An Assessment of the Livestock Feed Security Program

By

David Robert Petkau

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A Thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements for the degree of

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Abstract

The Livestock Feed Security Program is designed to insure the winter feed requirements of cows, bulls, steers, heifers, sheep, goats, bison, stallions and pregnant mares. Unlike individual yield insurance programs, insurance indemnities in the Livestock Feed Security Program, are calculated using representative hay yields in an area.

The theoretical case for insurance (the basis for a mutually beneficial contract between the insurer and the insured) rests on the ability of an insurance company to reduce producer uncertainty. To be an effective means of reducing uncertainty, the payments made under an insurance program must be reasonably correlated with changes in the producer's income stream. With an area yield insurance program, like the Livestock Feed Security Program, the correlation of the payments made by the program with changes in the producer's income stream could be a major obstacle to its widespread adoption.

Payments by the Livestock Feed Security Program between 1984 and 1988 were simulated and were compared with individual yield insurance payments calculated from long term average yields borrowed from the Cultivated Forage Insurance Program. The correspondence of the payments made by an area yield insurance program with producer losses was measured, and stochastic dominance criteria were used to test whether a

preference for an individual yield insurance program could be established over an area yield insurance program for a risk averse producer.

If the years between 1984 and 1988 are treated as one period, an individual yield insurance program that offers similar coverage levels to an area yield insurance program appears preferable, on the basis of stochastic dominance tests, to an area yield insurance program.

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Chapter 1: Introduction

The Livestock Feed Security Program[1] is designed to insure the winter feed requirements of cows, bulls, steers, heifers, sheep, goats, bison, stallions and pregnant mares, and is what will be called an area yield insurance program. Unlike individual yield insurance programs, insurance indemnities in the Livestock Feed Security Program, are calculated by measuring the hay yields from selected "representative" fields in an area. These yields are averaged and compared to a long term average yield. If these selected yields fall below the area's long term average yield, indemnities are paid to each of the participating livestock producers in the area, regardless of their own hay yields.

1.1 Economic Problem

The attraction of an area yield insurance program are the potential advantages an area yield insurance program may have over an individual yield insurance program. One of the significant advantages of an area yield insurance program is

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[1] The Livestock Feed Security Program was introduced in 1984 in seven municipalities. Fifteen municipalities were added a year later. In 1986, the program was offered in every Manitoba municipality.

Similar programs were created in Alberta, Saskatchewan and Ontario. In Alberta, Saskatchewan and Ontario computer based simulations of hay yields have been used to determine payments. Rainfall, temperatures and other meterological data are used to generate a "representative" yield.

the reduced potential for program abuse in an area yield insurance program compared to the potential for program abuse in an individual insurance program. Administrative costs may be lower as well. Lower administrative costs and savings from reduced program abuse could allow higher coverage levels (Miranda [1991], Bardsley et al [1984]).

However, a significant problem for an area yield insurance program is a possible lack of correspondence between the payments made by the program and producer losses. Circumstantial evidence that a lack of correspondence between the payments made by the program and producer losses was a problem for the Livestock Feed Security Program is presented below.

1.1.1 Evidence of Problems

Before the Livestock Feed Security Program was developed, programs to stabilize producer returns and to prevent the possibility of a drought induced contraction of the livestock industry in Manitoba consisted of ad hoc emergency assistance programs, funded entirely by governments. At the time it was created, it was hoped that the Livestock Feed Security Program would replace ad hoc emergency assistance programs[2], while requiring the financial participation of producers in the program.

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[2] Source: The Manitoba Co - Operator, January 10th, 1985.

However, when a widespread drought hit the province in 1988, resulting in reduced hay yields throughout much of the province, another ad hoc assistance program, called the Livestock Drought Assistance Program[3], was created to help livestock producers cope with the drought. The need for an additional program like the Livestock Drought Assistance Program in reaction to the 1988 drought can be partially attributed to sharp declines in the participation rate in the Livestock Feed Security Program. In 1988, the participation rate was 23.5% of all eligible cows, or roughly 105,000 cows. In 1986, the participation rate peaked at 45.0% of all eligible cows or approximately 198,000 cows.

Under an area yield crop insurance contract a producer may experience a significant lack of correlation between the payments made under the area yield program and his/her yield losses. The potential lack of targeting of payments with producer losses may be a significant problem for an area yield insurance program. The theoretical case for insurance (the basis for a mutually beneficial contract between the insurer and the insured) is built on the ability of an insurance

[3] The Livestock Drought Assistance Program paid up to $60 per head of cattle and $12 for sheep and goats, towards the feed requirements of animals held over the winter. Payments were determined by the difference between the average hay yield from fields selected for the Livestock Feed Security Program and 80% of the long term average yield in the area. The budget for this program was $100 million, and covered cattle, sheep and goat producers in Manitoba, Saskatchewan and Alberta.

company to reduce uncertainty[4]. To be effective as an insurance program, the payments made by an area yield insurance program must be reasonably correlated with changes in the producer's income stream to leave a producer with a reasonable expectation that payments will be made by an area yield insurance program when the producer's own yields are low.

The Manitoba Crop Insurance Corporation has made various efforts since 1989 to improve area homogeneity, the representativeness of the yields measured in the area, and thus the correspondence of payments with producer losses.

For example, to improve area homogeneity municipal boundaries which had been used to define designated areas were discontinued in 1990 and replaced with polygon boundaries. The old municipal boundaries could contain soils with different characteristics. Therefore, yield loss variability of alfalfa, alfalfa - grass and grass fields in a municipality could be caused by different soils. The new boundaries defined geographical areas with soils of similar characteristics.

Other measures were taken to improve the responsiveness of the program including: 1) determining separate payouts for tame and native hay in each designated area; 2) allowing producers to specify up to four areas from which they obtain

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[4] The insurance company can not change the probability of a unfavourable event occurring but it can reduce the uncertainty about a person's financial position at the end of a period of time. The probability of an unfavourable event occurring is defined in this study as the risk.

the forage requirements as well as their reliance on tame and/or native hay in each area; 3) introducing an indemnity schedule that triggered payments when the average yield in the area was less than 80% of the long term average yield (prior to 1989, payments began only when calculated production was less than 70% of the long term average yield); 4) increasing the number of yields measured (monitors) from 950 to 1350; and 5) where the reliability of data permitted, polygons were further divided into even smaller areas.

1.1.2 Individual Yield Insurance

The Manitoba Crop Insurance Corporation in addition to the Livestock Feed Security Program offers an individual yield insurance program for alfalfa, alfalfa - grass and grass, called the Cultivated Forage Insurance Program (CFIP). Premium rates are generally higher and the insurance coverage available is generally lower. As a result, if the targeting of payments with producer losses is not a problem with the Livestock Feed Security Program (LFSP) then the LFSP would be an attractive alternative to the CFIP.

The Livestock Feed Security Program could move to smaller and smaller areas in order to improve the homogeneity and the representativeness of the yield(s) measured in each area until each area corresponded to one field. At that time the Livestock Feed Security Program would have turned into an individual yield insurance program which would offer the best possible targeting of payments with producer losses.

1.2 Objectives

The objectives of this study are to measure the correspondence of payments made by an area yield insurance program[5] with producer losses, and test whether a risk averse producer prefers an individual yield insurance program[6] over an area yield insurance program. Producer losses are calculated using long term average yields assigned to a producer for the purposes of calculating yield losses under the Cultivated Forage Insurance Program.

Payments made by the Livestock Feed Security Program between 1984 and 1988 are simulated and compared with individual yield insurance payments. Stochastic dominance is used to establish whether a risk averse producer prefers an area yield insurance program for alfalfa, alfalfa- grass and grasses to an individual yield insurance program. Although the variance resulting from an area yield insurance program is probably higher than the variance resulting from an individual yield insurance program, if the average payment for most

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[5] Indemnities in an area are calculated using representative yields in an area. Indemnities are not based on the producer's individual yields.

[6] Indemnities are calculated by comparing an individual's yield against a long term average yield. Individual indemnities are by definition equal to the producer's loss.

people is higher under an area yield insurance program, it is possible that an area yield insurance program will be preferred to an individual yield insurance program.

Numerical analysis will provide additional insight into the relative benefits of the two program designs.

1.3 Organization of the Study

This study is divided into six chapters. In Chapter 2, the advantages and disadvantages of the Livestock Feed Security Program and the Cultivated Forage Insurance Program are discussed. Chapter 3 outlines the theoretical framework and a review of previous studies. Chapter 4 describes the methodology used in the study. Results are presented in chapter 5. The study is concluded in Chapter 6.

Chapter Two: Background

The objectives of the following chapter are to: outline some of the theoretical advantages and disadvantages of an area yield insurance program and an individual yield insurance program; provide specific details of the Livestock Feed Security Program and the Cultivated Forage Insurance Program; identify how some of the theoretical advantages of an area yield insurance program are encompassed in the Livestock Feed Security Program; outline the criteria for area homogeneity; and present a historical summary of the Livestock Feed Security Program.

2.1. Advantages of an Area Yield Insurance Program

Area yield insurance programs, like the Livestock Feed Security Program, have a number of theoretical advantages over individual yield insurance programs. The most important advantages of an area yield insurance program result from the limited and imperfect information available to the insurer, and the costs associated with gathering additional information.

2.1.1 Administrative and Information Costs

Administrative costs should be lower under an area yield insurance program because claims do not have to be adjusted individually and verification of individual production histories is no longer required. The administrative costs associated with verifying individual production histories and adjusting individual yield loss claims may be very high (Bardsley, Abey and Davenport 1984. Miranda 1991).

Administrative costs associated with crop insurance in Canada are paid by the provincial and federal governments so producers will not see any direct benefit resulting from savings in administrative costs. However, there may be an indirect relationship between lower administrative costs and higher coverage level.

2.1.2 Premium Setting

Second, information regarding the distribution of the area yield is generally more reliable than information regarding the distributions of individual yields, therefore insurers should be better able to accurately assess the actuarial fairness of premiums under an area yield insurance program (Miranda, 1991).

2.1.3 Moral Hazards or Program Abuse

Third, insurance claims resulting from individual yield insurance coverage are thought to be higher than they would be in area yield insurance program because producers can alter their production practices in a manner that increases their chances of collecting an indemnity under the individual yield insurance coverage. In order to combat the costs associated with this type of behaviour, crop insurance programs typically require a large deductible in order to make the realization of potential market income more attractive than the probable income to be realized from the crop insurance contract. The large deductibles[7] that are required to combat moral hazard in individual yield crop insurance contracts may limit its effectiveness in stabilizing producer returns.

Under an area yield insurance contract a producer can not significantly increase his indemnity by unilaterally altering his production practices. Thus under an area yield insurance program, the costs associated with program abuse should be sharply reduced and large deductibles or limits on coverage levels should not be required (Miranda, 1991).

2.2 The Livestock Feed Security Program

Coverage levels in the Livestock Feed Security Program are based on the type and number of eligible livestock held over the winter. Insurance indemnities paid out under the Livestock Feed Security Program are based on yields from selected fields in the area, rather than individual yields.

[7] In an individual yield insurance program, moral hazard can be addressed by subsequently adjusting premiums and/or coverage levels. The major potential disadvantage for an individual yield insurance program using this approach is the lag between the abuse of the program and the readjustment of coverage or premiums. Producers are also not obligated to purchase insurance coverage and therefore may simply not purchase insurance coverage when the coverage is eventually adjusted.

2.2.1 Eligibility[8]

All livestock producers overwintering eligible livestock are able to insure with the program. The total number of each livestock type selected must be insured.

Eligible livestock include:

a) Cows Including Bison - Adult cows which have calved at least once or a pregnant heifer which will calve by November 30th of the coverage year.

b) Bulls Including Bison - which will reach breeding age by November 30th of the coverage year.

c) Steers & Heifers Including Bison - all those over 400 lbs by November 30th of the coverage year.

d) Horses - stallions and pregnant mares

e) Sheep & Goats -all to be overwintered

2.2.2 Dollar Coverage Levels

i) Cows, Bulls & Horses - coverage is available in $20 increments from a minimum of $60 to a maximum of $220 per animal.

ii) Steers & Heifers - coverage is available in $20 increments from a minimum of $60 to a maximum of $120 per animal.

iii) Sheep & Goats - coverage is available in $20 increments from a minimum of $20 to a maximum of $60 per

[8] The terms and conditions outlined here are contained in a pamphlet published by the Manitoba Crop Insurance Corporation.

animal.

