BENEFITS AND COSTS OF HEDGING THE CAD/USD EXCHANGE RATE AND ITS EFFECT ON MITIGATING CWB WHEAT POOL ACCOUNT DEFICIT PROBABILITIES

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By

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ABSTRACT

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Benefits and costs of hedging the CAD/USD exchange rate and its effect on mitigating CWB wheat pool account deficit probabilities.
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The CWB has the stated objective of increasing producer returns through maximizing sales revenue and minimizing operating costs. To maximize producer returns the CWB derives value from single-desk selling, price pooling and the initial price guarantee.

The initial price allows the CWB to offer a price floor to producers which is guaranteed by the Federal government. This guarantee has come under review in recent World Trade Organization (WTO) negotiations with opponents stating that the Federal government is unfairly subsidizing producers. Therefore developing methods to hedge the initial payment and remove the CWB dependency on the Federal government guarantee has taken on considerable importance.

Hedging the initial price has two components, the first is commodity risk, and the second is currency risk. Commodity risk basically consists of the risk that wheat prices decrease significantly from the announcement of the initial payment resulting in a wheat pool account deficit. Currency risk relates to the risk of the Canadian dollar (CAD) increasing vis-à-vis the United States dollar (USD) resulting in lower wheat prices. This is due to the fact most sales are made in USD, necessitating the conversion of USD for CAD in order to pay Canadian producers. Given recent increases in exchange rate volatility this later risk is important.

The goal of this study is to evaluate the currency risk present in the initial payment and to examine alternate means of mitigating this risk. A number of call option strategies will be evaluated to determine its ability to reduce the probability of a wheat pool account deficit by offsetting the effect of a rising CAD.

The policy variables analyzed in the thesis are the initial payment as a percentage of the Pool Return Outlook for wheat and the strike price of the call options purchased. Therefore the study will examine the effect of inputting varying initial payment levels and different strike prices for the call options in the model. This will allow for quantifiable insight into cost versus risk reduction comparisons. These comparisons will be useful in determining the most efficient mode of action for the CWB.

ACKNOWLEDGEMENTS

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CHAPTER ONE

Introduction

1.1 Background

The Canadian Wheat Board (CWB) is the single desk seller of wheat and barley produced by western Canadian farmers destined for export markets and for domestic human consumption in designated areas of Canada. The CWB has the stated objective of increasing producer returns through maximizing sales revenue and minimizing operating costs. Three main facets of the CWB from which producers derive value are single-desk selling, price pooling and the initial price guarantee (CWB[3], 2003).

The initial price allows the CWB to offer a price floor to producers which is guaranteed by the Federal government. This guarantee has come under review in recent World Trade Organization (WTO) negotiations with opponents stating that the Federal government is unfairly subsidizing producers. Therefore developing methods to hedge the initial payment and essentially remove the CWB dependency on the Federal government backing of the initial price has taken on considerable importance.

Hedging the initial price has two components, the first is commodity risk, and the second is currency risk. Commodity risk basically consists of the risk that wheat prices decrease significantly from the announcement of the initial payment resulting in a wheat pool account deficit. Currency risk relates to the risk of the Canadian dollar (CAD) increasing vis-à-vis the United States dollar (USD) resulting in lower wheat prices. This is due to the fact most sales are made in USD, necessitating the conversion of USD for CAD in order to pay Canadian producers.

In theory hedging commodity and currency risk can be accomplished through the use of futures and/or options contracts. Shorting wheat futures contracts will protect the price of wheat when the hedge is initiated. However this strategy is unable to hedge the exact initial price set by the CWB. A more accurate method of hedging the initial payment would be the use of wheat put options. The main problem with this strategy is the limited availability of traded put options at the initial payment level. For these and other reasons, to be discussed further in Chapter two, hedging commodity risk will be given minimal attention. Call options will allow for the flexibility to hedge a particular exchange rate, offering the most efficient and effective means of reducing increases in the CAD and minimizing the probability of a wheat pool account deficit.

1.2 Need for the study

Previous research has evaluated the value western Canadian producers receive through the initial payment guarantee. Unterschultz and Novak, (1997) concluded this implicit subsidy was negligible and not a major contributor to market distortions. Alternative means of protecting the initial payment have not been evaluated in the academic literature perhaps due to the Federal government backing of the initial payment guarantee. However recent WTO trade talks have resulted in the slating of government financing, the underwriting of losses, and future monopoly powers of the CWB up for negotiation. This has resulted in the need to examine methods of protecting the initial payment in event the Federal government guarantee is used as a concession for trading with other nations. This study looks at ways the CWB can hedge the currency risk inherent in offering the initial price for wheat. The study will consequently map out

various currency strategies depicting a cost versus deficit reduction matrix for the CWB to consider in event the Federal government backing of the initial payment is abolished. There is an inherent trade off between the risk reduction and the cost of the strategy. The most effective strategy can correspondingly be implemented to mitigate exchange rate risk within the initial payment and therefore minimize the probability of a wheat pool account deficit.

1.3 Problem statement

Uncertainty surrounding the fate of the CWB initial payment guarantee in WTO negotiations has stimulated a need to develop alternative means of protecting the initial payment for wheat. Pool account deficits occur when the average CAD price for wheat falls below a previously announced initial payment level. Declines in CAD wheat sale revenue occur when the USD price of grain falls and/or the CAD appreciates vis-à-vis the USD. Given recent increases in exchange rate volatility this later risk is important. Therefore means of managing the exchange rate risk associated with the initial payment requires careful analysis of expected net returns and the risk of future pool account deficits.

1.4 Objectives

The goal of this study is to evaluate the currency risk present in the initial payment and to examine alternate means of mitigating this risk. A number of call option strategies will be evaluated to determine its ability to reduce the probability of a wheat pool account deficit by offsetting the effect of a rising Canadian dollar.

This will include examining the effect of inputting varying initial payment levels and different strike prices for the call option in the model. This will allow for quantifiable insight into cost versus risk reduction comparisons. These comparisons will be useful in determining the most efficient mode of action for the CWB.

1.5 Organization of thesis

Chapter two contains a detailed look into the relevant literature surrounding the CWB and its monopoly position in wheat and barley procurement. The chapter also outlines various measures to hedge both commodity and currency risk explaining each measures suitability. Lastly it gives a brief introduction into the model used to simulate pool account deficits.

Chapter three goes into detail explaining the conceptual framework for estimating the costs and impacts of implementing the currency hedge. The chapter explains how the benefits of the options hedge work to decrease the probability of a pool account deficit and how the options premiums are calculated. The simulation model components, inputs and policy variables are evaluated to give the reader a better idea of how the information from the model will be used to evaluate current and future risk management policy.

Chapter four introduces the simulation model used to calculate wheat pool account deficit probabilities. This chapter delves into explaining how the wheat and exchange rate equations are calculated and implemented into the Monte Carlo simulation model. Chapter four is more technical in nature and evaluates how each input is calculated in the model and used to generate deficit probabilities. Deficit probabilities are simulated for a base scenario in order to generate a benchmark for the study. From this

benchmark wheat and exchange rate volatility are adjusted along with call option strike prices in order to generate a sensitivity analysis. The results allow policy measures to be made by considering initial payment levels and call option strike prices in order to derive a balance between option outlays and deficit protection from adverse exchange rate movements.

Chapter five concludes with recommendations and conclusions from the simulation results and potential policy actions for the CWB to consider. The chapter also outlines future research considerations and limitations of the study.

CHAPTER TWO

Review of relevant literature

2.1 CWB overview

According to the CWB[3] (2003), single-desk selling allows the CWB to brand Canadian wheat, allowing for premiums to be captured for providing customers with consistent quality and quantity. It also prevents firms or individuals from competing for sales and bidding away potential premiums. Benefits are also derived from having negotiation leverage when dealing with buyers and services from grain companies and rail lines. This feature also allows farmers to benefit from market development and new varieties as a result of investment in product development (CWB[3], 2003).

Price pooling allows farmers to receive the same price for their grain regardless of when it is delivered in the crop year. This study will look primarily at the wheat pool account as it is the largest and commands the most attention should a deficit arise. Within the CWB, revenue from grain sales is deposited into five pool accounts wheat, durum wheat, designated barley; feed barley pool A and B (CWB[3], 2003). All applicable classes, grades, and protein levels are placed into each pool as individual sales are made. Price differentials are tracked between each class/grade/protein level to determine a final pooled "selling price" for each class/grade/protein level.

A major change was made to feed barley in 2005 when two feed barley pooling periods were created in order to give farmers enhanced price signals throughout the year. The creation of two pools also improves the CWB's ability to source deliveries when sales opportunities arise (CWB[4], 2008). The pool is closed when all grain delivered

within the respective crop year is sold (Unterschultz and Novak, 1997). More recently, the single desk for export feed barley was removed by Order in Council. This action was later reversed by a court decision, with the two single desk pooling accounts remaining in effect as of December 2008.

For each pool account the initial payment provided to prairie farmers is guaranteed by the Federal government. Hence if the final pool realized return is less than the initial payment, farmers do not have to pay back the difference. The initial payment can be seen as a specialized put option[1] with an exercise price equal to the initial payment provided by Canadian taxpayers to western Canadian farmers (Unterschultz and Novak, 1997). As grain sales are made during the crop year, and the demand/supply makeup becomes clearer, upward adjustments and interim payments can be made to the initial payment up until the final payment is issued (Unterschultz and Novak, 1997).

2.2 CWB deficits

Although pool account deficits do not happen regularly its occurrence stirs up contentious debate from wheat producers around the world, especially from the United States. The most recent deficit occurred in the crop year 2002/03 when wheat pool account had a deficit of $85.4 million. The deficit resulted from a number of factors including a late harvested and drought reduced crop, market share gained by usually insignificant exporters and the surge in the CAD vis-à-vis the USD. The CAD rose by almost 19% compared to the USD over the six months following January 2003, beginning at $0.63 USD/CAD and reaching a high of $0.749 USD/CAD in mid June

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[1] Put option – Allows the buyer the right to sell an asset by a certain date for a certain price (Hull, 1991).

(Bank of Canada, 2008). This increase substantially reduced wheat selling prices for the CWB and was a major contributor to the deficit which shortly followed (CWB[1], 2003).

The previous CWB deficit occurred in the crop year 1990/91 where a deficit near $675 million was realized.[2] Contributing factors include the increased use of export subsidies by the European Union and export programs undertaken by the US announced after the initial payment was set. Also during this time export markets were lost to the Middle East as a result of the Gulf War. Lower wheat prices followed which forced the CWB to sell at below initial payment levels (CBC, 2002). The deficit of 1985/86 was also due to the US Export Enhancement Plan, which resulted in the initial payment & following adjustment payments falling short of the final sales number by approximately $23 million. The crop year 1938/39 produced a deficit of $61.5 million. This deficit was mainly due to the initial payment being set well above realistic open market expectations. Strong political lobbying pressured the federal government to set the initial payment well above market expectations, full knowing a deficit would ensue. During this period a dual market structure prevailed, allowing producers to deliver to the CWB or the open market. As a result of the initial payment being at such a premium to the open market, farmers delivered all of their grain to the CWB. A similar result occurred during the crop year 1935/36 where a CWB deficit of $12 million occurred. Dual marketing allowed farmers to deliver at the open market price when it exceeded the initial payment, and vise versa when the initial payment exceeded the open market price. This lead to 70% of deliveries going to the CWB, which had to sell the crop at market prices below the initial payment

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[2] It could be argued that the CWB deficit stemming from a higher initial payment level than final selling price would have been picked up by the CFIP/CAIS program to some degree due to overall lower wheat sales revenue for producers.

received by farmers (CWB[2], 2003). Below is a table which summarizes the deficits incurred by the CWB.

Table 2.1 - History of CWB deficits: 1976/77 to 2003/04

	Wheat	Durum	Barley	Designated barley	Oats	Total
2002/03	$85,388,000					$85,388,000
1990/91	$673,375,352	$69,612,457	$956,713			$743,944,522
1988/89					$32,361,239	$32,361,239
1986/87			$92,543,884	$17,970,279		$110,514,163
1985/86	$22,944,777		$171,370,689		$6,919,810	$201,235,276
1982/83			$5,544,235			$5,544,235
1981/82					$2,291,454	$2,291,454
1979/80					$778,942	$778,942
1977-79					$4,779,376	$4,779,376
Total	**$781,708,129**	**$69,612,457**	**$270,415,521**	**$17,970,279**	**$47,130,821**	**$1,186,837,207**

Source: Alta Ag. Food & Rural Dev., Economic & Competitiveness Unit: CWB Government Guarantees 2006.

History has shown that CWB deficits do occur but are quite infrequent. In the table above durum, barley, designated barley, and oats have had previous deficits however when compared to the wheat pool account the deficits become less of an issue. Therefore the wheat pool is the account that will receive the attention for the remainder of the study when considering protecting the initial price through currency hedging. Past deficits primarily were a result of the dual market and foreign policy changes, and not from exchange rate risk. However recent USD/CAD exchange rate fluctuations have proven that hedging the CAD is a task not to be overlooked.

2.3 CWB and WTO negotiations

Opponents of the initial payment guarantee state that the Federal government is unfairly subsidizing producers (WTO, 2004). In recent World Trade Organization (WTO) trade talks the Canadian government's initial payment guarantee has come to the forefront in discussions as part of an effort to eliminate export subsidies. In a package of framework and other agreements approved by all 147 WTO members, government financing and underwriting of losses, as well as future rules governing monopoly powers will be subject to negotiation. Referring to state trading enterprises the framework reads:

"Trade distorting practices with respect to export state trading enterprises including eliminating export subsidies provided to or by them, government financing, and the underwriting or losses. The issue of the future use of monopoly powers will be subject to further negotiation" (WTO, 2004).

This could result in a loss of the initial price guarantee provided by the Federal government to the CWB. The initial price guarantee is a significant part of the value the CWB provides farmers. In the event the government guarantee is banished, means of continuing to provide a price floor commands careful consideration.

In comparison the Australian Wheat Board (AWB) discontinued underwriting initial payments to growers in 1999. The Australian government now guarantees a percentage of AWB borrowings for its operations (NFU, 2002). The AWB is now a publicly traded company which offers producers various programs, from the ability to select the timing of grain sales, hedge currency risk, and others providing producers with enhanced flexibility.

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Although the initial payment guarantee is a highly contentious issue revolving around the CWB, a number of other factors are at play which adds to the mix (Wilson and Dahl, 2002). Claims of special privileges and protections which give the CWB unfair advantages in grain marketing include:

1. Government borrowing at reduced rates and export credit extensions
2. Price pooling
3. Lack of price transparency
4. Preferential transportation legislation and regulations
5. Non-tariff import barriers

In addition to the above claims, it is argued by the U.S. that the CWB is able to enter long-term credit sales risk free due to its supply monopoly on Canadian wheat. The CWB also has the ability to call supplies at anytime without having to consider market signals or prices (Wilson and Dahl, 2002). Commercial firms do not have the ability to offer extended credit sales over the long-term due to supply uncertainty.

The CWB is able to borrow money at the lowest interest rate available due to Federal government backing (Wilson and Dahl, 2002). The money is used for daily operational activities as well as to lend money to farmers and pay them up front for grain not already sold. The CWB has minimal assets to use as collateral for the substantial amount of funds it requires, therefore necessitating Federal backing of loaned funds.

