratic price movements in the November contract, specifically, that may not necessarily be representative of the value of canola in the broader marketplace.

The November canola futures contract is used throughout the period instead of the nearby futures price as this contract represents production for the particular growing season of interest. The nearby futures price series between April 1 and October 15 would incorporate the prices from the May and July futures months, but these are reflective of production from the previous growing season. Soybean oil futures prices are from the Chicago Board of Trade.

Actual premiums and liabilities for canola from Manitoba were obtained from Agriculture and Agri-Food Canada's Production Insurance National Statistical System (PINSS) and from the Manitoba Agricultural Services Corporation (MASC).

## Methodology

### Canola Futures for Hedging Canola Crop Insurance Losses:

This section examines using a long (buying) canola futures position for hedging yield crop insurance losses.

Conventional hedging methodology involves estimating a simple hedge ratio through the following linear regression model:

$$\Delta S_t = \alpha + \beta * \Delta F_t + \varepsilon_t \quad (2.1)$$

where  $S_t$  and  $F_t$  are the changes in cash and futures prices for period  $t$ . The ordinary least squares estimator of  $\beta$  provides an estimate of the minimum-variance hedge ratio, with  $\alpha$  as the constant regression parameter and  $\varepsilon_t$  being the error term.

The challenge with the conventional hedging methodology is that the analysis of the canola futures contract is being considered to hedge crop insurance losses, and not a cash price that the traditional model assumes.

There has also been extensive work on cross hedging in a range of agricultural and other commodity markets, including Franken and Parcell (2011) who study hedging fishmeal with corn and soybean meal futures, Adams and Gerner (2012) who examine hedging jet fuel with a number of crude oil and other energy futures contracts and Kim, Brorsen and Yoon (2014) who compare hedging winter canola with canola and soybean oil futures. But the basic model for most cross hedging analysis is similar to that for more conventional hedging, with futures values compared against cash prices.

However, from a hedger's perspective, of primary importance is whether the hedging instrument utilized provides an offsetting effect against the underlying risk exposure. Therefore, a long canola futures position is considered to test its effectiveness against crop insurance losses for yield. This research assumed a hedge position for 10 percent of expected production for each growing season. This level was not determined by an optimal hedge ratio, but rather reflected the relatively limited open interest in the ICE Canada Futures canola futures contract. While the size of the open interest varies,

recent figures have an open interest that equates to approximately 25 percent of the size of the Canadian canola crop, compared to higher levels for futures markets such as corn and soybeans in the United States, markets which also have the benefit of greater daily trading volumes. This liquidity constraint may limit the size of any potential hedge position.

*Canola Options for Hedging Canola Crop Insurance Losses:*

This section examines using a long (buying) canola call option position for hedging yield crop insurance losses.

One challenge with a long futures hedge position is the potential losses when the futures price goes down. Unlike a traditional hedge, where the value of the hedging instrument and underlying asset move up and down together and losses in one market are offset by gains in the others, crop insurers face one-dimensional risk. Losses increase when yields are poor, but premium income is set, and therefore does not increase regardless of how far above the insured threshold level that production may be.

In addition, large declines in futures prices may not only correspond with years of bigger yields, but also can happen during years when yields are relatively low and indemnities paid are relatively high. In these instances, the long futures position potentially might actually add to already relatively large insurance losses, rather than reduce them. The limited liability nature of a long option position may more closely reflect the one-directional nature of crop insurance risks, as the benefit of a long call option hedge position is that any potential hedging losses are confined to the cost of the option premium paid, while the hedge position gains are theoretically infinite. In this case a long call option position could be established in the spring, once insured acres are known, against the November futures contract, which is the first futures contract that represents the season's production where losses are a concern.

*Long (Buying) Canola Futures / Short (Selling) Soybean Oil Futures for Hedging Canola Crop Insurance Losses:*

This section examines using a long (buying) canola futures position and an equal short (selling) soybean oil futures position for hedging canola yield crop insurance losses.

Other factors beyond Western Canadian production affect canola prices as well, including the broader global vegetable oil market. For example, a sharp decline in canola yield may not have a material impact on futures prices if global vegetable oil markets see a large drop in values. Accounting for the impact of other vegetable oil markets allows us to more closely determine the actual impact of canola yield on prices.

Therefore, a hedge is also considered that includes a long canola futures minus a short soybean oil futures spread position. If canola production falls short of expectations in Canada, one might expect prices to increase relative to other vegetable oil markets. This could mean that even in years when canola decreases in absolute terms, it may increase in relative terms within the global vegetable oil complex. By matching a short soybean oil futures position with the long canola futures position, the effects of global vegetable oil prices can be somewhat reduced from the canola futures price direction. In other words, the offsetting soybean oil futures position makes the results of the hedge focused on the relative strength or weakness of canola compared to other oilseed markets. This spread position could, in turn, provide a positive contribution to the LCR during periods when canola yields underperform if it results in relative strength for canola prices, which then includes hedging gains even when the absolute price of canola declines. This could result in a more effective hedge position for managing canola yield crop insurance losses than simply being outright long the November canola futures.

*Examining the Standard Deviation and Semivariance of the Hedged and Unhedged Positions:*

Using minimum-variance to determine the hedge ratio creates challenges for crop insurers as it regards all extreme outcomes as undesirable. In the case of crop

insurers, there is the desire to manage against large declines in yield. But there is no benefit when yields come in above the insured levels. In other words, crop insurers face one-directional risk.

The semivariance of the unhedged and hedged positions was also examined to reflect the one-directional risk that insurers face. In this case, the hedge ratio is better determined by minimizing the semivariance of the portfolio, which is defined as

$$E\{\max(K - T, 0)^2\} \quad (2.2)$$

where E is the expected function, K is the random value, and T is a specific target value. Thus, semivariance is measured as the expected value of squared deviations below a fixed target value (Turvey and Nayak, 2003). The portfolio is efficient when semivariance is minimized for a given expected value. Other analysis of semivariance in the agricultural sector includes work by Mattos, Garcia and Nelson (2008).

The reference point, T, is a specific target LCR that is viewed as within an acceptable level of loss, and beyond which losses become more damaging. The average LCR for canola during the observation period is 8.9 percent. A target LCR of 9.0 percent was examined for the semivariance calculation.

An efficient portfolio that included a futures hedge would be determined by solving the semivariance minimizing hedge ratio,  $\omega$ , as follows (Woodard and Garcia, 2008):

$$\text{Min } \Sigma\{\text{Max}[Y_k - (Y_{t,k}^{IPd} - \omega_k f_{t,k}), 0]\}^2 \quad (2.3)$$

where  $\omega$  is the hedge ratio measured in the number of metric tonnes of canola,  $Y_{t,k}^{IPd}$  is the dollar value of indemnities paid,  $Y_k$  is the targeted level of acceptable indemnities paid out and  $f_{t,k}$  is the change in the price of the November canola futures contract between April 1 and October 15.

## Results

### Results: The Effectiveness of a Canola Long (Buying) Futures Hedge

The first result showed the average LCR over the observation period was higher when incorporating a long canola futures hedge position for Manitoba, at 8.8 percent compared to 8.5 percent for the unhedged position (results shown in Table 2.1 and Figure 2.1). The actual LCR for canola in Manitoba for each year was compared to an LCR that was adjusted to reflect a long November canola futures position on 10 percent of anticipated production for each year from 1980 to 2018. Anticipated production was estimated by taking the seeded area for each year and the expected trend yield. This provides a forecast for the number of tonnes of expected production. The position was established on April 1 and liquidated on October 15, with any gains or losses added to or removed from the indemnities paid, resulting in an adjusted LCR for that year.

For example, in 1980 there were 800,000 acres of canola planted in Manitoba. The estimated trendline yield for that year was 20.6 bushels per acre (or 0.467 metric tonnes per acre), which points to an expected production of 374,453 metric tonnes. A 10 percent hedge equates to a long position in the November canola futures contract of 37,445 tonnes.

The long futures position will reduce the adjusted LCR in years when the futures price increases from April 1 to October 15 and increase it in years when the futures price declines. The futures price declined in 19 of the 39 observation periods, which is roughly what one might expect if market moves are assumed to be random in nature.

However, the direction of the change in the futures price didn't always correspond with a relatively higher or lower LCR for that same year. In some years the long futures hedge position reduced the LCR, including in the highest year (1980, when the LCR would have been reduced from 37.3 percent to 33.0 percent). In 1983 a moderate LCR of 10.1 percent was actually reduced to a negative LCR due to a sharp rise in the futures price.

But in other years the LCR was increased when incorporating a long (buying) futures hedge, including in some years when the LCR was already relatively high (such as 1989 when the LCR increased from 30.2 percent to 35.4 percent and 2005 when the LCR increased from 24.1 percent to 26.1 percent). There were also several years where the LCR was relatively low, but where a sharp drop in the futures price resulted in a much higher LCR than was actually realized (1981, 2000, 2008).

The average actual LCR during the observation period was 8.5 percent, while the LCR when incorporating a long futures hedge on 10 percent of expected production was 8.8 percent, indicating that on average the hedge had a negative effect during the observation period.

While the actual LCR would have been reduced in the single biggest loss year in the observation period, the increase in the average LCR over the period, and the number of years when it was increased even though the LCR was moderately high suggests that a long futures hedge isn't very effective in consistently reducing crop insurance losses.

When considering the relationship between reported yields and LCR, it is interesting to note that there are several years when the actual yield was above the expected trend line yield, and yet the LCR was relatively high (1986, 2015), or where the actual reported yield was below the trend line yield and the LCR was relatively low (1995, 2001). This could be due to heavy losses in a few areas, resulting in lots of claims, whereas other areas had above average yields, bringing the overall average yield levels up. This also reflects the one-sided risk nature of crop insurance losses, where payouts are required in any cases where losses exceed threshold levels, but where the income is limited to the premiums paid. The LCR, actual yield and long-term regression yield are shown in Table 2.2.

*Results: The Effectiveness of a Long (Buying) Canola Call Option Hedge*

The second result also showed that a long call option position was not very effective in reducing yield crop insurance losses for Manitoba, as the average LCR

remained at 8.5 percent for both the hedged and unhedged positions (results shown in Table 2.1 and Figure 2.2).

One challenge with a long futures position is the potential hedging losses when the futures price goes down. In some years these losses can be substantial. Unlike a traditional hedge, where the value of the hedging instrument and underlying asset move up and down together and losses in one market are offset by gains in the others, crop insurers face one-dimensional risk. Losses increase when yields are poor, but premium income is set, and therefore doesn't increase regardless of how far above the insured threshold level that production may be.

In addition, as mentioned above, large declines in futures prices do not only correspond with years of bigger yields, but also can happen during years when yields are below trend line expectations and indemnities paid relatively high. In these instances, the long futures position actually adds to already large insurance losses, rather than reduce them.

The benefit of a long call option hedge position is that any potential hedging losses are confined to the cost of the option premium paid, while the hedge position gains are theoretically infinite. The limited liability nature of a long option position may more closely reflect the one-directional nature of crop insurance risks.

The call option hedge position assumes purchasing an at-the-money (ATM) call option on April 1, and then determines the intrinsic value as of October 15<sup>th</sup>, and assumes there is no time value remaining on the option (canola call options actually expire a few business days after the 15<sup>th</sup> of the month, but any time value remaining on the options would be negligible, and would not affect the effectiveness of the hedge).

In determining the value of the ATM option premium, the average ATM option value was examined for each year from 1998 to 2007. When the futures price was not exactly at the strike price (since strike prices are set in \$10 per metric tonne increments, and the futures price trades in \$0.10 per metric tonne increments), the option value was adjusted to reflect this difference assuming a delta of 0.5. The average cost of an ATM call option during this period was \$19 per metric tonne, ranging from a low of \$16.25 to

a high of \$23.40. For purposes of the analysis an ATM option cost of \$19 per tonne for each year is assumed.

Once again, a hedge position on 10 percent of expected production is assumed. The net gain or loss on the call option position was subtracted from or added to the indemnities paid to calculate an adjusted LCR for each year. There was a reduction in the net indemnities paid in years when the increase in futures price increase exceeded the \$19 cost of the call option. There was a net increase in the net indemnities paid when the futures price increase was less than \$19.

The results show that a call option hedge is not particularly effective at reducing crop insurance losses over a period of time. The LCR with the call option hedge was 8.5 percent, equal to the actual LCR over the observation period. But overall only 13 of the 39 years resulted in the LCR being lowered by having a long call option hedge.

Some of the deep hedging losses experienced in the long futures hedge were avoided due to the limited liability nature of a long option position. In addition, the single biggest LCR observation was reduced (1980, when the actual LCR would have been reduced from the actual level of 37.3 percent down to 35.5 percent). However, in second and fourth highest LCR years (1989 and 2005) the hedge adjusted LCR was higher than the actual LCR. This reflects the fact that the futures price didn't increase by more than the \$19 per tonne cost of the option premium, resulting in a net loss on the hedge position in those years.

*Results: The Effectiveness of a Long (Buying) Canola Futures / Short (Selling) Soybean Oil Futures Hedge*

The third hedge analysis considered a position that was comprised of a long canola futures position and an equal short soybean oil futures position (results shown in Table 2.1 and Figure 2.3). While canola futures prices are influenced by the size of Canadian production, there are other factors that influence prices as well, including the price strength or weakness of other global vegetable oil markets. This means that, for

example, there may be years when canola production falls short of expectations in Canada, which in turn leads to canola prices being relatively stronger than other vegetable oil markets, but where canola prices still decline in absolute terms due to a weak global vegetable oil market overall.

By matching a short soybean oil futures position with the long canola futures position, the effects of global vegetable oil prices can be reduced from the canola futures price direction. This may allow for, i.e. canola futures to perform relatively stronger even if trading lower in absolute terms, which in turn could result in a more effective hedge position for managing canola yield crop insurance losses than simply being outright long the November canola futures.

The canola futures contract size is 20 metric tonnes of seed. The CBOT soybean oil futures contract size is 60,000 pounds of soybean oil. In measuring an offsetting number of soybean oil futures contracts, the amount of oil in a canola futures contract is taken into account. Canola is approximately 42 percent oil and 58 percent meal. This means there is approximately 18,514 pounds of vegetable oil in each canola futures contract. When compared to the 60,000 pound soybean oil contract, one would sell one soybean oil contract for every three long canola contracts. The analysis examined putting this spread position on for 10 percent of expected canola production for each year in the observation period.

The results of the futures spread hedge are more favorable than for either the outright long canola futures hedge or the canola call option hedge. The average LCR when adjusted for the spread position is 7.9 percent, below the actual LCR of 8.5 percent during the observation period. Although it modestly increased the LCR in the single highest year (1980), it reduced the LCR in four of the next five highest years. When looking solely at the lower LCR over the observation period, this type of hedge position may help to reduce losses for provincial crop insurers for canola, perhaps reflecting the relative strength in canola prices versus the broader oilseed market as a whole when canola production is smaller than expected.

Results: Standard Deviation and Semivariance of Hedged and Unhedged positions

Even in instances where the average LCR over a period of time is not reduced significantly, there may be value to insurers if hedging can reduce the variability of the LCR from one year to the next. The results in Table 2.1 show that the various hedge position did not reduce the variability of LCR during the observation period.

The standard deviation of the LCR during the period was 8.38 percent. This compares to a standard deviation of 9.08 percent for a canola futures hedge, 8.52 percent for a hedge using canola call options, and 8.93 percent for the canola-soybean oil futures spread position.

The results were similar when considering the semivariance at the 9 percent LCR threshold level. A lower semivariance is favorable, reflecting fewer losses below the specified threshold level. The sum of the squared deviations at the 9 percent LCR threshold level for an unhedged position was 20.07. The same figure for the long canola futures hedge was 22.33. The semivariance for the canola call option hedge and the long canola futures / short soybean oil futures hedge were both modestly above the unhedged position as well, at 20.10 and 20.60, respectively. In other words, there was no reduction in the semivariance for any of the hedged positions over the unhedged position.

In summary, none of the hedge positions showed a lower standard deviation or semivariance at the 9 percent threshold level than the unhedged position.

## **Summary**

Crop insurers face significant risks, with the spatially correlated nature of crop insurance losses increasing the risk insurers face compared to if yields were independent across geographic regions. Additional methods to manage risk for insurers could reduce the potential for catastrophic losses and possibly lead to more efficient pricing of premiums. The objective of this chapter is to examine the potential to use grain futures and options to reduce crop insurance losses for canola in Manitoba, from the perspective of the insurer. If a decline in production that coincides with higher indemnities paid to

producers also results in higher futures prices, then a long (buying) futures or call option position may offset some of the insurance losses.

This study uses Statistics Canada data for seeded area, yield and final production for canola in Manitoba from 1980 to 2018. Seeded area is combined with the predicted long-term regression yield to estimate the production that would be expected ahead of the actual growing season for each year. Canola futures prices for the November contract from 1980 to 2018 are from ICE futures Canada. Soybean oil futures prices are from the Chicago Board of Trade. Actual premiums and liabilities for canola for Manitoba from 1980 to 2018 were obtained from Agriculture and Agri-Food Canada's Production Insurance National Statistical System (PINSS) and from the Manitoba Agricultural Services Corporation (MASC).

The study considered a long (buying) canola futures hedge, a long (buying) canola call option hedge and a long (buying) canola futures / short (selling) soybean oil futures spread hedge. Any gains or losses from the hedge position are applied to the indemnities paid. Gains in the hedge position result in reducing the net indemnities paid, while losses in the hedge position add to the net indemnities paid. The average loss cost ratio (LCR, which is the ratio of indemnities to liabilities) is compared between an unhedged position and when incorporating the hedging gains or losses from each of the three different hedging strategies.

The first result showed the average LCR over the observation period was higher when incorporating a long canola futures hedge position for Manitoba (Table 2.1 and Figure 2.1). Any time the futures price declined during the observation period, this would result in losses to the portfolio that would not exist in an unhedged position. While this would be expected approximately 50 percent of the time if price changes were assumed to be random, it also happened in some years when it might not have been expected, such as when canola production was below expectations. This caused losses to be increased even in some years when the LCR was already relatively high. In addition, the long canola futures hedge position showed a higher standard deviation and semivariance at the 9 percent threshold level than the unhedged LCR, indicating that the hedged LCR showed more variability over the observation period as well.

The second result showed that the use of a long canola call option hedge also did not prove to be very effective in managing crop insurance losses (Table 2.1 and Figure 2.2). The limited liability of a long option position reduced some instances of the deep hedging losses that resulted in the long futures position hedge in years when futures prices showed sharp declines. However, in most years the increase in the futures price did not exceed the premium paid for the option, which means there were net hedging losses that added to the net indemnities paid. The result is that a hedge using a long call option had the same LCR during the observation period as the unhedged LCR, while having a very slightly higher standard deviation and semivariance, providing essentially no net benefit.

The third result showed that the futures hedge that included a long canola futures position / short soybean oil futures spread position was somewhat more effective (Table 2.1 and Figure 2.3). The purpose of the short soybean oil portion of the position is to offset the effect of world vegetable oil markets on the canola futures price. Canola price changes are influenced by factors beyond just regional production, including the value of global vegetable oil prices. The spread position shows the relative strength of canola futures prices compared to soybean oil futures prices, which may cause hedging gains or losses to more closely reflect canola production increases or decreases from initial expectations by muting the influence of global vegetable oil prices on canola values. For this position the average LCR including hedge adjustments from the spread position were lower than the actual LCR that was not hedged by an average of 0.6 percent (the actual LCR was 8.5 percent compared to 7.9 percent when the spread position was included). The futures spread hedge position showed a higher standard deviation of the LCR than an unhedged position, as well as a very modestly higher semivariance.