2.2.3 Yield Determination

Long-term average yields are determined on a designated area basis for alfalfa, alfalfa-grass mixtures and grasses.

Each year yields of selected forage producers are measured, averaged by area, and compared to the long-term average yield. A percentage of the long-term average yield for each designated area is calculated by comparing the measured yield(s) against the long-term average yield.

Payouts are made to all insured farmers if the year's measured production is less than 80% of the long-term average yield or 70% of the long-term average yield depending on the critical yield level selected by the producer. The indemnity schedule is illustrated in Table 2.1.

Table 2.1: Indemnity Schedule

Calculated Production as a % of of Normal	Payout as a % of Coverage at 70% Level	Payout as a % of Coverage at 80% Level[9]
100%	0%	0%
80%	0%	0%
70%	0%	20%
60%	20%	40%
50%	40%	60%
40%	60%	80%
30%	80%	100%
20%	100%	100%

Every 1% drop of measured production below the critical yield level, results in a payment of 2% of the person's dollar coverage level, up to a maximum of 100%.

For example, if a livestock producer purchased $10,000 worth of coverage ($200 per cow x 50 cows) at the 70% level and measured production in the area was 50% of normal, the claim would be 40% of $10,000 or $4,000. At the 80% coverage level the claim would be 60% of $10,000 or $6,000, If measured production was determined to be 20% of normal, this would be considered a complete loss at the 70% level and the producer would be paid 100% of coverage, or $10,000. At the 80% level the producer would be paid 100% of coverage if measured production was determined to be 30% of normal.

[9] The 80% option was introduced in 1989.

TABLE 2.2

Premium Rates For The Livestock Feed Security Program
As A Percentage Of The Coverage Level Selected
With Payouts Beginning At 70%

YEAR	PREMIUM
1984	6.86%
1985	7.34%
1986	9.00%
1987	12.00%
1988	12.00%

2.2.4 Premiums

The premium rates for insurance coverage under the Livestock Feed Security Program between 1984 and 1988 are shown in Table 2.2. The producer paid 50% of this rate and the federal government paid the other 50%[10]. Between 1984 and 1987 the premium rate nearly doubled. In 1984, the premium was $6.86 for every $100 of coverage. By 1987, the premium had reached $12.00 for every $100 of coverage.

The premium rate is not increased for coverage in the more drought prone areas of the province, or lowered for coverage in less drought prone areas of the province. Although the likelihood of a payout from the program will drop in risk prone areas if the benchmark long term average yield in the

[10] Beginning in 1990, the provinces started to pay 25% of the premium while the federal government share dropped to 25% of the premium.

area falls over time due to extended droughts, a uniform premium rate is a potential cause of adverse selection[11].

2.3 The Cultivated Forage Insurance Program

Long term average yields borrowed from the "All Risk Cultivated Forage Insurance Program" are used to calculate the payments made by an individual yield insurance program later in this study. As the individual yield insurance program is an alternative to the Livestock Feed Security Program, outlining the terms and conditions of the program will be helpful later in this study.

The Cultivated Forage Insurance Program is available to producers of alfalfa, alfalfa - grass mixtures, grasses and sweet clover. Native species, such as slough grass, couch grass, etc. which are utilized to produce hay are not eligible for this program. Coverage under the Cultivated Forage Insurance Program must be selected by August 31st of each year for coverage to apply for the ensuing year[12].

From 1984 to 1988, producers could select between two levels of dollar coverage. The two dollar coverage levels were

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[11] The variance around the mean is not accounted for, and therefore payouts may be higher in one area than in another area with the same average yield. Producers in the areas of higher potential payouts are more likely to participate than producers in areas of lower potential payouts.

[12] The terms and conditions outlined here are those which were in effect in 1989. Terms and conditions are changed from time to time. In 1990 the deadline was January 31st, 1990.

$40 (low) or $45 (high) per tonne[13]. These dollar coverage levels applied to all hay types.

The long term average yield assigned to a field depends on a soil classification rating. Each quarter section of arable land in Manitoba is in one of the fifteen basic risk areas defined by the Manitoba Crop Insurance Corporation. The soils of each quarter section of land are also rated on a scale from "A" (the highest rating) to "J" (the lowest rating). The risk area also affects the long term average yield. For example, the long term average alfalfa yield for a type "H" soil in risk area 1, is 0.820 tonnes / acre. In risk area 34, on soil zone C, the long term average yield is 1.300 tonnes / acre. The insured yields (long term averages) are based on 15 year histories.

Premiums are set by risk area and hay type as a dollar amount per acre. There is no adjustment of the premium for the different soil zones in a risk area. However, the long term average yield declines on the lesser rated soils and therefore the effective cost of insurance coverage goes up. In risk area 9, the cost of insuring an alfalfa field in a soil rated a B was about $7.20 per $100 of coverage. In a soil rated as J, the cost would have been $11.35 per $100 of coverage. The producer pays one half of this premium.

Insurance indemnities are calculated from the difference

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[13] The high dollar option of $45 / tonne has remained unchanged since at least 1984. In 1984 the low dollar option was $27 / tonne.

between the coverage level (in tonnes/acre) and the actual yield. Yield appraisals are carried out by Manitoba Crop Insurance Corporation adjustors.

2.4 Practical Comparison of the LFSP and CFIP

2.4.1 Practical Advantages of the LFSP

Producers deciding between the Cultivated Forage Insurance Program or the Livestock Feed Security Program have many factors to weigh. The Livestock Feed Security Program has many attractive features that undoubtedly influence the decisions made between these two programs.

First, the cost of the coverage under the Livestock Feed Security Program is lower than the cost of insurance coverage under the Cultivated Forage Insurance Program. For example, insurance coverage under the Cultivated Forage Insurance Program, would have cost about $17.60 for every $100 of coverage on a field of alfalfa hay in risk area 1, in soil zone J. The premium for a producer of grass hay in the same field classification was about $24.20. In 1986, under the Livestock Feed Security Program, the premium rate for a producer of grass or alfalfa hay in these areas was just $9 for every $100 of insurance coverage[14].

Secondly, producers can purchase higher coverage under the Livestock Feed Security Program compared to the coverage

[14] Coverage is defined as the maximum payment possible under the program.

available under the Cultivated Forage Insurance Program. At the high dollar option of $45 a tonne, based on expected hay consumption of 3.0 tonnes per year per cow, a livestock producer could purchase about $135 of feed insurance under the Cultivated Forage Insurance Program. With the Livestock Feed Security Program, a livestock producer could purchase $220 of feed insurance per cow, or over $70 for every tonne of hay required by the animal.

Third, beginning in 1989, a livestock producer using the Livestock Feed Security Program could elect a trigger of 80% of the area's long term average yield. The highest available coverage level under the Cultivated Forage Insurance Program is 70%.

Fourth, the indemnity schedule used by the Livestock Feed Security Program pays out two percent of coverage for every one percentage point drop in yield below the guaranteed level. The Cultivated Forage Insurance Program pays one percent of coverage for every one percentage point drop of yield below the guaranteed level.

Finally, the Livestock Feed Security Program provides insurance coverage for crops that MCIC can not or will not insure individually like native hay, or for producers who rely on hay purchased from other farmers.

2.4.2 Problems

The apparent increase in benefits with the Livestock

Feed Security Program combined with a lower premium rate requires further investigation. A possible explanation is: 1) the premium rate charged is too low, or 2) that the averages used to calculate indemnities reduces the number or the aggregate amount of the payouts. The potential lack of correlation between payments and producer losses is a major disadvantage of an area yield insurance program. In fact, the payments made by an area yield insurance program are perfectly correlated with individual yield losses only under very strict conditions.

There are two situations in which the payments made by an area yield insurance programs are exactly the same as the payments made by a program that uses individuals' yields. These situations are: 1) yields in an area are always equal, or 2) each individual experiences the same proportional reduction in yields.

If forage yields, y_i, $i=1,2,...n$, on n fields in a designated area are equal, $y_1 = y_2 = ... = y_n$, then any one of these yields is completely representative of each of the yields in the area.

Secondly, if each producer experiences the same proportional reduction in yields, an average will reflect all the yield losses in the area. For example, if the average of the expected yields of a group of three farmers in an area is four tonnes/acre, and individual expectations of yields are six, four and two tonnes per acre, respectively, and if actual yields in each field fall by 50%, the area average falls to two tonnes/acre, or 50% of the group's expected yield (Table 2.3).

Table 2.3:

Equal Yield Reductions of 50%

	Expected Yield	Actual Yield	% Loss
Producer 1	6 tonnes	3 tonnes	50%
Producer 2	4 tonne	2 tonnes	50%
Producer 3	2 tonne	1 tonne	50%
Average	4 tonne	2 tonnes	50%

Without equal proportional losses, an average of the yields in the area can not mirror the losses of every producer. Some producers will be over-compensated. Others will be under-compensated (Table 2.4).

Table 2.4:

Yield Reductions of One Tonne

	Expected Yields	Actual Yields	% Loss
Producer 1	6 tonne	5 tonnes	16.7%
Producer 2	4 tonne	3 tonnes	25.0%
Producer 3	2 tonne	1 tonne	50.0%
Average	4 tonne	3 tonnes	25.0%

In table 2.4 all yields are one tonne short of the expected yields. The payout which is based on the average yield, over-compensates Producer 1, exactly compensates Producer 2 and under-compensates Producer 3.

2.4 Rainfall

The amount of rainfall a field receives during the growing season is critical to hay yields. The importance of available water is illustrated by the way computer models simulate alfalfa yields based on the balance between the amount of water available to the plants and the atmospheric demands placed on the plants.

Raddatz (1987) analyzed the spatial representativeness of rainfall measurements for Winnipeg over two accumulation periods - one day and one month. Using 8-9 years of data, Raddatz concluded that: a) the probable error for rainfall amounts extrapolated over distances of 10 km is +/- 126 percent for estimates of daily rainfalls, and +/- 36 percent for estimates of monthly accumulations, and b) that the probable error for area-average amounts with station densities of 1 per 707 km^2 is 85 percent for estimates of daily values and 24 percent for estimates of monthly totals.

These findings suggest that rainfall amounts change over relatively small areas. If the moisture available to alfalfa plants varies significantly over short distances then yields may also vary significantly over relatively short distances creating problems for an area yield insurance program.

2.4. Other reasons for Yield Differences

Yields are also affected by different management practices. For example, on areas fertilized with nitrogen, high temperatures were found to be more detrimental than low rainfall to growth (Waddington 1973). Fick [1984] found a significant relationship between yields, cutting date and cutting interval in a model of alfalfa yields in New York State.

2.5 Historical Summary

Table 2.5 presents a historical summary of the Livestock Feed Security Program. Large amounts of coverage have been contracted under the Livestock Feed Security Program. Between 1984 and 1988 almost $98.5 million of feed insurance coverage was purchased. A high percentage of this coverage was purchased in 1986.

The participation rate in the Livestock Feed Security Program is also shown. The increasing number of potential cows eligible under the program is a result of the extension of the program to more municipalities. Table 2.5 shows that 57.4%, 50.6% and 45.0% of potential cattle were insured with the program in 1984, 1985 and 1986, respectively.

TABLE 2.5:

A Summary of the Livestock Feed Security Program
1984 - 1988

	1984	1985	1986	1987	1988	Total
Cows Insured	19 085	80 816	197 901	116 275	104 755	518 832
Potential Cows	33 238	159 772	440 000	444 000	446 000	1 523 010
Participation Rate	57.4%	50.6%	45.0%	26.2%	23.5%	34.1%
Insurance Coverage	$3 420 260	14 679 070	39 225 960	21 505 900	19 634 760	98 465 950
Payout @70%	$1 013 744	5 661 748	14 221	1 490 054	8 651 087	16 830 854
Payout /Coverage @70%	0.30	0.38	0.00	0.07	0.44	0.17
Actual Premium Rate	6.86%	7.34%	9.00%	12.00%	12.00%	
Insurance Coverage	$3 420 260	14 679 070	39 225 960	21 505 900	19 634 760	98 465 950
Payout[15] @80%	$1 578 861	8 524 079	287 290	3 721 572	11 859 708	25 971 510
Payout /Coverage @80%	0.46	0.58	0.01	0.17	0.60	0.26

In 1987, the participation rate fell from 45.0% to 26.2% of potential cows. The participation rate appears to level off at 23.5% in 1988. In 1989, after the 1988 drought and with some additional government incentives[16], the participation rate increased to 76.0% (not shown).