Lack of transparency has many interpretations but basically refers to the lack of full disclosure of the cost and pricing structure undertaken by the CWB. The ability of the CWB to pool grain allows for special pricing flexibilities and market power not otherwise available to other commercial grain firms. Price pooling also contributes to the lack of transparency; however various studies examining this issue have mixed views of whether

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transparency or lack thereof actually contributes to trade distortions (Wilson and Dahl, 2002). Schmitz and Furtan found that if the CWB were to be replaced by multinationals, no greater transparency would result. They argue that the U.S. futures markets are what world grain prices are based on. These markets are fundamentally linked to local cash markets throughout the world. Accordingly these price relationships are what traders and State Trading Enterprises (STE) base their decisions on (Wilson and Dahl, 2002).

U.S opponents of the CWB argue that certain discriminating rules and regulations are in place which results in non-tariff barriers against US imported wheat (Schnepf, 2004). The Canada Grains Act states that imported wheat cannot be mixed with domestic wheat within the elevator system. Canadian law also caps the revenue that railroads can generate on the shipment of domestic grain but not on imported grain. Hence, shipping fees for imported grain have the potential to be above or below that charged for domestic grain. Domestic grain also has preferred treatment to imported grain during the allocation of government owned rail cars (Schnepf, 2004). While these policies may have discriminatory components to them neither is directly related to the CWB, or the CWB Act.

The above factors including the initial price guarantee are ever pressing issues faced by the CWB. Each allegation of such requires careful attention to ensure the CWB operates within the guidelines set out during WTO negotiations. The initial price guarantee and methods to ensure its viability however will command the attention of this study.

2.4 Futures hedging

Hedging in agricultural markets is a well known phenomenon and is described in many text books. The brief overview provide below is a summary of the material in Blank, Carter, and Schmiesing (1991), which provides a very good overview of the theory and practice of agricultural hedging.

Hedging the initial payment requires attention to both commodity and foreign exchange risk. Hedging refers to the simultaneous holding of a position in the futures/options market while planning to sell or purchase the physical commodity (Blank, Carter, and Schmiesing, 1991). The theory is that the two positions offset each other essentially locking in a value with a high probability of certainty (Blank, Carter, and Schmiesing, 1991).

A futures contract is an agreement to buy or sell a particular asset, commodity, currency at a certain price at a certain time in the future. Futures' hedging requires a margin account to initiate the hedge which the broker holds as security in event the position is in a losing situation. A long hedge refers to the purchasing of a futures contract typically to reduce price uncertainty when a commodity needs to be purchased in the future. If the price of the commodity increases from the time the contract is purchased and the time the physical commodity is bought the increase in value of the futures contract offsets the higher price paid for the physical commodity at the going spot rate. This results in the actualized price paid for the commodity approximately being the going spot rate when the hedge was first initiated (Blank, Carter, and Schmiesing, 1991).

A short hedge is typically initiated when an individual is long i.e. has a commitment to sell a product, in the physical commodity and wishes to sell a futures

contract for an upcoming time period to lock in a profit. If the commodity in question declines in value, the futures portion of the hedge will profit from the ability to purchase the futures contract at a lower price than was paid. This will offset the decrease in value from having to sell the physical commodity at a lower price than was available when the hedge was first initiated (Blank, Carter, and Schmiesing, 1991).

Both the previous hedging examples assume that the basis remains constant throughout the hedge. The basis most simply put is the difference between the futures and spot price. Economists sometimes refer to it as 'time and place' utility. It represents time value of money, transportation costs, interest, and varying local demand/supply situations. Essentially when an individual initiates a futures hedge, price risk is substituted for basis risk. If the basis widens i.e. becomes larger, a short hedger will lose some of the effectiveness of the hedge. Conversely, a long hedger will gain from the widening of the basis and end up with an actualized selling price greater than anticipated (Blank, Carter, and Schmiesing, 1991).

2.5 Options hedging

Hull, (1991) describes the use of futures options to reduce price risk. Options markets and futures options markets are another outlet with which hedging positions can be initiated. An options contract represents the underlying asset where an options futures contract represents a futures contract on the underlying asset. Option hedging comes closer to providing traditional price insurance than futures markets; derived from the fact a floor or ceiling price can be established through their use. A call option is the right, but not the obligation, to buy an asset/commodity/currency at a specific price before a certain

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end date. A put option gives the holder the right, but not the obligation, to sell an asset/commodity/currency by a certain date for a specific price. This is opposed to futures contracts where the holder has the obligation to either deliver or accept delivery of the underlying asset. American options can be exercised anytime up until the expiration date, while European options can only be exercised on the expiration date (Hull, 1991).

When an individual purchases a call option, the buyer expects the futures price to rise, profiting from the difference between the asset price and exercise price. Call options are used for hedging purposes to protect the individual from prices above the strike price, essentially providing a price ceiling. A put option on the other hand is purchased when the buyer expects the price to fall, or to provide protection from decreasing prices by establishing a price floor. The seller or writer of an option receives a premium, which is paid by the buyer for the right to control one futures contract.

The premium of an option is determined by the supply/demand situation for the option for a specific time. The premium is affected by many factors including (Blank, Carter, and Schmiesing, 1991):

1. The relationship of the strike price to the underlying futures price
2. The time remaining until the option expires
3. The volatility of the price of the underlying futures contract
4. Interest rate levels

When an options exercise price is equal to the spot price the option is trading "at-the-money", if the option has intrinsic value and time value it is known as trading "in-the-money", and when an option has no intrinsic value, and only time value it is known as "out-of-the-money". Intrinsic value can be defined as the value the option has if exercised immediately or the amount the option is trading in-the-money. Time value is the premium

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buyers are willing to pay for the expectation that the underlying asset will favorably change increasing the value of the option to a profitable level. An options time value decreases as the expiration date nears, resulting in only intrinsic value remaining when the option expires (Blank, Carter, and Schmiesing, 1991).

As a rule the more volatile the underlying asset, the greater the option premium is. This is due to the fact the option has an increased chance of taking on intrinsic value sometime before the expiration date. Sellers of options take on more risk by writing options with greater volatility and therefore insist on greater time values. Interest rates theoretically have the effect of reducing option premiums. This stems from the fact the premium paid from buyers generate increased returns for writers due to higher interest rates. The time value of the premium increases for option buyers theoretically resulting in their demand for lower premiums. However, research shows that in actual market operations, the effect of interest rates on option premiums is negligible (Blank, Carter, and Schmiesing, 1991).

The purchaser of an option can do either one of two things during the life of the option. Assuming the option is American the buyer can sell it early and receive the market value of the option net of transaction costs. The buyer can also choose to exercise the option and enter a futures contract or purchase the underlying asset, assuming a call, or sell a futures contract or underlying asset if the option is a put. An individual enters the futures market through exercising the option, where the individual can either sell/buy futures to close out their position or accept/make delivery of the underlying futures asset. It should be noted that only a small percentage of futures/option contracts are exercised,

however the threat of this action is ultimately what drives the futures and spot price together, net of the basis (Atkin, 1989).

When hedging with options an important factor to consider is the options delta. The delta measures the responsiveness of the option premium to the underlying futures contract. Delta values usually depend on the extent to which the option is "in" or "out-of-the- money". Deep "in-the-money" options usually have values close to 1 meaning that there is a one-to-one ratio between the underlying futures and the option premium. Deep "out-of-the-money" options have a delta value close to zero. This is due to the fact there is no intrinsic value within the option only time value. Options "at-the-money" have delta values near 0.5, resulting in the option value adjusting approximately half the underlying futures move. Therefore when hedging with options a greater amount of coverage may be needed than a one-to-one ratio in order to effectively mitigate adverse price swings in the futures market (Blank, Carter, and Schmiesing, 1991).

An example where option hedging was attempted in the market was the Cattle Options Pilot Project (COPP). The COPP was a program allowing producers to purchase a put option combining live cattle futures and the CAD/USD exchange rate all in one option at a premium less than if the two were purchased separately. The project was brought on due to the fact market premiums for options on cattle futures and CAD/USD exchange rates were higher than the real market value of the options. Therefore the COPP allowed producers finishing cattle to hedge their risk at a reduced premium (Karantininis, McNinch, and Brown, 1997).

2.6 Option valuation

Means of valuing option premiums include the Black-Scholes option pricing formula and Monte Carlo simulation. In 1973 Fischer Black and Myron Scholes discovered a major breakthrough in the valuation of options. Their formula can be used to price European call and put options on non-dividend paying stocks. The basic premise behind the option pricing formula is that a risk-less portfolio can be set up from an appropriate amount of stock and options. The gain/loss in the stock exactly offsets the gain/loss in the option resulting in the value of the portfolio over a short period of time being known with certainty. The mathematical-economic model can be used to price options on futures contracts as well as options on physical commodities. The main difference being futures contracts do not pay dividends while stocks can pay dividends (Hull, 2002).

Through adjusting the original model for pricing European options on non-dividend paying stock, the formula can be used to cover European options on a stock paying a known continuous dividend yield. The formula can also be adjusted to value foreign currency, due to the fact it is analogous of a stock paying a known dividend yield. Owners of foreign currency receive a risk free interest rate on their money, which in this case is equal to the dividend yield (Hull, 2002).

The assumptions made by Black and Scholes when they first developed their option pricing formula include (Hull, 1991):

1. Stock price behavior is lognormal
2. No transaction costs or taxes, securities are perfectly divisible
3. No dividends on the stock during the life of the option
4. No arbitrage opportunities
5. Security trading is continuous

6. Investors can borrow or lend at the same risk-free rate of interest

7. Short-term risk-free rate of interest is constant

These assumptions allowed Black and Scholes to develop a formula to value options. Over time some of these assumptions have been relaxed. Such as permitting the rate of interest and volatility to be functions of time and allowing dividends to be taken into account (Hull, 1991). When developing an option pricing model assumptions must be made involving price movements over time. The most common assumption is that prices follow a random walk[3], implying that prices at any future time follow a lognormal distribution. Lognormally distributed variables are restricted to being positive, with a skewed distribution, unlike the symmetrical normal distribution (Hull, 1991).

A second, more general method to value options is through Monte Carlo simulation. Monte Carlo simulation charts numerous courses for exchange rates to follow. From this distribution of exchange rates the expected payoff distribution is determined which is then discounted at the risk free rate. The flexibility of Monte Carlo to incorporate alternative assumptions about price movements and the nature of the contracts, allows it to examine a wider range of possibilities relative to the highly structured Black Scholes formulation (Hull, 2002).

In this thesis valuing option premiums and consequent payoffs will be pursed by way of Monte Carlo simulation allowing for the direct measurement of deficit probabilities. This methodology also aids in modeling compatibility considering wheat prices and exchange rates will also be simulated with Monte Carlo (Hull, 2002).

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[3] Random walk implies that proportional changes in prices over a short period of time are normally distributed. The process is also known as geometric Brownian motion (Hull, 1991).

2.7 Forward hedging

Forward contracts are a third means with which hedging can be facilitated. A forward contract is less flexible than futures or option markets in that it calls for the purchase or sale of an asset at a certain time for a specific price. Forward contracts are not traded on an exchange; therefore they can not be traded to a third party in order to close out a position like futures contracts. Forward contracts do not have to conform to the specification of an exchange; therefore they can be customized to meet the needs of the parties. Forward contracts are also not marked to market like futures contracts. The contracts are settled at the delivery date, at which delivery or final cash settlement takes place (Hull, 1991).

2.8 Commodity risk

Wheat contracts from the Minneapolis Grain Exchange (MGEX) are the closest substitute for CWRS wheat sold by the CWB. Figure 2.1 shows the volume of MGEX spring wheat futures and options volume. The total number of 5000 bushel contracts in August of 2008 was 152,005 which equates to 20.684 million tonnes with an open interest of 36,327 contracts, which is just over 4.94 million tonnes. This volume of open interest in the futures is small compared to the size of the typical CWB CWRS pool account of 12 million tonnes (CWB[4], 2006). The amount of tonnes the CWB would need to hedge may cause distortions and artificial price movements due to the number of contracts needed to properly execute the hedge.

Figure 2.1 also depicts the options volume for the MGEX. In the month of August 2008 the number of contracts trading hands was 2326 representing 316,514 tonnes with

an open interest of 4703 representing 639,968 tonnes. The CWB would need much more

liquidity in the MGEX wheat options market to execute an efficient call hedge.

Figure 2.1 - MGEX futures and options volume

MINNEAPOLIS GRAIN EXCHANGE
Volume and Open Interest
Reported in Contracts
August 2008

| Futures | Contract | Volume | | | | | | Month-End Open Interest | | |
| | | August | | | Year-to-Date | | | | | |
Contract	Unit	2008	2007	Change	2008	2007	Change	2008	2007	Change
Spring Wheat - open outcry	5,000 bu.	45,187	133,974	-66%	404,609	750,562	-46%	36,327	59,146	-39%
Spring Wheat - electronic	5,000 bu.	80,000	50,733	58%	449,237	249,139	80%	---	---	---
Spring Wheat - EFP & EFR transactions	5,000 bu.	26,818	28,624	-6%	116,232	133,366	-13%	---	---	---
Hard Red Spring Wheat Index	5,000 bu.	0	2	-100%	0	2	-100%	0	2	-100%
Hard Red Winter Wheat Index	5,000 bu.	0	6	-100%	0	6	-100%	0	6	-100%
Soft Red Winter Wheat Index	5,000 bu.	0	0	0%	0	0	0%	0	0	0%
National Corn Index - open outcry	5,000 bu.	0	0	0%	0	0	0%	---	----	---
National Corn Index - electronic	5,000 bu.	0	14	-100%	0	18	-100%	0	11	-100%
National Soybean Index	5,000 bu.	0	0	0%	0	0	0%	0	0	0%
TOTAL		152,005	213,353	-29%	970,078	1,133,093	-14%	36,327	59,165	-39%

| Options | Contract | Volume | | | | | | Month-End Open Interest | | |
| | | August | | | Year-to-Date | | | | | |
Contract	Unit	2008	2007	Change	2008	2007	Change	2008	2007	Change
Spring Wheat - open outcry	5,000 bu.	2,321	3,240	-28%	41,322	21,204	95%	4,703	2,356	100%
Spring Wheat - electronic	5,000 bu.	5	0	---	530	1	52900%	---	----	---
Hard Red Spring Wheat Index	5,000 bu.	0	0	0%	0	0	0%	0	0	0%
Hard Red Winter Wheat Index	5,000 bu.	0	0	0%	0	0	0%	0	0	0%
Soft Red Winter Wheat Index	5,000 bu.	0	0	0%	0	0	0%	0	0	0%
National Corn Index - open outcry	5,000 bu.	0	0	0%	0	0	0%	---	----	---
National Corn Index - electronic	5,000 bu.	0	0	0%	0	0	0%	0	0	0%
National Soybean Index	5,000 bu.	0	0	0%	0	0	0%	0	0	0%
TOTAL		2,326	3,240	-28%	41,852	21,205	97%	4,703	2,356	100%

| TOTAL FUTURES AND OPTIONS | Volume | | | | | | Month-End Open Interest | | |
| | August | | | Year-to-Date | | | | | |
	2008	2007	Change	2008	2007	Change	2008	2007	Change
	154,331	216,593	-29%	1,011,930	1,154,298	-12%	41,030	61,521	-33%

Source: Minneapolis Grain Exchange website www.mgex.com. Accessed Dec 1, 2008.

