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An Economic Analysis of a Crop Cost Approach to Crop Insurance

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

Department of Agricultural Economics and Farm Management

by

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Any error or omissions contained in this thesis are solely the responsibility of the author.

ABSTRACT

Severe fluctuations in yields and prices for Canadian grain producers have had a dramatic effect on producers' financial risk. Crop insurance programs have been designed as one risk management tool available to producers. Although the traditional yield based crop insurance and a new Gross Revenue Insurance Plan (GRIP) provide some income risk protection there remain a number of problems and concerns.

An alternative insurance scheme is proposed that would provide coverage as a function of the costs incurred to produce the crop. The crop cost insurance is not yield based, but rather is based on the historical financial performance of the producer. Coverage is calculated as a percentage of input costs for the production of all crops. Any shortfall between the level of coverage and an estimated crop income is made up by an insurance payout. Premiums are based on a percentage of coverage, at a rate that will actuarially balance.

This study simulates a yield based program, a GRIP based program and the proposed crop cost program at three rates of coverage. The three programs are assessed and compared in terms of their ability to stabilize income, cost and other characteristics.

The results of these comparisons indicate that the crop cost program at 100 percent basket coverage provides greater gross margin stability at a price that is insignificantly different from the simulated yield program. The GRIP plus yield program provides greater gross margin stability than a crop cost program at 120 percent basket coverage,

but at a higher cost in premiums. Each of these findings is consistent regardless of the producer's level of input or risk area.

The simulated crop cost program at 100 percent basket coverage requires similar financial demands of the crop insurance corporation but at different times than the simulated yield program. The crop cost alternative makes relatively greater payouts than the yield system in years when crop prices are low and when cash requirements are greatest for the producer. The simulated GRIP plus yield program creates the greatest financial demands on the crop insurance corporation.

1.0 INTRODUCTION

1.1 Background

Over time, western Canadian grain farmers have had to deal with extreme fluctuations in yield and price. The result of either and often both types of fluctuations has had a dramatic impact on farm income. Table 1.1 presents the net and gross incomes of Manitoba farmers since 1954. From this table it can be seen that net income has been less than 25 percent of gross income on only 12 occasions since 1954, and 11 of those 12 years have taken place since 1979.

Crop insurance programs have been one of the major risk management tools available to producers to deal with variations in income. Since 1961 the Manitoba Crop Insurance Corporation (MCIC) has offered yield insurance based on a percentage of area yield averages. A recent insurance program, the Gross Revenue Insurance Plan (GRIP), began in 1991. This program insures the value of production at 70 percent of an Indexed Moving Average Price (IMAP) multiplied by the area long term average yield with adjustments for individual productivity, by an individual producer's average yield. Although each of these programs eliminates some of the income risk associated with production, the yield system in particular has not adequately protected all producers from the financial difficulties of the past several years.

There are four major areas where the present yield based crop insurance program has difficulty meeting the needs of producers. These include: i) insuring for price risk and not just yield risk; ii) providing coverage that accurately reflects the individual financial risk of each producer; iii) reducing moral hazard where production decisions may be influenced by the insurance program; and iv) eliminating selective participation.

Table 1.1 Changes in Income

Year	Gross Income	Net Income	Net/ Gross		% Change Net Income
1954	188	66	35.1%		
1955	173	84	48.6%		27.3%
1956	209	124	59.3%		47.6%
1957	198	68	34.3%		-45.2%
1958	222	124	55.9%		82.4%
1959	229	97	42.4%		-21.8%
1960	223	103	46.2%		6.2%
1961	239	45	18.8%	*	-56.3%
1962	251	159	63.3%		253.3%
1963	270	107	39.6%		-32.7%
1964	299	156	52.2%		45.8%
1965	342	164	48.0%		5.1%
1966	377	137	36.3%		-16.5%
1967	375	152	40.5%		10.9%
1968	365	163	44.7%		7.2%
1969	351	118	33.6%		-27.6%
1970	336	89	26.5%		-24.6%
1971	378	155	41.0%		74.2%
1972	497	164	33.0%		5.8%
1973	628	365	58.1%		122.6%
1974	827	311	37.6%		-14.8%
1975	947	391	41.3%		25.7%
1976	887	275	31.0%		-29.7%
1977	882	281	31.9%		2.2%
1978	1144	341	29.8%		21.4%
1979	1340	233	17.4%	*	-31.7%
1980	1492	40	2.7%	*	-82.8%
1981	1648	410	24.9%	*	925.0%
1982	1721	289	16.8%	*	-29.5%
1983	1798	52	2.9%	*	-82.0%
1984	1980	313	15.8%	*	501.9%
1985	2000	561	28.1%		79.2%
1986	2075	378	18.2%	*	-32.6%
1987	2092	380	18.2%	*	0.5%
1988	2059	150	7.3%	*	-60.5%
1989	2100	451	21.5%	*	200.7%
1990	1969	491	24.9%	*	8.9%

Note: * Signifies a net income less than 25 percent of gross income
Source: Manitoba Agriculture Yearbook 1990

Although the GRIP program has eliminated many of the difficulties associated with price risk and selective participation, there remain serious difficulties with the GRIP program. These include: i) providing coverage that accurately reflects individual risk; and ii) moral hazard and the influence of the program on production decisions. Each of the four problem areas are discussed in terms of both the yield program and GRIP program, as applicable, in the following section.

1.1.1 Price Risk Insurance

Traditional yield based crop insurance programs have been based on insuring a percentage of the long term average yield for an individual's area or region. Yield however, is only part of the farm income equation. The other part of the equation is price. Over time, price has become more variable and net income cannot be stabilized based on yield insurance alone.

Table 1.2 presents the average price of hard red spring wheat for producers in Manitoba. From Table 1.2 it can be seen that of the 9 years, since 1954, in which prices have dropped more than 10 percent relative to the previous year, 8 have occurred since 1975. It can also be seen that the coefficient of variation[1] for wheat prices is 0.123 for the period from 1954 to 1971, compared to 0.249 for the period from 1972 to 1988.

With yield based insurance, in years with low prices the producer still has great exposure to economic loss. In years of high prices, exposure to MCIC may be higher than market conditions would dictate. As an example, consider the following two yield

[1] Coefficient of variation is calculated as the standard deviation divided by the mean.

Table 1.2 Changes in Wheat Prices and Production

Year	Yield Bushels	Price/ Bushel	Gross Income	% Change Yield	% Change Price		% Change Income
1954	13.2	1.31	$17.29				
1955	20.2	1.42	$28.68	53.0%	8.4%		65.9%
1956	25.6	1.30	$33.28	26.7%	-8.5%		16.0%
1957	22.3	1.32	$29.44	-12.9%	1.5%		-11.6%
1958	24.6	1.36	$33.46	10.3%	3.0%		13.7%
1959	23.1	1.38	$31.88	-6.1%	1.5%		-4.7%
1960	23.6	1.61	$38.00	2.2%	16.7%		19.2%
1961	11.7	1.76	$20.59	-50.4%	9.3%		-45.8%
1962	26.3	1.70	$44.71	124.8%	-3.4%		117.1%
1963	19.3	1.71	$33.00	-26.6%	0.6%		-26.2%
1964	25.1	1.63	$40.91	30.1%	-4.7%		24.0%
1965	24.4	1.65	$40.26	-2.8%	1.2%		-1.6%
1966	24.3	1.78	$43.25	-0.4%	7.9%		7.4%
1967	25.6	1.64	$41.98	5.3%	-7.9%		-2.9%
1968	26.8	1.31	$35.11	4.7%	-20.1%	*	-16.4%
1969	25.6	1.24	$31.74	-4.5%	-5.3%		-9.6%
1970	21.8	1.42	$30.96	-14.8%	14.5%		-2.5%
1971	29.4	1.37	$40.28	34.9%	-3.5%		30.1%
1972	26.5	1.86	$49.29	-9.9%	35.8%		22.4%
1973	25.7	4.30	$110.51	-3.0%	131.2%		124.2%
1974	21.1	4.00	$84.40	-17.9%	-7.0%		-23.6%
1975	25.2	3.53	$88.96	19.4%	-11.8%	*	5.4%
1976	27.1	2.80	$75.88	7.5%	-20.7%	*	-14.7%
1977	31.6	2.67	$84.37	16.6%	-4.6%		11.2%
1978	30.6	3.61	$110.47	-3.2%	35.2%		30.9%
1979	25.0	4.62	$115.50	-18.3%	28.0%		4.6%
1980	21.2	5.52	$117.02	-15.2%	19.5%		1.3%
1981	31.3	4.75	$148.68	47.6%	-13.9%	*	27.0%
1982	34.0	4.48	$152.32	8.6%	-5.7%		2.5%
1983	27.2	4.74	$128.93	-20.0%	5.8%		-15.4%
1984	30.9	4.68	$144.61	13.6%	-1.3%		12.2%
1985	40.0	3.95	$158.00	29.4%	-15.6%	*	9.3%
1986	33.2	3.05	$101.26	-17.0%	-22.8%	*	-35.9%
1987	29.9	2.69	$80.43	-9.9%	-11.8%	*	-20.6%
1988	18.3	4.71	$86.19	-38.8%	75.1%		7.2%
1989	28.9	4.06	$117.33	57.9%	-13.8%	*	36.1%
1990	39.7	2.97	$117.91	37.4%	-26.8%	*	0.5%

Coefficient of Variation for Prices from 1954 to 1971	0.123
Coefficient of Variation for Prices from 1972 to 1990	0.249

Note: * Signifies a crop in prices of more than 10 percent
Source: Manitoba Agriculture Yearbook, 1990

insurance cases, assuming a 20 bushel per acre coverage level and $60.00 per acre input costs.

In Case One, if the price of wheat was $2.50 per bushel, maximum coverage per acre in the event of a crop failure would be (20 bu. * $2.50/bu.) = $50.00. This would result in the producer experiencing a $10.00 per acre deficit, relative to the level of variable costs. In this case the program has been unable to cover the producer's exposure to variable cost risk.

In Case Two, if the price of wheat were $6.00 per bushel, maximum coverage per acre in the event of a crop failure would be (20 bu. * $6.00/bu.) = $120.00. This would provide the producer with maximum coverage equal to twice the costs of his/her inputs. Suppose that the producer actually produces 10 bushels per acre. The income from the crop will consist of receive $60.00 per acre from production and another $60.00 per acre from crop insurance. Under this scenario, the corporation pays out more than is required to stabilize income, cover input costs and allow the producer to seed next year's crop.

Two separate surveys of producers dealing with crop insurance in Saskatchewan (Weisensel et al) and Alberta (Alberta Agriculture) conclude that farmers strongly desire a form of income insurance or some other means of more accurately insuring costs of production. The recently established Gross Revenue Insurance Plan (GRIP), has been designed specifically to complement traditional crop insurance in order to provide adequate coverage levels in years when crop prices are low. In it's first year of operation the level of coverage provided by the GRIP program was significantly higher than for yield coverage alone for most crops. However a significant premium is required to provide this coverage, and the coverage level reflects the historical price and yield of the crop rather than the actual costs of production.

1.1.2. Financial Risk Considerations

Under the present yield based program or the GRIP program, operators who choose above average levels of inputs (i.e., fertilizer and chemicals) have no means of insuring for their greater degree of financial exposure in the event of a crop failure. Alternatively, producers who choose little or no inputs (limited exposure to risk) are presently able to receive the equivalent level of coverage (in excess of the true exposure to risk). Each of these producers may be influenced to use a level of inputs based on their crop insurance coverage rather than on the economic potential of their production.

Skees and Reed demonstrate that this type of inconsistency creates an environment for adverse selection. Those producers who, through prudent decision making, have reduced their likelihood of making a claim are effectively subsidizing producers who may have chosen their input levels imprudently and increased their chances of a claim. In any actuarially sound insurance program, premiums must reflect or cover the ultimate payouts of claims. If the premium that an individual pays does not adequately reflect the potential benefit of the program to that individual, they are discouraged from remaining in the program. Alternatively, the producers who are most likely to make a claim will be disproportionately encouraged to remain in the program. As low risk producers leave the program, premium costs rise due to the increased proportion of higher risk producers.

The adverse selection environment is further magnified and the proportion of low risk participants in the program continues to erode.

The present yield based crop insurance program has made some effort to acknowledge and accommodate producers who show a good claim history, through the use of reduced premium charges and adjustments to coverage levels. Premium and coverage adjustments based on past performance, compared to the risk area averages, have resolved part but not all of this discrepancy in Manitoba. Premiums may be reduced by up to 25 percent for good performance, and increased by up to 25 percent for poor performance (Manitoba Crop Insurance, 1989). There is however, no adequate means of dealing with variations in cash or variable costs, in terms of providing coverage levels that would reflect this variation in risk.

The GRIP program is intended to move each producer to individualized yield records and will ultimately establish premiums and coverage levels based on individual performance. This will improve the program in terms of reduced potential for adverse selection, but will not provide any opportunity for producers to adjust the level of coverage to match their unique financial risks.

1.1.3 Moral Hazard and Influence on Production Decisions

Under certain circumstances, both yield and GRIP programs can influence production decisions and create an opportunity for moral hazard (Wiesensel et al). Coverage pricing and, in the case of the yield program, reseeding benefits and individual contracting can influence the producer to make management decisions based on the crop insurance program rather than on a sound agronomic and economic basis.

For example, in the case of the yield program a producer may use summerfallow acres for one crop and plant other crops on the remaining acres.[2] In this way the producer is ensuring that the most productive acres do not increase the average yield of another crop in the event of a need for a claim. These types of decisions create a moral hazard if decisions become program driven rather than being based on sound agronomic rotations.

Pricing levels with the present yield program can also create moral hazard. Coverage prices are established in advance of the growing season. If crop prices drop within the season, and if production is anticipated to be near coverage levels, the producer will be encouraged to make management decisions based on receiving a greater return for production not harvested than for production that is harvested.[3] As much as possible a crop insurance program should be neutral or encourage producers to make cropping decisions based on the same criteria they would use if there were no program (Alberta Agriculture).

The GRIP program can also influence the cropping decisions of the producer (Gray et al). The level of coverage for a particular crop is based on an IMAP and may provide very different production incentives than the market place in that particular year.

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[2] Saskatchewan and Alberta Crop Insurance do have adjustments for fields that are planted on stubble versus summerfallow.

[3] Although this allows the producer to make moral hazard gains in the short run, the increase in the claim will affect the producer's long term coverage.

If historical prices for a crop have been high but the market price for a particular year is low, the producer may be encouraged to grow that crop because of the coverage level, in spite of the poor market price. When coverage levels are highest and general market prices are lowest there is a greater potential for this type of moral hazard to occur.

1.1.4 Selective Participation

Producers with yield based coverage may also practise selective participation. In years when spring moisture conditions are poor, a number of producers may participate in the program for that year only, due to the increased probability of a claim. Unfortunately, those who participate on a continuing basis ultimately subsidize these selective participators in an area based system that is not sensitive to individual performance (Weisensel et al). Some producers may also elect to insure only part of the crop for a particular year. They may choose to insure the crop with the highest level of coverage or the crop planted on the most marginal land with higher expectation of making a claim. In either case, the producer is given the opportunity to selectively insure and take advantage of the program relative to those producers who consistently participate.

The GRIP program requires that producers enter into five year contracts, and that all eligible crops are insured (i.e., no short term selective participation). There is however some opportunity for selective participation in the choice of crops chosen for production. A producer may chose to only grow a certain crop in the years when the coverage level for that crop is attractive and avoid growing the crop in years when it is not. This type of selection is one form of moral hazard in the program.

The ultimate goal of insurance is to allow producers to cope with years of difficulty and equitably provide support to allow producers to farm another year (Alberta Agriculture, and Canada-Manitoba Crop Insurance Corporation 1989-90). Each of the present programs, yield and GRIP, have some weaknesses and leave opportunity for review and possible improvements.

1.2 Economic Problem

Based on the previous discussion both the yield and GRIP based programs have a number of limitations in dealing with the current income variability of producers. An insurance alternative based on previous financial performance (i.e., ability to recover variable costs of production) rather than yield performance has been suggested as an alternative to the present programs. This program would provide insurance coverage based on the producer's financial exposure, measured as crop operating costs.

The crop cost model, as it is referred to throughout this study, would provide coverage at a level based on the input costs to grow that crop. The premiums for crop cost insurance would be calculated as a percentage of the coverage provided and would be based on the historical ability of the producer to produce a crop with income greater than their input costs. Although the concept seems plausible, there has been little effort to explore the strengths and weaknesses of such a program in comparison to the more conventional yield based and GRIP based models. A number of unanswered questions remain. Would the crop cost program provide equal or better coverage? What premium costs would be required? How well would a crop cost program stabilize producers income? Would the crop cost be an improvement with respect to adverse selection and moral hazard? Would there be greater financial exposure to MCIC? Answers to these questions are required in order to determine if a cost based insurance program would provide a reasonable alternative to current problems.

1.3 Research Objectives and Hypotheses

The research objective of this study is to establish if the crop cost concept of insurance can provide adequate coverage and income stability to producers at an acceptable premium cost in relation to a yield and\or GRIP based system. This objective will be met by focusing on two main areas. The first will be to describe and model the implementation of a cost based form of crop insurance. The second will be to determine whether the proposed program is an improvement over the concept of an individualized yield based program and/or the concept of a revenue based program such as GRIP.

Within the general research problem several specific research objectives will be met. First, the study will review alternative methods of crop/income insurance, including a yield based program and the GRIP plan, with emphasis on the principles of coverage and operational guidelines required. Secondly, the concept of a crop cost insurance scheme will be reviewed in detail. Within this detailed review, the operational guidelines and considerations of this program will be discussed, and the rationale for the design will be established.

The third objective is to design three operational models. These models will simulate the performance of each, the proposed crop cost program, the concept of a yield based program and the concept of a GRIP program. Historical production records from previous crop insurance participants will be used to test run a simulated output for each of the programs.

The fourth objective is to compare each of the program alternatives with respect to their ability to provide adequate insurance coverage from the perspective of both producers and MCIC. The specific comparisons of greatest interest are outlined in the hypotheses in the next section. The final objective is to review some of the operational and administrative implications of implementing a cost based program in Manitoba.

Several specific hypotheses are to be tested within this study. These hypotheses are as follows:

Hypothesis 1: Coverage with a crop cost program will more accurately reflect the financial exposure or approximate variable costs of each producer, than will coverage for either a yield based program or a GRIP based program (by design).

Hypothesis 2: Gross margin income of producers (i.e., crop income plus insurance payout minus premiums minus variable costs) will have greater stability over time with a crop cost insurance program than with either a yield based program or a GRIP based program.

Hypothesis 3: Exposure to MCIC will be reduced, and consequently premium costs will be reduced, by incorporating the crop cost approach versus the yield and GRIP alternatives. Financial exposure to MCIC will also be reduced by establishing insurance on a total farm basket basis versus an individual crop basis, given similar levels of coverage.

Hypothesis 4: Farms with higher input costs (versus lower input costs), will have, on average, higher average gross margins and equivalent premiums per dollar of coverage under a cost based insurance program.

Hypothesis 5: Gross Margin income stability will be improved for both traditionally low yield and high yield production areas using the crop cost method of coverage, relative to either the yield or GRIP based programs.

Hypothesis 6: Predictability of premiums will be improved under the crop cost program relative to the GRIP program.

1.4 Outline of the Thesis

Chapter Two (Review of Present and Proposed Programs) provides a review of the principles, design, and operational characteristics of a yield based insurance scheme, the

GRIP concept, and the proposed crop cost concept. Chapter Three (Theoretical Framework) establishes the economic principles on which each of the insurance programs is based, and discusses the economic criteria by which the performance of each of these insurance programs can be assessed. Chapter Four (The Empirical Model) outlines the construction of each empirical simulation model and provides a discussion of the techniques used to test the six hypotheses and the relative performance for each of the simulated insurance schemes. The results of the simulation are presented and discussed in Chapter Five (Analysis and Results). Chapter Six (Conclusions) provides an overview of the study findings, identifies limitations of the study, and provides an indication of areas where opportunities for further research exist.

2.0 REVIEW OF PRESENT AND PROPOSED PROGRAMS

Three insurance programs are reviewed in this chapter. The yield and GRIP programs are presently available to producers and are discussed in terms of current operating procedures. Some anticipated changes for both programs are presented. This information is collected from a variety of sources including MCIC Annual Reports and other promotional material, as well as from discussions with Manitoba Crop Insurance staff and other farm management experts.

The crop cost program is at the concept stage only and is not presently available to producers. Many of the ideas and principles for a crop cost program have come from the Grains 2000 committee that presented the original framework for the Net Income Stabilization Account (NISA). Conversations with Bob Hopley, a Member of the Grains 2000 committee, were a major source of information. This chapter develops the conceptual and operational structure anticipated for a crop cost program, along with some of the rationale for the design of the program.

2.1 The Yield Based Program

The present crop insurance program in Manitoba is based on the principle of insuring crop yields. Yield coverage is normally 70 percent[4] of the 15 year yield average, multiplied by an estimated market price. In the case of wheat, average yields

[4] The Manitoba Crop Insurance Corporation has also, on occasion, offered alternative yield coverage, from 50 to 80 percent of area yield averages.

are based on a technology adjusted 25 year average.[5] For certain special crops like lentils, peas and corn, average yields are based on shorter time frames. Areas or regions are defined based on soil classifications so that crop regions have, as much as possible, similar yield potential. MCIC coverage has traditionally been based on area averages, with some coverage adjustments. However, as a result of the introduction of GRIP coverage, there have been suggestions that the present yield based program may move toward individual coverage with average yields being based on individual yield histories.

Crop insurance contracts are purchased on an annual basis with each crop being insured separately. All fields of any one crop are averaged together by taking the sum of the total production divided by the number of acres, to establish the crop yield. Contracts must be purchased by April 30, specifying levels of coverage (if there is a choice) and the particular crops to be insured. Premiums are due and payable on October 1 of the crop year.

Normally, pricing levels of each crop are set at the time of purchase of the contract and are based on the MCIC's best estimate of market prices.[6] In past years Manitoba has offered an alternative pricing scheme, allowing producers to choose their own crop price for insurance coverage. Producers can choose a price above the base price that the MCIC has set. In the event of an increase in market prices up to or beyond the price level chosen by the producer, insurance coverage will be set based on the

[5] A technology adjustment factor is used to adjust historical yields for the improvement in the technology of variety choices and other agronomic techniques. This adjustment is based on the methodology outlined by D.F. Kraft.

[6] Agriculture Canada provides the estimate of market prices.

producer-selected price level. If prices do not rise to the level of coverage chosen by the producer, MCIC will provide coverage up to the market price only, with the premiums being adjusted accordingly. If producers choose a coverage price lower than the eventual market price, they will not be able to change the coverage within the season. This pricing option allows the opportunity to obtain some additional coverage when prices rise during the crop season. Figure 2.1 outlines an example of two scenarios with the variable coverage price option.

Estimated market price set by the MCIC = $3.00

Producer chosen price level = $3.50

Scenario One:

Prices rise to $3.75 during the growing season.

Producers receives coverage at $3.50 times 70% of average yields.

Producer required to pay additional premiums in proportion to the additional coverage received 3.5/3.0 = 16.7% increase in premiums over the base rate.

The producer is not able to adjust the level of coverage during the growing season.

Scenario Two:

Prices rise to $3.10 during the growing season.

Producer receives coverage at $3.10 times 70% of average yields.

Producer required to pay additional premiums in proportion to the additional coverage received 3.1/3.0 = 3.33% increase in premiums over the base rate.

Figure 2.1 MCIC Pricing Option

From the example in Figure 2.1, Scenario One allows the producer to receive coverage up to the chosen price level ($3.50 per bushel) but not beyond that price. Premiums are increased by 16.7 percent to match the new level of coverage. Although actual market prices rose to $3.75 per bushel, the producer cannot adjust coverage from the original level that was chosen. In Scenario Two the producer receives coverage based on the actual market price only ($3.10 per bushel). Premiums are adjusted to reflect the increase in coverage over the base. Although a higher coverage price was chosen ($3.50 per bushel) the final coverage cannot exceed the actual market price unless the market price drops below the estimated market price. In that case the coverage price would remain at base coverage price.

Crop insurance payouts are calculated as the deficit between the actual yield and the level of yield coverage times the crop coverage price. Figure 2.2 gives a simple example to indicate how a yield based payout is determined.

average yield 30 bushels/acre

coverage level 70% * 30 bushels/acre = 21 bushels/acre

coverage price $ 3.00 per bushel

total dollar coverage 21 bushel/acre * $3.00 = $ 63.00/acre

Actual yield 17 bushel/acre

Insurance indemnity 21 - 17 = 4 bushel/acre * $ 3.00 = $12.00/acre

Figure 2.2 MCIC Yield Coverage

From the example in Figure 2.2 the long term average yield for the crop is 30 bushels per acre, with a coverage level equal to 70 percent of the average yield, or 21 bushels. The yield coverage (21 bushels), times the estimated market price for the crop ($3.00 per bushel) provides a total coverage level of $63.00 per acre. Because the actual crop production (17 bushels) falls below the coverage level (21 bushels), an insurance payout is triggered. The insurance payout is comprised of the difference between the level of yield coverage and the actual yield achieved (21 minus 17 or 4 bushels), multiplied by the estimated crop price ($3.00 per bushel) as set by MCIC, or an optional price as described earlier. In this case the payout is equal to $12.00 per acre.

Some special coverage adjustments are made in the event that a crop is reseeded prior to a predetermined seeding deadline. There are two different reseeding cases to consider; the field or part of a field may be reseeded to the same crop as was originally planted, or the field may be reseeded to a new crop. If the field is reseeded to the same crop, a reseeding benefit is paid that is equal to 25 percent of coverage, providing the original crop is assessed as one that justifies the reseeding. The total available coverage for that crop is then reduced by the amount paid out in the reseeding benefit.

If the field is reseeded to a different eligible crop prior to the predetermined seeding deadline for the new crop, a crop loss benefit of up to 50 percent of coverage is paid for the original crop. In addition, a reseeding benefit equal to 25 percent of coverage is paid to the producer to compensate for the costs of reseeding. The new crop is then considered as an entirely new crop and full premiums must be paid, establishing full coverage for the new crop for that year.

A loss cost formula is used by MCIC to set premium rates for each region and for each crop insured. The loss cost formula is an assessment of the total payouts as a percentage of coverage that MCIC has historically provided for that crop. Other specific adjustments are made as required to derive the risk area premium rates.[7] The premium per acre is then established by multiplying the premium rate for the area times the average coverage (tonnes per acre), all multiplied by the dollar value of the crop ($/tonne). Through this process the premiums are established in such a way that the overall premiums paid by producers, plus government contributions, should cover the costs of the program in the long run.[8]

Based on standardized Coverage Adjustment Tables, adjustments may be made to an individual's coverage in order to reflect past performance. Premium levels may also be increased or decreased by up to 25 percent, based on the individual's claims history. These adjustments are required with an area average yield program to reward or discourage those who demonstrate yield potential above or below the area average, respectively. As yield insurance moves in the direction of individual yield records, many of these adjustments will be built into the producer's individual yield history.

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[7] The Manitoba Crop Insurance corporation has offered a variety of levels of coverage in past. As a result a number of specific adjustments and assumptions are required to use the loss cost formula. A more complete description of specific methodology used in determining premiums is provided by an example MCIC Coverage Schedule in Appendix A.

[8] The Federal Government and Provincial Government each finance 50 percent of the administrative costs, and 25 percent of the premium costs for the yield program. The producer pays only 50 percent of the true premium cost.

Perhaps the greatest administrative challenge to the present system is ensuring that all producers have used appropriate management in the production of their crop. Below a certain level of production there is no shared loss. If a producer believes that a claim will be made there may be an incentive to reduce inputs and increase the amount of the claim. Those producers who neglect the use of fertilizer or chemical in an attempt to minimize costs and collect crop insurance do great damage to the reputation and actuarial soundness of the system, as discussed in the introduction. When establishing premiums, MCIC must factor in a cost for program abuse. In the cases where premium and coverage adjustments are not sensitive enough, many individuals have the opportunity to be adversely influenced by the program and take a disproportionate share of the benefits from the crop insurance program.

2.2 The Gross Revenue Insurance Program

The Gross Revenue Insurance Program (GRIP) was first introduced for the 1991/92 crop year. GRIP incorporates both historical yields and historical prices in the calculation of a minimum revenue coverage level for producers. The program is designed as a complement to the yield based or traditional crop insurance program. As stated earlier, yield based insurance alone cannot provide adequate cash flow to producers in years of poor prices. The GRIP program is designed to deal with this inadequacy.

Producers are required to sign up for five year terms. A minimum of three year's notice is required to cancel the contract[9]. The multiple year terms are designed to prevent producers from taking advantage of the program in the short term by choosing to participate in years when poor prices are expected and leaving the program in years with higher expected prices. Each crop type and acres to be grown must be registered with MCIC, with a seeded acreage report by the end of June. All insurable crops that are produced by the farmer must be insured within the terms of the contract. Premiums are due in October with the potential for premiums to be deducted from an initial or advance payout of claims. Coverage levels are based on the combination of two factors for each crop produced; long term average yield for the individual, and 70 percent of the 15 year Indexed Moving Average Price (IMAP).

