COMMODITY FUTURES AND OPTIONS FOR GRAIN REVENUE STABILIZATION IN WESTERN CANADA

By Bruce I. Love

A Thesis
Submitted to the Faculty of Graduate Studies
in Partial Fulfilment of the Requirements
for the Degree of

MASTER OF SCIENCE

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ABSTRACT

This study examines commodity futures and put options as an alternative to past agricultural policies for stabilizing gross revenues in the Western Canadian grain sector, from 1971 to 1990. The major past agricultural policies are identified and their ability to provide gross revenue stabilization is examined. Results show that past traditional policies did not stabilize revenues. Next, past agricultural policies are compared with the returns from selling futures and buying put options, along with crop insurance, over alternative time periods during the growing season. Results show that futures and put options combined with crop insurance could have provided higher levels of revenue stabilization for the aggregate grain sector than past agricultural policies. For the individual farmer using futures and put options, rather than the aggregate case above, revenue risk would have been less than that of past agricultural policies.

The use of futures is also examined as a risk management tool for the Canadian Wheat Board (CWB) and the farmers it represents. Results show losses were reduced without increasing overall revenue risk when futures were used under joint price and quantity risk.

Overall, the results of this study showed that futures and put options may have provided a viable market alternative to past agricultural policies for stabilizing gross grain revenues in the Western Canadian grain sector.

CHAPTER 1

INTRODUCTION

This is the first study to examine the use of futures and options as an alternative to traditional agricultural policy. It also contains the most thorough and complete data set to date on government transfers to farmers.

This analysis of using futures and put options for stabilizing grain revenues is based on five independent studies. Each study is a separate chapter which relates how futures or put options may provide a market alterative to past agricultural policies for stabilizing producer grain revenues. The focus is on gross revenue stabilization policy from 1971 to 1990.

The first study, chapter 2, analyzes the relevant past agricultural policies in the Western Canadian grains sector for their ability to stabilize revenue. These policies contain both explicit policy benefits, such as the Western Grain Stabilization Program (WGSP), and implicit policy benefits, such as the "Crow Benefit". The variability of grain revenues with and without policy transfers are examined. If these policy transfers are effective, producer gross revenues which include the transfers should have less variability compared to market revenues which do not include the policy transfers.

The third chapter examines the use of futures markets to stabilize aggregate revenues. The approach considers the growing season as the most relevant risk period for producers. This is because the decision to commit resources is often based on current prices and conditions, and once production resources are committed, they become a sunk cost for the producer. Also, production harvested can be sold either immediately for future delivery by forward contracts, or hedged with futures or options for a certain price, providing a certain return. By using alternative short selling time periods over the growing season, a range of results are generated which should provide more robust results than using only one short selling period.

However, futures can not stabilize production risk, so a more complete approach to stabilizing revenues should consider crop insurance. To do this, the alternative futures short selling returns are combined with net crop insurance payments and compared with past agricultural policy payments for stabilizing revenues.

The fourth chapter examines the use of put options instead of futures to stabilize aggregate grain revenues. The approach taken in this chapter follows that in chapter three, combining alternative put option premium changes with net crop insurance payments to stabilize annual aggregate grain revenues. The put option premium changes are from alternative time periods over the growing season. But, since agricultural options have only recently began trading, and not on all crops, put option premiums are estimated with Black's option pricing formula.

The fifth chapter takes the analysis to the farm level rather than the aggregate level as in earlier chapters, and follows how a producer would likely hedge expected production over the growing season. A "typical" farm is created in Manitoba, Saskatchewan, and Alberta to assess potential provincial differences. Each "typical" farm produces the same mix and proportion of crops as the province it is located in, but crop yields are from selected crop districts within each province. Alternative growing season periods of futures short selling returns and put options premium returns, along with crop insurance, are used in the management of the "typical" farms to stabilize expected grain revenues. These results are then compared with past agricultural policy transfers made to the "typical" farms to assess the effectiveness of futures and put options to stabilize expected farm revenues.

Chapter six examines how a firm like the CWB could use futures markets to stabilize its revenues, which in turn are revenues to farmers. The CWB situation offers a unique application for using futures as a risk management tool, since the CWB offers an initial payment when it faces both uncertain producer deliveries and an uncertain final selling price for the grain. At times, this simultaneous price and quantity risk has resulted in large unexpected losses for the CWB, particulary on the wheat pool account. To overcome these uncertainties, the CWB is modelled as administering a broad based stabilization program for grain producers, through hedging. The CWB could offer initial prices on wheat to stabilize prices over the growing season for producers, and hedge its risk on the initial payment. A Maximum Admissible Loss (MAL) model is constructed for the CWB to examine short hedging with futures. The MAL model uses hedging rules based on quantity and price uncertainty and sets lower bounds on the maximum admissible revenue losses from hedging in order to estimate the optimal hedge for the CWB.

The overall objective of this analysis is to determine whether futures and options can provide a viable market alternative to past agricultural policies. It provides insight as to how effective past policies have been in stabilizing farm revenues. Also, this analysis may lead to a better understanding of how more effective stabilization policies could be created in the future.

CHAPTER 2

STABILIZATION AND THE WESTERN CANADIAN GRAIN SECTOR

Introduction

The Western Canadian grain sector, which includes Manitoba, Saskatchewan and Alberta, has a number of agricultural policies designed to stabilize grain revenues during periods of unstable prices and unstable production. This chapter examines the major government program payments received by Western Canadian grain producers and their impact on gross revenue variability, using the most complete and comprehensive data set to date.

Financial aid for producers in the Western Canadian grain sector has grown by 100% in the last decade in response to declining and unstable grain revenues, as shown in Table 2.1 However, government transfers to support revenues have become a growing cost to tax payers and consumers, and have added to the provincial and federal budget deficits. Given the size and increasing cost of future government programs in the prairie grain sector, the effectiveness of past agricultural programs to stabilize producer revenue needs to be examined.

While the goal of agricultural policy is to stabilize and at times enhance farm grain revenues, the focus of this chapter is on revenue stabilization. This is not to say that revenue enhancement is not important, on the contrary, the

Table 2.1 Selected Agricultural Policy Benefits and Crop Insurance based on annual data from January 1 to December 31, 1971 to 1990.

Year	Federal Programs	Federal Adhoc Programs	Provincial Programs	Implicit Transfers	Rebates	Net Crop Insurance	Total Transfers
1971	14.482	0.000	3.950	210.734	4.791	-1.440	233.957
1972	61.233	0.000	0.350	237.690	5.602	0.140	304.875
1973	64.367	0.000	3.621	223.619	6.811	-1.641	298.419
1974	2.339	27.015	0.790	198.165	12.010	5.492	240.319
1975	1.625	0.190	0.500	254.627	16.651	31.775	273.594
1976	-23.177	0.000	0.030	286.251	19.543	3.237	282.647
1977	-27.137	0.000	0.018	361.395	27.081	13.431	361.357
1978	88.097	0.000	0.095	359.383	24.182	-4.276	471.757
1979	214.056	0.000	0.044	488.974	24.688	75.368	727.763
1980	-46.138	0.000	0.055	544.263	26.472	146.254	524.653
1981	-53.464	67.523	0.097	642.398	33.259	40.650	689.813
1982	-53.529	0.000	0.099	799.682	38.497	79.613	784.750
1983	-63.286	0.000	0.067	781.158	64.992	103.897	782.931
1984	175.203	0.000	7.532	654.283	72.560	272.515	909.578
1985	482.496	0.000	47.441	729.856	61.145	393.231	1320.938
1986	838.279	0.000	232.109	796.331	96.383	275.395	1963.102
1987	1369.524	815.072	35.813	942.061	59.671	-11.268	3222.141
1988	610.447	913.825	18.045	809.485	40.201	345.281	2392.003
1989	113.534	741.291	18.294	568.271	32.100	557.167	1473.491
1990	-129.000	14.925	40.707	1389.115	24.710	289.869	1340.457

Federal Programs: represents the net Federal transfers ($1,000,000's), to producers from:Western Grain Stabilization Program, Lower Inventory for Tomorrow, Two Price Wheat, Farm Income Assistance, and Migratory Waterfowl Damage Compensation. Source: calculations made by author.

Federal Adhoc Programs: represents the Federal transfers ($1,000,000's), to producers from the adhoc programs: Crop Assistance Program, Grain Embargo Compensation, Special Drought Assistance, Special Canadian Grains Program, and Two Price Wheat Compensation. Source: calculations made by author.

Provincial Programs: represents the Provincial transfers ($1,000,000's) made to producers from: Special Emergency Grants to Farmers, Crop Loss Compensation, Western Emergency Assistance, Crop Insurance Restoration, Retain Feed in Drought Areas Program, Crop Disaster Assistance, Saskatchewan Drought Assistance, Farm Fertilizer Price Protection, Grasshopper Control Program, and Alberta Flood Assistance. Source: calculations made by author.

Implicit Transfers: represents the net benefits ($1,000,000's) accruing to producers from: Canadian Wheat Board Shortfalls, and the Western Grain Transportation Act and Crow Rate. Source: calculations made by author.

Rebates: represents the benefits ($1,000,000's) received by producers from: Property Tax Rebates, Federal and Provincial Fuel Tax Rebates, Interest Rate Rebates, and Heating Fuel Rebates. Source: calculations made by author.

Net Crop Insurance: represents the annual net payment ($1,000,000's) received by producers from the crop insurance system. Source: calculations by author.

Total Transfers: represents the annual net benefits received by producers from the Federal Programs, Federal Adhoc Programs, Provincial Programs, Implicit Transfers, and Rebates groupings above.

survival of numerous farmers depends on revenue enhancement. However, revenue stabilization here is considered as a separate and distinct element of past agricultural policies, even if this was not explicitly stated in the policy's mandate. If the goal of revenue stability can be achieved, then any short fall in revenues could be made up with a direct and decoupled payment to the producer.

The focus is on aggregate stabilization rather than on a individual or crop basis, since nearly all programs such as the Western Grain Stabilization Program (WGSP) were not targeted specifically on a per producer or per crop basis. However, the aggregate stabilization of the grain sector cannot necessarily be used to draw conclusions about individual situations, but it is a very important factor in the stabilization of the Western Canadian Economy. Therefore, this chapter considers all grain producers in Western Canada, and analyses past agricultural policies for their ability to stabilize gross aggregate grain revenues.

The economic stability of the prairie grain sector and producer revenue is affected by three main factors:

1. The variability associated with the local weather and production.
2. The variability of world markets and commodity prices.
3. The uncertainty of agricultural policies.

If policy transfers are to provide a level of stability beyond that without the transfers, they should be negatively correlated with aggregate revenue. In other words, proportionally large payments should be made during periods of low revenue, and conversely, small or negative payments should be made during periods of relatively high revenue. Therefore, the objectives of this chapter are to use actual past data to determine:

1. The average level and variability of grain revenues with and without government transfers.
2. The correlation of government transfers with aggregate producer grain revenues.

These objectives should provide an approximate and relative measure of the effectiveness of past agricultural policies to stabilize producer revenues.

Western Canadian Grain Policy

Stabilization of producer revenue in the Western Canadian grain sector comes from three levels of government. The first is a federally based approach to stabilize farm revenue, which has resulted in programs such as the Western Grain Stabilization Program (WGSP) and federally sanctioned organizations such as the Canadian Wheat Board (CWB). Also included are the ad hoc programs to offset unpredictable occurrences, such as the drought of 1988, or the grain subsidy war between the United States and the European Community. The next level of government involvement is the combined effort of the provincial and federal governments to stabilize farm revenue, such as crop insurance. Finally, there are policies created solely by the provinces, including the top loading of federal programs such as the Saskatchewan Drought Assistance Program.

Benefits from the three levels of government involvement are received by the producer in several ways. Direct payments are the most common type of policy benefit received and the easiest to review. While other benefits such as fixed freight rates, interest rate subsidies, fuel and property tax rebates, and others, help to reduce the costs faced by the producer, these benefits are not as explicit as direct payments and are therefore more difficult to calculate, but are still analyzed in this chapter.

Stabilization Criteria

The effectiveness of any program is determined on the basis of its ability to meet its stated objectives. Spriggs and Van Kooten (1988) mention three basic objectives of agricultural policy in the Western Canadian grain sector:

1. To stabilize prices and the revenue received by producers.
2. To maintain and increase producers' income.
3. To address various political and social objectives.

These objectives suggest a wide range of interpretations and evaluation criteria exist to measure the effectiveness of agricultural policy. The third objective reaches beyond the economic nature of this study, so is not examined, but the ability of past agricultural policies to stabilize producer revenues is examined.

The traditional approach to measuring the effectiveness of agricultural policy was to consider only price stabilization and not revenue stabilization. Oli (1961) suggested that price stabilization policy in response to uncertain prices reduced the adverse effects of resource misallocation. Also, Massel (1969) extended this argument by suggesting that price stabilization can generate net benefits to society by reducing the misallocation of resources.

However, if price is "stabilized" or "fixed", and not allowed to vary inversely with quantity, producer revenue may be destabilized. Newberry and Stiglitz (1981) argue that price stabilization can lead to unstable revenues, and therefore reducing revenue variation is more relevant than reducing only price variation. This circumstance is particularly relevant for the Western Canadian grain sector, since revenue is the product of quantity and price, and quantity is partially determined by yield which varies widely with weather.

Also, Spriggs and Van Kooten (1988) suggest that optimal stabilization consider revenue stability rather than only price stability. Stabilization of revenue is justifiable when it provides transitional support to producers faced with rapid price changes, but economic reasons to do so on a long term basis have less support (Hallet). This is because stabilization becomes a subsidy to otherwise uneconomic production if continued on a long term basis. Also, government programs can become capitalized into the value of land and the stabilization aspect of the program is less effective in stabilizing producer revenues for new farmers (Gilson). Therefore, an effective stabilization policy would provide some degree of gross revenue stability for both existing and new producers while not directing resource allocation.

Timing of Policy Benefits

The ability of government programs to stabilize producer revenues can be affected by the timing of program payments made to producers. Agricultural policy benefits received by the producer, outside of the deficit period to which they apply, may destabilize revenues while those benefits received on a more timely basis will stabilize revenues. Also, the economic survival of producers depends on when cash flows (including government payments) are realized, and this can be described by cash flow accounting.

The cash flow approach captures the generally ad hoc and unpredictable nature of Canadian agricultural policy benefits. Based on cash flow accounting, government payments for a low farm revenue year may correctly show destabilization if they are paid out in the following year when farm revenues have improved. It is this effect on farm revenues that the analysis attempts to capture, since it leads directly to the ability of agricultural policies to stabilize revenues.

In contrast, policy payments may incorrectly indicate stabilization if they are instead based on accrual accounting, which means they are accounted for when they are announced, rather than when they are actually received. To adopt an accrual approach in this analysis would imply the producer has perfect knowledge (rational expectations) of agricultural policy, the expected benefits, and date of receipt. Although some farm programs maybe less ad hoc than others and consistent with rational expectations and producer anticipation of payments, these cases are likely to be the exception. Therefore, a cash flow approach is used here, where payments are accounted for when they are received.

Procedure and Data

A base model of Western Canadian grain revenues, excluding government transfers, is based on the annual revenues of six major crops which include all wheat, barley, oats, rye, flax, and canola. The data used are from 1971 to 1990, because not all of the data on government transfers was available prior to 1971 on a comparable basis. Also, Statistics Canada data on government transfers prior to 1971 is not comparable to data after 1971 due to a change in accounting procedures.

All major government programs, initiatives, and rebates in the Western Canadian grain sector are considered, net of producer contributions. The mean, standard deviation, and coefficient of variation are computed for producer revenue with and without policy transfers. The coefficient of variation (c.v.) is used as the primary measure of revenue variability. Since the c.v. is the standard deviation divided by the mean, it adjusts the variance for different means, so variability can be compared across the different revenue series.[1] To examine the nature of government transfers further, the correlation coefficient between producer market revenue and the various policy transfers is computed. The various government programs included in the calculations are:

1. Federal Programs: Western Grain Stabilization Program, Lower

Inventory for Tomorrow (LIFT), Two Price Wheat, Farm Income Assistance, and Migratory Waterfowl Damage Compensation.

2. Federal Ad hoc Programs: Crop Assistance Program, Grain Embargo Compensation, Special Drought Assistance, Special Canadian Grains Program, and Two Price Wheat Compensation.
3. Provincial Programs: Special Emergency Grants to Farmers, Crop Loss Compensation, Western Emergency Assistance, Crop Insurance Restoration, Retain Feed in Drought Areas Program, Crop Disaster Assistance, Saskatchewan Drought Assistance, Farm Fertilizer Price Protection, Grasshopper Control Program, and Alberta Flood Assistance.
4. Crop Insurance.
5. Implicit Transfers: Canadian Wheat Board (CWB) Deficits, the Western Grain Transportation Act (WGTA), and Crow Rate benefits.
6. Rebates: Property Tax Rebates, Federal and Provincial Fuel Tax Rebates, Interest Rate Rebates, and Heating Fuel Rebates.[2]

The policy transfers included in this analysis represent some 29 government programs. This number of government programs has often been overlooked due to the lack of a central source of information regarding government involvement in agriculture. Forbes, Hughes and Warley (1982) identified the need for information about farm support programs, and recommended that governments be required to provide this information on a regular basis. Statistics Canada appears to have responded to the need for information on farm support programs by providing annual data on direct payments to producers. However, a major shortfall in these data are the accounting for indirect program benefits. These shortfalls include the Crow rate and Western Grain Transportation Act, the At-and-East transportation subsidy, CWB deficits, and rebates on interest and fuel tax based on producer class, which are now included in this chapter. However, a number of quasi-subsidies that are not clear subsidies, such as, subsidized credit for grain sales, the interest free loan provided on the crop insurance deficit, and the governments contribution to the crop insurance system, are not included so the data in this chapter may underestimate the total benefit received by producers.

A second shortfall in the data are the accounting for the administrative costs of agricultural programs. The Auditor General (1990) addresses this specific problem regarding the Department of Agriculture and reports "..the Department ensure that the 1990/91 and future part 3's of the Estimates contain clear, consistent and complete information, notably in relation to resource allocation and program results". Administrative costs of government programs cannot be included in overall program cost since this data is not available. Without the administrative costs, the total costs of government programs are understated in this chapter as the net payments made to producers.

The subsidy or transfer calculations in this chapter are an attempt to be the most comprehensive to date for the Western Canadian Grain sector. However, they differ from the data offered by Statistics Canada, which does not include the indirect benefits, such as the WGTA and CWB deficits.

Results

Tables 2.2 and 2.3 provide a summary of the affect agricultural policies and programs had on aggregate producer gross revenue from the six crops selected for the period 1971 to 1990 inclusive. Table 2.2 shows the effects of selected agricultural policies on the mean and variability of producer revenues, while Table 2.3 shows the correlations between producer revenue and selected agricultural policy benefits. Both measures are of interest, because the mean and variability measure the effect of the magnitude of the policy transfers on revenue, while the correlation captures the direction and the degree of the relationship between the policy transfers and producer revenue. An effective stabilization policy should reduce the variability of producer revenues from what would have been the case without the policy benefits. This also implies that policy transfers should be negatively correlated with producer revenue to provide stabilization.

The results in Table 2.2 show that for all combinations of government programs considered, net of producer contributions, producer mean gross revenue was increased. However, for all but two of the transfer cases, producer revenue variability increased indicating destabilization, as measured by the coefficient of variation and standard deviation (Table 2.2, columns 2 & 3).[3]

The higher coefficient of variation for producer revenues that include ad hoc subsidies show ad hoc subsidies did not stabilize revenues. Table 2.3

Table 2.2 The Impacts of Selected Agricultural Policy Benefits and Crop Insurance on Annual Gross Aggregate Grain Revenues ($1,000,000's), from January 1 to December 31, 1971 to 1990.

Revenue Scenario	Mean	Standard Deviation	Coefficient of Variation
Grain Revenue Only	3873.302	1413.573	0.365
Grain Revenue + Federal Programs	4055.299	1480.649	0.365
Grain Revenue + Federal Adhoc Programs	4002.294	1481.178	0.370
Grain Revenue + Provincial Programs	3893.785	1420.433	0.365
Grain Revenue + Net Crop Insurance	4004.036	1498.229	0.374
Grain Revenue + Implicit Transfers	4437.189	1628.254	0.367
Grain Revenue + Rebates	3907.869	1429.504	0.366
Grain Revenues + Total Transfers	4803.229	1848.836	0.385
Grain Revenues + Total Transfers + Net Crop Insurance	4933.963	1945.224	0.394

Grain Revenue: represents the annual gross aggregate producer receipts ($1,000,000's) for all wheat, oats, barley, rye, flaxseed, and canola (includes CWB final payments when received and excludes policy transfers and CWB shortfalls to producers) for the period 1971 to 1990. Sources: calculations made by author.

Federal Programs: see Table 2.1.
Federal Adhoc Programs: see Table 2.1.
Provincial Programs: see Table 2.1.
Implicit Transfers: see Table 2.1.
Rebates: see Table 2.1.
Net Crop Insurance: see Table 2.1.
Total Transfers: see Table 2.1.

Table 2.3 Correlation Coefficients between Annual Gross Aggregate Grain Revenues and Selected Agricultural Policy Benefits, from January 1 to December 31, 1971 to 1990.

	Grain Revenue	Federal Programs	Federal Adhoc Programs	Provincial Programs	Net Crop Insurance	Implicit Transfers	Rebates
Federal Programs	0.056						
Federal Adhoc Programs	0.132	0.600					
Provincial Programs	0.118	0.545	0.024				
Net Crop Insurance	0.482	0.177	0.420	0.359			
Implicit Transfers	0.658	0.342	0.307	0.362	0.510		
Rebates	0.558	0.581	0.163	0.664	0.463	0.580	
Total Transfers	0.355	0.886	0.771	0.483	0.466	0.694	0.623

Variables and Sources as in Table 2.2

highlights the issue of timeliness as seen by the positive correlation, when high negative correlation would be most desirable between ad hoc subsidies and producer revenue without policy transfers. These ad hoc benefits were not received by the producer until some time after the deficit period to which they apply, which may be one reason why there is positive correlation in contrast to the negative correlation required for stabilization of producer revenues. For example, 1988 ad hoc payments were not fully received until the spring of 1989, an accounting year after the period which the payments applied.

Rebates also increase revenue variability for producers as shown in Table 2.2. Table 2.3 supports this, since there is a high positive correlation between rebates and revenue of 0.558. Rebates reflect a production based relationship, since they are linked to production. In this sense, rebates are one of the subsidies least "decoupled" from production. The high positive correlation of 0.658 between implicit subsidies and the producer revenue measure are also examples of production based subsidies. The implicit subsidy measure includes transportation benefits to producers and CWB shortfalls, though transportation benefits were much larger than CWB deficits covered by the government. The production based subsidies, due mostly to transportation benefits, increased average producer revenue during periods of high production without reducing the variability of producer revenue.

The results in Table 2.2 suggest that the revenue destabilizing effects of all programs are additive in their effect on revenue variability. Grain revenue alone shows a coefficient of variation of 0.365, however, when total transfers and net crop insurance benefits are added to this, variability is increased to 0.394.[4] This is supported by Table 2.3 which shows a positive correlation between each of the policy benefits and grain revenue. Therefore, the policy environment of the Western Canadian grain sector during this period did not provide effective revenue stabilization for the producer, since the variability of revenues were not reduced below what they would have been without the government transfers. However, substantial revenue enhancement was provided by the programs considered.

Conclusion

In general, the subsidies considered in this study increased total producer gross revenue, but they did not decrease the variability of those revenues. Both direct and indirect subsidies showed a positive correlation with producer gross revenue, in contrast to the negative correlation required for stabilization. The implicit subsidy group, the largest subsidy group, where the benefits mostly accrued on the basis of the volume shipped by rail, did not stabilize producer revenue.