Figure 2.2 depicts the production of wheat by class in the US. In the third column

the estimated production for hard spring wheat is 449,000,000 bushels which is just over

12.2 million tonnes. In the study the expected sales of wheat are 12 million tonnes

resulting in the two being relatively close. Spring wheat in the US accounts for roughly

21% of estimated total wheat production in 2007/08.

Figure 2.2 – US wheat production by class

```
               U.S. Wheat by Class: Supply and Use
=================================================================================
   Year beginning      :  Hard  :  Hard  :  Soft  :        :        :
      June 1           : Winter : Spring :  Red   : White  : Durum  : Total
=================================================================================
2007/08 (estimated)    :                    Million bushels
Beginning stocks       :    165     117      109      44       22       456
Production             :    962     449      358     227       72     2,067
  Supply, total 3/     :  1,127     614      481     280      134     2,635
Domestic use           :    452     240      217      73       83     1,066
Exports                :    538     305      209     170       42     1,264
  Use, total           :    990     546      426     243      125     2,330
Ending stocks, total   :    138      68       55      37        8       306
                       :
2008/09 (projected)    :
Beginning stocks       :    138      68       55      37        8       306
Production             :  1,035     512      614     254       85     2,500
  Supply, total 3/     :  1,174     620      679     300      133     2,905
Domestic use           :    512     244      350     106       89     1,302
Exports                :    455     220      185     120       20     1,000
  Use, total           :    968     464      536     226      109     2,302
  Ending stocks, total :
              November  :    206     156      143      74       24       603
               October  :    216     136      167      64       19       601
=================================================================================
Note: Totals may not add due to rounding.  1/ Marketing year beginning June 1.
2/ Marketing-year weighted average price received by farmers. 3/ Includes
imports.
```

Source: USDA: World Agriculture Supply and Demand Estimates, November 10, 2008. www.usda.com. Accessed Dec 1, 2008.

Given the relative size of the MGEX wheat options market finding traded put options with a strike price near the initial payment will not be plausible in most years. This would make it very difficult for the CWB to adhere to a consistent options hedge of the initial payment. Shorting futures contracts is another alternative with a similar problem of liquidity. Shorting sizeable amounts of futures contracts could move the market, reducing the effectiveness of efficient price discovery and effective hedging. Further contributing to the inadequacy of the short hedge is the brokerage fees and basis risk which can result in an ineffective hedge. For the above reasons hedging the commodity risk within the initial payment will not be able to be hedged away in an

efficient and consistent manner. Therefore the attention of this study will focus on strategies to mitigate the currency risk within the initial payment that being and increase of the CAD vis-à-vis the USD.

2.9 Currency risk

Foreign exchange risk is present in the initial payment due to the fact wheat sales are predominantly paid for in USD (Unterschultz and Novak, 1997). The risk of the CAD increasing is the risk the CWB faces when considering currency hedging. Increases in the CAD, essentially result in lower selling prices for wheat due to losses when USD are converted to CAD. Canadian wheat competes with US wheat in the world market, thus when the CAD rises against the USD, the CWB is forced to reduce its price to compete with US wheat. The CWB estimates that the rise in the CAD in 2002/03 equated to a $12.25 per tonne decrease in the final pool return for wheat. This loss in value across a pool size of slightly less than 8.7 million tones, results in an estimated loss of $106 million. Given that the total wheat pool account deficit in 2002/03 was $85.4 million strongly suggests a need to protect the pool accounts from increases in the CAD (CWB[1], 2003).

Currently the CWB pursues a forward currency hedge of ninety days to secure the exchange of USD for CAD at specified exchange rates. This hedging strategy is used to lock in the CAD value of a sale during the typical ninety day period between when grain is sold and when grain is delivered and payment is received. For the wheat pool account a specific amount of USD is converted to CAD via a forward contract. This allows the CWB to achieve the average exchange rate throughout the year based on when sales are

made versus when payment is received. Rather than hedging the foreign exchange risk of each sale, a specific amount of USD is converted to CAD each business day to achieve an average exchange rate for wheat sales. For the wheat pool account a specific amount of USD is converted to CAD via a forward contract. This ninety day exchange rate strategy however does not protect the pool from persistent longer term increases in the CAD/USD exchange rate when the initial payment is set.

In theory it is possible to protect the initial payment against adverse exchange rate increases during the crop year by hedging for longer periods of time. Purchasing CAD futures contracts will allow revenue to be generated when the CAD rises vis-à-vis the USD, offsetting the reduced amount of CAD that will be received when USD are converted into CAD after wheat sales are made. A long futures hedge essentially protects the CAD/USD exchange rate when the hedge is placed; ensuring the CAD value of the initial payment is protected. A long CAD futures hedge will require a margin account and carries with it the possibility of untimely margin calls in the event of abrupt devaluation.

A call option could also insulate the CWB from a rise in the CAD by effectively establishing a ceiling on the CAD/USD exchange rate. A call option is an option to buy the CAD at a certain exchange rate. When the CAD appreciates the option takes on value because the option owner can exercise the call, essentially buying CAD at a lower price and sell the dollars for more USD after the appreciation of the CAD vis-à-vis the USD. Option contracts can be purchased from an exchange such as the Chicago Mercantile exchange (CME) or Philadelphia Stock Exchange (PHLX), however lack of traded contracts at the desired strike prices and liquidity concerns can prevent a proper hedge to be placed. Figure 2.3 is taken from the CME website showing the volume of call options

for November of this year. It can be seen that the volume of call options is not liquid enough to pursue the highly specialized strategy of hedging the initial payment for the CWB.

"Of the $3.98 trillion daily global turnover, trading in London accounted for around $1.36 trillion, or 34.1% of the total, making London by far the global center for foreign exchange. In second and third places respectively, trading in New York accounted for 16.6%, and Tokyo accounted for 6.0%. In addition to "traditional" turnover, $2.1 trillion was traded in derivatives. Exchange-traded forex futures contracts were introduced in 1972 at the Chicago Mercantile Exchange and are actively traded relative to most other futures contracts. Forex futures volume has grown rapidly in recent years, and accounts for about 7% of the total foreign exchange market volume, or $280 billion per day in futures trading, according to The Wall Street Journal Europe (5/5/06, p. 20) Wikapedia Foreign Exchange Markets"

Figure 2.3 – CME call option volume

Type	Strike/Price	Last	NetChg	Open	High	Low	Close	Settle	Prior Settle	Hi/Lo Limit	ETS Vol.	Updated
200812	-	0.8451	0.0126	0.8285	0.8454	0.8245	0.8285	0.8325	0.8325	999.9999 0.0000	33392	01:51:39 pm 11/03/2008
CALL	8250	0.0238	0.0045	-	-	-	-	0.0193	-	999.9999 -9.9999	-	01:47:17 pm 11/03/2008
CALL	8300	0.0205	0.0041	-	-	-	-	0.0164	-	999.9999 -9.9999	-	01:47:17 pm 11/03/2008
CALL	8350	0.0173	0.0036	-	0.0085	0.0085	-	0.0137	-	999.9999 -9.9999	2	01:47:17 pm 11/03/2008
CALL	8400	0.0150	0.0036	-	0.0150	-	-	0.0114	-	999.9999 -9.9999	56	01:50:48 pm 11/03/2008
CALL	8450	-	-	-	-	-	-	-	-	-	-	-

Source: CWE website. www.cme.com. Accessed November 3, 2008.

The CWB could investigate the possibility of a call option using an "over the counter" exchange (OTC). An OTC contract is usually between two financial institutions or a financial institution and a corporate client. An advantage of OTC exchange is that the strike price and delivery date can be customized to meet the exact needs of the hedging party. However using this alternative is more costly than regular option markets due to the fact the financial institution writing the option commands a profit and incurs extra costs from conducting its own hedging activities to mitigate risks from writing contracts (Blank, Carter, and Schmiesing, 1991).

2.10 Monte Carlo Simulation

The cost and effects of financial instruments are often evaluated using a Monte Carlo analysis. Simulation of a stochastic process using a Monte Carlo approach is a procedure for sampling random outcomes for the process. A path for the asset price can be simulated by sampling the price change in each period from a lognormal distribution. While conditional probabilities and resulting values can sometimes be derived analytically if the problem is straightforward and enough assumptions are made, this is not feasible for many realistic situations. Fortunately, outcome and values can be easily derived numerically from Monte Carlo simulations for much more complex assumptions.

The Monte Carlo approach uses random number generators to simulate thousands of equally likely futures involving the price paths for a large number of prices. For each random future it is possible to calculate the implications for sales, call value etc. By averaging over all of the equally likely futures it is possible to calculate expected values, expected payouts etc. Thus Monte Carlo simulation is a very powerful tool for calculating

economic rewards in the presence of random price movements. Fortunately, this technique has become very fast and affordable with the advent of the PC and software to run the simulations.

A Monte Carlo stochastic simulation modeling will be employed in this study allowing for the various call option strategies to be analyzed. The model will be simulated in Microsoft Excel utilizing the program @Risk, which is a Microsoft Excel "add in" program. @Risk, pronounced "at risk", allows for the definition of random variables in an Excel worksheet as probability distributions. The software makes random draws from probability distributions of each exogenous variable included in the model, (in our case exchange rate and wheat price movements) and can calculate expected values and other moments of these distributions etc. Importantly, all cells that are dependant on random variables also become random variables within the spreadsheet. The @Risk program calculates and reports moments from these dependant random variables. The ability to specify payoffs as a function of the random exogenous variables allows for a broad spectrum of potential outcomes to be considered to accurately evaluate the risk and uncertainty of hedging alternatives (@Risk, 2004).

The power of @Risk is that this sampling procedure is conducted in a fast and efficient manner resulting in a distribution for each uncertain variable within the model (Hull, 2002). Moreover the Excel model lays out various sales and hedging scenarios and utilizes @Risk to simulate the model repeatedly so inputs and outputs can be represented by distributions instead of single values. This allows for probabilities to be evaluated and is at the core of evaluating call option deficit mitigation.

CHAPTER THREE

Conceptual framework for estimating the costs and impacts of currency hedging

3.1 Introduction

This chapter describes the wheat pool account deficit concerns for the CWB and methods of mitigating the probability of a deficit by using call option contracts. Chapter three also lays out the economic framework for the stochastic simulation model that will be used for the analysis in chapter 4. As mentioned in chapter 2 the objective of the CWB in the context of this paper is to maximize the expected pool return at each initial payment level for any given level of risk. In order to quantify the effect each option strategy has, the model is run at numerous initial payment levels and option strike prices. In each scenario the probability of a deficit is recorded and compared to an un-hedged scenario to identify how much deficit reduction is attributed to each strategy. Each option strategy also has a premium attributed to it which allows the decision maker to examine the trade off between deficit mitigation and option outlays. This trade off between option outlays and deficit reductions is at the heart of determining which strategy is worth pursuing for the CWB to maximize the expected wheat pool account.

Policy implications surrounding the initial payment revolve around deficit probabilities / WTO implications, and political support from prairie farmers. The higher the CWB sets the initial payment the higher the probability the CWB has of a pool account deficit. CWB pool account deficits attract a great deal of media coverage and further increase anti-State Trading Enterprise (STE) advocates claim that the CWB is a major contributor to market distortions. Conversely the higher the CWB sets the initial

payment the more upfront money prairie farmers receive and consequent political support for the CWB continuing as a single desk seller.

The CWB objective function is to maximize the expected pool return at each initial payment level and option strategy subject to the probability of a deficit being lower than a predetermined probability. In a more detailed explanation the expected value of the pool is equal to the Canadian dollar value of wheat sales plus the call option payoff minus the call option premium. This is subject to the probability the expected value of the pool being less than the initial payment level is not lower than the predetermined allowable percentage chance of a pool account deficit.

The CWB objective function can be expressed in the following equation:

$$Max \ \upsilon(A_{ik}) = \beta(B_{ik}) + \alpha(T_{ik}) - \lambda_{ik} \tag{3.1}$$

Subject to:

$$P(\upsilon(A_{ik}) < d_i) < \varepsilon$$

Where:

$\upsilon(A_{ik})$ = Expected value of pool

$\beta(B_{ik})$ = Canadian dollar sale value of wheat

$\alpha(T_{ik})$ = Call option payoff

λ_{ik} = Call option premium

d_i = Initial payment value of pool

ε = Allowable probability of pool account deficit

i = Initial payment level

k = Call option strike prices

Overall a strategy which leads to the examination of a central playing ground between initial payment levels and option outlays will allow the CWB to effectively mitigate the impact of a rising CAD. This will satisfy prairie farmers because they are receiving as high as possible up front money from the initial payment. This also serves to subdue WTO anti-STE proponents by lowering the percentage chance of a CWB deficit and further concessions required by WTO member countries. The chart below is useful to conceptually see the trade off between each possible strategy.

Table 3.1 – Matrix of possible option premiums and deficit probabilities

IP level	Option premium			% Deficit			
	1	1.05	1.1	1	1.05	1.1	un-hedged
60%	Cost 1	Cost 2	Cost 3	Deficit 1	Deficit 2	Deficit 3	Deficit 4
65%	Cost 4	Cost 5	Cost 6	Deficit 5	Deficit 6	Deficit 7	Deficit 8
70%	Cost 7	Cost 8	Cost 9	Deficit 9	Deficit 10	Deficit 11	Deficit 12
75%	Cost 10	Cost 11	Cost 12	Deficit 13	Deficit 14	Deficit 15	Deficit 16
80%	Cost 13	Cost 14	Cost 15	Deficit 17	Deficit 18	Deficit 19	Deficit 20

Source: Simulation results.

After analyzing table 3.1 it can be seen there are a number of possible policies to consider. As was mentioned before, higher initial payments lead to increased political support from farmers due to increased up front money. This however has an increased probability of a deficit and WTO repercussions. Hedging the CAD with options in-the-money will require larger premiums than similar options slightly out-of-the-money or at-the-money. In the economic framework of this paper option outlays are assumed to be equal to option payoffs. This may not be representative of practical applications and one would have to gauge how much deficit is actually reduced per actual dollar spent on

hedging. If this was not the case option premiums over time would become staggering and this initial payment hedging strategy would quickly lose support.

Another possible strategy is to establish a maximum probability for the pool account deficit and then work backwards to determine the most effective strategy. Under this scenario table 3.1 can be referenced to determine the highest initial payment level without going over the maximum probability of a deficit. It can also be determined whether or not hedging the initial payment can increase the initial payment level without going over the maximum probability of a deficit. Implications of this strategy could result in greater support from prairie farmers because they know the CWB is continually finding ways to pay them more money upfront. This also could have the effect of mitigating WTO concessions due to the fact the CWB has a plan in place to help ensure deficits are minimized.

Assuming correct hedging practices are employed the CWB could have profits associated with the call option hedge. If this happened these funds could be put away in a contingency fund or used for future premiums. The proceeds could also be distributed to producers which could further increase CWB support. Conversely the hedge could result in zero profits. In this scenario the premium paid is essentially the trade off for a reduction in the probability of a deficit. Implications could be uncertainty surrounding the hedging cost because the CWB never needed protection from a rising CAD. It could potentially be difficult to justify to prairie farmers that the premium is a trade off for risk reduction and over time has the potential to mitigate a potential deficit.