The premiums collected between 1984 and 1988 were not equal to the payments made. In three of the five years, the payout to coverage ratios were very high. On the other hand, in 1986, hardly any payments were made by the Livestock Feed

[15] Source: Manitoba Crop Insurance Corporation estimate.

[16] Producers who did not join the Livestock Feed Security Program in 1989 were not eligible for the second and final payment under the Livestock Drought Assistance Program.

Security Program. The premium rate required over this five year period in order to balance the premiums received with the payments made was 17% at the 70% level of coverage, and possibly 26% if the 80% trigger had been available since 1984.

There is an apparent relationship between the participation rates and the payout to coverage ratio from the previous year in Table 2.5. To determine the strength of this relationship the participation rate between 1985 and 1989 was regressed against the ratio of the payout (at 70%) to coverage level, lagged one period, and a dummy variable which was equal to one in 1989. The results of this regression are presented below. Standard errors are in parenthesis.

$$\text{Participation Rate} = 23.8 + \underset{(0.22)}{0.67}\ \text{Ratio} + \underset{(9.70)}{22.82}\ \text{Dummy}$$

$$n = 5 \quad R - \text{Squared} = 0.95$$

This regression presents the participation rate in time period (t), as a function of the payout to coverage ratio in time period (t-1), and a dummy variable for 1989. "Ratio" is significant at 5%, "Dummy" is significant at 10%. The coefficients imply that a one percentage point increase in the previous year's payout to coverage ratio increases the participation rate in time period (t) by 0.67 percent. The changes to the program in 1989, and the requirements of the Livestock Drought Assistance Program increased the participation rate in 1989 by 22.8 percent.

The significance of the payout to coverage level could be due to many factors. For example, the payout to coverage level could be acting as a proxy for changing expectations. A year in which hay yields are normal or above normal may lead producers to form expectations of similar yields in subsequent years. Similarly, a year in which hay yields are below normal may lead producers to revise the probabilities they had held of losses occurring in the future. Uninsured losses also result in the depletion of hay and financial reserves which have to be rebuilt. Producers may therefore be more vulnerable to supply disruptions after a bad year in which hay and financial reserves have been depleted.

On the other hand, the pattern to the participation rates may illustrate the potential difficulty the program may have in balancing the cumulative premiums received with the cumulative payments made by the program. This problem may be attributed to a lack of correspondence between the payments made by the program and producer losses.

Chapter Three: Literature Review

The objectives of this chapter are to outline a theoretical framework of insurance, and to give brief descriptions of the results and the methodologies employed in previous studies of area yield insurance programs.

3.1 Theory of Insurance[17]

The premise of an insurance contract is that a risk averse producer, who maximizes expected utility, will accept a lower expected income in return for a reduction of the variance of that income. The reasoning behind this potential trade-off between income and variance is illustrated in Figure 3.1.

3.1.1 Expected Utility

The curved line in Figure 3.1 represents a utility function which is concave to the origin. An income of either Y(1) or of Y(2) are equally likely. The mathematical expectation of income is equal to E(Y). Because of the concavity of the utility function, the increase in well being resulting from an increase in income from E(Y) to Y(2) is less than the increase in well being resulting from a change in income from Y(1) to E (Y).

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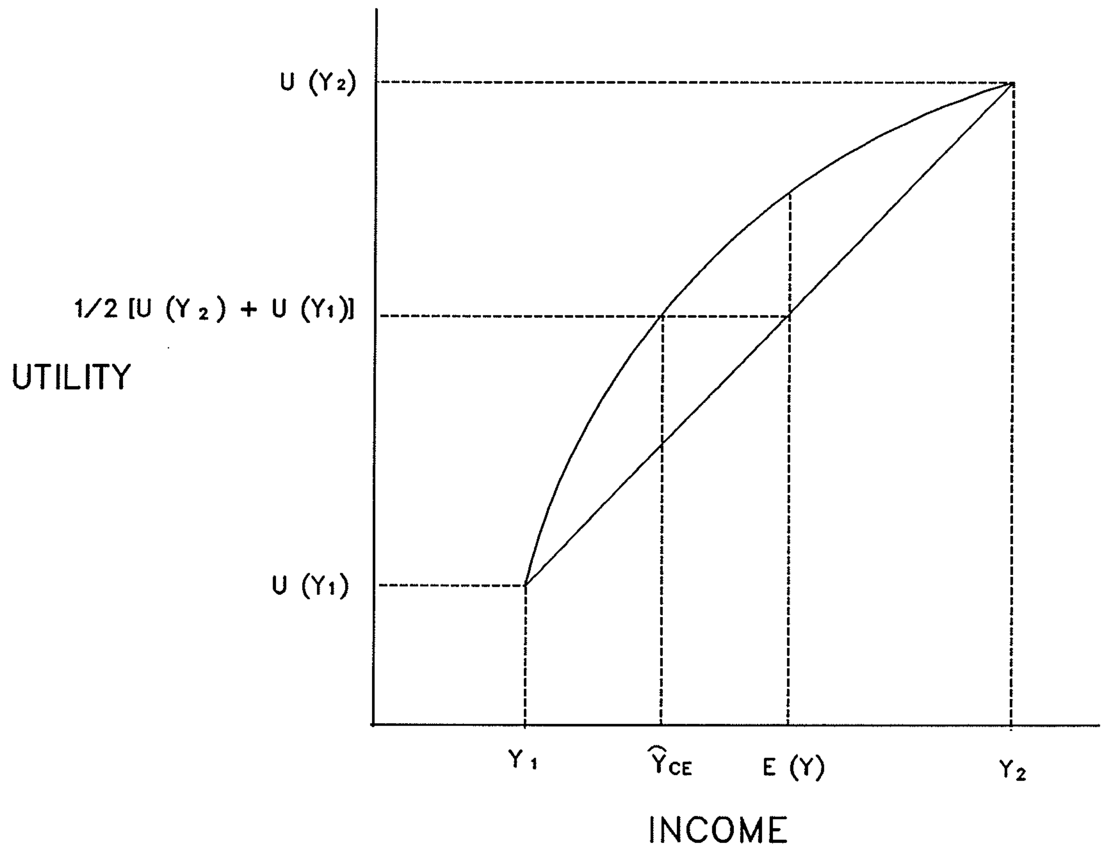
[17] The discussion in Robison and Barry was extremely helpful. The basic presentation in that book, Chapters 1-4 and 15, is closely followed in the following discussion.

Figure 3.1 Expected Utility & Certainty Equivalent Income



The expected utility from the two potential outcomes is equal to 1/2 [U(Y(2)) + U(Y(1))]. The utility associated with a certain income of YCE is equivalent to the expected utility from the two potential outcomes Y(1) and Y(2).

If an insurer is willing to eliminate the variance of the producer's income in exchange for a risk premium, a producer could pay a risk premium equal to the difference between YCE and E(Y) and be as well off. Placing the choice in the opposite context of accepting a risky return may make the concept clearer. If a risk averse producer is to be as well off accepting a risky choice Y(1),Y(2), the risky choice must yield an expected return high enough to compensate the producer for accepting the risk. In Figure 3.1, the expected return must be equal to E(Y) to compensate the risk averse producer for accepting the risk of either Y(1) or Y(2) rather than the certain outcome of YCE.

The concavity[18] of the utility function creates the possibility of a producer being willing to pay a premium to reduce the variance of income. If the producer's utility function is better described by a straight line[19], then expected income and certainty equivalent income are the same.

If the utility function is convex[20], the increase in well being resulting from an increase in income from E(y) to Y2 is greater than the increase in well being resulting from an increase in income from Y(1) to E (Y). As a result YCE is greater than E (Y). If the utility function is convex, a producer will seek uncertainty. Greater uncertainty is sought because of the possibility of a very high income. On the other hand, the possibility of a very low income is discounted.

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[18] A concave utility function implies diminishing marginal utility, or in other words, that the second derivative of the producer's utility function is negative.

[19] A straight line implies constant marginal utility.

[20] A convex utility function implies increasing marginal utility.

3.1.2 Theoretical Model of An Individual Yield Insurance Program

Table 3.1

Decision Matrix For An Individual Yield Insurance Program

		Choices	
Nature state	Probability	A_1 (Insurance)	A_2 (No Insurance)
yield loss	p	$W + W_o - \pi$	W_o
no yield loss	1 - p	$W + W_o - \pi$	$W + W_o$

This concept of a trade-off between variance and expected income and its relationship to an individual yield insurance program will be illustrated with the help of the decision matrix shown in Table 3.1. This decision matrix will be used to calculate a theoretical insurance premium for an individual yield insurance program.

Suppose W represents the value of a hay crop, and W_o represents another risk free asset. The probability of the hay crop turning out to be a total loss is represented by p, and (1-p) represents the probability of fully realizing the potential value of the hay crop. The premium paid by the producer to insure the hay crop is represented by π. The producer has two choices. He or she can chose to either purchase insurance coverage or not to purchase insurance coverage.

If insurance is purchased the expected value of the choice is:

$$E\ (A_1) = W + W_o - \pi \qquad (3.1)$$

The expected value of a choice not to purchase insurance is:

$$E\ (A_2) = pW_o + (1-p)(W + W_o) = W + W_o - pW \qquad (3.2)$$

The actuarial difference between the two choices is equal to:

$$E(A_1) - E(A_2) = pW - \pi \qquad (3.3)$$

The variances of the choices are:

$$\sigma^2 (A_1) = 0 \qquad (3.4)$$

$$\sigma^2 (A_2) = p(W_o - W_o - W + pW)^2 + (1-p)(W_o + W - W_o - W + pW)^2$$
$$= pW^2(p-1)^2 - (p-1)p^2W^2 = W^2p(1-p) \qquad (3.5)$$

In the next step an expression for an amount called the certainty equivalent income is created. Certainty equivalent income is calculated by subtracting an amount from the expected value of the income stream to account for the potential variance of the income stream.

$$Y_{CE1} = W + W_o - \pi \qquad (3.6)$$

$$Y_{CE2} = W + W_o - pW - (\beta/2)W^2p^2(1-p) \qquad (3.7)$$ [21]

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[21] ($\beta/2$) is a risk aversion factor. The higher this factor is, all other things being equal, the greater the producer's risk aversion. This factor essentially determines the rate at which

The maximum insurance premium the producer will pay is found by equating the certainty equivalents and solving for π. Setting (3.6) equal to (3.7) yields:

$$W + W_o - \pi = W + W_o - pW - (\beta/2)W^2p(1-p) \qquad (3.8)$$

and solving for π yields:

$$\pi = pW + (\beta/2)W^2p(1-p) \qquad (3.9)$$

The maximum premium is composed of the actuarial cost (pW) of yield loss and a component related to the variance of the income stream $[(\beta/2)W^2p(1-p)]$. Without government subsidies, the premium the producer will be willing to pay has to be greater than the actuarial cost, otherwise the insurer will not be able to cover administrative costs.

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expected returns are traded for variance. The nature of the trade - off between expected income and variance in the certainty equivalent expression was deduced using assumptions of constant absolute risk aversion and of normally distributed probability distributions of income (Robison and Barry [1987], Chapter Three).

3.1.3 Theoretical Model of an Area Yield Insurance Program

Table 3.2

Decision Matrix For An Area Yield Insurance Program

Nature state	Probability	Choices: A_1 (Insurance)	A2 (No Insurance)
yield loss	p	aW + Wo - π	Wo
no yield loss	1 - p	(1+b)W+ Wo - π	W + Wo

By making some modifications to the decision matrix in Table 3.1, the possibility that payments from an area yield insurance program may not be perfectly correlated with yield losses can be modeled. Two parameters are introduced in Table 3.2 to account for the correlation of payments. The first parameter (a) is a number greater than or equal to zero. In most circumstances it would be equal to or less than one. In Table 3.1, (a) would be equal to one. The second parameter (b) is a number greater than or equal to zero. In most circumstances it would be equal to or less than one. In Table 3.1, (b) would be equal to zero.