Three themes emerge from this analysis. First, stabilization benefits based on units of production tends to destabilize producer revenue. The producer may receive proportionally more of the benefit in periods of above average production as opposed to periods of low production when the benefit is required. Secondly, if producer payments are to provide stabilization they must be timely, which means they are paid out when needed. Thirdly, individual policies should not operate in exclusion to other policies. All policies should work together, or one policy benefit may adversely offset another's effectiveness to provide revenue stabilization.

This analysis raises a number of interesting observations for further research. First, it is difficult to measure stabilization effectiveness if policy makers have not announced specific or target levels for mean and variability of revenue. Secondly, when neither aggregate nor individual stabilization (e.g. per crop or per farmer) is given as the specific goal by policy makers, it is difficult to determine which criteria is the best for measuring stabilization effectiveness. However, this analysis used aggregate stabilization since nearly all government programs were not targeted on a specific crop or producer basis. Thirdly, stabilization effectiveness results may vary with calender year versus crop year data, and accrual accounting versus cash accounting. This brings up the issue of the timing of payments and the degree to which they can be correctly anticipated by the producer in a rational expectations framework, and which would likely require more sophisticated lead-lag analysis study. Fourthly, it is not clear whether nominal (undeflated) or real (deflated) revenue stabilization is the goal of policy makers, though this study analyzed nominal terms, since all farm programs were based on nominal data and attempted to stabilize nominal rather than real level revenue. Fifthly, though coefficient of variation was used to analyze stabilization, alternative variance measures could be used as different measures may provide alternative results on stabilization effectiveness. Finally, while this is not a highly rigorous statistical analysis of revenue stabilization, it represents the first study to document all major policy transfers and their effect on producer revenues in the Western Canadian grain sector.

End Notes

[1] In its inverse form, the c.v. is also a useful measure, as it becomes the Sharpe Ratio, used in finance, and measures the mean of a series in relation to its standard deviation or risk.

[2] Data on the rebates policy grouping is allocated to the grain sector based on gross sales. This weighting is based on total sales of grain and livestock, and weights rebates accordingly.

[3] The government did not provide a specific criteria or formula which it attempted to stabilize all past long-term revenue (e.g. a multi-year moving average as in the case of the Gross Revenue Insurance Plan or GRIP). Therefore, a simple average over the period was used, since the data period used in this study (20 years) is sufficiently long enough to analyze long-term stabilization.

[4] Nominal rather than deflated data are used since all farm stabilization programs were based on nominal data and attempted to stabilize nominal rather than real revenue, such as the WGSP, for example.

CHAPTER 3

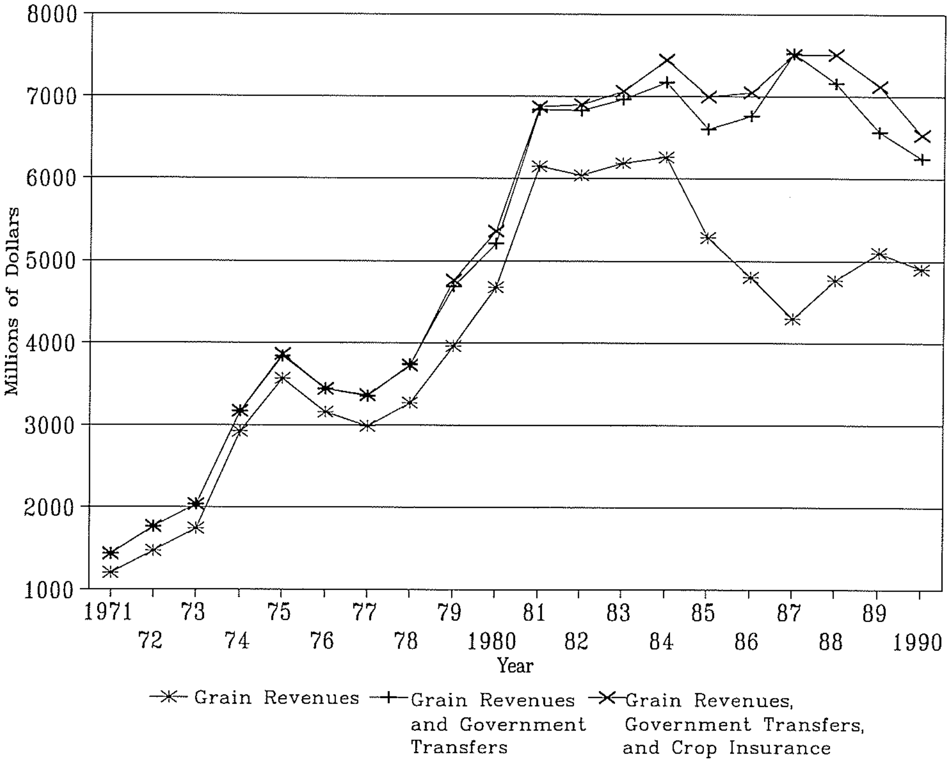
THE EFFECTIVENESS OF COMMODITY FUTURES FOR STABILIZING WESTERN CANADIAN GRAIN REVENUES

Introduction

This chapter examines the effectiveness of past agricultural policies to provide short-run revenue risk reduction, compared to commodity futures and crop insurance, for the Western Canadian grain sector which includes Manitoba, Saskatchewan, and Alberta. The focus of this study is to examine past policies and the use of futures and crop insurance from a policy-makers perspective.[1] Also, aggregate revenue stabilization is analyzed, rather than analyzing specific stabilization, such as per farmer, per crop, or per acre measures, because most of the past government programs were directed towards aggregate revenue stabilization.

Government support and policy directed transfers have become a large part of farm revenues, as shown by Figure 3.1. For example, in 1987, crop receipts were about four billion dollars, while government transfers and crop insurance were about two billion dollars. In other words, government transfers and crop insurance were about half as much as revenue from farm grain sales. The magnitude of these benefits indicate the need for a review of the past

Figure 3.1 Revenues, Government Transfers, and Crop Insurance Payments for the Western Canadian Grain Sector, 1971 to 1990.



Grain Revenues: represents the total crop receipts for the Western Canadian Grain Sector. This area includes Manitoba, Saskatchewan, and Alberta.

Government Transfers: represents the net transfers to producers under the following government programs: Western Grain Stabilization Program, Special Canadian Grains Program, Two Price Wheat Compensation, Migratory Waterfowl Damage Compensation, Crop Assistance Program, Grain Embargo Compensation, Special Drought Assistance, and Farm Income Assistance; Rebates from property taxes, interest payments, Federal and Provincial fuel taxes and, heating fuels; Provincial Programs which include Special Grants to Farmers, Crop Loss Compensation, Western Emergency Assistance, Saskatchewan Drought Assistance, Farm Fertilizer Price Protection, Grasshopper Control Program and, Alberta Flood Assistance; The net benefits accruing to producers from Canadian Wheat Board short-falls on the initial payment, the Crow Rate and the Western Grain Transportation Act.

Crop Insurance: represents the net payments to producers under the Crop Insurance system.

Source: calculations by author.

effectiveness of policies and suggests that alternative methods of stabilizing producer revenues should be explored. Also, Canada's commitment to the General Agreement on Tariffs and Trade (GATT) and the Canada U.S. Free Trade Agreement (FTA) suggests that stabilization of producer revenues should be more market oriented and decoupled from production decisions (Gilson). This set of factors suggests that new agricultural stabilization policies increase the self reliance of producers and involve them directly in the private sector, where grain markets move in response to world conditions.

In the private sector, futures markets exist primarily to transfer commodity price risk (Peck). The continued existence of these markets indicates they may be effective in reducing price risk. Therefore, hedging production with futures may be more effective for short-term price stabilization than agricultural policy. However, a more complete approach to stabilizing short-run producer revenue should also consider production risk, rather than only price risk, and so crop insurance is also included in this analysis.

Since this study attempts to examine the effectiveness of futures and crop insurance to stabilize short-run aggregate producer grain revenues, past policy benefits received by producers directly and indirectly through subsidized production and marketing costs are calculated. With the actual subsidy data, a comparison to past alternative policies such as one that includes the use of futures is possible. Also, this chapter extends previous U.S. work on futures markets as a policy alternative, to the Canadian situation. However, past Canadian agricultural policy was relatively ad hoc, and differs from the United States in that no explicit floor prices exist similar to the Non-Recourse Loan and Target Price programs. Therefore, a Canadian analysis is useful and therefore the objectives of this study are to:

1. Determine the past effectiveness of short-run aggregate revenue stabilization for the Western Canadian grain sector from short hedging grain futures, and
2. Determine which approach, hedging or past traditional policy, was more effective for stabilizing short-term farm grain revenues when combined with crop insurance.

Revenue Stabilization and Futures

Government intervention in the prairie grain sector has attempted to address the instability of producer revenues and returns to farm resources from one year to the next. The instability of producer revenue has been caused by the tendency of grain markets to fluctuate sharply in short-term price movement due to weather. This is further exaggerated by relatively low domestic demand and supply elasticities, which can create large variations in grain prices, and producer revenue. Consumers are also affected by large variations in grain prices, but not to the extent experienced at the farm level.[2] For the benefit of both producers and consumers, agricultural policy is often concerned with reducing the instability of commodity prices. (Canada Grains Council)

But, short-run farm revenue stabilization programs are also often justified, Brinkman (1981) identified three such grounds for stabilizing farm revenue:

1. Due to the uncertainties of fluctuating commodity prices, both producers and consumers should derive greater utility from secure, stable commodity prices and farm revenue, as opposed to commodity prices that fluctuate widely about the same average level.
2. With greater commodity price and revenue certainty producers could plan their production with greater confidence. Thus, producers would achieve a more efficient use of production resources. However, a certain degree of commodity price instability is desirable to eliminate the most inefficient producers.
3. Stabilization of the economic system itself is beneficial to society in general. Stable production and food costs aid in stability through the avoidance of short-run income redistributions throughout the entire economy.

These justifications for stabilization programs show the need for effective policies and programs to stabilize farm revenues. The risky nature of prairie grain production suggests that no perfectly effective method of stabilizing farm revenues exists. However, alternative policies should be explored to provide a measure of how effective they would be in relation to current policies. In general, two situations lend themselves to hedging as a replacement for existing stabilization policy: 1) when resources are committed to the production of a crop which has an unstable price, and 2) when a crop has been harvested but not marketed.

Only the first situation dominates the producer's need for short-run stabilization policy, since often producers commit resources based on expected prices (Newberry and Stiglitz). When commodity prices change from the expectations of the producer, and production is marketed at those prices, the producer then faces commodity price risk. After a crop has been harvested, the producer has the alternative to market the production for a certain known return, assuming it can be sold immediately or at a predetermined price for future delivery. This alternative makes situation 2) equivalent to speculation by the producer and beyond the needs of policy benefits, since this type of revenue risk is voluntary and taken on by the farmer hoping for a higher return.

The dominant need to stabilize producer's price expectations implies that stabilization policy account for growing season price risk. Futures and hedging may provide this type of intra year stability (Plato, USDA). But, futures may not provide for stability against long term (multi-year) market trends, since futures contracts are generally only used for up to a year in advance. However, the intra year variations in commodity prices should be reduced by hedging.

Agricultural policy already exists to reduce the variability of quantity or production in the form of crop insurance. Given that revenue variability is influenced by production and price variability, the combination of futures and crop insurance, may prove effective in stabilizing producer revenues. Recent research on futures as a policy alternative was developed as a result of the 1985 Food Security Act, that mandated a study of alternative policies for agriculture which considered the use of futures and options. One such study, by Heifner, Wright and Maish (1991), examined the feasibility of shifting Federal farm program budgetary risks to the private sector using two approaches:

1. Government "hedging" its price support commitments directly in futures and options markets.
2. Subsidizing farmer's use of futures, options, or cash forward contracts in lieu of price supports.

Results based on OLS regression of short selling futures returns on budget errors, or the difference between program estimates and actual costs, indicated that farm budgeting uncertainties could be reduced significantly by government hedging. Plato (USDA,1989) simulated the effectiveness of the futures and options markets to provide farm revenue stabilization (or revenue risk reduction) over a nine year period. This analysis considered five marketing strategies on the producer level:

1. Selling in the cash market, as the base case
2. Selling futures contracts
3. Purchasing put options (at and deep in the money)
4. Selling futures in combination with crop insurance
5. Purchasing put options in combination with crop insurance

The effectiveness of the hedging was measured in terms of the reduction in the standard deviation of producer revenue per acre in each of the marketing strategies relative to the base case 1, above. Results indicated that the effectiveness of futures and options in stabilizing short-run revenue was significantly improved when used in combination with crop insurance. However, results over the entire period of the analysis showed no significant stabilization of long-run revenues.

In general, previous research has shown that futures may provide at least the same level of stabilization for the producer that was provided by existing policies in the U.S. Also, previous research has demonstrated that futures which are not used more than one year ahead, offer primarily short-run stabilization (in contrast to limited long-run stabilization), which is consistent with the goal of this chapter. While US policies differ somewhat from Canadian policies, enough similarities exist between the two to suggest that futures may provide similar levels of short-run stabilization for the producer relative to that offered by agricultural policy.

Some argue that the demand for futures and options by farmers are reduced by the presence of government policies to stabilize grain prices (Turvey and Amanor-Boadu). Also, prairie grain producers have received short-run revenue stabilization without an actuarially sound premium attached (Figure 3.1). This means that stabilization programs often pay out more than is taken in from producer contributions, making it understandable why futures markets have not been used by producers. However, research is needed using actual past data to see how futures markets would have worked for stabilizing past short-run farm revenue in Western Canada.

Procedure and Data

This analysis uses the past correlation between changes in aggregate producer cash market revenues and the returns from selling futures on the six major crops in Western Canada, to analyze the effectiveness of futures for stabilizing annual past revenue changes. The six major crops include: all wheat (including durum), oats, barley, rye, flaxseed, and canola. The correlation between the returns from futures on the six crops and the annual change in aggregate cash revenues from those six crops, based on the fiscal year (January 1 to December 31) and excluding agricultural policy transfers, is compared over the period 1975 to 1990. The fiscal year is used because farmers, lenders, and government usually measure farm income over this period and it represents a standard measure for all involved.

By first examining correlation of changes in annual aggregate cash crop revenue with futures returns from individual crops over alternative hedging periods within the year, the individual crop hedge (short selling) returns can be combined into a single aggregate of hedging all six crops. These aggregate hedge returns are then combined with crop insurance to analyze the effectiveness of futures to stabilize short-run aggregate revenues. This approach, which uses the correlation between changes in aggregate revenues and returns from futures, rather than annual revenues and futures price, provides a measure which describes the effectiveness of hedging to stabilize the annual change in aggregate revenues, consistent with a policy perspective. However, this approach is not likely to be followed by farmers, who may be concerned with individual crop hedges (e.g. price stabilization or price enhancement versus aggregate revenue stabilization), so a more typical case of hedging is also included in the analysis. Next, past agricultural policy and crop insurance based on total transfers, net of producer contributions, are then compared with futures revenue for stabilizing producer cash market revenues.

While there are more than six crops, the six major crops are considered to approximate all crops because of the high correlation between the revenues of the six crops and total grain revenues for all crops. Secondly, the six crops make up a high proportion of total grain revenues (Table 3.1). The futures contracts used are: The Chicago Board of Trade December Wheat contract, The Winnipeg Commodity Exchange December contract for Barley, Oats, Rye, Flaxseed and, the November contract for Canola, since it does not have a December contract. These contract months are selected because more distant contracts tend to be thinly traded in the spring of the year and nearer contract months in the year would expire before harvest.

First, Ordinary Least Squares (OLS) Regression analysis is initially used to measure the correlation, or stabilization effectiveness that individual crop hedging revenues would have provided for stabilization, by offsetting annual changes in

Table 3.1 Proportions and Correlations of Six Western Canadian Crop Revenues Compared to Total Crop Receipts, for each Province, 1975 to 1990.

Province	Average Proportion of Six Crops to Total Crop Revenues	Correlation of Revenues From Six Crops with Total Crop Revenues
Manitoba	84.63	0.98
Saskatchewan	96.50	0.96
Alberta	90.50	0.98
Prairie Provinces	92.58	0.97

The annual revenues, based on the fiscal year January 1 to December 31, from the six crops include: all wheat (including durum), oats, barley, rye, flaxseed and canola. The annual revenues from the total crops include: all wheat (including durum), oats, barley, rye, flaxseed, canola, corn, sugar beets, potatoes, vegetables, mustard seed, sunflower seed, lentils, canary seed, peas, forage and grass seed, hay and clover and, miscellaneous crops. Source: Agricultural Economic Statistics, Statistics Canada, Catalogue 21-603E, 1990, Farm Cash Receipts From Farming Operations, CANSIM Databank, Statistics Canada, 1991.

aggregate revenue. The dependent variable, (ΔRev), is the annual change in aggregate producer cash market revenue, for all six crops, excluding government transfers. The independent variable is the futures returns for each crop, which is the change in intra year futures price from when the hedge is set ($\text{Futures}_{\text{set}}$), to when it is lifted ($\text{Futures}_{\text{lift}}$), multiplied by production. Since short selling is involved, a negative price change or price decrease over the growing season will result in a positive futures gain or positive hedge return. For the dependent variable, the annual *change* in aggregate cash market revenues, rather than only annual aggregate cash market revenues are used because this change more accurately describes intra year revenue variability. Also, aggregate revenue stabilization is measured rather than individual crop stabilization, as this is often the goal of policy makers. Futures returns (price change over the growing season multiplied by quantity) are used rather than only futures price, because this more accurately reflects the effectiveness of futures to reduce annual crop revenue variability rather than price variability, consistent with the approach of this chapter. The correlation between the annual change in aggregate producer cash market revenues and futures returns would be expected to be negative, if hedging is effective for revenue stabilization. A decreasing futures price, multiplied by quantity, would produce a positive short selling revenue gain, which would offset declining aggregate producer cash market revenue. This correlation is estimated with the following OLS equation:

$$\Delta Rev = \alpha + \beta((Futures_{set,\,j} - Futures_{lift,\,j}) \times Q_j) \tag{3.1}$$

where : ΔRev = the annual change in producer cash market revenues from the aggregate six crops considered
j = the individual crop
Q_j = the annual production of the crop selected

Since the prices selected for setting and lifting the hedge will vary due to the exact day the hedge is set and lifted, and may not reflect "average" prices for the period, a monthly average closing price is weighted by daily trading volume ($\overline{FP}_{j,m}$), to give price more weight consistent with heavier transactions quantity, and is generated as:

$$\overline{FP}_{j,m} = \sum_{i=1}^{n} FP_{i,j,m} \times \frac{V_{i,j,m}}{\sum V_{i,j,m}} \tag{3.2}$$

where : FP = daily closing futures price
V = daily trading volume
n = trading days in the month
i = date of trading day
j = crop or commodity selected
m = calender month

Based on (3.2), the value of $Futures_{set}$ and $Futures_{lift}$ in (3.1) become $\overline{FP}_{j,m}$ and $\overline{FP}_{j,n}$ respectively. The OLS regression model to estimate the effects of short hedging each crop selected is estimated as:

$$\Delta Rev = \alpha + \beta(\overline{FP}_{j,m} - \overline{FP}_{j,n}) \times Q_j \tag{3.3}$$

where : ΔRev = the annual change in producer cash market revenues from the aggregate six crops considered
m = opening calender month selected
n = closing calender month selected
j = the individual crop

Based on (3.3), a series of hedging strategies are estimated for each of the crops considered. The hedging strategies are based on the time period of the hedge. The hedges are set in either April or May and lifted in either November or December. Since alternative periods are used to set and lift the hedges, the results will be less time dependent, as opposed to using only one period.

Secondly, the futures returns from the alternative time periods above that form the best possible aggregate revenue stabilizing outcome, will define the upper bound, based on (3.3). The best stabilizing, or upper bound outcome is defined as the one with the strongest negative correlation, which is the highest R^2 value. Similarly, a lower bound, or least stabilizing outcome, is formed from the least effective combination of hedges for the six crops considered. The range of these two outcomes will show the past potential short-run aggregate revenue stabilization that may have been possible using futures. Also, this assumes that the goal of selling futures during the growing season, would have been to stabilize aggregate cash market revenue across all crops, similar to the goal of policy makers, trying to achieve aggregate revenue stabilization.

The upper bound hedge combination of short selling revenues, when summed across each of the crops, becomes the short selling revenue, called the "optimal" hedge strategy, for stabilizing aggregate cash revenues. The lower bound combination, when summed across each of crops, becomes the short selling revenue for the "non-optimal" hedge strategy, for stabilizing aggregate cash revenues. The range of potential revenue stabilization is measured by R^2, for the two equations, and is estimated by the OLS regression models of the form:

$$\Delta Rev = \alpha + \beta(Optimal\ Hedge\ Strategy\ Returns) \tag{3.4,1}$$

$$\Delta Rev = \alpha + \beta(Non\text{-}Optimal\ Hedge\ Strategy\ Returns) \tag{3.4,2}$$

where : ΔRev = the annual change in producer cash market revenues from the aggregate six crops considered

The "optimal" and "non-optimal" hedge strategies provide an indication of the range of potential stabilizing effects futures returns may have had on changes in aggregate cash revenues, based on the R^2 measure.[3] However, while this aggregate revenue stabilization would likely be the goal of policy makers, it is not likely the goal of farmers. To compare this case with results from how farmers likely would have hedged on average, and making no specific assumptions of their motives (e.g. price stabilization or enhancement), a "typical" hedge case is also analyzed. It is the futures revenue simply averaged across each crop, assuming equal amounts of crop hedged in each of the four hedging periods, and summed across crops. The ability of the typical hedge to stabilize aggregate farm revenue is measured by the R^2 in the following equation:

$$\Delta Rev = \alpha + \beta(Typical\ Hedge\ Strategy\ Returns) \tag{3.4,3}$$

where : ΔRev = the annual change in producer cash market revenues from the aggregate six crops considered

Restating (3.4,1), (3.4,2), and (3.4,3) in terms of the data, the OLS estimation of the range of potential hedging benefits is defined by estimating the following for the "optimal", "non-optimal", and "typical" hedge strategy:

$$\Delta Rev = \alpha + \beta\left(\sum_{j=1}^{6} (FP_{j,m} - FP_{j,n})\right) \times Q_j \tag{3.5}$$

where : ΔRev = the annual change in producer cash market revenues from the aggregate six crops considered

$(FP_{j,m} - FP_{j,n})$ is based on (3.2) for each of the six crops

Q_j = the annual production of the crop selected

The effectiveness of agricultural policy in the prairie grain sector for stabilizing annual grain revenues is considered in a similar fashion to short hedging the six crops considered. The annual policy transfers to producers (net of producer contributions), form the independent variable in the OLS model:

$$\Delta Rev = \alpha + \beta(Net\ Policy\ Transfers) \tag{3.6}$$

This is estimated for each of the Net Policy Transfers selected, which form the independent variables. The Net Policy Transfers are:

W.G.S.P.: The net annual payments to producers under the Western Canadian Grain Stabilization Program.

Federal Transfers: The net Federal Government transfers to producers from W.G.S.P., Special Canadian Grains Program, Two Price Wheat Compensation, Migratory Waterfowl Damage Compensation, Special Drought Assistance and Farm Income Assistance.

Rebates: The net Federal and Provincial Rebates from Property Taxes, Interest Payments, Federal and Provincial Fuel Taxes, and Heating Fuels.

Total Policy Transfers: The net combined transfers from Federal Transfers and Rebates above, Provincial Programs which include Special Grants to Farmers, Crop Loss Compensation, Western Emergency Assistance, Saskatchewan Drought Assistance, Farm Fertilizer Price Protection, Grasshopper Control Program and Alberta Flood Assistance and, Net benefits accruing to producers from the Crow Rate, Western Grain Transportation Act, and Canadian Wheat Board deficits.