3.2 Estimating the cost of the options purchased in each scenario

An important factor in the decision to purchase options to reduce the chance of a pool account deficit is the cost of the options. It is also important that the estimated premiums for options are consistent with the stochastic processes involved and the purchase decisions for each scenario examined. The ability to use historical data to calculate these premiums is limited to situations seen in the past and is of very little use. Fortunately the methodology for valuing options is well established in the literature and is extensively used as a tool for those using them in the market place.

The standard assumption in the finance literature is that options premiums should reflect a risk free interest rate. Risk neutral valuation is one of the most important assumptions for the analysis of derivatives. In a risk neutral world the expected return on all assets is the risk free rate of interest. This is due to the fact investors do not require premiums for taking risks. In a risk neutral world there are no transaction costs involved due to the fact premiums are not required for taking on risk. This means the present value of any cash flow is calculated by discounting the expected value by the risk free rate (Hull, 2002).

By including options as a small portion of a larger portfolio, investors can offset the associated risk of writing the option. Given a risk free rate, investors writing an option earn a premium, which reflects the expected payout of the option. While this assumption of perfect and risk free arbitrage is very strong, one could argue that if returns above the risk free rate were available, investors could arbitrage this advantage away. A more conservative assumption to make is that the options premium should reflect expected payouts, plus transactions costs plus a small risk premium. With this view of the

world, premiums that reflect expected payouts would represent the lower bound of what the market would demand for premiums. Given the practical difficulty in estimating the true market premiums the risk free zero transaction premiums will be used in the analysis, this is a lower bound for actual hedging costs.

The calculation of expected payouts as an estimate of premium cost is straight forward using the @Risk Monte Carlo simulation. In a risk neutral world the expected payoff from an option calculated by Monte Carlo simulation is also the expected cost. Therefore the cost of each option strategy is exactly equal to the expected payoff, the only difference being the payoff is a distribution and the cost is a single value. The Monte Carlo simulation is used to value option premiums by first simulating a course for exchange rates in a risk neutral world, calculating the expected options payoff, and discounting the payoff at the risk free rate. This procedure is carried out many times resulting in a random payoff distribution with the mean representing the expected payoff. Monte Carlo is also used to simulate wheat prices guaranteeing model compatibility (Hull, 2002).

3.3 Calculating wheat pool account deficits

In the absence of purchasing exchange rate options, a deficit will occur in the pool account when the value of sales in CAD net of all other costs is less than the initial payment. The stochastic distribution of sales revenue and pool account deficits can be derived in the @Risk Monte Carlo simulation of wheat prices and exchange rate movements. For each of the 10,000 equally likely futures, sales revenues and pool account balances are calculated. The proportion of these futures where a deficit occurs is

the probability of deficit. The average of the pool deficits represents the expected value of deficit.

The procedure is only slightly more complex when the exchange rates are hedged through the purchase of call options. In this case the distribution of the option payoff minus the premium, added to the distribution of wheat sales results in reduced probabilities of lower values i.e. deficits, regardless of the mean of the payoff and premium being the same (Hull, 2002). This can be represented by the following equation:

$$CAD\ Sales\ (NH) + Call\ payoff - Call\ premium = CAD\ Sales\ (H) \qquad \textbf{(3.2)}$$

Equation 3.2 depicts the intuition behind determining the deficit mitigating effects of call option hedging. In the above formula CAD Sales (NH) represents total CAD sales of wheat with no hedging, and CAD Sales (H) represents wheat sales after the gains or losses of hedging are included. Deficit probabilities are calculated before and after CAD hedging, the difference being the risk reduction gains or losses of CAD call option hedging.

To gain a visual understanding of how deficit probabilities are calculated figure 3.1 depicts CAD wheat sales with and without call option hedging.

Figure 3.1 – CAD wheat sales distribution with hedging (H) and no hedging (NH)
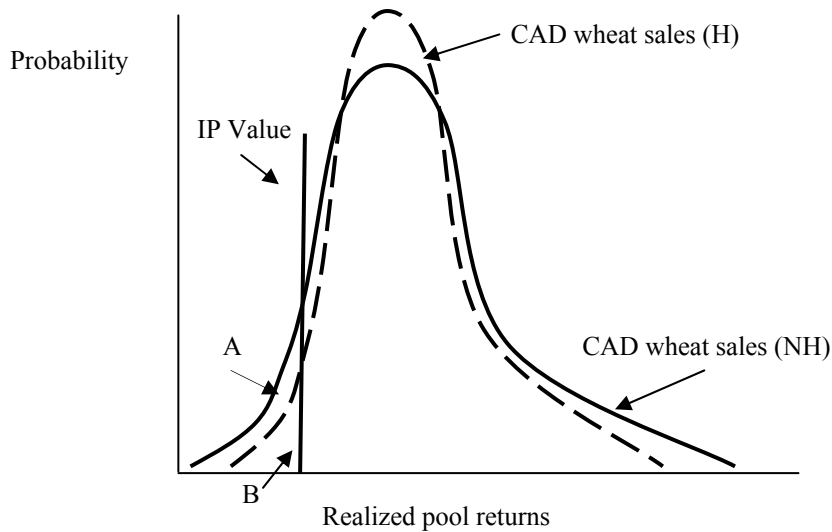
The probability of a deficit with no hedging is A + B, and with hedging it is only

B. It should be noted that every initial payment level corresponds to a different initial

payment value and therefore deficit probability. Also there are various call option

strategies pursued all resulting in varying degrees of reduction in the probability of a

deficit. Therefore the distributions represented in figure 3.1 are only for representation

purposes to illustrate the gains or losses from options hedging.

It should be noted that given the assumptions of a risk neutral world the larger the

payoff/premium the larger the deficit reduction. However outcomes are stochastic and

therefore payoffs and premiums will not equate from year to year but will tend to do so

on average. Moreover, this could result in the CWB forfeiting large option premiums,

expecting a payoff of equal value, only for the CAD to decrease vis-à-vis the USD and

render the call option worthless. With this said the decision maker must determine a

benchmark deficit probability at each initial payment level and feasible premium outlay

to use as insurance against a rise in the CAD. Chapter four contains simulation results

which allow for insight into benchmark deficit probabilities at each initial payment level

and risk/premium analysis of each call option strategy.

3.4 Model components

The model includes a number of uncertain inputs and variables. Variables whose

values have been fixed from the outset include the amount of wheat sold, initial currency

exchange rate, initial USD wheat price, timing of call option purchases and the CWB

August PRO. The length of the crop year is also set from August 1 to July 31 with all

sales and distributions happening in this time frame[4].

Certain variables in the model are of significant policy importance. These include

the initial payment value as a percentage of the August PRO and the exercise price of the

call option relative to the spot price. These policy variables will be evaluated at a range of

levels allowing for numerous scenario combinations to arise. The CWB will be most

interested in which combination mitigates the chance of a deficit while incurring the

minimum expenditure to implement.

3.5 Inputs

The study sources wheat volatility information from the June 2008 FAO food

outlook. In this report it is noted that monthly implied volatility has dramatically

increased in recent years increasing the risk faced by the CWB when setting initial

payment levels. Implied volatility refers to how much the market expects the price of

wheat to move in the future. Implied volatility is seen to be more responsive than

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[4] The CWB may begin sales earlier than August and beyond July 31 however the amounts in these periods
were omitted to simplify modeling.

historical volatility and therefore is more responsive to current market conditions. Because implied volatility cannot be observed it has to be inferred from the price of derivatives such as call options. This information is used to determine an appropriate monthly implied volatility for wheat (FAO, 2008).

To determine CAD/USD exchange rate volatility analysis done by CIBC World Markets on the implied volatility of the CAD/USD exchange rate is analyzed. In the analysis it is found that the current implied volatility has been steadily increasing in past months increasing the risk faced by the CWB when establishing initial price levels and determining strike prices for possible call option hedging (CIBC, 2008).

Both inputs are estimated using Monte Carlo simulation and are simulated for the year starting August 1 and ending July 31. This results in each input having a distribution of possible outcomes. Generating wheat and exchange rate distributions is at the core of determining the probability of a deficit, and hence the amount of deficit reduction achieved by each option strategy.

3.6 Variables

The excel model contains a number of variables whose values have been predetermined. For ease of computation each month of the crop year is allocated a sale of one million tonnes. Intuitively it can be seen that the greatest volatility in exchange rates and wheat prices exist further out in the crop year. Therefore if the crop year is extended past twelve months the increase in uncertainty will result in greater probabilities of deficits. The values can be adjusted to reflect any particular sales pattern but for modeling purposes, sales are assumed to be evenly distributed and totaling twelve million

tonnes. The initial USD wheat price is set at $350 per tonne, combined with an initial

exchange rate of 1 CAD/USD results in the August PRO being $350 Canadian per tonne.

Both initial values can be adjusted to reflect current market conditions at the start of the

crop year. However the values chosen here are an attempt to replicate current conditions

taking into consideration historical values and future expectations.

The timing of call option purchases plays a role in premium calculations in that

the longer the time to expiry the greater the uncertainty and therefore cost. It is assumed

that European OTC contracts are purchased at the outset of the year covering the initial

payment value in question. As far as exchange traded options, the CME or PHLX does

not offer currency option trading every month and may not have enough liquidity to

allow the CWB to carry out the option strategy under consideration. Therefore for ease of

modeling it is assumed that options are purchased at the outset of the crop year from an

over the counter (OTC) financial institution. Thus at the expiry date of the call options on

the CAD contracts will either be in-the-money at which time the CWB will sell them to

offset increases in the CAD or worthless meaning the CAD/USD exchange rate had

decreased. This procedure of purchasing call options and redeeming them at time of

expiry will be carried out between the CWB and OTC financial institution. It assumes no

transaction costs or brokerage fees.

3.7 Policy variables

The model contains two variables which bare significant policy implications. First

is the initial payment as a percentage of the August PRO. The initial payment is the first

money farmers receive for their wheat. Logically the greater the price the more money

farmers have to pay bills and arguably corresponds to greater political support for the

CWB. Bare in mind the higher the initial payment as a percentage of the current price the

greater the probability wheat sales could fall below the initial payment value. The model

will be simulated at varying levels to determine how high the initial payment can be set

without undertaking unnecessary amounts of deficit risk.

Figure 3.2 - Initial payment levels
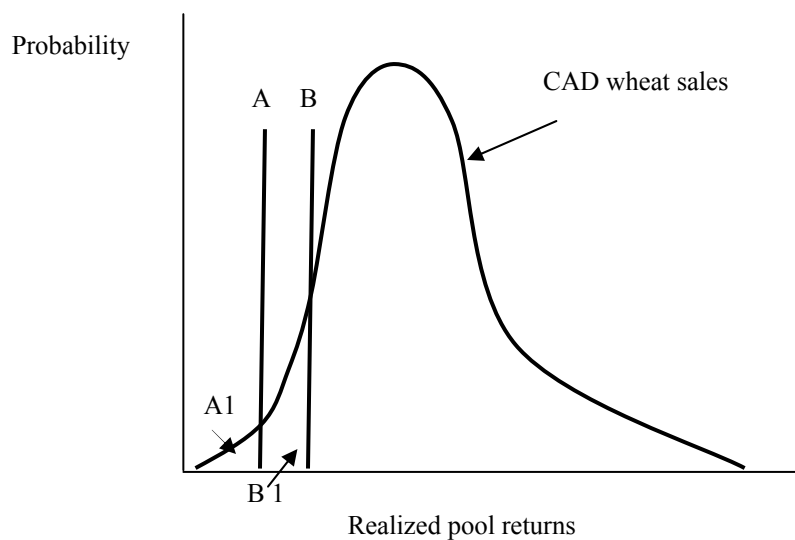
In figure 3.2 the vertical line A represents a low initial payment with a low deficit

probability of A1. The vertical line B represents a high initial payment with a higher

probability of a deficit equal to A1 + B1. Higher initial payments allow for increased

upfront money to farmers; however they also carry with them an increased risk of a

deficit if commodity prices decline or exchange rates suddenly change. To hedge the

CAD risk inherent in initial payment A and B long call option contracts will be

purchased. Due to the higher value inherent with initial payment B more contracts are

needed which result in an increased cost for the hedge. Higher costs lose popularity when

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the hedge is not profitable because producers start thinking the hedge is unnecessary. However having the hedge in place reduces the risk of a deficit over the longer term and ultimately provides increased protection from a pool account deficit and consequent repercussions.

The second parameter is the call exercise price relative to the initial exchange rate. At the outset of the crop year the exchange rate is set at 1 CAD/USD. It can however be adjusted to represent current market conditions and expectations. It is the goal of this study to mitigate exchange rate risk, namely ensure that losses in wheat sales due to exchange rates are minimized to avoid wheat pool account deficits. This will be attempted by simulating the model with strike prices at-the-money and out-of-the-money to determine how much risk can be eliminated and at what cost. Analyzing varying option strike prices is useful due to the fact the greater the contract strike price is out-of-the-money the lower the premium. In theory the higher the risk reduction strategy sought the higher the cost incurred. This also holds true in this scenario as the closer the option strike prices are to the current exchange rate the greater the premium to obtain them. This stems from the fact that options closer to being in-the-money have a higher chance of paying off and therefore premiums to purchase them are higher. The CWB will have to weigh approximate option outlays to corresponding reductions in the probability of a deficit and budget accordingly.

CHAPTER FOUR

The Simulation Model

4.1 Model overview

The goal of the model is to calculate the risk reducing effects of applying call option hedging to the CAD. This is an attempt to reduce the negative effects of a rise in the CAD compared to the USD. The model assumes global wheat prices are denominated in U.S. currency and are highly correlated to wheat prices quoted on the Minneapolis Grain Exchange (MGEX). Currency risk is therefore present when the CWB has to price sales in USD and convert sales money back to Canadian dollars. Hence an increase in the CAD vis-à-vis the USD results in a reduction in the CAD selling price. To mitigate currency risk the model analyzes adjusting the initial payment as a percentage of the August PRO and analyzing various call option strike prices. The initial payment value for the year is subsequently the number of tonnes of wheat sold multiplied by the initial payment per tonne.

4.2 Model structure

The two stochastic exogenous variables in the model are wheat prices and the CAD/USD exchange rate. In chapter three a brief overview of the theory behind Monte Carlo simulation was given. Below is a more in-depth discussion of the formulas and assumptions utilized in order to simulate input values.

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Monte Carlo simulation assumes exchange rates and wheat price behavior follow

a geometric Brownian motion pattern[5]. In this process the return to the holder of an asset

under any period of time is normally distributed. Returns between any two intervals are

therefore independent. Brownian motion has been used in physics to describe the

movement of a particle after it has been exposed to number of small molecular shocks

(Hull, 2002). To illustrate geometric Brownian motion consider figure 4.1.