Currently, average yields are being calculated in the same manner as for the yield based system (i.e., by risk areas and soil classifications). The GRIP system may, however, be moving towards individual yield histories. It is suggested that within four years (1994), all GRIP contract holders may have the yield portion of their coverage fully adjusted based on their individual production history, where adequate records are available. This deals with one of the problems discussed earlier; that is, some progressive producers may achieve yields above the other producers in their risk area and soil classification. Under the area based system, these producers cannot receive a sufficient adjustment to meet their required level of coverage. Ultimately, it is anticipated that the

[9] There is also an option to terminate the contract by paying back any net benefit received from the program in the past.

criteria for establishing long term individual average yields will be the same for the GRIP program as it will be for the standard yield coverage, due to their intended complementarity.

The price portion of the GRIP calculation is a 15 year IMAP. Prices for eligible crops are indexed by an input price index developed by Agriculture Canada. The index is designed to calibrate the value of each crop over time in relation to the change in production costs.

The GRIP coverage is calculated as the product of the average yield for the crop, multiplied by 70 percent of the IMAP for the crop. Payouts are made if there is a shortfall between the level of coverage and the crop income, that has not been covered by the standard yield based crop insurance coverage. Building from the previous example for yield insurance in Figure 2.2, an example of the additional GRIP coverage and its relationship with the standard crop insurance contract is outlined in Figure 2.3.

From the yield based example (Figure 2.2) the yield based total coverage equals $63.00 per acre or 70 percent of average yield, (30 bushels) times the estimated market price. In this example, there would be a yield based payout of $12.00 per acre.

The GRIP coverage is equal to the producer's average yield (30 bushels) multiplied by 70 percent of the IMAP ($4.00 per bushel), to achieve a total coverage level of $120.00 per acre. The GRIP payout is then calculated as the GRIP coverage level ($120.00) minus the crop income (17 bushels times $3.00, or $51.00), minus any yield average yield 30 bushels/acre

coverage level 70% * 30 bushels/acre = 21 bushels/acre

coverage price $ 3.00 per bushel

total dollar coverage 21 bushel/acre * $3.00 = $ 63.00/acre

Actual yield 17 bushel/acre

Insurance payout 21 - 17 = 4 bushel/acre * $ 3.00 = $12.00/acre

IMAP (Indexed moving average price) example $ 5.71

Average Yield	= 30 bushels/acre
Crop income	= Yield * market price
	= 17 bushels * $3.00 = $ 51.00
GRIP coverage	= 70% * IMAP * AVG Yield
	= 70% * $5.71 * 30 bu = $ 120.00
GRIP payout	= GRIP coverage - crop income - yield payout
	= $ 120.00 - $ 51.00 - $ 12.00 = $ 57.00
Total payout	= GRIP payout + yield insurance payout
	= $ 57.00 + $12.00 = $ 69.00

Figure 2.3 MCIC GRIP Coverage

based payout ($12.00).[10] The total payout of the complementary systems is therefore $57.00 plus $12.00 or $69.00 per acre.

[10] Actual crop income is established at the end of the crop year by multiplying the measured yield times the average annual price for the crop.

Producers do have the option of taking only GRIP coverage without yield coverage. In that case GRIP payouts are calculated as if the producer would have received a yield payout through the yield based insurance. The GRIP only option provides more of a "price insurance only" alternative to producers who either feel that they do not require yield insurance or who believe that due to adverse selection or other reasons, they will not recover the benefits of crop insurance given the premium costs required.

In the event that a field has been reseeded, the GRIP coverage itself does not provide a reseeding benefit. Reseeding benefits are only provided through the complementary yield based program. Therefore, the level of GRIP coverage and GRIP payouts are unaffected by crops that have been reseeded.

MCIC sets GRIP premium levels based on the likelihood of a shortfall between the GRIP coverage level and the coverage level provided through the yield coverage program. A simulation is used to estimate the distribution of possible producer income possibilities. Each of the average yields for a crop over the last twenty years is multiplied by each of the average prices of the crop (including support payments), over the past twenty years to create 400 possible income observations. Based on the distribution of these observations, estimates are made for the likelihood of incomes reaching the GRIP coverage level. The estimated frequency and degree of this shortfall is used to calculate an estimated loss to coverage ratio for the program. The loss to coverage, or loss to cost, ratio is the basis for the premium.

Certain other estimates are incorporated into the premium calculation, such as program manipulation, interest, quality and unknown factors. Premiums are set to be actuarially sound, in that total premium collection plus government assistance should approximately equal projected payouts over the long run.[11] Given the limited data and experience with this program the accuracy of this estimation technique is uncertain.

Manitoba producers are also eligible for additional coverage or compensation based on a Superior Management Adjustment. The adjustment is an option provided as yield histories move completely to individual's yield records. Producers who achieve yields above the level of their risk area will be eligible to receive additional coverage. The additional coverage will be based on the percentage in improvement of the individual's yield compared to the area average for that year. If the individual's yield is more than 5 percent over the area average, the producer will be eligible for additional coverage to a maximum of 25 percent. The additional eligible coverage is calculated as the percentage improvement of the individual over the average minus 5 percent. Figure 2.4 provides an example of how the superior management adjustment works.

From the example in Figure 2.4, if a producer achieves yields that are 20 percent above the area average (30 versus 25), he/she would be eligible for 15 percent extra coverage (20-5=15). The producer will also be required to pay the additional premium associated with the increased level of coverage in the event of a claim.

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[11] Although the premium for GRIP coverage is sometimes discussed in terms of total coverage, it is important to recognize that the premium paid for GRIP only provides coverage that is required beyond the eligible yield coverage. Any reference to GRIP premiums as a percentage of total coverage grossly under estimates the true cost of the additional GRIP coverage.

Area annual yield (AREAY) = 25 bushels

Area long term average yield (AREALTAY) = 25 bushels

Individual annual yield (INDY) = 30 bushels

Individual long term average yield (INDLTAY) = 25 bushels

INDY/INDLTAY	-	AREAY/AREALTAY	-	.05	=	INCOV
1.2	-	1.0	-	.05	=	0.15

WHERE

INCOV = Percentage increase in coverage (not to exceed 25 percent)

Figure 2.4 Superior Management Adjustment

Although GRIP is a new program and has not yet been thoroughly tested, a number of areas have been identified which create potential for abuse. Several of these areas have been discussed by Gray et al. Three of these concerns are outlined below.

By using an IMAP, the coverage level for a crop may not reflect the prevailing market conditions. Under these circumstances a producer may be encouraged to produce a crop based on the GRIP coverage rather than on market signals for that crop. As a result, the program is not likely to be market neutral.[12] Total payouts for certain crops may be increased, due to increased acres being seeded.

[12]Market neutral refers to providing no additional incentive or influence to the producers choice of crops.

A second problem with GRIP, related to the previous concern, is that the program is not market volume sensitive. Producers may be encouraged to grow specialty crops because of the GRIP support level even though the resulting supply for that product may be far in excess of the demand. This situation could result in production beyond the contracts available from the market place. As a result, the increase in supply may drive down the price of the product, causing further GRIP payouts from MCIC to meet the gross revenue protection level. In each case, or due to the combination of these two effects, MCIC is destined to pay out greater amounts due to the program's influence on producers' cropping decisions. Provided producers are able to reach yields consistent with their average, there will be no direct negative impact for producers as a result of selecting this type of crop choice strategy. Under the present GRIP funding formula, taxpayers cover two thirds of the costs of this program. The potential for moral hazard that is built into the GRIP system may potentially cost taxpayers a great deal of money.

Another opportunity for abuse is the possibility of a producer growing a specific crop only once. It is feasible for a producer to use few or no inputs and make a claim under GRIP. Although the producer's yield average for that crop will be affected under the individualized coverage, he/she will suffer no long term negative effects from this strategy if the crop is not grown again. In a system that is actuarially sound, others will ultimately pay for this abuse, creating an environment for adverse selection.

2.3 Proposed Crop Cost Based Program

The proposed crop cost insurance is unique, relative to the other two programs, in that it is not based on historical yields. Rather, it is based on historical financial performance or the ability of the producer to recover cash costs or eligible costs. The insured producer must, through standardized estimates and crop input receipts, confirm the level of cash (eligible) costs allocated to crop production for that year. The producer would then purchase insurance based on the expected income required to cover those costs. This would be done on a whole farm, or basket of crops basis, rather than crop by crop.

Contracts would be for five year terms in order to prevent producers from entering the program to take advantage of short term price fluctuations. A minimum of two years notice would be required to exit from the program. Initial estimates for coverage levels would be required prior to seeding and adjustments could be made throughout the year as unexpected expenses occur. Premiums would be due at harvest time.

Coverage would not be based on individual crops, but on a basket of crops. The diversification of crop insurance over the whole farm rather than individual crop coverage should lower the probability of a payout and consequently reduce the required premiums. Any gains or returns above the coverage level for one crop would be used to reduce the payout on a crop that falls below the coverage level. Using the basket approach also more accurately represents the producer's risk over the entire farm. The basic coverage level would be equal to the eligible variable costs for the production of all crops. This system can also support the concept of insuring a scaled up or scaled down proportion of the farm's eligible costs. For example, if a producer has eligible variable costs of $60.00 per acre, the standard coverage level would be $60.00 per acre. However, if a producer is in a very cash tight position and cannot bear the risk of receiving an income equivalent to cash costs only, an option could be provided for the producer to insure up to 125 percent of cash costs, or $75.00 per acre. Alternatively, a producer who is willing to accept greater risk, but not all of the production risk, may consider a level of coverage that is equal to 75 percent of eligible cash costs or $45.00 dollars per acre.

Premiums for each of these optional levels of coverage would reflect the inherent risks and probabilities of achieving the associated level of income. As coverage levels increase, the probability of achieving an income equivalent to that level drops at an accelerated rate. For example, it is anticipated that the premiums required for 125 percent coverage would be greater than 125 percent of the premiums for the basic (i.e., 100 percent) coverage. Alternatively, producers choosing a 75 percent coverage level would have premium costs that are less than 75 percent of those for the basic coverage.

The costs of production or eligible variable costs would be estimated in one of two ways, depending on the type of expense. Fuel, machinery, labour and seed costs would be derived through regional surveys, due to the difficulty of confirming the actual costs for each individual producer. It is also felt that these costs are relatively constant within regions and are not the greatest cause of variation in expenses among producers.[13]

[13] A crop cannot be planted without incurring at least a minimum level of costs for seed, tillage and labour.

Fertilizer and chemical costs would be derived through actual supplier invoices. Fertilizer and chemical purchases make up a significant portion of the producer's expenses and can vary a great deal among different producers and from one year to another.[14] The total of these eligible cash costs would be charged an interest rate equal to the prime rate, for a period of six months. This approximates the cost (or opportunity cost) of operating capital from the time when inputs are purchased to the time when production is sold.

Certain other circumstances would also be accommodated, as required. In the event that reseeding is necessary, coverage for the additional seed cost, plus an approximation for additional machinery and fuel costs would be factored into the level of coverage. Crops planted on land that had been summerfallowed the previous year would be eligible for an enhanced coverage level, equivalent to the lesser of either the tillage costs associated with summerfallow or the contribution of nitrogen from summerfallow.

Certain other costs would not be included as eligible variable costs. Interest on intermediate and long term debt is not dependent on production levels. This cost varies according to leverage ratios and total capital investment. The proposed system's coverage levels are intended to insure variable cash cost expenses to enable the producer to plant another crop next year in the event of a crop income shortfall. Debt costs are a capital investment risk rather than a production risk. The crop cost program is not intended to provide any variation in coverage based on financial strength and capital investment.

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[14] A crop can be grown without any fertilizer and chemical under some conditions, while at other times fertilizer and chemical costs can amount to half of the crops variable expenses.

A few miscellaneous costs may not be included within the eligible cash costs of the program. However, the program remains sound for two reasons. Additional variable costs that are common to all farms would be compensated for through a lower premium rate. The premium rate would reflect the level of coverage required to insure only those costs explicitly considered by the insurance program. Producers with additional, unique, cash costs would have the opportunity to increase their coverage levels, (e.g., 120 percent of their eligible cash costs). To receive this extra level of coverage producers would of course pay a higher premium rate, due to the greater exposure to risk.

Payouts under the crop cost system would be based on any deficit between the level of coverage purchased (i.e., a percentage of eligible costs) and the estimated income from production at a specifically determined date. The estimated income from production would be estimated as the actual crop yield times a specifically derived November price.

Estimated November prices would be based on November initial payments for Canadian Wheat Board grains (approximately 85 percent of total payments), or 90 percent of the average November street prices in the case of non-board grains.[15] For grains that are available for sale through either the Canadian Wheat Board or non-board markets, the higher of the two prices would be used.

The reasoning behind using a percentage of the final or total price is to encourage complete and thorough harvesting of all crops. If a producer is certain that a particular crop will receive a payout, and the coverage crop price is equal to the market price, there

[15] For hard red spring wheat, initial payments and adjusted initial payments have varied between 70 percent and 100 percent of the total payment, since 1980, with the average being 87 percent. (CWB Annual Report 1989). As a result 85 percent can be considered as a reasonable target.

is little incentive to properly harvest the crop. Income from that field (crop harvested plus payout) will be the same regardless of the care taken at harvest time. In years when insurance provides a higher per bushel price than the market, the producer is actually encouraged to do a poor job of harvesting. Every bushel not harvested is worth more than those that are harvested and sold through the market.

By basing the insurance coverage on a percentage of the anticipated market price (85 to 90 percent), the producer should be encouraged to do a complete job of harvesting the crop. The incentive is that a harvested bushel will be worth 100 percent of the market price, whereas an unharvested bushel will be worth only 85 to 90 percent of the anticipated market price. Figure 2.5 mathematically outlines how this can influence the producers harvesting decisions.

Coverage or 100% of eligible costs = $60.00

Actual yield = 15 bushels

November street price = $3.00 per bushel

Crop Cost Payout = Coverage minus (yield times modified November price)

Crop Cost Payout = $60.00 - (15 * 90% ($3.00)) = $ 19.50

Total Crop income = actual crop income + Crop Cost payout

Total Crop income = (15 bu. * $3.00) + $19.50 = $64.50

Figure 2.5 Percentage of Market Price Harvesting Incentive

From the example in Figure 2.5 the producer will receive an insurance payout ($19.50 per acre), plus the income from the sale of the crop ($45.00 dollars), for a total crop income of $64.50 per acre. If the producer had decided to not harvest the crop (i.e., no income from the sale of the crop) the maximum total income to the producer would be the crop cost payout of $60.00 per acre.

From this example it can be seen that producers with very little yield would have less total income opportunity than those who have a crop just short of meeting their variable costs or level of coverage. If the field was at a zero yield level, the producer receives $60.00 income per acre, and if the crop yield is 15 bushels per acre, the producer receives a total of $64.50 per acre. This difference in income opportunity can be justified in part by the reduced handling and harvesting costs associated with the smaller or zero yielding crop.

Premiums would be developed based on the probability distribution of an income/expense ratio. Effectively, this would establish the information required to utilize a crop loss formula as is done with both the GRIP and yield based programs. The details of how to evaluate the crop loss ratio and establish a specific premium is an actuarial challenge beyond the scope of this study. It is important to note that developing a premium for the crop cost system should be no more difficult than for the GRIP based system, providing that adequate information for the crop loss formula is available.[16]

[16] Observation made by Neil Hamilton, Director of Research, Manitoba Crop Insurance Corporation.

It must be recognized that although the coverage levels would be determined on a whole farm basis, each crop has a different level of risk in each area and the income/expense and loss to cost ratios would be different for each crop. Premium rates would therefore need to be established for each individual crop and the total farm premium would be based on a weighted average of the individual crop premiums, minus a diversification factor. This diversification factor would be determined by the historical correlation between incomes for each crop that is grown.

Because of diversification, the likelihood of a poor return from a mix of crops is lower than that of having a poor return with just one crop. The influence of environmental conditions and/or crop prices is different for each crop and often the income lost from one crop can be compensated for by the potential of another crop.

The crop cost proposal would require special treatment of producers who enter the program with no recorded production or income history or who have never grown a specific crop before. It is anticipated that new producers would start with area average premiums and phase in their personal record histories over three to five years. If a producer were to introduce a new crop that they had not grown previously, the premium rate used in the weighted average for that crop could be based on the producer's financial performance in relation to the area for other crops, and could be indexed on that ratio minus a risk factor for first time production.

The crop cost approach to crop insurance has some potential for abuse if producers inaccurately report final yields or crop expenses. In the case of fertilizer and chemical, expenses would be confirmed or verified by supplier invoices. Certain limits may be placed on maximum rates and/or costs per acre. Material maintained for tax statements may also be used to verify expenses, if required. In the case of yield verification the problems inherent in the present system of measuring bins and estimating production would remain.

Some concern has been raised that producers, particularly those with more than one hundred percent eligible cost coverage, would be encouraged to use an increased amount of inputs. There are two cases to consider, one as a strategy to manipulate the program and the second as a response to the reduced risk of income loss.

Producers may attempt to manipulate the program by taking an "all or nothing" approach to a high risk, high return cropping decision. There are two factors that should discourage this strategy. Any increase in expense raises the level of coverage and the premiums that are associated with that coverage. Although premiums are not yet determined, it is likely that the additional premium paid, particularly at the higher coverage levels, may eliminate a great deal of the additional anticipated gains. Producers are also discouraged from using excessive inputs due to the influence that a significant loss would have on future coverage and premiums under an individually based program.

There may also be some potential for producers to increase the their level of inputs, not in an attempt to manipulate the program, but simply in response to the limited down side for increasing input expenses versus not using enough inputs. It is unknown how significant an effect that may be. Maximum levels for inputs would need to be established.

This discussion has illustrated the crop cost approach from a conceptual viewpoint. The chapter related to empirical modelling considerations (Chapter Four) provides a discussion of the system that is actually simulated in this study. While the simulations are not identical to the conceptual program, the empirical modelling is based on most of the ideas expressed in this chapter.

3.0 THEORETICAL FRAMEWORK

This chapter provides the theoretical basis for the study. The theory of how firms make production decisions is reviewed. The effects of risk and insurance on those production decisions are also reviewed. Also included is a discussion of the fundamentals of insurance and the effects of diversification as a technique to reduce risk.

3.1 The Theory of the Firm

A competitive firm has two types of costs associated with production; fixed costs and variable costs. Fixed costs (land, buildings, equipment etc.), do not vary as production increases or decreases. They are sunk costs that are incurred regardless of the level of production.

Variable costs do vary with production, and will increase or decrease in relation to the potential production level. As a result, each unit of output has a marginal cost associated with it. Under the assumption that the objective of the firm is to maximize profit, the firm produces additional units of output as long as the increased income (marginal revenue) exceeds the marginal cost of the additional unit. In the case of the grain producer, an additional bushel of crop will be grown only if the expense to produce that bushel will be offset by the expected additional income from the sale of that extra bushel.

Optimal production, under conditions of complete certainty, is determined by the equality of marginal cost and marginal revenue. Regardless of the level of fixed costs, the firm will continue to produce in the short run providing there is a positive level of production where marginal cost is less than or equal to marginal revenue (Varian). Assuming that the firm makes decisions within a perfectly competitive market, this can be empirically determined as follows in equation 3.1.

$$\text{Max. } Y = P*Q - C(Q) - B \tag{3.1}$$

where:

Y = profit

P = output price

Q = output

C(Q) = variable cost, as a function of Q

B = fixed costs

The first order condition for this maximization problem is:

$$dY/dQ = P - C'(Q) = 0 \quad \text{or} \quad P = C'(Q) \tag{3.2}$$

In other words, profit is maximized where marginal revenue (P) is equal to marginal cost (C'(Q)).

The derivative of the profit function (3.1) with respect to output Q determines the optimal level of output to produce, based on given prices and technology. It is at this production level that the marginal cost of one additional unit of output is equal to its marginal revenue (or market price). Providing the total income (P*Q) is greater than the variable costs (C(Q)) the firm will continue to produce in the short run even though profit may be negative, due to the fixed costs. If total income is less than the variable costs, however, the firm will not produce. This then suggests that the shut down point for a firm is, in the short run, only influenced by its ability to meet its variable costs. The crop cost concept of insurance is based on the principle that in any given year, the variable costs associated with production will be recovered in order to ensure that the firm will continue production in the short run. The variable costs of production will be estimated by a calculation of eligible cash costs.

The theory of the firm further suggests the means by which the firm will optimize the allocation of resources to maximize profit. In the simplest case, the case of complete certainty, the firm will allocate each input on the basis of its individual marginal factor cost and the resultant marginal value product. Each input will be added to a level where marginal factor cost equals marginal value product (Varian).[16] For example, a grain producer will apply an additional dollar of fertilizer if he/she can expect at least an additional dollar in returned income, regardless of his/her fixed land or machinery investment costs. The fertilizer decision in any one year is completely independent of the fixed costs.

3.2 Theory of the Firm and Risk

There is often some confusion between the terms risk and uncertainty. Uncertainty is when the outcome of a particular event is unknown and can only be estimated through some probability of occurrence. An example of uncertainty is the amount of rainfall that

[16] The logic behind establishing the optimum input level at the point where marginal factor cost equals marginal value product, is equivalent to establishing the optimum output at the point where marginal cost equals marginal revenue. Marginal factor cost and marginal value product are derived as a function of a particular input, while marginal cost and marginal revenue are derived as a function of output. The optimal input and output results will be constant for both.

a certain field may receive (Black). Risk, however, is an attempted measurement of the effect that the uncertain condition may have on profit or utility. In the rainfall example, the risk is the resultant yield and income from that crop, as a result of different rainfall outcomes. The crop cost program focuses directly on the risk associated with profit maximization, whereas the yield based programs use yield risk as an approximation for profit risk.

The production decisions of the firm or producer become more complex and more realistic with the inclusion of uncertainty and risk. Given some level of uncertainty, it is often assumed that utility maximization may provide the best model of analyzing economic decisions, rather than expected profit maximization (Dionne and Harrington). The most likely outcome or expected return does not reflect the range of potential outcomes for the producer. Individuals have varying degrees of risk tolerance, and the variability of potential outcomes will influence decisions of all but the risk neutral producer.

Preference ordering may be represented by a utility function. The numerical magnitudes of utility levels have no intrinsic meaning and represent ordinal units only (Varian). For purposes of this study Von Neumann-Morgenstern conditions are assumed. This implies that the utility function is continuous and concave for all positive outcomes and therefore each producer will make choices on either a risk neutral or risk averse basis.

Under conditions of an uncertain outcome, the producer may choose an action that has a lower expected return but has a range of outcomes that are less variable. A simple example of a risk averse producer would be one who would choose the certainty of

$100.00 per acre income, versus a 50 percent chance of $60.00 per acre and a 50 percent chance of $150.00 per acre. Although the expected average outcome of the second choice is $105.00 per acre ($60.00 * 50% + $150.00 * 50% = $105.00), the producer still prefers the complete certainty of $100.00 per acre.

Pratt demonstrates that the utility maximizing producer will choose inputs and an optimum level of production, in an uncertain environment, based on establishing a certainty equivalent. The certainty equivalent is the outcome that the producer would require, with complete certainty, that would leave him/her indifferent between it and the uncertain scenario. Assuming that price and quantity are normally distributed, $P \sim N(\overline{P}, \sigma_p^2)$ and $Q \sim N(\overline{Q}, \sigma_q^2)$ for a given set of inputs and assuming that price and quantity are independent (i.e., the covariance of quantity and price equals zero), the producer attempts to maximize the expected utility of profit. This can be represented by the utility maximization problem illustrated in equation 3.3.

$$\text{Max } E[U(Y)] \tag{3.3}$$

where:

Y = profit

Pratt derives the identity that this is equivalent to maximizing a certainty equivalent, given the assumption of normality and constant risk aversion, within a relevant range.

$$Max\ CEy = E[Y] - \frac{1}{2}\lambda\sigma_y^2 \tag{3.4}$$

where λ = the producers function of risk tolerance

In terms of the simple example,

$$E[Y] = P*Q - C(Q) - B \tag{3.5}$$

and,

$$\sigma_y^2 = P^2\sigma_q^2 + Q^2\sigma_p^2 + \sigma_p^2\sigma_q^2 \tag{3.6}$$

Therefore, maximizing CE_y is equivalent to:

$$Max\ P*Q - C(Q) - B - \frac{1}{2}\lambda[P^2\sigma_q^2 + Q^2\sigma_p^2\sigma_q^2] \tag{3.7}$$

The first order condition for this optimization problem is:

$$P - C'(Q) - \frac{1}{2}\lambda[P^2\sigma_q^{2\prime} + 2Q\sigma_p^2 + \sigma_q^{2\prime}] = 0 \tag{3.8}$$

where $\sigma_q^{2\prime}$ equals the derivative of σ_q^2 with respect to Q

The equation, simplified further, can be stated as:

$$P = C'(Q) + \lambda Q\sigma_p^2 + \frac{1}{2}\lambda(P^2 + \sigma_p^2)\sigma_q^{2\prime} \tag{3.9}$$

This may be compared to the original example, without uncertainty:

$$P = C'(Q) \tag{3.10}$$

From these last two equations (3.9 and 3.10) it can be seen that if there were no uncertainty, this problem would simplify into a straightforward profit maximization problem. The difference, as a result of uncertainty, is the variance of price (σ_p^2), the variance of quantity (σ_q^2), and the producers acceptance of risk (λ). Providing $\sigma_q^{2\prime}$ (or $d\sigma_q^2/dQ$) is not negative, these factors clearly result in reduced utility and a reduction in the optimum level of production for the risk averse producer. Consequently, any reduction in either variance or the producer's risk reduction factor will stimulate greater production and allow the producer to achieve a higher level of utility. If $\sigma_q^{2\prime}$is negative, then there will be some counter effect where the increase in quantity increases utility. The extent to which this will affect optimum output is dependant on risk preferences (λ) and the magnitude of $\sigma_q^{2\prime}$. Normally, $\sigma_q^{2\prime}$ may be expected to be positive. In other words, an increase in output will cause an increase in the variance of output.

In relation to the crop cost study, this work creates a framework to help understand, in theory, how the producer makes his/her production input decisions. It also supports the need for each individual to make production and input decisions based on their unique circumstances and individual risk tolerance.

The success of a crop cost system relies on the individual judgement of each producer to choose the crops and levels of inputs that maximize expected utility. The program itself will allow enough freedom to the producer so that he/she will not be discouraged from making allocation choices in the same manner as if there was no insurance program and profit variance were reduced.

It is important to mention that as input costs and output prices vary, the output or yield that will maximize profit may also vary considerably from one year to the next. A unique profit maximizing output will be required for all input and output price combinations. One of the strengths of the crop cost insurance program is that coverage is based on the unique costs incurred to reach the profit maximizing output. Using an insurance program that bases coverage on a percentage of historical output or yields, the producer may find that in some years the level of coverage does not reflect the unique circumstances and appropriate output or yield targets for that years production.

3.3 The Insurance Choice

The example in the previous section highlights the effect of price and quantity variance on the firm's utility maximization problem. Fleisher outlines that risk creates losses and inefficiencies in the market through misallocation of resources between enterprises and among competing firms. Risk management also consumes a great deal of time and money and generates no return. Although in some cases a risk may create a competitive advantage for those more capable of managing the risk, in general risk is considered to be bad. Insurance provides one possible means of reducing risk for the firm or the producer.

Insurance reduces the expected return by the value of the premium but makes up for this loss in income by eliminating the impact of a very poor outcome or total loss.

Although the expected income is reduced, reduction of variance may result in greater expected utility for some risk averse producers. If this is the case, it is optimal for these producers to insure.

In the simple case, the producer has two potential outcomes, one where production proceeds normally and income exceeds insurance coverage levels, and the other where production and/or income falls short of coverage levels. The two outcome case is represented empirically in equations 3.11 to 3.15. Without insurance, profit may be represented as:

$$Y = P*Q - C(Q) - B \tag{3.11}$$

With insurance, profit will be either:

$$Y_i = P*Q - C(Q) - B - I \quad \text{if } P*Q > Y_{min} \tag{3.12}$$

or

$$Y_i = Y_{min} - C(Q) - B - I \quad \text{if } P*Q < Y_{min} \tag{3.13}$$

where

Y_i = profit with insurance

I = Insurance premium

Y_{min} = coverage level

The resulting certainty equivalents are as follows:

$$CE_{yi} = E[Y_i] - \frac{1}{2}\lambda\sigma^2_{yi} \text{ with insurance} \tag{3.14}$$

and

$$CE_y = E[Y] - \frac{1}{2}\lambda\sigma_y^2 \text{ without insurance} \quad (3.15)$$

The two certainty equivalents can be compared with respect to; the expected income (E[Y]) and the risk cost factor ($\frac{1}{2}\lambda\,\sigma_y^2$). If the certainty equivalent, or level of utility, with insurance is higher than without insurance, the producer will choose insurance. It is clear that variance of income will be reduced due to the certainty of a minimum income from the insurance (i.e., truncating the distribution of profit). With insurance, each producer has an expected payout that can be represented mathematically as in equation 3.16.

$$\textit{Expected payout} = \int_0^{Y_{min}} f(Y)(Y_{min} - Y)dY \quad (3.16)$$

If the expected payout is greater than the cost of insurance, all risk averse and risk neutral producers would be better off with insurance.[17] However, if the expected payout is less than the cost of the premium, the producer's decision will depend on the level of risk aversion or his/her function of risk tolerance (λ). The degree to which the insurance

[17] With Federal and Provincial governments contributing half of the premium costs to the current program, it could be anticipated that, if the system treated all producers equitably, all producers who are risk averse would participate in the program.

option is preferred to the non-insurance option will indicate the maximum level of premium (I) that the producer would be willing to pay.