To provide complete revenue stabilization, as measured by R^2, crop insurance is also considered in combination with futures. The payments received under crop insurance (C.I. Benefits), net of producer contributions, forms the independent variable in the OLS models:[4]

$$\Delta Rev = \alpha + \beta_1(\textit{Optimal Hedge Strategy Returns}) + \beta_2(\textit{C.I. Benefits}) \tag{3.7}$$

$$\Delta Rev = \alpha + \beta_1(\textit{Non-Optimal Hedge Strategy Returns}) + \beta_2(\textit{C.I. Benefits}) \tag{3.8}$$

$$\Delta Rev = \alpha + \beta_1(\textit{Typical Hedge Strategy Returns}) + \beta_2(\textit{C.I. Benefits}) \tag{3.9}$$

Finally, crop insurance and past policies are compared to the futures equations above for stabilization ability, using the R^2 measure. Therefore, the policy benefits defined in (3.6) above are also combined with crop insurance benefits in the OLS model:

$$\Delta Rev = \alpha + \beta_1(\textit{Net Policy Transfers}) + \beta_2(\textit{C.I. Benefits}) \tag{3.10}$$

Results

The effectiveness of the hedge to stabilize annual changes in aggregate revenues will be reflected in the R^2 for the model, based on equation (3.3). An R^2 of 1 indicates perfectly effective hedges for stabilizing revenues, while an R^2 of 0 indicates no hedging effectiveness. But, since the *changes* in aggregate cash market revenues and futures revenues are used rather than only revenues and futures prices themselves, low R^2 values and low statistical significance would be expected. Also, a negative relationship between stabilization programs and the changes in revenues is expected, so tests used for statistical significance are one tailed tests.

Changes in total crop cash market revenues are the dependent variable, since this describes short-run stabilization, which is stabilizing around average changes in total crop revenue levels. This is in contrast to using only total crop revenue levels, which describes long-run stabilization, which is instead stabilizing around the mean of total crop revenue. Therefore, results presented here are short-run, and reflect attempts to stabilize changes in revenue, around average changes in revenue, as opposed to long-run results that attempt to stabilize revenue around the average of revenue itself, rather than changes in it.

The results of the futures hedging strategies for stabilizing aggregate cash market revenue from the individual crops considered in this analysis, based on equation (3.3), are presented in Table 3.2. All of the Durbin-Watson statistics in this study showed that autocorrelation was either not present or in the inconclusive range. In general, these results show the negative signs on the futures returns as hypothesized, and lend support for stabilization of short-run

Table 3.2 Relationship Between Selected Futures Revenue and Annual Change in Total Grain Receipts, using OLS Regression, 1975 to 1990.

Crop	Hedge Period	Intercept	Independent Variable Coefficient	R^2	Durbin-Watson Statistic
Wheat	April - November	118.486	-0.249 (-0.995)	0.066	1.336
	April - December	100.251	-0.072 (-0.285)	0.006	1.410
	May - November	130.086	-0.318 (-1.188)	0.092	1.327
	May - December	109.000	-0.112 (-0.405)	0.012	1.393
Oats	April - November	128.968	-3.272 (-1.311)	0.109	1.397
	April - December	113.730	-3.269* (-1.404)	0.123	1.427
	May - November	126.295	-3.265 (-1.288)	0.106	1.380
	May - December	110.963	-3.252* (-1.379)	0.120	1.412
Barley	April - November	118.716	-1.355** (-2.073)	0.235	1.378
	April - December	111.517	-1.221** (-1.910)	0.207	1.376
	May - November	142.754	-1.465** (-2.020)	0.226	1.336
	May - December	131.786	-1.290** (-1.833)	0.194	1.336
Rye	April - November	109.466	-16.490** (-2.100)	0.240	1.295
	April - December	138.227	-15.170** (-1.762)	0.182	1.291
	May - November	129.591	-18.371** (-2.202)	0.257	1.292
	May - December	160.353	-16.928** (-1.835)	0.194	1.283
Flaxseed	April - November	207.619	-9.498** (-2.525)	0.313	2.066
	April - December	202.029	-7.380** (-1.938)	0.211	1.910
	May - November	231.014	-11.768** (-3.260)	0.432	2.114
	May - December	232.093	-9.591** (-2.511)	0.311	1.983

Table 3.2 (Continued) Relationship Between Selected Futures Revenue and Annual Change in Total Grain Receipts, using OLS Regression, 1975 to 1990.

Crop	Hedge Period	Intercept	Independent Variable Coefficient	R^2	Durbin-Watson Statistic
Canola	April - November	144.240	-2.113^{**} (-1.932)	0.211	1.545
	April - December	130.326	-2.052^{**} (-1.764)	0.182	1.629
	May - November	186.880	-2.283^{**} (-1.786)	0.186	1.523
	May - December	167.490	-2.132^{*} (-1.570)	0.150	1.598

t-values in parentheses; * significant at the ten percent level; ** significant at the five percent level; based on one tail test, since coefficient is expected to be negative.

The dependent variable is the same for all equations and is the annual change in gross producer receipts ($1,000,000's) based on the fiscal year January 1 to December 31, for wheat, oats, barley, rye, flaxseed, and canola (includes CWB final payments when received and excluding policy transfers to producers) for the period 1975 to 1990. Source: Agricultural Economic Statistics, Statistics Canada, Catalogue 21-603E, 1990 and calculations by author.

The independent variables are the change in futures prices which are the average volume weighted daily price change between months shown (multiplied by production), and is from the Chicago Board of Trade (December Wheat Contract) and the Winnipeg Commodity Exchange (December Oat, Barley, Rye, Flaxseed and January Canola Contracts) average daily closing price ($/tonne), multiplied by production. Source: Statistical Annual of the Chicago Board of Trade, Chicago Board of Trade, 1970-90. Exchange Rates used in the analysis are based on the average monthly spot price for the Canadian Dollar. Source: The Bank of Canada Review, Account 3400, The Bank of Canada, 1970-90. Statistical Annual of the Winnipeg Commodity Exchange, Winnipeg Commodity Exchange, 1974-1991.

aggregate revenues through hedging.

Flaxseed futures returns showed the most effectiveness for stabilizing aggregate cash grain market revenues, as seen in Table 3.2. The R^2 values that ranged from 0.432 to 0.211 suggest that considerable variability in aggregate revenues would have been eliminated by hedging. The results for the hedging strategies for rye indicate that annual aggregate revenues would be stabilized by hedging with futures, with R^2 values that range up to 0.257. The results for canola futures showed an effective hedge, with R^2 values that ranged from 0.150 to 0.211, but suggest smaller benefits to stabilizing aggregate revenues than hedging with rye futures or flaxseed futures. However, all of these three Non-Canadian Wheat Board crops show that considerable variability in short-run grain revenues would have been removed by hedging with futures.

The results of selectively hedging wheat, oats and barley, which are the Canadian Wheat Board (CWB) grains, are shown in Table 3.2. The results show the correct negative signs to support stabilization through hedging, though barley dominates as the most effective CWB grain to hedge aggregate revenues with an R^2 that ranged from 0.235 to 0.194. Wheat was the least effective CWB crop to hedge for stabilization, as was shown by the lowest R^2 range, between 0.006 to 0.092, which was the lowest of all crop futures considered in this analysis. But, the R^2 for all CWB grain revenues suggest that hedging would still provide some stabilization of aggregate revenues. The reduced effectiveness of hedging aggregate revenues with CWB grain versus non-board grains may be because:

1) The proportion of aggregate revenue made up by CWB grains is high enough to stabilize aggregate revenues.[5]
2) The initial payment offered by the CWB forms a floor price for board grains such as barley, so may act to stabilize revenues if the barley open market price were to fall below the CWB price.

The results in Table 3.2 also illustrate that substantial differences lie between periods in which the hedge is carried out. The implication of this is that theoretical hedge models used in this type of application are subject to either over or under stating the potential benefits from hedging. For this reason, upper and lower bounds where placed on the results of hedging by defining an "optimal" and "non-optimal" hedge strategy.

Based on the results from equation (3.3) contained in Table 3.2, the optimal hedge strategy was determined to be the following:

Wheat: May - November Hedge
Oats: April - December Hedge
Barley: April - November Hedge
Rye: May - November Hedge
Flaxseed: May - November
Canola: April - November Hedge

Based on the results from equation (3.3) contained in Table 3.2, the non-optimal hedge strategy, the opposite of above, was determined to be the following:

Wheat: April - December Hedge

Oats: May - November Hedge

Barley: May - December Hedge

Rye: April - December Hedge

Flaxseed: April - December Hedge

Canola: May - December Hedge

Table 3.3 compares policy transfers with futures revenues for stabilizing aggregate revenues for the six crops used in this study. All coefficients had negative signs, indicating a stabilizing effect on short-run aggregate revenues. The optimal hedge for the six crops provided the greatest amount of revenue stabilization, with an R^2 of 0.193. The typical hedge, or average of hedging returns, also showed relatively high levels of stabilization, as compared to the traditional policies, with an R^2 of 0.120. The typical hedge was the futures revenue simply averaged across each crop, assuming equal amounts of crop hedged in each of the four hedging periods, and summed across crops. The net benefits from WGSP provided results similar to the typical hedge, with an R^2 of 0.127. The non-optimal hedge, which defines the lower range of potential hedging effectiveness in this study with an R^2 of 0.120, still exceeded the sum of individual policy transfers, or total transfers. The traditional agricultural policies, in order of their effectiveness to stabilize short-run producer revenues, based on R^2, were: Rebates, W.G.S.P., Total Policy Transfers, and Federal Transfers.

Table 3.3. Relationship between Annual Changes in Gross Aggregate Grain Receipts for Six Crops and Alternative Stabilization Methods, 1975 to 1990.

Stabilization Method	Intercept	Independent Variable Coefficient	R^2	Durbin-Watson Statistic
Optimal Hedge	149.156	-0.297** (-1.830)	0.193	1.578
Non-Optimal Hedge	134.907	-0.164 (-0.956)	0.061	1.427
Typical Hedge	145.784	-0.234* (-1.381)	0.120	1.326
W.G.S.P.	219.621	-0.573* (-1.430)	0.127	1.620
Federal Transfers	156.678	-0.185 (-0.729)	0.037	1.513
Rebates	528.860	-10.686* (-1.538)	0.144	1.931
Total Policy Transfers	289.682	-0.185 (-0.924)	0.058	1.541

t-values in parentheses; * significant at the ten percent level; ** significant at the five percent level; based on one tail test, since coefficient is expected to be negative.

The dependent variable is the same for all equations and is the annual change in gross producer revenues ($1,000,000's) based on the fiscal year January 1 to December 31, for wheat, oats, barley, rye, flaxseed, and canola (includes CWB final payments when received and excluding policy transfers to producers) for the period 1975 to 1990. Source: Agricultural Economic Statistics, Statistics Canada, Catalogue 21-603E, 1990 and calculations by author.

The independent variables:

Optimal Hedge is based on the combination of futures hedge revenues that would have proven the most effective in stabilizing total revenue from the six crops considered; May - November hedge for wheat, April - December hedge for oats, April - November hedge for barley, May - November hedge for rye, May - November for flaxseed, and the April - November hedge for canola, based on Table 3.2. These results ($1,000,000's), are then combined, on an annual basis, to analyze the effectiveness of the hedges to stabilize changes in gross producer grain revenues from the six crops.

Non-Optimal Hedge is based on the least effective combination of hedges to stabilize the total revenue from the six crops considered; April - December hedge for wheat, May - November hedge for oats, May - December hedge for barley, April - December hedge for rye, April - December hedge for Flaxseed, and May - December hedge for canola, based on Table 3.2. These results ($1,000,000's), are then combined, on an annual basis, to analyze the effectiveness of the hedges to stabilize changes in gross producer grain revenues from the six crops.

Typical Hedge is the futures revenue simply averaged across each crop, assuming equal amounts of crop hedged in each of the four hedging periods, and then summed across crops ($1,000,000's).

W.G.S.P. represents the annual net payments ($1,000,000's), to producers under the Western Grain Stabilization Program for the years 1975 to 1990. Source: Western Grain Stabilization Program: Annual Report 1987-88, Publication 5201B, Minister of Supply and Services, 1990.

Federal Transfers represent the net Federal Government transfers ($1,000,000's), to producers from: W.G.S.P., Special Canadian Grains Program, Two Price Wheat Compensation, Migratory Waterfowl Damage Compensation, Crop Assistance Program, Grain Embargo Compensation, Special Drought Assistance, and Farm Income Assistance. Source: Calculations by author.

Rebates represent the net Federal and Provincial rebates ($1,000,000's), from; Property Taxes, Interest payments, Federal and Provincial Fuel Tax and, Heating Fuels. Source: Calculations by author.

Total Policy Transfers represent the net combined transfers ($1,000,000's), from: Federal Transfers and Rebates from above and, Provincial Programs which include the net producer benefits from; Special Grants to Farmers, Crop Loss Compensation, Western Emergency Assistance, Saskatchewan Drought Assistance, Farm Fertilizer Price Protection, Grasshopper Control Program and, Alberta Flood Assistance, and Net benefits accruing to producers from the Crow Rate and the Western Grain Transportation Act. Source: calculations by author.

Table 3.4 considers a complete approach to stabilizing revenues by including crop insurance, as well as the price stabilization offered by futures. The results indicate that optimal futures hedging in combination with crop insurance provided the highest degree of revenue stabilization with an R^2 of 0.218. But, even the non-optimal hedge and crop insurance combination displayed more potential to stabilize producer revenues with an R^2 of 0.102 than did the sum of government policies considered or total transfers in Table 3.4. The overall effect of policy, measured by the variable Total Transfers and crop insurance, showed the worst effect on stabilizing producer revenues with an R^2 of 0.076.[6] The typical hedge and crop insurance combination, which showed an R^2 of 0.154, provided similar levels of stabilization as the WGSP and Rebates variables in combination with crop insurance. Comparing Table 3.4, and Table 3.3, the use of futures hedges for stabilization appear to have been more effective when used with crop insurance, as evidenced by the higher R^2 values in Table 3.4.

Conclusion

Results show that futures in combination with crop insurance held a greater potential for stabilizing short-run aggregate producer revenues than did existing agricultural policy. Considerable differences were found in the ability of short hedging to stabilize farm revenues from the six crops considered. For this reason, bounds were placed on the ability of hedging to stabilize revenues. Even the lower bound of this range or worst case of potential benefits from hedging,

Table 3.4 Relationship Between Annual Changes in Gross Aggregate Grain Receipts for Six Crops and Alternative Stabilization Methods and Crop Insurance, 1975 to 1990.

Independent Variables		Intercept	Coefficients		R^2	Durbin-Watson Statistic
X_1	X_2		X_1	X_2		
Optimal Hedge	Crop Insurance	243.118	-0.283* (-1.689)	-0.594 (-0.640)	0.218	1.320
Non-Optimal Hedge	Crop Insurance	257.043	-0.158 (-0.904)	-0.760 (-0.770)	0.102	1.415
Typical Hedge	Crop Insurance	255.558	-0.223 (-1.286)	-0.690 (-0.718)	0.154	1.359
W.G.S.P.	Crop Insurance	312.495	-0.535 (-1.293)	-0.623 (-0.645)	0.155	1.624
Federal Transfers	Crop Insurance	249.166	-0.142 (-0.531)	-0.666 (-0.642)	0.066	1.559
Rebates	Crop Insurance	555.247	-9.756 (-1.293)	-0.397 (0.395)	0.155	1.932
Total Transfers	Crop Insurance	335.175	-0.145 (-0.656)	-0.552 (-0.516)	0.076	1.557

t-values in parentheses; * significant at the ten percent level; ** significant at the five percent level; based on one tail test, since coefficient is expected to be negative.

The dependent variable is the same for all equations and is the annual change in gross producer revenues ($1,000,000's) based on the fiscal year January 1 to December 31, for wheat, oats, barley, rye, flaxseed, and canola (includes CWB final payments when received and excluding policy transfers to producers) for the period 1975 to 1990. Source: Agricultural Economic Statistics, Statistics Canada, Catalogue 21-603E, 1990 and calculations by author.

The independent variables:

Optimal Hedge: see Table 3.3.
Non-Optimal Hedge: see Table 3.3.
Typical Hedge: see Table 3.3.
W.G.S.P.: see Table 3.3.
Federal Transfers: see Table 3.3.
Rebates: see Table 3.3.
Total Policy Transfers: see Table 3.3.

Crop Insurance represents the net payments ($1,000,000's), to producers under the Crop Insurance system. Source: Agricultural Economic Statistics, Statistics Canada, Catalogue 21-603E, 1990.

exceeded the ability of the combined government policies selected to stabilize short-run cash market farm revenues.

When crop insurance was included into the analysis, results showed that futures were an even more effective stabilizing tool than past agricultural policies. One reason for poor government policy performance may be that since government payments are lagged, they are not actually paid out in the low revenue year, but may be lagged and paid out in the next year, which may be a high revenue year. Also, if government payments are linked to farm revenue or production, government programs may pay out more in good years, and less in bad years, which would also be ineffective in stabilizing revenue.

This study only examined the ability of futures to stabilize short-run aggregate farm revenues. But to enhance farm revenue, government policy could also subsidize the use of futures for short hedging. The degree of subsidization would depend on the level of income transfer provided for in the policy being replaced. As a replacement for past stabilization policies, futures appeared to be more effective. However, a futures stabilization policy may be more difficult to implement than past policies. For example, if hedging was carried out by the producer, how would the individual or government cover margin calls? Would government participation in the market cause problems? What proportion of expected production would be hedged given the inherent risk of production? What adverse effects on price would the increased short positions have in the market? Also, the effects of the increased volume of futures demanded by producers on futures price is uncertain. These are a few of the issues that must be considered before futures or options could be considered as an alternative for stabilization policy.

While this study is not the final word, it is the first to analyze the relative effectiveness of futures for short-run aggregate revenue stabilization in Western Canada, and demonstrates that some past farm programs may have been relatively ineffective for stabilization, compared to futures hedging. This highlights the need for government to provide timely program benefits, and negatively correlated with farm revenue, if they are to be effective for the farmer. It appears that commodity futures markets may offer the type of risk reduction needed by the producer to stabilize short-run revenues, and therefore merit further investigation.

End Notes

[1] Since the objective of this study is to analyze the past effectiveness of stabilization for the Western Canadian grain sector as a whole, only aggregate stabilization policy is analyzed. While stabilization analyzed on more specific levels such as per farmer, per acre, or per crop may be of interest, they are beyond the scope of this analysis. Also, many major government programs such as the Western Grain Stabilization Program (WGSP) were aggregate in nature, rather than farmer specific or crop specific, so this study is concerned with aggregate rather than more specific stabilization effectiveness. As well, since agriculture forms a large share on GNP in Western Canada, aggregate grain stabilization is important in stabilizing the Western Canadian economy as a whole. Short-run stabilization is examined, because futures and options would ordinarily be expected to only stabilize revenue within a year. Also, though many farm programs have been designed to provide income enhancement rather than stabilization, they are still included in this analysis, as they may still have an impact on stabilization.

[2] Commodity price fluctuations at the producer level usually exceed those at the retail level for basically three reasons: 1) the small proportion raw farm products represent of the value of processed foods, and related to this 2) the relatively large costs of food retailing which includes both fixed (buildings) and non-fixed (labour) costs, 3) the increased use of constant retail-value markups as opposed to percentage-value markups. (Marion, Mueller, Cotterill, Geithman, and Schmelzer)

[3] R^2 is used because this analysis is attempting to measure the past negative correlation between variables, or the effectiveness of the change in the option premiums over the growing season multiplied by production, to offset or stabilize the change in producer revenue. This measure extends the traditional measure of price hedging effectiveness to revenue stabilization effectiveness, since traditional hedging effectiveness measures only the price correlation between cash price and futures price.

[4] This analysis uses a regression model and estimates correlation to measure stabilization effectiveness, rather than a simulation model, since farm programs in Western Canada tend to be very ad hoc in nature, with a temporary time frame, and so are much more difficult simulate in the same way as US policy, which is less ad hoc. For example, programs such as drought assistance, interest rate rebates, and Western Emergency Assistance did not have formal planning, and were often implemented for no set time frame, which the farmer or policy analyst could predict in advance. Also, even programs less ad hoc in nature, such as WGSP, still have an uncertain payment system in place, so the farmer or policy

analyst could not accurately predict the payment timing or size in advance, in order to easily and accurately simulate it. However, since this study uses correlation instead of simulation, and attempts to analyze the past rather than predict the future, it has the advantage of using actual data rather than simulated data (e.g. actual price and quantity), and so does not require simulation assumptions (e.g. price and quantity distributions), which may in some ways predetermine the results, from what would have actually happened. Also, Heifner, Wright and Maish (1991) use regression analysis in a similar application to the one used here, where the objective was to examine the effectiveness of futures and options to stabilize past farm budget errors.

Regarding the use of change in revenue, since the objective of this chapter is to measure stabilization of changes in inter year revenue, the changes within the year must be computed so they can be compared across years. Also, changes in revenue is used since gains from hedges are a change variable, and transfers from government programs are also a change variable, since some years they can be negative (e.g. WGSP). Also, working in changes of variables rather than levels allows trends to be removed from the data.

[5] During the period of this study sales to the CWB of wheat and barley represented on average 78%, and 45% respectively of total annual production. Although oats is no longer a CWB grain, sales to the CWB represented on average were 12% of total annual production until 1989.

[6] This analysis does not attempt to compare the magnitude of B coefficients across equations, only the sign and R^2, because the purpose of this analysis is not to measure the magnitude of transfers, but only to measure the effectiveness of transfers. For example, a B coefficient of -2.0 from one program may provide the same relative stabilization dollar for dollar, as a coefficient of -20.0 from another program, even though the magnitude of the stabilization is 10 times greater in the latter case. In other words, this analysis attempts to measure relative effectiveness of stabilization or policy, rather than the amount of the stabilization. Therefore, statistical tests of B coefficients across equations are not used, and only the R^2 measure is used across equations, since the R^2 measures correlation. As well, no conclusions are drawn concerning cause and effect, since only correlation is of interest here. In other words, independent variables would not be expected to impact or "cause" the dependent variable.

CHAPTER 4

THE EFFECTIVENESS OF COMMODITY OPTIONS FOR STABILIZING GRAIN REVENUES

Introduction

This study examines the effectiveness of commodity options combined with crop insurance versus past agricultural policy to reduce short-run aggregate revenue risk for the Western Canadian grain sector, which includes Manitoba, Saskatchewan, and Alberta. Since large transfers of public funds have been used in the past to provide aggregate stabilization of farm revenues, it is important to analyze the relative short-run effectiveness of Western Canadian farm programs compared to the more market oriented stabilization methods, such as options.[1]

Since this study attempts to examine the performance of commodity options and crop insurance in comparison to past policies for stabilizing producer revenues, past policy benefits received by grain farmers directly, and indirectly through subsidized production costs, are calculated. With the actual subsidy data, a comparison to alternative policies such as options is possible. Since options have only been traded since 1982, and not on all crops, option premiums must be estimated. Black's (1976) formula is used with actual futures data to estimate the option premiums. Overall, this study attempts to add a degree of realism in analyzing stabilization effectiveness, by using the most complete and up to date data set on government transfers. Also, this analysis extends previous U.S. work on options as a policy alternative, to the Canadian situation.

Put Options and Revenue Stabilization

Options on agricultural commodity futures have only recently began trading in North America, with options trading in the United States beginning in 1982 and in Canada in 1991. Prior to 1982, farmers had only the futures market to hedge price risk, by either buying or selling futures contracts, depending on their position in the cash market.

Similar to the buying and selling positions taken in the futures market, the options market offers similar positions through paying a premium to buy put options and call options. A put option provides the holder the right to sell the underlying futures contract at a specified exercise price or strike price for a limited time. A call option provides the holder the right to buy the underlying futures contract at a specified exercise price or strike price for a limited time. In other words, options can be viewed as price insurance, which guarantee a specified price, where the cost of this guaranteed price is the option premium.

The purchase of put options to hedge the price of expected production, prior to committing production resources, will create a floor price for the crop during the growing season. If the market price falls below the strike price (the exercise price of the underlying futures contract), when the crop is harvested, the option would gain value and be sold for a price above its original purchase price, to offset the losses in the cash market. Conversely, if the market price moves above the strike price of the option, the put option would lose value and be sold for an amount below the purchase price (or may become worthless and allowed to expire), and the higher market price for production may more than offset the cost of the option. However, the growing season hedge, or short hedge with put options can have adverse effects on overall producer returns when commodity prices rise during a crop failure (Conroy and Rendleman). This means that even though prices for production are higher, the reduced production may leave the farmer unable to offset the cost of the put option.