Figure 4.1 – Graph of two CAD/USD exchange rate paths
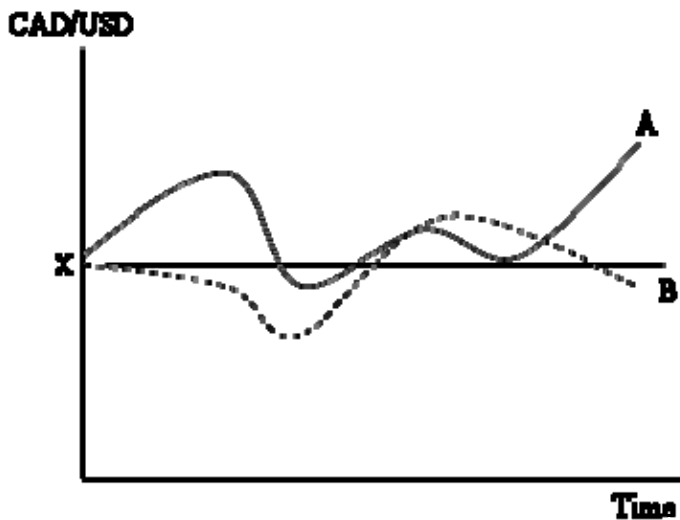
The equation expressing the behavior of wheat prices and exchange rates is identified by:

$$\frac{\partial S_t}{S_t} = \mu\, \partial t + \sigma\, \partial z \qquad\qquad (4.1)$$

Where μ is the per period growth rate and σ is the one period coefficient of

variation in prices and ∂z. In the above equation the natural logarithm of wheat prices and

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[5] Geometric Brownian motion is equivalent and interchangeable with the term random walk (Hull, 1991).

exchange rates ln$S$ follows a Wiener process represented by ∂z . A Wiener process is a stochastic process with a mean change of zero and variance of one per period. More formally the Wiener process ∂z follows two main properties:

1) A change Δz during a small interval of time Δt is expressed $\Delta z = \varepsilon\sqrt{\Delta t}$, where

ε is a random draw from a standard normal distribution, with mean 0 and

standard deviation 1.

2) The values Δz for any two different small time intervals represented by Δt

are independent of one another (Hull, 2002).

The change in S in a small interval of time Δt is equal to:

$$\ln S(t + \Delta t) = \ln S(t) + (\mu - \sigma^2/2)\Delta t + \sigma\varepsilon\sqrt{\Delta t} \tag{4.2}$$

This implies that the logarithm of price or exchange rate takes a random walk, where the log of price one period in the future, $\ln S(t + \Delta t)$, is equal the log of price in the current period, $\ln S(t)$, plus a deterministic time trend $(\mu - \sigma^2/2)$, plus $\sigma\varepsilon$ a normal random variable with mean zero and a variance of σ^2.

This is equivalent to equation 4.3:

$$S(t + \Delta t) = S(t)e^{(\mu - \sigma^2/2)\Delta t + \sigma\varepsilon\sqrt{\Delta t}} \tag{4.3}$$

In the equation 4.3 St is the price of wheat and exchange rate at time t, μ denotes the expected return[6], and σ is the standard deviation. The left hand side of the equation $S(t + \Delta t)$ is the expected value after a change in time Δt. As was mentioned above the stochastic part of the equation is represented by ε, which is a random draw from a normal distribution with mean of zero and standard deviation equal to one (Hull, 2002). In order to properly capture the risk in exchange rates and wheat prices over a twelve month period equation 4.3 is slightly modified to capture the cumulative volatility from month to month as shown in equation 4.4 below.

$$S(t + 2) = S(t + 1)e^{(\mu - \sigma^2/2) + \sigma\varepsilon} = S(t)e^{2(\mu - \sigma^2/2) + \sigma\varepsilon_1 + \sigma\varepsilon_2}$$

(4.4)

In equation 4.4 the numbers one through twelve represent the months August through July. For example when replicating wheat prices or exchange rates for November it would require four draws from a standard normal distribution represented by equation 4.5.

$$\sum_{i=1}^{4} \varepsilon_i = \varepsilon_1(\text{Aug}) + \varepsilon_2(\text{Sept}) + \varepsilon_3(\text{Oct}) + \varepsilon_4(\text{Nov})$$ (4.5)

In the equation 4.2 ln S is normally distributed ensuring $S(t + \Delta t)$ in equation 4.3 has a lognormal[7] distribution. A variable that is lognormal in distribution has a value

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[6] μ equals the risk free interest rate in a risk neutral world. If S represents wheat prices $\mu = r$; for exchange rates $\mu = r - r_f$, where r is the domestic rate, and r_f is the foreign risk-free rate (Hull, 2002).

[7] A random variable x is lognormal if $x = e^y$, where y is normally distributed. Moreover, a random variable is lognormal if its natural logarithm is normally distributed (Hull, 2002).

between zero and infinity, resulting in a skewed distribution to the right hand side. Lognormality is essential for forecasting wheat prices and exchange rates due to the requirement of non-negative values (Hull, 2002).

Drift in mean values in both inputs from month to month is represented by, $e^{(\mu - \sigma^2 / 2)\Delta t}$ which is the expected return minus half the variance multiplied by the change in time raised to the power of "e". The drift is negligible resulting in a near constant mean with the volatility, i.e. standard deviation, increasing by the square root of time. Modeling this way reflects the fact the mean will stay fairly constant; however the volatility increases with each successive month in the crop year. Intuitively it can be seen that later on in the crop year is when there exists the greatest uncertainty and consequent chance of a deficit (Hull, 2002).

4.3 Data and model parameters

As was mentioned in section 4.1 the goal of the model is to mitigate currency risk inherent in wheat sales for the CWB. First USD wheat prices and CAD/USD exchange rates are determined by Monte Carlo simulation creating a probability distribution for each input. The USD wheat price distribution is divided by the exchange rate distribution resulting in a CAD wheat price distribution. The sales price distribution is multiplied by the number of tonnes of wheat sold resulting in a distribution for total CAD wheat sales. In this scenario exchange rate risk is fully present each time USD wheat prices are converted to Canadian currency.

To calculate the call option value the CAD/USD exchange rate distribution is analyzed. Exchange rates are determined through Monte Carlo simulation which assumes

a risk-neutral state. The option value is calculated by taking the payoff from each call option being in-the-money, taking the mean, and discounting the value at the risk free rate. The option payoff is determined by implementing a logical test into the model spreadsheet. The test states that if a value from the exchange rate input distribution is greater then the option strike price it is subtracted from the strike price to get the payoff. If the value from the distribution is not greater than the strike price the test simply concludes with the payoff being zero, meaning that particular path for exchange rates did not end up in-the-money. This creates a payoff distribution consisting of option profits from exchange rates being above the strike price and values of zero if exchange rates fall below the strike price. The option payoff mean is the expected payoff evaluated at a specific call option strike price. Evaluating the payoff over various numbers of iterations will ultimately yield different payoffs. To be as accurate as possible this study evaluates the model over ten thousand iterations ensuring all possible outcomes are properly represented.

To better understand how the model exactly works consider the flow chart below which explains in detail each step of the process to generate wheat pool account deficit probabilities.

4.4 Monte Carlo Simulation flow chart

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1. Set starting values

- Initial wheat price as a percentage of the PRO
- Initial CAD/USD exchange rate
- Call option strike price
- Volatility of wheat prices and CAD/USD exchange rates
- Tonnes of wheat sold per month
- Discount rate of USD and CAD

---

2. Simulate USD wheat prices and CAD/USD exchange rates for each month using the below formula

$$S(t + \Delta t) = S(t)e^{(\mu - \sigma^2/2)\Delta t + \sigma \sum_{i=1}^{T} \varepsilon_i \sqrt{\Delta t}}$$

The stochastic part of the equation is represented by ε_i, which is a random draw from a normal distribution with mean of zero and standard deviation equal to one. The model calculates 10,000 draws for each value of ε_i. Both exchange rates and wheat prices will have twelve 10,000 draws for each value of ε_i, one for each month of the crop year.

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3. Calculate CAD wheat prices

Calculate the CAD wheat price distribution by dividing the distribution of USD wheat prices generated in step 2 by the distribution of CAD/USD exchange rates generated in step 2 for each month of the crop year. This is where the increase in the CAD reduces the final wheat selling price for the CWB.

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4. Calculate the call option payoff from the CAD/USD exchange rate distribution for each month in the crop year

For example in figure 4.2 assume the call option strike price is 1.05 CAD/USD or 1.05 USD = 1 CAD. Anytime the CAD/USD is above 1.05 CAD/USD the option will generate a payoff meaning the CAD increased versus the USD i.e. assume 1 random draw was 1.06 CAD/USD the payoff would be (1.06-1.05 = 0.01), this payoff is multiplied by the initial payment value to get the call value.

i.e. (Call payoff/month) * 70% * ($350/t) * (1M tonnes/month) = call value per month

Figure 4.2 - Call option payoff

Probability

1 CAD/USD

1.05 CAD/USD

Call payoff

Realized pool returns

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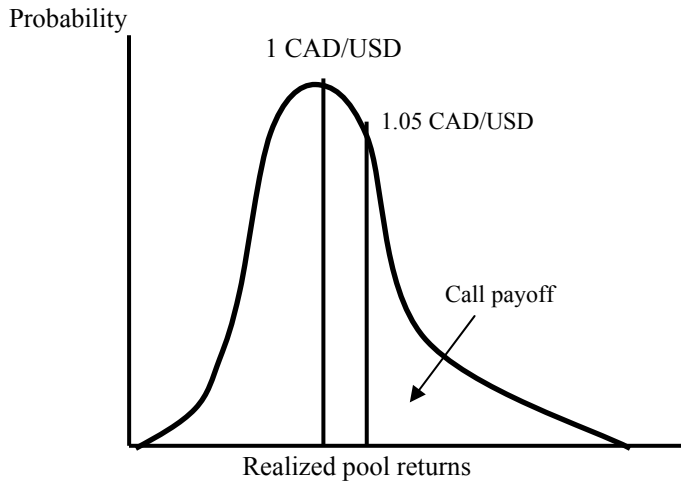
5. Generate the CAD un-hedged wheat sales distribution for each month

This is done by multiplying the wheat price distribution each month by the amount of tonnes sold each month of the crop year

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6. Generate the CAD hedged wheat sales distribution

This is calculated by adding the call option value distribution to the CAD un-hedged (UH) wheat sales distribution and subtracting the mean of the call option value distribution. The call option value _mean_ is the premium paid at the outset of the crop year while the call option value _distribution_ is the expected gains from the hedge. This process is done for each month of the crop year. Note that call option value, CAD wheat sales (UH), and CAD wheat sales hedged are probability distributions while the **call premium** is a single value.

Call option value + CAD wheat sales (UH) – **Call premium** = CAD wheat sales hedged

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7. Determine the probability of a deficit from both the un-hedged and hedged CAD wheat sales distribution

This is done by determining the probability of sales below the initial payment values. The initial payment values are generated by taking the total tonnes of grain sold in the crop year and multiplying it by the initial CAD selling price and again by the initial payment percentage under consideration. For example the initial payment value for 70% would be = 12M tonnes x $350/t x 70% = $2,940M. The graph below visually depicts how this is achieved. The deficit when no hedging of the CAD is in place is A + B and when hedging is pursued only B.

Figure 4.3 - CAD wheat sales deficit probability
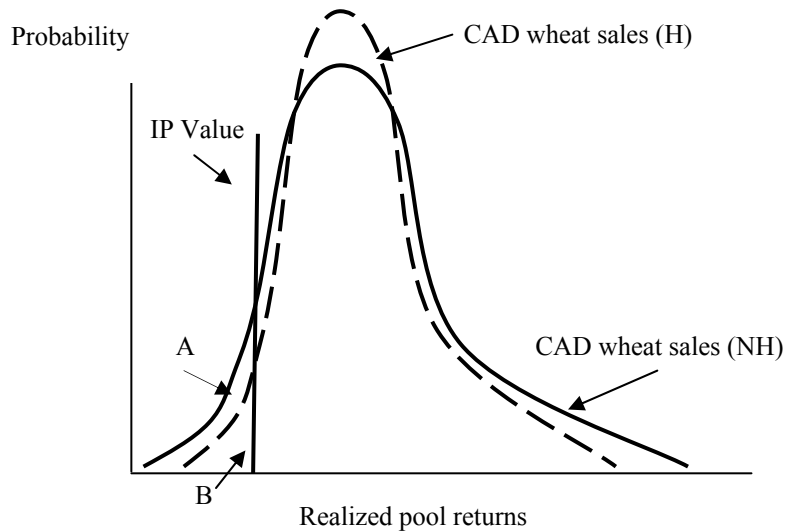
4.5 Simulating deficit reductions

The study evaluates the model with a number of base scenario values in order to generate benchmark probabilities of wheat pool account deficits. From this base scenario wheat price and exchange rate volatility are adjusted as well as the strike price for call option purchases.

For ease of computation the model assumes that options will be purchased at-the-money which is 1 CAD/USD and out-of-the-money at 1.05 and 1.1. In the base case scenario the call options will be purchased at 1.05 CAD/USD which is 5 percent out-of-the money assuming initial parity of the USD and CAD. The model however has the capacity to evaluate deficit calculations at varying exchange rates. The initial price as a percentage of the August PRO is represented by 60%, 65%, 70%, 75% and 80% of the PRO. At each larger initial payment level more call option contracts are needed to protect the value of the initial payment. For use in the base scenario the initial payment as a

percentage of the PRO will be 70% which previous initial payment levels have been approximated.

Overall deficit reductions are determined by evaluating the probability of a deficit under an un-hedged scenario and comparing it to the chance of a deficit with exchange rate hedging in place. Calculation of a deficit is thus the percentage chance total CAD wheat sales are less than the total initial payment value.

The simulation model makes a number of assumptions regarding the data used to produce the results in Appendix A. In a CIBC World Markets strategy paper it is calculated that the implied volatility for the CAD/USD exchange rate has been increasing (CIBC, 2007). Figure 4.4 depicts the three month implied volatility for the CAD/USD exchange rate showing how it has changed over time. In order for the volatility to be inputted into the model the three month volatility is used to approximate a monthly standard deviation. A monthly standard deviation of 3% per month[8] is used to generate the CAD/USD exchange rate probability distribution in the base scenario.

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[8] Monthly implied volatility is determined by taking the third root of the three month implied volatility. If the three month volatility is 9% the one month would be, $y^x = 9^{1/3} = 2.08\%$.

Figure 4.4 – Exchange rate implied volatility

Source: CIBC World Markets: FX Trade Strategy. Data from Jun 4, 2005 – July 26, 2007.
Accessed July 1, 2008.

Wheat volatility was sourced from the Food & Agriculture Organization outlook paper. The paper calculates that recent wheat price volatility is at very high levels (FAO, 2008). Figure 4.5 shows annual and monthly implied volatility.