To review how different types of insurance affect the insurance decision, equations 3.11 to 3.16 can be looked at from the perspective of quantity insurance and income insurance. Without insurance, profit is:

$$Y = P^*Q - C(Q) - B \tag{3.17}$$

while, with yield insurance, profit is:

$$Y_i = P^*Q - C(Q) - B - I \quad \text{if } Q > Q_{min} \tag{3.18}$$

or

$$Y_i = P^*Q_{min} - C(Q) - B - I \quad \text{if } Q < Q_{min} \tag{3.19}$$

With income insurance, profit is:

$$Y_i = P^*Q - C(Q) - B - I \quad \text{if } P^*Q > (P^*Q)_{min} \tag{3.20}$$

or

$$Y_i = (P^*Q)_{min} - C(Q) - B - I \quad \text{if } P^*Q < (P^*Q)_{min} \tag{3.21}$$

where:

Y_i = profit with insurance

I = Insurance premium

Q_{min} = yield coverage level

P^*Q_{min} = income coverage level

Comparing certainty equivalents

$$CE_{yi} = E[P*Q_{min}] - \frac{1}{2}\lambda\sigma_{yi}^2 \text{ with yield insurance} \tag{3.22}$$

and

$$CE_y = E[P_{min} * Q_{min}] - \frac{1}{2}\lambda\sigma_{yi}^2 \text{ with income insurance} \tag{3.23}$$

where:

$$\frac{1}{2}\lambda\,\sigma_{yi}^2 = \frac{1}{2}\lambda\,[P^2\sigma_q^2 + Q^2\sigma_p^2 + \sigma_p^2\sigma_q^2] \tag{3.24}$$

It can be seen that yield insurance reduces variance with respect to quantity only, while income insurance provides a reduction in the combination of variances of price and quantity. This supports one of the most important aspects of the design and operation of a crop cost system of insurance; that is, to provide insurance for both the price and quantity effects on profit.

3.4 Insurance Theory

Recognizing the significant role insurance can play in reducing the variance or the risk for the producer, it is important to understand some of the principles of insurance and some of the potential hazards or administrative challenges. The topics of insurance principles, adverse selection and moral hazard are reviewed in this section.

3.4.1 Insurance Principles

Most insurance is based on the concept of pooling risk, or distributing risk so that each individual need never carry the burden of a negative outcome all at one time (Greene). For an insurance program to be considered actuarially fair, each participant should expect that, over the long run, premiums will sum to an amount approximately equal to the costs of lost production if one was not insured.[18]

Fleisher outlines several conditions that should be met for a risk to be ideally insurable. Individuals in the insurance pool should not have risks that are highly correlated in a positive way. Through crop insurance, the risks of crop production are distributed over other sectors of society (i.e., federal and provincial governments contribute to the program), distributed over all participating farmers, and distributed over time. If there is a high level of correlation between risks of individuals or over time there is a reduced opportunity for the insurer to pool the risk. If risk is perfectly without positive correlation, the insurer can expect that in any one year the expected premiums received will approximately equal the expected payouts. In the case of yield insurance there is a high level of correlation between participants and over time for risks such as drought. In the case of the GRIP program, there is the correlation of yields between producers plus the correlation of prices between producers and over time that reduces the theoretical insurability of the program. The crop cost program would also have positive correlation between participants and over time. It is uncertain if the correlation of prices

[18] In reality, with Federal and Provincial funding in the present Crop Insurance program, the producer should anticipate that on average and over the long run, total premiums paid should equal approximately half of the expected payouts from the program and, in the case of GRIP, approximately one third.

and yields for the crop cost system would be more or less severe than for the GRIP program.

A second condition that must be met is that the insurer must be able to determine a probability distribution of outcomes. A sufficient number of participants must be in the risk pool to establish a sound probability distribution. Botts and Boles provide one of the first documented crop insurance approaches, using a normal curve distribution. Based on historical yield information for a homogeneous group of producers from a given area, a distribution of potential yields is established. Knowing the average yield and standard deviation of the distribution, the proportion of acres that fall below a certain coverage level can be established. The pure premium or theoretical premium is derived from a loss cost ratio as follows:

$$L = AC - AR \qquad (3.25)$$

where

L = loss cost ratio

A = proportion of acres below the coverage level

C = the coverage level in bushels per acre

R = the average yield of acres where yields are below the coverage level

The loss cost ratio times the value of the unit of coverage establishes the required premium. Certain assumptions are made when using a normal distribution, including symmetry. Nelson et al provide evidence that the use of a normal curve may bias the loss cost ratio, and suggest an alternative distribution. Regardless of the type of distribution used, the loss cost approach can be used to determine premium requirements for the GRIP and crop cost programs as well. Fleisher discusses that the probability of outcomes for price and/or revenue related insurance programs are much more difficult to establish.

An additional important condition for an insurable risk is that the losses are accidental and measurable. If losses can be created intentionally the ability of the insurer to predict losses is greatly reduced. This represents a case of moral hazard and will be dealt with in a later section. The insurer must also be able to accurately measure the loss to determine the required payout and to establish expected losses for the future.

Fleisher suggests that there are few examples of private crop insurance companies due to the fact that crop risk violates the requirements of being a purely insurable risk. As a result, governments have become involved in either subsidizing and operating crop insurance programs.

3.4.2 Adverse Selection

Certain difficulties sometimes occur with generalized insurance coverage. A number of cases of adverse selection were described in the introduction for this study. Adverse selection takes place when the benefits of a program or insurance scheme are not equitably distributed among a range of different participants. Dionne and Harrington define adverse selection as a state "when the insurer cannot observe an individual's risk at the time policies are issued and the individual has superior information about his or her risk."[19] As a profit maximizer or utility maximizer, each producer must find the combination of crops and inputs that, given uncertainty, are most likely to maximize the producer's objectives. If certain producers are more likely to claim or benefit from insurance coverage than others, and these producers have more information about their level of risk than the insurer does, adverse selection may take place. Dionne and Harrington review a number of insurance related research articles that identify techniques used to reduce the likelihood of adverse selection.

By providing the option of partial insurance and sorting on that basis, Rothschild and Stiglitz suggest that higher risk clients have a tendency to demand full coverage while lower risk clients will seek partial coverage options. The client's choice alone provides information on the client's risk that the insurer may not have otherwise known. The insurer will then sort clients based on their level of coverage and be able to make additional assumptions about the loss to coverage ratios and premiums required for each group. The crop cost approach allows for varying rates of coverage that may be useful in assessing the risk of each coverage group.

If insurance contracts are multi-period contracts, Cooper and Hayes suggest that experience rating encourages a client to self-declare their level of risk, due to the net benefit or detriment it may have on future contracts. Cooper and Hayes suggest that one of the limitations of their findings is the assumption that the insurance company is a monopoly. In the case of crop insurance this is an accurate assumption. Each of the

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[19] Dionne and Harrington, Foundations of Insurance Economics, Readings in Economics and Finance. page 18.

insurance schemes (yield, GRIP, and crop cost), by using an individual record history, incorporates a high level of experience rating in the development of appropriate coverage levels and/or premiums.

Risk categorization, or the grouping of insurers on the basis of any relevant characteristic, is another method of reducing adverse selection. Crocker and Snow review the benefits of categorizing under the assumption that there is no cost to receiving the categorization information. They find that when categorization is costless, efficiency is always enhanced. Their study examined automobile insurance and categorizing on the basis of sex, race, and age. Although categorizing on the basis of these categories may be considered discriminatory by social standards, risk categorization did improve the efficiency of insurance market. In the case of crop insurance this can be used to support the case that any additional information, particularly costless information, can improve the efficiency of the insurance system. The crop cost system of insurance, as an individualized record history program, provides a great deal of information beyond just yield information about the individual clients. As any of the crop insurance programs move toward individualized coverage, they should become more efficient. They also run the risk of significant bias when individual information is limited. For example, if a producer's coverage and premium calculations are adjusted based on two years of available information and one of those years is very non-typical, the coverage may not be reflective of the individual's real risk situation.

3.4.3 Moral Hazard

Moral hazard is another potential insurance problem. Moral hazard is defined, by Holstrum, as an alteration in input use which deviates from social optimality due to conflicting incentives and asymmetric information. In the crop insurance case, moral hazard occurs when the producer chooses a combination of inputs that deviates from the social optimum, in order to increase the likelihood of collecting from crop insurance. Moral hazard will also create an environment for adverse selection if a portion of the crop insurance participants can take advantage of certain incentives within the crop insurance system while others cannot. Those who, as a result of moral hazard, receive a disproportionate share of the benefits of crop insurance without paying the appropriate costs, pass their costs on to those who are unable to take advantage of the system.

Looking at the issue of moral hazard in more detail, Shavell refers to moral hazard as the tendency of insurance protection to alter an individual's motive to prevent loss. Incomplete coverage and observation of care are two methods of reducing moral hazard. With the crop cost pricing strategy, reducing the level of coverage to a percentage of what would be received without loss (i.e., setting prices at 85 to 90 percent of market prices) encourages the producer to prevent loss. The GRIP program in particular does not use incomplete coverage to reduce moral hazard.

Observation of care, or a detailed monitoring of the care taken by the policy holder to reduce the likelihood of making a claim, is another strategy suggested for reducing moral hazard. It can take place ex-ante, when the policy is purchased, or ex-poste when a claim is made. Observation of care by the insurer allows the insurer the opportunity to either adjust coverage prior to any claim, or deny or reduce a claim based on the tendency of the contract holder to prevent loss. The efficiency of imperfect information for observation of care either ex-ante or ex-poste is dependent on the cost of the observation and the accuracy of the information (Shavell). The crop cost program has some advantages in design that improve the insurer's quality of information in observation of care. The producer will not be able to receive payouts for any expense that is not supportable through either standardized estimates in the case of seed, fuel, and machinery costs, or actual invoices for fertilizers and chemicals. Tax records could also be used to audit actual crop inputs and quantities of grain marketed.

3.5 Diversification and Risk

Portfolio and diversification theory provide some useful insights into how a total farm crop cost approach may work. This section provides the framework for understanding how diversification may reduce the variance of returns, the probability of an insurance payout, and consequently, the cost of insurance. Diversification may also effect the overall insurance choice for the producer.

Investment theory suggests that an investor with one financial product has a certain expected return and variance or probability distribution of outcomes around the expected return (Cameron). The example is equally applicable for a producer growing one crop. Through diversification to two financial products, or in this case two crops for production, the expected return will become the weighted average of the two investment products or crops. The overall variance is however, somewhat more complex to derive.

Intuitively, the variance of the combined products or crops should be less than the variance of each of the individual products or crops. This is due to the reduced likelihood of both products or crops preforming poorly at the same time. The extent of this reduction in variance is dependent on the covariance between products or crops.

Covariance of asset yields or income from production, reflects two factors; the variance of each yield by itself, and the degree of correlation between the two yields (i.e., the extent to which they move together, independently or in opposite directions). The degree of correlation between two asset or crop yields Y_i and Y_j is measured by a correlation coefficient ($\mathbf{P}_{ij}$), whose value must lie between -1 and +1. A value of +1 implies that the two move together equally (i.e., perfect positive correlation) and a value of -1 implies the two move in equal magnitude but in opposite directions (i.e., perfect negative correlation).

The covariance between the two assets or crops can be described by the formula provided in equation 3.26, as follows:

$$COV_{ij} = \sqrt{\sigma_i^2}\sqrt{\sigma_j^2}\,\mathbf{P}_{ij} \qquad (3.26)$$

where:

COV_{ij} = the covariance between i and j

σ_i^2 = variance of i

σ_j^2 = variance of j

$\mathbf{P}_{ij}$ = correlation between i and j

With the knowledge of the covariance we can now determine the total variance of the combined products or crops can be determined by the formula in equation 3.27, as follows:

$$\sigma^2 = X_i^2\sigma_i^2 + X_j^2\sigma_j^2 + 2X_iX_jCOV_{ij} \tag{3.27}$$

where:

σ^2	= total variance
X_i	= % share of i
X_j	= % share of j
σ_i^2	= variance of i alone
σ_j^2	= variance of j alone
COV_{ij}	= covariance of i and j

In the event that the two products or crops are not independent of each other, the outcome of one will either positively or negatively influence the outcome of the other. This outcome will be dependent on the correlation. If the correlation coefficient equals +1 the diversification has not reduced risk at all. If the correlation coefficient equals 0 the two products behave independently of each other. If the correlation coefficient equals -1 then the variability of one product will completely offset the variability or risk of the other. This can be referred to as a perfect hedge (Cameron).

Grain producers have a number of different crops to choose from in any given year, and the expected income and variance for each crop is quite difficult to assess. Although the above portfolio approach to crop diversification is difficult to apply empirically at the farm level, the principles are important in understanding the farm decision making process (Zeering et al). Intuitively it can be anticipated that a mix of crops will behave somewhat independently of each other, thus reducing the overall variance. Providing the crops are not perfectly correlated, some level of diversification will always reduce the variance of income. The gains from this reduction in risk may be offset by a reduction in expected return from the diversification. The extent to which this offset will be found acceptable is dependent on the producer's risk preference (λ).

Incorporating this into the simple example, the certainty equivalents of the one crop and two crop case are shown in equations 3.28 to 3.29.

In the case of one crop, the certainty equivalent (CE_y) is as follows:

$$CE_y = E[Y] - \frac{1}{2}\lambda\sigma_y^2 \tag{3.28}$$

In the case of two crops, the certainty equivalent is as follows:

$$CE_y = p_1E[Y_1] + p_2E[Y_2] - \frac{1}{2}\lambda(p_1^2\sigma_1^2 + p_2^2\sigma_2^2 + 2p_1p_2cov(Y_1, Y_2)) \tag{3.29}$$

where p_1 and p_2 are the proportion of each crop or asset within the mix. Given that a crop mix that is not perfectly, positively correlated will reduce variance, it is clear that diversification can reduce the overall variance of yield and influence the certainty equivalent (CE) or utility of profit.

This principle can be applied to the insurance programs being reviewed in this study. The present system works on an individual crop basis and premiums are established without consideration to the farm crop mix. From the above example, it can be seen that by diversifying crops and reviewing variance on an overall farm basis, risk is reduced. The crop cost program establishes ultimate coverage and premiums on a basket of crops total farm basis. Based on diversification theory the basket approach will reduce premiums paid and reduce expected payouts. Figure 3.1 provides an example of comparing basket to individual crop coverage.

From the example in Figure 3.1 it can be seen that the payouts under the basket coverage are only $350.00 compared to a net $2,750.00 payout on an individual crop basis. In any actuarially balanced program, the net payouts will equal the net premiums paid over time. Therefore it can be anticipated that the premium required for the basket coverage illustrated in Figure 3.1 will be significantly lower than for the individual crop coverage.

Another interesting factor relevant to portfolio theory is the fact that, as the portfolio broadens, there becomes less and less need for high levels of insurance coverage. Mayers and Smith introduce the concept that firms with varying portfolios and internal risk reduction will require varying levels of coverage to maximize the utility of expected income. In general it has been assumed that the more diversified the portfolio, the less the need for insurance. Mayers and Smith provide foundation for an exception

Wheat coverage $60.00 per acre on 200 acres

Barley coverage $55.00 per acre on 150 acres

Canola coverage $70.00 per acre on 100 acres

Wheat income $72.00 per acre

Barley income $50.00 per acre

Canola income $55.00 per acre

On a crop by crop basis the following payouts would be calculated

Wheat

($60.00 coverage - $72.00 income * 200 acres = no payout

Barley

($55.00 coverage - $50.00 income) * 150 acres = $750

Canola

($75.00 coverage - $55.00 income) * 100 acres = $2000.00

Total payout of $2750

On a basket of crops basis the following farm payout would be calculated;

Wheat

($60.00 coverage - $72.00 income) * 200 acres = -$2400.00

Barley

($55.00 coverage - $50.00 income) * 150 acres = $750

Canola

($75.00 coverage - $55.00 income) * 100 acres = $2000.00

Total payout

-$2400 + $750.00 + $2000.00 = $350.00

Figure 3.1 Basket versus Non-Basket Coverage

to this assumption for any portion of the portfolio that could be considered non-marketable assets. In the case of crop insurance the general rule applies, considering the production being insured is highly marketable. This again supports the need for an insurance program to provide a range of coverage options, consistent with the design of the crop cost insurance program.

4.0 EMPIRICAL MODEL

4.1 Introduction

Within this chapter, the data and criteria used to model the three separate insurance alternatives are reviewed. A simulation model is used to approximate the performance of a yield based program, a Gross Revenue Insurance Program (i.e., GRIP) and the proposed crop cost based program. The design of each of these programs will, for the most part, be based on the descriptions of each program from Chapter Two. There will be some adjustments based on data limitations and programming complexity. As stated in the objectives of the study, each alternative program will be assessed based on its performance in a number of areas including the ability to meet crop input risks and stabilize gross margin income.

4.2 Simulation Approach

Three simulation models have been constructed based on historical production records from 1981 to 1990. Incorporating historical production records into each of the three simulation models allows the opportunity to assess what would have happened to the sample group of farms over the ten years being reviewed if these alternative programs had been available. The simulation approach allows the testing of a variety of insurance program alternatives for each producer, within a large sample set of producers.

The yield based program is simulated to provide individualized coverage at 70 percent of the producer's individual average yield. The GRIP based program is simulated to provide coverage at the individual producer's average yield times 70 percent of the

Indexed Moving Average Price (IMAP). The proposed crop cost program is simulated to provide three different coverage levels; 80 percent, 100 percent and 120 percent of eligible costs incurred by the individual. Through the simulation of each of these programs, the performance of each insurance program can be assessed. In order to most equitably compare the alternative programs, the three way comparison is made as if each program began in 1981 and actuarially balanced by farm at the end of ten years.

4.3 Sample set

The sample set of farms included in this study is restricted according to several criteria. The sample is limited to those producers with available crop production records from Manitoba Crop Insurance Corporation (MCIC), and whose primary land base is in risk areas two and six. Fields in adjacent risk areas with the same contract number as those identified in risk area two and six are also included in the sample set. Risk area two has a traditionally higher risk of crop failure and lower yields, while risk area six has a traditionally lower risk of crop failure and higher yields. The location of each region is shown in Figure 4.1. These areas were determined based on availability of sufficient MCIC data. Table 4.1 outlines the yields and variability of the two crop risk areas for wheat and flax. The two risk areas were chosen to allow an evaluation of the benefits for each of the alternative insurance programs under different production risk circumstances. The sample set of producers is also restricted to those who have participated in the crop insurance program and have grown a minimum of one crop of

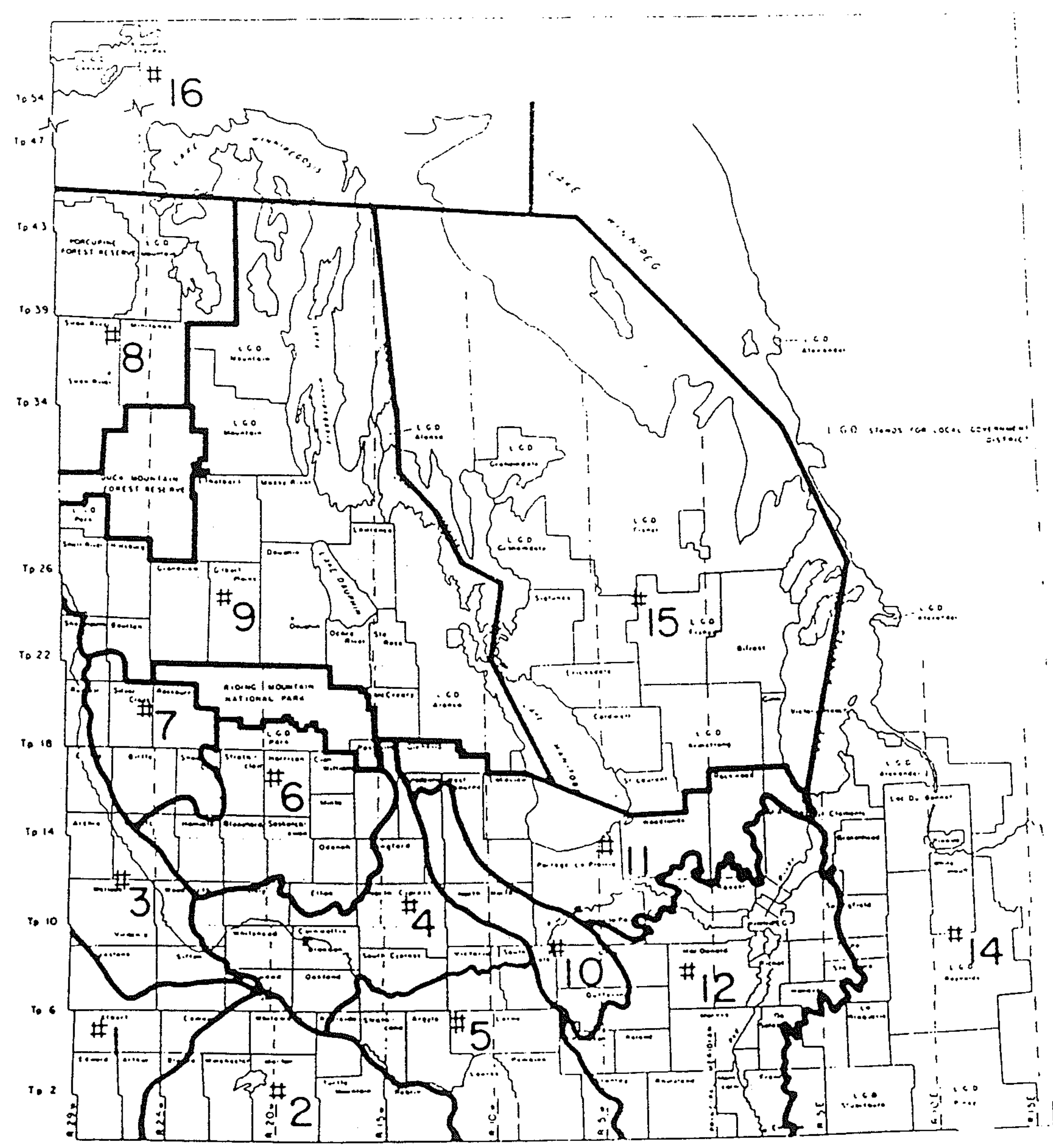

Figure 4.1 MCIC Risk Areas

Table 4.1 **Comparison of Yields and Yield Variability for Risk Areas Two and Six (bushels/acre)**

Year	Wheat Risk Area Two	Wheat Risk Area Six	Flax Risk Area Two	Flax Risk Area Six
1960-90				
Mean Yield	26.46	29.65	12.74	14.33
Standard Deviation	6.99	5.82	4.42	4.30
Coefficient of Variation	0.26	0.20	0.35	0.30
1961-70				
Mean Yield	26.00	29.04	10.68	12.18
Standard Deviation	3.18	2.17	2.53	1.77
Coefficient of Variation	0.12	0.07	0.24	0.14
1971-80				
Mean Yield	25.95	29.49	12.20	14.30
Standard Deviation	5.36	4.06	2.92	3.11
Coefficient of Variation	0.21	0.14	0.24	0.22
1981-90				
Mean Yield	30.37	32.57	16.06	17.42
Standard Deviation	8.69	7.11	5.10	5.00
Coefficient of Variation	0.29	0.22	0.32	0.29

Source: MCIC yield data 1960-1990

wheat in each of the ten years being reviewed.[20] The other crops included with hard wheat are durum wheat, barley, flax and canola.[21] For farms in the study group with other crops in their rotation, total acres are reduced by that amount for that year. These crops are chosen to meet three interrelated criteria. They represent the major crops grown

[20] It was felt that it is important to be able track at least one major crop through entire ten year period with yield information in every year.

[21] Both Argentine and Polish varieties were included together in canola records. The MCIC records used were only split by variety type after 1984. For this study the canola records for 1985 - 1990 were combined.

in the areas, and include two crops marketed almost exclusively through the Canadian Wheat Board and two crops not marketed through the Canadian Wheat Board.

To restrict the data to information that is useful for analysis, records are eliminated from the data set if nitrogen fertilizer, phosphate fertilizer or yields are unknown. Some special treatment is also required to deal with reseeding information. MCIC maintains two separate field records for any field that has been reseeded to another crop. If any field record matches the acres and legal description of a reseed field record for the same year, the two records are assumed to be the same field. The information is combined and the record with a zero or unknown yield is considered to be the original crop. If there are no records that match the reseeded record it is assumed that the field is reseeded to the same crop.

The years 1981 through 1990 are chosen for the study and sample data are limited to that time frame. The time period includes years when yields and income have been both high and low. Restricting the study to only ten years reduces the effect of changing technology. MCIC survey data include the required chemical use information beginning in 1981.

Given the above criteria and data restrictions, 231 producers remain in the sample set with a total of 17,258 different crop records over the ten years. The average farm size for producers and fields used in this study is 599.14 acres. It is recognized that due to the elimination of all but the specified crops, the real farm size for many of the producers is expected to be larger. Of the 231 producers in the sample, 119 are based in Risk Area Six and 112 are based in Risk Area Two.

4.4 Farm Level Data

Historical MCIC survey records from 1981 to 1990 are the primary data source for the study. Each MCIC survey contains individual field information by year and crop. The information includes acres of each crop seeded, average crop yields, fertilizer applied by nutrient (in pounds), chemical applied by product, reseeding information, soil classification, risk area and whether the crop was seeded on summerfallow or stubble.

By choosing MCIC records in defining the sample set the assumption is made that those who have participated in the crop insurance program in the past represent a reasonable cross section of producers. Although it may be argued that the sample could be skewed toward the risk averse producer[22], this group is representative of producers likely to seek crop insurance of some form.

4.4.1 Crop Income

For all models, total crop income in any year is based on the final yield from the MCIC records multiplied by the prairie average farm gate price for a standard grade of each crop. The prairie average farm gate prices used in this study are the same prices used by the National Grains Bureau in calculating the Indexed Moving Average Price (IMAP) for GRIP. It is felt that each price used in the study should be derived with as similar a methodology as possible. Although the National Grains Bureau provided these

[22] By excluding farmers that do not use crop insurance it is understood that this group may not be representative of all producers.

prices, they would not disclose the complete methodology used to derive the prices.[23] Annual crop prices are provided in Table 4.2.

Crop Insurance records do not provide information on the final grade of the crops grown. For this study it is assumed that each crop would grade as follows: Durum Wheat (#3 CWAD), Hard Wheat (#2 CWRS), Barley (#1 CW), Canola (#1 Can) and Flax (#1 CW). The same grade standards are used as the quality guarantee in the current MCIC yield and GRIP programs (MCIC Annual Report 89-90).

To establish the average yields for each producer, the actual yield histories from MCIC data are used. Average yields for each producer and each crop are established in two steps. A producer's annual average yield for a crop is based on the yield for each field weighted by the number of acres in each field. The long term average yield for that crop is calculated as the sum of each of the annual average yields divided by the number of years that the crop is grown.

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[23] The procedures for deriving the IMAP and establishing grade specific prices from the Statistics Canada all grade annual prices were considered confidential by the National Grains Bureau.

Table 4.2 Average Annual Prairie Crop Prices (Dollars per Bushel)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
CWRS2	5.00	4.63	4.80	4.71	3.70	2.89	3.13	4.88	4.11	2.94
CWAD3	4.86	4.51	4.97	4.89	4.13	3.25	3.77	4.92	3.73	2.61
Barley 1CW	2.58	2.08	2.58	2.47	2.07	1.45	1.37	2.45	2.38	1.60
Flax 1CW	8.01	6.40	8.11	8.00	6.69	4.39	5.20	9.20	8.63	5.77
Canola 1 Can	6.41	6.31	8.67	8.01	6.07	4.61	5.89	6.88	6.11	5.83

Source: National Grains Bureau

CWRS2 = Canadian Western Red Spring wheat, grade #2
CWAD3 = Canadian Western Amber Durum wheat, grade #3
Barley 1CW = Canadian Western barley, grade #1
Flax 1CW = Canadian Western flax, grade #1
Canola 1 Can = Canadian canola, grade #1

4.4.2 Defining Costs

4.4.2.1 Fertilizer Costs

Fertilizer costs are based on the spring price of dry fertilizer products, as determined by an annual Manitoba Agriculture survey[24], multiplied by the number of pounds of actual nutrient of each product applied. MCIC records provide the pounds of each nutrient used on each field. Although a variety of other fertilizer products may have been used, including anhydrous ammonia and fluid fertilizers, available MCIC records do not provide any information by product type. For the average producer over the time period studied, dry fertilizers can be considered the most accessible form of fertilizer application and represent the highest percentage of use.[25] Table 4.3 provides the fertilizer prices used to calculate total fertilizer costs.

4.4.2.2. Pesticide Costs

Herbicide and chemical costs are estimated based on the cost per acre of each pesticide product identified from the MCIC records. The cost of each herbicide product is calculated based on annual Manitoba Agriculture cost per acre herbicide surveys for registered rates of application.[26]

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[24] Material gathered and recorded by John Ewanek, Soils Specialist with Manitoba Agriculture.