The overall result is that hedging with canola futures or call options was not shown to be effective in reducing crop insurance losses in Manitoba. Hedging using a spread position of long canola futures and short soybean oil futures did lower the LCR when compared to the actual LCR, which suggests this might be considered as a risk management method for canola yield crop insurance losses, although this needs to be weighed against the higher standard deviation and modestly higher semivariance.

The results suggest that there may be further opportunities for study. Manitoba is the smallest canola producer of the three Prairie provinces, so a similar examination for Saskatchewan or Alberta may show a relatively stronger relationship between canola yield losses and prices. Deeper analysis of the connection between the canola and soybean oil futures price relationship and provincial crop insurance losses may improve the effectiveness of the spread hedge position. Incorporating some flexibility in the hedge position, such as using specific rules to limit the losses on the futures hedge position, may improve the performance of hedge positions.

In addition, canola production is relatively small within the wider global oilseed complex, meaning canola prices are influenced by the price movement in other more dominant oilseeds, such as soybeans. As a result, hedging may potentially be more effective in larger crops such as soybeans or corn, particularly when insurers provide coverage for an entire country, and not a specific region within a country.

**Table 2.1. Actual LCR and LCR with Hedging Gains or Losses Included Using a Long (Buying) Canola Futures Hedge, Long (Buying) Canola Call Option Hedge and a Long (Buying) Canola Minus Short (Selling) Soybean Oil Futures Hedge for Manitoba, 1980 - 2018.**

Year	Actual LCR	LCR 10% Futures Hedge	Difference from Actual	LCR 10% Call Option Hedge	Difference from Actual	LCR 10% Long Canola Minus Short Soybean Oil Futures Hedge	Difference from Actual
1980	37.3%	33.0%	-4.3%	35.5%	-1.7%	38.5%	1.2%
1981	5.8%	11.5%	5.7%	8.6%	2.8%	2.7%	-3.1%
1982	17.6%	21.3%	3.6%	20.4%	2.8%	15.7%	-1.9%
1983	10.1%	-5.2%	-15.2%	-2.5%	-12.5%	16.0%	6.0%
1984	9.9%	6.7%	-3.2%	9.2%	-0.7%	9.5%	-0.4%
1985	10.7%	19.5%	8.8%	12.6%	1.9%	11.9%	1.2%
1986	11.4%	18.2%	6.8%	13.2%	1.7%	11.6%	0.2%
1987	5.9%	2.3%	-3.6%	4.6%	-1.3%	4.3%	-1.6%
1988	29.7%	25.6%	-4.1%	27.5%	-2.2%	26.8%	-2.9%
1989	30.2%	35.4%	5.2%	31.8%	1.6%	29.8%	-0.4%
1990	7.0%	10.6%	3.6%	8.8%	1.8%	11.3%	4.2%
1991	2.2%	6.3%	4.1%	4.2%	2.0%	2.0%	-0.2%
1992	7.8%	7.0%	-0.8%	8.8%	1.1%	6.1%	-1.6%
1993	9.6%	9.2%	-0.4%	10.9%	1.3%	11.2%	1.6%
1994	5.1%	1.6%	-3.4%	3.4%	-1.7%	-0.5%	-5.6%
1995	4.6%	4.7%	0.1%	6.6%	2.0%	5.5%	0.9%
1996	0.7%	0.7%	0.0%	1.9%	1.1%	-2.3%	-3.0%
1997	2.7%	2.2%	-0.5%	3.1%	0.5%	2.0%	-0.7%
1998	4.6%	4.9%	0.3%	5.7%	1.0%	5.1%	0.5%
1999	2.4%	4.6%	2.2%	3.5%	1.1%	2.3%	-0.2%
2000	4.5%	7.7%	3.2%	6.1%	1.6%	2.9%	-1.6%
2001	5.3%	2.9%	-2.4%	4.2%	-1.1%	0.6%	-4.7%
2002	4.9%	0.4%	-4.5%	1.4%	-3.5%	2.3%	-2.6%
2003	3.1%	2.0%	-1.1%	2.9%	-0.2%	4.2%	1.1%
2004	8.3%	13.7%	5.4%	9.4%	1.1%	6.8%	-1.5%
2005	24.1%	26.1%	2.0%	25.3%	1.1%	26.8%	2.7%
2006	2.7%	0.3%	-2.4%	1.7%	-1.0%	0.5%	-2.2%
2007	6.7%	4.4%	-2.3%	5.3%	-1.4%	4.1%	-2.5%
2008	2.5%	9.6%	7.1%	3.2%	0.7%	4.7%	2.2%
2009	1.9%	3.9%	2.1%	2.7%	0.8%	1.6%	-0.3%
2010	10.2%	6.3%	-3.9%	7.0%	-3.3%	9.1%	-1.2%
2011	10.8%	12.0%	1.3%	11.4%	0.6%	10.9%	0.1%
2012	11.9%	11.3%	-0.5%	11.9%	0.0%	9.0%	-2.8%
2013	1.8%	3.8%	2.0%	2.3%	0.5%	1.6%	-0.3%
2014	4.0%	6.3%	2.4%	4.6%	0.6%	2.8%	-1.2%
2015	8.8%	8.2%	-0.7%	8.8%	0.0%	7.3%	-1.6%
2016	2.5%	2.4%	-0.1%	3.0%	0.5%	2.3%	-0.3%
2017	0.6%	-0.1%	-0.7%	0.5%	-0.1%	-0.3%	-0.9%
2018	1.6%	2.2%	0.6%	2.2%	0.6%	1.0%	-0.6%
Average LCR	8.5%	8.8%		8.5%		7.9%	
Std Dev	8.38%	9.08%		8.52%		8.93%	
Semivariance 9%	20.07	22.33		20.10		20.60	

\*Semivariance is the sum of the squared deviations above the threshold level.

Notes: The actual LCR averages 8.5 percent during the observation period, below the average LCR that has been adjusted to include a long (buying) canola futures hedge and equal to the average LCR that has been adjusted to include a long call option on November canola futures.

The long canola minus short (selling) soybean oil futures hedge shows a lower average LCR during the observation period than the actual LCR, at 7.9 percent. The standard deviation of the actual LCR during the observation period was lower than the LCR that was adjusted for the long canola futures hedge, the long call option hedge and the long canola minus short soybean oil futures hedge. The semivariance at the 9 percent level was also lower for the actual LCR than when the LCR was adjusted to include each of the three hedge positions.

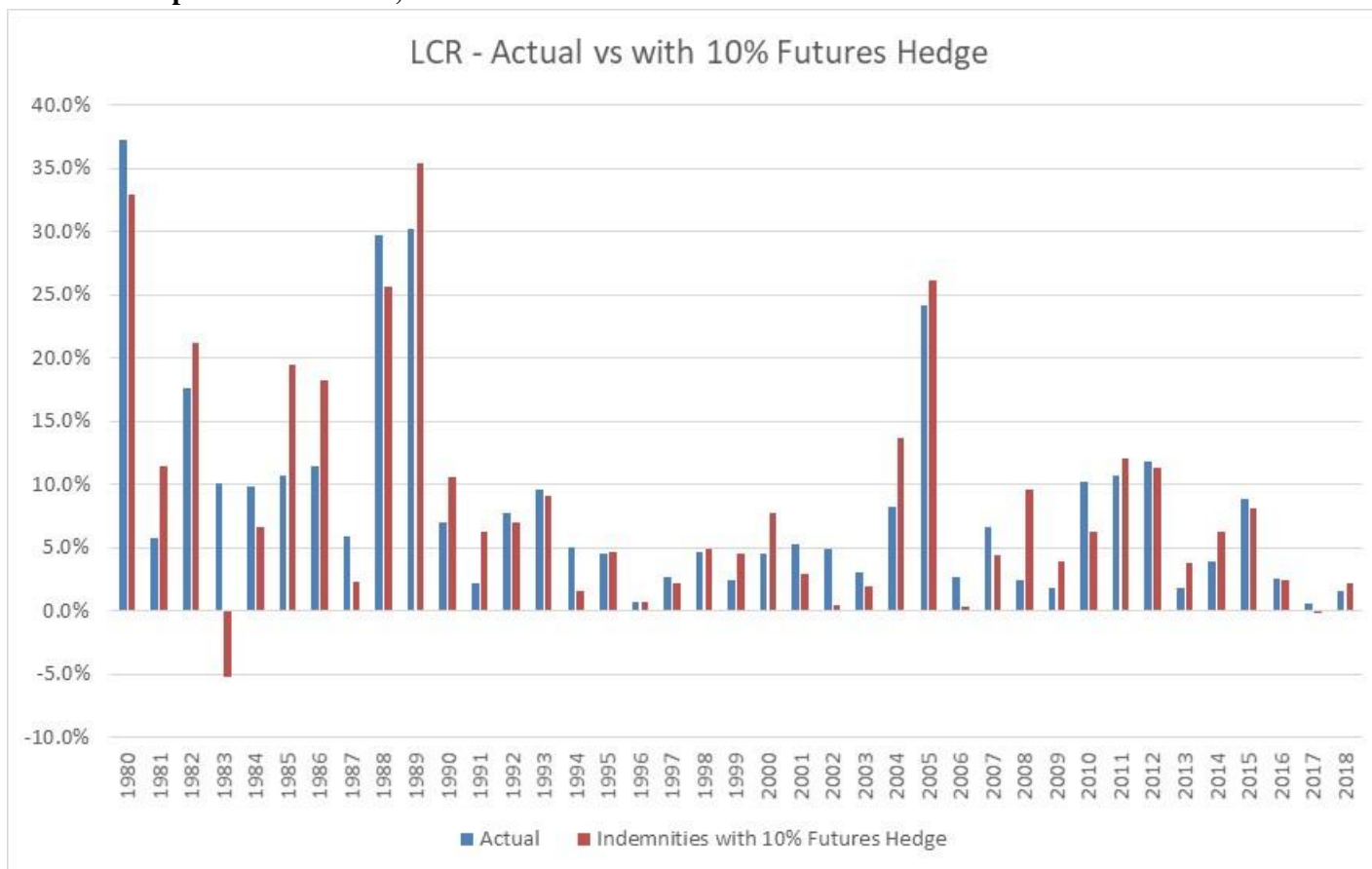
**Table 2.2. Canola Loss-Cost-Ratio, Canola Yields and Canola Futures Price Changes from 1980 to 2018 for Manitoba.**

Year	LCR	Statistics Canada Yield (bu/acre)	Long-term Regression Yield (bu/acre)	Difference	Futures Price Change (Canadian Dollars per MT)	Percent Futures Price Change
1980	37.3%	16.2	20.6	-4.4	31.8	10.32%
1981	5.8%	22.5	21.1	1.4	-39	-10.55%
1982	17.6%	20.7	21.5	0.8	-24.8	-7.36%
1983	10.1%	18.4	21.9	-3.5	107	32.47%
1984	9.9%	20.0	22.3	-2.3	23.9	6.33%
1985	10.7%	28.0	22.8	5.2	-86.6	-21.43%
1986	11.4%	25.5	23.2	2.3	-74.6	-23.68%
1987	5.9%	25.8	23.6	2.2	29.8	12.61%
1988	29.7%	17.5	24.0	-6.5	41.7	13.12%
1989	30.2%	15.5	24.5	-9.0	-62.6	-17.80%
1990	7.0%	23.3	24.9	-1.6	-38.5	-11.43%
1991	2.2%	28.0	25.3	2.7	-39.4	-12.64%
1992	7.8%	28.1	25.7	2.4	8.1	2.73%
1993	9.6%	22.0	26.2	-4.2	4.9	1.58%
1994	5.1%	26.2	26.6	-0.4	36.6	10.54%
1995	4.6%	23.3	27.0	-3.7	-0.6	-0.15%
1996	1.0%	30.4	27.4	3.0	0.3	0.07%
1997	2.7%	28.1	27.9	0.2	9.4	2.56%
1998	4.6%	29.1	28.3	0.8	-4.8	-1.29%
1999	2.4%	30.6	28.7	1.9	-39.1	-12.21%
2000	4.5%	28.4	29.1	-0.7	-37.9	-13.06%
2001	5.3%	26.6	29.6	-3.0	36.4	12.75%
2002	4.9%	29.8	30.0	-0.2	87.6	26.24%
2003	3.1%	31.3	30.4	0.9	24.2	6.86%
2004	8.3%	30.8	30.8	0.0	-95.9	-24.72%
2005	24.1%	25.7	31.3	-5.6	-32.9	-11.23%
2006	2.7%	32.5	31.7	0.8	32.6	11.58%
2007	6.7%	28.3	32.1	-3.8	49.8	12.82%
2008	2.5%	36.9	32.5	4.4	-194.2	-32.57%
2009	1.9%	39.8	33.0	6.8	-47.7	-11.01%
2010	10.2%	31.4	33.4	-2.0	111.6	28.85%
2011	10.8%	28.3	33.8	-5.5	-39.4	-6.82%
2012	11.9%	25.7	34.2	-8.5	18.7	3.24%
2013	1.8%	41.4	34.7	6.7	-77.6	-13.98%
2014	4.0%	35.1	35.1	0.0	-72.1	-14.97%
2015	8.8%	39.5	35.5	4.0	19.9	4.41%
2016	2.5%	37.1	36.0	1.1	3.3	0.68%
2017	0.6%	44.0	36.4	7.4	22.3	4.68%
2018	1.6%	43.0	36.8	6.2	-20.6	-3.97%

Notes: As expected, in general the LCR tends to be higher in years when the actual yield comes in below the long-term regression yield (e.g. 1980, 1988, 1989, 2005). However, there were also years that had a high LCR but where the actual yield came in above the long-term regression yield (e.g. 1985, 1986), and where there was a relatively low LCR when the actual yield came in below the long-term regression yield (e.g. 1995, 2000). Futures prices might be expected to increase or decrease when actual yields are below or above the long-term regression yield, respectively. This is the general pattern, although there are years when futures prices increased

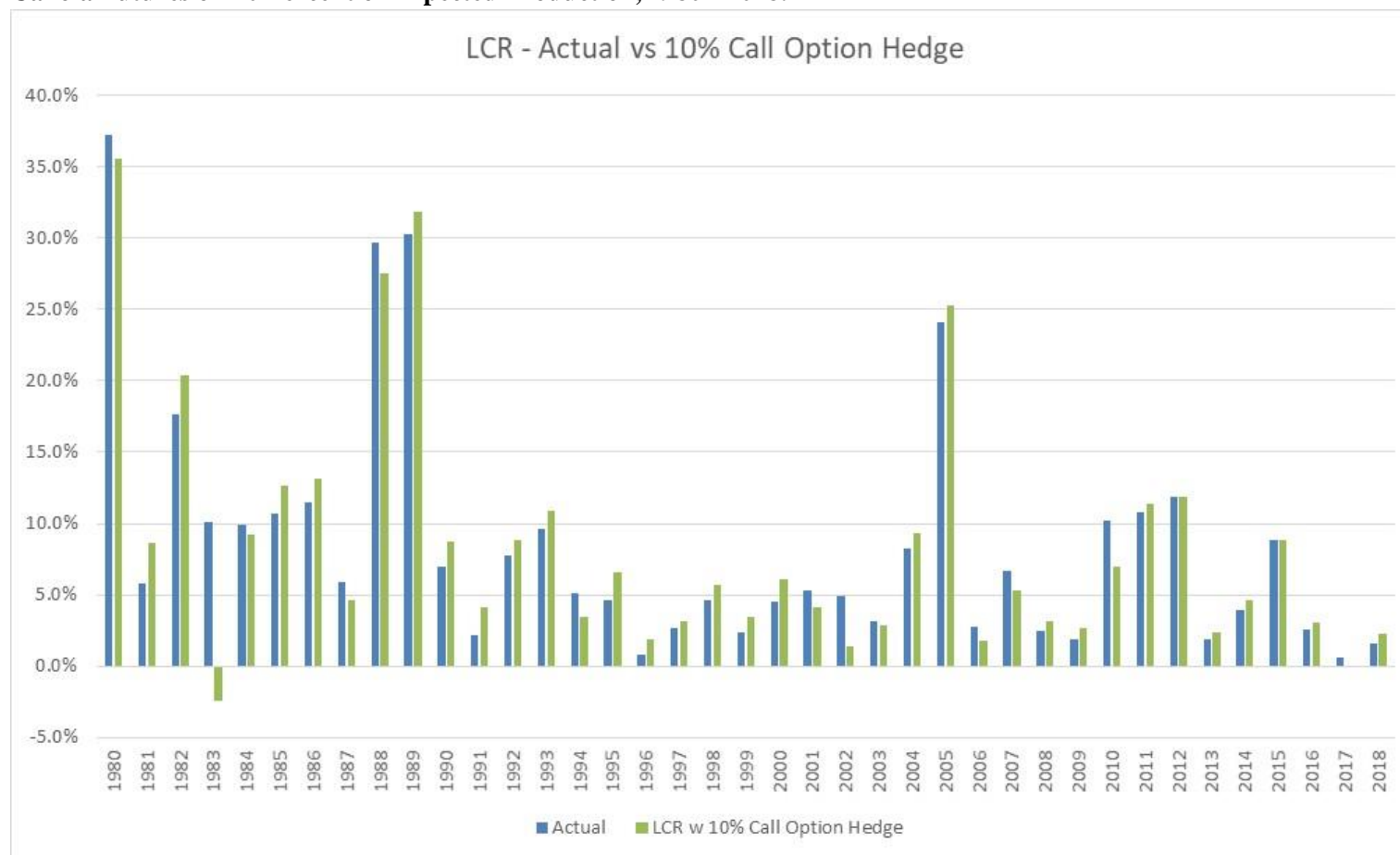
even when yields came in above the regression line (e.g. 1987, 2003, 2015) and when futures prices decreased even when yields came in below the regression line (e.g. 1989, 2005, 2011).