Figure 4.5 – Wheat price implied volatility
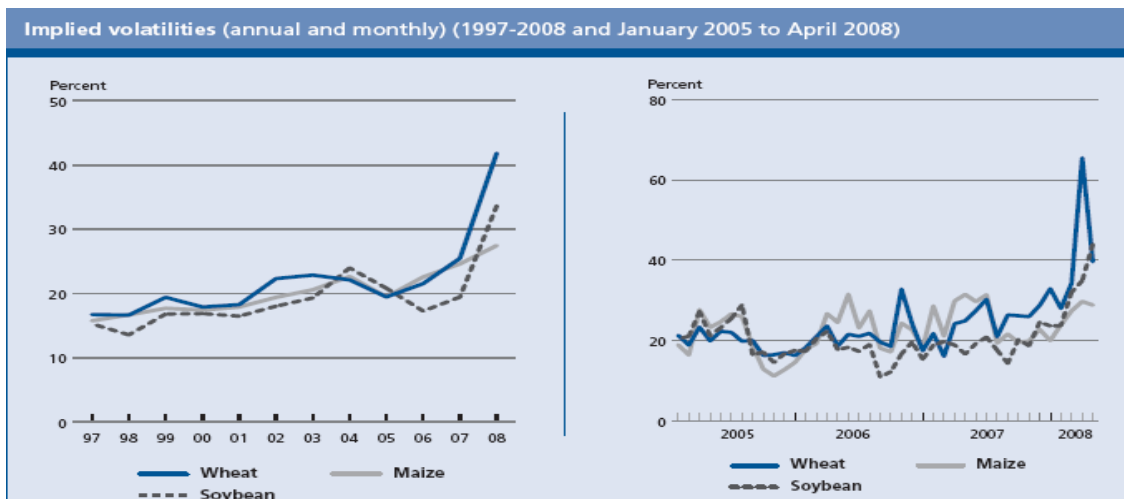
Source: FAO Food Outlook - Global Market Analysis. June 2008. Accessed July 1, 2008.

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The paper graphs annual and monthly wheat volatility depicting a sharp increase in volatility in the first six months of 2008. The simulation model requires monthly volatility which is approximated to be 10% per month in the base scenario simulation. This value is an approximation of current volatility in the wheat market but can be seen to be significantly higher depending on the exact economic factors at play. This high volatility also reiterates how important solid marketing and risk management strategies are to farmer's welfare (FAO, 2008).

Initial wheat prices and exchange rates are inputted in the model as single values and represent current market values at the time of this study. The initial wheat price in USD is $350/tonne and the initial exchange rate is 1 CAD/USD. These values represent approximate current values at the time of this study and will serve well as base scenario inputs into the model. It is assumed that the currency hedge is implemented at the same time as the initial payment in August. The model assumes that no interim or adjustment payments are made throughout the crop year. It is also assumed that if additional payments are made to the pool account, the chance of a deficit is calculated to be very small due to grain already sold by the CWB at higher prices. Wheat sales are assumed to be 1 million tonnes per month for a total of 12 million tonnes representing that the CWB spreads out sales throughout the crop year to obtain an average wheat selling price throughout the year. Table 4.1 lists out the base scenario values described above and used in the Monte Carlo simulation model to calculate the results.

Table 4.1 – Base scenario values

Parameters	Base values
Tonnes of wheat sold per month	1,000,000
Initial wheat price	$350
Monthly standard deviation of wheat prices	10%
Initial exchange rate CAD/USD or USD=CAD	1
Monthly standard deviation of exchange rates	3%

Policy variables	
Percent hedge of initial payment	70%
Call option strike price CAD/USD or USD=CAD	1.05

4.6 Results and sensitivity analysis

This study evaluates the model at the base scenario settings seen in table 4.1 in order to establish a benchmark deficit probability. The model then simulates the initial payment level at 60%, 65%, 75%, and 80% of the PRO in order to capture the probability of a deficit across a range of initial payment levels.

Appendix A.1 to A.4 show a detailed view of the model results in its entirety and will be referenced throughout the remainder of this chapter. Appendix A.1 to A.3 has three tables depicting the results of the simulations allowing important policy objectives to be determined. Appendix A.4 is a sensitivity analysis table where the volatility of exchange rates, volatility of wheat prices and call option strike prices are adjusted to determine the effect on the pool deficit. Note that all call option premiums are considered in the deficit probability results and therefore all costs are accounted for and deficit probabilities are net of call option premiums. The results of the base scenario simulation are captured in figure 4.6 which shows the range of deficit probabilities across the initial payment levels.

Figure 4.6 – Efficiency frontier - Base scenarios
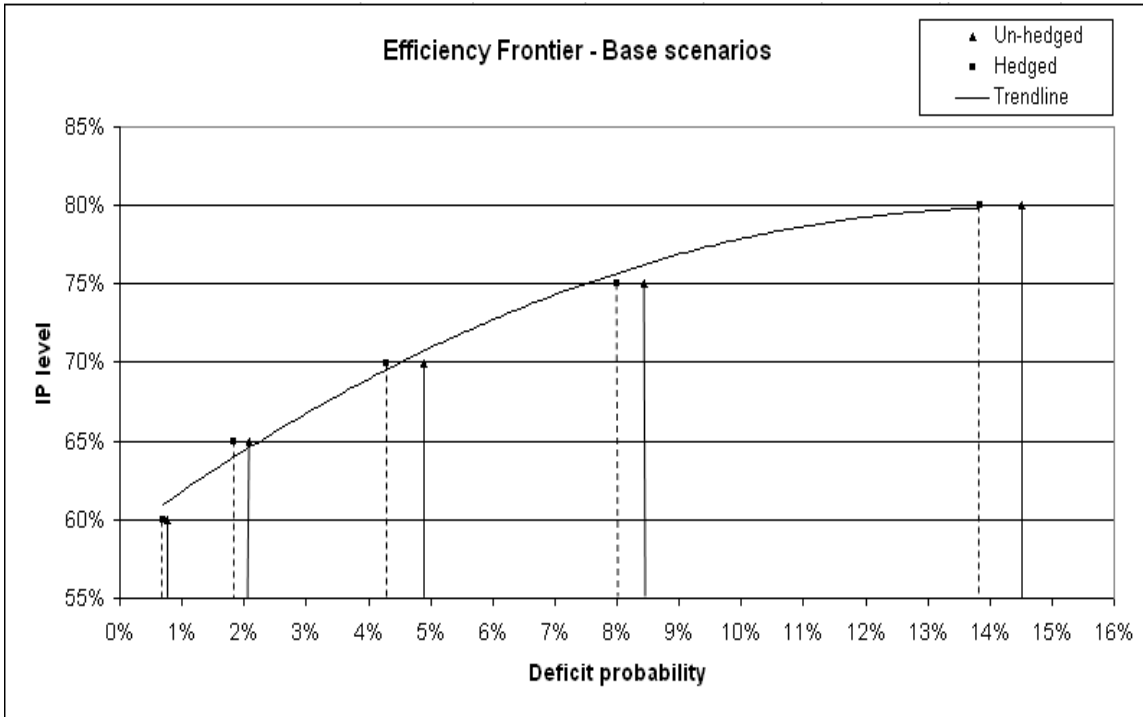
Source: Simulation results.

In the above figure it can be seen that the greater the initial payment level set by the CWB the greater the probability of a deficit. The solid line coming down from each initial payment level represents the deficit when no hedging is undertaken and the dashed line represents the deficit when currency hedging is pursued. This comes as predicted as it is expected that reducing the effect of an increasing CAD would decrease the probability of a deficit. For example consider a 70% initial payment level, under base assumptions the probability of a deficit is 4.89% representing an average dollar deficit of ($10,813,205)[9] and when currency hedging is in place a 4.29% probability of a deficit for an average dollar deficit of ($9,538,920). In this base assumption the option premium for

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[9] The number in parenthesis represents the average dollar value of the pool account deficit.

this hedge is $36,243,985. This decrease in percentage chance of a deficit is attributed to the fact the call option takes on value whenever the CAD increases versus the USD, and adds to the total wheat pool return lowering the risk of a deficit. The graph also shows clearly that as the initial payment level is increased beyond 70% it results in approximately doubling and tripling the probability of a deficit. This coincides well with traditional initial payment levels set by the CWB which range between 60% and 70% of the PRO. Adjusting the initial payment level is an important policy tool for the CWB. If the CWB can increase the initial payment level due to the benefits of currency hedging without increasing a possible deficit they will win substantial political support from producers. This will also bode well during WTO negotiations because the CWB can now reduce their exposure to an increasing CAD and better manage sales revenues.

So far only the base scenario has been evaluated in the simulation model; however it is interesting to see the results when the volatility of wheat and exchange rates are adjusted as well as the call option strike price. Figure 4.7 depicts the deficit probability when the wheat volatility is adjusted from 10% (standard deviation) to 5% and 15%.

Figure 4.7 - Sensitivity analysis adjusting wheat price volatility
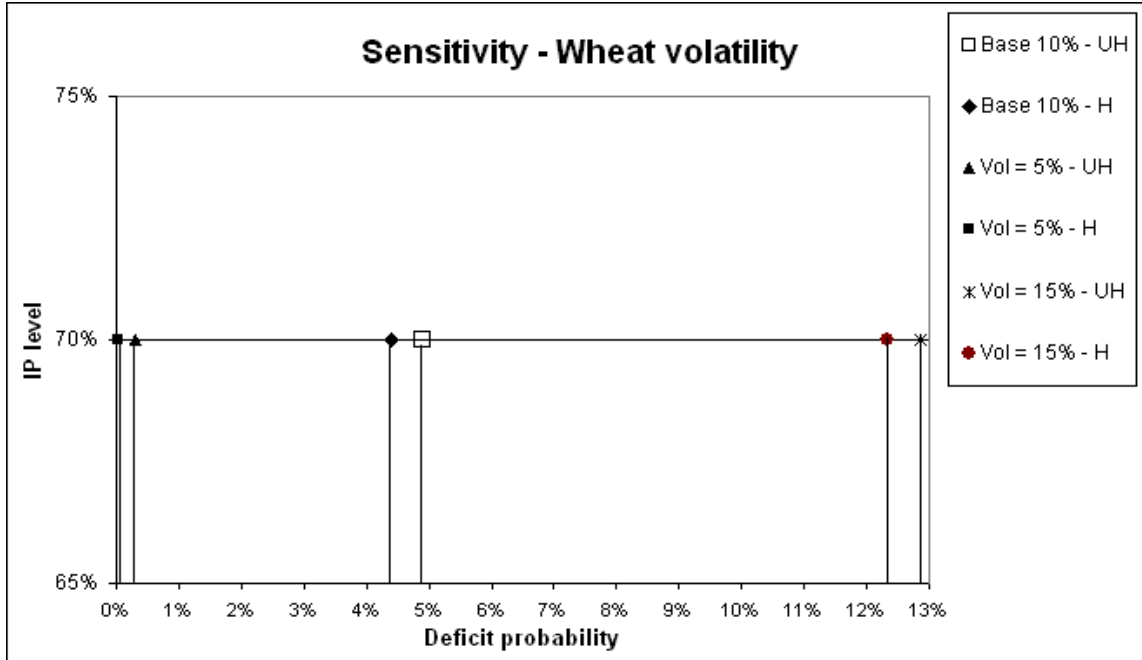
Source: Simulation results.

Figure 4.7 shows that when the wheat price volatility drops off to a 5% standard deviation per month the probability of a deficit is greatly reduced to 0.11% ($104,086) under a no hedge scenario and 0.02% ($19,563) when hedging is present. These numbers are considerably less than the base scenario and basically represent no real chance of a pool account deficit when wheat price volatility is low. However when the volatility is increased to 15% the probability of a deficit rises considerably to 12.86% ($48,200,458) in an un-hedged scenario and 12.33% ($46,269,643) when hedging is present. In both cases the call option premium is $36,243,985. Understanding how an increase in wheat volatility can considerably affect the chance of a deficit reiterates how important the initial payment level is to mitigating the chance of a deficit. For example an increase of

wheat price volatility to 15% has a deficit just short of setting the initial payment level to 80% of the PRO in the base scenario.

Currency volatility however is an important factor when considering the overall sales revenue equation. This can be seen in Figure 4.8 and 4.9 which represents the results of the simulation model when exchange rate volatility is adjusted.

Figure 4.8 – Sensitivity analysis adjusting CAD/USD volatility
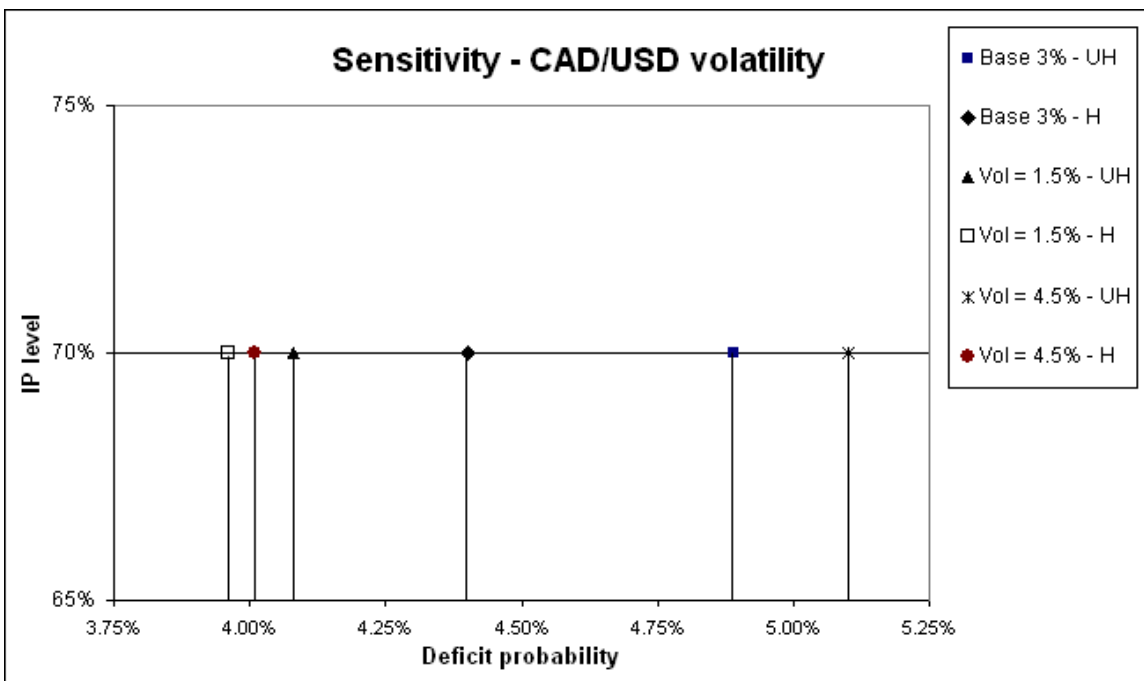
Source: Simulation results.

Figure 4.8 takes into consideration adjusting the exchange rate volatility from 3% to 1.5% and up to 4.5%. This will give a better understanding of the incremental impact exchange rate volatility has on overall deficit probabilities. Consider the base scenario of 3% standard deviation per month, the un-hedged probability of a deficit is 4.89%

($10,813,205) and the hedged deficit probability is 4.29% ($9,538,920) showing a positive response to the call option hedge.

Now consider reducing the volatility to 1.5% per month. When the simulation is run the deficit probability drops to 4.08% ($9,551,490) un-hedged and 3.96% ($8,874,971) when hedging is factored in. Call option premiums are $5,677,571 due to the low risk involved when exchange rate volatility is low. The percentage drop is small due to the large presence wheat price volatility plays in the big picture of wheat pool account deficits.

Figure 4.8 also takes into consideration deficit probabilities when currency volatility rises to 4.5% per month. In this scenario the deficit probability un-hedged is 5.1% ($12,390,497) and 4.01% ($9,383,334) hedged, with a call premium of $68,360,593. In this scenario it can be seen that the spread between the un-hedged and hedged deficit is greater due to the increasing effects of the call option when the exchange rate volatility is high. This increased option benefit is also accompanied with higher premiums due to the volatility of exchange rates and increased chance the option will be in-the-money. Figure 4.9 considers the deficits when the volatility is increased to 6% and 9% and represents high exchange rate volatility.