[25] The Manitoba Agricultural Yearbook 1990 lists that 490.7 tonnes of dry fertilizer was used as compared to 187.5 tonnes of other fertilizer formulations in the province.

[26] This information has been gathered and maintained by the Soils and Crops Branch of Manitoba Agriculture with the information released on a limited basis.

Table 4.3 Fertilizer Cost in Dollars per Pound of Actual Nutrient

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Nitrogen (N)	0.29	0.20	0.26	0.29	0.28	0.27	0.23	0.23	0.24	0.23
Phosphate (P)	0.28	0.26	0.26	0.27	0.27	0.27	0.24	0.26	0.26	0.23
Potash (K)	0.11	0.12	0.12	0.12	0.10	0.10	0.10	0.13	0.13	0.12
Sulphur (S)	0.13	0.15	0.12	0.13	0.08	0.15	0.16	0.20	0.23	0.22

N prices are based on dry Urea formulations
P prices are based on dry Mono Ammonium Phosphate
K prices are based on dry Potassium Chloride
S prices are based on crystalline Ammonium Sulphate from 1981 to 1985
and Ammonium Sulphate Prills from 1986 to 1990

Source: John Ewanek, Soils Specialist, Manitoba Agriculture

Additional assumptions are required to derive the appropriate herbicide cost for several different circumstances. In the event that a product price is not available, the price of a similar product is used. If only one year of price information is missing, an average of the previous and following years prices is used. If a product is not registered for use in a particular crop, the information is assumed to be incorrect and no cost is charged against the field. If a product has a variety of application rates, the cost is based on the rate most commonly applied.[27] If products are most likely to be used on a spot treatment basis, an estimate of the percentage of acres covered times the cost per acre is used to determine an overall cost per acre. Product use estimates are provided by market research departments for each of respective products. Additional specific assumptions and a cost per acre summary for each product are provided in Appendix B.

Insecticide price information is provided by Manitoba Agriculture and other independent crop consultant sources. This information is very limited.[28] Where specific historical insecticide costs are not available, the costs are based on 1990 or 1991 prices for each product and are adjusted back to previous years based on the percentage change in the price of the closest competitive product.[29] All products used as seed treatments in canola are considered at zero cost due to the standard incorporation of seed treatment

[27] Determination of the most common rates are based on the author's personal experience as a crop input consultant, along with a variety of expert opinions.

[28] Mark Goodwin, Joanne Buth, and Gary Platford from the Soils and Crops branch of Manitoba Agriculture and Scott Lamont from Redfern Farm Services were consulted on historical prices and expected rates of the chemicals used in this study.

[29] Furidan 480 prices were the chief source of competitive product information and were considered a better source of indexing than the more general crop input indices.

in the seed cost. This assumption is made because seed treatment in canola is considered to be a standard procedure and is consequently poorly reported as a specific chemical use.[30] Additional specific assumptions and a cost per acre summary for each product are provided in Appendix C.

4.4.2.3 Standardized Seeding, Labour and Machinery Costs

Seeding costs are estimated based on Manitoba Agriculture Farm Planning Guides.[31] Canola seeding costs include the standard cost of seed treatment. Table 4.4 outlines the seed costs for each crop for each year.

Machinery costs are estimated based on Manitoba Agriculture Farm Planning Guides for each crop and year. Machinery costs include the variable costs of maintenance, fuel, and lubricants plus miscellaneous building repair and overhead. Table 4.5 outlines the machinery costs for each year.

Labour costs are estimated based on the hours of labour required for each crop (Pokrant et al), multiplied by the average hired farm labour cost per hour. Labour costs

[30] The use of specific chemicals as insecticides is considered to be very poorly reported in the MCIC records. For example, in 1981 only three fields were recorded as using Counter when it was considered a relatively standard practice for all canola fields at that time.

[31] The planning guides incorporate a variety of surveyed farms and expert opinions from Manitoba Agriculture to establish approximate crop budgeting costs for each crop.

Table 4.4 Seed Costs in Dollars per Acre

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Wheat	10.50	10.50	8.10	8.45	7.81	7.50	5.75	5.31	6.75	5.50
Barley	8.00	8.00	7.00	6.00	6.38	5.63	4.90	4.13	5.13	4.38
Flax	8.57	8.40	7.15	8.60	8.56	12.00	7.50	5.60	10.40	8.40
Canola	6.70	6.70	6.70	8.20	8.50	8.50	7.60	6.00	8.50	7.90

Source: Manitoba Agriculture Farm Planning Guides, 1981-1990

Table 4.5 Machinery Costs for All Crops in Dollars per Acre

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Machinery Cost	15.00	20.00	21.00	21.00	21.00	24.00	22.00	22.00	22.25	24.50

Source: Manitoba Agriculture Farm Planning Guides (machinery plus other costs), 1981-1990 per hour are determined using a 1979 wage level[32] and a farm labour cost index[33] to derive the estimate of average wages through the time period. Table 4.6 outlines the estimated labour costs for each crop and year.

4.4.2.4 Special Costs of Reseeding and Summerfallow

Reseeding costs require some special considerations. The cost of additional seed is equal to the original seed cost estimate. The machinery cost of reseeding is assumed to be 25 percent of the machinery cost for a full year. This estimate is based on the approximate cost of one tillage and one seeding operation as a percentage of the total machinery variable cost.[34] These two costs (i.e., additional seed and machinery expense) are then added to the field costs of a reseeded field. The estimates of reseeding costs are outlined in Table 4.7.

Compensation is provided for summerfallow in this study. The use of summerfallow in a rotation is considered as a pre-investment for the future crop. The benefit of summerfallow is calculated as being equal to 47 pounds of spring applied

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[32] Manitoba Agriculture Statistical Yearbook - hourly wage for 1979 non farm labour pool employees. The year 1979 was used because it was the last year that hourly labour wages were recorded.

[33] Statistics Canada Prairie farm labour wage index for non farm labour pool employees as presented by telephone Statistics Canada Agriculture branch Winnipeg office.

[34] A University of Manitoba Crop Production Simulator was used to compare the cost of one tillage and one seeding operation to the cost of all machinery operations for one year for a typical producer.

Table 4.6 Labour Costs in Dollars per Acre

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Wheat	5.43	5.78	5.98	6.24	6.44	6.61	6.77	7.07	7.44	7.69
Barley	6.77	7.19	7.45	7.77	8.01	8.23	8.43	8.81	9.26	9.58
Flax	5.04	5.36	5.55	5.78	5.97	6.13	6.27	6.56	6.90	7.13
Canola	6.22	6.62	6.85	7.14	7.37	7.57	7.75	8.10	8.52	8.81

Source: Manitoba Agriculture Yearbook 1979
Statistics Canada, Farm Labour Index.

Table 4.7 Reseeding Cost in Dollars per Acre*

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Wheat	14.25	15.50	13.35	13.70	13.06	13.50	11.25	10.81	12.31	11.63
Barley	11.75	13.00	12.25	11.25	11.63	11.63	10.40	9.63	10.69	10.51
Flax	12.32	13.40	12.40	13.85	13.81	18.00	13.00	11.10	15.96	14.53
Canola	10.45	11.70	11.95	13.45	13.75	14.50	13.10	11.50	14.06	14.03

* based on 25% of machinery cost plus the price of seed

Source: Manitoba Agriculture Farm Planning Guides, 1981-1990
Crop Production Simulator, Department of Agricultural Economics, University of Manitoba

nitrogen fertilizer.[35] The benefit of legumes in a rotation as a nitrogen source is not taken into consideration due to limited previous crop information.

4.4.2.5 Operating Capital

Total non-interest costs are calculated as the sum of the above costs (i.e., fertilizer, chemical, seed, machinery, labour, reseeding, and summerfallow compensation). This cost, multiplied by one half of the Royal Bank prime interest rate, as of the first of May of each year is used to estimate operating interest costs.[36] Total interest costs are based on one half of the prime interest rate assuming a six month repayment schedule. Total operating costs (or eligible costs) are then calculated as the sum of seed cost, machinery cost, fertilizer and chemical costs, labour cost, summerfallow compensation, reseeding cost and operating interest costs. The interest rates used are summarized by year in Table 4.8.

4.5 Modelling a Yield Based Program with Individualized Coverage

The yield based system is modeled to provide individualized coverage at 70 percent of the individual producer's average yield, multiplied by an estimate of market price. Although individual average yield adjustments are not presently used in Manitoba,

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[35] The actual benefit of these crop rotations may vary a great deal from year to year. Based on a sixteen year average of all fields soil tested by the Manitoba Provincial Soil Test Lab the residual nitrogen in summerfallow fields varies from 45 to 49 pounds per acre higher than the residual nitrogen from wheat, barley, canola or flax fields.

[36] Royal Bank prime rate figures as of May first for each year were provided by Scott Stothers, Assistant Manager, Agricultural Services Manitoba West.

Table 4.8 Interest Rates

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Prime Rate	18.50%	17.00%	11.00%	11.50%	10.75%	10.50%	9.25%	10.25%	13.50%	14.75%

Source: Royal Bank of Canada Prime Interest Rate, May 1, 1981-1990 it is suggested that with the introduction of the GRIP system, designed to work with an individual average yield adjustment, the yield system will be required to do the same. Individualized yield adjusted coverage is available in Alberta and Saskatchewan. The yield model also differs from the present system in that Provincial and Federal financial contributions are not included in the calculation of premium rates.

4.5.1 Coverage Levels

Coverage levels are set based on 70 percent of an average yield calculation multiplied by an estimate of market prices. To establish the average yields for each producer the actual yield histories from MCIC data are used. The average yield for each crop is calculated as discussed earlier; that is, as the simple ten year average of the weighted average for each year. This ten year average for each crop by producer is the average yield used in the calculation of coverage. For some crops, fewer than ten years of yield information is available, and average yields are based on the years with yield records only.[37]

Coverage prices, or the price per bushel set by MCIC for each crop is set at the same level used by the corporation in that year.[38] The coverage prices are based on a guaranteed grade of #2 CWRS, #3 CWAD, #1 CW Barley, #1 CW Flax, and #1 Can Canola. Normally there would be a coverage adjustment factor for crop quality or grade that is below the insurance

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[37] From an operational point of view, individualized yield programs require a minimum number of years yield history in order to establish an unbiased average yield. Area averages, or an indexed area average may be incorporated into the individual average yield estimate, until an adequate yield history is available. For this study, those restrictions were removed.

[38] Provided by Neil Hamilton, Director of Research, Manitoba Crop Insurance Corporation.

standard. In this case, the adjustment factor is not required due to data limitations and the assumption of certain grades for each crop. Table 4.9 provides the crop coverage prices used for yield coverage.

4.5.2 Payouts

Insurance payouts for the simulated yield program are triggered if crop yields in that year drop below the coverage level (i.e., 70 percent of the long term average yield). The payouts are calculated as the shortfall between the yield for the crop and the yield coverage level multiplied by the coverage price, as set by MCIC.

Certain other payouts are made for reseeded crops in a manner similar to the present yield based system. There are two separate reseeding cases. The reseeded crop may be the same as the original crop in that field or the reseeded crop may be a different crop. In the case where the crop reseeded is the same as the original crop, a reseeding benefit is paid out as 25 percent of the total level of coverage for that crop on those acres. The reseeded crop is then eligible however, for only 75 percent of total coverage on the acres reseeded. The reseeding payout then reduces the total eligible coverage for that crop by the amount of the payout.

If the reseeded crop is different from the original crop, a reseeding benefit equal to 25 percent of coverage is normally paid for the original crop along with a 50 percent of coverage payout (stage one loss). An entirely new contract is then established for the reseeded crop at full coverage with full premiums also being due. For the purpose of this study a modified approach is used to deal with fields reseeded to different crops. They are dealt with as if they were

Table 4.9 MCIC Coverage Prices in Dollars per Bushel

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
CWRS	3.81	4.08	4.08	4.08	4.08	4.08	3.13	2.99	4.63	3.95
CWAD	3.81	4.08	4.08	4.08	4.08	4.08	3.13	3.13	4.90	3.95
Barley	2.39	2.61	2.61	2.61	2.61	2.29	1.42	1.31	2.07	1.85
Flax	6.10	6.60	6.60	6.86	7.11	7.11	5.21	5.08	7.11	7.11
Canola	5.22	5.67	5.67	5.90	6.35	6.35	4.76	5.44	6.01	5.90

Source: Manitoba Crop Insurance Corporation originally seeded to the same crop as was finally sown. This is done for two reasons. Firstly, the same number of contracts for each insurance scheme is maintained for each year. Secondly, eliminating the need to establish a new contract for the reseeded crop reduces the complexity of the programming required. There should be no significant loss of accuracy in assessing each of the three insurance schemes as a result of this estimation. The total number of reseeded fields is 61 out of a total of 17,258 individual field records. Only 29 of these are fields reseeded to different crops (i.e., less than 0.02 percent of the sample). In each case the yield of the original crop is not factored into the producer's long term yield average for that crop.

4.5.3 Premiums

Premium costs for each producer under the yield based program are calculated by totalling all payouts by crop for each individual producer over the time reviewed and dividing them by the total coverage purchased,[39] as illustrated by equation 4.1:

$$Yprem(i) = \Sigma Ypay(i) \;/\; \Sigma(70\% * AY(i) * MCIC(i) * AC(i)) \qquad (4.1)$$

where

Yprem(i) = premium as a percentage of coverage for crop
Ypay(i) = payout for crop
AY(i) = ten year average yield for crop
MCIC(i) = coverage price for crop
AC(i) = acres of crop

[39] Although individual yield adjusted programs would normally have premiums set on a pooled risk basis between producers, premiums for this study are set by individual performance to ensure that each producer's net gain or loss from insurance over the ten years is zero.

Use of this method in setting premiums forces overall premiums to equal overall payouts for each crop over the ten years under consideration. The resulting premium is the amount that would have been required to balance each individual account, and consequently the total program, for the time period being studied. Although an operational crop insurance system does not have the luxury of hindsight to establish premium levels, it is important that for this study each alternative insurance scheme is forced to a net balance of zero. This ensures that each insurance option is compared based on the same aggregate financial result.

4.5.4 Yield Basket Approach

Because the crop cost approach to insurance requires that it be operational on a crop basket basis rather than an individual crop basis, the yield simulation has been modified to create the payouts and premiums required given a yield based model using a basket approach.

A payout will be triggered under the basket approach if the sum of all crop yields, multiplied by their respective yield coverage price in any one year, is lower than the sum of all coverage yields (i.e., 70 percent of average yield), multiplied by their respective yield coverage price for that year. The payout will be equal to the difference between the actual yields multiplied by the coverage price minus the sum of the coverage yields times the coverage price, as illustrated in equation 4.2:

$$BP = \Sigma(CY(i) * CP(i) * Ac(i)) - \Sigma(OY(i) * CP(i)) * Ac(i) \quad (4.2)$$

where

BP = Basket insurance payout

OY(i) = Observed yield of each crop

CP(i) = Coverage price for each crop

CY(i) = Coverage yield for each crop

AC(i) = Acres of each crop

To establish premiums for the yield based system with a basket approach, the sum of all payouts received by a producer is divided by the sum of all coverage. This creates a premium as a percent of coverage for the entire farm, as shown by equation 4.3:

$$Bprem = \Sigma(BP) / \Sigma\, CY(i) * CP(i) * AC(i) \quad (4.3)$$

where

Bprem = the basket premium as a percentage of coverage

BP = Basket payout

CY(i) = Coverage yield for crop

CP(i) = Coverage price for crop

AC(i) = Acres of crop

Σ = Summation over all years

4.6 Modelling the GRIP System

4.6.1 Coverage

The GRIP system provides a level of coverage as a complement to the yield based system. This level of coverage is based on the individual's average yield and an IMAP for the past fifteen years of prices. Average yields are calculated in the same manner as for the yield based model, using the simple ten year average for each of the weighted annual crop yield averages for each producer. The IMAP prices are calculated and provided by the National Grains Bureau.[40] These prices are based on historical crop prices (farm gate prairie average) and are adjusted by a farm input price index specific to the GRIP program. The IMAP prices used are based on the same grade assumptions as were made earlier for the yield based coverage. Coverage levels are set at the individual producer's average yield multiplied by 70 percent of the IMAP for each crop. IMAP prices are listed in Table 4.10.

4.6.2 Payouts

A payout under the GRIP model is triggered when the crop income (observed yield times annual price) plus the payout from the yield system is less than the producer's average yield multiplied by 70 percent of the IMAP.[41] Payouts are established as the

[40] These IMAP figures are unpublished estimates provided by Gwen Cromwell, Policy Economist, National Grains Bureau, Winnipeg. Variations in the IMAP estimates may have occurred during the time taken to prepare this study.

[41] The annual crop prices are the same prices that are used in the estimation of annual income and are provided in Table 4.2.

Table 4.10 Indexed Moving Average Prices in Dollars per Bushel

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
CWRS2	5.85	6.24	6.23	6.38	6.55	6.41	6.20	6.18	6.14	5.92
CWAD3	6.58	7.04	7.04	7.22	7.43	7.28	7.09	7.11	7.14	6.62
Barley 1	3.22	3.41	3.39	3.47	3.55	3.49	3.40	3.40	3.35	3.09
Flax 1cw	11.42	12.05	12.00	12.11	12.27	11.81	11.52	11.47	11.28	10.76
Canola 1	9.25	9.72	9.66	9.93	10.34	10.11	9.77	9.72	9.68	9.56

CWRS2 = Canadian Western Red spring wheat, #2 grade
CWAD3 = Canadian Western Amber Durum wheat, #3 grade
Barley 1 = #1 Canadian Western barley
Flax 1cw = #1 Canadian Western flax
Canola 1 = #1 Canada canola

Source: National Grains Bureau

amount required to cover any deficit between the value of the crop grown plus yield coverage payouts, and the GRIP coverage level. The value of the crop grown is established as the yield times the average annual price for that crop in that year. Equation 4.4 illustrates the GRIP payout calculation:

$$Gpay(i) = (AY(i) * 70\% * IMAP(i)) - YPay(i) - (OY(i) * AP(i)) \quad (4.4)$$

where

Gpay(i)	= GRIP payout for crop
AY(i)	= Average yield for crop
IMAP(i)	= Indexed moving average price for
Ypay(i)	= Yield payout for crop
OY(i)	= Observed yield for crop
AP(i)	= Annual price for crop

4.6.3 Premiums

To establish premium levels for the GRIP program the sum of all payouts over the ten years for each crop for each customer is divided by the sum of additional coverage provided by the GRIP program for each producer and each crop. This premium rate then represents the amount of premium payment required as a percentage of coverage to make the program balance at the end of the ten years.[42] This is demonstrated in equation 4.5.

[42] Again this is a departure from how premiums are actually set for the GRIP system. This model allows for no pooling of risk between producers.

$$Gprem(i) = \Sigma(Gpay(i)*Ac(i))/ \Sigma((IMAP*70\%*AY)(i)*Ac(i)-(CY(i)*Ac(i))) \quad (4.5)$$

where

Gprem(i)	= GRIP premium as a percentage of coverage for crop
Gpay(i)	= GRIP payouts per acre of crop
Ac(i)	= Acres of crop
IMAP(i)	= IMAP for crop
AY(i)	= Average yield for crop
CY(i)	= yield coverage per acre of crop
Σ	= Summation over all years

As with the yield based system, premium levels are forced to exactly equal the total payouts from the program at the end of the ten years studied. If a field is reseeded, the GRIP coverage and premium only apply to the final crop. The original crop is disregarded.

4.6.4 Basket Approach

The GRIP system is also simulated with a basket approach to establish a comparison to the proposed crop cost model. A payout will be triggered under the basket approach if the sum of all crop yields multiplied by the annual crop price plus the payouts from yield insurance in any one year is lower than the sum of all average yields multiplied by 70 percent of the IMAP price for that year. The payout will be equal to difference between the sum of the actual yields multiplied by the annual crop coverage price minus the sum of the coverage yields times the coverage price, as illustrated by equation 4.6.

$$GRBP = \Sigma(AY(i)*70\%*IMAP(i)) - \Sigma YPay(i) - \Sigma(OY(i)*AP(i)) \quad (4.6)$$

where

GRBP	= GRIP basket insurance payout per acre
AY(i)	= Average yield for each crop
IMAP(i)	= Indexed moving average price for each crop
Ypay(i)	= Yield payout for each crop
OY(i)	= Observed yield of each crop
AP(i)	= Annual price of each crop
Σ	= Summation of crops per year

To establish premiums for the GRIP based program with a basket approach, the sum of all payouts for each producer is divided by the sum of all coverage above the yield coverage. This creates a premium as a percent of coverage, as shown by equation 4.7.

$$Gprem=\Sigma\Sigma(Gpay(i)*Ac(i))/\Sigma\Sigma((IMAP*70\%*AY)(i)*Ac(i)-(CY(i)*Ac(i))) \quad (4.7)$$

where

Gprem(i)	= GRIP premium as a percentage of coverage for crop
Gpay(i)	= GRIP payouts per acre of crop
Ac(i)	= Acres of crop
IMAP(i)	= IMAP for crop
AY(i)	= Average yield for crop
CY(i)	= yield coverage per acre of crop
$\Sigma\Sigma$	= Summation over all years and crops

4.7 Modelling the Proposed Crop Cost Program

The proposed crop cost program provides coverage based on eligible variable costs. Fuel, machinery, seed, labour, fertilizer, chemical costs and others for each individual producer are all based on survey material collected by Manitoba Agriculture and the U of M production cost simulation model, as outlined earlier. Eligible costs are defined as the input costs for this study. The crop cost system would normally operate on a crop basket basis, but for this study it is simulated on both an individual crop basis and a crop basket basis in order to make specific comparisons. As with the yield and GRIP simulations the program is designed to actuarially balance by individual at the end of the ten years.

4.7.1 Coverage

The levels of coverage are established at 80, 100 and 120 percent of the eligible costs per acre, as defined earlier. For example, if a producer has 75 dollars per acre of eligible expenses, he/she would have crop cost coverage of 60 dollars per acre at 80 percent coverage, 75 dollars per acre at 100 percent coverage, and 90 dollars per acre at 120 percent coverage.

4.7.2 Payouts

Payouts from the crop cost insurance plan on a basket basis are triggered if the sum of the estimated income of all crops is less than the sum of all eligible costs multiplied by the rate of coverage. The payout then equals the difference between the coverage and income levels. The estimated income of each crop is based on the actual yield times a November or modified November price for each crop.

November prices are calculated based on a prairie average farm gate price provided by Statistics Canada for each year reviewed. The Statistics Canada prairie average farm gate price uses the same basis and transportation cost assumptions as are used in the calculation of the IMAP by the National Grains Bureau.[43] Adjustments are required to make this price grade specific.

Farm gate prairie average prices are available for each crop year by specific grade, for each crop year by all grade and for November for all grades. To derive a November price by specific grades the adjustment outlined in equation 4.8 is required.

$$NPBG = (APBG / APAG) * NPAG \qquad (4.8)$$

where

NPBG = November price for specific grade

APBG = annual price by specific grade

APAG = annual price for all grades

NPAG = November price for all grades

The specific grade annual price, divided by the all grade annual price, times the all grade November price, is used to approximate the November specific grade price.

[43] As determined by telephone conversations with Ed Hamilton, Agriculture Division, Statistics Canada, Ottawa

This estimation is based on the assumption that the distribution of grades for November deliveries is representative of the distribution of deliveries for the rest of the year.

For grains handled by the Canadian Wheat Board (CWRS, CWAD, and barley), estimated November income for wheat and barley is based on 100 percent of the November specific grade price derived earlier. The November price normally will be equivalent to the initial price for that year, and is expected to be approximately equal to 85 percent to 95 percent of the final price received. In most years a producer can anticipate a non-zero final payment. This provides the incentive for complete harvesting as discussed in Chapter two. Based on the price information used in this study, November prices vary from 65 percent to 106 percent of annual average prices for wheat.[44] Table 4.11 outlines the full range of November prices and their relation to annual prices.

For crops not marketed through the Canadian Wheat Board, there is no expectation of a final payment. For this reason, estimated income used in the calculation of crop cost payouts for canola and flax is based on 90 percent of the specific grade November price, as derived earlier. The reasoning behind using a percentage of the final price is to encourage complete and thorough harvesting of all crops, as discussed previously. November prices vary from 85 percent to 113 percent of annual prices. After the adjustment, prices vary from 77 percent to 102 percent of the annual price. Table 4.12

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[44] The 106 percent is an anomaly presumably based on a significant shift in the distribution of deliveries by grade in November compared to the remainder of the crop year. Normally with an initial payment system it would be impossible for the producer to receive a higher price in November than later in that crop year.

Table 4.11 November Prices in Dollars per Bushel

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
CWRS #2	4.28	4.14	4.12	4.22	3.65	3.07	2.44	3.84	3.45	2.89
CWAD #3	4.19	4.20	4.03	4.29	3.71	2.88	2.45	4.18	3.36	2.61
Barley #1	2.34	2.08	2.12	2.31	2.15	1.43	1.01	2.29	1.72	1.51
Flax #1	8.47	6.59	7.69	8.09	6.95	4.83	4.44	9.08	8.02	6.53
Canola #1	6.18	6.36	8.18	8.27	6.40	4.78	5.18	6.96	6.02	5.86

November Prices as a Percentage of Annual Prices

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
CWRS #2	86%	89%	86%	90%	99%	106%	78%	79%	84%	98%
CWAD #3	86%	93%	81%	88%	90%	89%	65%	85%	90%	100%
Barley #1	91%	100%	82%	94%	104%	99%	74%	93%	72%	95%
Flax #1	106%	103%	95%	101%	104%	110%	85%	99%	93%	113%
Canola #1	96%	101%	94%	103%	106%	104%	88%	101%	99%	100%

Source: National Grains Bureau
Statistics Canada

Table 4.12 Adjusted November Prices in Dollars per Bushel and as a Percentage of Annual Prices

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Flax #1	7.63	5.93	6.92	7.28	6.25	4.35	4.00	8.17	7.22	5.87
Canola #1	5.56	5.73	7.36	7.45	5.76	4.30	4.66	6.27	5.42	5.27
Flax #1	95%	93%	85%	91%	93%	99%	77%	89%	84%	102%
Canola #1	87%	91%	85%	93%	95%	93%	79%	91%	89%	90%

* derived from Table 4.11

outlines November prices, adjusted November prices and the percentage of Annual prices. Once estimated November prices are established, crop cost payouts on a crop basket basis are calculated as illustrated in equation 4.9.

$$BCCpay = \Sigma ((Elcst(i) * RC) - (AY(i) * MNP(i)) \quad (4.9)$$

where

BCCpay = Crop Cost payout per acre for the entire farm
Elcst(i) = Eligible cost for crop
RC = Rate of Coverage (80, 100, or 120 percent)
AY(i) = Actual Yield
MNP(i) = Modified November price
Σ = Summation of crops by year

4.7.3 Premiums

To establish premiums on a crop basket basis the total payouts over the ten years are divided by the total level of coverage for each producer.[45] An illustration of how this is calculated is provided in equation 4.10.

$$BCCprem = \Sigma(BCCpay * Ac) / \Sigma(CCco * Ac) \quad (4.10)$$

where

BCCprem = the Crop Cost premium as a percentage of coverage
BCCpay = the payouts from the crop cost program
CCcov = the total level of coverage
Ac = acres of all crops for each year
Σ = Summation over all years

[45] An operational crop cost program would establish some pooling of risk between producers. This model does pool risk in that way. The net benefit for each producer over the ten years will equal zero.

4.7.4 Individual Crop Basis

The crop cost approach is also simulated on an individual crop basis. Crop cost coverage for the individual crop system is based on 80, 100, and 120 percent of the eligible costs accrued for each crop independently.

Payouts on a crop cost individual crop basis are triggered if the estimated income for a particular crop is less than the eligible costs multiplied by the percentage of coverage. The payout is calculated as the difference required to meet the level of coverage for that crop. Estimated income is calculated as the observed yield times the November or modified November price. Equation 4.11 outlines this mathematical relationship.

$$CCpay(i) = (Elcst(i) * RC) - (AY * MNP(i)) \qquad (4.11)$$

where

CCpay(i)	= Crop Cost payout for crop
Elcst(i)	= Eligible cost for crop
RC	= Rate of Coverage (80, 100, or 120 percent)
AY(i)	= Actual Yield for crop i
MNP(i)	= Modified November price for crop i
Σ	= Summation of crops per year

Premiums are established to actuarially balance each crop at the end of the ten year period. Premiums are calculated as the sum of payouts by crop over the ten years divided by the total coverage level by crop as illustrated in equation 4.12.

$$CCprem(i) = \Sigma CCpay(i) \,/\, \Sigma CCcov(i) \qquad (4.12)$$

where

CCprem(i)	= the Crop Cost premium as a percentage of coverage for crop
CCpay(i)	= the payouts from the crop cost program for crop
CCcov(i)	= the total level of coverage for crop
Σ	= Summation over all years

4.8 Analysis

The above simulation models create ten potential insurance alternatives to assess in terms of the overall objectives for the study. These ten alternatives include the yield based program by individual crop and by basket, the GRIP Program by individual crop and by basket, and the crop cost alternatives at 80, 100 and 120 percent coverage for both basket and individual crop coverage.