**Figure 2.1. Actual Annual LCR for Canola in Manitoba vs LCR That Includes a Hedge of a Long (Buying) Canola Futures Position on 10 Percent of Expected Production, 1980 - 2018.**



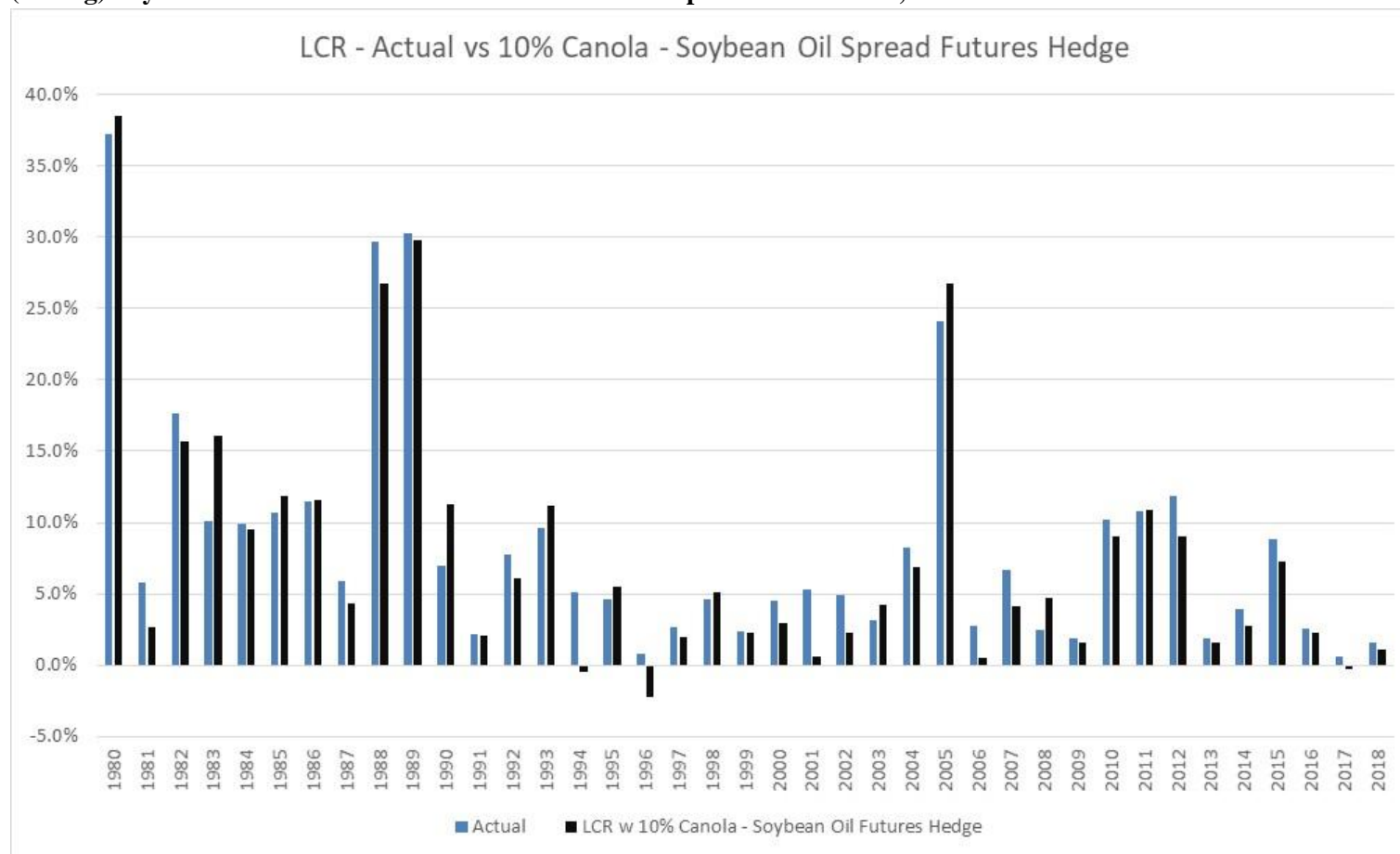
Notes: The results show the actual LCR for canola in Manitoba compared to the LCR that was adjusted to reflect a long November canola futures position on 10 percent of anticipated production. For example, 1988 shows that the hedge position resulted in a lower LCR than the actual LCR, while in 2004 the actual LCR was lower than the LCR that was adjusted to reflect the hedge position. The long (buying) canola futures hedge reduced the LCR in the two of the three highest years (1980 and 1988), although increased the LCR in some years that were already relatively high (1989 and 2005). The average actual LCR for the observation period was 8.5 percent, while the average LCR with the long canola futures hedge was 8.8 percent.

**Figure 2.2. Actual Annual LCR for Canola in Manitoba vs LCR That Includes a Hedge of a Long (Buying) Call Option on November Canola Futures on 10 Percent of Expected Production, 1980 - 2018.**



Notes: The results show the actual LCR for canola in Manitoba compared to the LCR that was adjusted to reflect a long call option on the November canola futures contract on 10 percent of anticipated production. For example, 1988 shows that the hedge position resulted in a lower LCR than the actual LCR, while in 1989 the actual LCR was lower than the LCR that was adjusted to reflect the hedge position. The long (buying) canola call option hedge reduced the LCR in two of the three highest years (1980 and 1988), although increased the LCR in two other years when the LCR was relatively high (1989 and 2005). The average LCR with the long call option on the November canola futures hedge was 8.5 percent, equal to the actual LCR over the observation period.

**Figure 2.3. Actual Annual LCR for Canola in Manitoba vs LCR That Includes a Hedge of a Long (Buying) Canola Futures Minus a Short (Selling) Soybean Oil Futures Position on 10 Percent of Expected Production, 1980 - 2018.**



Notes: The results show the actual LCR for canola in Manitoba compared to the LCR that was adjusted to reflect a long (buying) canola futures minus a short (selling) soybean oil futures spread hedge on 10 percent of anticipated production. For example, 1982 and 1988 shows that the hedge position resulted in a lower LCR than the actual LCR, while 1980 and 2005 were years where the actual LCR was lower than the LCR that was adjusted to reflect the hedge position. The average actual LCR for the observation period was 8.5 percent, while the average LCR with the hedge position of a long canola futures minus a short soybean oil futures spread was 7.9 percent.

# **CHAPTER 3**

## **HEDGING EFFECTIVENESS FOR WESTERN CANADIAN WHEAT PRODUCERS**

### **Introduction**

Wheat is one of the most important crops in Canada, representing nearly 25 percent of seeded area in 2019, and an even higher proportion in the three Prairie provinces (Alberta, Saskatchewan and Manitoba). The selling of wheat for producers has evolved over time. Until August 1, 2012 most of the wheat grown in Western Canada, constituting the vast majority of total Canadian production, was mandated by law to be marketed through the single desk selling agency of the Canadian Wheat Board (CWB). The exception was wheat sold directly into the livestock feed and ethanol markets, which typically would represent only approximately 20 percent of production. Although producers had the ability to participate in one of several Producer Pricing Options (PPOs), most wheat was marketed through the pooled returns of sales, less the cost of administration, selling and delivery. This meant that there was essentially no need or ability for producers to make selling or risk management decisions in the way that US producers did for wheat, or Canadian producers did for other crops, including those with futures markets, such as canola.

The removal of the CWB single desk in 2012 began a new era for Western Canadian producers as they are now solely responsible for selling their wheat in an ‘open’ market. This also means that producers are responsible for managing their price risk. Selling decisions are also forced to be made without much recent history of open market cash prices from which to base analysis on.

Hedging with futures may be an effective way of managing price risk for some producers. There are no wheat futures contracts that trade on Canadian exchanges. Instead, Canadian wheat hedgers look to one of the three wheat futures contracts that trade on U.S.-based exchanges. Most of the wheat grown in Canada is hard red spring wheat, which most closely resembles the contract specifications of the Minneapolis futures contract (compared to the

Chicago futures contract, which is a soft red winter wheat, or the Kansas City hard red winter wheat contract).

For Canadian producers, using a U.S. futures contract in U.S. dollars has the potential to increase basis risk, including foreign exchange risk, possibly reducing its effectiveness to hedge prices. The basis risk is not just in the currency, as this could also theoretically be hedged. When the cash market exposure is in a different country than the delivery location of the futures contract there is also the potential for additional variability between cash and futures market price behavior due to factors such as government policy, logistics and trade flows that might affect prices differently in one country than the other. A number of farmers may be reluctant to use futures contracts due to their perceived complexity, but may be more comfortable with cash forward contracts that are typically available in Canadian dollars. For some producers who may be reluctant to use futures contracts due to complexity or the requirement for posting margin funds, using forward contracts may be an alternative in a number of situations.

The objective of chapter three is to examine the effectiveness of the Minneapolis hard red spring wheat futures contract to reduce hard red spring wheat cash market price risk in Manitoba. Evaluation is based on both the more traditional measure of variance reduction as well as considering downside risk measures, such as semivariance and value-at-risk (VaR). Canadian cash market prices from the 'open' commercial market will be used, something that was not available until August 2013. The results may provide lessons for other crops that are grown in Canada and have U.S.-based futures contracts, such as soybeans, corn and oats. Currently the only crop grown in Canada that can be hedged on a domestic contract is canola, which trades on the ICE Futures Canada exchange, with a par delivery pricing point in central and eastern Saskatchewan.

A comparison will also be made to hard red spring wheat prices in North Dakota. Essentially the only thing that separates a Manitoba farm and a North Dakota farm is the international border. If the Minneapolis futures contract is considerably more effective at reducing price risk for North Dakota producers, then this creates a competitive advantage to the U.S. producer, something that may be of interest to policy makers.

The remainder of this chapter is organized as follows. The next section reviews the literature that examines hedging, including in an international context. After this is an overview of the data, followed by the methodology section, after which an examination of the potential effectiveness of using Minneapolis hard red spring wheat futures to manage price risk for a Manitoba wheat producer. This is followed by a summary section.

## **Literature Review**

There is a vast amount of literature on hedging in agricultural markets. Much early work focused on reducing the price variability of a cash market exposure, including calculating variance minimizing hedge ratios. Some commonly cited early papers include Peck (1975), Rolfo (1980) and Kahl (1983). Another method to calculate optimal hedge ratios is by maximizing utility, with utility being maximized in a linear function that is increasing in expected return and decreasing return variance (Grant, 1985). Further literature examines hedge ratios under different scenarios, such as using price differences, price levels or percentage price changes (Witt, et al, 1987), or applying more advanced methods of calculating hedge ratios beyond the slope parameter from a simple hedge regression.

For example, Myers and Thompson (1989) use a more generalized optimal hedge ratio estimation that depends on a model that determines equilibrium spot and futures price movements, which allows for a more flexible specification of equilibrium pricing models. Bond and Thompson (1986) consider optimal commodity hedging with the Capital Asset Pricing Model, and find that the optimal hedge ratio will be significantly altered when looking at a portfolio of assets rather than a single commodity. This could apply to many farms, as most operations grow more than one crop. Nelson and Collins (1985) incorporate a Sharpe ratio so that both the potential for excess returns and risk reduction are considered. Other work considers how transaction costs impact hedge ratios, including adding the dimension of stochastic costs (Andrade, Mattos and Arruda de Souza Lima, 2018).

A number of papers provide a broad overview of different models and developments in hedging research over time. Some of the more comprehensive and reflective surveys includes

Collins (1997), Tomek and Peterson (2001), Lien and Tse (2002) and Garcia and Leuthold (2004).

Hedging in offshore markets introduces an additional consideration, include exchange rate uncertainty. Thompson and Bond (1987) examine hedging Australian export wheat on the CBOT, and use the mean-variance criteria when considering hedging decisions by an offshore trader that wishes to stabilize revenue in domestic currency terms. When the exchange rate remains fixed the optimal hedge ratio becomes identical to that of a domestic hedger. However, in the presence of exchange rate uncertainty, the variances and covariances of spot and futures prices in local currency terms are unlikely to be the same as they are for the prices in U.S. dollar terms.

Novak and Unterschultz (1996) used mean square error (MSE) as the risk measure of the net price, which calculates the squared deviation of the realized net price from a forecast net price. Their work examined a Canadian cattle feeder using U.S.-based futures markets for hedging, where the added risk of adverse currency moves is a consideration. While basis risk was still significant, the results showed that commodity hedging removed a large portion of the total price risk.

Other research that considered hedging in a Canadian market context includes Braga (1990), who studied corn and soybean hedges in Ontario and found that a simple commodity hedge is shown to be less effective than a joint commodity and currency hedge in replicating the adjusted basis changes. Love and Boyd (1994) considered futures and options as an alternative to past agricultural policies in stabilizing revenues for grain farmers in Western Canada, and found short selling futures and buying put options to be more effective, both in aggregate and at the individual farm level. Carter and Loynes (1985) looked at hedging in the Canadian cattle market and found that the basis was too variable to consider using futures markets to hedge price risk, which in turn leaves the Canadian cattle industry without a useful mechanism for price risk management.

Research has also been done to look at hedging effectiveness beyond just a mean-variance or utility maximization framework. For example, producers may be more concerned about avoiding adverse outcomes rather than reducing price variability specifically. As a result it

is also worth considering downside risk measures. Papers that looked at semivariance in an agricultural context include Turvey and Nayak (2003) and Mattos, Garcia and Nelson (2008). Some examples of where VaR is used in an agricultural setting include Manfredo and Leuthold (1999 and 2001), Sanders and Manfredo (2002) and Bamba and Maynard (2004).

Past research provides a useful framework from which to examine the effectiveness of using U.S.-based futures markets for Canadian wheat producers, or whether policy makers need to consider other means of price risk management.

## **Data**

This study uses average elevator prices for hard red spring wheat in Manitoba and North Dakota. Weekly prices are collected from September 2013 to July 2020. Futures prices are taken from the Minneapolis Grain Exchange (MGE) hard red spring wheat contract. The contract month used is the one immediately after the period that the hedge is in place. For example, a hedge for the month of January would use the next futures contract month, which is March. Currency values are taken from the Chicago Mercantile Exchange (CME) Canadian dollar futures contract.

The study looks at hedging periods of one month. Research suggests that hedging effectiveness improves when longer periods are used, and producer hedging decisions might also typically look at periods of more than one month. However, extending hedging periods greatly reduces the number of observations, something that is already a limitation given the relatively short history of open market wheat pricing in Western Canada.

No observations were taken when the cash price would be hedged in a futures contract that represents the next marketing year. For example, July cash prices are still for the 'old' crop year, but would have to be hedged in the September contract, which reflects 'new' crop year production, since the hard red spring wheat harvest typically takes place in August and early September. The 'old crop cash price - new crop futures price' relationship can be volatile, which would potentially distort the results. In addition, the vast majority of producer hedging decisions

will be done within the same marketing year. This left a total of ten monthly observations taken in each of the six full marketing years examined (September to June).

## Methodology

Much analysis around hedging effectiveness examines the reduction in variability of returns. Conventional hedging methodology involves estimating a simple hedge ratio through the following linear regression model:

$$\Delta S_t = \alpha + \beta \Delta F_t + \varepsilon_t \quad (3.1)$$

where  $S_t$  and  $F_t$  are the changes in cash and futures prices for period  $t$ . The ordinary least squares estimator of  $\beta$  provides an estimate of the minimum-variance hedge ratio, with  $\alpha$  as the constant regression parameter and  $\varepsilon_t$  being the error term.

While there are numerous models that develop more sophisticated methods of calculating optimal hedge ratios, research suggests that these models do not tend to perform materially better than naïve or simple hedge ratios, particularly when applying the models to out-of-sample data (Grant and Eaker, 1989 and Collins, 2000). Given the limited data series available for Canadian hard red spring wheat cash prices and research supporting a relatively simple approach, the hedge ratios used in the analysis include a naïve hedge ratio and a minimum variance hedge ratio using the monthly data from the previous three marketing years.

Mean square error (MSE) is used as a measure by which the actual returns deviate from expected returns, and can be used as a measure of hedging effectiveness. MSE is calculated as follows:

$$MSE = \frac{\sum_{t=-j+1}^{T-j} (NP_{t+j} - N\tilde{P}_{t+j})^2}{T - 1} \quad (3.2)$$

where  $NP_{t+j}$  is the realized price for period  $t+j$ ;  $N\tilde{P}_{t+j}$  is the forecast net price for period  $t+j$ ;  $T$  is the total number of periods, and  $j$  is the forecast horizon.

When there is no hedge, the MSE is

$$MSE = \frac{\sum_{t=-j+1}^{T-j} [(FP_{t+j}X_{t+j} - FP_{j,t}X_t) + (B_{t+j} - \tilde{B}_{t+j})]^2}{T - 1} \quad (3.3)$$

This reflects the total price risk as a function of change in the futures price,  $FP_{j,t}$  to  $FP_{t+j}$ , the exchange rate risk in  $X_t$  to  $X_{t+j}$ , and the basis risk,  $\tilde{B}_{t+j}$  to  $B_{t+j}$ .

In the case of a perfect futures and currency hedge, the only remaining risk is the basis risk, where the MSE would be calculated as:

$$MSE = \frac{\sum_{t=-j+1}^{T-j} [(B_{t+j} - \tilde{B}_{t+j})]^2}{T - 1} \quad (3.4)$$

One requirement in determining an expected price is estimating what the basis level will be at the end of the hedging period. The relatively short price history for prices to Western Canadian wheat producers in the open market system limits the extent to which a detailed basis model can be constructed. However, literature suggests that relatively simple methods of calculating basis levels are widely used, including simple averages or seasonal moving averages (Garcia and Sanders, 1996).

The three different methods of estimating basis levels for the expected price component in the calculation for MSE are a) basis remains unchanged from the current spot price level; b) a three-year seasonal moving average for the estimated hedging period; c) an average of the current spot basis and the three-year seasonal moving average (e.g. an average of a) and b)). These basis forecasts establish the expected price from which the MSE is calculated to determine the realize price from what was expected by the hedger.

### Downside Risk Measures:

Most hedge analysis looks at hedge effectiveness in terms of reducing variability of actual returns or realized returns relative to expectations. However, even if a hedge may not be highly effective in reducing the variability of returns when measured in terms of variance, perhaps it may still potentially reduce some of the steep downward moves that might be of a concern to producers. In addition, many producers may be more concerned specifically with the risk of downside price moves rather than the variability. For this reason the semivariance and value-at-risk are also examined.

### Semivariance:

The semivariance of the portfolio is defined as

$$E\{\{\max(K - T), 0\}^2\} \quad (3.5)$$

where E is the expected function, K is the random value, and T is a specific target value. Thus, semivariance is measured as the expected value of squared deviations below a fixed target value (Turvey and Nayak, 2003). The portfolio is efficient when a hedge ratio is calculated so that the semivariance is minimized for a given expected value.

An efficient portfolio that included a futures hedge would be determined by solving the semivariance minimizing hedge ratio,  $\omega$ , as follows (Woodard and Garcia, 2008):

$$\text{Min } \sum\{\text{Max}[Y_k - (Y_{t,k}^{cash} - \omega_k f_{t,k}), 0]\}^2 \quad (3.6)$$

where  $\omega$  is the hedge ratio,  $Y_{t,k}^{cash}$  is the change in the cash market price,  $Y_k$  is the targeted level of returns and  $f_{t,k}$  is the change in the futures price.

In this study a hedge ratio is not calculated that is efficient to a specific semivariance level, but rather are calculating the semivariance of the hedge ratios already being used, specifically the naïve hedge ratio and the minimum variance hedge ratio using the previous three years of returns. The threshold level is set at a 3 percent and 5 percent decline in monthly returns.

### Value-at-Risk:

Another method of specifically measuring downside risk is value-at-risk (VaR). VaR is defined as the worst expected loss over a given time horizon under normal market conditions at a given confidence level.

Market risk may be described as the potential profit or loss for a portfolio that is left unchanged over a period of  $h$  days. The formula for the change in portfolio value is

$$\Delta_h P_t = P_{t+h} - P_t \quad (3.7)$$

where  $P$  is the price of the portfolio on day  $t$  (Alexander 2001). A  $100(1-\alpha)\%$   $h$ -period value at risk measure is the nominal amount  $C$  such that

$$\text{Prob}(\Delta P < -C) = \alpha \quad (3.8)$$

where  $\Delta P$  denotes the change in portfolio value over a prespecified holding period  $h$ , and  $\alpha$  is a sufficiently small probability, such as 1 percent or 5 percent (Alexander, 2001).

There are several methods for computing VaR, with the parametric method being amongst the most common. In this method the VaR is largely determined by the volatility of the portfolio returns over the holding period where volatility is measured by standard deviation. The standard deviation is multiplied by the  $Z$ -value for the selected confidence level and the initial portfolio dollar amount to arrive at a dollar value. This dollar value is the VaR of the portfolio for the chosen confidence level.