However, the risk of crop failure, or yield risk, can be offset by crop insurance, and when combined with put options, potentially offers a more complete form of revenue insurance than put options alone (Plato, USDA). When yields are low, and grain prices high, the loss on put options will be partially offset by crop insurance payouts. Alternatively, when yields are high and grain prices are low, the losses from crop insurance will be partially offset by the gains from hedging with put options.

Previous Research

Analysis of options as a short hedge alternative to futures for producers, suggests that put options provide a favourable price risk management strategy, when yield uncertainty is high. Hauser and Eales (1987) examined nine strategies for option hedging, futures hedging, and unhedged positions. They concluded that hedging with options was most acceptable to the hedger who is risk adverse, for outcomes below the expected hedge price.

Other research on commodity options as a policy alternative was developed as a result of the 1985 Food Security Act, which mandated a study of alternative policies for agriculture that considered the use of futures and options (USDA). Heifner, Wright and Maish (1991) examined the feasibility of shifting Federal farm program budgetary risks to the private sector using two approaches:

1. The government "hedging" its price support commitments directly in futures and options markets.
2. Subsidizing farmer's use of futures, options, or cash forward contracts in lieu of price supports.

Results indicated that farm budgeting uncertainties could be reduced significantly by government hedging. Glauber and Miranda (USDA, 1989) used a simulation analysis to compare a subsidized put option program to current price support programs in the United States. Results indicated that market prices would be slightly lower under a subsidized put option program. This result was due to the simulated removal of the market floor price provided by the Non Recourse Loan Program and the difference in commodity price represents the potential welfare gain to consumers.

Irwin, Peck, Doering, and Brorsen (USDA, 1989) simulated the effects of existing and options hedging programs on producer revenue, consumer costs, and tax payer costs in the United States corn market. Results indicated that subsidized put options provided producers with returns at least equivalent to the target price and loan programs, and provided a net benefit to consumers in terms of lower prices. Also, Plato (USDA, 1989) simulated the effectiveness of the futures and options markets to provide farm revenue stabilization and results indicated that the effectiveness of futures and options in stabilizing revenue was significantly improved when used in combination with crop insurance.

Procedure and Data

This analysis examines the past correlation between changes in cash revenues and the returns from intra year put option premium changes on the six major crops in Western Canada. These include: all wheat (including durum), oats, barley, flaxseed, rye and canola. The correlation between the returns from put options is compared with the producer cash revenue change from the previous year for total crops based on annual sales, for the fiscal year (January 1 to December 31), excluding agricultural policy transfers, and for the period 1975 to 1990. This correlation should be negative, assuming put options are successful for stabilizing producer cash revenues. By evaluating options first on an individual crop basis, they can later be combined into a single aggregate of all crops, and considered along with crop insurance to analyze the effectiveness of options to stabilize overall grain revenues. Also, by examining the annual change in revenues as opposed to only revenues, short-run stabilization is measured, which is the focus this chapter.

The fiscal year time period is used because it represents a standard measure for farmers, lenders and government. Past agricultural policy and crop insurance based on total transfers, net of producer contributions, are then compared to put option revenue stabilization. Revenue stabilization is used here rather than price stabilization, since it is revenue stabilization that the farmer and government policy makers are generally concerned with.

Black's option valuation model is used to simulate the premiums on put options for the futures contracts underlying the six crops reviewed in this study. Black's option valuation model has relatively wide acceptance for uses similar to the one applied here (Plato, USDA; Irwin, Peck, Doering and Brorsen, USDA). The futures contracts used are: The Chicago Board of Trade (CBOT) December Wheat contract (since Canadian wheat futures are only for feed wheat), the Winnipeg Commodity Exchange (WCE) December contract for Barley, Oats, Flaxseed, the October contract for Rye and, the January contract for Canola. These contract months are selected because more distant contracts tend to be thinly traded in the spring of the year, and options on nearer contract months in the year would expire before harvest.

To estimate option premiums with Black's Model, five basic pieces of information are needed to determine the value of the option, which include:

1). Futures price

2). Strike price

3). Interest rate

4). Annualized volatility

5). Time to expiration

The futures price used is the corresponding futures price at which the put option is purchased to set the hedge and is sold to lift the hedge. Two alternative hedge periods are considered to provide an indication of the variability of the effectiveness of a put option short hedge to stabilize producer revenues. The hedges are set on the first trading day in April or May and both are lifted on the first trading day in November, except for Rye which is lifted on the first day of September. The hedging period for Rye differs from the other crops considered due to a growing season that ends with harvest around the month of August, as opposed to September or October for the other crops.

Strike prices for options on futures are actually set by exchanges as a "band" around market prices, in increments. Therefore, the increment scale adopted for strike prices in this study are similar to options currently traded in the United States. Strike prices on oilseeds, which include canola and flaxseed, are set in $10/tonne increments and the cereal grains, which includes rye, barley, oats, and wheat, are set in $5/tonne increments. The strike price selected in this study is the closest increment to the futures price on the date the option value is estimated. For example, the strike price selected for flaxseed on the first trading day in May would be $360/tonne, if the futures price on this date was $363.50/tonne (based on the December contract). Also, the strike price when the hedge is lifted, on the first trading day in November, will correspond to the strike price established when the hedge was set.

Interest rates used in the Black's Option model for this study are the prevailing Government of Canada short-term bond rates at the time the option values are estimated. These rates are used because they have no default risk, and cover the time period of the short hedge used. Price volatility in Black's Option model represents the price volatility of the underlying asset, a futures contract in this case. Price volatility is calculated by using annualized volatility, which is based on the variance of the price for the futures contract underlying the option.

The time to expiration is the number of days between when the option is purchased, until when the option expires. In this study, the days to expiration parallel the time period of the hedge. Using Black's model the value of the put option when the hedge is set and lifted are estimated for strike prices at-the-money when the hedge is set. According to option pricing theory, strike prices at-the-money have a hedge ratio or delta of approximately 0.5. The hedge ratio is the rate at which the option value changes in relation to the underling futures contract. Therefore, a hedge ratio of 0.5 will require twice as many options as futures contracts to complete the hedge. To be consistent with this, twice as many options are purchased, similar to how a farmer would act when hedging expected production. Thus, two options are purchased when the hedge is set, in order to provide a beginning effective hedge ratio of 1, or a delta neutral hedge.

The correlation analysis initially examines the correlation between the annual change in total grain revenues summed across all crops (without government program benefits) and the returns from short hedging (buying put options), over alternative periods for each of the crops considered. This determines the range of past potential short-run revenue stabilization that may have been possible using options. It assumes the goal of buying put options would have been to stabilize aggregate revenue across all crops, similar to the general goal of policy makers trying to achieve revenue stabilization. However, this may be somewhat different than the "typical" goals of individual farmers, who may hedge with options to stabilize price or enhance price for individual crops, rather than to stabilize revenue across all crops, from a policy perspective. Therefore, this "typical" situation is also included in the later analysis, for comparison.

The correlation between the annual change in aggregate producer cash market revenues and the individual crop returns from short hedging with put options, over alternative periods, is estimated with the following OLS Regression equation:

$$\Delta Rev = \alpha + \beta((Option_{j,m} - Option_{j,n}) \times Q_j) \qquad (4.1)$$

where : ΔRev = the annual change in total producer cash market revenues summed across the six crops (excluding government transfers)

m = the first trading day in the month the hedge is set

n = the first trading day in the month the hedge is lifted

j = crop or commodity selected

Q = annual production

The dependant variable, which is the annual change in total revenues summed across the six crops, is used because this analysis is from a policy perspective with a view to stabilizing overall revenues as opposed to individual crop revenues. The annual change in grain receipts from the previous year rather than annual grain receipts is used because this more accurately describes intra year revenue variability, consistent with short-run stabilization. Similarly, changes in option premiums (multiplied by quantity), over the period the options are held, are used because option revenue more accurately reflects the benefits of a short hedge on current crop revenue variability, than option price alone.

A series of hedging strategies are estimated, to define the optimal period of either April - November or May - November for individual crop hedges to stabilize aggregate revenue across all crops, measured by R^2 in (4.1). Since alternative periods are used to set and lift the hedges, the results will be more robust and less fragile than using only one hedging period. The potential revenue stabilization from buying put options on individual crops is used to develop an indication of the combined potential benefits from hedging the six crops, where hedging benefits are measured by the R^2 measure.[2] The combination of individual crop hedges based on (4.1) that form the best possible revenue stabilizing outcome for the aggregate of six crops, based on R^2, define the upper bound. Similarly, a lower bound is defined from the least effective combination of hedges for the aggregate of six crops considered.

The upper bound hedge combination, which is the sum of hedge returns (change in option premium multiplied by production) across each crop for the most stabilizing hedge, becomes the "Optimal" hedge strategy for stabilizing revenues and will have the highest R^2. The lower bound combination, which is the sum of returns across each crop for the least stabilizing hedge, becomes the "Non-Optimal" hedge strategy for stabilizing revenues and will have the lowest R^2.

After the Optimal and Non-Optimal hedge returns are determined, their ability to stabilize the annual change in aggregate farm revenue is measured in terms of correlation, given by R^2, estimated by OLS for the following equations:

$$\Delta Rev = \alpha + \beta(Optimal\ Hedge\ Strategy) \tag{4.2}$$

$$\Delta Rev = \alpha + \beta(Non\text{-}Optimal\ Hedge\ Strategy) \tag{4.3}$$

The "optimal" and "non-optimal" hedge strategies provide an indication of the range of potential stabilizing effects put option returns may have on changes in aggregate revenues. However, while this aggregate revenue stabilization would be the goal of policy makers it is not likely the goal of farmers. To compare this case with results from how farmers likely would have hedged on average, and making no specific assumptions of their motives (e.g. price stabilization or enhancement), a "typical" hedge case is also analyzed. It is the option revenue simply averaged across each crop, assuming equal amounts of crop hedged in each of the two hedging periods, and summed across crops. The ability of the typical hedge to stabilize aggregate farm revenue is measured by the

R^2 in the following equation:

$$\Delta Rev = \alpha + \beta(Typical\ Hedge\ Strategy) \tag{4.4}$$

Restating (4.2), (4.3), and (4.4) in terms of the data, the OLS estimation of the range of potential hedging benefits is defined by estimating the following for the "optimal", "non-optimal", and "typical" hedge strategy:

$$\Delta Rev = \alpha + \beta\left(\sum_{j=1}^{6} (Option_{j,\,m} - Option_{j,\,n}) \times Q_j\right) \tag{4.5}$$

where: $(Option_{j,m} - Option_{j,n})$ is based on (4.2), (4.3), and (4.4)

The effectiveness of agricultural policy for stabilizing changes in annual grain revenues is considered in a similar fashion to hedging with options above, so is measured by the degree of negative correlation between the two. The annual policy transfers to producers (net of producer contributions), form the independent variable in the OLS model:

$$\Delta Rev = \alpha + \beta(Net\ Policy\ Transfers) \tag{4.6}$$

This is estimated for each of the Net Policy Transfers selected, which forms the independent variables. The Net Policy Transfers are:

W.G.S.P.: The net annual payments to producers under the Western Canadian Grain Stabilization Program.

Federal Transfers: The net Federal Government transfers to producers from W.G.S.P., Special Canadian Grains Program, Two Price Wheat

Compensation, Migratory Waterfowl Damage Compensation, and Special Drought Assistance.

Rebates: The net Federal and Provincial Rebates from Property Taxes, Interest payments, Federal and Provincial Fuel Taxes, and Heating Fuels.

Total Policy Transfers: The net combined transfers from Federal Transfers (including WGSP) and Rebates above, Provincial Programs which include Special Grants to Farmers, Crop Loss Compensation, Western Emergency Assistance, Saskatchewan Drought Assistance, Farm Fertilizer Price Protection, Grasshopper Control Program and Alberta Flood Assistance and, Net benefits accruing to producers from the Crow Rate, Western Grain Transportation Act, and Canadian Wheat Board deficits.

To provide complete revenue stabilization, crop insurance is also considered in combination with put options. The payments received under crop insurance (C.I. Benefits), net of producer contributions, form an independent variable in the OLS models:[3]

$$\Delta Rev = \alpha + \beta_1(\mathit{Optimal\ Hedge\ Strategy}) + \beta_2(\mathit{C.I.\ Benefits}) \tag{4.7}$$

$$\Delta Rev = \alpha + \beta_1(\mathit{Non\text{-}Optimal\ Hedge\ Strategy}) + \beta_2(\mathit{C.I.\ Benefits}) \tag{4.8}$$

$$\Delta Rev = \alpha + \beta_1(\mathit{Typical\ Hedge\ Returns}) + \beta_2(\mathit{C.I.\ Benefits}) \tag{4.9}$$

Crop insurance and the past policy environment is also considered. The selected policy benefits defined in (4.6) above are also combined with crop insurance benefits in the OLS model:

$$\Delta Rev = \alpha + \beta_1(\textit{Net Policy Transfers}) + \beta_2(\textit{C.I. Benefits}) \qquad (4.10)$$

Results

The results of the put option hedging strategies for stabilizing total cash market revenue from the crops considered in this analysis, based on equation (4.1), are presented in Table 4.1. The ability of the hedge to stabilize revenues will be reflected in the R^2 measure for the model. An R^2 of 1 indicates perfectly effective hedges for stabilizing producer cash market revenues, while an R^2 of 0 indicates no hedging effectiveness for stabilizing revenues. However, since *changes* of levels in total grain revenues and in hedging returns are used rather than only levels in total grain revenues and hedging return levels, relatively low R^2 values and low statistical significance would be expected. Also, tests used here for statistical significance are based on one tailed tests because a negative relationship between stabilization programs and the changes in aggregate producer cash market revenues is expected.

Changes in total producer cash market revenues are used as the dependent variable since this describes short-run stabilization, which is stabilizing around average *changes* in total crop revenue levels. This is in contrast to using only total crop revenue levels, which describes long-run stabilization, which is stabilizing around the mean of total crop revenue. In other words, results here are short-run, and reflect attempts to stabilize changes in revenue, around average changes

Table 4.1 Relationship Between Selected Put Option Revenue Changes and Annual Change in Total Receipts, using OLS Regression, 1975 to 1990.

Crop	Hedge Period	Intercept	Independent Variable Coefficient	R^2	Durbin-Watson Statistic
Wheat	April - November	132.673	-0.539* (-1.364)	0.117	1.272
	May - November	114.611	-0.334 (-0.880)	0.052	1.248
Barley	April - November	232.733	-1.716* (-1.435)	0.128	1.276
	May - November	159.837	-1.040 (-0.905)	0.055	1.237
Oats	April - November	175.448	-5.469 (-1.124)	0.083	1.167
	May - November	136.521	-2.724 (-0.599)	0.025	1.267
Flaxseed	April - November	210.185	-8.991** (-2.134)	0.245	1.841
	May - November	190.637	-7.829** (-1.795)	0.187	1.656
Rye	April - October	179.984	-25.502** (-1.945)	0.213	0.980
	May - October	168.010	26.726** (-2.192)	0.256	0.989
Canola	April - November	166.308	-2.903** (-2.042)	0.229	1.630
	May - November	161.503	-2.793* (-1.657)	0.164	1.494

t-values in parentheses; * significant at the ten percent level; ** significant at the five percent level; based on one tail test, since coefficient is expected to be negative.

The dependent variable is the same for all equations and is the annual change in total receipts, which is the sum of receipts for the six crops ($1,000,000's), based on the fiscal year January 1 to December 31. Source: calculations by author.

The independent variables are the change in option premiums for each crop multiplied by quantity produced in the current year ($1,000,000's). The premiums for put options ($/tonne) are estimated with Black's option valuation model for the first trading day in the months shown, with strike prices set at the nearest increment to at-the-money when the hedge was set. Source: calculations by author.

in revenue, whereas long-run results would attempt to stabilize revenue around the average of revenue itself, rather than changes in it.

The results in Table 4.1 show the negative hypothesized signs as expected on the option returns, and support stabilization through hedging. In other words, changes in put option premiums multiplied by quantity produced are generally negatively correlated with changes in total producer cash market revenue.

Flaxseed options showed the most effectiveness for stabilizing producer cash market revenues, as seen in Table 4.1. The results for hedging strategies for rye, shown in Table 4.1, indicate that grain revenues would have been stabilized by hedging with rye put options. Results show the correct signs and relatively high R^2 values of ranging from 0.213 to 0.256.[4] Changes in aggregate cash market revenues also showed a relatively high potential for stabilization by short hedging with canola put options, as evidenced by the relatively high R^2 values in Table 4.1. The estimated hedges showed the expected signs and significant t values for the April to November hedge period. The R^2 values that ranged from 0.229 to 0.126 suggest that considerable variability in grain revenues would have been removed by short hedging with canola put options.

Lower R^2 values for option revenues from wheat, barley, and oats in Table 4.1 suggest that hedging would have provided some, though limited benefits in stabilizing returns to producers. This may be because of the influence the Canadian Wheat Board (CWB) has had over these crops during the period of this study, similar to the case analyzing futures markets presented in chapter 3.

The results in Table 4.1 also illustrate that differences lie between periods in which the hedge is carried out. The implication of this is that theoretical hedge models used in this type of study are subject to either over stating or under stating the potential benefits from hedging. For this reason, bounds where placed on the results of hedging, similar to chapter 3.

Based on the results from equation (4.1) contained in Table 4.1, the optimal hedge strategy was found to be the following:

Wheat: April - November Hedge
Barley: April - November Hedge
Oats: April - November Hedge
Flaxseed: April - November Hedge
Rye: May - October Hedge
Canola: April - November Hedge

Based on the results contained in Table 4.1, the non-optimal hedge strategy, the opposite of above, was found to be the following:

Wheat: May - November Hedge
Barley: May - November Hedge
Oats: May - November Hedge
Flaxseed: May - November Hedge
Rye: April - October Hedge
Canola: May - November Hedge

Table 4.2 compares policy transfers with put options for stabilizing short-

Table 4.3 Relationship Between Annual Changes in Gross Aggregate Grain Receipts for Six Crops and Alternative Stabilization Methods Combined with Crop Insurance, 1975 to 1990.

Independent Variables		Intercept	Coefficients		R^2	Durbin-Watson Statistic
X_1	X_2		X_1	X_2		
Optimal Hedge	Crop Insurance	276.631	-0.418* (-1.641)	-0.573 (-0.613)	0.210	1.266
Non-Optimal Hedge	Crop Insurance	251.435	-0.258 (-1.032)	-0.668 (-0.678)	0.118	1.270
Typical Hedge	Crop Insurance	263.641	-0.338 (-1.325)	-0.621 (-0.645)	0.159	1.248
W.G.S.P.	Crop Insurance	312.495	-0.535 (-1.293)	-0.623 (-0.645)	0.155	1.624
Federal Transfers	Crop Insurance	249.166	-0.142 (-0.531)	-0.666 (-0.642)	0.066	1.559
Rebates	Crop Insurance	555.247	-9.756 (-1.293)	-0.397 (0.395)	0.155	1.932
Total Policy Transfers	Crop Insurance	335.175	-0.145 (-0.656)	-0.552 (-0.516)	0.076	1.557

t-values in parentheses; * significant at the ten percent level; ** significant at the five percent level; based on one tail test, since coefficients are expected to be negative.

The dependent variable is the annual change in gross producer receipts ($1,000,000's) based on the fiscal year January 1 to December 31, for wheat, oats, barley, rye, flaxseed, and canola (includes CWB final payments when received and excluding policy transfers to producers) for the period 1975 to 1990. Source: Agricultural Economic Statistics, Statistics Canada, Catalogue 21-603E, 1990.

The independent variables:
Optimal Hedge: see table 4.2.
Non-Optimal Hedge: see table 4.2.
Typical Hedge: see table 4.2.
W.G.S.P.: see table 4.2.
Federal Transfers: see table 4.2.
Rebates: see table 4.2.
Total Policy Transfers: see table 4.2.

Crop Insurance represents the net payments ($1,000,000's), to producers under the Crop Insurance system. Source: Agricultural Economic Statistics, Statistics Canada, Catalogue 21-603E, 1990.

showed an R^2 of .118. Comparing Table 4.3, and Table 4.2, the use of put option hedges may have been more effective when used with crop insurance to stabilize producer revenue, than was past agricultural policy, as evidenced by their higher R^2 values in Table 4.3.

Conclusion

Results show that put options in combination with crop insurance had a greater potential for stabilizing short-run producer cash market revenues than did past agricultural policy. However, options have only recently become available for a limited number of agricultural commodities, in the United States since 1982 and in Canada beginning in 1991, so actual data is limited. Therefore, the hedging results in this analysis were based on estimated put option values from actual futures prices using Black's Option Valuation Model, and so the results presented here may vary somewhat from the actual stabilizing benefits hedging with options would have on farm revenues.

Considerable differences were found in the effectiveness of short hedging to stabilize short-run farm revenues from the six crops considered. For this reason, bounds were created to show a range of the potential ability of put options to stabilize revenues. Even the lower bound of this range exceeded the ability of the combined government policies to stabilize short-run farm revenues. Results showed that put options which provide price insurance, were an even more effective short-run stabilizing tool than past agricultural policies when crop insurance was included in the analysis.

In comparison to past revenue stabilization policies, put options appeared to be more effective. However, implementing a commodity option based stabilization program for the future may be difficult, similar to the case of futures reviewed in chapter 3. What proportion of expected production should be hedged given the inherent risk of production? Would the increased demand for put options drive up option premiums or push down futures price in the short-run? What effect would government participation in the markets have? Are farmers opposed to using options? These are a few of the issues that must be considered before put options could be considered as an alternative for stabilization policy.

While this study is only the first to analyze the relative effectiveness of options for short-run stabilization in Western Canada, it shows that some past farm programs may have been relatively ineffective for short-run aggregate cash market revenue stabilization, compared to hedging with put options. This highlights the need for government program benefits to be provided on a more timely basis if they are to be effective for the farmer. It appears that commodity option markets may offer the type of revenue risk reduction needed by the producer, and therefore merit further investigation.

End Notes

[1] Since the objective of this study is to analyze the past effectiveness of stabilization for the Western Canadian grain sector as a whole, only aggregate stabilization policy is analyzed. While stabilization analyzed on more specific levels such as per farmer, per acre, or per crop may be of interest, they are beyond the scope of this analysis. Also, many major government programs such as the Western Grain Stabilization Program (WGSP) were aggregate in nature, rather than farmer specific or crop specific, so this study is concerned with aggregate rather than more specific stabilization effectiveness. As well, since agriculture forms a large share on GNP in Western Canada, aggregate grain stabilization is important in stabilizing the Western Canadian Economy as a whole. Short-run stabilization is examined, because futures and options would ordinarily be expected to only stabilize revenue within a year.

[2] R^2 is used because this analysis is attempting to measure the past negative correlation between variables, or the effectiveness of the change in the option premiums over the growing season multiplied by production, to offset or stabilize the change in producer revenue. This measure extends the traditional measure of price hedging effectiveness to revenue stabilization effectiveness, since traditional hedging effectiveness measures only the price correlation between cash price and futures price.

[3] This analysis uses a regression model and estimates correlation to measure stabilization effectiveness, rather than a simulation model, since farm programs in Western Canada tend to be very ad hoc in nature, with a temporary time frame, and so are much more difficult simulate in the same way as US policy, which is less ad hoc. For example, programs such as drought assistance, interest rate rebates, and Western Emergency Assistance did not have formal planning, and were often implemented for no set time frame, which the farmer or policy analyst could predict in advance. Also, even programs less ad hoc in nature, such as WGSP, still have an uncertain payment system in place, so the farmer or policy analyst could not accurately predict the payment timing or size in advance, in order to easily and accurately simulate it. However, since this study uses correlation instead of simulation, and attempts to analyze the past rather than predict the future, it has the advantage of using actual data rather than simulated data (e.g. actual price and quantity), and so does not require simulation assumptions (e.g. price and quantity distributions), which may in some ways predetermine the results, from what would have actually happened. Also, Heifner, Wright and Maish (1991) use regression analysis in a similar application to the one used here, where the objective was to examine the effectiveness of futures and options to stabilize past farm budget errors.