The majority of comparisons are made at the whole farm level. In the case of basket coverage programs the information provided by the simulation results is already at the total farm level. In the case of non-basket coverage most comparisons will be made using the sum of individual coverage results. It is important to note that the total level of coverage from the sum of individual crops is much different than the total level of coverage from a basket perspective. For this reason several comparisons between each of the alternative insurance programs can only be accurately made as either both basket or non-basket comparisons.

The purpose of the study is to review each of the simulated alternatives to discover if the crop cost model of insurance has merit. There are three questions identified as most important in comparing each of the alternatives: i) how effectively does the insurance coverage match the variable costs associated with production; ii) how well does the insurance program stabilize income over the ten years reviewed; and iii) how stable is each program in terms of the financial risk for MCIC and the ability to predict premium rates? It is also of interest to discover how high input or low input producers and/or producers from different risk areas are affected by each of the alternative programs. To make those comparisons the population is sub-divided as outlined in Figure 4.2.

4.8.1 Covering Variable Costs

A simple ratio of total farm coverage as a percentage of eligible costs is used to measure the effectiveness of each program in meeting the variable cost expenses of the crop for each producer. Both the mean of the ratio and the variability of this ratio will be assessed for each individual producer and a paired test is used to measure the significance of the results. The coverage to eligible cost ratio is monitored to assess the effect of input use and risk area. Each of these alternatives is evaluated on an overall farm basis.

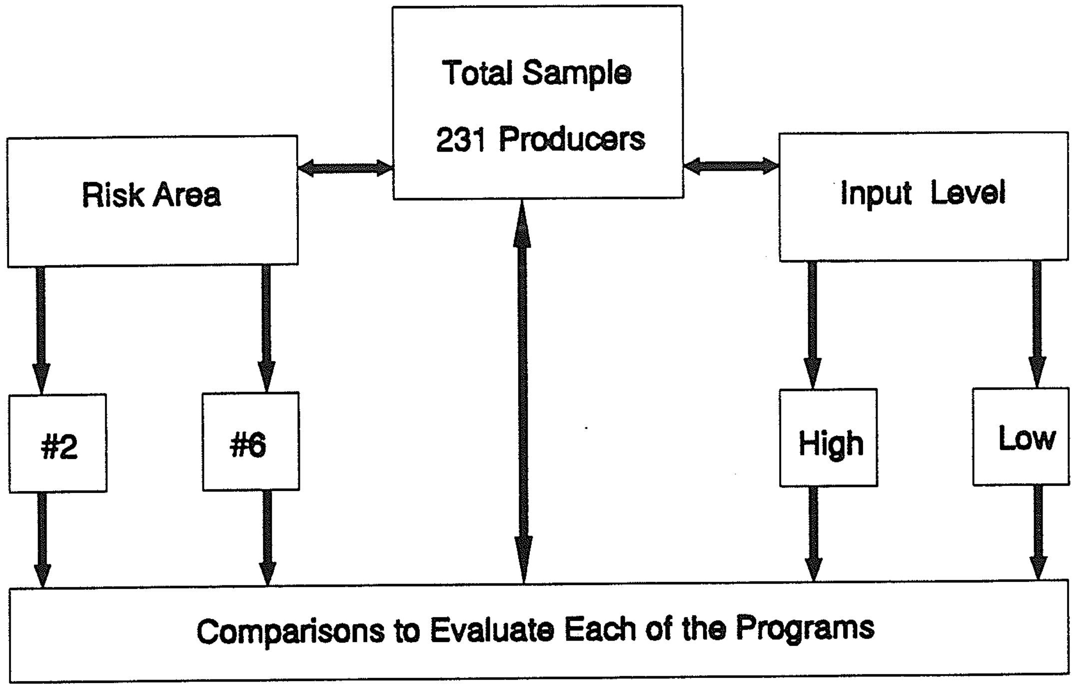

Figure 4.2 Breakdown of Sub-groups

4.8.2 Stability of Income

Each program is assessed for its ability to stabilize income. Gross margins are used as the estimate of income and are examined on a per acre basis. Gross margins for the farm are calculated as the crop income (observed yield times annual crop price) plus any insurance payout minus insurance premiums minus eligible costs, as illustrated by equation 4.13.

$$GM = (\Sigma(OY * AP) + \Sigma Pay - \Sigma Prem - \Sigma\ Elcst) / \Sigma AC \qquad (4.13)$$

where

GM = Gross Margin per acre

OY = observed yield

AP = Annual Price

Pay = Insurance payouts

Prem = Insurance premiums

Elcst = Eligible costs

AC = Acres

Σ = Summation over crops

Gross margins are calculated for each producer for each of the ten years and for each of the ten insurance alternatives. The gross margin is also calculated for each producer and year assuming there is no insurance at all. Because of the design of the simulation, actuarially balanced, it is known that each producer will have the same net gross margin at the end of the ten years for each of the insurance alternatives. Therefore it is of greatest interest to evaluate the variability of the gross margin for each program.

The variability of gross margins over the ten years is estimated using the standard deviation for each producer and each program. A paired test is used to compare the deviation between programs by producer.[46] The specific program comparisons will be:

[46] The specific assumptions and considerations required to use the standard deviation as a measure of variability will be deal with in more detail in the discussion of the study results, in the next chapter.

i) crop cost 80 percent basket versus yield coverage, ii) crop cost 100 percent basket versus yield coverage, iii) crop cost 120 basket versus GRIP plus yield coverage, iv) Crop cost 100 basket versus Crop cost 100 individual coverage.

After establishing the inherent variability of each of the programs and comparing the variability of each of the previous pairs of coverage, an assessment is made to discover if the costs of coverage are comparable. The average premium per acre is calculated for each program and each producer over the ten years. Again a paired test is used to test the differences in premium costs between programs for statistical significance.

If a pair of insurance programs provide equal stability of gross margins and one can be obtained at a lower cost per acre than the other, the program is considered to be superior. Alternatively, if a pair of insurance programs can be obtained at equal costs per acre and one has greater gross margin stability than the other, it is considered to be superior.

4.8.3 Financial Exposure to MCIC

The sum of all payouts distributed minus the sum of all premiums received for each year is the net financial gain or loss to MCIC in that year. The net loss for each insurance program is calculated for each year over all producers. A cumulative gain or loss is also monitored to assess which program creates the greatest cash demands or financial risk for the corporation. The design of the simulation models forces each of the programs to balance at the end of the ten years. The variation within those ten years gives an indication of the potential exposure to MCIC with each of the simulated programs.

Another important consideration in comparing insurance programs is the ability of the corporation to predict appropriate premium levels. This study is based on the simplifying assumption that premiums are set with perfect knowledge, to make each of the programs balance at end of the ten years. A comparison is made between the predicability of premiums for the GRIP system and the crop cost system at 120 percent of eligible costs. If MCIC were required to set premiums for the crop cost or the GRIP program, the premiums would likely be based on a payout (loss) to coverage ratio. The more stable that ratio is, the more likely that the predicted premium will be accurate. For this study, the predictability is estimated based on the variability of the payout to coverage ratio for the two programs. The variability is estimated by the standard deviation of the payout to coverage ratio for each producer over the ten years for each of the two programs. A paired test is used to test the differences for statistical significance.

5.0 ANALYSIS AND RESULTS

This chapter provides a discussion of the empirical analysis for the three simulation models and their economic behaviour. The three simulated insurance programs, in their basket and sum of individual crop (i.e., non-basket) forms, generate unique premium rates, levels of coverage and insurance payouts over the ten years. As a general overview, average premiums, average coverage and average payouts for all producers over the ten years are reviewed for each program. The specific hypotheses outlined in the first chapter are then discussed and tested. Finally, the simulation and statistical test results are combined to provide an overall discussion concerning the performance of the alternative insurance programs.

5.1 General Results

5.1.1 Premiums

Premiums were calculated to balance each program over the ten year period modeled. Table 5.1 outlines the average premium per acre and standard deviation for each of the insurance program alternatives on a total farm basket and non-basket basis. The average premium for each producer for the basket coverage is calculated as the simple average of annual per acre basket premiums over the ten year period. The average premium for the non-basket coverage is calculated as the simple average of the annual average premiums, where the annual average premium is weighted by the acres of each crop grown. The average premiums in Table 5.1 are simple averages over all producers.

Also in Table 5.1 are the average premium rates for wheat only, where the average premium for each individual is calculated as the simple average of wheat premiums over the ten years, and the overall average premium is the simple average of the individual average premiums.

Table 5.1 Average Premium Costs per Acre *

	Eligible Cost	Yield Premium	GRIP Premium	CC80 Premium	CC100 Premium	CC120 Premium
Wheat						
Mean	77.79	3.19	19.55	1.72	4.19	8.36
Std Dev	10.48	2.81	5.67	2.35	3.91	5.72
Basket						
Mean	77.45	2.44	19.63	1.41	3.96	8.31
Std Dev	9.08	2.20	5.48	1.94	3.48	5.30
Individual						
Mean	77.45	4.15	20.37	2.64	5.64	10.44
Std Dev	9.08	2.99	6.13	2.50	3.97	5.66
Basket minus Individual						
Mean	0.00	-1.71	-0.74	-1.23	-1.68	-2.13
Std Dev	0.00	-0.78	-0.65	-0.56	-0.49	-0.36

CC80 = Crop Cost 80 Percent Coverage
CC100 = Crop Cost 100 Percent Coverage
CC120 = Crop Cost 120 Percent Coverage
Std Dev = Standard Deviation
Mean = Average Value
Individual = The Sum Of Individual Crop Coverage or Non-Basket
Basket = The Basket Of Crops Coverage

* Mean values represent the average of all producers while Standard deviations are the deviations among producers

A number of interesting observations can be made from Table 5.1. The lowest premium cost is for the crop cost program at 80 percent coverage using the basket approach. As anticipated, using the basket approach results in reduced premium costs for all forms of insurance. This reduced cost is expected due to the reduced probability of payouts with the basket approach. The non-basket GRIP program has the highest premiums. It is important to note that GRIP premiums and yield premiums are recorded separately. For producers participating in both programs, as is normally the case, the total premium for GRIP plus yield coverage is the sum of the individual yield and GRIP premiums.

Another interesting observation is that as crop cost coverage rates increase from 80 to 100 to 120 percent of eligible costs, premium rates increase at a more than proportional rate, as was anticipated from the discussion in Chapter Two. Under the basket approach the crop cost 80 percent option provides 80 percent of the coverage that the crop cost 100 percent option provides, with a corresponding premium that is 35.6 percent of the premium for the crop cost 100 percent program (i.e., \$1.41/\$3.96). Alternatively, the crop cost 120 percent basket option provides 20 percent more coverage than crop cost 100 percent basket option with corresponding premiums that are equal to 209.8 percent of the premium for the 100 percent option (i.e., \$8.31/\$3.96).

For 93 of the 231 producers, the premium required for the crop cost program at 80 percent basket coverage was equal to zero. This also occurred, to a lesser extent, for crop cost at 100 percent and for yield coverage. This outcome is improbable in an operational insurance program. Zero premiums occur in this simulation due to the method used to derive the premium. The premium is simply calculated as the value of total payouts divided by the total level of coverage. In the above cases, the producer did not receive a payout under that insurance plan and consequently is not required to pay a premium in a system modeled to actuarially balance at the end of the ten years. In a program where rates are set in advance there will always be some risk of production being below the coverage level and an associated non-zero premium. As a result premium costs are underestimated by the simulation in relation to the actual premiums that would be charged and the value of the coverage.

Another area of interest is the comparison of wheat premiums to the basket and non-basket premiums. In all but one case, the wheat only premiums are higher than the basket premiums and lower than the non-basket premiums. This supports the logic that the risk associated with wheat is lower than for the average crop. Therefore, including wheat with other crops in a basket (i.e., diversification) results in reduced overall premium costs per acre. As with the basket and sum of individual crop alternatives, the crop cost 80 percent coverage premium for wheat is lowest and the GRIP coverage is the highest. It is also observed that eligible costs for wheat are slightly higher than for the average of all crops.

5.1.2 Coverage

Coverage levels for each of the programs are derived based on the criteria discussed in Chapter Four. Table 5.2 outlines the level of coverage in dollars per acre under each of the alternative programs, on a basket, non-basket and wheat only basis.

Table 5.2 Average Coverage per Acre *

	Eligible Cost	Yield Coverage	GRIP Coverage	CC80 Coverage	CC100 Coverage	CC120 Coverage
Wheat						
Mean	77.79	82.89	54.71	62.23	77.79	93.35
Std Dev	10.48	14.31	11.79	8.39	10.48	12.58
Basket or Individual						
Mean	77.45	81.59	52.79	61.96	77.45	92.94
Std Dev	9.08	15.00	12.75	7.26	9.08	10.89

CC80 = Crop Cost 80 Percent Coverage
CC100 = Crop Cost 100 Percent Coverage
CC120 = Crop Cost 120 Percent Coverage
Std Dev = Standard Deviation
Mean = Average Value
Individual = The Sum Of Individual Crop Coverage or Non-Basket
Basket = The Basket Of Crops Coverage

* Mean value represent the average of all producers while standard deviations are the deviations among all producers.

It is important to note that, although the coverage levels for both basket and non-basket programs are set at the same dollar value, the opportunity or likelihood of receiving a payout from each is quite different. The basket approach will have fewer occasions when payouts are made because of the mixing of gains from one crop to cover the losses in another crop. The basket coverage will only be equal to the comparable non-basket coverage if all crops have production below the coverage level (i.e., no opportunity for cross-crop compensation).

GRIP and yield coverage levels are separated in the above table. As discussed earlier the GRIP coverage is in addition to yield coverage and coverage from the two programs is the sum of yield and GRIP coverage (i.e., 81.59 + 52.79 = 134.38 dollars per acre). Discussing GRIP coverage alone is necessary in the development of premiums for GRIP but can be very misleading when discussing coverage per acre for the producer without the implied use of yield insurance as a complement.

It is interesting to note that wheat coverage is higher than the coverage for the average of all crops, suggesting that wheat requires a higher level of investment than the other crops. This is also supported by comparing the eligible cost of wheat to the average of all crops (Table 5.1).

5.1.3 Payouts

Payouts for each of the insurance alternatives are calculated as discussed in Chapter Four. Table 5.3 provides a summary of payouts for each program, using the basket, non-basket and wheat only approach.

Again GRIP and yield information is provided separately. The total payouts for the producer with GRIP and yield coverage will be the sum of the two. The smallest average payout is for the crop cost 80 percent basket coverage program with the greatest payout occurring for the non-basket GRIP program.

These results are also consistent for the wheat only coverage. As expected, on the basis of premiums paid wheat payouts are lower than payouts with the sum of individual crops and higher than the payouts with the basket coverage for each insurance program, with one exception. Payouts under the GRIP basket coverage are higher than they are for wheat alone.

Table 5.3 Average Payout per Acre ($/acre) *

	Eligible Cost	Yield Payout	GRIP Payout	CC80 Payout	CC100 Payout	CC120 Payout
Wheat						
Mean	77.79	3.07	18.90	1.70	4.07	8.10
Std Dev	10.48	9.69	21.51	6.49	10.78	16.00
Basket						
Mean	77.45	2.37	19.12	1.40	3.85	8.05
Std Dev	9.08	7.20	20.04	5.40	9.73	15.06
Individual						
Mean	77.45	4.11	19.91	2.61	5.52	10.20
Std Dev	9.08	9.11	18.40	6.34	10.36	15.16
Basket minus Individual						
Mean	0.00	-1.74	-0.79	-1.21	-1.67	-2.15
Std Dev	0.00	-1.90	1.64	-0.94	-0.63	-0.10

CC80 = Crop Cost 80 Percent Coverage
CC100 = Crop Cost 100 Percent Coverage
CC120 = Crop Cost 120 Percent Coverage
Std Dev = Standard Deviation
Mean = Average Value
Individual = The Sum Of Individual Crop Coverage or Non-Basket
Basket = The Basket Of Crops Coverage

* Average value represent the average of all producers while standard deviations are the deviations among producers.

The following sections incorporate a more precise empirical analysis to test the specific hypothesis outlined in the objectives of the study.

5.2 Comparative Coverage of Costs

The first hypothesis is designed to test the ability of each of the alternative insurance programs to effectively and accurately cover the variable (eligible) costs of production. Comparisons are made on the basis of a coverage to eligible cost ratio. The ratio is examined for each insurance program and for each individual producer over the ten year period. This ratio is analyzed in terms of both the average (expected value) and the standard deviation (variability) over the ten years of the program. The average ratio provides an indication of the level of coverage that can be expected from each program, while the standard deviation of that ratio gives an indication of the range of possible ratios or coverage in any one year. A mean and standard deviation of the coverage to eligible cost ratio is established for each producer for the three insurance program alternatives.

The yield, GRIP plus yield and crop cost at 100 percent coverage are the only three alternatives for which this ratio is reviewed, for two reasons. Firstly, there is no appropriate comparison of coverage levels using the basket versus non-basket approach. Although the distinction between basket and non-basket is necessary in defining premiums and payouts, the value used to define coverage is the same. Secondly, the coverage to eligible cost ratio for the crop cost program will, by model design, exactly equal the proportion of eligible costs it is designed to cover. An example is provided to show this relationship. Table 5.4 outlines the summary of resulting means and standard deviations for the coverage to eligible cost ratios.

Three interesting results can be observed from Table 5.4. Firstly, the average coverage to eligible cost ratio for the yield insurance program is 1.06. In other words yield coverage is on average equal to 106 percent of the eligible costs. Recognizing that one of the objectives of MCIC is " to provide an opportunity to Manitoba farmers to protect their cash investment in their seeded crops from all uncontrollable natural hazards "(Canada-Manitoba Crop Insurance Annual Report 1989-90), the ability of a yield

Table 5.4 Summary of Coverage as a Percentage of Eligible Costs

	Yield/ Eligible	GRIP+/ Eligible	CC100/ Eligible	Yield Dev	GRIP+ Dev	CC100 Dev	GRIP+ Dev-Yield Dev
Average Ratio	1.062	1.750	1.000	0.166	0.176	0.000	0.045
Standard Deviation	0.120	0.203	0.000	0.042	0.053	0.000	0.018

YIELD/ELIGIBLE = yield coverage to eligible cost ratio
GRIP+/ELIGIBLE = GRIP plus yield coverage to eligible cost ratio
CC100/ELIGIBLE = crop cost 100 percent coverage to eligible cost ratio
YIELD DEV = standard deviation of the YIELD/ELIG ratio
GRIP+ DEV = standard deviation of the GRIP+/ELIG ratio
CC100 DEV = standard deviation of the CC100/ELIG ratio
GRIP+ DEV - YIELD DEV = difference in the natural log of the standard deviation

program to exactly cover input costs can be tested.

As represented in equation 5.1, the confidence interval is equal to the observed mean (1.062) plus or minus the product of the critical t-value multiplied by the ratio of the sample standard deviation to the square root of the sample size. For a two-tailed t-test at a 95 percent confidence level, the critical t-value is 1.960. As shown in 5.1, this results in a confidence interval of 1.047 to 1.077.

$$1.062 \pm 1.960 * 0.120 / 15.199 = 1.047 \text{ to } 1.077 \qquad (5.1)$$

The confidence interval does not include the value 1.0 , so the coverage to eligible cost ratio is significantly different than 1.0. Although this provides evidence that the average coverage to eligible cost ratio is not equal to one, it does not provide evidence of the degree of variation in this ratio, and to what advantage or disadvantage to the producer.

A second point to consider from Table 5.3 is the demonstration of the relationship that crop cost coverage at 100 percent will have a coverage to eligible cost ratio of 1.0 with a zero variance. Based on this evidence, it is assumed that the crop cost coverage at 80 percent would then provide a mean coverage to eligible cost ratio of 0.8 with a standard deviation of 0.0, and crop cost at 120 percent would provide a mean ratio of 1.2 with a standard deviation of 0.0 . This is expected given the methodology used to derive crop cost coverage.

For this study, the same source of information has been used to define both the producers' input costs and the eligible costs for crop cost coverage. If actual input cost information were available, a ratio could be derived between the level of coverage, as defined by the standardized rules proposed in this study, and the actual input costs. In that case it can be anticipated that there would be some differences in the mean ratio and the standard deviation. Actual fertilizer costs are anticipated to vary the most from the estimates used in the study, due to the assumptions required and the magnitude of the expense.

The third observation worthy of review is a comparison of the variability associated with the coverage to eligible cost ratio for the GRIP program plus yield program to the variability for the ratio associated with the yield program alone. This is done in two steps. The first step requires establishing a mean measure of variability of the coverage to eligible cost ratio for each producer for each program. These observations provide a distribution of mean variability values for each program. The second step involves the use of a paired analysis to establish if the difference in the mean variability between programs is significantly different than zero.

The standard deviation is used as the measure of the variability for each producer for each of the programs. The natural log of the standard deviation is used to improve the likelihood that the distribution of standard deviations for 231 producers are approximately normally distributed (Steele and Torrie). Another factor affecting the normality of a sample is the size of the sample. The central limit theorem states that increases in sample size increase the probability of a variable having a normal distribution. A sample of 231 producers can be considered to be a sufficiently large sample. In addition to the assumption of normality, an assumption is made that all observations are independent.

A paired t-test is used to compare the difference between the variability of the two programs for each of the 231 producers.[47] In this case, a new distribution based on the difference between the mean variation of the GRIP plus yield program and the mean variation of the yield program for each customer is established. By establishing a single distribution of individual differences and calculating the mean, and standard deviation for the 231 differences, a confidence interval for the differences may be estimated. This confidence interval is used to test if the difference in the mean variability estimates is significantly different than zero. The confidence interval is calculated as discussed earlier (equation 5.1).

[47] A paired test is required because of the design of the simulation models. Because each program is simulated for the same individuals, the condition of independence between the two distributions is not met.

The 95 percent confidence interval for this two-tailed paired t-test is (0.010 , 0.080). Zero does not fall within the confidence interval. Therefore, the mean difference is significantly different than zero. The variability of the coverage to eligible cost ratio is greater with the combination GRIP and yield program than with the yield program alone. It is expected that the GRIP program should provide a more constant coverage to eligible cost ratio because of the less variable price from the IMAP used to establish coverage. However a change in eligible costs will have more effect on the deviation of the GRIP ratio than it does on the deviation of the yield ratio because of the greater level of coverage provided by the GRIP program.

Testing of this first hypothesis has provided evidence in support of the hypothesis. The crop cost programs by design establish consistent coverage to eligible cost ratios of 0.8, 1.0, and 1.2 with no variability (i.e., a standard deviation of 0.0). Also of interest, are the findings that yield coverage is on average greater than eligible costs, and that the GRIP plus yield coverage provides a greater level of coverage as a percentage of eligible costs with significantly greater variability, than does the yield program.

5.3 Stability of Gross Margins

The second hypothesis is designed to test for the stability of gross margins under alternative programs. A similar procedure to that used in the previous section is utilized here. The mean and standard deviation of the gross margin per acre are calculated for each insurance program, for each producer, over the ten years. Because of the model design it is known that each insurance program balances at the end of the ten year period.

Therefore, it is also known that the net gross margin for any one producer at the end of the ten years will be the same regardless of insurance program. What is of greatest interest, therefore, is the variability of the gross margin from one year to the next.

Because of the variation in total acres for a single producer from one year to the next, the average gross margin using a simple average may not equal the net gross margin at the end of the ten years. Although it would be possible to use a weighted average of gross margins, it is more helpful to review the problem on an individual gross margin per acre decision basis. In any given year the producer anticipates a certain gross margin per acre for a crop. To an extent, the producer expects the gross margin for a certain crop to be is equally likely if one hundred or one thousand acres of the crop are grown.[48] Given that the purpose of the analysis is to evaluate the stability of gross margins from the producers standpoint, the use of a simple average is appropriate.

As in the previous analysis, the natural log of the standard deviation is used as the estimate of mean variability in gross margins for each producer over the ten year period. The two distributions of variability values are compared by individual producer to create a distribution of differences in mean variability values. A paired t-test is again used to compare the mean variability of several pairs of insurance program choices to discover if the difference in means is significantly different from zero.

The program combinations chosen for comparison are selected on the basis of anticipated similar performance in gross margin stability. Table 5.5 outlines the comparisons made, the sample mean difference in gross margin variability, the paired t-

[48] Of course, if economies of size exist, this assumption may not be strictly valid.

test standard deviation, the 95 percent confidence interval and the result of the test for equal variability in gross margins.

Table 5.5 Paired Comparison in Gross Margin Stability *

Comparison	Mean Difference	Paired Standard Deviation	95 Percent Confidence Interval	Significant Difference
basket crop cost 80 vs yield	0.0613	0.0070	0.0476, 0.0750	yes
basket crop cost 100 vs yield	-0.0460	0.0089	-0.0634, -0.0285	yes
basket crop cost 120 vs GRIP+	0.3617	0.1679	0.0326, 0.6908	yes
basket crop cost 100 vs crop cost 100	0.2750	0.0030	0.2692, 0.2808	yes

* Significant difference is established if the value zero is not within the confidence interval.

The results from Table 5.5 imply a number of important points and leave a few questions unanswered. One result is that the crop cost 80 percent basket coverage creates more variability in gross margins than does the yield based system. Therefore, in terms of gross margin variability the yield system would be considered superior to crop cost 80 percent basket coverage. Comparing the crop cost 100 percent basket coverage to the yield system, it can be seen that with 95 percent confidence the crop cost 100 percent coverage provides less gross margin variability than the yield program. Therefore, the crop cost system can be considered to be superior in terms of reducing gross margin variability. Comparing the crop cost at 120 percent basket coverage to the GRIP plus yield program, it can be seen that the crop cost program provides greater gross margin variability. Therefore, the GRIP plus yield program would be considered superior in terms of reducing gross margin variability.

The comparison between crop cost 100 percent basket versus non-basket provides an unexpected result. The basket version provides greater gross margin variability than the non-basket version. In terms of gross margin stability only, the non-basket version would be considered superior. A priori, it could be expected that the basket version would preform better, due to the income sharing between crops prior to payouts. The basket approach at 100 percent coverage, by design of the basket approach, is anticipated to make fewer payouts and require lower premiums than the non-basket 100 percent coverage. The source of this misconception has been mentioned earlier; that is, the basket coverage cannot be directly compared with the non-basket program in terms of level of coverage. By design, the two programs behave quite differently. Although it is not appropriate to compare the two programs in terms of their level of coverage, the comparison of gross margin stability is appropriate.

From the five comparisons in Table 5.5 several additional comparisons can be considered for further investigation. These are outlined in Table 5.6.

Based on the observation of the basket to non-basket coverage from the crop cost 100 percent coverage in Table 5.5, a comparison is made between both the crop cost non-basket 80 percent and 100 percent coverage to the yield program in Table 5.6. Again the crop cost 80 percent does not provide enough gross margin stability to be considered

Table 5.6 Paired Comparison in Gross Margin Stability *

Comparison	Mean Difference	Paired Standard Deviation	95 Percent Confidence Interval	Significant Difference
I cc80 vs yield	0.0190	0.0067	0.0059, 0.0321	yes
I cc100 vs yield	-0.0730	0.0079	-0.0885, -0.0575	yes
B GRIP+ vs GRIP+	-0.0820	0.0113	-0.1041, -0.0599	yes

I cc80 = crop cost 80 percent individual coverage
I cc100 = crop cost 100 percent individual coverage
B GRIP+ = Basket GRIP plus yield coverage
GRIP+ = Individual GRIP plus yield coverage

* Significant difference is established if the value zero is not within the confidence interval.

equal to the yield system. The crop cost non-basket version is an improvement over the yield program in terms of gross margin variability. With the recent establishment of the GRIP program there has been some discussion as to whether the program should be basket or individual crop based. From Table 5.6 it can be seen that in spite of the differences in how coverage is defined, the basket version of GRIP plus yield provides better stability for gross margins than the non-basket version. This observation is the reverse of the crop cost 100 percent coverage basket versus non-basket result. Due to the high levels of coverage provided on several occasions, for many producers the GRIP program paid out on all crops in the same year. As a result, the total payouts for the basket version are near the level of payouts for the non-basket version. The premium for the basket and non-basket versions are also very similar. Referring back to Table 5.1, it can be seen that GRIP basket premiums are 96 percent (19.63/20.37) of the GRIP individual premiums, while for the crop cost 100 percent coverage in our earlier example basket premiums are 70 percent (3.96/5.64) of non-basket premiums. For the GRIP program, the advantage of providing coverage at the basket level outweighs the reduced dollars available for payouts.

From the second hypothesis it can be seen that the crop cost program at 80 percent coverage, in both the basket and non-basket approaches, does not provide the same gross margin stability as the yield program. However, the crop cost program at 100 percent coverage with both the basket and non-basket approaches provide an improvement in gross margin stability over the yield program. It is also seen that the crop cost program at 120 percent basket coverage is not as effective as GRIP plus yield at stabilizing gross margins. Hypothesis two is therefore only partially supported, as the crop cost option is able to provide greater gross margin stability than the yield program only.

5.3.1 Premium Costs

At this point, only comparisons in gross margin variability have been made. To relate the ability of each program to reduce gross margin variability to the cost of coverage or premium required, an analysis is done on comparative premiums for each of the combinations of programs tested earlier.