The formula for parametric VaR is

$$\text{VaR}_{\alpha,h} = Z_{\alpha} \sigma_t - \mu_t. \quad (3.9)$$

where  $Z_{\alpha}$  percentile of the standard normal density,  $\sigma_t$  is the standard deviation of the portfolio and  $\mu_t$  is the expected portfolio return over the holding period. Given that monthly wheat prices approximately follow a random walk the assumption is that  $\mu=0$ . Since  $Z_{\alpha}$  is the constant given by the choice of statistical distribution, it becomes  $\sigma_t$  that determines the VaR (Alexander 2001).

Volatility is estimated using the exponentially weighted moving average (EWMA) suggested by JP Morgan Risk Metrics™. The EWMA is expressed as

$$\sigma_t^2 = \lambda\sigma_{s,t-1}^2 + (1 - \lambda)r_{s,t-1}^2 \quad (10)$$

where  $\lambda$  is the weight given to the previous day's volatility estimate and  $(1-\lambda)$  is the weight given to the previous day's return. The aim of this approach is to better capture recent changes in volatility than what would be measured in an equally weighted measure of standard deviation. JP Morgan Risk Metrics™ suggests a decay factor of 0.97 when forecasting monthly volatility.

The VaR will be calculated at the 90 percent level both for an unhedged position as well as a hedged position for a Manitoba wheat producer to estimate the extent to which hedging using the Minneapolis hard red spring wheat futures contract may reduce the potential for large downside price moves.

#### Summary of methods:

To summarize, a hedging analysis will be performed on Manitoba hard red spring wheat prices using the Minneapolis hard red spring wheat futures contract using a naïve and a minimum variance hedge ratios, and considered against an expected basis level that is unchanged from the previous month, a three-year seasonal average, and an average of the basis unchanged from the previous month and the three-year seasonal average. This will measure the extent to which hedging reduces the variability of actual returns relative to expected returns based on three different methods of forecasting basis.

In addition, a semivariance and VaR will be calculated to measure the extent to which hedging reduces significant downside price risk. The purpose is to examine whether hedging can reduce significant price loss, even if the overall variability of returns is not brought down significantly.

These same calculations will be done for North Dakota to provide a comparison on hedging performance for a U.S. producer relative to a Canadian producer. This may give some observations on the extent to which Canadian wheat producers may or may not be at a

competitive disadvantage in regards to the ability to effectively hedge price risk using futures contracts.

## **Results**

### *Reducing Variability of Manitoba Wheat Prices:*

The first result looks at the extent to which hedging with futures reduces the variability of Manitoba wheat prices, both in outright terms and relative to price expectations. Since futures prices and the currency can be hedged, price expectations are largely based on a forecast for cash basis levels. The variability is measured by mean square error (MSE) and standard deviation.

Table 3.1 shows the results for unhedged and hedged positions for Manitoba wheat prices. The MSE for unhedged cash prices with an expectation that basis levels will remain unchanged from the current spot basis during the one month hedge period is 139.08 for the 40 observations between the 2016/17 and 2019/20 marketing years, with a standard deviation of \$11.64 per metric tonne. When incorporating a naïve hedge the MSE drops significantly, to just 11.23, while the standard deviation slips to just \$3.18 per tonne. In other words, incorporating a simple one-for-one hedge and assuming the basis level will remain unchanged during the hedge period greatly reduces the variability of returns. The MSE is also reduced significantly when using a three-year moving average hedge ratio and expecting that the basis remains unchanged, to 13.47 and a standard deviation of \$3.45, somewhat more than the naïve hedge.

One of the challenges for Manitoba hedgers is that there are years when the relationship between cash and futures prices is more variable and less predictable. This impacts results that draw on information from previous years to make hedging decisions. For example, the 2013/14 season (e.g. September 2013 to June 2014) showed a divergence between Manitoba wheat prices and the Minneapolis futures price. An extended logistical backlog severely impaired rail movement in Western Canada during the winter, which depressed local prices to producers. US grain movement was not impacted in the same way, which in turn caused a greater disconnect between Manitoba cash prices and Minneapolis futures prices. This affects the decisions for, e.g. the subsequent three years in when using the three-year rolling hedge ratio or using the three year

average basis for the hedging period when making price forecasts. This caused a hedge ratio of just 0.58 for the 2016/17 marketing year. The data from the 2013/14 crop year drop off for the next two crop years as a three year rolling average is used. This caused the subsequent hedge ratios for 2017/18 and 2018/19 to increase to 0.83 and 0.86, respectively. This is a reflection of how the hard red spring wheat price relationship between Canadian cash and the Minneapolis futures are susceptible to ‘shocks’ that are less easily arbitrated away in a manner that might be more likely with U.S. cash markets, including either directly through, or by the threat of, the delivery mechanism of the futures market.

The basis variability from one year to the next also materially impacts the ability to lock in a price relative to price expectations if those expectations are formulated based on prices from previous years. This shows up in the MSE results across both unhedged and hedged positions. In the case of an unhedged position, when the price expectation is based on the three-year average basis for the hedge period, the MSE is 262.14 and the standard deviation is \$15.95 per tonne. When the price expectation is based on a forecast basis of an average of the previous month basis and the three year average the MSE is 171.29 and the standard deviation is \$12.90 per tonne. Both of these figures are much higher than the MSE when the price expectation is based on the assumption that the basis remains unchanged during the hedge period.

A similar trend shows up in the effectiveness of a hedged position to reduce the MSE relative to the expected price, both for a naïve hedge and a hedge ratio calculated on a rolling three year basis. The MSE for a naïve hedge when the forecast basis is the average of the period for the previous three years was 112.40, well below the unhedged MSE of 262.14. However, the hedged MSE is not significantly lower than the unhedged MSE when assuming the basis remains unchanged during the observation period. In other words, while hedging significantly reduces the variability in realized returns relative to expectations, the great deal of basis variability in one season to the next in Manitoba wheat prices means that incorporating previous years’ prices into the expectations increases the variability of actual returns relative to projected returns, when compared to assuming that basis levels will remain unchanged during the hedge period. This doesn’t affect the ability to reduce the variability of returns within the season, but the volatility in basis levels from one marketing year to the next greatly reduces the ability for producers to generate price expectations on a more forward looking basis.

The relatively short duration of the hedge period may play a role in why incorporating previous years' basis levels into price expectations has the effect of increasing the MSE for both unhedged and hedged positions. A period of one month may be too short a period for basis levels to shift a great deal, whereas longer hedging windows provide more opportunity for basis levels to change in a meaningful way that might otherwise be captured in historical seasonal patterns. Given the limited data set, using hedging windows of, e.g. three months, would reduce the observations to as few as 12 periods, compared to the 40 that are available when using monthly data.

Note that all the results assumed that the currency was hedged as well. Results were also compiled where hedge positions were in place for wheat but where the currency was not hedged. This can be found in Appendix 3.A. These results showed that a hedge that was only for wheat prices and not currency reduced MSE from the unhedged position, but generally not as much as when both wheat and currency are hedged.

In summary, hedging with the Minneapolis hard red spring wheat futures contract greatly reduces the variability of returns for Manitoba hard red spring wheat producers. This is particularly the case when price expectations are based on recent basis levels. When price expectations incorporate the history of previous years then the variability of actual returns relative to expected returns becomes more volatile. This reflects how much basis levels in Manitoba fluctuate from one year to the next, reducing the extent to which past history can help forecast future returns.

#### *Reducing Downside Risk of Manitoba Wheat Prices:*

For many producers, the goal of hedging may be more focused on the reduction of severe downside price moves rather than managing the variability of returns. Semivariance and value-at-risk (VaR) are two methods that specifically consider downside price risk.

Semivariance measures the squared deviation of returns below a specific threshold level. In this case a 3 percent and 5 percent threshold declines in monthly returns is considered. An unhedged position showed a semivariance of 560.97 at the 3 percent threshold and 164.95 at the

5 percent level. In the case of both the naïve hedge and a hedge using a hedge ratio the semivariance for the same period is essentially zero. In other words, both hedge positions eliminated monthly declines in excess of 3 percent or 5 percent (the lone exception was a single month where a naïve hedge resulted in a loss of 3.03 percent, fractionally more than the threshold level). The results of the semivariance calculation are shown in Table 3.2.

VaR is the estimate of the maximum downside loss for a specific confidence level under normal market conditions. This study used a 90 percent VaR, which is the estimated maximum loss in 9 out of 10 months. VaR is calculated using the parametric method, which multiplies the calculated portfolio standard deviation by the accompanying z-value to come up with the maximum loss. The standard deviation was computed using an Exponentially Weighted Moving Average with a decay factor of 0.97. VaR was calculated for the unhedged position, a position with the naïve hedge and a hedge that is calculated using a hedge ratio.

The results show that both the naïve hedge and a hedge ratio significantly reduce the average VaR at the 90 percent level. The average 90 percent VaR for an unhedged position during the period was 6.37 percent, compared to 2.71 percent and 2.80 percent for the naïve hedge and the hedge ratio positions, respectively. In other words, while the VaR on any given month varies as the calculated standard deviation varies, on average one month in ten might expect a loss in excess of 6.37 percent for an unhedged position, compared to one month in ten seeing losses in excess of 2.71 percent and 2.80 percent for the naïve hedge and hedged calculated using a hedge ratio.

A 90 percent VaR means that one in ten months would have a loss that exceeds the threshold level. Out of the forty observations, one would anticipate four months where losses exceeded the VaR estimate. Four months exceeded the estimate for the unhedged position, essentially what one would expect. However, there were no observations that exceeded the VaR estimate for the naïve hedge and only one observation for the hedge using a hedge ratio. This is below what would be expected, suggesting that even the reduced VaR calculation for the hedge positions was overestimating the actual risk at the 90 percent level. One factor that may have contributed to this low number of observations that exceeded the calculated VaR is the general decline in the volatility of returns during the observation period (see Figure 3.1). This would

affect the VaR figure since the volatility calculation is based on the volatility shown in previous months, causing an overestimation of VaR during a period of declining volatility. Results of the VaR calculation are shown in Table 3.3.

In summary, hedging significantly reduces the risk of downward moves for Manitoba hard red spring wheat prices when considering semivariance with a 3 percent and 5 percent threshold and VaR at the 90 percent confidence level.

#### *Hedging Effectiveness of Futures for Manitoba Wheat Prices Relative to North Dakota Wheat Prices:*

One consideration is the extent of the hedging effectiveness of the Minneapolis hard red spring wheat futures contract for Manitoba wheat producers relative to North Dakota producers. For an unhedged position with the expectation that basis remains unchanged the MSE for North Dakota was 111.54 and standard deviation of \$10.41 per tonne (results for North Dakota shown in Table 3.4). This is lower than for the Manitoba producer (139.08 MSE and standard deviation of \$11.64 per tonne), but not dramatically lower.

When using a naïve hedge and assuming that basis levels remain unchanged the MSE drops to 6.72 with a standard deviation of returns of just \$2.20 per tonne. This is lower than for Manitoba prices under the same assumptions (MSE of 11.23 and standard deviation of \$3.18), but again not by a great deal.

The difference in results between North Dakota and Manitoba becomes starker when price expectations incorporate basis levels from previous years. The MSE and standard deviation of returns are higher in North Dakota when projecting a basis that is an average of the previous three years for that hedging period and when using an average of the basis at the beginning of the period and the average from the previous three years. This is a similar trend to the Manitoba hedge positions, but the increase is a fraction of that shown for Manitoba. For example, the MSE for a naïve hedge when assuming a basis that remains unchanged compared to a three-year average basis for that hedge period goes from 6.72 up to 24.19. The same comparison for Manitoba shows the MSE increasing from 11.23 up to 112.40. A similar contrast shows up when basis expectations are based on an average of the current basis and the average of the previous

three years, with the MSE for North Dakota at 10.88 compared to 33.03 for Manitoba (see Figure 3.2 for a comparison of basis volatility between Manitoba and North Dakota). The figures when using a hedge ratio are very close to the naïve hedge for North Dakota, for the simple reason that the North Dakota hedge ratio was consistently very close to 1 in each year (0.84 for 2016/17, 1.01 for 2017/18, 0.98 for 2018/19 and 0.985 for 2019/20).

In summary, hedging is very effective at reducing variability and large downside moves for North Dakota hard red spring wheat prices. The extent to which price variability is reduced is greater than what is shown for Manitoba. This is particularly the case when price expectations are partially based on basis levels from previous seasons. This reflects the higher level of consistency and lower basis volatility in North Dakota from one season to the next when compared to Manitoba prices. This also shows up in the hedge ratios when calculating the ratio based on the previous three years.

## **SUMMARY**

Wheat is one of the most important crops in Canada. The selling of wheat for producers has evolved over time, with the most significant recent change being the removal of the single desk monopoly of the Canadian Wheat Board in 2012. This change meant that producers became responsible for their own selling and risk management decisions in a way that they hadn't been before.

Hedging may be an effective way to manage price risk for some producers. In the case of wheat there are no futures contracts that trade on Canadian exchanges. Instead, hedgers need to look to one of the three wheat futures contracts that trade in the U.S. In the case of Canadian producers, most of the wheat grown is hard red spring wheat, which most closely resembles the contract specifications of the Minneapolis hard red spring wheat futures contracts. There was no open market cash price history upon which to evaluate the effectiveness of using futures contracts to manage price risk when the CWB single desk was removed. Examination of unhedged and hedged returns can now be done using cash price data rather than values inferred from other methods.

The objective of this chapter is to examine the effectiveness of the Minneapolis hard red spring wheat futures contract to reduce hard red spring wheat cash market price risk in Manitoba. Evaluation is based on both a reduction in the variance of returns relative to expectations for the hedging period, as well as downside risk measures such as semivariance and value-at-risk (VaR). The currency is also hedged to remove the effects of foreign exchange fluctuations from the results.

Mean square error (MSE) is the measure by which variability of returns are evaluated. This is calculated based on how the actual price varies from the expected price for the period. This requires a forecast for the basis during the hedge period. The different basis forecasts include the basis remaining unchanged during the hedge period, using an average from the previous three years for the specific hedge period, and using an average of the basis remaining unchanged and the three previous years' average.

The results showed that hedging with Minneapolis hard red spring wheat futures significantly reduces the price risk for Manitoba wheat producers. This includes both the variability of returns as well as downside risk measures, specifically semivariance and VaR. The reduction in variability was the greatest when the expectations were for the basis to remain unchanged during the hedge period. When the expected return incorporated a history from previous years the reduction in the MSE relative to an unhedged position was reduced. This is a reflection of how variable Manitoba basis levels are from one year to the next, and indicates that while price risk can be significantly reduced by hedging, high basis volatility makes the creation of expected prices much more difficult when looking beyond the current season.

This contrasts with North Dakota hedge results, which also showed more variability when incorporating expectations from previous years, but to a much lesser extent. In other words, there is much greater basis predictability from one year to the next for a North Dakota producer.

The results have important implications for policy makers. Government programs to manage price risk are relatively limited for producers in Canada. However, the effectiveness of hedging using futures markets means that private sector methods for price risk management are available. At the same time, basis variability and unpredictability from one season to the next

creates challenges for Manitoba producers, adding to uncertainty when making longer term selling and risk management decisions. The results may also provide lessons for other crops that are grown in Canada and have U.S.-based futures contracts, such as soybeans, corn and oats.

**Table 3.1. Mean square error (MSE) and Standard Deviation for Manitoba Hard Red Spring Wheat Returns for Unhedged, a Naïve Hedge and a Hedge Using a Rolling Three-Year Hedge Ratio Relative to Expected Returns Assuming that the Basis is Unchanged for the Period, the Basis is an Average of the Previous Three Years for the Period, and the Basis is an Average of the Unchanged Basis and Average of Previous Three Years for the Marketing Years 2016/17 to 2019/20.**

<b>Position</b>	<b>Basis Unchanged</b>		<b>Basis Avg. of Previous 3 Years for Hedge Period</b>		<b>Basis Average of Previous Month and Avg. of Previous 3 Years for Hedge Period</b>	
	<u>MSE</u>	<u>Std. Dev.</u>	<u>MSE</u>	<u>Std. Dev.</u>	<u>MSE</u>	<u>Std. Dev.</u>
No Hedge	139.08	11.64	262.14	15.95	171.29	12.90
Naïve Hedge	11.23	3.18	112.40	10.45	33.03	5.67
Hedge Ratio	13.47	3.45	117.85	10.71	36.91	6.00

Note: MSE is calculated based on expected returns. Forecasting an expected return requires a forecast of the basis at the end of the hedge period. The methods for forecasting basis is the basis remaining unchanged from the beginning of the hedge period, the basis being the average of the previous three years for that hedge period, and the basis being the average of the that period for the previous three years and the basis at the beginning of the hedge period. Results show that both the MSE and the Standard Deviation declines significantly with both a naïve hedge and using a hedge ratio across all three methods of forecasting basis. The MSE and Standard Deviation show the largest decline when assuming that the basis remains unchanged relative to basis expectations that incorporate previous years in the forecast.

**Table 3.2. Semivariance of Hard Red Spring Wheat Monthly Returns for Manitoba and North Dakota for Unhedged, a Naïve Hedge and a Hedge Based on a Rolling Three-Year Hedge Ratio at the 3 Percent and 5 Percent Levels for the Marketing Years from 2016/17 to 2019/20.**

Position	Manitoba		North Dakota	
	<u>3 percent</u>	<u>5 percent</u>	<u>3 percent</u>	<u>5 percent</u>
No Hedge	560.97	164.95	571.59	214.36
Naïve Hedge	.01	0	0	0
Hedge Ratio	0	0	0	0

Note: Semivariance is a measure of downside price risk. The results show that both a naïve hedge and a hedge position using a hedge ratio essentially eliminates any downside price moves at the 3 percent and 5 percent level in both Manitoba and North Dakota (the single exception is one month where the return was -3.03 percent for a naïve hedge for Manitoba). This compares to multiple monthly losses in excess of 3 percent and 5 percent for unhedged positions. The results show that hedging essentially eliminates large downside price moves in monthly returns.