As in the previous example, expected values, variances and certainty equivalent expressions are calculated.

The expected values of the two choices are:

$$E\ (A_1) = p\ (\ aW + W_o - \pi) + (1-p)[\ (1+b)(W) + W_o - \pi\ ]$$

$$E\ (A_1) = W_o - \pi + W\ (pa + 1 - p + b - pb) \qquad (3.10)$$

$$E\ (A_2) = W_o + (1-p)\ W \qquad (3.11)$$

The variances of the two expressions are:

$$\sigma^2\ (A_1) = p\ [aW + W_o - \pi - W_o + \pi - W\ (pa + 1 - p + b - pb)]^2$$

$$+ (1-p)\ [W + bW + W_o - \pi - W_o + \pi - W\ (pa + 1 - p + b - pb)]^2$$

$$\sigma^2\ (A_1) = pW^2\ [a - pa - 1 + p - b + pb]^2 + (1-p)W^2\ [-pa + p + pb]^2 \qquad (3.12)$$

$$\sigma^2\ (A_2) = W^2\ p\ (1-p) \qquad (3.13)$$

The certainty equivalent expressions for A1 and A2 are:

$$Y_{CE1} = W_o - \pi + W\ (pa + 1 - p + b - pb) - (\beta/2)\{\ pW^2\ [a - pa - 1 + p - b + pb]^2 + (1-p)W^2\ [-pa + p + pb]^2\ \} \qquad (3.14)$$

$$Y_{CE2} = W_o + (1-p)\ W - (\beta/2)\ \{\ W^2\ p\ (1-p)\ \} \qquad (3.15)$$

The maximum insurance premium the producer will pay is found by equating the certainty equivalents and solving for π. Setting (3.14) equal to (3.15) yields:

$$W_o - \pi + W\ (pa + 1 - p + b - pb) - (\beta/2)\{ pW^2\ [a - pa - 1 + p - b + pb]^2 + (1-p)W^2\ [-pa + p + pb]^2 \} - W_o - W + pW + (\beta/2)\ \{ W^2\ p\ (1-p)\ \} = 0 \qquad (3.16)$$

The maximum premium is given by:

$$\pi = W\ (pa + 1 - p + b - pb) - W + pW - (\beta/2)\{ pW^2\ [a - pa - 1 + p - b + pb]^2 + (1-p)W^2\ [-pa + p + pb]^2 \} + (\beta/2)\ \{ W^2\ p\ (1-p)\ \} \qquad (3.17)$$

Equation (3.17) can be reduced to:

$$\pi = W\ (pa + b\ (1-p)) + \beta/2\ W^2\ p\ \{ 2(1-p)(a-b) - (1-p)(a-b)\}^2$$

$$\pi = W\ (pa + b\ (1-p)) + \beta/2\ W^2\ p\ (1-p)(a-b)\ \{2+b-a\} \qquad (3.18)$$

By substituting numbers into equation (3.18) the implications that the correspondence of payments with losses has on the maximum premium a producer will pay should become clear.

First suppose that the probability of a yield loss is 50%, p = 0.5, that a = 1.0, and b = 0. These parameters replicate the decision matrix in Table 3.1. Because a = 1.0, if there is a yield loss the area yield insurance pays 100% of the loss. Because b = 1, if there is no yield loss the area yield insurance does not pay anything. In this example, payments from the area yield insurance program are perfectly correlated with yield losses. Substituting the parameter values for a, b and p into (3.18) and solving for π, yields:

$$\pi = 0.5\ W + (\beta/2)\ W^2\ (0.25) \qquad (3.19)$$

The first part of the equation is the estimated actuarial cost of the insurance coverage. The second part of the equation is the amount over and above the actuarial cost that the producer is willing to pay to reduce the variance of the income stream. Note that as long as β is greater than zero, the maximum premium the producer would pay is greater than the actuarial cost of the insurance.

Now suppose that a = 0, and b = 1.0 , and that the probability of a yield loss is unchanged at 50%. This time payments from the area yield insurance program are not perfectly correlated with the producer's yield loss. With a = 0, and b = 1.0, the insurance program pays out when the producer does not have a yield loss, but if the producer has a yield loss the insurance does not pay out. The extreme nature of these parameters results in a higher income variance with crop insurance coverage compared to the income variance without crop insurance coverage.

After substituting the new parameter values into equation (3.18) and solving for π, the maximum premium the producer would pay is given by the following equation:

$$\pi = 0.5\ W - (\beta/2)\ W^2\ (0.75) \qquad (3.20)$$

Note that although the first component of the premium has not changed, the producer is now not willing to pay the full actuarial cost of the insurance.

These two examples illustrate the importance of the correlation of payments with yield losses. The premium a risk averse producer will pay for insurance coverage falls as the correlation between yield losses and insurance payments weakens.

3.2 Review Of Related Studies

The previous discussion on the importance of the correlation of payments with producer losses highlights the importance of the assumption of homogeneous yields. This assumption is an important part of the arguments made for area yield insurance.

Capstick and Cochran (1984) examined this assumption of area homogeneity in a study of the yield distributions from 30 cotton farms in Arkansas. They constructed and compared these distributions to one another and to county average distributions. They concluded that the use of county average yield data to identify risk efficient strategies for farmers (even those with similar risk preferences) had the potential of producing inaccurate predictions. County averages were inadequate largely because of substantial differences between individual farm distributions. These different distribution of yields meant neither county averages not data from another farm could adequately substitute for data from the farm being studied.

In other work, Miranda (1991) focused on the ability of area yield insurance program to deal with the problems encountered in individual yield insurance program with respect to adverse selection, moral hazard and higher administrative costs.

Miranda adapted some of the concepts from capital asset pricing theory. These concepts are used to describe the relationship between risk and expected return. In capital asset pricing theory the total return from an asset is broken into systematic and unsystematic risk components.

An individual's total yield risk can also be decomposed into a systematic component that is explained by factors affecting all producers in the area and a nonsystematic residual component. The systematic and unsystematic[22] components are statistical relationships between movements in a producer's yield to movements in the area average yield. The greater the nonsystematic residual component, the less correlated a producer's yields will be to changes in the area average yield.

Area yield insurance covers only systematic risk. But

[22] The unsystematic residual component corresponds with the error term in a linear regression equation, if the dependent variable was the average yield in the area and the independent variable was an individual's yield.

because area yield insurance would be free of moral hazard problems it would not require large deductibles or the limits on insurance coverage that are part of an individual yield insurance program.

Using yield series from 102 western Kentucky soybean producers Miranda measured the percent variance reduction from three alternative crop insurance programs. These were respectively: 1) an individual yield insurance program, 2) a full coverage area yield insurance program, and 3) an optimal coverage area yield insurance program.

Under the individual yield insurance program, whenever a producer's own yield fell below 75% of the normal yield, he or she received an indemnity equal to the shortfall. Under the full coverage area yield program, whenever the area yield fell below 88.5% of normal[23], each producer received an indemnity equal to the shortfall in the area yield.

Under the optimal coverage area yield program producers could choose to purchase insurance for more than 100% of their acreage. The average level of optimal coverage level across the producers in the study was 160%, or in other words, producers on average, in an optimal coverage area yield program would purchase insurance for 60% more acreage than they would actually plant. Under the optimal coverage area yield program, whenever the area yield fell below 95% of the

[23] A critical yield of 88.5% of the normal area yield results in the same premium, on average, as a 75% critical yield in the individual yield insurance program.

normal area yield, each producer received an indemnity equal to the shortfall in the area yield times his elected level of coverage.

Miranda concluded that for most producers, the improved coverage of systematic yield risk obtained through lower deductibles and higher coverage under the optimal coverage area-yield plan outweighed the nonsystematic yield risk protection provided by an individual-yield plan. That is, for most producers, optimal area-yield insurance would provide better overall yield risk insurance than individual yield insurance. Unfortunately, the optimal coverage area yield program was also three times more expensive, and for producers whose yields were not highly correlated with area average yields, individual yield insurance was better at reducing variances.

Two papers in the **Australian Journal of Agricultural Economics** have examined the idea of rainfall insurance, another version of area yield insurance program. Indemnities in a rainfall insurance program would be based on the precipitation occurring at a specific recording site.

Patrick (1988), in the first paper, explored the demand for an individual multiple peril crop insurance program and a rainfall insurance program in a survey of 60 Mallee[24] wheat farmers. He asked 60 randomly selected farmers for the maximum premium they would be willing to pay for each of these

[24] Mallee is a region in Australia.

hypothetical insurance programs.

He found that 57% of the farmers surveyed would not participate in the rainfall insurance program, and that less than 12% of the producers would pay more than the estimated value of the expected indemnities that would be paid out of the rainfall insurance program over time. In contrast, only 25% of the producers would not participate in the multiple peril crop insurance program, and one half of the producers would be willing to pay the estimated actuarial cost of the coverage or more.

In the second study of a rainfall insurance program, Bardsley, Abey and Davenport (1984) examined the necessary conditions for the existence of a financially viable, unsubsidized crop insurance scheme for Australian farmers. They modeled an insurance program in which the indemnities could be calculated on the basis of meteorological observations at a specific recording site in an area.

They regarded an unsubsidized crop insurance program as a way of saving to cover an anticipated future loss. If this program is actuarially fair, then over time these savings must equal the actual claims paid out. Their subsequent analysis was therefore based on the costs and benefits of an insurance program with the costs and benefits of self insurance.

Their analysis of the potential benefits of an insurance contract is based on the cost of maintaining all of the liquidity necessary in a self insurance situation to cover potential income losses, which they equated with the difference between short and long term interest rates.

A potential advantage of an insurance contract is that the stock of liquid assets required by the insurance corporation per person insured to cover most of the probable losses that will occur during the year maybe less than that required by an individual. As a result, the insurer can invest a portion of the producer's funds at longer term interest rates for a economic benefit equal to the difference between short and long term interest rates.

Offsetting this potential economic benefit are costs to administer the program, and the probable lack of a perfect correlation of payments from the insurance policy with the producer's income stream. As the correlation of payments from the insurance policy with the producer's income stream declines, the higher the percentage of liquid assets the producer must hold independently to meet financial losses.

Bardsley et al concluded, from an analysis of the Australian wheat industry that crop insurance against drought would be unattractive from an efficiency point of view, and that the funds locked up in an insurance pool would be put to better use if they remained in the hands of the farmers (p.13). The reasons for this conclusion were: 1) The correlation between payouts and drought loss was not high enough, 2) the intraclass correlation of the insurer's risk among areas was not low enough, 3) the differences in the costs of liquidity between a government backed insurer and an individual were not high enough to create an advantageous insurance contract, and 4), any possible advantage were quickly reduced when administrative costs were included.

What is particularly notable about their paper is that the analysis of the costs and benefits of an insurance contract makes no references to a utility function, but is instead based on specific measurable monetary costs, like the difference between short and long term interest rates.

Chapter Four: Methodology

The objectives of this chapter are to describe the steps taken to create a historical simulation of the Livestock Feed Security Program between 1984 to 1988, describe the calculation of individual producer losses using Cultivated Forage Insurance yields, and explain the stochastic dominance criteria used in the next chapter.

4.1 Database

Alfalfa, alfalfa - grass and grass yields were supplied by the Manitoba Crop Insurance Corporation (MCIC). The largest number of hay yields in the database were reported by Manitoba producers on the MCIC questionnaire that was sent out regularly up until 1991. The rest of the yields in the database were measured by the Manitoba Crop Insurance Corporation (called monitor yields). A broad cross-section of hay yields throughout Manitoba is represented in this database.

There are few continuous time series in the database. Gaps in the data make time series analysis difficult. Most of the time series between 1984 and 1988 were made up of less than three yields from one field. As a result it was not possible to calculate the effect the Livestock Feed Security Program had on yield variances with any degree of confidence in the results.