Figure 4.9 – Sensitivity analysis adjusting CAD/USD volatility

Source: Simulation results.

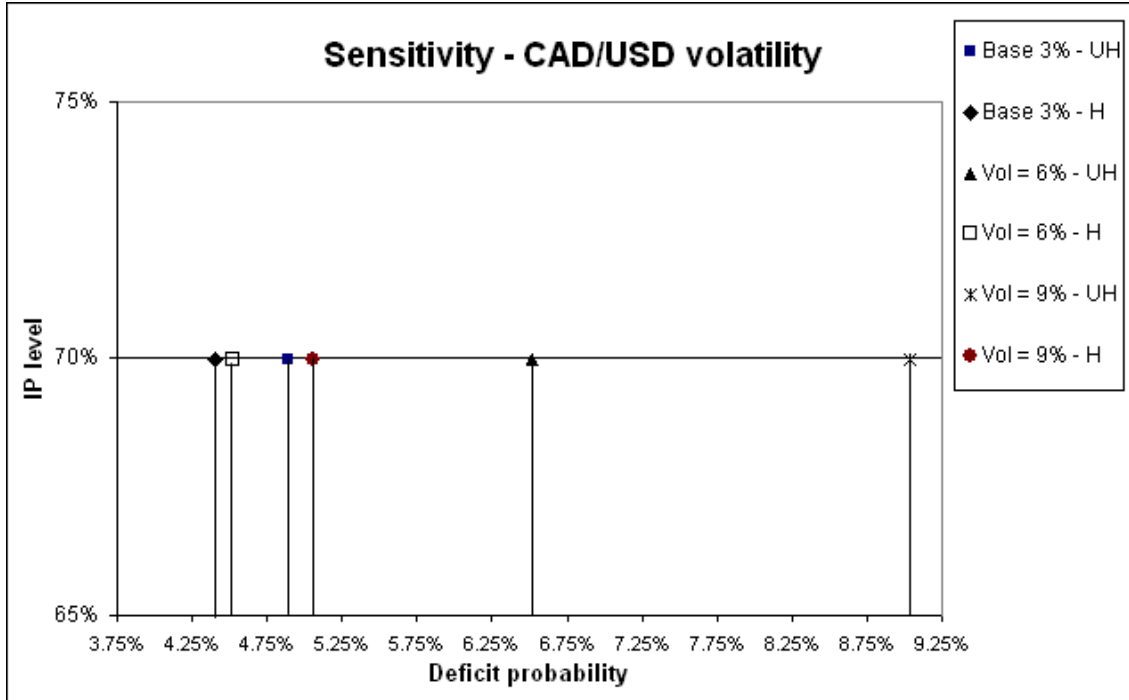In figure 4.9 the effect of increasing exchange rate volatility from 3% (base) to 6% and 9% can be seen. An increase in the exchange rate volatility to 6% results in an un-hedged deficit probability of 6.52% ($17,837,003) and a hedged deficit probability of 4.52% ($10,732,565), for a call premium of $124,590,744. Consider now a volatility of 9% and the un-hedged deficit probability increases to 9.04% ($28,946,441) and 5.06% ($11,694,761) when hedging is in place for a call premium of $230,501,819. Increasing the volatility clearly shows that exchange rate volatility can considerably influence the wheat pool deficit. It also shows how increasingly costly it becomes to hedge exchange rates due to the chance the option will become profitable over time. It is interesting to note that when CAD/USD volatility is 9% the probability of a deficit when hedging is pursued is comparable to the probability of a deficit when no hedging is pursued when

the initial payment is 70% and not far off the deficit under the base scenario when hedging is present. This proves that exchange rate volatility is an important factor contributing to the possibility of wheat pool account deficits. It therefore is prudent to consider its impact and devise strategies to mitigate its adverse effect on the wheat pool account.

So far the wheat price and exchange rate volatility has been adjusted in our sensitivity analysis however it is interesting to see the effect of hedging the exchange rate risk at various strike prices to determine its effect on deficit probabilities. Figure 4.10 takes into consideration the base hedge at 1.05 and evaluates deficit levels at 1 and 1.1 CAD/USD.

Figure 4.10 – Sensitivity analysis adjusting call option strike prices
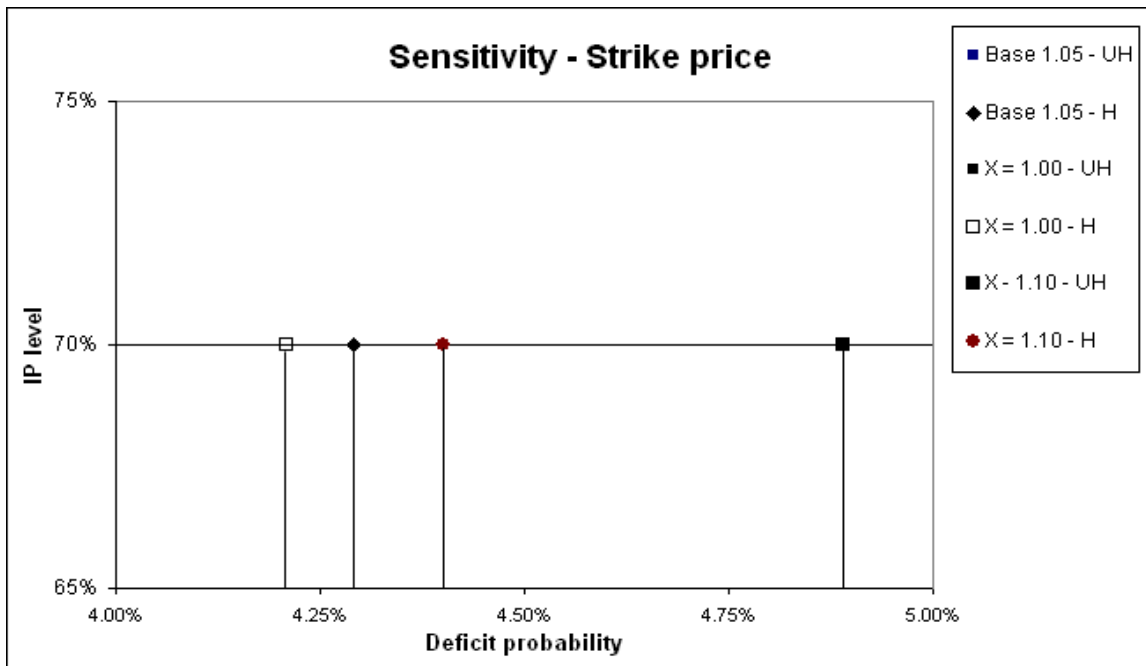
Source: Simulation results.

In figure 4.10 all scenarios share the same un-hedged deficit probability of 4.89% ($10,790,754) and represented by the point to the far right hand side of the graph. When considering hedging the exchange rate at 1 the probability of a deficit is 4.21% (7,132,073) for a premium of $90,192,814. Hedging exchange rates at 1.05 results in a deficit probability of 4.29% ($9,538,920) with a premium of $36,243,985 and at 1.1 results in a deficit probability of 4.4% ($9,598,667) for a premium of $14,050,458. It can be seen from figure 4.10 that the probability of a deficit is reduced very marginally the closer the hedge is to the starting exchange rate, however its cost increases substantially from just over $14 million at 1.1 to over $90 million with an at-the-money hedge of 1 CAD/USD. This information will prove very useful when budgeting for exchange rate hedging and establishing acceptable deficit probabilities. If comparable deficit probabilities can be achieved with spending considerably less option premiums it is going to be more attractive for the CWB to pursue. This can be seen in the marginal difference in deficit reduction from hedging at 1.1 versus 1.05 with a cost savings of approximately $22 million dollars. It is important to realize that over the full number of iterations the expectation is that option premiums will equal option profits however in any one individual year the premium could prove worthless. A balance between option outlays and deficit probabilities must be attained to structure a strong long term plan for the CWB to mitigate unfavorable exchange rate movements.

Appendix A.1 to A.4 show a number of results for all possible scenarios considered in this study. In order to visually represent all the possibilities consider figure 4.11 which compares the premium of the call option to the probability of a deficit that arises for different initial prices and different hedging strategies.

Figure 4.11 – Probability of deficits and premiums for each initial payment level
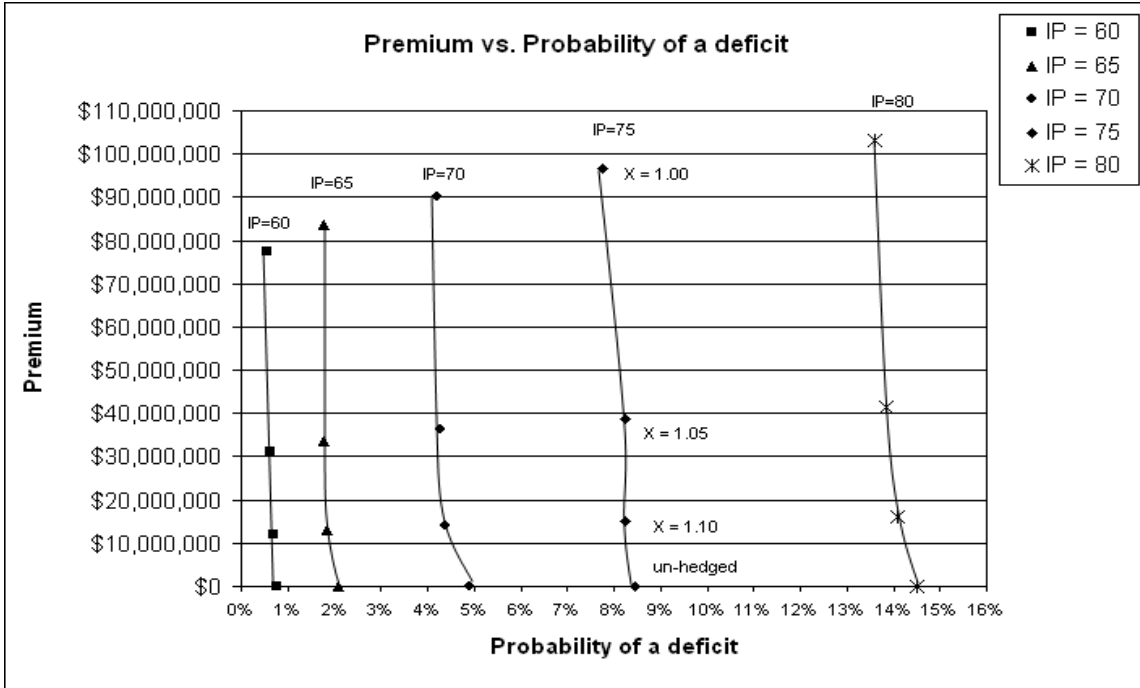
Source: Simulation results.

The vertical lines in figure 4.11 represent each initial payment level hedged i.e. 60% through 80% and depicts the intersection between option premiums and deficit probabilities. Each increasing point up the line represents the deficit at call option strike prices getting closer to the initial exchange rate of 1 CAD/USD. For example consider the initial payment line 75%. This represents the possible probability of deficits when 75% of the expected PRO is hedged with currency call options. The bottom point on this line represents the deficit probability when no hedging is in effect. The next point up the line represents the deficit probability when an out of-the-money position is purchased at a strike price of 1.1 CAD/USD. The third point from the bottom represents the base scenario where call options are purchased at 1.05 and the very top point represents the cost and deficit probability when options are purchased at-the-money i.e.1 CAD/USD.

The graph shows that the premium becomes increasingly greater the closer options are purchased to the current exchange rate. Table 4.2 is the data used to produce figure 4.11 showing the deficit probabilities and cost for all initial payment levels and call strike prices (X) considered in the study.

Table 4.2 – Deficit probabilities and option premiums used in figure 4.11

	IP = 60%		IP = 65%		IP = 70%	
	% deficit	Premium	% deficit	Premium	% deficit	Premium
un-hedged	0.76%	$0	2.09%	$0	4.89%	$0
X = 1.10	0.70%	$12,043,250	1.84%	$13,046,854	4.40%	$14,050,458
X = 1.05	0.64%	$31,066,273	1.78%	$33,655,129	4.29%	$36,243,985
X = 1.00	0.54%	$77,308,126	1.78%	$83,750,470	4.21%	$90,192,814

	IP = 75%		IP = 80%	
	% deficit	Premium	% deficit	Premium
un-hedged	8.45%	$0	14.51%	$0
X = 1.10	8.26%	$15,054,062	14.09%	$16,057,666
X = 1.05	8.26%	$38,832,841	13.84%	$41,421,698
X = 1.00	7.74%	$96,635,157	13.61%	$103,077,501

Source: Simulation results.

The graph also represents how deficit probabilities dramatically increase the greater the initial payment is to the August PRO. It is therefore important to choose the initial payment to establish an allowable probability of a deficit and consider the use of exchange rate hedging to augment that level to maximize producer payments upfront while minimizing the deficit probability.

4.7 Summary

Chapter four outlines a number of results of the model and how adjusting a few key variables affect the probability of a wheat pool account deficit. In order to grasp the effect of changing volatility's and policy variables a base scenario was generated. From this base scenario wheat and exchange rate volatility as well as call option strike prices were adjusted to generate a sensitivity analysis on the base scenario. From this a number of key policy implications are generated. The first being determining the initial payment as a percentage of the PRO and second is determining at which strike price the call options will be purchased at.

Looking at figure 4.6 it can be seen that increasing the initial payment has a significant impact on the deficit. Increasing the initial payment from 60%, 65%, 70%, 75% and 80% increases the deficit probability under the no-hedge base scenario from 0.76%, 2.09%, 4.89%, and 8.45% all the way to 14.51% under an initial payment level of 80%.

To further analyze the results the study considers the impact of adjusting wheat price volatility on the base scenario. As was mentioned above increasing wheat price volatility to 15% results in an un-hedged deficit probability of 12.86% and a volatility of 5% equates to an un-hedged deficit probability of 0.11%. This result tells us that when wheat volatility is high the CWB must consider a policy of lowering the initial payment level to mitigate the chance of a deficit. The exact initial payment level will depend on the current and forecasted wheat volatility. Hedging wheat prices could also be considered to help protect wheat sale prices however this approach is beyond the scope of this study.

The focus of the study is on the effect of exchange rates on the wheat pool account deficit. Figure 4.8 and 4.9 shows the results when the CAD/USD exchange rate volatility is adjusted from 1.5%, 3%, 4.5%, 6% and 9%. This results in an un-hedged and (hedged) deficit probability of 4.08% (3.96%), 4.89% (4.29%), 5.1% (4.01%), 6.52% (4.52%) and 9.04% (5.06%) respectively. This result reiterates how significant a role the volatility in the CAD/USD exchange rate has on pool account deficits. The sensitivity analysis also concludes that the higher the volatility the greater the impact hedging has on decreasing the probability of a wheat pool account deficit. This can be seen as the increasing difference between the un-hedged deficit and hedged deficit probability results.