**Table 3.3. Value-at-Risk (VaR) of Hard Red Spring Wheat Monthly Returns for Manitoba and North Dakota for Unhedged, a Naïve Hedge and a Hedge Based on a Rolling Three-Year Hedge Ratio at the 90 percent Level for the Marketing Years from 2016/17 to 2018/19**

Position	Manitoba	North Dakota
No Hedge	6.37%	6.28%
Naïve Hedge	2.71%	2.22%
Hedge Ratio	2.80%	2.28%

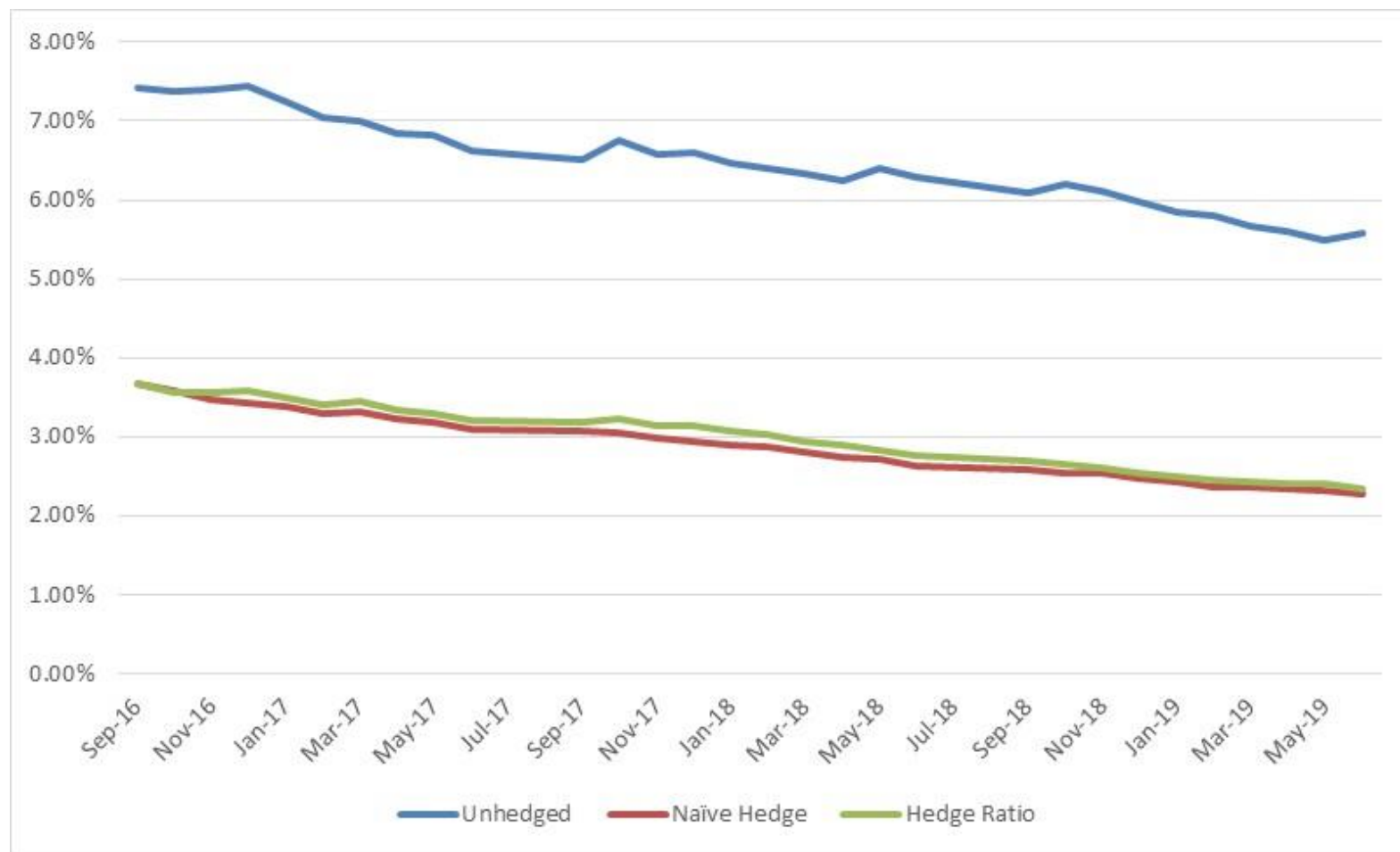
Note: VaR is an estimate of the maximum downside loss within a specific confidence level. This downside loss is significantly reduced when using a naïve hedge and a hedge position using a hedge ratio. For Manitoba the average VaR at the 90 percent level during the observation period goes from 6.37 percent for an unhedged position down to 2.71 percent and 2.80 percent for a naïve hedge and hedge ratio, respectively. The decline in the average VaR is even greater in North Dakota, going from 6.28 percent for an unhedged position down to 2.22 percent and 2.28 percent for a naïve hedge and hedge position using a hedge ratio.

**Table 3.4. Mean square error (MSE) and Standard Deviation for North Dakota Hard Red Spring Wheat Returns for Unhedged, a Naïve Hedge and a Hedge Using a Rolling Three-Year Hedge Ratio Relative to Expected Returns Assuming that the Basis is Unchanged for the Period, the Basis is an Average of the Previous Three Years for the Period, and the Basis is an Average of the Unchanged Basis and Average of Previous Three Years for the Marketing Years 2016/17 to 2019/20.**

<b>Position</b>	<b>Basis Unchanged</b>		<b>Basis Avg. of Previous 3 Years for Hedge Period</b>		<b>Basis Average of Previous Month and Avg. of Previous 3 Years for Hedge Period</b>	
	<u>MSE</u>	<u>Std. Dev.</u>	<u>MSE</u>	<u>Std. Dev.</u>	<u>MSE</u>	<u>Std. Dev.</u>
No Hedge	111.54	10.41	106.69	10.12	102.35	9.95
Naïve Hedge	6.72	2.20	24.19	4.83	10.88	3.25
Hedge Ratio	7.44	2.26	23.58	4.78	10.93	3.26

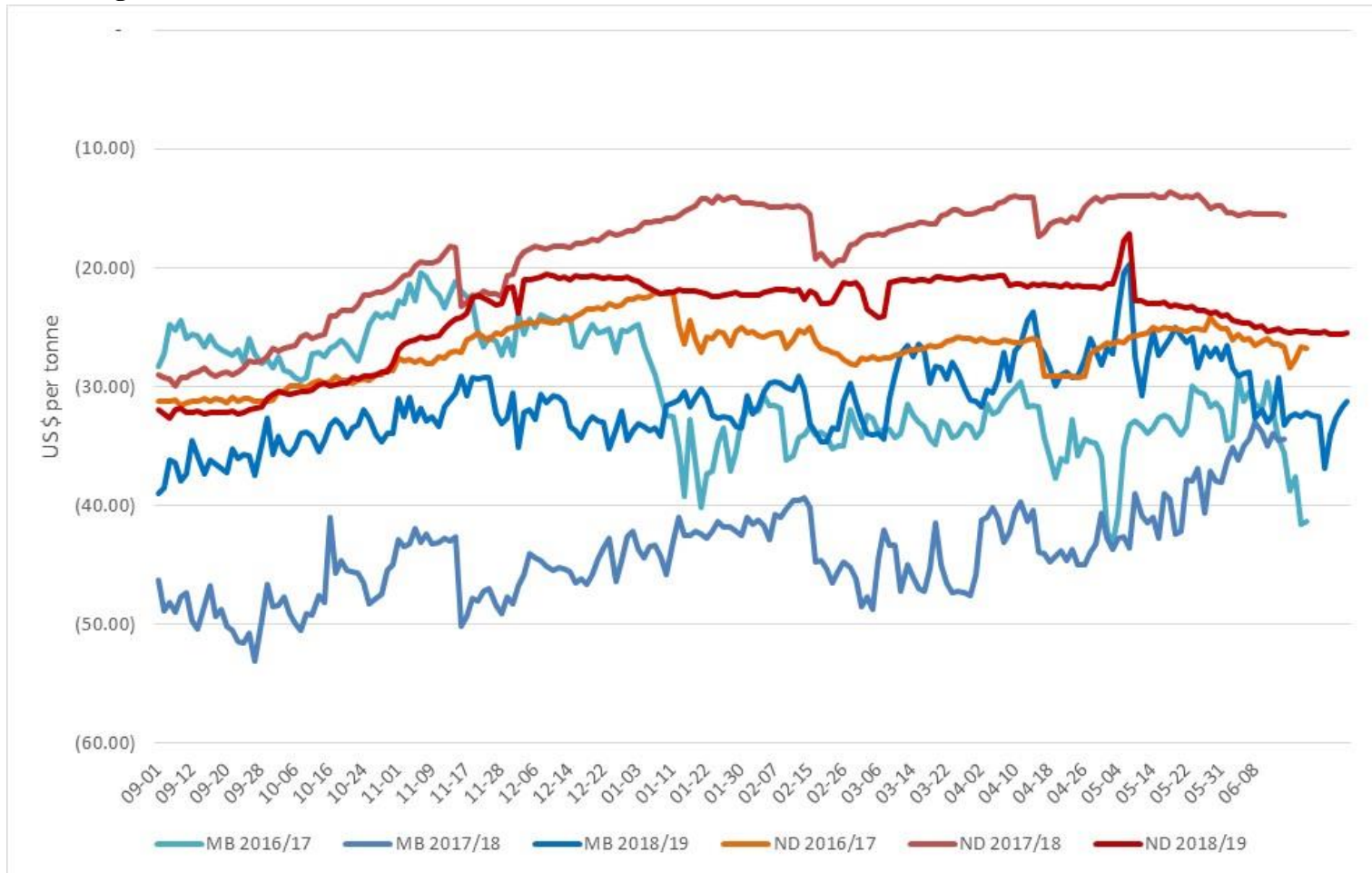
Note: MSE is calculated based on expected returns. Forecasting an expected return requires a forecast of the basis at the end of the hedge period. The methods for forecasting basis is the basis remaining unchanged from the beginning of the hedge period, the basis being the average of the previous three years for that hedge period, and the basis being the average of the that period for the previous three years and the basis at the beginning of the hedge period. Results show that both the MSE and the Standard Deviation declines significantly with both a naïve hedge and using a hedge ratio across all three methods of forecasting basis. The MSE and Standard Deviation show a larger decline when assuming that the basis remains unchanged relative to basis expectations that incorporate previous years in the forecast.

**Figure 3.1. Value-at-Risk at the 90 Percent Level for Unhedged, Naïve Hedge and a Hedged Position Using a Rolling Three-Year Hedge Ratio for Hard Red Spring Wheat in Manitoba.**



Note: VaR is an estimate of the maximum downside loss within a specific confidence level. This downside loss is significantly reduced when using a naïve hedge and a hedge position using a hedge ratio. For Manitoba the average VaR at the 90 percent level during the observation period goes from 6.37 percent for an unhedged position down to 2.71 percent and 2.80 percent for a naïve hedge and hedge ratio, respectively. The general decline in volatility during the observation period resulted in a downward trend in VaR for both the unhedged and hedged positions.

**Figure 3.2. Hard Red Spring Wheat Basis Levels for Manitoba and North Dakota from September to June for the 2016/17 to 2018/19 Marketing Seasons.**



Note: Basis levels in Manitoba show much more volatility than North Dakota within each season and also from one season to the next.

### Appendix 3.A: Hedge Position for Manitoba Hard Red Spring Wheat with no Currency Hedge

A fully hedged position for a Manitoba wheat producer would require both a futures hedge and a currency hedge since the cash market price risk is in Canadian dollars while the Minneapolis hard red spring wheat futures contract is denominated in U.S. dollars. However, producers could choose to only hedge the wheat futures contract and not hedge the currency portion.

Measuring the effectiveness of a wheat-only hedge uses the same method as for a fully hedged position. In this case the mean square error (MSE) is calculated as follows:

$$MSE = \frac{\sum_{t=-j+1}^{T-j} [(FP_{t+j})(X_{t+j} - X_t) + (B_{t+j} - \tilde{B}_{t+j})]^2}{T - 1} \quad (3.A.1)$$

where the price risk is a function of the exchange rate fluctuation in  $X_t$  to  $X_{t+j}$  for the final futures value  $FP_{t+j}$ , and the basis risk,  $\tilde{B}_{t+j}$  to  $B_{t+j}$ .

Results show that a position where the wheat portion of the price risk is hedged but no currency hedge is in place reduces the MSE and standard deviation of returns compared to a completely unhedged position, but not by as much as when both the wheat and the currency are hedged (results shown in Table 3.A.1). In other words, Manitoba hard red spring wheat producers can reduce their price risk by only hedging with the Minneapolis hard red spring wheat futures contract, but can further reduce their total price risk when hedging the currency as well.

**Table 3.A.1. Mean square error (MSE) and Standard Deviation for Manitoba Hard Red Spring Wheat Returns for Unhedged, a Naïve Hedge and a Hedge Using a Rolling Three-Year Hedge Ratio Relative to Expected Returns Assuming that the Basis is Unchanged for the Period, the Basis is an Average of the Previous Three Years for the Period, and the Basis is an Average of the Unchanged Basis and Average of Previous Three Years for the Marketing Years 2016/17 to 2018/19.**

Position	Basis Unchanged		Basis Avg. of Previous 3 Years for Hedge Period		Basis Average of Previous Month and Avg. of Previous 3 Years for Hedge Period	
	<u>MSE</u>	<u>Std. Dev.</u>	<u>MSE</u>	<u>Std. Dev.</u>	<u>MSE</u>	<u>Std. Dev.</u>
No Hedge	129.37	11.17	293.05	16.69	184.40	13.22
Naïve Hedge, Both Wheat and Currency	9.67	2.96	144.47	11.80	37.74	6.00
<b>Naïve Wheat Hedge, No Currency Hedge</b>	<b>37.53</b>	<b>5.88</b>	<b>248.45</b>	<b>15.47</b>	<b>173.63</b>	<b>12.94</b>
Hedge Ratio, Both Wheat and Currency	13.69	3.50	152.97	12.14	45.13	6.60
<b>Hedge Ratio Wheat, No Current Hedge</b>	<b>30.53</b>	<b>5.34</b>	<b>152.28</b>	<b>12.12</b>	<b>55.95</b>	<b>7.35</b>

Note: MSE is calculated based on expected returns. Forecasting an expected return requires a forecast of the basis at the end of the hedge period. The methods for forecasting basis is the basis remaining unchanged from the beginning of the hedge period, the basis being the average of the previous three years for that hedge period, and the basis being the average of the that period for the previous three years and the basis at the beginning of the hedge period. Results show that both the MSE and the Standard Deviation decline with both a naïve hedge and using a hedge ratio across all three methods of forecasting basis. When there is no currency hedge (e.g. only a wheat futures hedge), the decline in the MSE is significant when the assumption is that the basis remains unchanged during the hedge period, but the decline is relatively modest when price expectations incorporate basis levels from previous years

## **CHAPTER 4**

# **MANAGING PRICE RISK FOR WESTERN CANADIAN GRAIN PRODUCERS: HOW MUCH DOES SIMPLE DIVERSIFICATION REDUCE RISK AND IS HEDGING EFFECTIVE IN A PORTFOLIO CONTEXT?**

### **Introduction**

The Western Canadian agricultural industry faces considerable risk for both production and price. There are various ways that Canadian producers can manage risk in their operation. This includes government programs (such as the various offerings under the federally administered Business Risk Management (BRM) programs, which includes crop yield insurance and AgriStability, a federally administered margin insurance program) and private methods (private margin insurance contracts, price risk management contracts done directly with grain buyers or hedging on futures exchanges). Aside from traditional crop yield insurance, government risk management programs in Canada have had relatively low participation from producers, particularly the AgriStability margin insurance program (Guenther, 2016; Dawson, 2020). This means that, outside of crop insurance, Canadian producers may often rely largely on private methods of managing risk.

The role of government in Canadian agricultural risk management is an ongoing issue (including recommendations made by Ker, et al, 2017). Much of the policy discussion has focused on margin insurance and general industry support rather than specifically on crop price risk. However, the ability for producers to effectively manage price risk could be an important part of the discussion given its role in helping producers protect margins. Good risk management requires methods that can be used effectively.

Hedging with futures may be an effective way to manage price risk for some producers. Most hedging analysis focuses on commodities where the cash price exposure is in the same country and currency as the exchange where the futures contract

is listed (e.g. a corn producer in Iowa hedging on the Chicago Board of Trade). However, for Canadian producers, using a U.S. futures contract in U.S. dollars can create additional basis risk, which includes foreign exchange risk, for the hedger. Increased basis risk remains, even when foreign exchange is hedged (Thompson and Bond, 1987, indicate that the variance covariance matrices across the cash and futures prices can differ significantly when the currency is not hedged). With the exception of canola, which is the only agricultural futures contract on a Canadian exchange, this could impact the effectiveness of using futures contracts for Canadian producers. A number of farmers may be reluctant to use futures contracts due to their perceived complexity, but may be more comfortable with cash forward contracts which are typically available in Canadian dollars. For some producers who may be reluctant to use futures contracts due to complexity or the requirement for posting margin funds, using forward contracts may be an alternative in a number of situations.

The potential role of futures contracts to manage price risk for Western Canadian farms has also changed over time. Most importantly, the removal of the single desk for the Canadian Wheat Board (CWB) in Western Canada in 2012 means that producers now must rely on private methods for managing price risk rather than on the price pooling that was primarily used previously (the CWB provided some limited options for producers to use other methods of pricing their wheat within the single desk system, although the majority of wheat stayed within the pool pricing). Non-durum wheat is the largest or second largest crop in Western Canada by seeded area.

In addition, planted area for other crops that have futures markets have also been increasing (canola, soybeans, corn and oats). The combined effect of changes to the wheat marketing system and change in crop mix means that the area devoted to ‘hedgable’ crops in the three Prairie provinces of Alberta, Saskatchewan and Manitoba more than doubled in a decade, going from 20.59 million acres in 2010 up to 43.56 million in 2020. In other words, the potential for futures markets to play a more direct role in farm risk management strategies has increased significantly in a relatively short period of time.

Asset diversification can be another form of risk management. Price risk at the farm level is often thought of in terms of the individual crop. However, essentially every farm grows more than one crop. In this way there is a certain amount of ‘natural price risk management’ that becomes part of the operation. This could affect the way in which futures contracts might be utilized to reduce downside risk for producers.

While there is some research on examining hedging within a portfolio of assets, as well as hedging in international markets, there is less research when considering a portfolio of assets that are primarily hedged in foreign markets. The combination of foreign exchange risk and increased basis risk can have a significant impact on the effectiveness of using futures contracts when looking at the price risk across the enterprise as whole. This leaves a limited understanding of how and if, for example, hedging with futures contracts is an effective form of price risk management when looking across an entire Canadian farming operation.

For Canadian policy makers, knowing that hedging with futures contracts can potentially be an effective method of managing price risk would give the confidence that existing methods can have an important role to play in the broader risk management discussion. For a number of Western Canadian grain producers, a better understanding of how futures contracts could assist them may result in increased usage as a way to manage price risk.

The objective of chapter four is to examine the effectiveness of using futures contracts to manage price risk for a Manitoba farm that grows four different crops – hard red spring wheat, soybeans, canola, and corn. This includes examining the variability in revenue across the portfolio of crops for both hedged and unhedged positions as well as the reduction in steep downside losses. Evaluation is based on both the more traditional measure of variance reduction as well as considering downside risk measures, such as semivariance and value-at-risk (VaR). This will help determine how much additional price risk is managed by the use of hedging with futures for a Canadian producer compared to the simple diversification that comes from growing several different crops.

The remainder of this chapter is organized as follows. The next section reviews the literature that examines hedging, including in a multicommodity context. After this is a section on the data, followed by the methodology section, after which is examination of the effect of diversification on reducing price risk for a Manitoba farm, as well as the impact of various hedging methodologies. This is followed by a summary section.

## **Literature Review**

There is a vast amount of literature on hedging in agricultural markets. Much early work focused on reducing the price variability of a cash market exposure, including calculating variance minimizing hedge ratios. Some commonly cited early papers include Peck (1975), Rolfo (1980) and Kahl (1983). Another method to calculate optimal hedge ratios is by maximizing utility, with utility being maximized in a linear function that is increasing in expected return and decreasing return variance (Grant, 1985). Further literature examines hedge ratios under different scenarios, such as using price differences, price levels or percentage price changes (Witt, et al, 1987). Others include Myers and Thompson (1989), which use a more generalized optimal hedge ratio estimation that depends on a model that determines equilibrium spot and futures price movements, which allows for a more flexible specification of equilibrium pricing models. Nelson and Collins (1985) incorporate a Sharpe ratio so that both the potential for excess returns and risk reduction are considered.

A number of papers provide a broad overview of different models and developments in hedging research over time. Some of these surveys include Collins (1997), Tomek and Peterson (2001), Lien and Tse (2002) and Garcia and Leuthold (2004).

There have also been numerous studies that consider agricultural hedging from a portfolio or multiproduct approach. Bond and Thompson (1986) used the Capital Asset Pricing Model (CAPM) framework and found that optimal hedge ratios were significant reduced when adding stock market shares to the admissible portfolio.