To make the best use of all the yield information in the database, the payments made by the Livestock Feed Security Program were compared to producer losses calculated from the long term average yields (LTAYs) assigned to a field under the Cultivated Forage Insurance Program. This approach resulted in a fairly encompassing cross sectional analysis of the payments made by the Livestock Feed Security Program with producer losses. With the exception of 1984, over five thousand yields were involved in the analysis.

4.2 Modelling The Livestock Feed Security Program

To generate the payments made by the Livestock Feed Security Program it was necessary to calculate long term average yields for alfalfa, alfalfa - grass and grasses in each designated area of the program between 1984 and 1988. Averages of the yields measured from the "representative" fields in each designated area were compared against these long term average yields.

4.2.1 Establishing the Long Term Average Yield In Each LFSP Area

From 1984 to 1988 the designated areas in the Livestock Feed Security Program were simply municipalities. In an effort to improve the homogeneity of the areas, soil zones, called polygons were used instead of municipal boundaries to define the designated areas. These polygons are geographical areas containing soils with very similar characteristics. There are well over a hundred of these areas relevant to this study. They vary in size and shape. Previous data collection techniques were not orientated to capture yield data on a polygon basis. Therefore, in a number of these polygons there were either no yields or there were so few yields with such a large variance that an average of the few yields available was not necessarily representative of the true average yield for the area. As a result, means of creating consistent yield series for alfalfa, alfalfa - grass and grasses in each of the polygons were needed.

Consistent yield series for alfalfa, alfalfa - grass and grasses were created by calculating and comparing the bounds on the error of estimation associated with the yields in the polygon and the bounds on the error of estimation associated with the yields in areas encompassing a number of similar polygons (called agro - ecological resource areas).

4.2.2 Calculation of the Bounds on the Error of Estimation

The calculations of the bounds on the error of estimation are described below:

Estimation of the Population Mean for a Simple Random Sample[25]

Estimate of the population mean:

$$\hat{\mu}=\overline{y}=\sum_{i=1}^{n}\frac{y_i}{n}$$

Variance of the estimator:

$$\hat{\sigma}^2_{\overline{y}}=\frac{s^2}{n} \qquad \textit{where} \qquad s^2=\sum_{i=1}^{n}\frac{(y_i-\overline{y})^2}{n-1}$$

Calculation of the bounds on the error of estimation:

$$\overline{y} \pm \textit{critical t-statistic x } \hat{\sigma}_{\overline{y}}$$

A larger t - statistic increases the bounds on the error

[25] Source: Mendenhall and Reinmuth [1982] Chapter 15, specifically, Section 15.4 and Section 15.5; and SAS User's Guide:Basics, specifically, the section entitled "Introduction to SAS Descriptive Statistics. The Means Procedure in SAS calculates a statistic called STDERR. This was used with t-statistics appropriate for the size of the sample and the desired level of significance of the bounds.

of estimation. The t-statistic is affected by the number of yields in the average and the desired confidence level in the estimates, i.e., from 5% to 1%. The bounds on the error of estimation also increase as the variance in the sample increases.

The probable bounds within which the true average of the population lies can be calculated from the number of yields making up the sample using a variation of this formula. For example, if just one yield is measured to estimate the average yield of a population of 10 fields, and the standard deviation of the yields in the entire population is known to be 0.4277 tonnes/acre, the true average yield of the population is probably within 0.855 tonnes/acre of the measured yield. This result was found by solving the following equation for B (Mendenhall and Reinmuth 1982, page 720):

$$n=\frac{N\sigma^2}{(N-1)D+\sigma^2} \qquad where \qquad D=\frac{B^2}{4}$$

4.2.3 Agro - Ecological Resource Areas

Each of the polygons were aggregated into what are called "agro-ecological resource areas[26]", to create a larger area

[26] An agro - ecological resource areas is a group of polygons, that share similar agro - ecological resource characteristics like soils, weather patterns and terrain. The risk areas used by the Manitoba Crop Insurance Corporation correspond to various groups of these agro - ecological resource areas.

with a larger number of yields in it.

Exceptions to the boundaries defined by the agro-ecological resource areas were made if the polygon grouping defined on the basis of the agro-ecological resource area resulted in high errors of estimation compared to other areas. If this was the case two or more agro-ecological resource areas may have been joined into one area or a few polygons may have been moved to other groups. The entire process involved consulting a map and constantly recalculating the bounds of estimation associated with the new area. Basically polygons were moved in areas like northwest Manitoba. Much larger areas were needed to calculate an average yield for grasses, than for alfalfa and alfalfa - grass.

After averages and errors of estimation had been calculated by polygons and agro - ecological resource areas, criteria were set to judge the statistical reliability of the averages. Basically an average was regarded as good whenever the bounds associated with that average were less than 0.25 tonnes/acre at a confidence level of 5%. In other words, the average was good if the true population mean was expected to fall within 0.25 tonnes of the sample average, nineteen times out of twenty. As average hay yields are usually less than 2 tonnes/acre, bounds of 0.25 tonnes/acre may be generally associated with estimation errors of plus or minus 12.5%.

The choice between the agro-ecological yield and the polygon yield, on a year by year basis, was based on the following criteria: 1) If the bounds on the polygon yield were less than 0.25 tonnes/acre, or 2) if the bounds on the polygon yield were greater than 0.25 and the difference between the bounds on the agro-ecological resource area yield and the bounds on the polygon yield were less than 0.05 tonnes/acre, the average of the yields in the polygon was chosen over the agro - ecological yield. This condition ensured that the yields in the polygons were not needlessly aggregated. In other words, if a larger yield sample did not result in an improvement in the bounds greater than 0.05 tonnes/acre, the polygon yield was chosen over the agro-ecological resource area yield.

The errors of estimation associated with the averages from unaggregated polygons were often significantly greater than 0.25 tonnes /acre, which meant that the average used in the historical yield series resulted from a comparison of the errors of estimation associated with the unaggregated polygons and the errors of estimation associated with the averages calculated from the yields in the agro - ecological resource areas.

The entire procedure eventually resulted in a series of annual average yields between 1972 and 1988 for alfalfa, alfalfa - grass and grasses in each designated area or polygon. Long term average yields were calculated using a ten year series with a two year lag. In calculating the long term average yields for 1988, the ten year series that was used ended in 1986.

4.2.4 Calculation of the Representative Average Yield in the Area

To determine the percentage of insured coverage that was paid out by the Livestock Feed Security Program, the average of the yields measured in the area was calculated and compared to the long term average yield. In areas, where no yields had been measured, the yields in those areas were deleted from the database and from further analysis. Also, fields, primarily river lots, that had not been classified to a polygon were deleted.

4.2.5 Calculation of Area Yield Insurance Payments

After the area average yield had been expressed as a percent of its long term average value, the indemnity schedules shown in Table 4.1 were used to determine the percentage of the producer's coverage paid out by the program. If the area average was less than 80% of the long term average yield (LTAY) payouts were triggered. Payouts were calculated with one of the two schedules shown in Table 4.1. The first schedule paid 1% of a person's coverage for every percentage point below the 80% trigger. It also corresponds with the schedule used to calculate individual producer losses. The second schedule paid 2% for each percentage point below the

80% trigger. It corresponds to the payout structure of the actual Livestock Feed Security Program (LFSP).

Two schedules were used to isolate the cost of the 2% for 1% feature, and the effect the 2% for 1% feature had on the correspondence of payments with producer losses. In both schedules, if the area average was less than 30% of the long term average yield (LTAY), the area yield insurance program paid 100% of the person's coverage. This introduces a discontinuity in the 1% for 1% indemnity schedule as payouts jump from 50% to 100% at 30% of the LTAY.

Table 4.1: Indemnity Schedule

Calculated Production as a % of of LTAY	Payout as a % of Coverage 1% for Each 1%	Payout as a % of Coverage 2% for Each 1%
100%	-	-
80%	-	-
70%	10%	20%
60%	20%	40%
50%	30%	60%
40%	40%	80%
30%	100%	100%
20%	100%	100%

4.3 Calculation of Individual Yield Losses From CFIP Yields

Producer losses were calculated by comparing the producer's yield against a long term average yield from the Cultivated Forage Insurance Program. Each yield in the database was matched to a long term average yield from the Cultivated Forage Insurance Program. These yields from the Cultivated Forage Insurance Program were assumed to reflect the yield a producer expected from a particular field. Yields (primarily river lots) that were not identified by risk area or soil zone were dropped from the database.

Each of the yields in the database was compared against these long term average yield (LTAY) to determine an individual's loss. Each yield was expressed as a percentage of the long term average yield. If the actual yield was less than 80% of the long term average yield the 1% for each 1%

indemnity schedule shown in Table 4.1 was used to calculate the payment from an individual yield insurance program. If the actual yield was less than 30% of the LTAY, 100% of the insurance coverage was paid out.

The discontinuity in the 1% for 1% indemnity schedule at 30% of the LTAY may have unintentionally introduced some bias into the results. Producer losses calculated from yields that were less than 30% of the LTAY may be weighted more heavily than they should be. There will however be a continuum of yields between 0% and 30% of the LTAY, or in other words, the yields that are below 30% of the LTAY will not all work out at exactly 30% of the LTAY. There is also an offsetting adjustment in the comparisons that follow because the area yield insurance payments are calculated with the same discontinuity in the 1% for 1% indemnity schedule, and because the 2% for 1% indemnity schedule pays out 100% of insurance coverage when the average yield in the area is below 30% of the LTAY.

Nevertheless, the discontinuity in the indemnity schedule may overstate producer losses and understate the overcompensation resulting from the area yield insurance payments. However, it is unlikely that any of the conclusions of this study are fundamentally altered by the discontinuity in the indemnity schedule. The individual yield insurance program may be badly designed but it is consistent with the payments made by the area yield insurance program when the average yield is below 30% of the LTAY.

Once individual losses and area yield insurance payments had been determined, the area insurance payments were compared to the individual losses to assess their correspondence with each other. Both individual losses and area yield insurance payments were left expressed as a percentage of the producer's coverage. The differences between the individual losses and area yield insurance payments were calculated. An exact correspondence between individual losses and area yield insurance payments would result in no difference in the percentages. Otherwise the area yield insurance payment had to be either higher or lower than the individual loss. The results were analyzed by differentiating between areas of LFSP payments and areas of no LFSP payments, and by adding up producer losses, LFSP payments and the differences between producer losses and the LFSP payments. Basic counts of the number of yields below 80% of the LTAYs in areas of LFSP payments and in areas of no LFSP payments were done to establish the difference between the probabilities of loss in areas of LFSP payments and the probabilities of loss in areas of no LFSP payments.

4.4 First and Second Degree Stochastic Dominance

An analysis of the correspondence between losses and payouts will not establish preferences. Although the variance resulting from an area yield insurance program may be higher than the variance from an individual yield insurance program, if the average payment for most producers is higher under an area yield insurance program than it is under an individual yield insurance program, then an area yield insurance program may be preferred to the individual yield insurance program.