Regarding the use of change in revenue, since the objective of this chapter is to measure stabilization of changes in inter year revenue, the changes within the year must be computed so they can be compared across years. Also, changes in revenue is used since gains from hedges are a change variable, and transfers from government programs are also a change variable, since some years they can be negative (e.g. WGSP). Also, working in changes of variables rather than levels allows trends to be removed from the data.

[4] Although the returns from hedging rye with put options showed positive autocorrelation, this part of the analysis only determined the hedging combinations based on relative effectiveness among possible combinations. Therefore, assuming all R^2 values for rye are inflated by similar amounts due to autocorrelation, they still can be compared to each other in a relative sense.

[5] During the period of this study sales to the CWB of wheat and barley represented on average 78%, and 45% respectively of total annual production. Although oats is no longer a CWB grain, sales to the CWB represented on average were 12% of total annual production until 1989.

[6] This analysis does not attempt to compare the magnitude of B coefficients across equations, only the sign and R^2, because the purpose of this analysis is not to measure the magnitude of transfers, but only to measure the effectiveness of transfers. For example, a B coefficient of -2.0 from one program may provide the same relative stabilization dollar for dollar, as a coefficient of -20.0 from another program, even though the magnitude of the stabilization is 10 times greater in the latter case. In other words, this analysis attempts to measure relative effectiveness of stabilization or policy, rather than the amount of the stabilization. Therefore, statistical tests of B coefficients across equations are not used, and only the R^2 measure is used across equations, since the R^2 measures correlation. As well, no conclusions are drawn concerning cause and effect, since only correlation is of interest here. In other words, independent variables would not be expected to impact or "cause" the dependent variable.

CHAPTER 5

USING COMMODITY MARKETS VERSUS TRADITIONAL AGRICULTURAL PROGRAMS FOR REVENUE STABILIZATION: THE INDIVIDUAL FARM CASE

Introduction

This chapter examines the effectiveness of commodity futures and put options for stabilizing individual farm grain revenues compared to past agricultural policies. The analysis covers the Western Canadian grain sector, which includes Manitoba, Saskatchewan, and Alberta. The individual, or farm case scenario, is analyzed here rather than some higher level of aggregation (e.g. sectoral level, or national level) because stabilization of individual revenues may not be reflected in more aggregated analysis. Also, an aggregation of farm revenues across the provinces would not permit provincial comparisons of the revenue stabilizing effects of government programs, futures, and options.

While futures and options markets may reduce commodity price risk, quantity risk or production risk, cannot be reduced through the futures or options markets, so a more complete approach to stabilizing short-run producer revenue expectations is also used here, which includes crop insurance.

The past benefits received by producers directly and indirectly through subsidized production and marketing costs are calculated, and with this actual subsidy data, a comparison to alternative policies for revenue stabilization is possible. Therefore, the objectives of this study are to:

1. Examine the past effectiveness of short hedging expected production with futures and options for stabilizing expected revenues over the growing season, and
2. Determine whether short hedging or past agricultural policy would have been more effective for stabilizing expected revenues.

Futures, Options, and Traditional Agricultural Policy

Commodity futures and options offer the producer a potential way to stabilize expected prices for crops with contracts traded on commodity exchanges. By hedging expected production before the crop is planted, the producer may reduce the risk of misallocating production resources to what may otherwise become uneconomic crops by harvest time (Peck). However, futures and options hedging have received relatively little use by producers and perhaps part of the reason for this lies in the structure of past agricultural policy.

Within the structure of some past agricultural policies have been elements of price stabilization, which reduces the demand for futures and options by farmers. The regular intervention of government in response primarily to price instability would tend to lead producers to expect government price support and not consider hedging production with futures and options. Support for this point can be found in the fact that Western Canadian grain producers have received revenue stabilization without an actuarially sound premium attached. What this has meant for producers is that revenue stabilization programs often pay out more than is taken in from producer contributions, making it understandable why futures and options markets have not been used more intensively by producers.

However, futures and options may offer a market alternative to past agricultural policies for stabilizing short-term revenue (Heifner, Wright, and Maish). The ability of the grain producer to allocate production resources effectively will depend on the level of revenue risk surrounding the production decision at planting. An effective short-run stabilization program should not influence the producers decision of what to produce, but reduce the variance of grain revenues from those expected when resources are committed at planting. Since futures and options contracts are traded within this time period, they may be more suited to stabilizing short run revenue risk than traditional agricultural policies. Also, an analysis based on stabilizing short-run revenue risk is valid, since many of the past policies were designed to address realized revenue risk over the growing season time period. Furthermore, even if some past policies address primarily longer run targets, they may also impact the short run variability of producer revenues, and should therefore be considered.

Procedure and Data

This analysis examines the correlation between changes in expected cash market revenues over the growing season for three "typical" farms with the returns from short selling futures and buying put options. While no true typical farm can be defined, this analysis attempts to approximate a typical farm for each province. The three typical farms are 1000 acre grain farms producing only the major six crops in Western Canada, with a farm located in each of the western provinces of Manitoba, Saskatchewan, and Alberta. The six major crops include all wheat (including durum), oats, barley, flaxseed, rye, and canola.

The correlation between the returns from short selling futures and buying put options is compared with the total change, or difference, between expected cash market revenues and those revenues actually received by the farmer for all six crops produced on the typical farms. This correlation should be negative if futures and put options are effective in stabilizing expected revenues. Also, futures and options short positions are then combined with crop insurance, for a more complete approach to stabilizing expected revenues.

The growing season period of risk is used because often producers commit resources based on expected prices (Newberry and Stiglitz). When commodity prices change from the expectations of the producer, and production is marketed at those prices, the producer then faces revenue risk. Short hedging (with options or futures) may reduce this type of intra-year revenue instability.

The growing season establishes the time period for the producer to the set and lift short hedges, but the government benefits received by the producer are measured on a fiscal year basis. This means that all benefits received by producers are accounted for in this study when they are received, and each year begins on January 1st and ends on December 31st. Also, past policy transfers and crop insurance are based on net transfers to producers, consistent with the returns from short selling futures and put options.

A typical farm is created in each province to examine the farm level effects of short hedging with futures or put options, government programs, and crop insurance on expected grain revenues. The typical farms created in this analysis attempt to provide a base for results that are comparable to more specific farm profiles. Also, the crops selected and planted follow the provincial averages in an attempt to be consistent with typical farms.

Each typical farm is 1000 acres in size and is limited to producing only the six major crops, without summer fallow. More specific details of the typical farms' construction, management, and revenues can be found in Appendix A. While there are more than six crops produced in Western Canada, the six major crops are used to approximate all crops because of the high correlation between the gross revenues of the six crops and total grain revenues. Also, the six crops make up a high proportion of total grain revenues, as seen in Table 3.1.

The difference between the expected revenues and realized revenues for each farm becomes the variable describing the growing season revenue risk for the farmer, ΔRev. This variable may be viewed as changes in cash market revenue only, and does not include government subsidies. The returns from futures, put options, government payments, and crop insurance should be negatively correlated with ΔRev if they are effective in reducing the growing season revenue risk for the typical grain farm.

Futures and put options are explored as alternatives to each other. Therefore, the returns from short selling futures and buying put options are calculated for the same intra-year time periods. This allows for these two alternative short hedging vehicles to be compared.

The short hedges are set on the first trading day in April or May and both are lifted on the first trading day in November, except for Rye which is lifted on the first day of September. The hedging period for Rye differs from the other crops considered due to a growing season that ends with harvest around the month of August, as opposed to September or October for the other crops.

The futures prices used are for the Chicago Board of Trade December contract on wheat, the Winnipeg Commodity Exchange December contracts on oats, barley, flax, and rye, and the November contract on canola. These contract months are selected because more distant contracts tend to be thinly traded in the spring of the year, and options on nearer contract months in the year would expire before harvest.

The size of the hedge or quantity of futures to be sold or put options to be bought is based on a percentage of expected production for each farm. Expected production in the current year is the five year historical average of yield multiplied by the seeded acreage. Hedging a percentage range of expected production is explored to increase the robustness of the results and indicate the effects of alternative futures and put options hedges on revenue risk.

The correlation between the growing season change in expected revenues and the returns from short hedging all six crops with futures, over the alternative periods, is estimated with the following OLS regression equation:

$$\Delta Rev = \alpha + \beta\left(\sum_{j=1}^{6} (Futures_{j,\,m} - Futures_{j,\,n}) \times Q_j \right) \tag{5.1}$$

where : ΔRev = growing season change in expected cash market revenues from realized revenues summed across the six crops (excluding government transfers)
$Futures$ = the futures price for the crop or commodity selected
m = the first trading day in the month the hedge is set
n = the first trading day in the month the hedge is lifted
j = crop or commodity selected
Q = annual production

Short hedging with options follows the same procedure as futures, however, put options have not been traded on all the crops used in this analysis, or over the time period of the analysis. Therefore, put option premiums are calculated with Black's option pricing formula for each of the six major crops based on the same futures contracts used in the futures short hedging portion of this analysis.

Black's option valuation model is used to compute the premiums on put options for the futures contracts underlying the six crops reviewed in this study, since it has relatively wide acceptance for estimating option premiums. A more detailed description of how Black's option valuation model is used in this study can be found in Appendix B.

The quantity of put options to be bought in any given year and for each crop is consistent with the futures short selling models. In particular, the correlation between the growing season change in expected revenues and the returns from short hedging with put options, over the alternative periods, and alternative quantities, is estimated with the following OLS regression equation:

$$\Delta Rev = \alpha + \beta\left(\sum_{j=1}^{6} (Option_{j,m} - Option_{j,n}) \times Q_j\right) \tag{5.2}$$

where : ΔRev = growing season change in expected cash market revenues from realized revenues summed across the six crops (excluding government transfers)
$Option$ = put option premium
m = the first trading day in the month the hedge is set
n = the first trading day in the month the hedge is lifted
j = crop or commodity selected
Q = annual production

The effectiveness of agricultural policy for stabilizing expected revenues over the growing season is considered in a similar fashion to hedging with futures or put options above. The annual policy transfers to producers (net of producer contributions) on a typical 1000 acre farm form the independent variable in the OLS model:

$$\Delta Rev = \alpha + \beta(Net\ Policy\ Transfers) \tag{5.3}$$

This OLS model is estimated for each of the Net Policy Transfers selected, which forms the independent variables. The Net Policy Transfers are:

W.G.S.P.: The net annual payments to producers under the Western Canadian Grain Stabilization Program.

Federal Transfers: The net Federal Government transfers to producers from W.G.S.P., Special Canadian Grains Program, Two Price Wheat Compensation, Migratory Waterfowl Damage Compensation, and Special Drought Assistance.

Rebates: The net Federal and Provincial Rebates from Property Taxes, Interest payments, Federal and Provincial Fuel Taxes, and Heating Fuels.

Total Policy Transfers: The net combined transfers from Federal Transfers (including WGSP) and Rebates above, Provincial Programs which include Special Grants to Farmers, Crop Loss Compensation, Western Emergency Assistance, Saskatchewan Drought Assistance, Farm Fertilizer Price Protection, Grasshopper Control Program and Alberta Flood Assistance, Canadian Wheat Board deficits and, Net benefits accruing to producers from the Crow Rate, and the Western Grain Transportation Act.

To provide complete revenue stabilization, crop insurance is also considered in combination with futures and put options. The payments received under crop insurance (C.I. Benefits), net of producer contributions, form an independent variable in the OLS models:

$$\Delta Rev = \alpha + \beta_1(Futures) + \beta_2(C.I.\ Benefits) \tag{5.4}$$

$$\Delta Rev = \alpha + \beta_1(Options) + \beta_2(C.I.\ Benefits) \qquad (5.5)$$

Crop insurance and the past policy environment is also considered. The selected policy benefits defined in (5.3) above are also combined with crop insurance benefits in the OLS model:

$$\Delta Rev = \alpha + \beta_1(Net\ Policy\ Transfers) + \beta_2(C.I.\ Benefits) \qquad (5.6)$$

All futures returns, put options returns, and government payments alone and in combination with crop insurance are defined in terms of OLS models. The OLS models are used to measure the correlation between variables, where the dependant variable is the same in each case, which is the change in cash market revenues (excluding government transfers) from what was expected. The R^2 in each model should provide an indication of the relative strength each approach has in stabilizing revenues. Also, the sign on the independent variable(s) provides an indication of the alternative stabilization methods effect on growing season revenue risk.

Results

Futures, Put Options, and Government Transfers Without Crop Insurance

Table 5.1 shows the results of the first step in the analysis where futures and put options alone are compared with selected government transfers for stabilizing growing season revenue risk based on equations 5.1, 5.2, and 5.3. Since the analysis is based on an OLS estimation of correlation between variables,

Table 5.1 Relationship Between Annual Revenue Risk for Typical Farms in Western Canada and Alternative Stabilization Methods, 1975 to 1990.

Farm Location	Stabilization Method	Intercept	Independent Variable Coefficient	R^2	Durbin-Watson Statistic
Manitoba	April-November Futures (60%)	-19231.409	-0.225 (-0.502)	0.018	1.487
Saskatchewan	April-November Futures (60%)	-30104.545	-0.402 (-0.699)	0.034	1.606
Alberta	April-November Futures (60%)	-20500.163	-2.216 (-5.507)*	0.684	1.159
Manitoba	May-November Futures (60%)	-18894.648	-0.331 (-0.669)	0.031	1.562
Saskatchewan	May-November Futures (60%)	-29745.947	-0.534 (-0.817)	0.046	1.673
Alberta	May-November Futures (60%)	-18318.193	-2.387 (-4.876)*	0.629	1.288
Manitoba	April-November Options (60%)	-17434.212	-0.422 (-1.103)	0.080	1.588
Saskatchewan	April-November Options (60%)	-29401.267	-0.329 (-0.653)	0.030	1.637
Alberta	April-November Options (60%)	-12002.164	-1.800 (-4.194)*	0.557	1.824
Manitoba	May-November Options (60%)	-17996.985	-0.330 (-0.893)	0.054	1.594
Saskatchewan	May-November Options (60%)	-29679.346	-0.281 (-0.581)	0.024	1.622
Alberta	May-November Options (60%)	-14702.414	-1.465 (-3.583)*	0.478	1.268
Manitoba	Federal Programs	-16953.490	-0.186 (-0.387)	0.011	1.509
Saskatchewan	Federal Programs	-29342.936	-0.113 (-0.161)	0.002	1.558
Alberta	Federal Programs	-43802.579	1.781 (1.524)*	0.142	1.423
Manitoba	Provincial Programs	-19917.601	70.411 (0.278)	0.005	1.366
Saskatchewan	Provincial Programs	-28967.261	-8.432 (-0.941)	0.059	1.448
Alberta	Provincial Programs	-22626.241	-1.904 (-0.229)	0.004	1.535

Table 5.1 (Continued) Relationship Between Annual Revenue Risk for Typical Farms in Western Canada and Alternative Stabilization Methods, 1975 to 1990.

Farm Location	Stabilization Method	Intercept	Independent Variable Coefficient	R^2	Durbin-Watson Statistic
Manitoba	Rebates	-18419.374	-1.650 (-0.072)	0.000	1.396
Saskatchewan	Rebates	-18644.094	-25.140 (-0.662)	0.030	1.498
Alberta	Rebates	-10794.431	-18.564 (-1.225)	0.097	1.695
Manitoba	Total Policy Transfers	-16884.963	-0.183 (-0.384)	0.010	1.507
Saskatchewan	Total Policy Transfers	-28736.796	-0.159 (-0.234)	0.004	1.571
Alberta	Total Policy Transfers	-39270.025	1.229 (1.173)	0.089	1.444

t-values in parentheses; * significant at the five percent level; ** significant at the ten percent level; based on one tail test, since the coefficient is expected to be negative.

The dependent variable, or revenue risk, is the same for all equations and is the annual difference between expected farm revenues and those realized by a typical 1000 acre grain farm producing only the six major crops, wheat, barley, oats, flaxseed, canola, and rye. Expected revenues are based on a five year moving average of yield multiplied by the expected price for the current year, in April, for each Year of the analysis. Expected prices are based on the three month average cash price for all grains except wheat, during January, February, and March of the year in question. The expected prices for Spring and Durum wheat are based on the prevailing initial payment in the spring of the year plus any final payment received at this time, for the year in question. The realized farm revenues are the actual yields for the six grains, in the crop district the farm is located in, multiplied by the farm gate price for those crops in the fall of the year.

The independent variables:

Federal Programs represent the net Federal Government transfers (in dollars), to typical producers in Western Canada from: W.G.S.P., Special Canadian Grains Program, Two Price Wheat Compensation, Migratory Waterfowl Damage Compensation, Crop Assistance Program, Grain Embargo Compensation, Special Drought Assistance, Canadian Wheat Board Deficits, and the net benefits accruing from the Crow Rate and the Western Grain Transportation Act. Source: Calculations by author.

Provincial Programs represent the net Provincial transfers (in dollars), where they would apply to typical producers in Western Canada from; Special Grants to Farmers, Crop Loss Compensation, Western Emergency Assistance, Saskatchewan Drought Assistance, Farm Fertilizer Price Protection, Grasshopper Control Program and, Alberta Flood Assistance. Source: calculations by author.

Rebates represent the net Federal and Provincial rebates (in dollars), to typical producers in Western Canada from; Property Taxes, Interest payments, Federal and Provincial Fuel Tax and, Heating Fuels. Source: Calculations by author.

Total Policy Transfers represent the net combined transfers (in dollars) for all government programs listed above. Source: calculations by author.

April to November Futures represents the net annual returns (in dollars) from short selling futures contracts over the April to November period for each of the six grains in each year of the analysis. The quantity of futures sold is sixty percent of the expected production for each crop. Expected production is a five year moving average of yield multiplied by the planted acreage for each crop in the current year.

May to November Futures represents the net annual returns (in dollars) from short selling futures contracts over the May to November period for each of the six grains for each year of the analysis. The quantity of futures sold is sixty percent of the expected production for each crop.

April to November Options represents the net annual returns from buying put options on futures contracts over the April to November period for each of the six grains for each year of the analysis. Option premiums where estimated using Black's formula. The quantity of put options purchased is sixty percent of the expected production for each crop.

May to November Options represents the net annual returns from buying put options on futures contracts over the May to November period for each of the six grains for each year of the analysis. Option premiums where estimated using Black's formula. The quantity of put options purchased is sixty percent of the expected production for each crop.

a Durbin-Watson Statistic is included. The Durbin-Watson Statistics in Table 5.1 indicates that the results are either not autocorrelated or are in the inconclusive range.

The results of short selling 60% of expected production are presented since these results represent an approximate median of results from short selling between 10% and 100% of expected production on each of the typical farms. Overall, the results in Table 5.1 show that both futures and put options stabilized expected revenues on each of the typical farms. All coefficients on the returns from either futures or options are negative indicating a stabilizing effect. Also, the R^2 for each short hedge return (using either futures or options) shows distinct differences in the level of revenue risk stabilization between typical farms. Clearly, the use of futures and/or put options benefit the typical Alberta farm the most. Even the lowest R^2 for Alberta of 0.478 for the May to November option hedge exceeds all the short hedge R^2 results in either Manitoba or Saskatchewan. For example, results for Saskatchewan reached a considerably lower R^2 of 0.046.

The period of the short position also had an impact on the effectiveness of futures and options to stabilize expected revenues. For example, the results for the typical Manitoba farm showed an R^2 of 0.018, for the April to November period, while the May to November period show a larger R^2 of 0.031. Table 5.1 shows that total government transfers to the typical farms did not exceed the effectiveness of either futures or put options to stabilize expected revenues. In other words, R^2 values for futures and options stabilization were higher than that of traditional agriculture programs. For the typical Manitoba farm, no single government policy exceeded the ability of the least stabilizing futures or options returns to reduce growing season revenue risk. For the typical Saskatchewan farm, only provincial programs exceeded all of the futures and options returns to reduce revenue risk. However, this particular result for Saskatchewan is less important than total policy transfers, because total policy transfers include all government programs, and they did not exceed the least effective market alternative, the May to November put options returns. In Alberta, the use of futures or put options far exceeds any of the government policies to stabilize revenue.

There are substantial provincial differences in the effectiveness of past policies to stabilize expected revenues based on the results of equation 5.3 shown in Table 5.1. Federal programs appear to have little stabilization in Manitoba and Saskatchewan, though they do have the expected negative relationship indicating some reduction in risk. This is in contrast to Alberta where the relationship is positive, indicating a destabilizing effect on expected revenue there. Also, the effectiveness of provincial programs vary widely in their ability to stabilize expected revenue, with Saskatchewan receiving the greatest benefit from provincial programs, and Manitoba the least. In general, the differences between provinces for the same groups of agricultural policies indicates that not all regions receive equal amounts of revenue stabilization from the government.

In Table 5.1, the total policy transfers variable provides an overall picture of the effectiveness of past agricultural policies to stabilize growing season revenue risk. Total policy transfers indicate a wide range in the effectiveness of all past agricultural policies to stabilize growing season revenue risk across provinces for the typical farms. Manitoba farms received the most stabilization as indicated by a negative relationship between total policy benefits and revenue risk, and an R^2 of 0.01. This is in contrast to the typical Alberta farm, where the positive relationship between total policy benefits and revenue risk indicate that expected growing season revenue received no stabilization from government programs.

Futures, Put Options, and Government Transfers Combined With Crop Insurance

Table 5.2 presents the last stage of the analysis with the results of including crop insurance along with futures, options, and government programs based on equations 5.4, 5.5 and 5.6. As in the results presented in Table 5.1, the Durbin-Watson statistic shows either no autocorrelation, or else the inconclusive range.

Overall, futures and options appear to be more effective than past policies to stabilize expected revenues, when crop insurance is included for the typical farms. Saskatchewan would have benefitted the least from alternative policies that included futures and options. But as the results in Table 5.2 show, the level of expected revenue stabilization offered by total government programs is comparable to that of either futures or put options. For example, the R^2 value for the total transfers and crop insurance model was 0.561, while the least effective market alternative was using put options and crop insurance over the May to

Table 5.2 Relationship Between Annual Revenue Risk for Typical Farms in Western Canada a Alternative Stabilization Methods in Combination with Crop Insurance, 1975 to 1990.