The second policy tool the CWB has is setting the strike price for the call options purchased to reduce the effect of a rising CAD. Figure 4.10 shows the results of purchasing call options at 1, 1.05 and 1.1 CAD/USD. Purchasing options at 1, 1.05 and 1.1 results in an un-hedged and (hedged) deficit probability of 4.89% (4.21%), 4.89% (4.29%) and 4.89% (4.4%). The call premiums for these options are $90,192,814, $36,243,985 and $14,050,458 respectively. It is evident that purchasing options at 1 CAD/USD results in the most effective hedge at 4.21%, however its premium is nearly 2.5 times that of the base 1.05 CAD/USD for a marginal 0.08% reduction in deficit probability.

From the sensitivity analysis it can be seen that options out-of-the money will cost substantially less than at the initial level of 1 CAD/USD while providing marginally less deficit protection. It is also conclusive that these options provide protection in the event

the CAD/USD exchange rate volatility increases substantially and therefore plays an

important role in reducing the probability of a deficit.

CHAPTER FIVE

Conclusions and Recommendations

5.1 Summary

Chapter five outlines a number of conclusions drawn from the results presented in chapter four. The chapter also outlines needs for future research and limitations of the study.

The goal of the research is to mitigate the adverse impact on the CWB wheat pool value when an increase in the CAD vis-à-vis the USD increases the probability of a deficit. This is done by evaluating the effect of purchasing CAD call options which add revenue to the pool account when the CAD increases therefore reducing the probability of a deficit. The CWB also has the ability to adjust the initial payment as a percentage of the PRO, which is a critical factor to consider when evaluating wheat pool deficit probabilities. It can therefore be seen that the CWB has two policy tools at its disposal, the initial payment level as a percentage of the PRO and purchasing CAD call options to mitigate the probability of a wheat pool account deficit.

Chapter four outlines the results of the base scenario and a number of sensitivity analysis adjustments. The base scenario takes into consideration the initial payment level at 60%, 65%, 70%, 75% and 80% of the PRO. It also assumes an initial volatility for wheat prices and CAD/USD exchange rate at 10% and 3% per month respectively. Additionally it assumes call options are purchased at 1.05 CAD/USD which five cents out-of-the money considering an initial CAD/USD exchange rate of 1. The results of the base scenario can be seen in figure 4.6.

From the results presented in chapter four setting the initial payment level as a percentage of the PRO between 65% and 70% results in a low level of risk. This will depend on the volatility of wheat prices and market outlook. At this level the CWB will be able to provide producers with a relatively high price for wheat deliveries while maintaining a low probability of a deficit i.e. at 65% and 70% initial payment levels the un-hedged probability of a deficit is 2.09% and 4.89% respectively. The wheat price sensitivity analysis shows that when the monthly volatility increased to 15% the un-hedged probability of a deficit increased substantially to 12.89%. Therefore the CWB will have to gauge this volatility carefully and set initial payment levels accordingly.

The second policy tool is the strike price of the call options purchased. The initial CAD/USD exchange rate is 1 meaning that strike prices closer to 1 will be more expensive due to the higher probability of the option being in-the-money. The study looks at hedging at 1, 1.05, and 1.1 CAD/USD and found that the incremental decrease in the probability of a deficit was outweighed by the increase in premium for the option. The un-hedged probability of a deficit in the base scenario is 4.89% resulting in a benchmark for the call options to be compared against. Purchasing options at 1 CAD/USD, assuming all other variables are constant in the base scenario, yields a probability of a deficit of 4.21% for a premium of $90,192,814. While purchasing options a 1.05 and 1.1 yields a probability of a deficit of 4.29% and 4.4% for a premium of $36,243,985 and $14,050,458 respectively. The call options therefore provide revenues to the wheat pool reducing the probability of deficits.

The currency volatility sensitivity analysis shown in figure 4.8 and 4.9 illustrates that as the CAD/USD volatility increases from the base 3% to 4.5%, 6% and 9% the

probability of a deficit un-hedged and (hedged) increased to 4.89% (4.29%), 5.1% (4.01%), 6.52% (4.52%) 9.04% (5.06%) respectively. It can be seen that as the CAD/USD exchange rate volatility increases so does the probability of a deficit. It can also be seen that the spread in the un-hedged and hedged probability of deficits increases with the volatility. For example the hedged probability of a deficit when the volatility is 9% i.e. 5.06% is approximately the same as the un-hedged probability of a deficit when the volatility is 4.5% i.e. 5.1%. Thus the effects of the call options are increased when the volatility of the CAD/USD exchange rate increases. In a period of high exchange rate volatility and low grain price volatility hedging exchange rates could reduce the probability of a deficit. When grain prices are volatile the initial payment is a far greater determinant of wheat pool account deficits and exchange rate hedging has little impact. Therefore at the outset of the crop year the decision maker must take into consideration both current and forecasted wheat price and exchange rate volatility and determine how much risk he/she is willing to accept and set the initial payment and purchase option contracts accordingly.

5.2 Limitations and future research

There are a number of assumptions in the model from which deficit probabilities are derived. Such as the volatility of wheat prices[10] and exchange rates, total tonnes of wheat sold and the timing of sales throughout the crop year. The model assumes the pool is twelve months in length and makes assumptions on initial exchange rate and wheat price values. The study also assumes no interim or adjustment payments are made after

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[10] The monthly wheat price volatility in the FAO Food Outlook may underestimate the specific volatility the CWB faces in its wheat pool account. Therefore the actual volatility the CWB faces may increase/decrease depending on the type, amount and grade of wheat delivered in any one crop year.

the initial payment is set and that transaction costs are nil due to risk neutral valuation. The inputs and assumptions in the study were an attempt to evaluate deficit probabilities at approximate market conditions, however the model has the capacity to take any set of assumptions and cater to those requests in order to evaluate wheat pool deficit probabilities.

Future research would revolve around evaluating the effects of adjusting the CAD/USD exchange rate and wheat price volatility at various stages in the crop year and adjust the timing of wheat sales throughout the crop year. The model also has the capacity to evaluate the effects of the CWB making interim and adjustment payments in the crop year with coinciding increases/decreases in wheat price and exchange rate volatility. Future research will also be needed to find appropriate OTC institutions and evaluate their offering and premiums for call option contracts and how they can fit in the CWB overall risk mitigation strategy. In summary the model has the power to evaluate many assumptions and scenarios which will allow it to be an effective tool for setting initial price levels and evaluating the effectiveness of CAD call options on reducing the probability of a wheat pool account deficit.

APPENDIX A.1 – A.4

Sensitivity analysis

A.1

Strike price = 1 CAD/USD					

Parameters	1	2	3	4	5
Tonnes of wheat sold per month	1,000,000	1,000,000	**1,000,000**	1,000,000	1,000,000
Initial wheat price	$350	$350	**$350**	$350	$350
Initial standard deviation of wheat	10.00%	10.00%	**10.00%**	10.00%	10.00%
Initial exchange rate CAD/USD	1.00	1.00	**1.00**	1.00	1.00
Initial standard deviation of exchange rates	3.00%	3.00%	**3.00%**	3.00%	3.00%

Policy variables					
Percent hedge of initial payment	**60%**	**65%**	**70%**	**75%**	**80%**
Call option strike price CAD/USD	1.00	1.00	**1.00**	1.00	1.00

Results					
Probability of wheat pool deficit (un-hedged)	0.76%	2.09%	4.89%	8.45%	14.51%
Average dollar value of deficit (un-hedged)	$1,222,013	$4,073,056	$10,790,754	$24,353,955	$47,848,752
Probability of wheat pool deficit (hedged)	0.54%	1.78%	4.21%	7.74%	13.61%
Average dollar value of deficit (hedged)	$723,946	$2,480,598	$7,132,073	$17,056,531	$35,551,801
Call option premium	$77,308,126	$83,750,470	$90,192,814	$96,635,157	$103,077,501

A.2

| (Base)
Strike price = 1.05CAD/USD | | | | | |

Parameters	1	2	3	4	5
Tonnes of wheat sold per month	1,000,000	1,000,000	**1,000,000**	1,000,000	1,000,000
Initial wheat price	$350	$350	**$350**	$350	$350
Initial standard deviation of wheat	10.00%	10.00%	**10.00%**	10.00%	10.00%
Initial exchange rate CAD/USD	1.00	1.00	**1.00**	1.00	1.00
Initial standard deviation of exchange rates	3.00%	3.00%	**3.00%**	3.00%	3.00%

Policy variables

	1	2	3	4	5
Percent hedge of initial payment	**60%**	**65%**	**70%**	**75%**	**80%**
Call option strike price CAD/USD	1.05	1.05	**1.05**	1.05	1.05

Results

	1	2	3	4	5
Probability of wheat pool deficit (un-hedged)	0.76%	2.09%	4.89%	8.45%	14.51%
Average dollar value of deficit (un-hedged)	$1,213,793	$4,054,848	$10,813,205	$24,405,097	$48,629,859
Probability of wheat pool deficit (hedged)	0.64%	1.78%	4.29%	8.26%	13.84%
Average dollar value of deficit (hedged)	$930,086	$3,275,535	$9,538,920	$22,509,257	$45,454,360
Call option premium	$31,066,273	$33,655,129	$36,243,985	$38,832,841	$41,421,698

A.3

Strike price = 1.10 CAD/USD

Parameters	1	2	3	4	5
Tonnes of wheat sold per month	1,000,000	1,000,000	**1,000,000**	1,000,000	1,000,000
Initial wheat price	$350	$350	**$350**	$350	$350
Initial standard deviation of wheat	10.00%	10.00%	**10.00%**	10.00%	10.00%
Initial exchange rate CAD/USD	1.00	1.00	**1.00**	1.00	1.00
Initial standard deviation of exchange rates	3.00%	3.00%	**3.00%**	3.00%	3.00%

Policy variables

	1	2	3	4	5
Percent hedge of initial payment	**60%**	**65%**	**70%**	**75%**	**80%**
Call option strike price CAD/USD	1.10	1.10	**1.10**	1.10	1.10

Results

	1	2	3	4	5
Probability of wheat pool deficit (un-hedged)	0.76%	2.09%	4.89%	8.45%	14.51%
Average dollar value of deficit (un-hedged)	$1,049,904	$3,573,905	$10,790,754	$23,410,151	$46,923,654
Probability of wheat pool deficit (hedged)	0.70%	1.84%	4.40%	8.26%	14.09%
Average dollar value of deficit (hedged)	$986,782	$3,378,559	$9,598,667	$22,477,902	$45,618,066
Call option premium	$12,043,250	$13,046,854	$14,050,458	$15,054,062	$16,057,666

A.4

| (Base) Strike price = 1.05 CAD/USD |
| Sensitivity analysis |

Parameters	6	7	8	9
Tonnes of wheat sold per month	1,000,000	1,000,000	1,000,000	1,000,000
Initial wheat price	$350	$350	$350	$350
Initial standard deviation of wheat	**5.00%**	**15.00%**	10.00%	10.00%
Initial exchange rate CAD/USD	1	1	1	1
Initial standard deviation of exchange rates	3.00%	3.00%	**1.50%**	**4.50%**

Policy variables				
Percent hedge of initial payment	70%	70%	70%	70%
Call option strike price CAD/USD	1.05	1.05	1.05	1.05

Results				
Probability of wheat pool deficit (un-hedged)	0.11%	12.86%	4.08%	5.10%
Average dollar value of deficit (un-hedged)	$104,086	$48,200,458	$9,551,490	$12,390,497
Probability of wheat pool deficit (hedged)	0.02%	12.33%	3.96%	4.01%
Average dollar value of deficit (hedged)	$19,563	$46,269,643	$8,874,971	$9,383,334
Call option premium	$36,243,985	$36,243,985	$5,677,571	$68,360,593

Parameters	10	11	12	13
Tonnes of wheat sold per month	1,000,000	1,000,000	1,000,000	1,000,000
Initial wheat price	$350	$350	$350	$350
Initial standard deviation of wheat	10%	10%	10.00%	10.00%
Initial exchange rate CAD/USD	1	1	1	1
Initial standard deviation of exchange rates	**6.00%**	**9.00%**	3.00%	3.00%

Policy variables				
Percent hedge of initial payment	70%	70%	70%	70%
Call option strike price CAD/USD	1.05	1.05	**1**	**1.1**

Results				
Probability of wheat pool deficit (un-hedged)	6.52%	9.04%	4.89%	4.89%
Average dollar value of deficit (un-hedged)	$17,837,003	$28,946,441	$10,790,754	$10,790,754
Probability of wheat pool deficit (hedged)	4.52%	5.06%	4.21%	4.40%
Average dollar value of deficit (hedged)	$10,732,565	$11,694,761	$7,132,073	$9,598,667
Call option premium	$124,590,744	$230,501,819	$90,192,814	$14,050,458

APPENDIX B

Wheat account deficit distributions (base scenario in Appendix A.2)

Deficit distribution for 60% initial pmt level un-hedged

Probability of wheat pool deficit (un-hedged)	0.76%
Average dollar value of deficit (un-hedged)	$1,213,793
Max dollar value of deficit (un-hedged)	$818,660,900

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Values in 10^{-11}

Values in Millions

Deficit distribution for 60% initial pmt level hedged

Probability of wheat pool deficit (hedged)	0.70%
Average dollar value of deficit (hedged)	$986,782
Max dollar value of deficit (hedged)	$836,614,800

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Values in 10^{-11}

Values in Millions

Deficit distribution for 65% initial pmt level un-hedged

Probability of wheat pool deficit (un-hedged)	2.09%
Average dollar value of deficit (un-hedged)	$4,054,848
Max dollar value of deficit (un-hedged)	$1,028,661,000

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Y-axis: Values in 10^ -11. X-axis: Values in Billions

Deficit distribution for 65% initial pmt level hedged

Probability of wheat pool deficit (hedged)	1.84%
Average dollar value of deficit (hedged)	$3,378,559
Max dollar value of deficit (hedged)	$1,048,111,000

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Y-axis: Values in 10^ -11. X-axis: Values in Billions

Deficit distribution for 70% initial pmt level un-hedged

Probability of wheat pool deficit (un-hedged)	4.89%
Average dollar value of deficit (un-hedged)	$10,813,205
Max dollar value of deficit (un-hedged)	$1,238,661,000

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Deficit distribution for 70% initial pmt level hedged

Probability of wheat pool deficit (hedged)	4.40%
Average dollar value of deficit (hedged)	$9,598,667
Max dollar value of deficit (hedged)	$1,259,607,000

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Deficit distribution for 75% initial pmt level un-hedged

Probability of wheat pool deficit (un-hedged)	8.45%
Average dollar value of deficit (un-hedged)	$24,405,097
Max dollar value of deficit (un-hedged)	$1,448,661,000

Deficit distribution for 75% initial pmt level hedged

Probability of wheat pool deficit (hedged)	8.26%
Average dollar value of deficit (hedged)	$22,509,257
Max dollar value of deficit (hedged)	$1,471,103,000

Deficit distribution for 80% initial pmt level un-hedged

Probability of wheat pool deficit (un-hedged)	14.51%
Average dollar value of deficit (un-hedged)	$48,629,859
Max dollar value of deficit (un-hedged)	$1,658,661,000

Deficit distribution for 80% initial pmt level hedged

Probability of wheat pool deficit (hedged)	13.84%
Average dollar value of deficit (hedged)	$45,454,360
Max dollar value of deficit (hedged)	$1,682,599,000

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