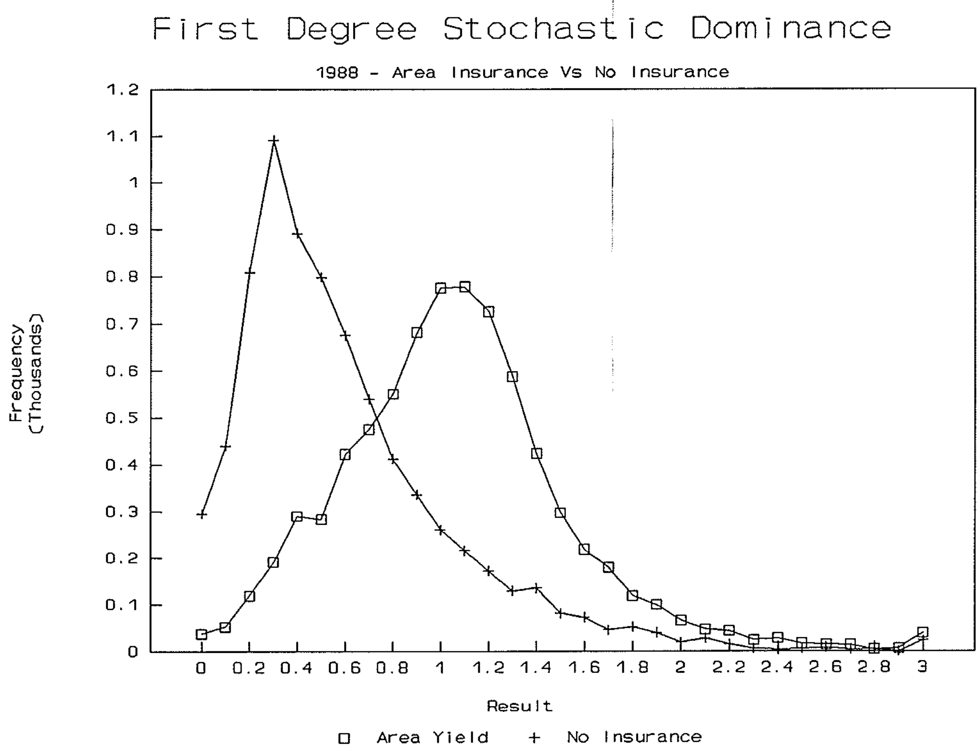
First and second degree stochastic dominance tests can establish preference between distributions with different means and variances without requiring an exact mathematical description of the appropriate utility function[27]. Second degree stochastic dominance (SSD) tests are used to establish the preference of a risk averse producer between insurance programs.

The distributions necessary for these tests were created by expressing each yield as a percentage of the long term average yield and adding the payout made by each of the insurance programs.

[27] The discussion in the chapter four called "Ordering Risky Choices" in Robison and Barry's book is concise and quite helpful.

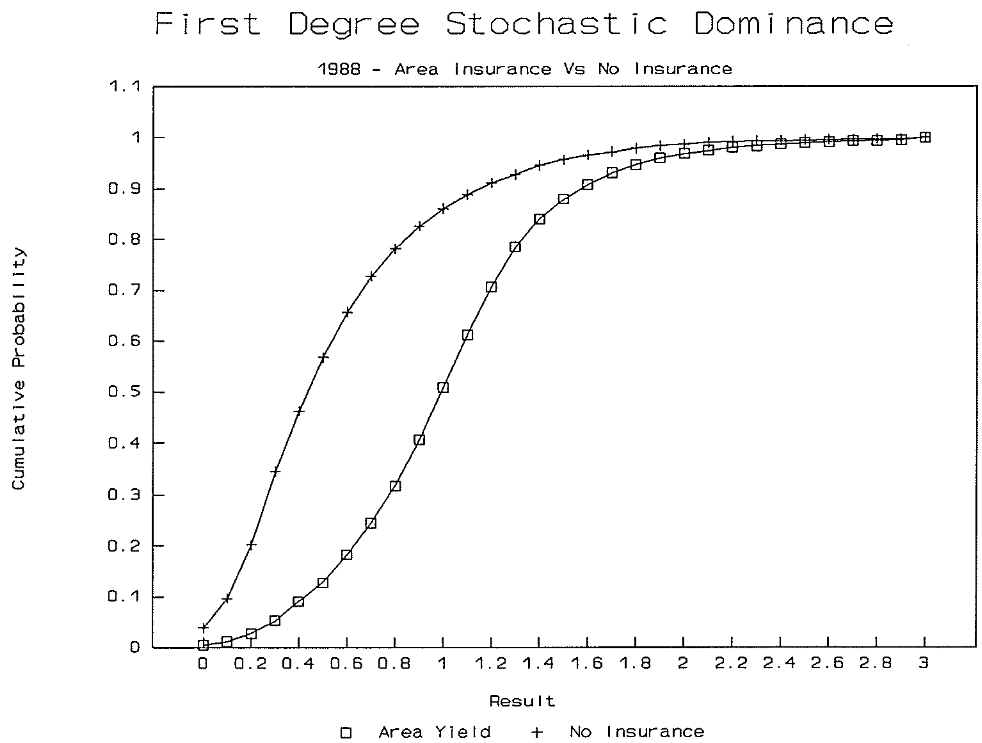
4.4.1 First Degree Stochastic Dominance

Figure 4.1



The one assumption in first degree stochastic dominance (FSD) tests is a person always prefers better possibilities to poorer possibilities. The distribution on the left in Figure 4.1 is a distribution of hay yields without insurance. The distribution on the right includes payments from an area yield insurance program provided at no cost to the producer. The area yield distribution in Figure 4.1 dominates the no insurance distribution as illustrated by the first degree stochastic dominance test in Figure 4.2. The cumulative probabilities of progressively better outcomes under each option were calculated to create the graph in Figure 4.2.

Figure 4.2



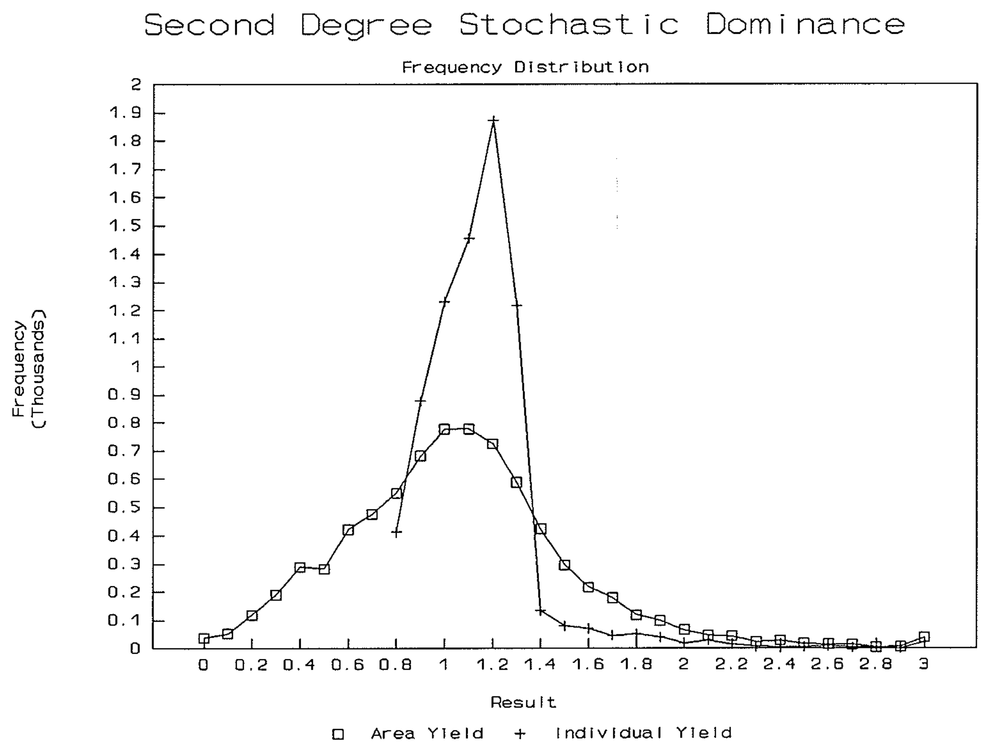
The cumulative distribution of yield equivalents without insurance is always above the cumulative distribution of yield equivalents with an area yield insurance program without premiums. Therefore a more favourable outcome is always more likely with an area yield insurance program funded entirely by governments, compared to the case of no insurance. Figure 4.2 illustrates first degree stochastic dominance.

First degree stochastic dominance (FSD) is not particularly discriminating. If the two cumulative probability distributions above crossed each other, FSD tests do not indicate the preferred choice.

4.4.2 Second Degree Stochastic Dominance

The results of an area yield program compared to an individual yield program is shown in Figure 4.3[28].

Figure 4.3



Figures 4.4 and 4.5 will be used to illustrate a second degree stochastic dominance test using the individual yield insurance program and the area yield insurance shown in Figure 4.3. In second degree stochastic dominance tests, a risk averse decision maker, who maximizes expected utility, is assumed.

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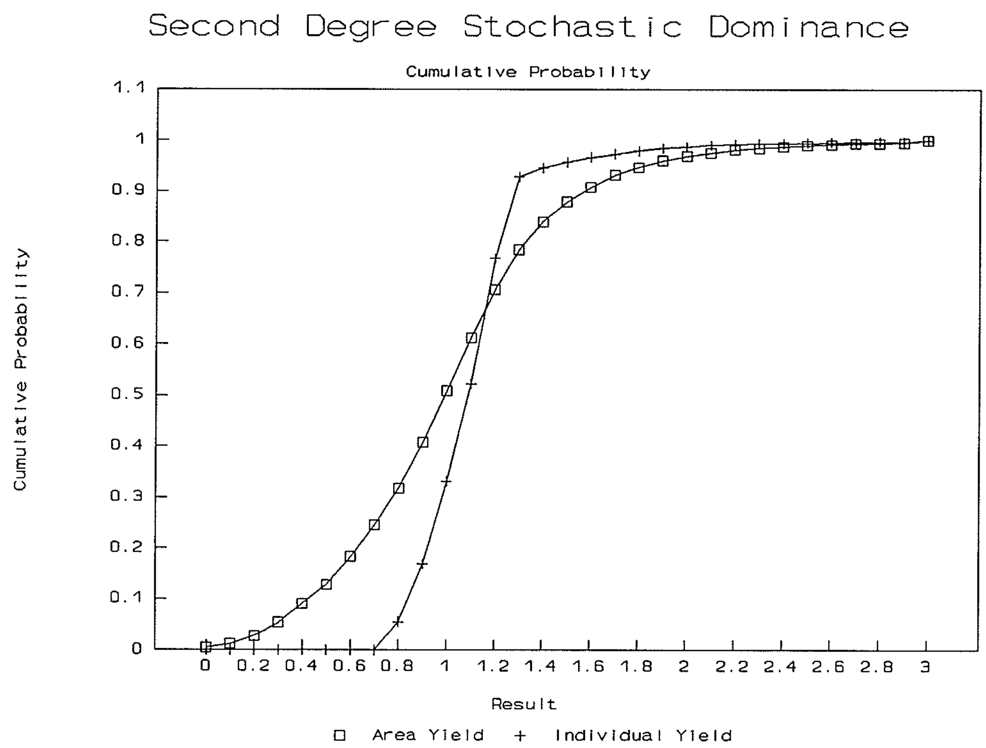
[28] The X axis labelled "Result" in these figures is the producer's actual yield plus the payment from the program, if any, expressed as a proportion of the producer's long term average yield (LTAY).

Figure 4.4



The cumulative probability distributions cross in Figure 4.4, and as a result, first degree stochastic dominance tests are not helpful. In order to establish second degree stochastic dominance, the difference in the areas between the two cumulative probability distributions before the area yield insurance program crosses the individual yield insurance program must be greater than the difference between the two areas under the cumulative probability distributions after they cross. The differences between the two areas under the cumulative probability functions are shown in Figure 4.5.