Farm Location	Stabilization Methods (Independent Variables)		Intercept	Independent Variable Coefficients		R^2	Durbin-Watson Statistic
				X_1	X_2		
Manitoba	April-November Futures (60%)	Crop Insurance	-11742.397	-0.329 (-0.828)	-4.357 (-2.229)*	0.289	1.748
Saskatchewan	April-November Futures (60%)	Crop Insurance	-14601.113	-0.321 (-0.796)	-7.246 (-3.958)*	0.562	2.102
Alberta	April-November Futures (60%)	Crop Insurance	-12624.469	-2.141 (-5.614)*	-4.879 (-1.672)**	0.740	1.354
Manitoba	May-November Futures (60%)	Crop Insurance	-11538.454	-0.394 (-0.898)	-4.280 (-2.210)*	0.296	1.792
Saskatchewan	May-November Futures (60%)	Crop Insurance	-14651.999	-0.315 (-0.676)	-7.168 (-3.866)*	0.556	2.073
Alberta	May-November Futures (60%)	Crop Insurance	-10259.199	-2.304 (-4.921)*	-5.039 (-1.580)**	0.689	1.388
Manitoba	April-November Options (60%)	Crop Insurance	-10022.189	-0.457 (-1.36)**	-4.280 (-2.295)*	0.345	1.737
Saskatchewan	April-November Options (60%)	Crop Insurance	-14563.850	-0.127 (-0.352)	-7.224 (-3.835)*	0.545	2.043
Alberta	April-November Options (60%)	Crop Insurance	-6431.230	-1.708 (-3.895)*	-3.774 (-1.013)	0.589	2.046
Manitoba	May-November Options (60%)	Crop Insurance	-11160.518	-0.305 (-0.924)	-4.104 (-2.126)*	0.298	1.729
Saskatchewan	May-November Options (60%)	Crop Insurance	-14667.838	-0.092 (-0.267)	-7.250 (-3.843)*	0.543	2.031
Alberta	May-November Options (60%)	Crop Insurance	-7840.950	-1.385 (-3.370)*	-4.495 (-1.130)	0.525	1.515
Manitoba	Federal	Crop Insurance	-13067.156	0.056 (0.124)	-4.234 (-2.053)*	0.253	1.606
Saskatchewan	Federal	Crop Insurance	-18452.975	0.419 (0.842)	-7.735 (-4.095)*	0.564	2.028
Alberta	Federal	Crop Insurance	-33499.542	2.025 (1.821)*	-7.970 (-1.650)*	0.291	1.850
Manitoba	Provincial	Crop Insurance	-12521.758	12.093 (0.053)	-4.153 (-2.070)*	0.252	1.623
Saskatchewan	Provincial	Crop Insurance	-14777.041	-1.554 (-0.230)	-7.197 (-3.703)*	0.542	1.980
Alberta	Provincial	Crop Insurance	-11655.702	-1.712 (-0.210)	-6.775 (-1.265)*	0.113	1.708
Manitoba	Rebates	Crop Insurance	2359.371	-21.036 (-0.978)	-4.936 (-2.377)*	0.303	1.584
Saskatchewan	Rebates	Crop Insurance	-4368.547	-22.209 (-0.840)	-7.278 (-3.990)*	0.564	1.810
Alberta	Rebates	Crop Insurance	-9174.638	-10.132 (-0.510)	-4.608 (-0.675)*	0.127	1.723

Table 5.2 (Continued) Relationship Between Revenue Risk for Typical Farms in Western Canada and Alternative Stabilization Methods in Combination With Crop Insurance, 1975 to 1990.

Farm Location	Stabilization Methods (Independent Variables)		Intercept	Independent Variable Coefficients		R^2	Durbin-Watson Statistic
				X_1	X_2		
Manitoba	Rebates	Crop Insurance	2359.371	-21.036 (-0.978)	-4.936 $(-2.377)^*$	0.303	1.584
Saskatchewan	Rebates	Crop Insurance	-4368.547	-22.209 (-0.840)	-7.278 $(-3.990)^*$	0.564	1.810
Alberta	Rebates	Crop Insurance	-9174.638	-10.132 (-0.510)	-4.608 $(-0.675)^*$	0.127	1.723
Manitoba	Total Policy Transfers	Crop Insurance	-12986.389	0.046 (0.104)	-4.220 $(-2.052)^*$	0.253	1.610
Saskatchewan	Total Policy Transfers	Crop Insurance	-18294.637	0.379 (0.782)	-7.727 $(-4.062)^*$	0.561	2.033
Alberta	Total Policy Transfers	Crop Insurance	-29435.259	1.489 (1.476)	-7.999 $(-1.591)^{**}$	0.238	1.838

t-values in parentheses; * significant at the five percent level; ** significant at the ten percent level; based on one tail test, since the coefficient is expected to be negative.

The dependent variable is the same for all equations and is the annual difference between expected farm revenues and those realized by a typical 1000 acre grain farm producing only the six major crops, wheat, barley, oats, flaxseed, canola, and rye. Calculated as in Table 5.1.

The independent variables:

Federal Programs: see Table 5.1.
Provincial Programs: see Table 5.1.
Rebates: see Table 5.1.
Total Policy Transfers: see Table 5.1.
April to November Futures: see Table 5.1.
May to November Futures: see Table 5.1.
April to November Options: see Table 5.1.
May to November Options: see Table 5.1.

Crop Insurance represents the net payments, to producers under the Crop Insurance system. Source: Calculations by Author.

November time period, with an R^2 of 0.543.

As Table 5.2 indicates, the typical Alberta farm showed the greatest potential for revenue stabilization from the use of futures and put options in combination with crop insurance, compared to the performance of past traditional policies. The traditional policy setting in Alberta, described by the total transfers and crop insurance model in Table 5.2, had an R^2 of 0.238 while the least effective market alternative was buying put options over the May to November time period with an R^2 of 0.525. This indicates a substantial improvement in revenue risk reduction over the growing season for the typical Alberta farm, when management includes the use of crop insurance combined with futures and put options.

All government policy transfers when combined with crop insurance reduced growing season revenue risk, except for the case of Alberta seen at the bottom of Table 5.2. For the typical Manitoba and Saskatchewan farms, the positive sign on the total policy transfers variables, as seen in Table 5.2, is not consistent with the relationship found for the total policy transfers variables in Table 5.1. This suggests multicollinearity between the independent variables in the Manitoba and Saskatchewan cases. But overall, as indicated by the general increase in R^2 values between Table 5.1 and Table 5.2, crop insurance was generally effective in reducing growing season revenue risk.

Conclusion

The results of this study are based on what would have happened in the past, not necessarily what would happen in the future. Therefore, the policies, yields, prices, and management of the typical farms used in this study may not necessarily be repeated in the future.

But this study showed that in general, futures and options may have been more effective than past traditional policies to stabilize the expected revenues of typical farms in western Canada. Also, the effectiveness of government programs, futures, and put options to stabilize short run revenue was improved by including crop insurance into the management of the typical farms.

Substantial differences were found between the ability of both past government programs and the alternative futures and options programs to stabilize revenue between the typical farms studied. The typical Saskatchewan farm benefitted the most from traditional government policies while the typical Alberta farm benefitted the least. But the opposite held for the use of futures and options, where the typical Alberta farm had expected revenues stabilized the most from futures and options, and the Saskatchewan farm the least.

In summary, the use of futures and options were more suited to stabilizing growing season revenue, than were past agricultural policies. Also, the use of futures and options to enhance revenue could be made possible by varying degrees of government subsidization of futures and options for producers. Therefore, in a policy environment directed towards more decoupled policies that involve more self reliance on the part of producers, the use of futures and options may be an alternative worth studying by government policy makers who are attempting to manage revenue risk.

CHAPTER 6

MAXIMUM ADMISSIBLE LOSS MODELLING: HEDGING UNDER PRICE AND QUANTITY UNCERTAINTY

Introduction

Often the firms response to price risk and hedging are modelled under one of the following situations:[1] 1) output price risk (Feder, Just, and Schmitz; Peck; and Holthausen) , 2) quantity or production risk (Karp; Paroush and Wolf), 3) basis risk (Batlin) or, 4) some combination of the previous three (Rolfo; Chavas and Pope).[2] This study builds on this research by formulating an empirical model for defining optimum hedging levels for the firm which is exposed to revenue risk, due to output price risk and quantity risk.

The theoretical models for defining the firm's optimal hedge a priori have usually followed a pattern of specifying a utility function for the firm to define risk aversion. A mean-variance type analysis of firm profit is used as an approximation of the utility function, which is maximized, and solved for the optimal hedge level (Kahl; Chavas and Pope). As a departure from this approach, Karp (1987) has formulated the optimal hedge as a stochastic control problem. However, the objective of this chapter is to present an alternative empirical method for solving the optimal hedge problem under both price and quantity risk, using a maximum admissible loss (MAL) which maximizes revenue subject to a maximum admissible revenue loss.

The MAL model maximizes revenue from the decision set available to the firm, but with a limit on the maximum admissible revenue loss acceptable from the decisions taken by the firm, similar to the well known "safety first" strategy of risk management. Since price risk along with quantity risk is often a common risk faced by agricultural firms, this approach therefore examines the combination of these two types of risk, or revenue risk, and extends traditional empirical hedging models beyond only price risk, or only quantity risk. The MAL approach permits risk to be defined in terms of revenue losses, which are easily calculated in applied settings, and therefore avoids the somewhat arbitrary selection of a risk aversion parameter for the firm. For example, a firm may wish to restrict its maximum admissible revenue losses to 20 cents per bushel of production, but may not find this as efficient or as accurate to define this risk aversion in terms of a non-monetary risk aversion parameter.

A MAL model is applied here to the optimal hedge problem where the firm is faced with limiting its revenue risk, originating from both quantity and price risk. The firm assumed here is a large first handler, such as a co-operative, central selling agency, or agent representing the farmer for a commodity that has a futures market. The firm's objective therefore is to maximize returns to its members (farmers), similar to the traditional competitive firm maximizing profits.

The specific example used in this chapter is for wheat handled by the

Canadian Wheat Board (CWB), which should provide an indication of the potential of the MAL model for applications to the large traditional competitive firm, since the CWB is the largest handler of wheat in Canada. However, this hedging model can be applied to any firm facing price and quantity risk, subject to maximum admissible losses, such as the Cotton Growers Cooperative or a mutual fund facing an uncertain incoming flow of investment funds.

But, since the CWB acts as an agent for the farmer, it cannot directly influence production decisions, in contrast to the way the traditional firm has been modelled.[3] Also, the CWB must accept all member deliveries, and provide an initial payment and a pooled final payment (paid after the CWB has in turn sold the wheat), in contrast to how the firm as a processor has been modelled (Tzang and Leuthold; Schnabel).[4] As well, the CWB must absorb losses from any initial price made to the farmer, above the final selling price. This is because the CWB cannot predetermine farmer deliveries, and so the CWB is exposed to considerable price risk and quantity risk, resulting in revenue risk.[5]

Model Description

A two stage modelling process is used to examine if short hedging (selling futures) based on a MAL model can reduce the revenue risk faced by the CWB from producer deliveries of wheat. The first stage models the CWB's decision to set the initial payment revenue, given the opportunity to hedge this revenue. To do this, a MAL model is specified to set the level of initial payment, and also determine the quantity to hedge, based on expected deliveries from producers.

The objective of the CWB is to maximize producer returns, so the MAL model has an objective function which maximizes the expected producer returns from a tonne of wheat delivered to the CWB. But, the decisions specified in the objective function are constrained by limiting the maximum admissible losses associated with those decisions. Also, constraints are specified to define the relationships between the decision variables used in the MAL model. The initial payment, final payment, and quantity hedged form the decision variables in the MAL model. These decision variables are solved as integers since they represent a yes/no decision and their coefficients in the objective equation are based on expected returns.

The risk associated with the decision variables in the objective function is defined as the loss that would have occurred if these decisions had been followed during a time period previous to the objective function. A multi year time period is selected to evaluate risk because it represents both a long term approach to risk management and yet captures the variability of markets. This time period is chosen from data previous to this analysis, so results will be out of sample.

The second stage of the model measures the effectiveness of the MAL model in the first stage by using decisions selected by the MAL, which include setting the level of initial payment and quantity to hedge. The initial payment decision is applied to the actual producer deliveries made to the CWB wheat pool, and the resulting gain from selling futures is transferred to the pool account if it is facing a loss.[6] These initial price and hedge decisions are then compared with the historical CWB management of the wheat pool account to establish a bench mark for measuring the effectiveness of the MAL model to hedge revenue risk.

Decision Rules and Variables

Objective Equation

The first stage of the MAL model begins with the specification of the objective equation which maximizes the expected revenue to producers from one tonne of wheat delivered to the CWB and the revenue from short selling futures (hedging). Expected revenues are based on an initial payment offered to producers before the crop is produced and an expected final payment after the crop is marketed by the CWB, similar to the current operation of the CWB.

The objective equation has three parts which are the decisions faced by the CWB and include the decision to sell futures. The first is the initial payment decision (I_p), which is an integer value 0 or 1 because it is a yes/no decision, and has a coefficient value based on a percentage of the prevailing Chicago Board of Trade (CBOT) December wheat futures in the spring ($ValueI_p$). This is because the CWB must decide on an initial payment to pay the producer based on the world market it sells into, generally in spring before the crop is harvested or marketed. The second part is a final payment decision (FP_p), which is an integer value 0 or 1 because it is a yes/no decision. This final payment is payed out of any surplus revenue beyond the initial payment after the CWB has marketed the grain and has an expected value (ValueFP$_p$). The third part is the decision to sell futures on a percentage of expected deliveries (H$_p$), which is an integer value 0 or 1 because it is a yes/no decision, and has a coefficient value (ValueH$_p$) based on an average of past hedge revenues per tonne of wheat delivered to the board.

The objective equation of the MAL model is:

$$Max{:}\ = \sum_{p=j}^{k} ValueI_p \times I_p + \sum_{p=j}^{k} ValueFP_p \times FP_p + \sum_{p=a}^{b} ValueH_p \times H_p \qquad (6.1)$$

(This determines the contribution, per tonne, to total revenue from the Initial Payment, Final Payment, and Short Selling Revenue)

where : $ValueI$ = expected Initial Payment Revenue
$ValueFP$ = expected Final Payment Revenue
$ValueH$ = expected short selling futures returns (hedge revenue)
I = the decision to follow the initial payment rule
FP = the corresponding final payment to the initial payment rule I$_p$
H = the decision to follow the short hedging rule
p = the percentage rate in set increments
j = start of cash price range as a percentage value
k = end of cash price range as a percentage value
a = start of futures price range as a percentage value
b = end of futures price range as a percentage value

The objective equation (6.1) states a range for each decision variable. The range for the initial payment rule and corresponding final payment has been set to accommodate a wide range of values. The short hedging decision explores a wide range of alternative quantities to be hedged, which allows the selection of a hedge quantity less than the expected deliveries to the CWB, since the quantity to be hedged is often less than production (Peck).

Initial Payment (Ip)

The objective equation (6.1) generates an initial price in the MAL model, with a decision rule for the CWB to follow when setting the initial payment. The value of the initial payment decision rule (I_p) is a percentage of the April average closing price of the CBOT December Wheat futures contract and is specified as:[7]

$$ValueI_p = p\% \times \sum_{i=1}^{d} (CF_{i,\,m} \times ERate_{i,\,m}) \times \frac{1}{d} \tag{6.2}$$

(This determines the expected value of the initial payment ($ValueI_p$), for a given initial price decision (I_p), in the objective equation (6.1))

where : $ERate$ = Average Noon Spot Exchange Rate (Canadian dollars per U.S. dollar)
CF = daily closing futures price on the CBOT December wheat contract
d = trading days in the month
i = date of trading day
m = calender month, April
p = percentage rate in set increments

Final Payment (Fp)

The value of the expected final payment ($ValueFP_p$) in the current year must be estimated since it is a part of the CWB revenues to be maximized. For each initial payment decision in the past there will be a final payment that will result. The value of the expected final payment ($ValueFP_p$) is estimated by taking an average of past final payments during the period of the constraints. An average over the time period of the constraints (x), described later, are used because this period is also used to describe risk in the MAL model. The expected final payment values ($ValueFP_p$) in the objective equation are also discounted by the prevailing riskless rate of return for one year at the time the initial payment is announced. The discount on the expected final payments is to reflect the delay in getting the final selling price to the producer. Therefore, the value of the expected final payment ($ValueFP_p$) is an average of previous possible final payments, discounted by the current riskless interest rates, which is specified by:

$$ValueFP_p = Disc \times \sum_{y=1}^{x} (CWBFSP_y - ValueI_{p,y}) \times \frac{1}{x} \tag{6.3}$$

(*This determines the expected Final Payment value ($ValueF_p$), linked to the Initial Payment, in the objective equation (6.1)*)

where : $ValueFP$ = expected final payment
$CWBFSP$ = the average final selling price received by producers for wheat across all grades delivered to the CWB
$Disc$ = average yield on 1 to 3 year Canada Savings Bonds for the last week in April of the year of the objective equation (6.1)
y = the years preceding the objective equation (6.1)
$ValueI$ = expected Initial Payment Revenue
x = number of years in the model constraints
p = percentage rate in set increments

Hedge Decision (Hp)

The expected futures selling revenue (ValueHp) from the decision to hedge, which is an integer variable (Hp), in the objective equation of the MAL model must be estimated since it is part of the total revenue being maximized by the CWB. This analysis estimates the returns from short selling futures based on three factors: First, the quantity of futures to sell is determined as a percentage of expected producer deliveries ($CWBDel_{est}$). Secondly, a futures price that reflects market conditions in a given month is estimated by taking a volume weighted monthly average futures price (FPW_m), at the time futures are sold and bought back to complete the short sale. Thirdly, the period futures are short sold over will affect the returns from short selling futures, and therefore alternative selling periods are explored to short sell futures over the time period expected to maximize returns.

As mentioned above, the expected returns from selling futures (ValueHp) in the objective equation (6.1), include the effects of the quantity of futures to sell, futures price, and selling period explained below and is specified by:

$$ValueH_p = \sum_{y=1}^{x} \left(((p\% \times CWBDel_{est,\ y}) \times (FPW_{m,\ y} - FPW_{n,\ y})^{\max}) \times \frac{1}{CWBDel_y} \right) \times \frac{1}{x} \qquad (6.4)$$

(This determines the coefficient value for each of the hedging decisions (H_p), which are integers, in the objective equation (6.1))

where : $ValueH$ = expected final payment
$(FPW_{m,y} - FPW_{n,y})^{\max}$ = the returns from $Hedge^{\max}$ based on (6.7) below
$CWBDel_{est}$ = estimated producer deliveries of wheat to the CWB
p = percentage rate in set increments
FPW = monthly average futures closing price weighted by trading volume
y = the years preceding the objective equation (6.1)
m = calender month for opening the hedge, April or May
p = calender month for closing the hedge, November or December

The expected returns from selling futures (ValueHp) depends on the quantity of futures sold since it is the product of the expected price change over the period futures are sold and the quantity sold. Therefore, the quantity of futures sold in the MAL model are percentage of expected total deliveries of all grades of wheat, in tonnes, made by producers to the CWB ($CWBDel_{est}$) and is estimated by the OLS model:

$$CWBDel_{est} = \alpha + \beta_1 AverageProduction_{t-1} + \beta_2 Planting_t + e_t \qquad (6.5)$$

(This estimates the expected producer deliveries of grain to the CWB)

where : $CWBDel_{est}$ = estimated producer deliveries of wheat to the CWB

Average $Production_{t-1}$ = the average wheat production for the CWB area in the preceding 3 years, in tonnes

$Planting_t$ = the planting intentions for wheat in the CWB area, in the current year, in acres

The estimate of deliveries to the CWB ($CWBDel_{est}$) is used as a bench mark on which to base hedging quantities. Previous research has indicated that the optimal quantity to short hedge, when quantity is uncertain, may be less than what is expected or estimated (Kahl). Also, Peck (1975) suggests that models of hedging to stabilize revenues include some parameter allowing uncertainty around production. Therefore, the decision variable to hedge (H_p) is broken down into a percentage range over the percentage of expected producer deliveries to be hedged.

The prices selected for setting and lifting the wheat hedge should reflect market conditions and not be sensitive to any particular trading date. A particular trading date may overstate or understate the price the hedge is set and lifted and in turn distort the hedge returns. Therefore, a monthly average closing price, weighted by daily trading volume (FPW_m), is generated as:[8]

$$FPW_m = \sum_{i=1}^{n} (CF_{i,m} \times ERate_{i,m}) \times \frac{V_{i,m}}{\sum V_{i,m}} \qquad (6.6)$$

(This estimates an average futures price for setting and lifting the short hedges)

where : FPW = monthly average futures closing price weighted by trading volume

CF = daily closing futures price on the CBOT December wheat contract
V = daily trading volume
$ERate$ = Average Noon Spot Exchange Rate (Canadian dollars per U.S. dollar)
n = trading days in the month
i = date of trading day
m = calendar month

Four alternative short selling periods are explored, since in practice, hedges may be set over alternative periods. These include selling futures in either April or May and buying futures in either November or December to close out the position. The short selling returns for each of the four alternative short selling periods are averaged individually over the period of the constraints (x). The choice of which short selling period to use in the objective equation (6.1) and constraints, is the period that has the highest annual average returns (Hedge^{max}) of the alternative short selling periods and is defined as:

$$Hedge^{\max} = Max: \left[\sum_{y=1}^{x} (FPW_{m,y} - FPW_{n,y}) \times \frac{1}{x} \right] \qquad (6.7)$$

(This selects the period to set and lift the hedge, from alternative hedging periods, based on the maximum historical hedging returns during one of the alternative hedging periods)

where : $Hedge^{max}$ = maximum annual average returns from one of the alternative short hedging periods and includes a brokerage charge of \$25 per futures contract
m = calender month for opening the hedge, April or May
n = calender month for closing the hedge, November or December
FPW = monthly average futures closing price weighted by trading volume
x = number of years in the model constraints
y = the years preceding the objective equation (6.1)

In the objective equation and constraints, the expected value of the short selling returns begins with the selection of the short selling period to be used, $Hedge^{max}$ (6.7). This time period defines the returns from short selling futures by setting the selling and buying times for the futures. The range of estimated producer deliveries, $CWBDel_{est}$ (6.5) specifies the quantity of futures to be short sold, which defines the short selling decision in terms of revenues, i.e. price times quantity. This futures selling revenue, ValueH (6.4), is then averaged over the period of the constraints, for each quantity increment, to estimate the expected value of short selling futures in the year of the objective equation. However, these average returns are also divided by the expected producer deliveries to the CWB in the year of the objective equation to make the returns from selling futures consistent with the value maximized in the objective equation (6.1) of the MAL model.

MAL Model Constraints

The constraints describe the risk associated with the decisions specified in the objective function (6.1) as the losses that may have occurred in the x years during the period of the constraints. The constraints during this time period divide risk into two areas: the first for the wheat pool account and the second for a separate futures hedging (short selling) account. The risk to the wheat pool account is the risk of an initial payment above the final selling price of wheat. The risk to the futures hedging account is the risk of losses on the futures short selling.

The risk for the initial price rule I_p with $ValueI_p$ is:

$$\sum_{y=1}^{x} (CWBFSP_y - ValueI_{p,y}) \times I_p + Y_y \geq 0 \tag{6.8}$$

(This constraint sets the level of the initial price risk to the CWB, in revenue per tonne, from a particular initial price rule followed in the objective equation (6.1), during the period of the constraints (x))

where : $CWBFSP$ = the average final selling price received by producers for wheat across all grades delivered to the CWB
$ValueI$ = expected Initial Payment Revenue
x = number of years in the model constraints
y = the years preceding the objective equation (6.1)
Y = the loss associated with the initial price rule selected
p = percentage rate in set increments
I = the decision to follow the initial payment rule

There is no specification of risk for the final payment since it is linked to the initial payment because a final payment is made as a result of an initial price below the final selling price received by the CWB for the wheat. Therefore, the model constraints specifies the direct relationship between the initial payment decisions (Ip) and the final payment decisions (FPp), which are integers, as:

$$\sum_{y=1}^{x} I_p - FP_p = 0 \tag{6.9}$$

(This constraint links the initial payment to the final payment, so there can only be one final payment for each initial payment))

where : I = the decision to follow the initial payment rule
p = percentage rate in set increments
x = number of years in the model constraints
FP = the corresponding final payment to the initial payment rule I_p
y = the years preceding the objective equation (6.1)

By defining (6.9), the final payment (FP_p) is linked to a corresponding initial payment (I_p), and the risk of no final payment becomes the risk of an initial payment above what the CWB ultimately receives for the wheat.