The mean premium per acre for each producer is calculated for each insurance program. A paired t-test is used to compare the mean premiums of each program over the ten years for each producer. The difference in mean premiums for all 231 producers is tested to determine if the difference is statistically different than 0.0 . Because this paired analysis is done using means rather than a measure of variability, using the natural log of observation is not required. A summary of those results is displayed in Table 5.7.

Table 5.7 Paired Comparison of Premium Costs ($/acre) *

Comparison	Mean difference	Paired Standard Deviation	Confidence Interval as percent	Significant Difference
B cc80 vs yield	-2.7409	0.1618	-3.0580, -2.4239	yes
B cc100 vs yield	-0.1966	0.2108	-0.6098, 0.2166	no
B cc120 vs GRIP+	-16.2120	0.4477	-17.0895, -15.3345	yes
B cc100 vs I cc100	-1.6811	0.0789	-1.8357, -1.5265	yes
I cc80 vs yield	-1.5090	0.1522	-1.8073, -1.2106	yes
I cc100 vs yield	1.4845	0.2078	1.0773, 1.8918	yes
B GRIP+ vs GRIP+	-19.2116	0.1277	-19.4619, -18.9613	yes

B cc80 = crop cost 80 percent basket coverage
B cc100 = crop cost 100 percent basket coverage
B cc120 = crop cost 120 percent basket coverage
I cc100 = crop cost 100 percent individual coverage
I cc80 = crop cost 80 percent individual coverage
B GRIP+ = GRIP plus yield basket coverage
GRIP+ = GRIP plus yield coverage

* Significant difference is established if the value zero is not within the confidence interval.

Based on the statistical comparisons made in Table 5.7, it is established that the premiums for the crop cost program at 80 percent basket coverage are lower than the yield premiums. The premiums for the crop cost program at 100 percent basket coverage are considered not statistically different than the premiums for the yield program. The crop cost 120 percent basket coverage has a significantly lower premium per acre than the GRIP plus yield program. The 100 percent crop cost program has a significantly lower premium as a basket versus a non-basket program. The crop cost 80 percent and 100 percent programs with non-basket coverage are significantly lower and higher, respectively, than the premiums for the yield program. The GRIP program on a basket basis requires a significantly lower premium than the GRIP program on a non-basket basis. Table 5.8 combines the significant information from Tables 5.5, 5.6 and 5.7.

Table 5.8 Gross Margin and Cost Comparison *

Comparison	Gross Margin Stability	Cost
Basket Crop Cost 80 vs Yield	Lower	Lower
Basket Crop Cost 100 vs Yield	Greater	Same
Basket Crop Cost 120 vs Grip +	Lower	Lower
Basket Crop Cost 100 vs Crop Cost 100	Lower	Lower
Individual Crop Cost 80 vs Yield	Lower	Lower
Individual Crop Cost 100 vs Yield	Greater	Higher
Basket GRIP+ vs GRIP+	Greater	Lower

* GRIP+ = GRIP plus yield program

Only two comparisons provide conclusive results. The crop cost 100 percent basket coverage program provides better gross margin stability than does the yield program, at the same price per acre. GRIP plus yield coverage on a basket basis provides better gross margin stability at a lower price than does the non-basket GRIP plus yield coverage. With each of the other comparisons of programs there is a trade-off between greater gross margin stability and premium costs. There are no other comparisons where one program is clearly superior in both categories. In terms of the second hypothesis, then, the crop cost approach is able to provide greater gross margin stability than the yield program, with no significant difference in price.

5.4 Financial Exposure to MCIC

The third hypothesis provides an opportunity to analyze the total financial exposure of MCIC for each of the alternative programs over the ten years being studied. The totals for all premiums received minus payouts distributed are summarized in Table 5.9.

Because of the design of each of the insurance models, it is known that the average premium minus payout for each insurance program is equal to zero. Of most interest under these circumstances is the variability of the surplus and/or deficit and the extreme values for net differences on an individual year and cumulative basis. Premiums and payouts are in gross terms and no averages or deviations are calculated. Consideration was given to estimating the deviation of net income for each of the programs over the ten years but, given the small sample size (i.e., only ten years), the statistical test for variability is likely not appropriate. Therefore, the maximum and minimum financial requirements of each program over the ten years are examined and compared.

Table 5.9 Net Financial Demands to MCIC by Program ($ 000's)

Year	Basket Yield Net	Basket GRIP Net	Basket GRIP+ Net	Basket CC80 Net	Basket CC100 Net	Basket CC120 Net	Individ Yield Net	Individ GRIP Net	Individ GRIP+ Net	Individ CC80 Net	Individ CC100 Net	Individ CC120 Net
81	139	1561	1699	104	309	633	170	1321	1491	163	355	649
82	308	1608	1917	155	412	869	330	1213	1543	138	387	798
83	338	1585	1923	170	440	821	447	1366	1813	258	532	845
84	334	865	1199	174	471	927	390	728	1118	277	562	941
85	402	2260	2662	191	533	1128	168	2095	2262	311	688	1276
86	388	-2632	-2244	170	419	677	619	-2399	-1779	257	511	675
87	192	-2288	-2096	-192	-644	-1659	145	-2211	-2066	-450	-1052	-1961
88	-1490	-1389	-2879	-380	-1028	-1891	-1638	-1115	-2753	-523	-1182	-1968
89	-1046	-2430	-3476	-586	-1442	-2584	-1133	-1967	-3101	-689	-1385	-2345
90	435	860	1296	193	530	1078	503	969	1471	257	584	1092
Maximum	435	2260	2662	193	533	1128	619	2095	2262	311	688	1276
Minimum	-1490	-2632	-3476	-586	-1442	-2584	-1638	-2399	-3101	-689	-1385	-2345
Standard Deviation	683	1947	2363	283	743	1437	756	1722	2136	390	841	1459

GRIP+ - GRIP plus yield program
CC80 - Crop cost 80 percent coverage
CC100 - Crop cost 100 percent coverage
CC120 - Crop cost 120 percent coverage
Individ- Non-basket coverage

It can be seen that the highest annual net surplus and the highest annual net deficit is for the GRIP plus yield program on a basket basis. The lowest annual net surplus and the lowest annual net deficit are both associated with the crop cost 80 percent basket coverage program. Each of these results is not surprising, given the level of coverage and payouts identified in previous sections. One surprising result is that the basket GRIP plus yield program has greater extreme deficits and surpluses than the non-basket GRIP plus yield program.

The case of the smallest net payout or greatest surplus with the basket option can be easily explained. The fact that when not all crops are below the GRIP plus yield coverage level the potential payout for any one crop is reduced by the income from crops above coverage levels accounts for this result. Cases where the basket version provides the greatest net payout or deficit in one year can be explained by a combination of two factors. The first is that in any year where the production income of each crop is below the coverage level, the payout under the basket and non-basket programs will be the same (i.e., there is no opportunity to share the gains from other crops because all crops are below coverage levels). Secondly, given that in most years this does not occur (i.e., at least one crop has a production income above the coverage level), the premium paid per acre will be lower for the basket program than for the non-basket program. Therefore, in a year of low prices when all crops are eligible for payouts, the basket system will provide the same payout, but will have collected fewer premium dollars. Consequently, the net annual deficit will be larger than for the non-basket version in that year.

Based on Table 5.9, Figures 5.1 and 5.2 demonstrate a graphical comparison of the various combinations of programs and the financial requirements of MCIC over the ten years of each program.

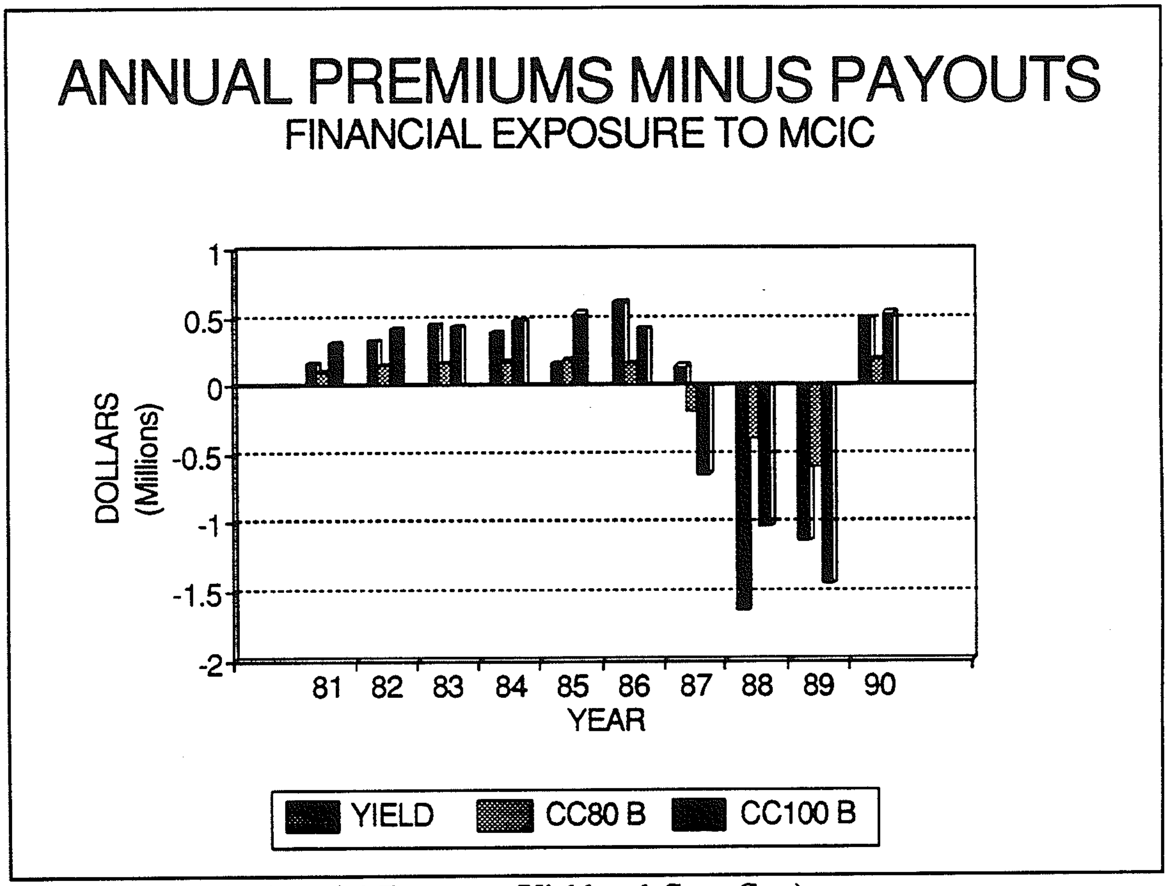

Figure 5.1 MCIC Financial Exposure (Yield and Crop Cost)

From Figure 5.1 it can be seen that the crop cost program at 80 percent basket coverage (CC80) clearly has much lower financial requirements than the crop cost 100 percent basket coverage (CC100) or the yield coverage (YIELD). Looking at the direct comparison between the yield and crop cost 100 percent basket coverage, it is noticeable that the two programs follow each other quite closely with the exception of 1985, 1987 and 1989. Each of the programs runs an annual surplus until 1987. In 1987, the yield program continues to build on the surplus by collecting more premiums than are distributed as payouts. The crop cost program paid out more than it took in through premiums drawing from the cumulated surplus.

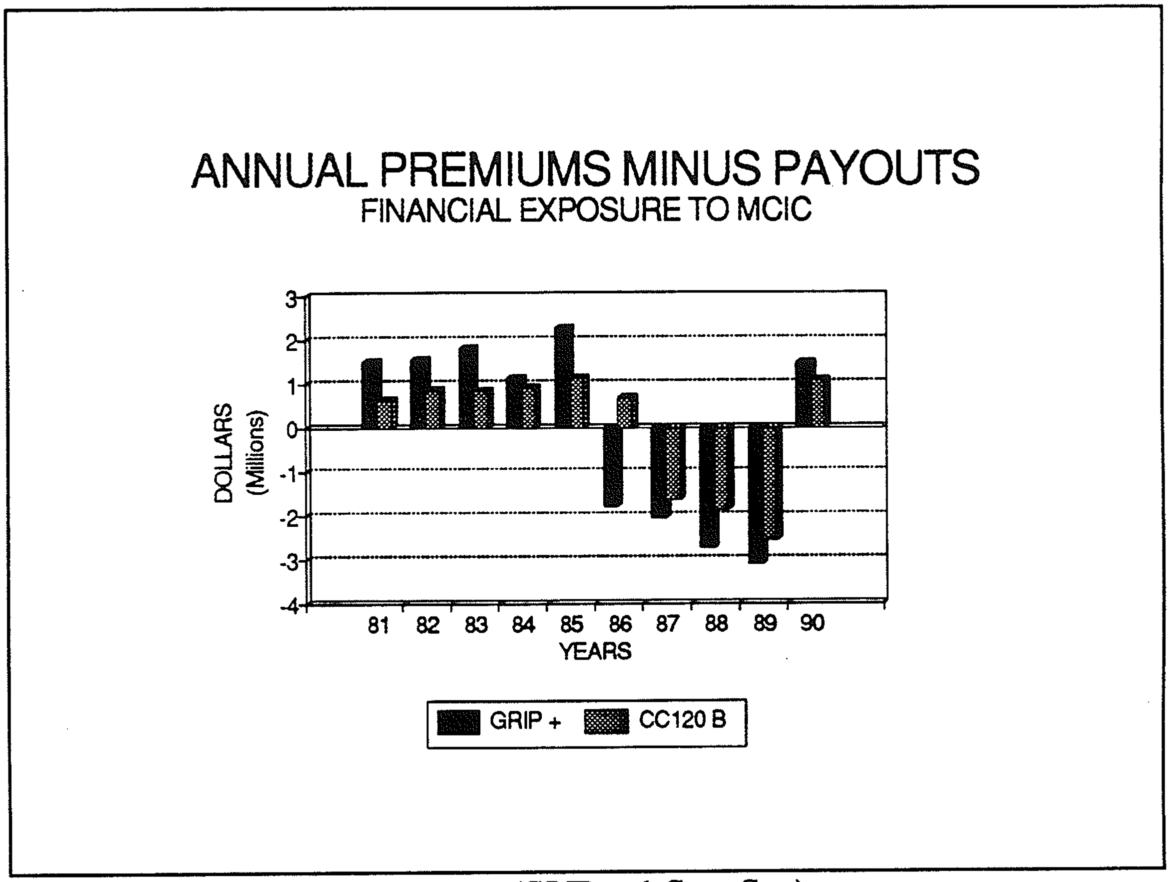

Figure 5.2 MCIC Financial Exposure (GRIP and Crop Cost)

Given the similar levels of coverage the two programs are intended to provide, differences in payouts from one year to the next need to be explained on the basis of how payouts are triggered. As an example, for any given yield below the yield coverage level, as prices rise the yield model will make increasing payouts while the crop cost model will make increasingly smaller payouts. Alternatively, when prices are declining the yield model will make smaller payouts and the crop cost model will make increasingly larger payouts. Referring to Figure 5.1 and Table 5.10 over the years 1987 to 1989, the following scenario seems to have occurred. In 1987, average yields were near normal, thus triggering few yield payouts whereas average prices had just dropped thus triggering a more substantial crop cost payout than yield payout. In 1988 yields dropped substantially but crop prices were up. This created the environment where yield payouts would be higher than crop cost payouts. In 1989 yields improved but prices declined, triggering proportionately greater crop cost payouts than yield payouts.

Table 5.10 Yield and Price of Wheat from 1987 to 1989 *

	1987	1988	1989
Wheat Prices	$ 3.13	4.88	4.11
Average Wheat Yields	26.9	17.6	24.2

Source: Statistics Canada and MCIC

* Wheat prices based on #2 CWRS prairie average and wheat yield are based on combined yields of risk areas two and six

As discussed in the background section of this study the producer's true financial risk is the cost incurred to produce the crop. The crop cost program follows more closely the cost requirements of the producer by paying out only in the years when income is inadequate. This allows a more efficient use of premium dollars.

From Table 5.9 and Figure 5.2 it can be seen that the GRIP program (GRIP+) requires greater financial commitment and financial risk to the MCIC than the crop cost 120 percent basket coverage (CC120). In all years but 1986, both of the programs run either a surplus or deficit. Prices declined significantly in 1986 and although yields were quite good, the IMAP was near its peak level and the GRIP program paid out a proportionately larger amount than it took in through premiums. Conversely the crop cost model took in more premiums than it distributed in payouts.

Figure 5.3 illustrates the cumulative premium minus payout balance for each of the programs over the ten years. As designed, the net balance at the end of the ten years is equal to zero for each program. Although this scenario shows a span of years where MCIC spends most of the time with a surplus, in any other given time period there is just as great a likelihood that the majority of payouts could be required in the earlier years rather than the later years.

The third hypothesis is inconclusive as a result of this analysis. The crop cost 80 percent coverage presents the least exposure to MCIC, crop cost 100 percent coverage presents similar exposure to the corporate to the yield program, and crop cost 120 percent coverage provides less financial exposure to MCIC than the combined GRIP and yield programs.

5.5 The Influence of Input levels

The fourth hypothesis is designed to test whether being a high or low input producer has any impact on the effectiveness of the alternative insurance programs. Particular attention is paid to relative premium rates. The sample population was divided in half based on average eligible cost per acre. Table 5.11 outlines some of the general comparisons of premiums, coverage and premiums as a percentage of coverage.

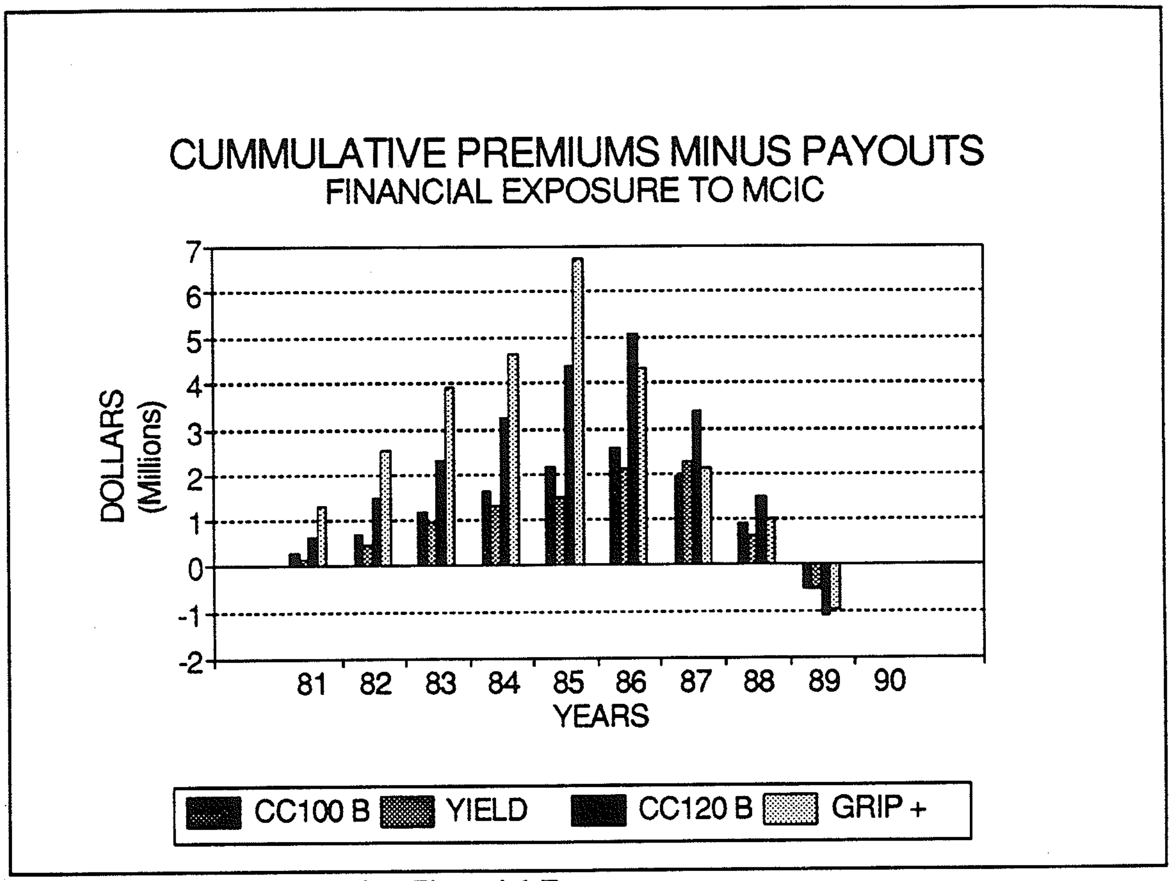

Figure 5.3 MCIC Cumulative Financial Exposure

The result of most significance is that under all insurance programs, producers with higher inputs have a higher level of coverage and lower premium rates than average or lower input producers. The one exception to this is the GRIP premium. However, when premiums are reviewed as a percentage of coverage, all program premiums are lower for the high input producers, including the GRIP premium. This is an important finding in terms of the crop cost program. It provides an indication that high input farms in general may have a lower risk of claiming than lower input farmers and the additional expense for inputs may be providing increased financial stability rather than increased

Table 5.11 Premium and Coverage Summary by Input Level ($/acre)

			All Producers		High Input		Low Input	
			Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
	Eligible	Cost	77.45	5.46	81.64	2.83	73.22	4.01
No Insurance	Gross	Margin	41.97	14.33	44.47	14.71	39.46	13.53
Individual	Yield	Premium	4.15	2.69	4.05	2.89	4.25	2.47
Individual	GRIP	Premium	20.37	3.83	21.13	3.79	19.61	3.72
Basket	CC80	Premium	1.41	1.93	1.11	1.74	1.72	2.07
Basket	CC100	Premium	3.96	3.45	3.51	3.52	4.40	3.33
Basket	CC120	Premium	8.31	5.21	7.82	5.46	8.81	4.92
Individual	Yield	Coverage	81.59	10.71	86.10	9.81	77.05	9.63
Individual	GRIP	Coverage	52.79	7.69	55.76	7.19	49.79	7.02
Basket	CC80	Coverage	61.96	4.36	65.31	2.27	58.58	3.21
Basket	CC100	Coverage	77.45	5.46	81.64	2.83	73.22	4.01
Basket	CC120	Coverage	92.94	6.55	97.96	3.40	87.87	4.81
Individual	Yield	Payout	4.11	2.55	4.05	2.80	4.17	2.29
Individual	GRIP	Payout	19.91	3.59	20.66	3.53	19.16	3.50
Basket	CC80	Payout	1.40	1.92	1.14	1.80	1.67	1.99
Basket	CC100	Payout	3.85	3.39	3.46	3.50	4.24	3.24
Basket	CC120	Payout	8.05	5.11	7.65	5.41	8.46	4.79
Yield	Premium	Percent	5.21%	3.43%	4.84%	3.57%	5.58%	3.25%
GRIP	Premium	Percent	38.68%	5.39%	37.92%	5.09%	39.44%	5.59%
CC80	Premium	Percent	2.33%	3.21%	1.70%	2.66%	2.96%	3.59%
CC100	Premium	Percent	5.17%	4.53%	4.30%	4.31%	6.04%	4.59%
CC120	Premium	Percent	9.01%	5.69%	7.98%	5.57%	10.05%	5.64%
GRIP+	Premium	Percent	18.34%	3.18%	17.82%	3.21%	18.86%	3.08%

GRIP+ = GRIP plus yield
Premium Percent = premium as a percentage of coverage

Average = average of each producers average observation
Standard Deviation = deviation of average observations

financial risk.[49] In the process of setting premiums for the crop cost model, high input

[49] This would of course depend upon the inputs being increased.

producers may not need to be considered a higher risk even though they have the potential for a greater claim under a crop cost system.

When comparing yield coverage for the high input producer versus the low input producer, it can seen that average coverage for high yield producers is 12 percent (86.10/77.05) higher than for low input producers. Consequently, yields are 12 percent higher for the high input producer.

To review the gross margin variability of programs for high and low input producers the average and standard deviations of gross margins are calculated for each of the sub-samples. Table 5.12 and Figure 5.4 provide some comparisons between high input, low input and the total producer sample population. One of the most interesting observations in all alternative insurance programs is that without exception, the average gross margin for high input producers is higher than that for the lower input producers. The average standard deviation of the gross margins is without exception greater for the lower input producer.

Table 5.12 Variation in Gross Margins of Insurance Programs by Level of Input ($/acre)

	Input Level	Basket Yield	Basket GRIP	Basket CC80	Basket CC100	Basket CC120	No Insurance	Individual Yield	Individual GRIP	Individual CC80	Individual CC100	Individual CC120
Average GM	High	44.43	43.94	44.50	44.42	44.29	44.47	44.46	43.99	42.77	44.40	44.28
Average Std Dev	High	28.82	14.58	30.39	27.47	23.33	32.17	28.29	15.81	29.03	26.47	22.82
Average GM	Low	39.35	38.81	39.41	39.30	39.11	39.46	39.38	38.92	38.08	39.29	39.16
Average Std Dev	Low	29.70	16.04	30.99	27.86	23.84	33.59	29.38	17.24	29.85	27.41	23.83

Average GM = Average of Each Producers Average Gross Margin

Average Std Dev = Average of Each Producers Standard Deviation of Gross Margins

From Figure 5.4 it can be seen that the high input producers show a slight tendency toward lower gross margin variability. This is consistent for each of the programs reviewed, and appears to be influenced in a similar manner by each of the programs.

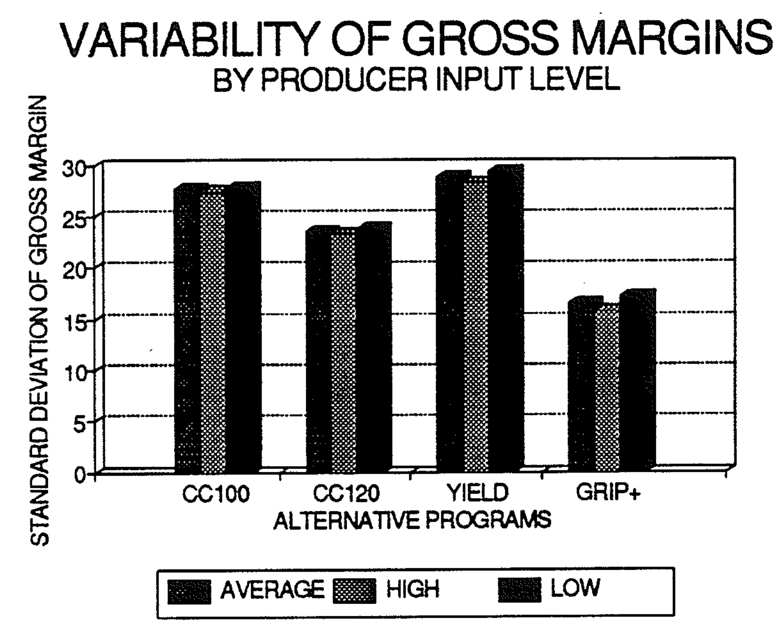

Figure 5.4 Gross Margin Variability by Input Level

Based on the analysis performed in the second hypothesis, the variability of gross margins between specific pairs of programs is performed on each subset of high and low input producers. The procedure used is consistent with the discussion in Section 5.3. The results of this analysis is presented in Table 5.13

Table 5.13 Paired Comparisons in Gross Margin Stability by Input Level *

High Input Comparison	Mean Difference	Paired Standard Deviation	95 Percent Confidence Interval	Significant Difference
basket crop cost 80 vs yield	0.0700	0.0098	0.0508, 0.0892	yes
basket crop cost 100 vs yield	-0.0340	0.0133	-0.0601, -0.0079	yes
basket crop cost 120 vs GRIP+	0.3990	0.0255	0.3490, 0.4490	yes
basket crop cost 100 vs crop costs 100	0.0043	0.0043	-0.0041, 0.0127	yes
Low Input Comparison				
basket crop cost 80 vs yield	0.5260	0.0099	0.5066, 0.5454	yes
basket crop cost 100 vs yield	-0.5730	0.0117	-0.5959, -0.5501	yes
basket crop cost 120 vs GRIP+	0.3246	0.0214	0.2827, 0.3665	yes
basket crop cost 100 vs crop cost 100	0.0170	0.0107	-0.0040, 0.0380	yes

GRIP+ = GRIP plus yield coverage

* Significant difference is established if the value zero is not within the confidence interval.

Table 5.13 shows that the results found with both the high input and low input producers is completely consistent with the original observations. Input cost levels do not influence the preference for any of the program choices as presented. It is important to note that input costs have been derived in a very standardized fashion and the true distribution of producers based on input cost may be different than those used in this study.

In relation to fourth hypothesis it is seen that high input producers have higher gross margins, lower variability in gross margins and ultimately lower premiums as a percentage of coverage for each program. It was anticipated that premiums would be equal therefore the fourth hypothesis is refuted.

5.6 The Influence of Risk Area

The fifth hypothesis is designed to discover if being a high or low risk area has any impact on the benefit to the producer of the alternative insurance programs. The sample population is divided based on whether their primary land base is in a higher risk area (Risk Area 2) or a lower risk area (Risk Area 6). Some general observations of coverage, premiums and premiums rates (premium/coverage) are outlined in Table 5.14.