Figure 4.5

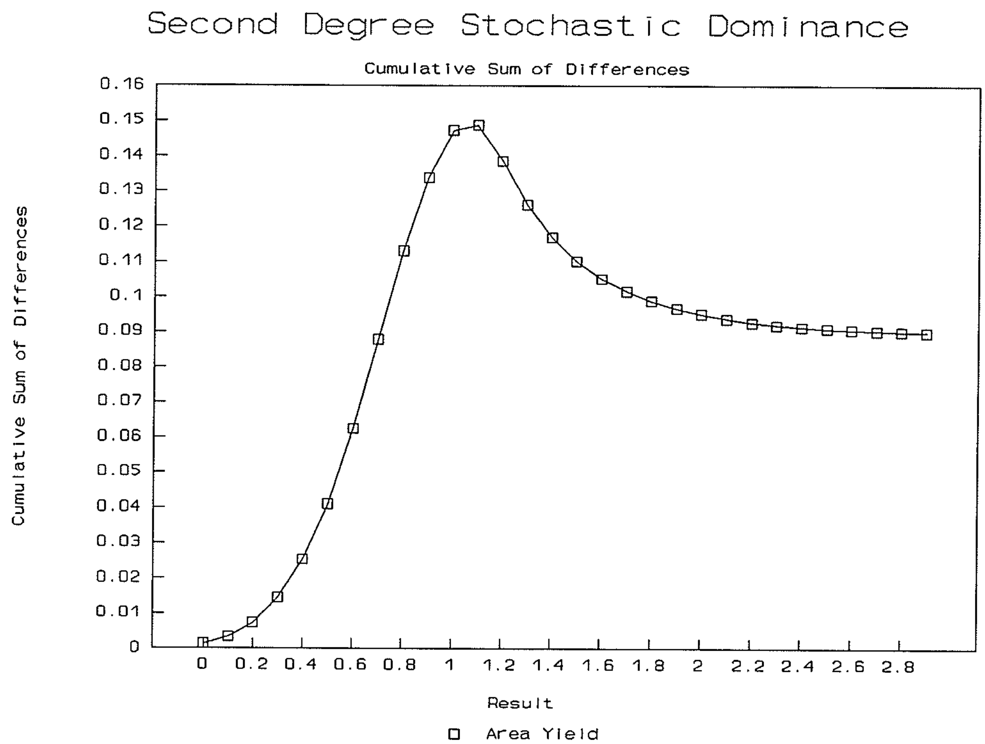


Figure 4.5 illustrates the cumulative difference in the areas under the two cumulative probability functions in Figure 4.4. The difference in the area under the cumulative probability functions after they cross, is not great enough to overcome the difference in areas before they cross. Because of the assumption of diminishing marginal utility, it is possible to argue that the individual yield insurance program in this example is unequivocally preferred over the area yield insurance program. This is because the cumulative probabilities of a better outcome at low yield levels using an individual yield insurance program is higher than the

cumulative probabilities of a better outcome with an area yield insurance program at correspondingly high yield levels.

Unfortunately second degree stochastic dominance test are also limited. If the area between the two distributions after they cross is greater than the area before they cross, second degree stochastic dominance tests can not be used to order or establish a preference between two distributions. If the area after they cross is greater than the area before they cross then at some point the cumulative difference between the areas turns negative. If the cumulative difference between the two areas does become negative, then the second distribution may or may not be preferred to the first distribution, depending on the specific risk attitudes (i.e., the curvature of the utility function) of the decision maker.

4.5 Actuarial Soundness

The cost of the insurance coverage is introduced in the stochastic dominance tests. In Chapter Two, the possibility that the initial premiums charged for insurance coverage under the Livestock Feed Security Program might have underestimated the actuarial cost of the program was discussed. In addition, the premium rate structure of the actual Cultivated Forage Insurance Program differs markedly from the uniform rate used in the Livestock Feed Security Program. In this study, the actual terms of the Cultivated Forage Insurance Program were altered to make the terms more closely resemble those of the

Livestock Feed Security Program, ie., the percentage of the long term average yield at which payments started was 80% rather than 70%. Given these modifications the existing rate structure of the Cultivated Forage Insurance Program was not appropriate.

Premium rates for both the Livestock Feed Security Program and the Cultivated Forage Insurance Program were calculated so that the aggregate premiums collected between 1984 and 1988 were equal to the aggregate payments made between 1984 and 1988. Premiums for each producer were calculated using identical premium rates.

4.6 Model Validation

A comparison of the payout to coverage ratios generated from this model with the payout to coverage ratios predicted by the Manitoba Crop Insurance Corporation, if the 80% option had been available since 1984, is presented in Table 4.2.

Table 4.2:

A Comparison of Payout to Coverage Ratios

Year	"Predicted" From Table 2.5 @ 80% Coverage	Results from current approach @ 80% Coverage
1984	46%	16%
1985	58%	18%
1986	1%	3%
1987	17%	14%
1988	60%	46%

Overall, the payout to coverage ratio under the current approach is lower than the payout to coverage ratio predicted by the Manitoba Crop Insurance Corporation. Possible reasons for the differences are: 1) areas covered by the actual program in 1984 and 1985 were different from the areas covered in the simulation, and 2) the weight given to each area in this simulation may differ from the actual situation, if there were proportionally more yields in the database compared to the proportion of contracts actually signed in the areas, 3) polygon boundaries were used in the simulation instead of municipal boundaries, 4) the simulation does not model native hay claims.

Chapter Five: Results

The objectives of the following chapter are to present the results of the analysis. The second part of the chapter focuses on whether an individual yield insurance program is preferred to an area yield insurance program.

5.1 Differences Between Areas of LFSP and Areas of No LFSP Payments

One test of area homogeneity is to identify areas of LFSP payments, and areas of no LFSP payments and count the number of yields in each area that were either above or below 80% of the long term average yield (LTAY). If a yield was below 80% of the LTAY it was counted as a loss. If it was above 80% of the LTAY it was counted as a "no loss". The probabilities of yield loss are compared in areas of LFSP payments and areas of no LFSP payments.

A high probability of a loss in areas of LFSP payments, combined with low probability of a loss in areas of no LFSP payments indicates a sharp differentiation between areas of LFSP payments and areas of no LFSP payments. If the probability of a loss in areas of no LFSP payments is close to the probability of a loss in areas of LFSP payments, then this would indicate a serious lack of homogeneity in an area and a lack of a clear differentiation between areas of LFSP payments and areas of no LFSP payments.

The results of these counts are shown in Table 5.1. Between 1984 and 1988, 66% of all the yields in areas of no LFSP payments were above 80% of the LTAY, compared to 34% of yields that fell below 80% of the LTAY. In areas of LFSP payments, the probabilities were almost exactly reversed, 32% of yields were above 80% of the LTAY, and 68% of yields were below 80% of the LTAY.

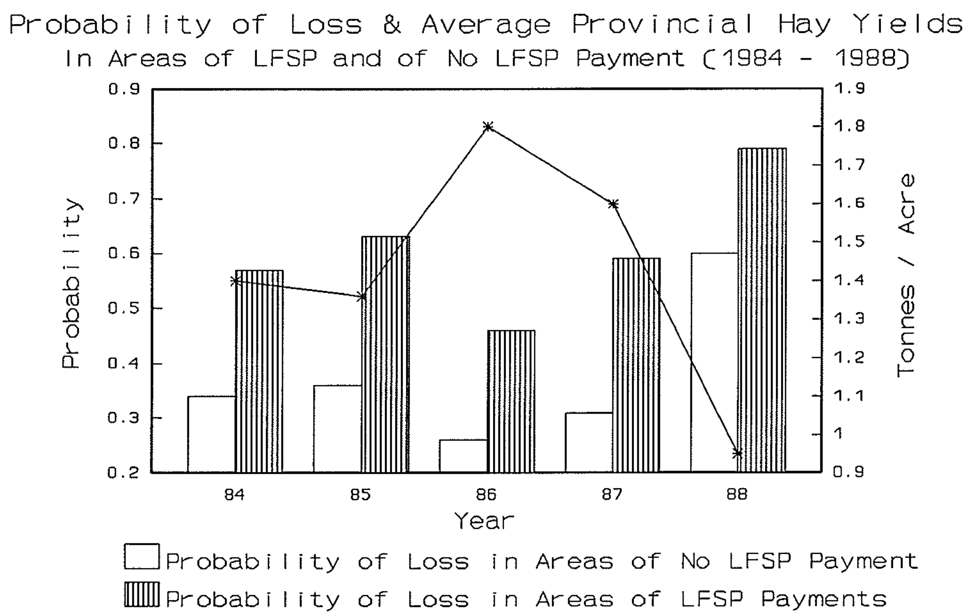
While there were differences between the probabilities of loss in areas of LFSP payments and areas of no LFSP payments, 34% of yields were above the LTAY (no loss) in areas of LFSP payments, and 32% of yields were below the LTAY (loss) in areas of no LFSP payments. The probabilities change from year to year. In 1988, 60% of the yields in areas of no LFSP payments were below 80% of the LTAY, compared to just 26% in 1986.

Table 5.1:
Conditional Probabilities
(1984 - 1988)

Year	Obs	Areas of No LFSP Payment		Areas of LFSP Payments	
		No Loss	Loss	Loss	No Loss
1984	2335	829 (66%)	426 (34%)	617 (57%)	463 (43%)
1985	5396	1880 (64%)	1053 (36%)	1548 (63%)	915 (37%)
1986	5664	3803 (74%)	1351 (26%)	233 (46%)	277 (54%)
1987	6319	2322 (69%)	1064 (31%)	1718 (59%)	1219 (41%)
1988	7617	576 (40%)	876 (60%)	4873 (79%)	1298 (21%)
1984 - 1988	27331	9410 (66%)	4770 (34%)	8989 (68%)	4172 (32%)

Between 1984 and 1988 there were significant changes in average provincial hay yields. In 1986, the average provincial hay yield was well above average. In 1988, it was well below average. In Figure 5.1 the probabilities of losses in areas of LFSP payments appear to be correlated with changes in the average provincial hay yield. The line graph in Figure 5.1 plots the average provincial hay yield. The bar graphs show the probabilities of loss in areas of no LFSP payment and in areas of LFSP payment.

Figure 5.1



The above average provincial hay yield in 1986 corresponds with the lowest probabilities of a yield being below 80% of the LTAY in areas of LFSP payments and in areas of no LFSP payments. In areas of LFSP payments, the probability of a loss was 46% compared to 57% to 79% in other years. In areas of no LFSP payments, the probability of a loss was just 26%, compared to probabilities that ranged between 31% and 60% in other years.

The highest probabilities of losses in areas of LFSP payments, and in areas of no LFSP payments occurred in 1988. In areas of LFSP payments, the probability of a loss was 79%. In the period from 1984 to 1987, these same probabilities ranged between 46% and 63%. In areas of no LFSP payments, the probability of a loss rose to 60%. Ironically, the probability of a loss in 1988, was as high in areas of no LFSP payments, as the probability of a loss in areas of LFSP payments between 1984 and 1987.

Table 5.1 and Figure 5.1 show that the probability of a loss was always higher in areas of LFSP payments than it was in areas of no LFSP payments. In 1986, for example, 46% of yields were below 80% of the LTAY in areas of LFSP payments versus 26% in areas of no LFSP payments. In 1988, 79% of yields were below 80% of the LTAY in areas of LFSP payments versus 60% in areas of LFSP payments.

The LFSP does not compare the losses in one area with the losses in another area, and on the basis of which area was hit worst decide which area receives the money available. One explanation for these results is that since there are more yields closer to 80% in a year of generally low yields, there will be areas that just miss a payout, and if yields are normally distributed more producers in areas of no LFSP payments will just miss receiving a payout.

5.1.4 Average Losses

Table 5.2:

Average Loss in Areas of No LFSP Payments and in Areas of LFSP Payments
(Average Loss Expressed As A Proportion of Long Term Average Yields [LTAYs])

Year	Areas of No LFSP Payments		Areas of LFSP Payments	
	Percentage of Yields Below 80%	Average Loss	Percentage Of Yields Below 80%	Average Loss Before Payment
84	34%	0.283	57%	0.306
85	36%	0.315	63%	0.327
86	26%	0.291	46%	0.309
87	31%	0.300	59%	0.351
88	60%	0.338	79%	0.424

Table 5.2 shows the average loss in areas of no LFSP payments and the average loss in areas of LFSP payments. The average loss in areas of no LFSP payments are consistently lower than the average loss in areas of LFSP payments. However, the differences between the average loss in areas of no LFSP payments and the average loss in areas of LFSP payments are not all that large. There are greater differences between the number of losses in areas of LFSP payments and the number of losses in areas of no LFSP payments. Still the average loss in areas of no LFSP payments was almost as high in 1988 (0.338), as the average loss in areas of LFSP payments in the period from 1984 through to 1987 (0.306 - 0.351).

5.2 Loss Coverage

The next three tables compare the payments made by the area yield insurance program (LFSP) with losses in areas of LFSP payments and losses in areas of no LFSP payments.

Total simulated losses in all areas of the province are shown in column (a) of Table 5.3. All losses were calculated as percentages of the person's LTAY. Therefore, losses on an individual basis can range from 0 to 1. Individual losses can not exceed 1, and as a result, total losses calculated can not exceed the number of observations in the dataset. For example, the total losses shown in column (a) could not exceed 2,335 in 1984 (the number of observations - see Table 5.1)

Losses in areas of no LFSP payments are shown in column (b), and losses in areas of LFSP payments are shown in column (c). The losses in column (b) plus the losses in column (c) equal the total losses in column (a). The proportion of total losses located in areas of no LFSP payment and in areas of LFSP payments are shown in parenthesis in columns (b) and (c), respectively.