The risk associated with the decision to short hedge (H_p) a percentage of expected producer deliveries of wheat is described by the losses associated with that decision during the period of the constraints (x) plus the amount the CWB is willing to risk in the current year, or year of the objective equation. The losses connected to hedging are specified in the model constraints as:

$$\sum_{y=1}^{x}\left(((p\% \times CWBDel_{est,\,y}) \times (FPW_{m,\,y} - FPW_{n,\,y})^{\max}) \times \frac{1}{CWBDel_{y}}\right) \times H_{p} + Z_{y} \geq 0 \qquad (6.10)$$

(This defines the losses of each hedge decision followed during the period of the model constraints)

where : $CWBDel_{est}$ = estimated producer deliveries of wheat to the CWB

$(FPW_{m,y} - FPW_{n,y})^{max}$ = the returns from Hedge^{max} based on (6.7) below

Z = the loss associated with the futures hedge selected

p = percentage rate in set increments

FPW = monthly average futures closing price weighted by trading volume

H = the decision to follow the short hedging rule

x = number of years in the model constraints

y = the years preceding the objective equation (6.1)

m = calender month for opening the hedge, April or May

n = calender month for closing the hedge, November or December

By defining the historical losses with each hedge decision (Z), the maximum admissible loss the CWB is willing to accept can be stated. Therefore, the risk of short selling futures (RISK) is defined as the maximum admissible revenue losses per tonne that the CWB is willing to risk on short hedging (Risk Premium) in the current year and on past short selling losses. This amount is defined as:

$$RiskPremium + \sum_{y=1}^{x} Z_y \geq RISK \tag{6.11}$$

(This sets the level of risk or possible losses the CWB (or firm) is willing to accept when deciding to hedge (H_p) in the objective equation (6.1))

where : *Risk Premium* = the amount the CWB is willing to risk on short hedging
Z = the loss on the futures hedge selected
$RISK$ = the cumulative losses on the futures hedge selected plus a premium for the level of risk
y = the years preceding the objective equation (6.1)
x = number of years in the model constraints

Since the CWB is modelled as selling futures to hedge the initial wheat price, the wheat pool and futures account are defined as separate accounts. Not only does this allow for different risk levels for each account, but the futures account is used to underwrite the initial price rule selected in the objective equation (6.1), and its effect on the wheat pool account. Therefore, the balance in the futures account will depend on the gains or losses from short selling futures and this is defined as:

$$\sum_{y=1}^{x} ValueH_{p,\,y} \times H_p + Sl_y - Sg_y \geq 0 \tag{6.12}$$

(This constraint creates a futures account that can be added to by gains from short selling or be used to offset wheat pool cash losses)

where : *ValueH* = expected short selling futures revenue (hedge revenue)
H = the decision to follow the short selling rule
p = percentage rate in set increments
y = the years preceding the objective equation (6.1)
x = number of years in the model constraints
Sl = the loss associated with the short selling decision

Sg = the gain associated with the short selling decision

The years with gains from short selling are used to offset the years with losses from short selling and underwrite the initial price rule (I_p) selected if it results in a loss for the CWB. Transfers of short selling gains between the futures account and the wheat pool account are used to offset losses from a final selling price that is below the initial price and are defined by:

$$\sum_{y=1}^{x} Sg_y - tH_y + tP_y = 0 \tag{6.13}$$

(This constraint permits transfers from the futures account created in (12) to offset losses on either futures selling or the wheat pool)

where :
tH = the transfer of selling futures gains to the futures account
tP = the transfer of selling futures gains to the wheat pool account
Sg = the gain associated with the short hedge decision
y = the years preceding the objective equation (6.1)
x = number of years in the model constraints

Also, the pool account cannot have a negative balance at the end of the crop year and only transfers from the futures account are available to offset such losses. This relationship is based on the principle that returns from short selling should offset the losses on an initial payment above the final selling price and is specified as:

$$\sum_{y=1}^{x} Y_y - tP_y \leq 0 \tag{6.14}$$

(This constraint permits the transfer of funds from the futures account to the wheat pool to offset losses from an initial payment below the final selling price received by the CWB for the wheat)

where :
Y = the loss on the initial payment rule selected
y = the years preceding the objective equation (6.1)

x = number of years in the model constraints
tP = transfers from the gains of hedging, or futures account, to the pool account

From time to time a surplus may exist in the futures account when funds from this account are not needed to offset losses from the initial payment or hedging. Any surplus funds (SURPLUS) in the futures account should not be used to subsidize the risk level in (6.11) in an attempt to provide a higher initial payment in the current year, but saved for future wheat pool deficits. Therefore, the following constraint is specified:

$$\sum_{y=1}^{x} Sl_y - \sum_{y=1}^{x} tH_y \leq -SURPLUS \qquad (6.15)$$

(This constraint allows the gains from selling futures in previous years to be used to offset losses from selling futures in later years, while also not allowing the futures selling gains from previous years to subsidize higher initial prices in the year of the objective equation (6.1))

where : $SURPLUS$ = the annual balance in the futures account
Sl = the loss associated with the decision to short sell futures
tH = the transfer of hedging gains to the futures account
y = the years preceding the objective equation (6.1)
x = number of years in the model constraints

This completes the specification of the MAL model to select the initial payment and intended futures short selling position. The MAL model is used to generate the initial wheat payment announced in the spring of the year, and to enter into short selling futures if required. These actions are then applied to producer deliveries made to the CWB to show the effect on the wheat pool account, in the second stage of the model. The results of the second stage of the model are then compared with historical CWB management of the wheat pool account for the crop years 1973/74 to 1990/91.

Results

The initial payment and corresponding final payment decisions were defined over a range of possible values extending above (110%) and below (80%) the prevailing spring CBOT futures price, in increments of 5%. The variable Hp, which is the decision to sell futures, or hedge, was broken down into a range from 50% to 100% of expected deliveries ($CWBDel_{est}$), in increments of 5% to permit selling futures in quantities of less than what is expected based on (6.5).[9] The period of the constraints (x) was determined to be nine years, based on optimizing futures returns previous to the analysis, in order to give out of sample results.

The MAL models' selection of initial payments and short hedge decisions, along with the result of their implementation, are shown in Tables 6.1 through 6.6. Even though short hedging could have begun in 1974, it was not until the 1983/84 crop year that short hedging was selected by the MAL models. This is because of the low expected returns from hedging, based on the nine year average of returns, before 1983. The format of the results in the tables follows the modelling process outlined, where initial prices and hedge positions are estimated, and returns computed. In the tables showing the effectiveness of short hedging, the historical CWB wheat pool account is included for comparison because it forms the bench mark for measuring the performance of the MAL

Table 6.1 Results of the Maximum Admissible Loss Model for the CWB Wheat Pool based on the Acceptable Loss of <u>$10/tonne</u> on Hedging, $0/tonne on the Initial Payment and Risk Described by the 9 years Previous to the Objective Equation*.

	Initial Payment Decision		Expected Final Payment Decision	Quantity Hedge Decision	
Crop Year	Percentage of CBOT futures price	Initial Payment "ValueIp" ($/tonne)	Final Payment "ValueFPp" ($/tonne)	percent hedged "Hp"	quantity hedged "CWBDel$_{est}$*p%" (tonnes)
1974/75	90	129.810	17.835	0	0
1975/76	90	120.686	19.474	0	0
1976/77	90	120.867	20.306	0	0
1977/78	85	95.649	23.951	0	0
1978/79	85	117.433	25.089	0	0
1979/80	85	122.293	27.764	0	0
1980/81	85	161.966	32.596	0	0
1981/82	85	179.377	36.085	0	0
1982/83	85	158.118	35.042	0	0
1983/84	95	166.571	14.813	55	13,099,335
1984/85	100	171.613	7.793	60	12,124,779
1985/86	95	163.887	15.848	60	10,831,563
1986/87	80	106.463	38.370	60	11,787,891
1987/88	80	107.360	36.773	60	8,791,297
1988/89	80	123.256	34.463	70	7,014,237
1989/90	90	163.643	17.634	65	10,685,070
1990/91	95	145.729	5.886	70	14,482,168

* The results in this table are based on the Maximum Admissible Loss (MAL) model; all dollar figures are in Canadian funds; model description in Appendix A.
" " indicate variables in the MAL model; variable description in Appendix A.
Sources: The Canadian Wheat Board Annual Report, 1965/66 to 1989/90, The Canadian Wheat Board, Chicago Board of Trade Statistical Annual, 1965 to 1990, Spot Exchange Rate, Account #3400, various issues, Bank of Canada Review, Canada Grains Industry: Statistical Handbook, Canada Grains Council, various issues, and calculations by author.

Table 6.2 The Effectiveness of Hedging the CWB Wheat Pool based on the Maximum Acceptable Loss of $10/tonne on Hedging, $0/tonne on the Initial Payment and Risk Described by the Previous 9 years. All Prices Reflect Average Returns to Producers for All Grades of Wheat received by the CWB.

	Historical CWB Actions			MAL Hedging Model Results					
Crop Year	Initial Payment ($/tonne)	Final Payment ($/tonne)	Pool Account ($)	Initial Payment ($/tonne)	Final Payment ($/tonne)	Pool Account ($)	Transfer to Pool from Hedging ($)	Futures Account Balance ($)	Futures Selling Returns ($)
1974/75	127.71	30.10	0	129.82	27.99	0	0	0	0
1975/76	135.89	7.47	0	120.69	22.67	0	0	0	0
1976/77	108.63	8.16	0	120.87	0.00	-59,510,380[a]	0	0	0
1977/78	106.14	8.04	0	95.65	18.53	0	0	0	0
1978/79	124.75	29.84	0	117.43	37.16	0	0	0	0
1979/80	150.90	37.03	0	122.29	65.64	0	0	0	0
1980/81	190.07	24.67	0	161.97	52.77	0	0	0	0
1981/82	171.99	26.44	0	179.38	19.05	0	0	0	0
1982/83	166.96	16.52	0	158.12	25.36	0	0	0	0
1983/84	166.09	24.29	0	166.57	23.81	0	0	223,887,890	223,887,890
1984/85	168.16	18.90	0	171.61	15.45	0	0	261,628,434	37,740,544
1985/86	145.90	0.00	-22,994,777	163.89	0.00	-142,467,943[a]	221,024,693	0	-40,603,741
1986/87	115.90	0.44	0	106.46	9.88	0	0	-125,098,117	-125,098,117
1987/88	112.72	16.26	0	107.36	21.62	0	0	-123,571,811	1,526,306
1988/89	167.22	18.81	0	123.26	62.77	0	0	-338,186,550	-214,614,739
1989/90	157.96	12.48	0	163.64	6.8	0	0	-222,587,055	115,599,495
1990/91	127.27	0.00	-743,944,520	145.73	0.00	-406,634,803[a]	699,503,197	-222,587,055	699,503,197
Total			-766,939,297			-608,613,126			697,940,835

Sources: The Canadian Wheat Board Annual Report, 1965/66 to 1989/90, The Canadian Wheat Board, Chicago Board of Trade Statistical Annual, 1965 to 1990, Spot Exchange Rate, Account #3400, various issues, Bank of Canada Review, Canada Grains Industry: Statistical Handbook, Canada Grains Council, various issues, and calculations by author.

[a] Includes transfers from the futures account.

Table 6.3 Results of the Maximum Admissible Loss Model for the CWB Wheat Pool based on the Acceptable Loss of $20/tonne on Hedging, $0/tonne on the Initial Payment and Risk Described by the 9 years Previous to the Objective Equation*.

	Initial Payment Decision		Expected Final Payment Decision	Quantity Hedge Decision	
Crop Year	Percentage of CBOT futures price	Initial Payment "ValueIp" ($/tonne)	Final Payment "ValueFPp" ($/tonne)	percent hedged "Hp"	quantity hedged "CWBDel$_{est}$*p%" (tonnes)
1974/75	90	129.810	17.835	0	0
1975/76	90	120.686	19.474	0	0
1976/77	90	120.867	20.306	0	0
1977/78	85	95.649	23.951	0	0
1978/79	85	117.433	25.089	0	0
1979/80	85	122.293	27.764	0	0
1980/81	85	161.966	32.596	0	0
1981/82	85	179.377	36.085	0	0
1982/83	85	158.118	35.042	0	0
1983/84	95	166.571	14.813	65	15,481,035
1984/85	100	171.613	7.793	75	15,155,973
1985/86	100	172.513	8.450	75	13,539,454
1986/87	80	106.463	38.370	75	14,734,863
1987/88	80	107.360	36.773	75	10,989,121
1988/89	80	123.256	34.463	95	9,519,322
1989/90	95	172.734	9.986	85	13,972,784
1990/91	95	145.729	5.886	95	19,654,370

* The results in this table are based on the Maximum Admissible Loss (MAL) model; all dollar figures are in Canadian funds; model description in Appendix A.
" " indicate variables in the MAL model; variable description in Appendix A.
Sources: The Canadian Wheat Board Annual Report, 1965/66 to 1989/90, The Canadian Wheat Board, Chicago Board of Trade Statistical Annual, 1965 to 1990, Spot Exchange Rate, Account #3400, various issues, Bank of Canada Review, Canada Grains Industry: Statistical Handbook, Canada Grains Council, various issues, and calculations by author.

Table 6.4 The Effectiveness of Hedging the CWB Wheat Pool based on the Maximum Acceptable Loss of $20/tonne on Hedging, $0/tonne on the Initial Payment and Risk Described by the Previous 9 years. All Prices Reflect Average Returns to Producers for All Grades of Wheat received by the CWB.

Crop Year	Historical CWB Actions: Initial Payment ($/tonne)	Historical CWB Actions: Final Payment ($/tonne)	Historical CWB Actions: Pool Account ($)	MAL Hedging Model Results: Initial Payment ($/tonne)	MAL Hedging Model Results: Final Payment ($/tonne)	MAL Hedging Model Results: Pool Account ($)	MAL Hedging Model Results: Transfer to Pool from Hedging ($)	MAL Hedging Model Results: Futures Account Balance ($)	MAL Hedging Model Results: Futures Selling Returns ($)
1974/75	127.71	30.10	0	129.82	27.99	0	0	0	0
1975/76	135.89	7.47	0	120.69	22.67	0	0	0	0
1976/77	108.63	8.16	0	120.87	0.00	-59,510,380[a]	0	0	0
1977/78	106.14	8.04	0	95.65	18.53	0	0	0	0
1978/79	124.75	29.84	0	117.43	37.16	0	0	0	0
1979/80	150.90	37.03	0	122.29	65.64	0	0	0	0
1980/81	190.07	24.67	0	161.97	52.77	0	0	0	0
1981/82	171.99	26.44	0	179.38	19.05	0	0	0	0
1982/83	166.96	16.52	0	158.12	25.36	0	0	0	0
1983/84	166.09	24.29	0	166.57	23.81	0	0	264,594,779	264,594,779
1984/85	168.16	18.90	0	171.61	15.45	0	0	311,770,459	47,175,680
1985/86	145.90	0.00	-22,994,777	172.51	0.00	-242,782,932[a]	261,015,783	0	-50,754,676
1986/87	115.90	0.44	0	106.46	9.88	0	0	-156,372,645	-156,372,645
1987/88	112.72	16.26	0	107.36	21.62	0	0	-154,464,763	1,907,882
1988/89	167.22	18.81	0	123.26	62.77	0	0	-445,727,623	-291,262,860
1989/90	157.96	12.48	0	172.73	0.00	0	38,228,312	-332,787,364	151,168,571
1990/91	127.27	0.00	-743,944,520	145.73	0.00	-156,812,275[a]	949,325,725	-332,787,364	949,325,725
Total			-766,939,297			-459,105,587			915,782,456

Sources: The Canadian Wheat Board Annual Report, 1965/66 to 1989/90, The Canadian Wheat Board, Chicago Board of Trade Statistical Annual, 1965 to 1990, Spot Exchange Rate, Account #3400, various issues, Bank of Canada Review, Canada Grains Industry: Statistical Handbook, Canada Grains Council, various issues, and calculations by author.

[a] Includes transfers from the futures account.

Table 6.5 Results of the Maximum Admissible Loss Model for the CWB Wheat Pool based on the Acceptable Loss of $30/tonne on Hedging, $0/tonne on the Initial Payment and Risk Described by the 9 years Previous to the Objective Equation*.

Crop Year	Initial Payment Decision		Expected Final Payment Decision	Quantity Hedge Decision	
	Percentage of CBOT futures price	Initial Payment "ValueIp" ($/tonne)	Final Payment "ValueFPp" ($/tonne)	percent hedged "Hp"	quantity hedged "CWBDel_{est}*p%" (tonnes)
1974/75	90	129.810	17.835	0	0
1975/76	90	120.686	19.474	0	0
1976/77	90	120.867	20.306	0	0
1977/78	85	95.649	23.951	0	0
1978/79	85	117.433	25.089	0	0
1979/80	85	122.293	27.764	0	0
1980/81	85	161.966	32.596	0	0
1981/82	85	179.377	36.085	0	0
1982/83	85	158.118	35.042	0	0
1983/84	95	166.571	14.813	75	17,862,730
1984/85	100	171.613	7.793	90	18,187,168
1985/86	100	172.513	8.450	90	16,247,345
1986/87	80	106.463	38.370	90	17,681,836
1987/88	80	107.360	36.773	90	13,186,945
1988/89	80	123.256	34.463	100	10,020,338
1989/90	95	172.734	9.986	100	16,438,569
1990/91	95	145.729	5.886	100	20,688,811

* The results in this table are based on the Maximum Admissible Loss (MAL) model; all dollar figures are in Canadian funds; model description in Appendix A.
" " indicate variables in the MAL model; variable description in Appendix A.
Sources: The Canadian Wheat Board Annual Report, 1965/66 to 1989/90, The Canadian Wheat Board, Chicago Board of Trade Statistical Annual, 1965 to 1990, Spot Exchange Rate, Account #3400, various issues, Bank of Canada Review, Canada Grains Industry: Statistical Handbook, Canada Grains Council, various issues, and calculations by author.

Table 6.6 The Effectiveness of Hedging the CWB Wheat Pool based on the Maximum Acceptable Loss of $30/tonne on Hedging, $0/tonne on the Initial Payment and Risk Described by the Previous 9 years. All Prices Reflect Average Returns to Producers for All Grades of Wheat Received by the CWB.

	Historical CWB Actions			MAL Hedging Model Results					
Crop Year	Initial Payment ($/tonne)	Final Payment ($/tonne)	Pool Account ($)	Initial Payment ($/tonne)	Final Payment ($/tonne)	Pool Account ($)	Transfer to Pool from Hedging ($)	Futures Account Balance ($)	Futures Selling Returns ($)
1974/75	127.71	30.10	0	129.82	27.99	0	0	0	0
1975/76	135.89	7.47	0	120.69	22.67	0	0	0	0
1976/77	108.63	8.16	0	120.87	0.00	-59,510,380[a]	0	0	0
1977/78	106.14	8.04	0	95.65	18.53	0	0	0	0
1978/79	124.75	29.84	0	117.43	37.16	0	0	0	0
1979/80	150.90	37.03	0	122.29	65.64	0	0	0	0
1980/81	190.07	24.67	0	161.97	52.77	0	0	0	0
1981/82	171.99	26.44	0	179.38	19.05	0	0	0	0
1982/83	166.96	16.52	0	158.12	25.36	0	0	0	0
1983/84	166.09	24.29	0	166.57	23.81	0	0	0	0
1984/85	168.16	18.90	0	171.61	15.45	0	0	305,301,668	305,301,668
1985/86	145.90	0.00	-22,994,777	172.51	0.00	-202,791,842[a]	301,006,873	361,912,484	56,610,816
1986/87	115.90	0.44	0	106.46	9.88	0	0	0	-60,905,611
1987/88	112.72	16.26	0	107.36	21.62	0	0	-187,647,175	-187,647,175
1988/89	167.22	18.81	0	123.26	62.77	0	0	-185,357,717	2,289,458
1989/90	157.96	12.48	0	172.73	0.00	0	0	-491,950,201	-306,592,484
1990/91	127.27	0.00	-743,944,520	145.73	0.00	-106,847,740[a]	38,228,312	352,333,136	177,845,377
							999,290,260	-352,333,136	999,290,260
			-766,939,297			-369,149,962			986,192,309

Sources: The Canadian Wheat Board Annual Report, 1965/66 to 1989/90, The Canadian Wheat Board, Chicago Board of Trade Statistical Annual, 1965 to 1990, Spot Exchange Rate, Account #3400, various issues, Bank of Canada Review, Canada Grains Industry: Statistical Handbook, Canada Grains Council, various issues, and calculations by author.

[a] Includes transfers from the futures account.

hedging model.

Since the MAL model does not explicitly state the optimum level of risk for the CWB, a range of maximum admissible losses were explored. This range included the specification of MAL models which allowed a maximum admissible revenue loss on futures selling of \$10/tonne (Table 6.1), \$20/tonne (Table 6.3), and \$30/tonne (Table 6.5). Also, since selling futures may be an alternative to the government covering losses on the initial payment, all MAL models set the risk of loss on the initial payment to zero.

The results of this study show that when futures were sold by the MAL model to underwrite the initial payment (1983/84 to 1990/91), the MAL models generated initial payments (Tables 6.1, 6.3, and 6.5) above those historically offered by the CWB (Tables 6.2, 6.4, and 6.6). Also, the losses from an initial price above the final selling price and futures selling were less than the historical losses faced by the CWB on the wheat pool. But, in all three MAL cases of selling futures by the CWB, large losses on the initial wheat payment occurred during the 1985/86 crop year. These losses were not offset by futures returns as expected, since the futures did not move down with world prices received by the CWB. For example, during the 1985/86 crop year, the futures price increased by \$3.57/tonne for the April to December short selling period used by the MAL models and the export price offered by the CWB declined approximately \$26/tonne during this period. An explanation of this may be the adverse basis adjustment created by the introduction of the Export Enhancement Program (EEP) in the United States.[10]

Short selling futures returns for the \$10/tonne MAL, \$20/tonne MAL, and \$30/tonne were 697, 915, and 986 million dollars, respectively (Tables 6.2, 6.4, and 6.6). Also, short selling returns were sufficient to under write most of the losses from the initial price set by the MAL models shown in tables 6.1, 6.3, and 6.5. For example, the large losses to the wheat pool would have been reduced from \$744 million without hedging to \$459 million under the \$20/tonne MAL hedging model shown in Table 6.2. This evidence of profitably hedging the initial payment shows the potential for the CWB using the private risk markets in a similar fashion to other large grain marketing companies. Also, the results from the account totals of Tables 6.2, 6.4, and 6.6, show substantial differences in total pool account losses that includes short selling futures, which suggests that the MAL approach is relatively sensitive, and adaptive, to risk levels defined in terms of admissible revenue losses per tonne. However, short hedging was less successful during the period when cash price was distorted in relation to futures, but the models could be improved by attempting to capture more timely information, such as the sale agreements made by the CWB.

The CWB's overall return in relation to risk on the wheat pool did not substantially worsen under short hedging, even though returns were higher under hedging, as shown in Table 6.7. For example, the \$20/tonne admissible loss MAL model produced a higher wheat pool return than the historical case, yet had almost an identical level of risk, as measured by the Sharpe ratio.[11] This return

Table 6.7 Sharpe Ratios for the Wheat Pool Account under the CWB and the MAL Model Hedge Scenarios, based on the period 1983 to 1990.*

	Actual CWB Actions	MAL Hedging Model Results		
		$10/tonne admissible loss on futures short selling	$20/tonne admissible loss on futures short selling	$30/tonne admissible loss on futures short selling
Sharpe Ratio:	4.682	4.893	4.688	4.599

* The Sharpe Ratio is the net annual average of the pool account divided by the standard deviation. Higher numbers represent higher returns in relation to risk. To calculate the Sharpe Ratio and make it describe the risk of losses from the initial payment and futures short selling, adjustments were made to the annual pool account values, under both the management of the CWB and the hedging models. The annual pool account values under the CWB were adjusted by subtracting the losses on the initial payment from the returns received by producers. The annual pool account values under the hedging models were similarly adjusted to reflect the risk of losses from an initial payment above the final selling price and short selling futures. The annual surplus gains from short selling futures was only applied to losses on the pool account and not distributed to producers. Any losses on the pool account, that were not covered by short selling futures, were subtracted from the returns received by producers. By adjusting the annual pool account values under the hedging models in the manner described, the Sharpe Ratio should describe the variability and therefore the risk of hedging the initial price with returns from a separate futures account. Also, the adjustments made to the annual pool account values should make the Sharpe Ratio measurement of risk comparable between the CWB and hedging model pool account values. The period used was from 1983 to 1990 because these were the years all the MAL models used in this study actively short sold futures.

to risk ratio may have been improved for the MAL models had they used a more advanced hedging rule, or more current information that accounted for the world cash price being distorted in relation to the futures because of the EEP. Also, the MAL models used here do not capture any proprietary information which the firm could use, if it were constructing the model.