Others have examined multiproduct hedging for multiple commodities. This includes Fackler and McNew (1993) that looked at the cash market positions and hedging ratios of a soybean processor, and found that both the fully hedged and hedge ratios derived from single commodity estimates were suboptimal to a multiproduct approach. Other approaches include Power and Vedenov (2010) looking at multi-commodity hedging from a lower partial movements-minimizing hedge ratio for a cattle feeding operator and found that much lower hedge ratios could be used when compared to the single-commodity minimum variance approach, and Tejeda and Feuz (2014) that estimated dynamic correlations using a regime switching method that better characterizes the relationships among prices. They found a significant improvement in margin variance and lower hedge ratios than when a naïve hedging strategy was incorporated, although the improvement was much reduced when examining out-of-sample data.

It should be noted that other analysis finds the effectiveness of various multivariate approaches is mixed, particularly when taking into account the complexity and cost of computation, and where naïve or simple hedge ratios may be just as effective, and in some cases even more so when applied to out-of-sample data (Grant and Eaker, 1989; Collins, 2000).

There has been work in agricultural hedging in international markets. Hedging in offshore markets introduces an additional consideration, include exchange rate uncertainty. Thompson and Bond (1987) examine hedging Australian export wheat on the CBOT, and use the mean-variance criteria when considering hedging decisions by an offshore trader that wishes to stabilize revenue in domestic currency terms. When the exchange rate remains fixed the optimal hedge ratio becomes identical to that of a domestic hedger. However, in the presence of exchange rate uncertainty, the variances and covariances of spot and futures prices in local currency terms are unlikely to be the same as they are for the prices in U.S. dollar terms.

Haigh and Holt (2000) consider a multiproduct scenario in international grain markets, including both grain and freight futures markets. They found that time-varying

simultaneously determined hedge ratios provide superior performance, even after accounting for the additional transaction costs that come from the more sophisticated strategies, and that the more computationally complex MGARCH approach may be more effective than more traditional approaches.

There has also been some research specifically on hedging in Canadian markets. Novak and Unterschultz (1996) used mean square error (MSE) as the risk measure of price, which calculates the squared deviation of the realized net price from a forecast net price. The work examined a Canadian cattle feeder using U.S.-based futures markets for hedging, where the added risk of adverse currency moves is a consideration. While basis risk was still significant, the results showed that commodity hedging removed a large portion of the total price risk.

Other research that considered hedging in a Canadian market context includes Braga (1990), who studied corn and soybean hedges in Ontario and found that a simple commodity hedge is shown to be less effective than a joint commodity and currency hedge in replicating the adjusted basis changes. Love and Boyd (1994) considered futures and options as an alternative to past agricultural policies in stabilizing revenues for grain farmers in Western Canada, and found short selling futures and buying put options to be more effective, both in aggregate and at the individual farm level. Carter and Loynes (1985) looked at hedging in the Canadian cattle market and found that the basis was too variable to consider using futures markets to hedge price risk, which in turn leaves the Canadian cattle industry without a useful mechanism for price risk management.

Research has also been done to look at hedging effectiveness beyond just a mean-variance framework. For example, producers may be more concerned about avoiding adverse outcomes rather than reducing price variability specifically. As a result it is also worth considering downside risk measures. Papers that looked at semivariance in an agricultural context include Turvey and Nayak (2003) and Mattos, Garcia and Nelson (2008). Some examples of where VaR is used in an agricultural setting include

Manfredo and Leuthold (1999 and 2001), Sanders and Manfredo (2002) and Bamba and Maynard (2004).

There has not been much recent literature on hedging in a Canadian market. This is relevant given how the structure of the market has significantly changed in some major crops. In addition, an examination of how futures contracts can reduce risk within the context of a portfolio of crops on a farming operation can provide an important contribution for agricultural risk management in Canada.

## **Data**

This study will look at revenue per acre for a Manitoba farm that grows an equal area of canola, hard red spring wheat, corn and soybeans, which would act as a reasonable proxy for a crop rotation in the province. Revenue per acre is used as this reflects the actual impact at the farm level, and also takes into account the differences in yields between the various crops' effects the variability of returns. For example, a 5 percent decline in price will have a different impact on revenue for hard red spring wheat at an average price of, e.g. \$6.00 per bushel and an average yield of 55 bushels per acre, than it will on corn, which might have a value of, e.g. \$4.50 per bushel and an average yield of 120 bushels per acre.

Data includes average Manitoba elevator prices for corn, canola, hard red spring wheat and soybeans from the 2013/14 to 2019/20 years (7 seasons), with the marketing year beginning on August 1 and ending on July 31. Canola futures prices will be used from ICE Futures Canada (formerly the Winnipeg Commodity Exchange), hard red spring wheat futures from the Minneapolis Grain Exchange, and corn and soybean futures from the Chicago Board of Trade. The value of the Canadian dollar is taken from the Chicago Mercantile Exchange. The contract month used is the one immediately after the period that the hedge is in place. For example, a hedge for the month of February would use the next contract month, which is March.

The study looks at hedging periods of one month. Research suggests that hedging effectiveness improves when longer periods are used, and producer hedging decisions might also typically look at periods of more than one month. However, extending hedging periods greatly reduces the number of observations, something that is already a limitation given the relatively short history of open market wheat pricing and where soybean and corn acres represent a sizeable portion of cropping area in the province.

The monthly period is from the first trading day of the month until the third last trading day of the month. While this modestly reduces the number of trading days in each monthly observation, there is the potential for futures prices to become more volatile and erratic in the final trading days prior to entering the delivery period. This can particularly be the case in relatively lower volume, less liquid futures contracts such as the ICE Futures Canada canola contract or the MGEX hard red spring wheat contract.

No observations were taken when the cash price would be hedged in a futures contract that represents the next marketing year. For example, July canola cash prices are still for the ‘old’ crop year, but would have to be hedged in the November contract, which reflects ‘new’ crop year production. The relationship between ‘old crop’ cash prices and ‘new crop’ futures prices can be volatile, which would potentially distort the results. In addition, the vast majority of producer hedging decisions will be done within the same marketing year. This left a total of nine monthly observations taken in each of the 7 full marketing years examined, beginning in October and ending in June.

Yield data for Manitoba is from Statistics Canada.

## **Methodology**

Much analysis around hedging effectiveness examines the reduction in variability of returns. Conventional hedging methodology under a static model involves estimating a simple hedge ratio through the following linear regression model:

$$\Delta S_t = \alpha + \beta * \Delta F_t + \varepsilon_t \quad (4.1)$$

where  $S_t$  and  $F_t$  are the changes in cash and future prices for period  $t$ . The ordinary least squares estimator (OLS) of  $\beta$  provides an estimate of the minimum-variance hedge ratio, with  $\alpha$  as the constant regression parameter and  $\varepsilon_t$  being an error term. Another approach is the utility maximizing mean-variance approach, with expected utility being a linear function that is increasing in expected return and decreasing variance. The mean-variance and minimum variance hedge ratio are consistent if the futures market is unbiased (Benninga, Eldor and Zilcha, 1983).

The OLS method has been criticized for being based on unconditional variance and covariance in the series, with conditional information being omitted (Myers and Thompson, 1989). Methods have also been developed that incorporate time series techniques, including multivariate GARCH models that incorporate time-varying hedge ratios. Research results are mixed on the extent to which GARCH methods perform better than the more easily computed OLS methods, particularly when accounting for the additional cost and effort of computation and higher transaction costs when adjusting hedge positions, particularly when applied to out-of-sample data (Grant and Eaker, 1989, and Collins, 2000). For this reason, and given the more likely hedge approach by producers of using less active and dynamic hedging strategies, the more traditional OLS methods of computing hedge ratios is used for the individual crops, which will then be compared against the broader farm portfolio.

In considering the change in value for the portfolio of crops, the equally weighted change in revenue per acre equals

$$\pi_{UNH,t} = W + S + R + C \quad (4.2)$$

where  $W$  is the one period change in revenue (which is price x yield) for hard red spring wheat,  $(W_t - W_{t-1})$ ,  $S$  is the one period change in revenue for soybeans,  $(S_t - S_{t-1})$ ,  $R$  is the one period change in revenue for canola,  $(R_t - R_{t-1})$ , and  $C$  is the one period change in revenue for corn,  $(C_t - C_{t-1})$ .

When incorporating the futures hedges, the returns are as follows:

$$\pi_{H,t} = W + b_{MW}MW + S + b_{SC}SC + R + b_{IR}IR + C + b_{CC}CC \quad (4.3)$$

where  $MW$  indicates the one period change in the futures price for Minneapolis hard red spring wheat futures,  $(MW_t - MW_{t-1})$ , with  $b_{MW}$  denoting the hedge ratio for the Minneapolis hard red spring wheat futures position,  $SC$  representing the one period change in the futures price for the Chicago Board of Trade soybean futures,  $(SC_t - SC_{t-1})$ , with  $b_{SC}$  being the hedge ratio for the Chicago Board of Trade soybean futures contract;  $IR$  representing the one period change in the futures price for the ICE Futures Canada canola futures contract,  $(IR_t - IR_{t-1})$ , and  $b_{IR}$  indicating the hedge ratio for the ICE Futures Canada contract, and  $CC$  being the one period change in the futures price for the Chicago Board of Trade corn futures contract,  $(CC_t - CC_{t-1})$ , with  $b_{CC}$  being the hedge ratio for the corn futures contract. The hedge ratio is 1 when a naïve hedge is incorporated.

The multiproduct hedge ratios for the portfolio are calculated as:

$$b_{MW} = \frac{\begin{vmatrix} Cov(MW, W) + Cov(MW, S) + Cov(MW, R) + Cov(MW, C) & Cov(MW, SC) & Cov(MW, IR) & Cov(MW, CC) \\ Cov(SC, W) + Cov(SC, S) + Cov(SC, R) + Cov(SC, C) & Var(SC) & Cov(SC, IR) & Cov(SC, CC) \\ Cov(IR, W) + Cov(IR, S) + Cov(IR, R) + Cov(IR, C) & Cov(IR, SC) & Var(IR) & Cov(IR, C) \\ Cov(CC, W) + Cov(CC, S) + Cov(CC, R) + Cov(CC, C) & Cov(SC, CC) & Cov(IR, CC) & Var(CC) \end{vmatrix}}{w} \quad (4.4)$$

for the hedge ratio for  $MW$ , which is the Minneapolis hard red spring wheat futures contract;

$$b_{SC} = \frac{\begin{vmatrix} Var(MW) & Cov(MW, W) + Cov(MW, S) + Cov(MW, R) + Cov(MW, C) & Cov(MW, IR) & Cov(MW, CC) \\ Cov(MW, SC) & Cov(SC, W) + Cov(SC, S) + Cov(SC, R) + Cov(SC, C) & Cov(SC, IR) & Cov(SC, CC) \\ Cov(MW, IR) & Cov(IR, W) + Cov(IR, S) + Cov(IR, R) + Cov(IR, C) & Var(IR) & Cov(IR, C) \\ Cov(MW, CC) & Cov(CC, W) + Cov(CC, S) + Cov(CC, R) + Cov(CC, C) & Cov(IR, CC) & Var(CC) \end{vmatrix}}{w} \quad (4.5)$$

for the hedge ratio for  $SC$ , which is the Chicago Board of Trade soybean futures contract;

$$b_{RI} = \frac{\begin{vmatrix} \text{Var}(MW) & \text{Cov}(MW, SC) & \text{Cov}(MW, W) + \text{Cov}(MW, S) + \text{Cov}(MW, R) + \text{Cov}(MW, C) & \text{Cov}(MW, CC) \\ \text{Cov}(MW, SC) & \text{Var}(SC) & \text{Cov}(SC, W) + \text{Cov}(SC, S) + \text{Cov}(SC, R) + \text{Cov}(SC, C) & \text{Cov}(SC, CC) \\ \text{Cov}(MW, IR) & \text{Cov}(SC, IR) & \text{Cov}(IR, W) + \text{Cov}(IR, S) + \text{Cov}(IR, R) + \text{Cov}(IR, C) & \text{Cov}(IR, CC) \\ \text{Cov}(MW, CC) & \text{Cov}(SC, CC) & \text{Cov}(CC, W) + \text{Cov}(CC, S) + \text{Cov}(CC, R) + \text{Cov}(CC, C) & \text{Var}(CC) \end{vmatrix}}{w} \quad (4.6)$$

for *RI* which is the ICE Futures Canada canola futures contract, and

$$b_{CC} = \frac{\begin{vmatrix} \text{Var}(MW) & \text{Cov}(MW, SC) & \text{Cov}(MW, IR) & \text{Cov}(MW, W) + \text{Cov}(MW, S) + \text{Cov}(MW, R) + \text{Cov}(MW, C) \\ \text{Cov}(MW, SC) & \text{Var}(SC) & \text{Cov}(SC, IR) & \text{Cov}(SC, W) + \text{Cov}(SC, S) + \text{Cov}(SC, R) + \text{Cov}(SC, C) \\ \text{Cov}(MW, IR) & \text{Cov}(MW, IR) & \text{Var}(IR) & \text{Cov}(IR, W) + \text{Cov}(IR, S) + \text{Cov}(IR, R) + \text{Cov}(IR, C) \\ \text{Cov}(MW, CC) & \text{Cov}(MW, CC) & \text{Cov}(IR, SC) & \text{Cov}(CC, W) + \text{Cov}(CC, S) + \text{Cov}(CC, R) + \text{Cov}(CC, C) \end{vmatrix}}{w} \quad (4.7)$$

For *CC*, which is the Chicago Board of Trade corn futures contract.

The denominator, *w*, is calculated as

$$w = \begin{vmatrix} \text{Var}(MW) & \text{Cov}(MW, SC) & \text{Cov}(MW, IR) & \text{Cov}(MW, CC) \\ \text{Cov}(MW, SC) & \text{Var}(SC) & \text{Cov}(SC, IR) & \text{Cov}(SC, CC) \\ \text{Cov}(MW, IR) & \text{Cov}(SC, IR) & \text{Var}(IR) & \text{Cov}(IR, CC) \\ \text{Cov}(MW, CC) & \text{Cov}(SC, CC) & \text{Cov}(IR, CC) & \text{Var}(CC) \end{vmatrix} \quad (4.8)$$

Returns for the portfolio of crops will be examined against the variability of returns for each individual crop, considered from an unhedged position as well as a naïve hedge and a simple hedge ratio, both with the currency hedged and unhedged. The purpose is to determine the extent to which the variability of returns differs when considering the crops in aggregate as opposed to focusing on each individual crop. In this sense, the variability of returns will take into consideration the natural diversification effect that comes with growing multiple crops on a farm. Hedge ratios for the individual crops will be calculated based on monthly price changes from the previous three marketing years. This means that hedge ratios are adjusted at the beginning of each marketing year, although are not adjusted within the season.

There are methods that more actively adjust hedge positions during the hedging period that might make the results more efficient. However, the computational effort and cost is not easily achievable for many commercial hedgers, especially producers, particularly when considering the mixed results for their effectiveness (as cited above). This is also supported by McNew and Fackler (1994), which suggest that a constant hedge ratio for periods is a suitable assumption, resulting in hedge strategies that are easier to implement.

Mean square error (MSE) is used as a measure by which the actual returns deviate from expected returns, and can be used as a measure of hedging effectiveness. MSE is calculated as follows:

$$MSE = \frac{\sum_{t=-j+1}^{T-j} (NP_{t+j} - N\tilde{P}_{t+j})^2}{T - 1} \quad (4.9)$$

where  $NP_{t+j}$  is the realized price for period  $t+j$ ;  $N\tilde{P}_{t+j}$  is the forecast net price for period  $t+j$ ;  $T$  is the total number of periods, and  $j$  is the forecast horizon.

When there is no hedge, the MSE is

$$MSE = \frac{\sum_{t=-j+1}^{T-j} [(FP_{t+j}X_{t+j} - FP_{j,t}X_t) + (B_{t+j} - \tilde{B}_{t+j})]^2}{T - 1} \quad (4.10)$$

This reflects the total price risk as a function of change in the futures price,  $FP_{j,t}$  to  $FP_{t+j}$ , the exchange rate risk in  $X_t$  to  $X_{t+j}$ , and the basis risk,  $\tilde{B}_{t+j}$  to  $B_{t+j}$ .

In the case of a perfect futures and currency hedge, the only remaining risk is the basis risk, where the MSE would be calculated as:

$$MSE = \frac{\sum_{t=-j+1}^{T-j} [(B_{t+j} - \tilde{B}_{t+j})]^2}{T - 1} \quad (4.11)$$

In this study it is assumed that expectations are for the basis to remain unchanged during the one month hedging window.

Downside Risk Measures:

Most hedge analysis looks at hedge effectiveness in terms of reducing variability of actual returns or realized returns relative to expectations. However, in some cases producers may be more concerned specifically with the risk of downside price moves rather than the variability. This may be of interest in this particularly study when considering if, for example, the unhedged portfolio of crop may still exhibit higher variability of returns than individual crops that are hedged, but where the diversification diminishes the frequency of sharp declines across the crop markets in aggregate. For this reason the semivariance and value-at-risk (VaR) are also examined for both the individual crop positions and the portfolio of crops.

Semivariance:

The semivariance of the portfolio is defined as

$$E\{[\max(K - T), 0]^2\} \tag{4.12}$$

where E is the expected function, K is the random value, and T is a specific target value. Thus, semivariance is measured as the expected value of squared deviations below a fixed target value (Turvey and Nayak, 2003). The portfolio is efficient when a hedge ratio is calculated so that the semivariance is minimized for a given expected value, with the semivariance minimizing hedge ratio,  $\omega$ , as follows (Woodard and Garcia, 2008):

$$\text{Min } \sum\{\text{Max}[Y_k - (Y_{t,k}^{cash} - \omega_k f_{t,k}), 0]\}^2 \tag{4.13}$$

where  $\omega$  is the hedge ratio,  $Y_{t,k}^{cash}$  is the change in the cash market price,  $Y_k$  is the targeted level of returns and  $f_{t,k}$  is the change in the futures price.

In this study the semivariance for monthly losses of 5 percent, 3 percent and 2 percent are considered for each individual crop and the portfolio of crops under each of

the different hedging scenarios. A hedge ratio is not calculated that is efficient to a specific semivariance level, but rather the semivariance is calculated based on the hedge ratios already being used, specifically the naïve hedge ratio and the minimum variance hedge ratio using the previous three years of returns.

Value-at-Risk:

Another method of specifically measuring downside risk is value-at-risk (VaR). VaR is defined as the worst expected loss over a given time horizon under normal market conditions at a given confidence level.

Market risk may be described as the potential profit or loss for a portfolio that is left unchanged over a period of  $h$  days. The formula for the change in portfolio value is

$$\Delta_h P_t = P_{t+h} - P_t \quad (4.14)$$

where  $P$  is the price of the portfolio on day  $t$  (Alexander 2001). A  $100(1-\alpha)\%$   $h$ -period value at risk measure is the nominal amount  $C$  such that

$$\text{Prob}(\Delta P < -C) = \alpha \quad (4.15)$$

where  $\Delta P$  denotes the change in portfolio value over a prespecified holding period  $h$ , and  $\alpha$  is a sufficiently small probability (Alexander, 2001).

There are several methods for computing VaR, with the parametric method being amongst the most common. In this method the VaR is largely determined by the volatility of the portfolio returns over the holding period where volatility is measured by standard deviation. The standard deviation is multiplied by the  $Z$ -value for the selected confidence level and the initial portfolio dollar amount to arrive at a dollar value. This dollar value is the VaR of the portfolio for the chosen confidence level.