There are a number of interesting observations that can be made from Table 5.14. Firstly, premiums for all programs are lower for the low risk area than for the higher risk area. The low risk area also has higher eligible costs and a higher level of coverage for all insurance programs, with the exception of the GRIP coverage.[50] In the case of GRIP coverage, however, the combined yield and GRIP coverage is higher than for the high risk area. In general, these results are not surprising. The low risk area has higher yields and less potential for crop failure. Therefore, it could be expected that this area would have

[50] This may be the result of a difference in the crops grown within each region.

Table 5.14 Premium and Coverage Summary by Risk Area ($/acre)

			All Producers		Low Risk Area		High Risk Area	
			Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
	Eligible	Cost	77.45	5.46	78.44	4.90	76.39	5.83
Gross	Margin	No Insurance	41.97	14.33	41.19	14.25	42.81	14.43
Individual	Yield	Premium	4.15	2.69	3.94	2.73	4.37	2.63
Individual	GRIP	Premium	20.37	3.83	19.58	3.74	21.22	3.75
Basket	CC80	Premium	1.41	1.93	1.33	1.85	1.50	2.01
Basket	CC100	Premium	3.96	3.45	3.68	3.41	4.25	3.48
Basket	CC120	Premium	8.31	5.21	7.77	5.35	8.89	5.03
Individual	Yield	Coverage	81.59	10.71	82.36	10.25	80.78	11.16
Individual	GRIP	Coverage	52.79	7.69	52.20	7.13	53.42	8.23
Basket	CC80	Coverage	61.96	4.36	62.75	3.92	61.11	4.66
Basket	CC100	Coverage	77.45	5.46	78.44	4.90	76.39	5.83
Basket	CC120	Coverage	92.94	6.55	94.13	5.88	91.67	7.00
Individual	Yield	Payout	4.11	2.55	3.99	2.65	4.23	2.45
Individual	GRIP	Payout	19.91	3.59	19.21	3.42	20.66	3.63
Basket	CC80	Payout	1.40	1.92	1.38	1.91	1.43	1.93
Basket	CC100	Payout	3.85	3.39	3.70	3.49	4.02	3.28
Basket	CC120	Payout	8.05	5.11	7.70	5.46	8.42	4.71
Yield	Premium	Percent	5.21%	3.43%	4.95%	3.56%	5.49%	3.26%
GRIP	Premium	Percent	38.68%	5.39%	37.60%	5.80%	39.83%	4.66%
CC80	Premium	Percent	2.33%	3.21%	2.18%	3.11%	2.49%	3.32%
CC100	Premium	Percent	5.17%	4.53%	4.73%	4.47%	5.64%	4.57%
CC120	Premium	Percent	9.01%	5.69%	8.29%	5.80%	9.78%	5.49%
GRIP +	Premium	Percent	18.34%	3.18%	17.59%	3.07%	19.13%	3.12%

GRIP+ = GRIP plus yield
Premium Percent = premiums as a percentage of coverage

Average = average of producers average observation
Standard Deviation = deviation of average observations

higher coverage levels and lower premiums for each program. The crop cost program responds as expected.

A review of gross margin stability for each of the risk areas is also made. Table 5.15 and Figure 5.5 provide some comparisons between the lower risk area, the higher risk area, and the total population.

It can be seen that, without exception, the mean gross margin and the variation in gross margins are lower for the low risk area, under all insurance alternatives. Although the difference in average gross margins is quite small, it is reasonable to expect that the lower risk area would have greater average gross margins. It is also important to note that the low risk area is potentially more diversified than the high risk area and a number of crops may have been eliminated from the sample, given the restrictions in crops used for this study.

It was expected that the variability of gross margins would be higher for the high risk area and the above results indicate that this is true. From Figure 5.5 it can be seen that producers from the low risk area show a tendency toward lower gross margin variability and do so for each of the programs reviewed. They appear to be influenced in a similar manner by each of the programs.

Table 5.15 Variation in Gross Margins of Insurance Programs by Risk Area ($/acre)

	Risk Area	Basket Yield	Basket GRIP	Basket CC80	Basket CC100	Basket CC120	No Insurance	Individual Yield	Individual GRIP	Individual CC80	Individual CC100	Individual CC120
Average GM	Low	41.23	40.84	41.24	41.21	41.12	41.19	41.24	40.88	39.74	41.20	41.11
Average Std Dev	Low	26.78	13.77	28.32	25.41	21.43	30.58	26.38	14.79	27.14	24.61	21.10
Average GM	High	42.62	41.97	42.74	42.58	42.34	42.81	42.66	42.10	41.17	42.56	42.40
Average Std Dev	High	31.89	16.94	33.20	30.06	25.87	35.31	31.43	18.36	31.88	29.41	25.69

Average GM = Average of Producers Average Gross Margins

Average Std Dev = Average of Producers Standard Deviation of Gross Margins

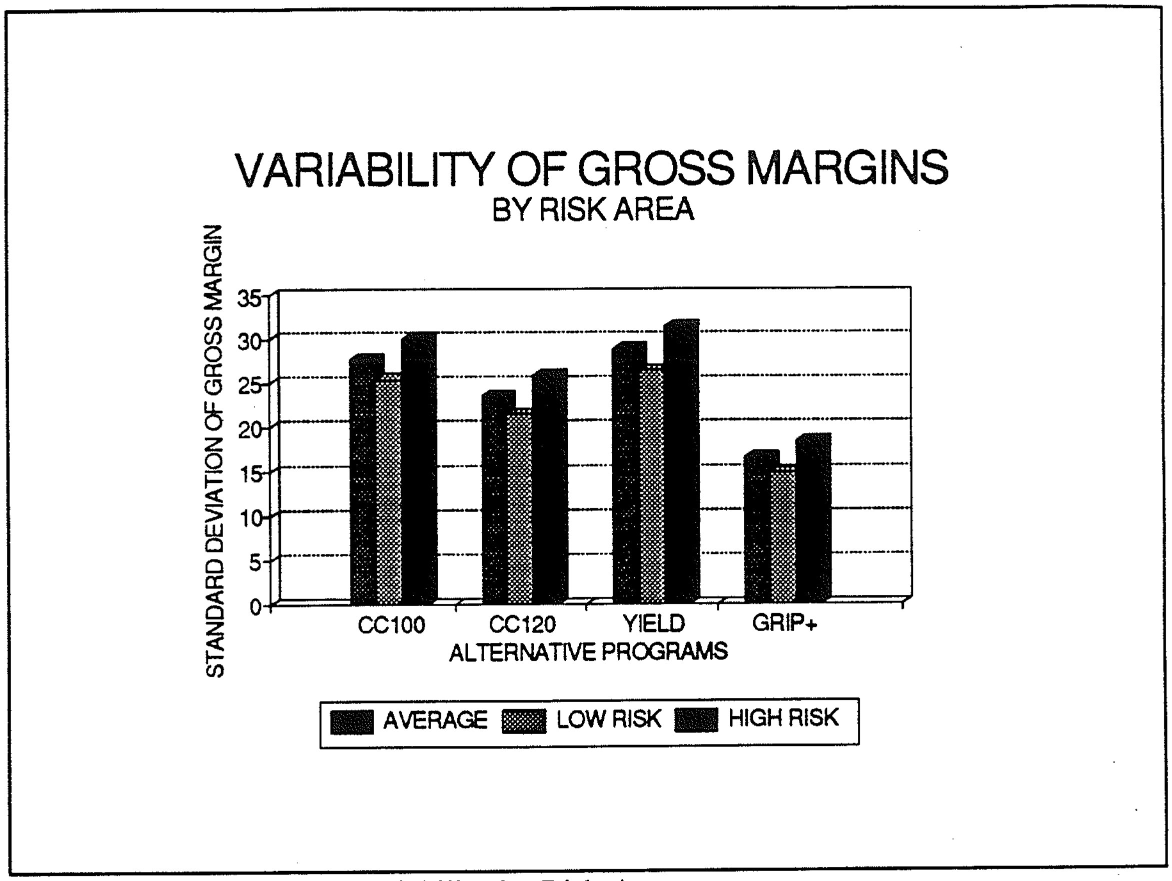

Figure 5.5 Gross Margin Variability by Risk Area

Based on the analysis performed for the second hypothesis in Section 5.3, comparing the variability of gross margins between specific pairs of programs, an identical analysis is performed on each subset of high and low risk producers. The results of this analysis is presented in Table 5.16.

It can be seen that the results for the high risk and low risk area are completely consistent with the original analysis. The effect of different levels of risk by area does not influence the relative ranking of program choices as previously presented. In terms of the fifth hypothesis, it is confirmed that in the case of the crop cost 100 percent

Table 5.16 Paired Comparisons in Gross Margin Stability by Risk Area *

High Risk Area Comparison	Mean Difference	Paired Standard Deviation	95 Percent Confidence Interval	Significant Difference
basket crop cost 80 vs yield	0.0700	0.0095	0.0514, 0.0886	yes
basket crop cost 100 vs yield	-0.0380	0.0112	-0.0600, -0.0160	yes
basket crop cost 120 vs GRIP+	0.3830	0.0238	0.3364, 0.4296	yes
basket crop cost 100 vs crop cost 100	0.0330	0.0040	0.0252, 0.0408	yes
Low Risk Area Comparison				
basket crop cost 80 vs yield	0.0510	0.0101	0.0312, 0.0708	yes
basket crop cost 100 vs yield	-0.0550	0.0139	-0.0822, -0.0278	yes
basket crop cost 120 vs GRIP+	0.3390	0.0236	0.2927, 0.3853	yes
basket crop cost 100 vs crop cost 100	0.0210	0.0043	0.0126, 0.0294	yes

GRIP+ = GRIP plus yield coverage

* Significant difference is established if the value zero is not within the confidence level.

coverage program, gross margin stability is improved for both the high risk area and low risk area in comparison to the yield program. The crop cost program at 120 percent coverage could not provide as much gross margin stability as the GRIP plus yields system for either the high or the low risk areas.

5.7 Predictability of Premiums

The sixth hypothesis is designed to provide an indication of the predictability in premiums between the GRIP program without the yield component, and the crop cost program at 120 percent basket coverage.[51] An estimate of the variability of a payout to coverage ratio is made for each producer over the ten years. Again, this measure of variability is based on the natural log of the standard deviation. The difference in mean variability estimates for each producer is used in a paired t-test to determine if the difference is significantly different than zero. Table 5.17 outlines the results of the paired test.

Table 5.17 Comparison of Payout to Coverage Variability

	Mean Ratio GRIP	Mean Ratio CC120	Standard Deviation Ratio GRIP	Standard Deviation Ratio CC120	Difference in Standard Deviation
Average	0.356	0.086	0.324	0.143	0.941
Standard Deviation	0.048	0.055	0.064	0.071	0.051*
Confidence Interval (0.932, 0.950)					

CC120 = crop cost 120 percent basket coverage
Difference in Standard Deviation = The difference in the natural log of the standard deviation
* Paired standard deviation
Confidence Interval based on a 95 percent confidence two tail t-test.

[51] Because premiums are established for the GRIP program on an independent actuarial basis, it is important to compare the crop cost system to the GRIP program independent of the yield program.

From Table 5.17 it can be seen that the mean difference in variability estimates for the two programs is 0.941 with a paired standard deviation of 0.051. The 95 percent confidence interval for a two tailed test is plus or minus 0.099. Therefore, the difference between the two mean variations is significantly different than zero. Although this explains very little about the exact methodology required to set premiums, it is an important point to establish.

MCIC normally sets premiums based on a historical or anticipated loss to cost ratio. Results from this analysis now support that the crop cost program has less variability in the payout to coverage ratio than the GRIP program. This suggests that potential premiums for the crop cost program will most likely fall within a narrower range of possibilities than for the GRIP program. As a result, it should be no more difficult to predict a premium for the crop cost program than for the GRIP program. Table 5.7 also confirms that the variability of net premiums and payouts are reduced with the crop cost model as compared to the GRIP model.

5.8 Discussion of Results

The analysis outlined in this section provides a variety of results within and beyond the objectives of the study. In a general overview of premiums, coverage, and payouts with each of the simulations, the crop coverage options provides a wide range of possibilities for coverage. In all cases the crop cost 80 percent basket coverage provides the least amount of coverage at the lowest cost with the smallest payouts. When compared to the yield program, the crop cost 80 percent basket coverage provides less coverage at a lower price. Producers requiring or demanding coverage at a lower level may, however, find the crop cost 80 percent coverage most suitable for their needs. Further investigation is required to assess the benefits of 80 percent coverage.

Basket coverage provides fewer payouts and requires lower premiums than the sum of individual crops for each of the programs. This is expected given the design of basket coverage. The crop cost programs are intended to operate with the basket approach only. Although some may consider that a limitation due to the lower expected payout, this study demonstrates that the maximum protection (coverage) per dollar of premium can be provided through the basket approach. The basket approach also relates more accurately to the overall farm risk. On an individual crop basis there are often cases where one crop may be triggering a payout while another could be incurring a significant profit. In terms of a baseline coverage for the whole farm that ensure that costs are covered, individual crop payouts may not have been required.

In the direct comparisons between the crop cost 100 percent basket versus non-basket, and the GRIP basket and non-basket, two important situations are identified. It is determined that gross margin stability is reduced with the basket approach when the level of coverage is low. In the case of GRIP, basket versus non-basket, the level of coverage is high and payouts are close to the same level. Because payouts are often on more than one or all crops in the GRIP basket, there are fewer opportunities to share profits between crops. As a result, premiums are lower for basket coverage but not by as much as would be the case if coverage levels were lower. The basket approach in spite of a marginal reduction in premium still provides greater gross margin stability.

In testing the first hypothesis it is seen that by design the coverage provided by the crop cost program accurately reflects the percentage of eligible costs that it was intended to cover. The yield program, although on average providing greater than 100 percent of eligible costs, does so with some degree of variability. The value of an insurance program is not only in terms of the level of coverage available but also in its ability to apply that coverage at the appropriate times. In direct comparison between crop cost at 100 percent basket coverage and yield coverage it can be seen that the crop cost applies the coverage more appropriately.

The result with the greatest importance is provided in the analysis of the second hypothesis. The crop cost 100 percent basket coverage provides significantly greater gross margin stability than the yield program and has a premium cost that is insignificantly different than yield coverage. Based on the assumption that reducing gross margin stability is beneficial, and that paying a lower cost for insurance is also beneficial, the crop cost 100 percent basket model is an improvement over the yield program as defined in this study.[52]

With each of the other program comparisons, there is a trade off between greater gross margin stability and premium cost. There are no other direct comparisons where one program is clearly superior in both categories.

The comparison of the crop cost 120 percent basket coverage to GRIP plus yield is another comparison of considerable interest. The GRIP plus yield program provides

[52] It is not specifically determined how the crop cost 100 percent basket would compare to the yield system with a basket approach. The comparison of crop cost 100 percent basket versus non-basket would indicate that basket coverage at a similar coverage level would reduce premiums and reduce gross margin stability.

greater gross margin stability but does so at a considerably higher cost. With any of the programs that have been modeled in this study, the programs are simply averaging income. It is logical that the program that receives a substantially larger premium to be redistributed, has more potential to significantly stabilize income. The important point is that the income is distributed appropriately over the years reviewed. A point worth considering when evaluating the performance of the GRIP system is that over the years reviewed the IMAP is heavily weighted with higher prices from the mid to late seventies. As IMAP prices continue to fall through the 1990's, as is anticipated, the GRIP coverage levels and premiums will drop. The scenario does potentially exist where IMAP could fall below the current market price and GRIP coverage would be reduced to little more than yield coverage only.[53]

In the comparison of programs for financial stability or exposure to risk for MCIC, it is graphically could be visually established that financial requirements for the crop cost 80 percent coverage are far lower than for any other program. Crop cost 100 percent basket coverage and yield coverage have similar financial requirements. However, their demands may occur in different years. The years in which the crop cost model pays the most are the years when payments are most required to cover the costs of production. In the years when prices are low, yield payouts are most likely lower than the crop cost payouts. Alternatively, when prices are high the yield program has a tendency to pay out more than the crop cost program.

[53] Although the total level of coverage may be same, the GRIP coverage would be based on 100 percent of average yields versus the yield coverage at 70 percent of average yields.

The financial demands of the GRIP system are far greater than the crop cost system or the yield based system. There is one year (1986) when the GRIP system pays out substantially while the crop cost 120 percent coverage maintains a net surplus for the year. Analysis of the first hypothesis shows that the GRIP plus yield coverage provides an average of 175 percent of eligible costs. It is fair to say that GRIP, given the IMAP at levels used in this study, provides coverage significantly higher than other programs and is therefore difficult to compare with other programs.

The comparison of high input to low input farmers illustrates one very important point. The premium levels for high input producers are lower than for low input producers even though the available coverage is higher. This suggests that perhaps higher input producers are not a higher risk to MCIC. In establishing the crop cost program that is based on eligible costs this is a very important consideration.

Each of the subsets of high and low input producers are analyzed in terms of the paired comparison of gross margin stability. The results of that analysis provide evidence that the benefit of alternative programs in terms of gross margin stability is not dependent on the input level of the producer.

A review of the two risk areas provides some mixed results. It was anticipated that the lower risk area would have higher gross margins and less variability in the margins. Although the variability is lower, the average gross margins are not higher. Graphically it is seen that the gross margin stability from one risk area to the other affected the yield, GRIP plus yield and crop cost programs in a similar way.

Each of the two risk areas are analyzed in terms of a paired comparison for gross margin stability, as used in the second hypothesis. The results of that analysis provides evidence that the benefit of programs in terms of gross margin stability is not dependent on the risk area of the producer.

The final hypothesis provides some evidence that the likelihood and magnitude of a payout for the crop cost 120 percent basket program is more stable than for the GRIP plan. Given that premiums are based on the anticipated payout to coverage ratios, establishing a predictable premium rate for the crop cost program should not be any more difficult than the GRIP program, provided the appropriate historical information is available.

In summary, the crop cost program shows potential to provide a variety of levels of coverage. The coverage is shown to more accurately reflect the financial risks of the producer. The basket approach shows merit in reducing premium costs and providing a minimum level of coverage. For a similar cost, the crop cost 100 percent basket coverage is able to provide gross margin stability that is superior to the yield system, over a range of input costs and risk areas. Although the financial risks to MCIC for the 100 percent crop cost basket program are similar to the yield program, the timing of the payouts are somewhat different and more closely match the financial risks of producers. High input producers appear to be less financially risky than low input producers and require lower premiums to receive a higher level of coverage. Low risk areas require lower premiums for a higher level of coverage. The results of this analysis provide some evidence that a crop cost approach should be considered as a possible alternative to the present crop insurance programs.

6.0 CONCLUSIONS

This chapter reviews the background and objectives of the study and the empirical approach used to assess the crop cost program. The significant results and conclusions of the simulation analysis are then summarized and presented. Finally, the limitations of the study, and a number of opportunities for further research are identified.

6.1 Purpose and Approach

It has been identified that grain producers have very significant price and yield risks associated with production. Crop insurance has provided one tool for the management of this risk. The traditional crop insurance program has provided yield coverage only.

Four areas are identified as limitations of the yield based insurance program: i) the yield based program is limited to yield insurance only and cannot provide adequate coverage to producers in years with low prices; ii) the yield based system cannot adequately match the appropriate coverage to the unique financial risks or variable costs to the producer; iii) there are occasions where a yield based system creates a moral hazard and influences producers to make crop selection and input use management decisions based on the insurance program; and iv) the yield system creates an opportunity for producers to selectively participate and enter the program only in the years and/or insure only the crops for which they anticipate receiving a payout.

The GRIP (Gross Revenue Insurance Plan) introduced in the 1991/1992 crop year provides coverage based on average yields and an IMAP (Indexed Moving Average Price) for total revenue protection. Although the GRIP program helps to resolve the problems of providing price insurance and eliminating selective participation, two significant problems remain: i) the GRIP program does not vary coverage according to the unique variable costs of the producer; and ii) the GRIP program provides significant opportunities for moral hazard.

Given the remaining problems associated with the yield and GRIP programs, an alternative insurance model, based on the costs of crop inputs, is proposed. The crop cost model provides coverage based on the inputs used to grow the crop. Payouts are triggered if the revenue from crop production is below the cost required to produce the crop. Premiums for the crop cost model would then be based on the historical financial performance of the farm rather than on yield performance.

The intention of this study is to develop the operational guidelines required for a crop cost program. A simulation model is then constructed for three types of insurance with coverage, premiums, and payouts being based on individual producer histories. The simulations include a yield based program, a GRIP based program designed as a complement to the yield based program, and the proposed crop cost program modeled at three rates of coverage.

An economic evaluation is conducted to establish comparisons between the crop cost and yield and/or GRIP program. The specific research objective is to discover if the crop cost model can provide equal or improved insurance coverage and income stability at an equal or reduced cost, relative to the yield and/or GRIP programs. The areas of special interest are outlined in six hypotheses and include; the efficiency and accuracy of coverage related to variable costs; the stability of gross margins; the financial exposure to MCIC; the effect of each program on high and low input producers and producers from high and low risk areas; and the predictability of setting premiums.

6.2 Simulation Results

In general, the simulations provide a range of opportunities for comparison. Overall, the crop cost approach shows promise as a potential risk management tool for producers in terms of premium cost, coverage levels and consistency. The crop cost 80 percent basket coverage is not easily comparable to the other programs due to a lower level of coverage, lower premium, lower price and reduced ability to stabilize gross margins. The most meaningful comparisons are between the crop cost 100 percent basket coverage and the yield program, and the crop cost 120 percent basket coverage and the GRIP plus yield program. Comparisons are made on the basis of ability to stabilize gross income, premium cost, effect on high and low input producers and high and low risk areas and the potential exposure to the corporation. From those comparisons there are seven areas where this study presents significant findings that provide valuable information.

6.2.1 Crop Cost 100 Percent Coverage versus Yield Coverage

The finding of greatest significance demonstrates that the crop cost insurance program at 100 percent basket coverage provides improved gross margin stability relative to the yield program, at an insignificant difference in cost. The reduction in gross margin variability is consistent for high and low input producers as well as for low and high risk areas. There were no specific tests done to determine what portion of this result was due to the basket effect or the crop cost program. It is anticipated, however, that if the comparison were made to the yield program with the basket approach, the basket effect would reduce gross margin stability and premium cost at a similar level of coverage, as was evidenced in the comparison of the crop cost 100 percent basket and non-basket comparison.

6.2.2 Crop Cost 120 Percent Coverage versus GRIP plus Yield Coverage

The 120 percent crop cost basket coverage program provides the closest alternative to the GRIP plus yield program. The GRIP and yield program provides greater gross margin stability, but does so at a greater premium cost. On average the GRIP plus yield premium for non-basket coverage is \$24.74 per acre and provides an average total coverage of 175 percent of eligible cash costs on an individual crop basis. The crop cost 120 percent coverage provides coverage at 120 percent of eligible costs on a basket basis, as per design, at a cost of \$8.31 per acre. Clearly, over the years of this simulation the GRIP plus yield program provides coverage well beyond the input or variable costs of the producer. Although, the crop cost program could be scaled up to provided 150 or even 175 percent of eligible costs, this would defy the principles of the cost based insurance and create numerous opportunities for moral hazard and program abuse.

Looking ahead it can be expected that the IMAP will decline as prices from the 1970's are dropped from the average and prices from the 1990's are included. There may in fact be a point were GRIP coverage is reduced to no more than yield coverage, at the 100 percent yield level, if the IMAP is less than or equal to the annual price. Although under the circumstances of this study the GRIP program provides a very high level of coverage, the coverage in years to come is still unknown, but is anticipated to be lower.

In the GRIP system, the producer has no control over the price level in the setting of coverage levels. One of the strengths of the crop cost plan is that the coverage will be consistent as a percentage of input costs and only the premiums will vary as required to keep the program actuarially sound.

6.2.3 Basket versus Non-Basket Coverage

The comparison between the sum of individual crop coverage and basket coverage is also of significance. In all cases, the basket coverage reduces the premiums required for the minimum level of coverage for the farm. In conjunction with the reduction in premiums, fewer payouts are made. Although this combined effect does not reduce gross margin variability as effectively as the sum of crops option at that level, the basket coverage does provide the same level of coverage if all crops are below coverage levels in the same year. In the one case (GRIP) where the basket coverage provides greater gross margin stability, it is noted that when payouts are made in the GRIP program they are often made to many or all crops for that year. As a result, premiums for the basket program in this case are not significantly lower than for the individual crop basis. The other advantages of the basket approach are greater than the disadvantage of marginally fewer payout dollars.

6.2.4 High Input versus Low Input Producers

It was found that producers who use higher levels of inputs actually have lower premiums per dollar of coverage than lower input producers for the crop cost, yield and GRIP programs. This is an important finding, considering that the last dollars spent, as marginal cost moves toward marginal revenue, would normally be considered the riskiest. It was also found that higher input producers have less variation in their gross margins. This may lead one to cautiously consider that investments in inputs up to a certain point can provide additional stability rather than instability. In the development of premiums for future crop cost programs this will be an important consideration. An insurance program that provides the producer with the freedom to choose the best combination of inputs for the unique situation, and receive coverage based on the costs associated with that optimum level, appears to be achievable through a crop cost program.

6.2.5 High Risk versus Low Risk Area

It was found that producers from the low risk area have lower premiums and lower variability in gross margins than producers from the higher risk area. Somewhat surprising, however, is the result that the low risk producers have lower average gross margins than high risk producers. Overall, the advantages of the crop cost system affect each risk area in a similar way. In the paired comparison of programs, risk area results are consistent with the average results in terms of performance of programs. From this analysis, there is no reason to consider that one risk area is at an advantage or disadvantage from the point of view of implementation of a crop cost program.

6.2.6 Risk to the Manitoba Crop Insurance Corporation

The GRIP plus yield program presents the greatest financial risk to the corporation in any one year and cumulatively over the ten years. The crop cost 100 percent basket coverage and the yield coverage demands similar financial requirements from MCIC. However, their peak demands are in different years. The yield program pays out the most in years when yields are low and prices are high. Conversely, the crop cost program pays out most when yields are low and prices are low. As a result, the conditions that create the greatest financial demands for the two programs are different, but of similar magnitude. For the producer, the timing of payouts may be more beneficial with the crop cost program.

In a review of MCIC's ability to predict premiums for the GRIP program versus the crop cost 120 percent basket program, it was discovered that the payout to coverage ratio is less variable for the crop cost program. As a result, it is anticipated that the range of likely premiums for crop cost program is smaller and therefore more predictable than for the GRIP coverage.

6.2.7 Matching the Financial Needs of The Producer

One of the other important contributions is that the crop cost program provides a more constant level of coverage in relation to eligible costs. Although this is seemingly obvious by the design of the model, it is an important contribution to producers' risk reduction. The yield program is intended to approximately cover input costs, but by the design of the system it may provide greater coverage in years when prices are high, and provide lower coverage in years when prices are low. This is contrary to the timing of the most critical demands of the producer. Also, the producer has virtually no control over the price used in the setting of yield coverage and cannot vary coverage for his/her specific risk, as would be possible with the crop cost system.

6.3 Conclusions

6.3.1 Producer Perspective

The crop cost program can provide effective coverage of input costs for producers. The premiums for the crop cost 100 percent basket coverage are insignificantly different than for the yield program, and the gross margin stability is improved. The crop cost program also demonstrates the ability to provide coverage that more accurately reflects input costs, particularly in years of low prices, when compared to the yield program. The crop cost 120 percent coverage, when compared to the GRIP plus yield system, demonstrates both reduced premium cost and reduced coverage.

6.3.2 MCIC Perspective

The crop cost program can provide effective coverage to producers without any increase in financial exposure to MCIC. The crop cost 100 percent basket coverage creates very similar financial demands to the yield program for MCIC. The crop cost 120 percent basket coverage has significantly lower financial demands than the GRIP plus yield program. The study also shows that, based on the variability of a cost to coverage ratio, the crop cost 120 percent basket program should have more predictable premiums than the GRIP program alone.

6.4 Limitations of the Study

Although the study results suggest a number of interesting conclusions, there are several reason to be cautious before accepting the clear superiority of a crop cost based system. Limitations in data, model design, the potential for producer abuse, and operational challenges create some reservations in the acceptance of this study on a more operational and less theoretical level.

6.4.1 Data Limitations

The use of historical MCIC survey records presents some areas for concern with respect to the study results. These records provide incomplete information in the following areas: crop grade and dockage, fertilizer product form, rate of herbicide or chemical used and if fields were spot treated, the timing of the purchase of inputs, and actual reseeding histories. Several major assumptions are required for each of the above areas in order to establish an estimated crop cost or eligible cost and the expected income from that crop. Also, when crop information is screened for inputs and yields in excess of normal limits, 91 cases are found. There are records where fertilizers are applied at two to three times normal rates. Those records remained in the study and were allowed to influence coverage and the setting of premium rates. In the comparison of the crop cost and yield programs these excess inputs effectively increase the premium cost for the crop cost program and reduce the accuracy of the coverage to eligible cost ratio for yield program. If the program were to become operational, limits may be required on certain inputs and practices.

The sample of producers used in the study also represents a limited number of candidates for this type of insurance. To be fair, the sample set can only be considered to be reflective of a group of producers that have chosen crop insurance in the past. Also, by limiting crop choices, the potential for the producer to increase gross margins or reduce gross margin variability may have been reduced.