Conclusion

The Maximum Admissible Loss (MAL) model used here is a first attempt to formulate the optimal hedging decision for the firm by modelling revenue risk, which accounts for price and quantity variation, rather than only price variation, subject to admissible futures revenue losses. The MAL model is used for forward price hedging and by design is adaptive, and will allow the user to incorporate more advanced hedging rules for more accurate price and quantity expectations for the firm. Also, this approach allows the researcher or firm to select the risk aversion parameter, quoted in terms of revenue loss rather than utility, that results in the preferred distribution of revenue.

Results for the example firm used here, the Canadian Wheat Board (CWB), suggest that this approach was successful in setting hedges for the firm that would offset revenue losses. With the exception of the 1985/86 crop year, and the introduction of export subsidies, the results of this study support the maximum admissible loss approach of using hedging (futures short selling) to offset pool account losses for the CWB.

The MAL model results provided higher initial payments for producers in five out of the eight years that the CWB would have hedged based on the MAL models. The management that included short selling futures, specified by the MAL models, resulted futures selling gains and substantially smaller wheat pool account deficits than the deficit under historical CWB management that did not include futures selling. Also, the Sharpe Ratio, which is defined as the mean divided by standard deviation, showed that while wheat pool returns increased substantially, risk levels (return variability) to the pool would not have increased had futures been short sold.

However, the CWB's use of futures may be limited by the setting of large hedge positions, which may temporally move the market down. This may reduce the gains from short selling, similar to the problem faced by large commodity funds who are taking large positions in the futures market. A possible strategy to overcome this limitation may be to hedge more than once a year and also on other exchanges, such as the Kansas City and Minneapolis futures exchanges, and also hedging with put options on the CBOT.

Applications of the MAL model for the firm are not limited to the type of firm used as an example in this study. Extensions of this could include co-operatives, grain marketing firms, and even governments who wish to hedge commodity revenue supports. In general, the MAL model could be applied to any firm that is faced with price and quantity uncertainty on either outputs or inputs, or both, where a futures market exists for the commodity in question.

Also, applications outside of agriculture could also use the MAL approach. For example, mutual funds faced with an uncertain flow of incoming investment funds could consider the MAL approach in defining the optimal hedge to hedge these incoming funds. In summary, this study provides an alternative method for solving the optimal hedge problem for the firm faced with both price and quantity uncertainty, which wants to limit its losses to maximum admissible amounts. Also, this method does not require risk aversion to be specified in utility terms, but rather only in dollar terms.

A hedging rule which better captures the variability of the market and places more weight on recent information may improve the MAL model's ability to select more opportune hedges for the firm. This could include the application of technical trading strategies, such as trend following systems, within the short hedge framework, similar to the trading systems which some commodity funds and large grain marketing companies currently use. While this chapter is only a first attempt at maximum admissible loss models for firm hedging under output price and quantity uncertainty, it does establish a new method for developing more advanced applications.

End Notes

[1] Risk here is defined as the difference between what was expected by the firm and what actually occurred, as opposed to the simple variance of what did occur.

[2] This would also include contract lumpiness, difference in grades, and a maturity date not coinciding with delivery.

[3] The traditional competitive firm in this paper would be modelled with a profit function dependant on the level of production. Therefore, the firm would be able to alter production in response to a hedged price and reduce a major portion of the quantity uncertainty or risk.

[4] Since the CWB's sales are relatively constant throughout the year, and it pools its sales, the returns to farmers are averaged or "hedged" in a sense. This is in contrast to the case if farmers sold wheat individually and only once or twice a year. Therefore, historical CWB returns are already "hedged" through price pooling, so hedging cash grain on hand maybe of limited interest. However, it is a forward selling hedge that is examined here, where futures are sold before the wheat is planted to hedge the price of wheat. A forward selling hedge is used because the CWB faces considerable risk on the Initial Payment, which is announced well before the final selling price is known.

[5] The Federal Government has covered CWB losses in the past, but due to budget restrictions, and the implications of the General Agreement on Tariffs and Trade, it is unlikely to in the future.

[6] In general, the CWB has created pool accounts for each grain under its control from which it buys and sells farmers grain. The pool account is closed annually and any surplus is distributed to farmers based on their deliveries to the pool during the year in question.

[7] The CBOT December wheat contract is used for the following reasons: First, the CBOT wheat futures is more representative of the world market which the CWB sells into than the Canadian Wheat futures market, which is for a feed wheat. Secondly, the volume of trade on the CBOT wheat contracts provides a higher degree of liquidity as opposed to the Kansas City and Minneapolis contracts, for example. Thirdly, the December month is used because it is actively traded in the spring of the year as opposed to more distant delivery contract months, which may not be as actively traded. Fourthly, the December contract covers the time period required by the short selling approach used in this analysis.

[8] Included in the futures price is a $25 per contract fee to cover brokerage

commissions, administration costs, and margin interest.

[9] Traditional hedging literature assumes quantity to be hedged is certain and constant. However, this study also takes into account the uncertainty of production from year to year, so quantity to be hedged (percent hedged) is generally lower than it would be for the certain quantity case. Also, since this study accounts for production uncertainty, the quantity of futures to sell (percent hedged) is allowed to vary from year to year. This is in contrast to traditional methods of restricting the amount to be hedged to a constant, which assumes a constant hedge ratio from year to year, due to assuming certain production levels.

[10] The EEP was announced in the fall of 1985 and provided payments to individual exporters to encourage exports of grains covered by the program. In 1985, these payments averaged $22.15 (U.S.) per tonne for wheat (Ackerman and Smith). This likely was responsible for pushing up prices on the December futures contract in relation to the world cash price and removing any short selling gains that would have existed in the absence of the EEP. Also, payments to exporters from the EEP varied from a low of $17.76 to a high of $38.35 per tonne during the period 1985 to 1989, adding to the widening basis between the CBOT Wheat futures market and CWB sales.

The market distortion or widening basis caused by the introduction of the EEP did level off somewhat and the futures returns returned to normal after 1985. The losses and gains on selling futures after 1985 did not exceed previous levels in the period of this investigation. However, if the EEP was suddenly removed and not replaced, the basis between the world cash and CBOT futures would likely narrow, and short hedging for the CWB should be profitable, just as it was unprofitable when export subsidies were introduced in 1985.

[11] The Sharpe Ratio used in this analysis is defined as the mean divided by the standard deviation, as in Schwager (1984).

CHAPTER 7

SUMMARY

Aggregate Stabilization

The five studies in this analysis are the first to examine the use of futures and options as an alternative to traditional western Canadian agricultural policy. They also contain the most thorough and complete data set to date on government transfers to farmers.

The first study, concerning the effectiveness of agricultural policies for stabilizing annual aggregate gross revenues in the grain sector, used data from 1971 to 1990. The major explicit and implicit transfers from agricultural policies were documented and compared with market revenues using the mean, standard deviation, and coefficient of variation.

Results showed that past agricultural policies increased producer grain revenues but did not decrease the variability of those revenues. In particular, policy transfers were found to be positively correlated with market revenues in contrast to negative correlation which is required for policy transfers to stabilize revenues.

Policy transfers based on production, such as transportation, were found to destabilize grain revenues because proportionally more of the benefit was received during periods of high production and periods of relatively higher revenues. Since policy transfers were accounted for on a cash flow basis, the results highlighted a need for policy transfers to be timely if they are to stabilize revenues. Also, analysis showed that agricultural policy benefits must be coordinated so the stabilization benefit of one program does not offset the benefit of another.

Futures and Put Options for Aggregate Revenue Stabilization

The second study analyzed commodity futures and put options as a market alternative to past agricultural policies for stabilizing aggregate gross revenues. Futures short selling and put options buying strategies were developed based on alternative time periods over the growing season. Put option values were calculated from actual futures prices using Black's Option Valuation model. The returns from the alternative futures and put options strategies were used to create a range of the effectiveness of futures and options to stabilize revenues. The worst of this range for short selling futures and buying put options still exceeded the ability of the government policies to stabilize revenues.

As a comprehensive approach to stabilizing aggregate grain revenues, crop insurance was considered in the analysis. Crop insurance was found to improve revenue stability when combined with futures and options. Overall, stabilization results were comparable between futures and put options hedging. One of the main reasons futures and options provide better stability than government programs is that payments are made immediately when the commodity market position is liquidated. This is in contrast to government payments which may take a year or more to reach the farmer.

Futures and Put Options for Individual Farm Revenue Stabilization

The second study analyzed futures and options for revenue stabilization on the individual farm level, based on how a producer would likely hedge expected production over the growing season. Typical farms were created in Manitoba, Saskatchewan, and Alberta to represent both farm level effects, and provincial differences in yields and policy transfers. Results showed that futures and options stabilized expected revenues more than government transfers. Expected grain revenues were defined in the analysis as historical yields multiplied by the three month average prices prevailing before spring planting. The effectiveness of futures and put options to stabilize short run revenues was also improved by including crop insurance.

The typical Saskatchewan farm had revenues stabilized the most from past government policies, while the typical Alberta farm benefitted the least. In contrast, the typical Alberta farm had revenues stabilized the most by futures and options, while the typical Saskatchewan farm had revenues stabilized the least. Overall, futures and put options were more effective in stabilizing individual farm revenue risk than were past policy transfers.

Futures Hedging Under Price and Quantity Uncertainty

Often firms acting as first handlers of agricultural production, such as the Canadian Wheat Board (CWB), are exposed to both price and quantity risk. This in turn means that farmers are also exposed to this risk. A Maximum Admissible Loss (MAL) model was formulated to reduce the revenue risk surrounding the initial payment on wheat. The MAL model maximizes revenue from the decision set available to the firm, but places a limit on the maximum admissible revenue loss acceptable from the decisions taken by the firm. Results for the CWB suggest that the MAL model was successful in setting hedges that would offset revenue losses. In particular, results showed that with the exception the 1985-86 crop year, the MAL model would have set futures hedges that would have reduced the wheat pool account losses realized by the CWB. Also, the MAL model set higher initial payments for producers in five out of eight years. The Sharpe Ratio, computed as the mean divided by the standard deviation, showed that the wheat pool account's risk levels would not have increased with futures hedging. Therefore, the MAL model suggests that hedging with futures can at least partially offset the revenue risk or variability of the wheat pool account.

Limitations of the Study

One possible limitation of this study is that it examined what happened in the past, and this may not necessarily be what will happen in the future. In other words, the yields, prices, and corresponding model results may not necessarily be repeated in the future. However, due to price cycles and other economic behaviour which tend to repeat, results here are likely a reasonable indicator of future results.

A second limitation is that the analysis only considered revenue stabilization and not revenue enhancement, which is an integral part of farm programs. Therefore, the analysis assumed that futures and options could be used to stabilize revenues and any short-fall in revenues could be made up by agricultural policy transfers. A more accurate analysis of the effectiveness of futures and options to replace past agricultural policies could consider the net cost of providing both revenue enhancement and revenue stabilization.

Finally, the effects of large increases in futures and options volumes on market prices were not explicitly considered in the analysis. Therefore, results of the analysis may slightly underestimate the effectiveness of futures and options to stabilize revenues since large hedging positions may temporarily move the market down before the hedges could be fully set.

Suggestions for Future Research

This study found that futures and put options were effective in stabilizing past grain revenues. However, future research should more thoroughly examine the effectiveness of futures and options to stabilize revenue under uncertainty. In particular, this would include the study of futures and options hedging decisions under alternative risk preference functions.

For the Canadian Wheat Board, futures and options hedging decisions should consider more advanced hedging strategies than those explored in this study. Models of firm hedging decisions under price and quantity risk should allow for continuous updating of positions (cash, futures, and options) in response to new information. Also, future research of the firm's hedging decisions under price and quantity uncertainty should consider alternative specifications for risk since the firm's actual risk preference is not known.

This study showed that futures and options hedging could more effectively stabilize annual farm revenues than past agricultural policy. However, large volumes of futures and options would have been required to hedge like this, and may have influenced the results of the analysis. Therefore, future research should consider the relationship between large hedge positions and market prices.

REFERENCES

Ackerman, Karen Z. and Mark E. Smith. Agricultural Export Programs, Background for the 1990 Farm Legislation, Economic Research Service, Commodity Economics Division, United States Department of Agriculture, 1990.

Agriculture Canada. Western Grain Stabilization Program Annual Report 1988-89. Minister of Supply and Services.

Bank of Canada. Bank of Canada Review, Ottawa Canada, Various issues.

Batlin, C.A. "Production under Price Uncertainty with Imperfect Time Hedging Opportunities in Futures Markets." Southern Economic Journal, 49(1983):681-92.

Black, F. "The Pricing of Commodity Contracts," The Journal of Financial Economics, 3(1976): 167-179.

Brinkman, G.L. "Farm Incomes in Canada," Economic Council of Canada and the Institute for Research on Public Policy, Minister of Supply and Services Canada, 1981.

Canada Grains Council. Canadian Grains Industry: Statistical Handbook, Winnipeg, Manitoba, Various Issues.

Canada Grains Council. "Government Policies Supporting Grain Production & Marketing, Canada and the United States," Winnipeg, 1986.

Canadian Grain Commission. Visible Grain Supplies and Disposition, Various issues.

Canadian Transport Commission. Annual Reports, Various issues.

Canadian Wheat Board. Annual Reports, Various issues.

Chavas, J. and R. Pope. "Hedging and Production Decisions Under a Linear-Variance Preference Function." Western Journal of Agricultural Economics, (1982):99-110

Chicago Board of Trade. Statistical Annual of The Chicago Board of Trade, Various issues.

Conroy, R. and R. Rendleman. "Pricing Commodities when both Price and Output are Uncertain," The Journal of Futures Markets, 4(1983): 439-450. Feder, G., R.E. Just and A. Schmitz "Futures Markets and the Theory of the Firm Under Price Uncertainty." Quarterly Journal of Economics, 44(1980):317-328.

Forbes, J.D., R.D. Hughes and T.K. Warley. Economic Intervention and Regulation in Canadian Agriculture. Economic Council of Canada and the Institute for Research on Public Policy. Ottawa: Supply and Services Canada, 1982.

Gilson, J.C. Western Grain Transportation: Report on Consultations and Recommendations, Supply and Services Canada, Ottawa, 1982, chapter 1.

Gilson, J.C. World Agriculture Changes: Implications for Canada. C.D. Howe Institute, Toronto, 1989.

Government of Canada. Report of the Auditor General of Canada to the House of Commons: Fiscal Year Ended 31 March 1990. Minister of Supply and Services Canada, 1990: p.104.

Hallet, Graham. The Economics of Agricultural Policy, Second Edition. Halsted Press, John Wiley & Sons, New York, 1981.

Hauser, R.J. and J.S. Eales. "Option Hedging Strategies," North Central Journal of Agricultural Economics, 9(1987): 123-134.

Heads, John. Estimates from CTC data on the Determination of Annual Rate Scale for the WGTA, University of Manitoba, Transport Institute, 1991.

Heifner, Richard G., Bruce H. Wright and Lynn J. Maish. "Prospects for Hedging Federal Farm Program Budgetary Risks," The Journal of Futures Markets, 11,(1991): 539-555.

Holthausen, D.M. "Hedging and the Competitive Firm Under Price Uncertainty." American Economic Review 69(1979):991-995.

Kahl, K.H. "Determination of the Recommended Hedging Ratio." American Journal of Agricultural Economics, 65(1983):603-605.

Karp, L.S. "Methods for Selecting the Optimal Dynamic Hedge When Production Is Stochastic." American Journal of Agricultural Economics, (1987):647-657.

Massel, Benton F. "Price Stabilization and Welfare," Quarterly Journal of Economics, 83(1969):284-298.

Marion, B.W., W.F. Mueller, R.W. Cotterill, F.E. Geithman and J.R. Schmelzer. "The Price and Profit Performance of Leading Food Chains," American Journal of Agricultural Economics, 61(1979): 420-433.

Newberry, David M.G. and Joseph E. Stiglitz. The Theory of Commodity Price Stabilization. Oxford: Clarendon Press, 1981.

Oli, Walter Y. "The Desirability of Price Instability Under Perfect Competition," Econometrica

Paroush, J., and A. Wolf. "Production and Hedging Decisions in Futures and Forward Markets." Economics Letters, 21(1986):139-143.

Peck, A.E. " Hedging and Income Stability: Concepts, Implications, and an Example." American Journal of Agricultural Economics, 57(1975):410-419.

Rolfo, J. "Optimal Hedging under Price and Quantity Uncertainty: The Case of a Cocoa Producer." Journal of the Political Economy, 88(1980):100-116.

Schnabel, J.A. "Hedge Ratios under Inherent Risk Reduction in a Commodity Complex: An Interpretation." Journal of Futures Markets, 1(1992):55-59.

Schwager, J. The Complete Guide to Futures Markets, Wiley, New York, 1984.

Snavely, King and Associates. 1977 Costs and Revenues Incurred by The Railways in the Transportation of Grain under the Statutory Rates, Prepared for the Grain Transportation Directorate, Transport Canada, Washington D.C., September 1978.

Snavely, King and Associates. 1980 Costs and Revenues Incurred by The Railways in the Transportation of Grain under the Statutory Rates, Prepared for the Grain Transportation Directorate, Transport Canada, Washington D.C., January 1982. 29(1961):58-64.

Spriggs, J. and G.C. Van Kooten. Rational for Government Intervention in Canadian Agriculture: A Review of Stabilization Programs, Canadian Journal of Agricultural Economics, 36(1988):1-22.

Statistics Canada. Agriculture Economic Statistics. Catalogue 21-603E, February, 1987.

Cereal and Oilseeds Review. Catalogue 22-007, Various issues.

Direct Payments to Producers. Catalogue 21-603, June, 1990.
Farm Cash Receipts. Catalogue 21-001, Various issues.
Farm Net Income. Catalogue 22-202, Various issues.
Grain Trade of Canada. Catalogue 22-201, Various issues.
Preliminary Analysis of the Contribution of Direct Government payments to realized net Farm Income. Catalogue 21-601 No.5, 1984.
Quarterly bulletin of Agricultural Statistics. Catalogue 21-003, Various issues.
Railway Operating Statistics. Catalogue 52-003, Various issues.

Transport Institute. Developments in Canadian Grain Transportation Policy: Proceedings of a Conference held in Winnipeg, June 20-21, 1988, Edited by John Heads, Occasional Paper No. 7, January 1989.

Turvey, Calum G. and Vincent Amanor-Boadu. "Evaluating Premiums for a Farm Income Insurance Policy," Canadian Journal of Agricultural Economics, 37(1989): 233-247.

Tzang, D.N., and R.M. Leuthold. "Hedge Ratios under Inherent Risk Reduction in a Commodity Complex." Journal of Futures Markets, 10(1990):497-504.

USDA. "Options, Futures and Agricultural Commodity Programs," Symposium Proceedings, Economic Research Service Report No. AGES870911, 1989.

Glauber, Joseph W. and Mario J. Miranda. "Subsidized Put Options as Alternatives to Price Supports," pp. 72-83.

Irwin, Scott H., Anne E. Peck, Otto C. Doering and B. Wade Brorsen. "A Simulation of Commodity Options as a Policy Alternative," pp. 60-71.

Plato, Gerald E. "Effectiveness of Futures and Options in Reducing Farmer Revenue Risk," pp. 84-93.

Winnipeg Commodity Exchange. Statistical Annual, Winnipeg, Manitoba, Various Issues.

APPENDIX A.

THE METHOD USED TO CALCULATE EXPECTED AND REALIZED REVENUES FOR THE TYPICAL FARM IN WESTERN CANADA

The cropping patterns of the typical farms match the provincial profile of production for the six major crops used in this study. This means that the typical farms will plant the same proportion of the six major crops as the total of all farms in the province. This assumes that the typical farms possess the provincial "average" decision of what crop to produce and how many resources to devote to it.

The yields realized on the typical farms are the yields for centrally located crop districts in each province. The use of actual yields is critical to the analysis, since many of the government programs are based on events surrounding yields. Also, to more accurately reflect the variability of yields on a typical farm, specific yield areas were assigned to each farm rather than provincial averages. The yield areas include crop district 7 for Manitoba, crop districts 6A & 6B for Saskatchewan, and census division 8 for Alberta.

The assignment of specific crop areas to each of the typical farms may not necessarily represent all farms in each of the provinces. However, each farm required a unique yield distribution in order to maintain an individual yield variation representative of what may have happened as opposed to using yield distributions based on larger sample sizes with less variation. Therefore, the use of yield distributions from areas within the provinces are necessary to maintain the focus of this analysis at the farm level.

Expected gross grain revenues are calculated in the same way for each typical farm. The expected revenue in any given year is the product of expected price and expected production in the spring of the year. Expected prices for barley, oats, flaxseed, canola and rye, are the three month average cash prices for each of these grains beginning in January for the current year. The expected price for wheat, since it falls under the CWB, is the prevailing initial payment plus any final payment received in the current year. This approach to expected prices assumes the producer considers only recent price information as relevant in formulating expected revenues.

The approach to formulating expected production attempts to capture the provincial average seeding decision yet maintain a yield distribution that could be expected on a typical farm. Expected production on each of the typical farms is the five year average of yield multiplied by the seeded acreage for each crop. The five year average yields for each of the six major crops are specific to the crop districts that the typical farms are located in. The seeded acreage for each of the crops in any given year matches the provincial distribution of the six major crops in that year.

The realized gross grain revenues received by the typical farms in any given year of the analysis attempts to reflect the actual gross revenues received by farms of the size and location studied here. To do this, realized revenues for the typical farms is the product of actual farm gate prices, and realized yields based on the crop area in which the typical farms are located, and seeded acreage of the six crops.

APPENDIX B.

VALUING OPTION PREMIUMS ON THE SIX MAJOR CROPS IN WESTERN CANADA USING BLACK'S OPTION VALUATION MODEL.

To estimate option premiums with Black's Model, five basic pieces of information are needed to determine the value of the option, which include:

1). Futures price

2). Strike price

3). Interest rate

4). Annualized volatility

5). Time to expiration

The futures price used is the corresponding futures price at which the put option is purchased to set the hedge and is sold to lift the hedge. As in the case of futures hedging in this analysis, two alternative hedge periods are considered to provide an indication of the variability of the effectiveness of a put option short hedge to stabilize producer revenues. Strike prices for options on futures are actually set by exchanges as a "band" around market prices, in increments. Therefore, the increment scale adopted for strike prices in this study are similar to options currently traded in the United States. Strike prices on oilseeds, which include canola and flaxseed, are set in $10/tonne increments and the cereal grains, which includes rye, barley, oats, and wheat, are set in $5/tonne increments. The strike price selected in this study is the closest increment to the futures price on the date the option value is estimated. For example, the strike price selected for flaxseed on the first trading day in May would be $360/tonne, if the futures price on this date was $363.50/tonne (based on the December contract). Also, the strike price when the hedge is lifted, on the first trading day in November, will correspond to the strike price established when the hedge was set.

Interest rates used in the Black's model for this study are the prevailing Government of Canada short-term bond rates at the time the option values are estimated. These rates are used because they have no default risk, and cover the time period of the short hedge used. Price volatility in Black's model represents the price volatility of the underlying asset, a futures contract in this case. Price volatility is calculated by using annualized volatility, which is based on the variance of the price for the futures contract underlying the option. This price variance is standardized around the price variance of the futures contract to twenty five trading days immediately preceding the date the option premium is estimated for.

The time to expiration is the number of days between when the option is purchased, until when the option expires. In this study, the days to expiration parallel the time period of the hedge. Using Black's model, the value of the put option when the hedge is set and lifted is estimated for strike prices at-the-money when the hedge is set. According to option pricing theory, strike prices at-the-money have a hedge ratio or delta of approximately 0.5. The hedge ratio is the rate at which the option premium changes in relation to the underling futures contract. Therefore, a hedge ratio of 0.5 will require twice as many options as futures contracts to complete the hedge. To be consistent with this, twice as many options are purchased, similar to how a farmer would act. Thus, two options are purchased when the hedge is set, in order to provide a beginning effective hedge ratio of 1, or a delta neutral hedge.