The formula for parametric VaR is

$$\text{VaR}_{\alpha,h} = Z_{\alpha} \sigma_t - \mu_t. \quad (4.16)$$

where  $Z_\alpha$  percentile of the standard normal density,  $\sigma_t$  is the standard deviation of the portfolio and  $\mu_t$  is the expected portfolio return over the holding period. Given that monthly prices approximately follow a random walk the assumption is that  $\mu=0$ . Since  $Z_\alpha$  is the constant given by the choice of statistical distribution, it becomes  $\sigma_t$  that determines the VaR (Alexander 2001).

Volatility is estimated using the exponentially weighted moving average (EWMA) suggested by JP Morgan Risk Metrics<sup>TM</sup>. The EWMA is expressed as

$$\sigma_t^2 = \lambda\sigma_{s,t-1}^2 + (1 - \lambda)r_{s,t-1}^2 \quad (4.17)$$

where  $\lambda$  is the weight given to the previous day's volatility estimate and  $(1-\lambda)$  is the weight given to the previous day's return. The aim of this approach is to better capture recent changes in volatility than what would be measured in an equally weighted measure of standard deviation. JP Morgan Risk Metrics<sup>TM</sup> suggests a decay factor of 0.97 when forecasting monthly volatility.

The VaR will be calculated at the 90 percent level for the unhedged and hedged positions for each individual crop and for the portfolio of crops, with a lower VaR calculation implying lower downside risk.

Summary of methods:

To summarize, a hedging analysis will be performed on the revenue per acre for both the individual crops and for the portfolio of crops for hard red spring wheat, soybeans, canola and corn in Manitoba. This includes an unhedged position, a naïve hedge and a simple hedge ratio for each crop, with the portfolio returns also considering hedge ratios calculated based on a multivariate basis. This will provide insight into how an unhedged portfolio of crops compares to both the unhedged and hedged returns for each individual crop on their own, and the extent to which the variability of the portfolio revenues might be reduced with lower hedge ratios, which in turn lowers the cost of hedging.

In addition, a semivariance and VaR will be calculated to measure the extent to which hedging reduces significant downside price risk, as well as how much diversification on its own can reduce significant price loss across a farming enterprise, even if the overall variability of returns may not be brought down significantly relative to a hedged position for each individual crop.

## Results

### Reducing Variability of Returns:

One traditional method of measuring risk is the variability of returns. Variability is measured both by mean square error (MSE), which measures the variability of returns relative to expectations, and standard deviation. As expected, the variability of returns per acre for the individual crops went down when a hedge position was established (with the lone exception of corn when using a naïve hedge and the currency was also hedged, where variability increased relative to an unhedged position). How much variability is reduced across the different hedging strategies varies by crop, but the greatest reduction was when a hedge ratio was calculated with the currency hedged. For example, the MSE of hard red spring wheat went from 427.06 for an unhedged position to 32.44 and 31.30 for a naïve hedge and when the hedge was calculated using a hedge ratio, respectively, with the currency hedged. The MSE for soybeans went from 299.14 for the unhedged position to 81.52 for a naïve hedge and 61.83 when a hedge ratio was used. The MSE tended to not decrease by the same amount when the currency was not hedged in most instances (see Table 4.1 for a summary of results for each crop).

The MSE for one acre of the unhedged portfolio of crops was 158.65, well below that for any unhedged individual crop on its own. The MSE for unhedged crops ranged from 243.59 for canola, or 34.9 percent above the portfolio of crops, to 427.06 for hard red spring wheat, which is 62.9 percent above that for the portfolio of crops. This reflects significantly lower variability of returns for unhedged positions when looking at the portfolio of crops rather than at each crop on an individual basis. This perhaps is not

unexpected, although it does verify the fact that there is a notable amount of ‘natural’ risk management that takes place within the context of the farm as a whole, when compared to looking at each individual crop.

When considering hedged positions, variability of returns for individual crops are significantly reduced when hedges are established relative to the unhedged portfolio of crops. The one notable exception is corn, where even a hedged position shows greater variability than the unhedged portfolio of crops. In other words, the MSE for unhedged positions is much lower when considering the portfolio of crops relative to each individual crop, although the hedged positions for individual crops is notably lower than the unhedged portfolio of crops in most instances.

For individual crops, the hedge ratio performs better than the naïve hedge. Given that hedge ratios are below 1 in all cases, this means that producers can reduce their variability of returns at a somewhat lower cost of hedging than a simple naïve hedge, even though the reduction in variability is not dramatic. Of note is that the lowest MSE is for the portfolio of crops when the hedge ratio for each individual crop is used, reflecting some of the ‘portfolio benefit’ of diversification.

Of interest is that the MSE is higher when using the multivariate method for computing the hedge ratio for the portfolio rather than the hedge ratios computed by individual crop. One reason may be the high degree of variability in the price relationships from one year to the next between the individual cash crops, which in turn impacts the calculated hedge ratio for the next season as well as the cash prices to the various futures contracts. Table 4.2 shows the average correlation across the observation period for each of the price relationships, as well as the minimum and maximum correlation for any individual year.

This may be where futures contracts listed in a different country from the cash market exposure, and the subsequent volatility on price relationships from one year to the next, may have an impact on using a multivariate approach to calculating hedge ratios. One might expect variability in cross relationships such as, e.g. cash corn prices and ICE canola futures, given that corn is imported into Manitoba from the US on a net

basis while canola is exported or crushed domestically (average correlation of 0.296, but ranging from -0.457 to 0.826).

However, there is also significant variability in the correlation of price relationships from one year to the next where one might expect more stability. For example, the average correlation between the soybean cash price to the CBOT soybean futures price is 0.800, but the range for a single year is from as low as just 0.373 to as high as 0.991. Cash corn and the CBOT corn futures price correlation is 0.750 across the period, but ranges from 0.213 and 0.960. The range of annual correlations between the cash and futures prices for hard red spring wheat and canola are much narrower.

This has implications for Canadian hedgers. To the extent that price information from previous years is used to determine hedge ratios, the volatility of the price relationships makes this more difficult. This doesn't make hedging ineffective – the MSE is significantly lower for hedged positions than for unhedged positions in most situations – but it does support taking a relatively simple approach to determining hedge positions for Canadian producers, particularly when considering the additional cost of computation and actively managing positions. Table 4.3 shows the different hedge ratios for each crop when calculated on an individual bases and when using a multivariate approach.

*Reducing Downside Risk for the Portfolio of Western Canadian crops:*

For many producers, the goal of hedging may be more focused on the reduction of severe downside price moves rather than managing the variability of returns. Semivariance and value-at-risk (VaR) are two methods that specifically consider downside price risk.

As expected, in all situations a hedge position reduces the semivariance compared to the unhedged position (results shown in Table 4.4). The results also show that semivariance for the unhedged portfolio of crops is lower than for each unhedged individual crop at each of the 2 percent, 3 percent and 5 percent thresholds. For

example, the semivariance for the unhedged portfolio at 2 percent is 26.197, at 3 percent is 12.873 and 5 percent is 1.885. This is not significantly lower than the values for the lowest individual crop, canola, which is 28.629 at 2 percent, 14.422 at 3 percent and 3.385 at 5 percent. The crop with the highest semivariance values is soybeans at 106.823 at 2 percent, 72.971 at 3 percent and 31.012 at 5 percent. The semivariance for hard red spring wheat and corn fall between canola and soybeans at all three threshold levels.

The results are mixed when comparing the semivariance of the unhedged portfolio of crops with the individual crops when they are hedged. The unhedged portfolio has a higher semivariance than hedged positions for hard red spring wheat and canola under each of the individual hedge scenarios considered (naïve hedge and a hedge ratio, both with the currency hedged and unhedged). The unhedged portfolio showed lower semivariance figures at nearly every threshold than the hedged position for corn and soybeans (with the only exceptions being 3 percent semivariance for a naïve and hedge ratio hedge for soybeans with no currency hedged and for corn at the 5 percent threshold using a hedge ratio with the currency hedged). In other words, the diversified unhedged portfolio reduces the frequency of sizeable downside moves more than a hedged position for corn and soybeans, although not as much as a hedged position for hard red spring wheat and canola.

What is also evident is the extent to which significant downside moves are essentially eliminated when looking at the portfolio of crops when they are hedged. There are no instances of monthly losses of 5 percent or 3 percent, while the number of months where losses exceeded 2 percent range from zero to two. In short, even in an unhedged situation, downside losses are lower when viewing the portfolio of crops instead of focusing on each crop individually. Even moderate downside losses are all but eliminated for a portfolio of crops that are hedged.

VaR is the estimate of the maximum downside loss for a specific confidence level under normal market conditions. This study used a 90 percent VaR, which is the estimated maximum loss in 9 out of 10 months. VaR is calculated using the parametric method, which multiplies the calculated portfolio standard deviation by the

accompanying z-value to come up with the maximum loss. The standard deviation was computed using an Exponentially Weighted Moving Average with a decay factor of 0.97. VaR was calculated for the unhedged position, a position with the naïve hedge and a hedge that is calculated using a hedge ratio.

The VaR at the 90 percent level for unhedged positions is lowest for portfolio of crops, at 4.45 percent, compared to any individual crops on their own (the lowest is corn, at 5.13 percent, up to 8.02 percent for hard red spring wheat. Results are shown in Table 4.4 and Figure 4.1). The VaR for hedged positions of individual crops is lower than the unhedged portfolio of crops in all instances but one (a naïve hedge for corn with the currency hedged has a higher VaR than the unhedged portfolio). The most significant reductions in VaR shows up in hard red spring wheat and canola, where the VaR gets cut to less than half in hedges where the currency is also hedged (specifically for hard red spring wheat, since no currency hedge is needed for canola). With the exception of corn, all of the other crops showed the lowest VaR for a hedge where a hedge ratio was used and the currency was also hedged.

#### Summary of Results:

The results show that the MSE for an unhedged portfolio of crops is significantly lower than each crop on its own, reflecting the fact that diversification reduces the variability of returns for a Manitoba farm. The unhedged portfolio shows higher variability than the hedged returns for each individual crop, with the exception of corn. This shows that while diversification reduces variability, on its own it is not more effective than hedging. The lowest variability of returns is when viewing the portfolio of crops, with each crop being hedged based on its own independent hedge ratio, and with the currency also hedged. Using hedge ratios calculated on a multivariate basis didn't reduce variability as much as when using hedge ratios on an individual basis, something that reflects how much the correlations can differ between the various price series from one season to the next.

The unhedged portfolio of crops also reduced the occurrence of downside moves more than each of the unhedged individual crops. In addition, the unhedged portfolio showed a lower semivariance at each of the 2 percent, 3 percent and 5 percent thresholds than either soybeans or corn with a hedge position. This shows that diversification, on its own, can significantly reduce the occurrences of larger losses. And while larger downside losses were reduced for each individual crop when hedging was incorporated, monthly losses in excess of 5 percent and 3 percent were completely eliminated for a hedged portfolio of crops during the observation period, while there were only a couple of instances of losses in excess of 2 percent. This was the case irrespective of the hedging strategy used (naïve hedge or a computed hedge ratio, both with the currency hedged and the currency unhedged). The value-at-risk at the 90 percent level was also lower for the portfolio of crops than the individual crops for unhedged positions, although the reduction was less pronounced when considering hedged positions.

## **Summary**

The Western Canadian agriculture industry faces considerable risk, including price risk. Hedging with futures can be an effective way of managing price risk. It's relevance for Western Canadian agriculture has grown substantially in the past decade due to changes in both the marketing structure for wheat and changes in seeded area. One challenge is that, aside from canola, all futures contracts are listed on U.S.-based exchanges. This increases basis risk, including foreign exchange risk, which in turn can reduce the effectiveness of hedging.

In addition, hedging is often viewed through the lens of a single commodity. However, most farms grow more than one crop. There is a certain amount of 'natural risk management' that comes through the diversification of growing multiple crops. This may also impact the role of using futures contracts for Canadian producers.

The objective of this chapter is to examine the effects of hedging for a Manitoba farm that grows hard red spring wheat, canola, soybeans and corn. It considers the

extent to which diversification on its own may reduce the need for hedging, as well as how effective hedging is for a Manitoba farm given the additional basis risk that comes from most futures contracts being listed on U.S.-based exchanges. Hedge positions are examined using a naïve hedge, a hedge ratio calculated on an individual crop basis, and a hedge ratio computed using a multivariate approach for the crop portfolio as a whole.

Data includes elevator prices for hard red spring wheat, canola, soybeans and corn for Manitoba. Futures prices are taken from the Minneapolis Grain Exchange, ICE futures Canada (formerly the WCE) and the Chicago Board of Trade. Yield estimates are from Statistics Canada.

Monthly returns are analyzed for the 2016/17 to 2019/20 marketing years. Mean square error (MSE) is the measure by which variability of returns was calculated. The expected return is estimated based on the assumption that basis level does not change during the hedge period. Downside risk measures such as semivariance and value-at-risk (VaR) are also examined.

The results showed that diversification on its own is able to substantially reduce the variability of returns relative to each individual crop on its own. However, hedging the individual crops showed a greater reduction in variability than diversification on its own. The greatest reduction in variability came when looking at the portfolio of crops that were hedged, particularly when individual crop hedge ratios were used. Hedging for the portfolio of crops was less effective when hedge ratios were calculated using a multivariate approach rather than computing them on an individual crop basis. This may partially be due to the fact that the price correlations between the various crops, and between the crops and their respective futures contracts, can vary substantially from one season to the next.

The frequency of downside moves was also reduced when looking at the unhedged portfolio of crops rather than each crop unhedged on its own. What is interesting is that the frequency of downside moves for the unhedged portfolio was lower than for hedged positions for soybeans and corn. The frequency of downside moves was lower for a hedged position for hard red spring wheat and canola. In this

sense, an unhedged diversified portfolio of crops is not more effective at reducing variability than the hedged position for individual crops, but it was shown to be more effective in some instances than a hedged position for an individual crop.

The hedged portfolio of crops showed that it all but eliminated any monthly losses below 2 percent (no instances of losses below 5 percent and 3 percent, with only a few instances below 2 percent, irrespective of the hedging ratio used). In other words, the combination of hedging and growing multiple crops on the farm can essentially remove the risk of even moderate downside losses.

The results have important implications for policy makers. There have been increased discussions about the role of government in managing risk in Canadian agriculture. While the conversation is broader than simply price risk, managing losses from downward price moves can be a key part of the wider policy goals. While the fact that most futures contracts are listed on U.S.-based exchanges, which in turn means increased basis risk and greater variability in the price relationships from one year to the next, they are shown to still be very effective for managing risk for Canadian producers.

**Table 4.1. Mean square error (MSE) and Standard Deviation for Monthly Changes in Revenue per Acre for Manitoba Hard Red Spring Wheat, Soybeans, Canola, Corn and a Portfolio of Each Crop Equally Weighted for Positions That Are Unhedged, and Using a Naïve Hedge and Hedge Ratio, with the Currency Both Hedged and Unhedged. The Portfolio Position Includes Hedge Ratios Calculated by Individual Crop and Calculated for the Portfolio as a Whole. The Period is for the Marketing Years from 2016/17 to 2019/20.**

Position						<u>Hedge Ratio for</u>
	<u>Unhedged</u>	<u>Naïve – FX</u> <u>Hedged</u>	<u>Hedge Ratio –</u> <u>Fx Hedged</u>	<u>Naïve – No</u> <u>FX Hedge</u>	<u>Hedge Ratio –</u> <u>No FX Hedge</u>	<u>Portfolio – FX</u> <u>Hedge</u>
Hard Red Spring						
Wheat						
MSE	427.06	32.44	31.30	95.18	119.19	
Std Dev	20.37	5.45	5.34	9.46	10.68	
Soybeans						
MSE	299.14	81.52	61.83	83.44	112.57	
Std Dev	16.52	8.83	7.53	8.84	10.18	
Canola						
MSE	243.59	33.43	30.42			
Std Dev	15.38	5.67	5.42			
Corn						
MSE	334.99	367.88	198.95	220.86	231.20	
Std Dev	17.90	18.63	13.90	14.54	14.99	
Portfolio						
MSE	158.65	30.83	14.00	26.27	39.00	37.60
Std Dev	12.34	5.42	3.69	5.04	6.14	5.98

Note: MSE is calculated based on expected returns, with the expectation that the basis will remain unchanged for the one month hedging period. Results show that the unhedged portfolio of crops has a lower MSE and standard deviation than any single crop on its own. The unhedged portfolio has a higher variability of returns than any single crop that is hedged, with the exception of corn. The lowest variability of returns was for the portfolio of crops when the hedge ratios were estimated individually by crop rather than using a multivariate approach.

**Table 4.2. Correlation Matrix for Cash and Futures Price Relationships with the Correlation for the entire 2013/14 to 2019/20 Marketing Years and Minimum and Maximum Correlation for Individual Years in the Period.**

	<b>Hard Red Spring Wheat</b>	<b>Soybeans</b>	<b>Canola</b>	<b>Corn</b>	<b>Mlps Wheat</b>	<b>CBT Soybean</b>	<b>ICE Canola</b>	<b>CBT Corn</b>
<b>Hard Red Spring Wheat</b>	1	0.311 (0.121, 0.885)	0.585 (0.286, 0.805)	0.161 (-0.453, 0.679)	0.906 (0.841, 0.994)	0.368 (0.071, 0.765)	0.561 (0.384, 0.795)	0.407 (-0.273, 0.754)
<b>Soybeans</b>	0.311 (0.121, 0.885)	1	0.509 (0.211, 0.885)	0.295 (-0.394, 0.838)	0.387 (0.119, 0.839)	0.800 (0.373, 0.991)	0.430 (-0.025, 0.802)	0.508 (0.001, 0.937)
<b>Canola</b>	0.585 (0.286, 0.805)	0.509 (0.211, 0.885)	1	0.228 (-0.458, 0.820)	0.488 (0.270, 0.788)	0.464 (-0.177, 0.847)	0.940 (0.882, 0.965)	0.396 (-0.249, 0.866)
<b>Corn</b>	0.161 (-0.453, 0.679)	0.295 (-0.394, 0.838)	0.228 (-0.458, 0.820)	1	0.256 (-0.512, 0.719)	0.491 (0.029, 0.920)	0.296 (-0.457, 0.826)	0.750 (0.213, 0.960)
<b>Mlps Wheat</b>	0.906 (0.841, 0.994)	0.387 (0.119, 0.839)	0.488 (0.270, 0.788)	0.256 (-0.512, 0.719)	1	0.476 (0.369, 0.867)	0.501 (0.265, 0.759)	0.533 (-0.288, 0.817)
<b>CBT Soybean</b>	0.368 (0.071, 0.765)	0.800 (0.373, 0.991)	0.464 (-0.177, 0.847)	0.491 (0.029, 0.920)	0.476 (0.369, 0.867)	1	0.419 (-0.467, 0.867)	0.706 (0.569, 0.933)
<b>ICE Canola</b>	0.561 (0.384, 0.795)	0.430 (-0.025, 0.802)	0.940 (0.882, 0.965)	0.296 (-0.457, 0.826)	0.501 (0.265, 0.759)	0.419 (-0.467, 0.867)	1	0.396 (-0.384, 0.881)
<b>CBT Corn</b>	0.407 (-0.273, 0.754)	0.508 (0.001, 0.937)	0.396 (-0.249, 0.866)	0.750 (0.213, 0.960)	0.533 (-0.288, 0.817)	0.706 (0.569, 0.933)	0.396 (-0.384, 0.881)	1

Note: Correlations tend to be the highest between a crop and its respective futures contract. Correlations can vary considerably from one season to the next.