There is no available information for each producer to compare the calculated eligible costs to the real input or variable costs. Data limitations have forced the assumption that they are the same. This may have a significant effect on the real gross margins for producers and may affect the accuracy of the crop cost system in establishing coverage that accurately reflects producers' input or eligible costs.

6.4.2 Model Limitations

There may be some question of whether the average crop yields for each individual are calculated in a way that is realistic. In the case of a crop other than spring wheat, many producers may have fewer than 10 years of records to support the average yield. In those cases, particularly if there are fewer than three years of records, the average yields and/or the average returns for those crops may be very non-typical.

It is anticipated that this may affect alternative programs in different ways. In the case of the yield or GRIP based programs a biased average yield may bias the available coverage for that crop. In the case of the crop cost program a biased average yield will not affect the coverage but may bias the premiums for that crop. The overall effect on each program is anticipated to be similar given the condition of each program balancing by producer at the end of the ten years studied. However, the actual coverage or premium derived may be different than what would be used in an operational program.

The model also assumes perfect knowledge of what would happen over the ten years of the study. This is done in order to set premiums at a level that would balance each of the programs by producer at the end of the ten years. The method used to derive premiums does not allow for any pooling of risk between producers. An operational crop cost, yield or GRIP program would use a pooled or modified pooled approach to set premiums.

In the case of crop cost 80 percent basket coverage there are 93 occasions where premiums are set at zero percent. Realistically, a mechanism would need to be designed to estimate the individual premium requirement, prior to coverage. Premiums in this study have been underestimated by removing any risk factor in premium selection and eliminating the pooling of risk between producers.

There is also some uncertainty as to whether the ten years chosen for the study are representative of past or future conditions. The study results can only be considered as an example of how each of the program would have performed under the conditions simulated from 1981 to 1990.

6.4.3 Potential for Abuse

Using existing crop records for the simulation has removed the opportunity for producers to modify cropping choices based on the conditions created with each of the insurance programs. The crop cost program is designed to be market neutral in terms of crop selection and reduce the likelihood of moral hazard and adverse selection. However, this study does not provide that proof, or create the opportunity for those characteristics to be assessed.

There is some concern that the crop cost program may encourage a general increase in inputs used due to the reduction in down side risk. Additional dollars spent on inputs will have an upside of increasing crop production and a down side of receiving the input investment back in an insurance payout, assuming 100 percent crop cost coverage. There is also potential for producers to use excessive or "up to the limit", levels of inputs, in a "go for broke" approach. This would have the highest probability of happening for producers who have coverage at more than 100 percent of eligible costs. There were no limits set for this study, nor has there been any emphasis on advantages or disadvantages for a producer to attempt to abuse the program.

6.4.4 Operational Challenges

Little effort has been made in this study to define exactly how the appropriate information can be gathered and how the crop cost approach could be administered. It is not identified whether the appropriate information is available to set premiums for this type of program. It is suggested that it would be no more difficult than for the present

GRIP system. That observation is based on the potential variability of the payout to coverage ratio of individual producers.

6.5 Opportunities for Further Research

This study provides only an initial analysis of the crop cost concept and is by no means exhaustive. The crop cost concept presents many new ideas and areas where further research could be considered. Based on this study, suggestions for further research fall within three general categories; farm level analysis, implementation, and policy implications. Some of the suggestions are designed as a means to eliminate many of the limitations of this study and/or present opportunities in related fields.

6.5.1 Farm Level Analysis

It would be useful to review the effect of the various insurance alternatives on each crop independently, to determine if any one crop lends itself to be more or less suitable for crop cost coverage. Crops with higher risks and higher expected returns, typically low acreage crops, should be reviewed. This would help to establish if the crop cost program is truly market neutral.

It is also important to examine the potential effect of producers who replace input costs with capital costs. For example, a producer may invest capital in anhydrous ammonia application equipment in order to reduce his/her fertilizer costs. Only the fertilizer is considered to be an eligible cash cost. Will the producer be able seek equitable coverage by increasing his/her coverage rate or is the replacement of variable inputs with capital inputs discouraged by the crop cost program?

Further study is also required to look at the appropriate compensation for incorporating more environmentally sustainable practices into the producers crop rotation. (i.e., green manure, legumes, etc.). How can this compensation be designed to ensure that the use of these practices is not discouraged by a crop cost insurance program?

Finally, further analysis is required to assess the potential for most hazard and adverse selection within a crop cost based insurance program. The crop cost approach, by design, removes some of the incentives for abuse that are present in current systems. However, it is possible that new opportunities for abuse would result from the implementation of this type of insurance program.

6.5.2 Implementation

Further study is required to determine the best means of setting premiums for the basket system, given the possibility of a variety of crop mixes from one year to the next. This may require the use of a weighted average of crop premiums minus a diversification factor. This diversification factor would be based on the correlation of income potential between various crops. The best means of establishing that premium and the value of diversification to the crop cost program would be a very valuable contribution.

At some point it will be necessary to assess the mechanism of an individually adjusted insurance scheme. For example, if a producer has four bad years in a row, would he/she be able to afford insurance if they were based on individually adjusted premiums and coverage? The individually adjusted coverage is a move to the "survival of the fittest" philosophy. The most appropriate combination of regional averages and individual records should be considered in the setting of coverage and premium rates.

There is also a need to review the required start-up strategy to implement a cost based insurance program. A means of dealing with new entrants to the program or the introduction of new crops into a producer's basket of coverage is also required. Suggestions may include using area averages as a starting point, with gradual adjustments based on pertinent information that becomes available.

The crop cost concept is based on the principle that each crop requires a unique set of management decisions and unique target yield depending upon the specific economic circumstances. A study could be done to establish the changes in optimum target yields, given changing input costs, output prices and environmental conditions. The greater this variation, the greater the importance of incorporating a crop cost type of insurance coverage.

6.5.3 Policy Implications

The present crop insurance system provides a vehicle for the transfer of public funds to the producer. A significant portion of the costs for both administration and premiums are paid by the taxpayer. It is important that the policy implications of a crop cost alternative be evaluated given a similar transfer of funds philosophy. One suggestion may include the possibility of public funds providing coverage to 50 percent of eligible cost for each producer, with the producer responsible for the full cost of any additional coverage.

It is also of great significance to review the crop cost concept in terms of its acceptability under the terms and conditions of General Agreement on Trade and Tariffs (GATT). If treasury dollars are used to cover any of the premiums or costs of the program, it must be supported that the crop cost concept does not provide an incentive for producers to increase or manage production based on the level of support.

BIBLIOGRAPHY

Alberta Agriculture. Canada - Alberta Crop Insurance, Report of the Alberta Review Panel. Alberta Agriculture. (1986).

Anderson, J.R., J.L Dillon, and J.B. Anderson. Agricultural Decision Analysis. The Iowa State University Press. (1977).

Bardsley, P., A. Abey, and S. Davenport. "The Economics of Insuring Crops Against Drought". The Australian Journal of Agricultural Economics. 28(1984):1-14.

Black, J.D. Production Economics. Henry Holt Company. (1926).

Borch, K. The Mathematical Theory of Insurance. D.C. Heath and Company. (1974).

Botts, R.R., and J.N. Boles. "Use of Normal-Curve Theory in Crop Insurance Ratemaking". Journal of Farm Economy. 39(1957):733-40.

Buhlmann, H. Mathematical Methods in Risk Theory. Springer-Verlag. (1970).

Cooper, R. and B. Hayes. "Multi Period Insurance Contracts". International Journal of Industrial Organization. 5(1987):211-231.

Crocker, K.J. and A. Snow. "The Efficiency Effects of Categorical Discrimination in the Insurance Industry". Journal of Political Economy. 94,(1986):321-344.

Cameron, N.E. Money, Financial Markets, and Economic Activity. St. John's College, University of Manitoba. (1983).

Dionne, G. and S.E. Harrington. Foundations of Insurance Economics, Readings in Economics and Finance. Kluwer Academic Publishers. (1992).

Fleisher, B. Agricultural Risk Management. Lynne Rienner Publishers. (1990).

Freifelder L.R. A Decision Theoretic Approach to Insurance Ratemaking. Hueber Foundation of Insurance Education, University of Pennsylvania. (1976).

Gray, R., W. Weisensel, K. Rosaasen, H. Furtan and D. Kraft. "Proposed Amendments to GRIP". Unpublished. (1991).

Greene M.R. Risk and Insurance. South-Western Publishing Co. (1977).

Holmstrum, B. "Moral Hazard and Observability". Bell Journal of Economics. (1979):74-91.

Hopley, B. "Crop Cost Insurance". Supplement to Grains 2000 proposal. (1989).

Leatham, D.J., B.A. McCarl and J.W. Richardson. "Implications of crop insurance for farmers and lenders". Southern Journal of Agricultural Economics. (1987):113-20.

Longmuir, C.N., M. Senkiw, A.D. Pokrant and C.F. Framingham. Crop Production Simulator. Department of Agricultural Economics and Farm Management, Faculty of Agriculture, The University of Manitoba. (1978).

Manitoba Agriculture. Manitoba Agriculture Yearbook 1990. Manitoba Agriculture. (1991).

Manitoba Crop Insurance. All-Risk Crop Insurance 1988. Canada Manitoba Crop Insurance pamphlet. (1988).

Manitoba Crop Insurance Corporation. Canada-Manitoba Crop Insurance Annual Report 1989-90. Manitoba Agriculture, Agriculture Canada. (1990).

Mayers, D. and C.W. Smith. "The Interdependence of Individual Portfolio Decisions and the Demand for Insurance". Journal of Political Economy. 91(1983):304-311.

Nelson C.H. "The influence of distributional assumptions on the calculation of crop insurance premia". North Central Journal of Agricultural Economics. 12(1990):71-78.

Newberry, D.M.G. and J.E. Stiglitz. The Theory of Commodity Stabilization - A Study in the Economics of Risk. Oxford University Press. (1981).

Paris, Q. "Long-run Comparative Statics under Output and Land Price Uncertainty". American Journal of Agricultural Economics. (1988):133-141.

Pokrant, A.D., S.R. Sabourin, C.N. Longmuir and C.F. Framingham. Cost and Returns of Producing Selected Crops and Livestock in Manitoba - 1979 and 1980. Department of Agricultural Economics and Farm Management, Faculty of Agriculture, The University of Manitoba. (1983).

Pratt, J. "Risk Aversion in the Small and in the Large". Econometrica. 32(1964):122-36.

Robison, L.J., and P.J. Barry. The Competitive Firms Response to Risk. McMillan Publishing Company. (1987).

Rothschild, M. and J.E. Stiglitz. "Equilibrium in Competitive Insurance Markets : An Essay on the Economics of Imperfect Information". Quarterly Journal of Economics. 30(1976):629-649.

Sandmo, A. "On the Theory of the Competitive Firm Under Price Uncertainty". Journal of Economic Literature. 61(1971):65-73.

Shavell, S. "On Moral Hazard and Insurance". Quarterly Journal of Economics. 93(1979):541-562.

Steele, R.G.D., and J.H. Torrie. Introduction to Statistics. McGraw Hill, Inc. (1976).

Skees, J. R. and M. R. Reed. "Rate Making for Farm-Level Crop Insurance: Implications for Adverse Selection etc". American Journal of Agricultural Economics. 68(1986):653-9.

Tisdell, C.A. The Theory of Price Uncertainty, Production, and Profit. Princeton University Press. (1968).

Varian, H.R. Intermediate Microeconomics. W.W. Norton & Co. (1987).

Weisensel, W.P., A. Schmitz and W.H. Furtan. The Saskatchewan All Risk Crop Insurance Program: An Evaluation of Land Use, Technology Adoption and Participation. Department of Agricultural Economics, University of Saskatchewan. (1990).

Zering, K.D., C.O. McCorkle, Jr., and C.V. Moore. "The Utility of Multiple Peril Crop Insurance for Irrigated, Multiple-Crop Agriculture". Western Journal of Agricultural Economics. 12(1987):51-9.

Appendix A

SCHEDULE W

RED SPRING WHEAT

The following terms and conditions apply to crop insurance for red spring wheat crops.

Coverage Determination

Coverage shall be determined by soil zone on the basis of 70% and 80% of the average all wheat yield over the most recent 25 years as reported by Manitoba producers to the corporation. Yields for all risk areas with the exception of Risk Area 16 are adjusted for recent technology according to the methodology outlined in "Measurement of the Technological Influence Upon Crop Insurance Coverages", by D.F. Kraft.

Coverage for Risk Area 16 shall be determined on the basis of 70% and 80% of the previous 15 year average yield as reported to the corporation by producers in Risk Area 16.

Coverage for red spring wheat shall be adjusted from all wheat based on the all-province yield of red spring wheat relative to all wheat as reported by Manitoba producers to the corporation.

Coverage for an insured person shall be adjusted according to the coverage adjustment tables prescribed by the corporation.

Premium Rate Methodology

Premium rates shall be calculated on a risk area basis.

The base rate for years prior to 1985 shall be established on the basis of loss experience calculated from wheat yields reported by Manitoba producers to the corporation. Coverage for this calculation is based on 67% of the previous 10 year average yield. Such premium rates are loaded on a risk area basis for losses due to quality and low appraisals. Such premium rates shall also be loaded for reseeding benefit losses on wheat on an all province basis.

For years 1985 to 1988, inclusive, annual premium rates shall be based on the ratio of actual red spring wheat losses to red spring wheat coverage on a risk area basis incurred at 67% of the 25 year average yield adjusted for technology.

The premium rates for all years prior to 1989 shall be adjusted for the difference between 67% and 70% coverage based on relative losses at 67% compared to 70% as calculated from yields as reported by Manitoba producers to the corporation.

For 1989 and subsequent years, the annual premium rate will be the ratio of actual red spring wheat losses to red spring wheat coverage on a risk area basis, incurred at 70% of the 25 year average yield adjusted for technology.

For each year of data added from 1989 on, the weighting placed on the data from years prior to 1989 will be reduced by 4 per cent.

The resulting premium rates shall be loaded for premium discounts and deficit recovery on a risk area basis.

The premium rate for wheat for Risk Area 15 shall be adjusted for biased participation according to Manitoba Crop Insurance and Manitoba Agriculture surveys of insured versus non-insured producers in Risk Area 15.

The premium rate for 70% coverage so established will form the base for calculating the premium rate for 80% coverage. The percentage increase in losses at 80% coverage compared to 70% coverage since 1967 is calculated using yield information supplied by Manitoba producers to the corporation. The resulting percentage increase by risk area is then applied to the premium for 70% coverage in order to calculate a corresponding premium for 80% coverage.

Final premium rates so established for 70% and 80% coverage shall constitute the average premium rates for each risk area.

Premium Determination

The premium per acre is determined by multiplying the average premium rate for each risk area by the average coverage in tonnes per acre for that risk area by the dollar value per tonne.

Premiums per acre so calculated shall be charged as the basic premium before discounts or surcharges for all acres so insured in that risk area.

Revised December 1990

Appendix B

Herbicide Pricing Assumptions

The majority of herbicide prices are derived from Manitoba Agriculture estimates of herbicide retail prices in unpublished records for each of the years reviewed. For most products, rates of application were assumed to be either the most common rate of application, or an average of rates, if each had an equal likelihood of being used. In the event that the rate and/or pricing was not clear based on the above criteria, the following assumptions were made for individual products:

1. Assure was assumed to be a data error in the years 1987, 1988, and 1989, given that the product was not registered until 1991. Therefore the price was entered as zero.

2. Amiben in 1985 was estimated based on the nearest available price in 1983.

3. Brominal, Bromox450 and Bromox720 from 1986 to 1990 were all estimated based on the closest competitive price of Buctril M.

4. Cobex in 1981 was estimated based on the competitive pricing of treflan.

5. Diphenoprop was estimated based on the competitive price of Estaprop in 1988.

6. Dowpon was estimated from the competitive price of Dalapon in 1984.

7. Dyamine in 1981 was based on the price of 2,4-D amine.

8. Edge was not registered in Manitoba until 1989 but several test sites were used to evaluate the product in 1987 and 1988. Prices for Edge in 1987 and 1988 were estimated at the 1989 retail price.

9. Ekko is an unregistered product on the crops reviewed in this study. Therefore prices were assumed to be zero.

10. Embutox prices in 1988 and 1989 were estimated based on the price of 2,4-D butyric.

11. The two formulations of estiamine were priced according to the cost of MCPA amine and 2,4-D amine.

12. Esterone pricing was based on the pricing of 2,4-D ester.

13. Excell price in 1988 was based on the 1989 price. Excell did not receive full registration until 1989.

14. Fusilade prices were based on the wild oat rate. Prices in 1984 were based on a comparison the competitive product Poast.

15. Glean was assumed not to be eligible for use in Manitoba and was eliminated from the cost of herbicides. Glean is not registered for use in Manitoba.

16. Hoefluran price and rate in 1985 was estimated based on the price of Treflan.

17. Laser price in 1989 was estimated based on the 1990 price, the first year it was officially registered.

18. MCPA 500 prices are equal to MCPA amine prices.

19. Lontrel rates are based on spot spraying on third of each field at the lower rate. This assumption is supported by DowElanco (Ken Kennedy) from in house market research.

20. Poast prices in 1981 and 1982 are estimated based on 1983 prices. Poast rates were based on the wild oat rate.

21. Premerge and Princep N have no recommended use on the crops used in this study. Product prices are therefore assumed to be zero.

22. Reglone prices in 1987 and 1988 are based on the closest available price information in 1989.

23. Roundup rates per field are based on the following assumptions, as supported by the Monsanto Manitoba Sales Manager.
    - Roundup at the light rate (one litre per acre) is on average applied approximately one half of the field.
    - Roundup at the full rate (two litres per acre) is on average applied to approximately one tenth of the field.

HERBICIDE PRICES

		1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AATREX	1	10.31									
AFOLAN	20	3.39	3.46	3.54	3.69	3.52	3.94	4.08	3.95	4.24	5.23
ALLY	30										
AMIBEN	35	17.86				25.49					
AMITROL	40				0.00	0.00		0.00		0.00	
ASSERT	43								13.34	15.08	15.08
ASSURE	45					0.00		0.00		0.00	
ASULOX	50	11.24	11.02	11.02	11.02	11.02	10.99				
ATRAZINE	60	9.93	9.46				8.76		8.43	8.93	
AVADEX	85	10.99	12.54	13.25	13.76	13.08	11.89	12.25	11.43	12.86	12.97
AV&TREF	89	17.77	20.03	21.10	20.26	19.65	17.10	17.36	16.54	18.40	18.52
AVENGE	90	11.76	12.81	13.25	13.57	14.42	14.84	14.84	12.88	13.98	14.01
BANVEL	95	1.53	1.71	1.87	1.99	2.20	2.30	2.21	2.15	2.16	2.19
BARFOX	104					2.79	2.78	2.96	2.96	2.96	
BASAGRA	105	17.43	19.10	19.55	20.44	21.04	21.67	19.44	15.92	16.72	18.06
BASFPON	115	2.86	2.79	3.41	3.23	3.23	3.23	3.23			
BENAZOLI	120	38.76	38.76	39.18	41.05	47.17	48.58	52.70			
BETAMIX	124										
BETENAL	122										
BETENEX	123		2.00								
BLADEX	121				9.87	10.87	11.31	11.71	10.74	10.44	11.07
BLAGAL	140	4.99	5.46	5.46	5.56	6.03	6.22	6.22	6.44	6.51	7.01
BLANK EN	0									0.00	
BROMINA	145	4.96	4.96	5.26	5.26	5.63	5.63	4.73	4.73	4.04	
BROMOX4	146		5.01	5.26	5.26	5.56	5.63	4.73	4.73	4.04	
BROMOX7	147						5.63	4.73	4.73	4.04	
BUCKTRIL	160	5.01	5.01	5.26	5.26	5.63	5.63	4.73	4.73	4.04	4.41
CIPC	172										
CARBYNE	170	8.14	8.74	9.29	10.63	9.28	9.30			7.53	7.69
COBEX	171	10.64									
COBUTOX	173										
DALAPON	240	2.67	2.81	2.89	3.14	3.11	3.21	2.91	2.91	2.91	
DIPHENO	250								4.35	5.22	4.97
DOWPON	260	2.54	2.74		3.04						
DUAL	265	16.92							1.96		
DY-AMINE	270		1.96								
DYVEL	300	2.84	3.16	3.44	3.67	4.05	4.23	4.20	4.05	4.43	4.25
EDGE	302							11.50	11.50	11.52	12.06
EKKO	305	15.90							0.00		
EMBUTOX	315				9.53	9.54			10.11	10.11	
ENDAVEN	316					9.28					
EPTAM	325	13.99	11.92	13.02	12.24	12.86	13.57	13.57	13.28		

ERADICA 335	27.14									
ESTAMINE 355	2.50	2.58	2.43	2.30	2.32	2.22	2.32	2.55	2.55	2.82
ESTAMINE 360	1.86	1.96	1.96	1.75	1.77	1.77	1.85	2.18	2.18	2.24
ESTAPRO 345	3.35	3.86	4.11	4.43	3.47	4.42	4.50	4.35	5.24	4.99
ESTERON 365	2.09	2.33	2.32	2.08	2.20	2.20	2.81	3.26	3.26	2.64
EXCEL 370								14.20	14.20	15.76
FORMULA 380										
FORTRES 379							14.22	14.22	14.22	14.07
FUSILADE 381				14.00	16.00		15.92	15.43	17.06	17.70
GLEAN 382		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00
GOAL 384										
GRAMOX 385										
HERITAGE 398										
HOEGRAS 400	12.52	13.85	14.74	15.16	15.16	15.14	13.89	10.86	12.52	12.98
HOE II 401			19.14	19.53	20.02	20.31	18.11	15.56	16.19	17.54
HOEFLUR 399					11.67					
JAVEX 786										
KIL-MORE 425	3.18	3.66	4.14	3.78	4.30	4.30	3.65	3.32	2.89	
LASER 428									10.50	10.61
LASSO 430										
LEXONE D 440	5.74	6.55	6.17	7.29	7.68	7.88	6.84	7.11	9.11	9.35
LONTREL 445			5.31	5.31	5.49	5.49	5.49	5.44	5.90	5.75
LOROX L 450	3.69	3.51	3.81	4.00	4.23	4.48	4.38	4.50	4.60	4.62
MARKSMA 460										
MATAVEN 465	11.74	12.90	13.41	14.75	12.81	13.90	13.90	13.21	13.21	14.95
MCPA AMI 470	2.50	2.58	2.43	2.30	2.32	2.22	2.32	2.55	2.55	2.82
MCPA EST 471	3.00	3.14	2.99	2.73	2.76	2.46	2.65	3.33	3.33	3.24
MCPA SO 472	2.73	2.93	2.80	2.65	2.66	5.33	2.77	3.61	3.61	7.43
MCPA 500 473								2.55	2.55	
MCPAK 40 475	3.10	2.85	3.14	2.85	2.97	2.98	3.76	3.50	3.50	3.48
MECOPR 480										
MUSTAR 490										15.62
NA TA TC 500	1.85	2.14	2.40	2.52	2.59	2.67	2.81	3.02	3.02	3.30
NORTRON 510										
NOTHING 870	0.00								0.00	
PARDNER 520	4.67	4.68	4.90	4.90	5.24	5.15	5.12	4.09	5.15	
PHENOXY 525										
POAST 526	15.00	15.00	15.48	14.71	16.60	16.87	17.33	15.27	18.32	19.06
PREMERG 540		0.00								
PRIMEXT 555	4.63									
PRINCEP 560										
RANDOX 581										
REFINE 582									3.52	3.68
REGLONE 580	9.56	9.56					12.00	12.00		
RIVAL 585					11.67	8.10	8.10	8.10	8.30	8.70
ROUNDUP 596	13.00	13.50	14.00	14.00	14.00	14.00	12.00	9.00	7.25	6.45
ROUNDUP 595	5.20	5.40	5.60	5.60	5.60	5.60	4.80	3.60	2.90	2.58
SABRE 601			5.26	5.25	5.62	5.62	5.62	4.88	4.04	
SENCOR 5 600	5.97	6.91	7.31	7.60	7.99	8.27	8.43		8.85	7.79

SIMADEX	615			0.00							
SINBAR	630										
SINOX PE	640										
STAMPED	650	5.68	7.50	7.90	7.89	8.40	8.56	8.56	8.27	8.70	9.28
STAMPED	655	7.50	8.24	8.68	8.67	9.24	9.39	9.39	9.39	9.39	9.76
SURPASS	658										
SUTAN+	660										
SWEEP	665							7.91			
TARGET	667	3.18	3.52	3.52	3.52	3.72	3.81	3.98	4.09	4.09	4.52
TCA SOLU	670	2.55	2.94	3.42	3.42	3.42	3.43	3.43	3.73	3.43	
TOK-RM	684										
TORCH	685	4.68	4.68	4.90	4.90	5.15	5.15	5.15	4.09	5.15	3.79
TORODON	705	2.34	2.62	3.00	3.00	3.38	3.38	3.54	3.64	4.04	4.29
TREFLAN	715	10.64	10.09	12.39	10.25	11.67	8.10	8.10	8.10	8.30	8.70
TREFLAN	716	6.78	7.49	7.86	6.50	7.40	5.17	5.03	5.03	5.30	5.56
TRIFLURE	720						8.10	8.10	8.10	8.30	8.70
TRIUMPH	722										17.75
TROPOTO	725	9.05									
TROPOTO	730	9.05								10.80	
WYPOUT	775	6.93									
YELLOW S	785										
24D AMIN	735	1.86	1.96	1.96	1.75	1.77	1.77	1.85	2.18	2.18	2.24
24D BUTY	737										
24D LVES	736	2.09	2.33	2.32	2.08	2.20	2.20	2.81	3.26	3.26	2.64
245-T	740						2.20				
273	787										

NOTE - BLANK SPACES INDICATE NO PRODUCT WAS USED IN THAT YEAR

NOTE - ZERO PRICE INDICATES NO COST CHARGED AGAINST THE USE OF THE PRODUCT
SEE PRICE ASSUMPTIONS

Appendix C

Chemical pricing assumptions

The majority of herbicide prices are derived from Manitoba Agriculture estimates of herbicide retail prices in unpublished records for each of the years reviewed. For most products rates of application were assumed to be either the most common rate of application or an average of rates, if each had an equal likelihood of being used. In the events that the rate and/or pricing was not very clear based on the above criteria the following assumptions were made for individual products:

1. Basic H was not considered an eligible cost because it is not registered by Agriculture Canada as a plant protection product.

2. Anchor and Vitaflow costs were based on the cost of Vitavax Dual Solution used on wheat at a seeding rate of ninety pounds per acre.

3. Bravo, Cocide, and Polyram are not registered for use in any of the crops reviewed. Their eligible costs were therefore assumed as zero.

4. Canocote, Benoloin, Captan, Counter, Agrox, Gamasan, Lindane, and Rovral are all seed treatments for canola. For the purpose of this study seed treatment costs for canola have been included in the costs of canola seed. Therefore, to eliminate double charging, each of these products were entered at zero eligible cost.

5. Ambush costs were estimated based on the cost of Lorsban for its most likely use.

6. Lorsban, Decis, Malithion, Sevin, and Vitavax costs were based on 1990 and 1991 costs indexed back to earlier years based on the time series price of Furadan. Although this is not a very sophisticated indexing system it does represent the price changes in the most commonly used insecticide product and the product with which most other insecticides must compete with in the market.

7. Ripcord and Hoppertox prices were based on the cost of Furadan for that year.

CHEMICAL PRICING SERIES

Chemical	Code	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	0										
BASICH	1					0.00	0.00		0.00	0.00	
ANCHOR	2							3.30		3.44	
BRAVO	3							0.00	0.00		
CANOCOTE	4							0.00	0.00	0.00	0.00
BENOLOIN	5			0.00	0.00	0.00					
BENLATE	6									14.21	14.87
AMBUSH	7	2.76	3.13	3.19	3.55	3.91	4.03	4.13	4.13		
CAPTAN	8								0.00		
COUNTER	10			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COCIDE	11					0.00					
DECIS	12					4.49			4.74	4.94	5.17
DITHANE	14										6.00
AGROX	18								0.00		0.00
FURADAN	21	1.67	1.89	1.93	2.15	2.37	2.44	2.50	2.50	2.60	2.72
GAMMASAN	25				0.00		0.00		0.00	0.00	
LORSBAN	37	2.76	3.13	3.19	3.55	3.91	4.03	4.13	4.13	4.30	4.50
LINDANE	39								1.95		
MALATION	40	3.24				4.59			4.84	5.05	5.28
POLYRAM	51									0.00	
REGLONE	55							12.32			
RIPCORD	56		1.89								
ROVRAL	57							0.00	0.00	0.00	0.00
SEVIN	69					7.99					9.20
VITAFLOW	80						3.21	3.30			
VITAVAX	81		1.48	1.51	1.68	1.85	1.91	1.95	1.95	2.04	2.13
HOPPERTOX	82							2.50		2.60	
NOTHING	87								0.00		0.00

NOTE - BLANK SPACES INDICTATE PRODUCT WAS NOT USED IN THAT YEAR
NOTE - ZERO PRICE INDICATES THAT NO COST WAS CHARGED AGAINST THE USE OF THE PR
SEE PRICE ASSUMPTIONS