**Table 4.3. Hedge Ratios by Crop by Year with the Currency Hedged.**

	<b>Hard Red Spring Wheat</b>	<b>Soybeans</b>	<b>Canola</b>	<b>Corn</b>
<b>2016/17</b>				
Individual	0.901	0.756	0.917	0.566
Multivariate	0.888	1.608	1.692	(0.260)
<b>2017/18</b>				
Individual	0.910	0.772	0.863	0.667
Multivariate	0.724	0.600	0.956	0.704
<b>2018/19</b>				
Individual	0.950	0.778	0.895	0.573
Multivariate	0.860	0.552	0.892	0.780
<b>2019/20</b>				
Individual	0.952	0.749	0.885	0.439
Multivariate	0.772	0.676	0.920	0.696

Note: The hedge ratios are calculated based on the previous three seasons of monthly price changes. The ratios vary within the same season when calculated on an individual crop basis compared to taking the multivariate approach. The biggest difference between the two approaches is in the 2016/17 season, when the multivariate approach suggests a hedge ratio above 1.6 for both soybeans and canola, and a small negative hedge ratio for corn (e.g. actually taking a long futures position instead of a short futures position). This may be reflective of changes in the cash price of corn being negatively correlated to several other prices in some early seasons. The hedge ratios in the following years tended to be not be dramatically different.

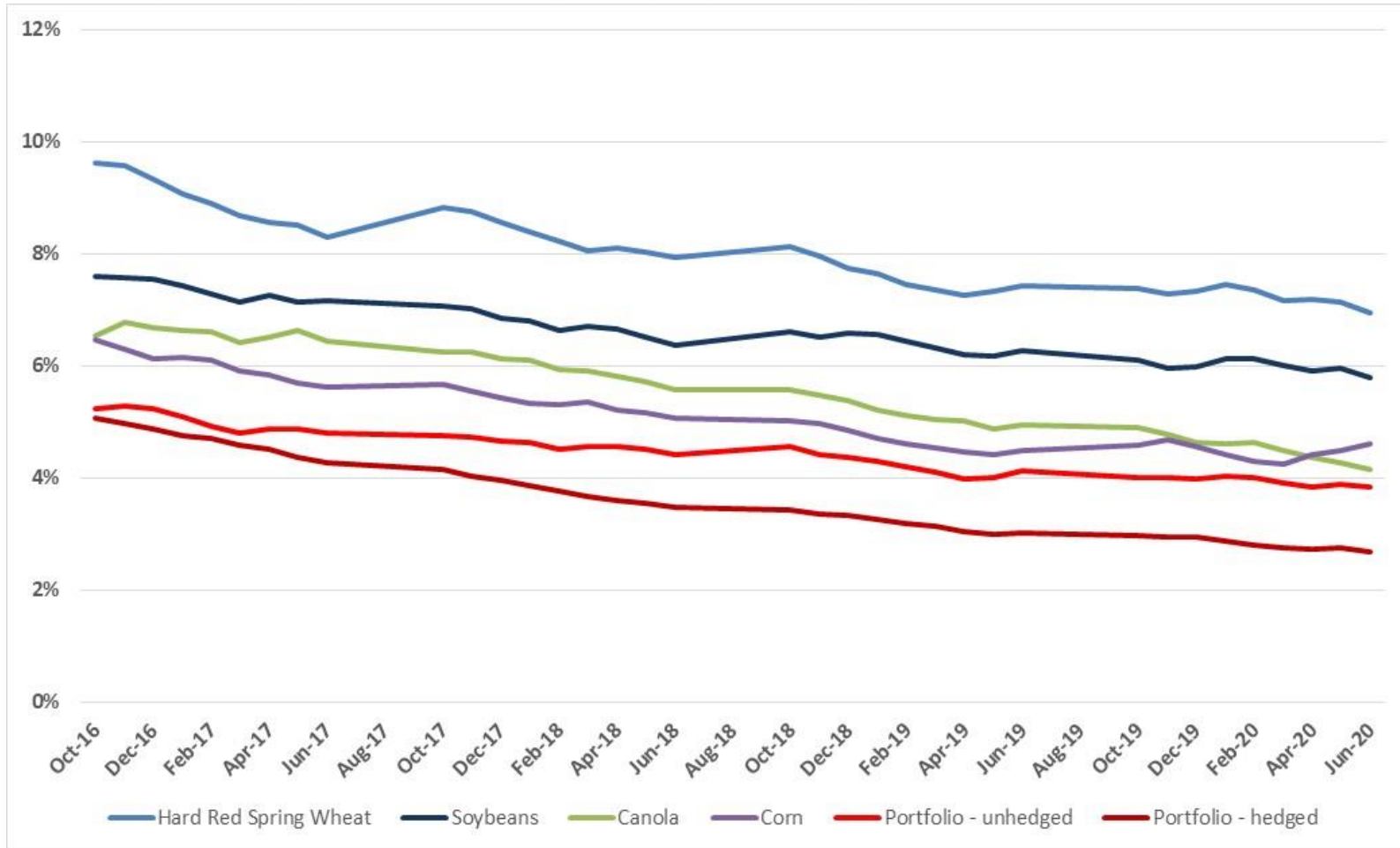
**Table 4.4. Semivariance and VaR for Manitoba Hard Red Spring Wheat, Soybeans, Canola, Corn and a Portfolio of Each Crop Equally Weighted for Positions That Are Unhedged, and Using a Naïve Hedge and Hedge Ratio, with the Currency Both Hedged and Unhedged. The Portfolio Position Includes Hedge Ratios Calculated by Individual Crop and Calculated for the Portfolio as a Whole. The Period is for the Marketing Years from 2016/17 to 2019/20.**

<b>Position</b>	<u>Unhedged</u>	<u>Naïve – FX Hedged</u>	<u>Hedge Ratio – Fx Hedged</u>	<u>Naïve – No FX Hedge</u>	<u>Hedge Ratio – No FX Hedge</u>	<u>Hedge Ratio for Portfolio – FX Hedge</u>
<b>CWRS</b>						
SemiVar 5%	22.084	0.00	0.00	0.00	0.00	
SemiVar 3%	51.480	0.834	0.610	1.557	1.983	
SemiVar 2%	76.641	2.789	2.105	4.471	7.166	
Var 90%	8.02%	3.54%	3.53%	4.06%	4.07%	
<b>Soybeans</b>						
SemiVar 5%	31.012	9.174	7.702	3.061	2.701	
SemiVar 3%	72.971	19.274	15.653	9.471	11.765	
SemiVar 2%	106.823	27.703	22.667	16.783	22.705	
Var 90%	6.62%	4.16%	3.88%	4.36%	4.52%	
<b>Canola</b>						
SemiVar 5%	3.385	0.00	0.00			
SemiVar 3%	14.422	2.233	1.370			
SemiVar 2%	28.639	5.304	4.087			
Var 90%	5.57%	1.84%	1.73%			
<b>Corn</b>						
SemiVar 5%	9.045	17.249	1.032	3.123	3.169	
SemiVar 3%	47.327	41.364	16.185	18.560	25.897	
SemiVar 2%	81.258	62.617	33.767	35.126	50.211	
Var 90%	5.13%	4.68%	4.18%	4.16%	3.67%	
<b>Portfolio</b>						
SemiVar 5%	1.885	0.00	0.00	0.00	0.00	0.00
SemiVar 3%	12.873	0.00	0.00	0.00	0.00	0.142
SemiVar 2%	26.197	0.354	0.00	0.400	0.461	2.213
Var 90%	4.45%	3.62%	3.43%	3.62%	3.74%	3.78%

Note: Semivariance is a measure of downside price risk. The results show that the semivariance is the lowest for the unhedged portfolio of crops relative to any single unhedged crop at each of the 5 percent, 3 percent and 2 percent thresholds. The unhedged portfolio showed a lower semivariance than a hedged position for corn across all hedge scenarios and for soybeans across most thresholds when the currency is hedged. The hedged portfolio of crops essentially eliminated any monthly losses of 5 percent and 3 percent, and only had a few observations where monthly losses exceeded 2 percent.

VaR is an estimate of the maximum downside loss within a specific confidence level. The 90 percent VaR is lower for the unhedged portfolio of crops than for each individual unhedged crop. The effects of the hedge positions on the VaR tend to be more modest than what was shown for semivariance.

**Figure 4.1 Value-at-Risk (VaR) at the 90 Percent Level for Hard Red Spring Wheat, Soybeans, Canola and Corn Prices in Manitoba, and for an Unhedged and Hedged Portfolio with an Equal Weighting of Each Crop from October 2016 to June 2020.**



Note: VaR is an estimate of the maximum downside loss within a specific confidence level. This downside risk is reduced for the portfolio of crops compared to any of the individual crops on their own, with an average VaR at the 90 percent confidence level of 4.45 percent for the portfolio and 8.02 percent for hard red spring wheat, 6.62 percent for soybeans, 5.57 percent for canola and 5.13 percent for corn. The average VaR for the portfolio that is hedged is 3.62 percent.

## **CHAPTER 5**

### **THESIS SUMMARY**

The Western Canadian agriculture industry faces considerable risk for both production and price. Agricultural risk management often uses multiple methods from both government and private industry. Futures and options contracts are one risk management method that is available for a number of crops. But while they are often viewed as being effective for managing price risk, this may be in a ‘narrowly traditional’ perspective. There is less research on the extent to which futures and options contracts might be applied to wider applications, and also the extent of their effectiveness and basis risk when risks in Canada are being hedged using contracts listed on U.S. exchanges.

The question is an important one within the wider discussions about risk management programs for Canadian agriculture. If futures and options can be effectively used more broadly, then these methods may be more confidently incorporated by industry.

This thesis is composed of three essays investigating applications of using futures and options to manage risk in the Western Canadian grain industry. The objective of the first essay, chapter two, was to examine the effectiveness of using futures and options to reduce losses for crop yield insurers. The objective of the second essay, chapter three, was to consider the effectiveness of using futures contracts to manage price risk for a Manitoba wheat producer. The objective of the third essay, chapter four, was to look at the role of futures contracts to manage price risk within a ‘portfolio’ of crops grown on a typical Manitoba farm.

## Testing the Effectiveness of Futures and Options for Reducing Risk for Crop Insurers: The Case for Canola in Manitoba

The objective of chapter two was to examine the potential to use grain futures and options to reduce crop insurance losses for canola in Manitoba, from the perspective of the insurer. Crop insurers face significant risks, with the spatially correlated nature of crop insurance losses increasing the risk insurers face compared to if yields were independent across geographic regions. Additional methods to manage risk for insurers could reduce the potential for catastrophic losses and possibly lead to more efficient pricing of premiums. If a decline in production that coincides with higher indemnities paid to producers also results in higher futures prices, then a long (buying) futures or call option hedge position may offset some of the insurance losses.

Data included premiums and liabilities for canola in Manitoba from 1980 to 2018, canola futures prices from ICE Futures Canada and soybean oil futures prices from the Chicago Board of Trade.

The study considered a long (buying) canola futures hedge, a long (buying) canola call option hedge and a long (buying) canola futures / short (selling) soybean oil futures spread hedge. Any gains or losses from the hedge position were applied to the indemnities paid. Gains in the hedge position result in reducing the net indemnities paid, while losses in the hedge position add to the net indemnities paid. The average loss cost ratio (LCR, which is the ratio of indemnities to liabilities) was compared between an unhedged position and when incorporating the hedging gains or losses from each of the three different hedging strategies.

The first result showed the average LCR over the observation period was higher when incorporating a long canola futures hedge position for Manitoba. Any time that the futures price declined during the observation period, this would result in losses to the portfolio that would not exist in an unhedged position. While this would be expected approximately 50 percent of the time if price changes were assumed to be random, it also happened in some years when it might not have been expected, such as when canola production was below expectations. This caused losses to be increased even in some

years when the LCR was already relatively high. In addition, the long canola futures hedge position showed a higher standard deviation and semivariance at the 9 percent threshold level than the unhedged LCR, indicating that the hedged LCR showed more variability over the observation period as well.

The second result showed that the use of a long canola call option hedge also did not prove to be very effective in managing crop insurance losses. The limited liability of a long option position reduced some instances of the deep hedging losses that resulted in the long futures position hedge in years when futures prices showed sharp declines. However, in most years the increase in the futures price did not exceed the premium paid for the option, which means there were net hedging losses that added to the net indemnities paid. The result is that a hedge using a long call option had the same LCR during the observation period as the unhedged LCR, while having a very slightly higher standard deviation and semivariance, providing essentially no net benefit.

The third result showed that the futures hedge that included a long canola futures position / short soybean oil futures spread position was more effective. The purpose of the short soybean oil portion of the position is to offset the effect of world vegetable oil markets on the canola futures price. Canola price changes are influenced by factors beyond regional production, including the value of global vegetable oil prices. The spread position shows the relative strength of canola futures prices compared to soybean oil futures prices, which may cause hedging gains or losses to more closely reflect canola production increases or decreases from initial expectations by muting the influence of global vegetable oil prices on canola values. For this position the average LCR including hedge adjustments from the spread position were lower than the actual LCR that was not hedged by an average of 0.6 percent (the actual LCR was 8.5 percent compared to 7.9 percent when the spread position was included). The futures spread hedge position showed a higher standard deviation of the LCR than an unhedged position, as well as a modestly higher semivariance.

The overall result is that hedging with canola futures or call options was not shown to be effective in reducing crop insurance losses in Manitoba. Hedging using a spread

position of long canola futures and short soybean oil futures did lower the LCR when compared to the actual LCR, which suggests this might be considered as a risk management method for canola yield crop insurance losses, although this needs to be weighed against the higher standard deviation and modestly higher semivariance.

### Hedging Effectiveness for Canadian Wheat Producers

The objective of chapter three was to examine the effectiveness of using futures contracts to manage price risk for Western Canadian wheat producers. Most hedging research assumes that the producer operates in the same country in which the hedging instrument is based (for example, a corn producer in Illinois using a corn futures contract that trades on the Chicago Board of Trade). However, a Canadian wheat producer using a futures contract in Chicago, Kansas City or Minneapolis that is denominated in U.S. dollars may face increased basis risk and reduced effectiveness to hedge prices.

The risk is not just in the currency, as currency could theoretically be hedged. When the cash market exposure is in a different country than the delivery location of the futures contract there is also the potential for additional variability between cash and futures market price behavior due to factors such as government policy, logistics and trade flows that might affect prices differently in one country than the other. Aside from canola, Canadian producers use futures contracts that are based in the U.S., which potentially increases risk through higher basis risk.

Wheat is particularly unique since, aside from being one of the most important crops grown in Canada, it has most recently traded on an ‘open market’ in Western Canada since 2012. This means that only recently has hedging effectiveness been able to be statistically evaluated based on actual cash prices, rather was done using inferred values from other price series.

Data included average elevator hard red spring wheat prices in Manitoba and North Dakota from 2013 to 2020 and futures prices from the Minneapolis Grain

Exchange. Hedging effectiveness for wheat was analyzed using mean square error, which measures the difference in actual returns relative to expected returns. Downside risk measures of semivariance and value-at-risk are also considered in assessing hedging effectiveness. The chapter also considered the effectiveness of hedging for a Manitoba producer relative to a North Dakota producer.

The results showed that hedging with Minneapolis hard red spring wheat futures substantially reduces the price risk for Manitoba wheat producers. This includes both the variability of returns as well as downside risk measures, specifically semivariance and VaR. The reduction in variability was the greatest when the expectations were for the basis to remain unchanged during the hedge period. When the expected return incorporated a history from previous years the reduction in the mean square error relative to an unhedged position was reduced. This is a reflection of how variable Manitoba basis levels are from one year to the next, and indicates that while price risk can be substantially reduced by hedging, high basis volatility makes the estimation of expected prices much more difficult when looking beyond the current season.

This contrasts with North Dakota hedge results, which also showed more variability when incorporating expectations from previous years, but to a much lesser extent. In other words, there is much greater basis predictability from one year to the next for a North Dakota producer.

#### Managing Price Risk for Western Canadian Grain Producers: How Much Does Simple Diversification Reduce Risk and is Hedging Effective in a Portfolio Context?

The objective of chapter four was to examine managing price risk across an entire grain operation for Western Canadian producers. Hedging with futures and options can often be an effective method of reducing price risk for a number of producers. For Canadian producers, basis risk, including foreign exchange risk, can reduce hedging effectiveness since the futures markets for many North American crops are listed on U.S.-based exchanges. Portfolio theory also points to reduced variability through a diversified collection of assets. Most farms grow more than one crop, which

means there is a certain amount of variance reduction that happens through diversification. This could significantly alter the extent to how futures contracts would be efficiently used by Canadian producers. This study considered how much diversification of the crop mix reduces price risk at the farm level, and whether an efficiently hedged portfolio can further help manage risk at the whole enterprise level for a Canadian farm.

Data included average Manitoba elevator prices for hard red spring wheat, canola, soybeans, and corn, from 2013 to 2020. Futures prices are from ICE Futures Canada for canola, the Minneapolis Grain Exchange for hard red spring wheat and the Chicago Board of Trade for corn and soybeans. Yield data is from Statistics Canada.

Mean square error (MSE) is used to measure how much actual returns vary from projected returns. Comparisons are made for the portfolio of crops relative to each crop on an individual basis for positions that are unhedged, a naïve hedge, hedge ratios calculated on an individual crop basis and a hedge ratio calculated for the portfolio of crops. In some cases producers may be more concerned about adverse outcomes rather than minimizing the variance of returns. For this reason downside risk measures will also be considered for the portfolio, including semivariance and value-at-risk.

The study looked at revenue per acre for a Manitoba farm for the 2013/14 to 2019/20 marketing years, that grows an equal area of canola, hard red spring wheat, corn, and soybeans, which would act as a reasonable proxy for a crop rotation in the province.

The results showed that diversification on its own is able to substantially reduce the variability of returns relative to each individual crop. However, also hedging the individual crops showed a greater reduction in variability than diversification on its own. The greatest reduction in variability came when looking at the portfolio of crops that were hedged, particularly when individual crop hedge ratios were used. Hedging for the portfolio of crops was less effective when hedge ratios were calculated using a multivariate approach rather than computing them on an individual crop basis. This may partially be due to the fact that the price correlations between the various crops in

Manitoba, and between the crops and their respective futures contracts, can vary substantially from one season to the next.

The frequency of downside moves was also reduced when looking at the unhedged portfolio of crops rather than each crop unhedged on its own. It is interesting that the frequency of downside moves for the unhedged portfolio were lower than for hedged positions for soybeans and corn. The frequency of downside moves was lower for a hedged position for hard red spring wheat and canola. In this sense, an unhedged diversified portfolio of crops is not more effective at reducing variability than the hedged position for individual crops, but it was shown to be more effective in some instances than a hedged position for an individual crop.

The hedged portfolio of crops showed to all but eliminate any monthly losses below 2 percent (no instances of losses below 5 percent and 3 percent, with only a few instances below 2 percent, irrespective of the hedging ratio used). In other words, the combination of hedging and growing multiple crops on the farm may essentially remove the risk of even moderate downside losses.

In summary, the hedging results from this thesis provide an interesting initial examination of the various hedging topics. However, some caution should be kept in mind regarding results as a somewhat limited number of years of data were available for specific analysis, such as the wheat producer hedging analysis. Also, prices may behave differently in the future than in the observation period used here, and so this is not the final word on the topics presented here. At the same time, this analysis should be useful to analysts and policy makers in further understanding the potential role of hedging by producers in Western Canadian agricultural risk management.

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