In 1984, 39.0% of all losses calculated were in areas of no LFSP payments and 61.0% were in areas of LFSP payments. In 1986, 84.5% of losses were in areas of no LFSP payments, compared to 15.5% that were in areas of LFSP payments. The proportions of losses in areas of no LFSP payments and in areas of LFSP payments in 1986 were almost exactly reversed in 1988. Only 12.5% of losses in 1988 were in areas of no LFSP payments, compared to 87.5% of losses in areas of LFSP payments. In 1984, 1985 and 1987 the proportion of total losses located in areas of LFSP payments was fairly steady at around 60%.

The LFSP payments simulated by the model are shown in column (d) of Table 5.3. Two different LFSP indemnity schedules were used to calculate the LFSP payments. In the top half of Table 5.3, the indemnity schedule paid 1% for each 1% of loss. In the bottom half of Table 5.3 the indemnity schedule paid 2% for each 1% of loss. The losses calculated in the first three columns are not altered by the indemnity schedule used.

The effect of changing the rate at which indemnities are paid is to effectively double LFSP payments. In 1984, for example, LFSP payments jumped from 192.8 to 384.1.

The magnitude of the LFSP payments compared to the losses in areas of LFSP payments are shown in the percentages in column (d). The percentages in column (d) were calculated by dividing the total LFSP payments in column (d) by the losses in areas of LFSP payments in column (c).

With the 2% payout for every 1% loss the LFSP payments are always greater than the losses calculated for areas of LFSP payments. In 1988, the LFSP payments shown in the bottom half of column (d) were 171.5% of the losses calculated for areas of LFSP payments (column (c)). In 1986, LFSP payments were over two and a half times larger than calculated losses.

Table 5.3
Loss Coverage
(Individual Losses & Payments Expressed As A Proportion Of Producer's LTAYs & Then Summed Over All Producers)

Year (In Parenthesis)	(a) Total Losses	(b) Losses In Areas Of No LFSP Payments (b/a)	(c) Losses In Areas Of LFSP Payments (c/a)	(d) LFSP Payments (d/c)	(e) Losses Covered In Areas Of LFSP Payments (e/c)	(f) Difference Between LFSP Payments & Losses Covered (f/c)
84	309.1	120.6 (39.0%)	188.5 (61.0%)	192.8 (102.3%)	93.2 (49.4%)	99.6 (52.8%)
85	837.8	331.7 (39.6%)	506.1 (60.4%)	479.4 (94.7%)	262.2 (51.8%)	217.2 (42.9%)
86	464.8	392.7 (84.5%)	72.1 (15.5%)	93.4 (129.5%)	35.4 (49.1%)	58.0 (80.4%)
87	921.0	318.8 (34.6%)	602.2 (65.4%)	438.9 (72.9%)	237.5 (39.4%)	201.4 (33.4%)
88	2363.0	294.7 (12.5%)	2066.8 (87.5%)	1837.7 (88.9%)	1332.9 (64.5%)	504.8 (24.4%)
		If the LFSP paid 2% for every 1% below 80%				
84	309.1	120.6 (39.0%)	188.5 (61.0%)	384.1 (203.8%)	139.3 (73.9%)	244.8 (129.9%)
85	837.8	331.7 (39.6%)	506.1 (60.4%)	956.8 (189.0%)	394.0 (77.9%)	562.8 (111.2%)
86	464.8	392.7 (84.5%)	72.1 (15.5%)	186.3 (258.4%)	53.6 (74.3%)	132.7 (184.0%)
87	921.0	318.8 (34.6%)	602.2 (65.4%)	869.7 (144.4%)	364.7 (60.6%)	505.0 (83.9%)
88	2363.0	294.7 (12.5%)	2066.8 (87.5%)	3544.0 (171.5%)	1793.4 (86.8%)	1750.6 (84.7%)

Although the LFSP payments were larger than the losses calculated for areas of LFSP payments, the payments do not exactly correspond with the losses in these areas. Column (e) matches LFSP payments against calculated producer losses. The percentages in column (e) were calculated by dividing the losses covered by LFSP payments in column (e) by the losses in areas of LFSP payments shown in column (c).

Using an indemnity schedule of 1% for 1%, about half of the losses in areas of LFSP payments were covered by the LFSP payments between 1984 and 1986. In 1987, only 39.4% of the losses were covered. In 1988, 64.5% of the losses were covered. However, by using an indemnity schedule of 2% for 1% about three quarters of the losses in areas of LFSP payments were covered by the LFSP payments between 1984 and 1986. The coverage drops to 60.6% in 1987, and increases to 86.8% of losses in areas of LFSP payments in 1988.

The difference between the LFSP payments and the losses covered by the LFSP payments is shown in column (f). The amounts in column (f) plus the amounts in column (e) equal the payments in column (d). The percentages in column (f) were calculated by dividing the amount in column (f) by the losses in areas of LFSP payments in column (c).

By increasing the rate at which payments are made (i.e, from 1% to 2%), the area yield insurance program covers a greater proportion of the losses in areas of LFSP payments. Increasing the rate also increases payments to individuals whose losses were not as bad as others in the area. In fact, a substantial proportion of the increased LFSP payment resulting from the change in the indemnity schedule from 1% for 1%, to 2% for 1% goes to these individuals.

In 1988, for example, changing the indemnity schedule to 2% for 1%, from 1% for 1%, increased the coverage of losses by 460.5, but at the same time increased the difference between the LFSP payments and the losses actually covered by those payments by 1245.8, or over 300%.

Table 5.4
Analysis of LFSP Payments
(Losses & Payments Expressed as a Proportion of LTAYs)

YEAR	No Loss (i)	Loss (ii)	Average Loss Before Payments (iii)	Average Loss After Payments (iv)	Percentage Reduction (v)	Average Over Payment On Losses (vi)	Average Payment With No Loss (vii)
			If the LFSP paid 1% for every 1% below 80%				
84	463	617	0.306	0.154	49.4%	0.033	0.171
85	915	1,548	0.327	0.158	51.8%	0.036	0.176
86	277	233	0.309	0.158	49.1%	0.043	0.173
87	1,219	1,718	0.351	0.212	39.4%	0.022	0.134
88	1,298	4,873	0.424	0.151	64.5%	0.046	0.215
			If the LFSP paid 2% for every 1% below 80%				
84	463	617	0.306	0.080	73.9%	0.140	0.341
85	915	1,548	0.327	0.072	77.9%	0.155	0.351
86	277	233	0.309	0.079	74.3%	0.158	0.346
87	1,219	1,718	0.351	0.138	60.6%	0.104	0.266
88	1,298	4,873	0.424	0.056	86.8%	0.246	0.423

Table 5.4 focuses on areas of LFSP payments. Table 5.4 and Table 5.5 are used to illustrate that there is a trade-off between an expected gain in areas of LFSP payments and a potential loss in areas of no LFSP payments, particularly when a 2% for 1% indemnity schedule is used.

The average loss calculated before and after LFSP payments, and the percentage reduction of loss are shown in columns (iii - v) of Table 5.4. Two possibilities are considered when LFSP payments are greater than the individual yield insurance payments (or producer loss). First, if yields are below 80% of the LTAY, and if the area yield insurance payments are greater than the individual yield insurance payments, the differences between the area yield insurance payments and the individual yield insurance payments are summed, and divided by the number of yields below 80% of the LTAY, to get the average shown in column (vi). Second, if yields are greater than 80% of the LTAY, the differences between the area yield insurance payments and the individual yield insurance payments (always equal to zero because the yields are greater than 80% of the LTAY) are summed, and divided by the number of yields that are above 80% of the LTAY in areas of LFSP payments, to get the average amounts shown in column (vii).

Changing the indemnity schedule cut the average loss after payments in half (column v). It also increased the average over payment on losses (column vi), and the average payment with no losses (column vii). The numbers between 1984 and 1986 are remarkably consistent with each other. In 1987 the numbers in columns (vi & vii) dip. They reach their highest levels in 1988. The average loss after payments (column iv) are at their highest level in 1987. They drop to their lowest level in 1988. Notably, the average loss before payments (column iii) was highest in 1988. The second highest average loss before payments was in 1987.

Table 5.5

Expected Gains

(Expected Gains & Averages Losses Are Expressed As A Proportion of LTAYs)

YEAR	Areas of LFSP Payments			Areas of No LFSP Payment		Overall Expected Gain
	No Loss (i)	Loss (ii)	Expected Gain In Areas of LFSP Payments (iii)	Average Loss (iv)	Average Expected Loss (v)	Column (iii) + Column (v) Weighted By The Number of Yields In Each Area
			If the LFSP paid 1% for every 1% below 80%			
84	0.073	-0.070	0.003	-0.283	-0.096	-0.050
85	0.065	-0.077	-0.012	-0.315	-0.113	-0.067
86	0.094	-0.052	0.042	-0.291	-0.076	-0.066
87	0.055	-0.111	0.056	-0.300	-0.094	-0.076
88	0.045	-0.083	-0.038	-0.338	-0.204	-0.069
			If the LFSP paid 2% for every 1% below 80%			
84	0.146	0.034	0.180	-0.283	-0.096	0.032
85	0.130	0.052	0.182	-0.315	-0.113	0.022
86	0.180	0.036	0.216	-0.291	-0.076	-0.049
87	0.110	-0.020	0.090	-0.300	-0.094	-0.008
88	0.089	0.150	0.239	-0.338	-0.204	0.154

Table 5.5 illustrates the trade-off between a potential loss in areas of no LFSP payments, and an expected gain in areas of LFSP payments. Columns (i) through (iii) calculate the expected gain in areas of LFSP payments resulting from the Livestock Feed Security Program. Column (i) of Table 5.5 was calculated by multiplying the average LFSP payment received by producers with yields higher than 80% of the LTAY (column (vii) of Table 5.4), by the proportion of yields in areas of LFSP payments that were greater than 80% of the LTAY. Column (ii) was calculated by first, subtracting the average overpayment made to producers with yields below 80% of the

LTAY (column (vi) Table 5.4) from the average loss after payments (column (iv) Table 5.4) and then, second, multiplying the difference by the proportion of yields in areas of LFSP payments that were less than 80% of the LTAY. Columns (i) and (ii) were added together to get column (iii). Column (iii) represents an expectation of a producer's gain in areas of LFSP payments.

With a 1% for 1% indemnity schedule a producer in an area of LFSP payments whose yield was below 80% of the LTAY could not expect to be entirely compensated for the loss (column ii). On the other hand, a producer whose yield was above 80% of the LTAY could expect a modest benefit from the program (column i). In 1984, 1986 and 1987 more producers were overcompensated than undercompensated. In 1985 and 1988 more producers were undercompensated than overcompensated (column iii).

Using a 2% for 1% indemnity schedule a producer in an area of LFSP payments whose yield was below 80% of the LTAY could expect to be entirely compensated for the loss except in 1987. Producers whose yield was above 80% of the LTAY could expect a significant benefit from the program. Overall, the 2% for 1% indemnity schedule gave producers in areas of LFSP payments a significant benefit. In 1987 the benefit was not quite as high.

Producers in areas of no LFSP payments were not as well off. Columns (iv) and (v) of Table 5.5 are used to calculate the expected loss in areas of no LFSP payments. Column (iv) is the average loss in areas of no LFSP payments. Column (v) is calculated by multiplying the average loss in column (iv) by the proportion of yields in areas of no LFSP payments that were below 80% of the LTAY. The average expected loss in areas of no LFSP payments was quite high in 1988 compared to the average expected losses before 1988.

By weighting the results in column (iii) and (v) by the proportions of yields located in areas of LFSP payments and in areas of no LFSP payments, a general impression of the importance of the benefits in areas of LFSP payments and the losses in areas of no LFSP payments may be gained. The overall expected gain is shown in the last column.

With the 1% for 1% indemnity schedule, the mathematical expectation is that the losses in areas of no LFSP payments outweigh the benefits in areas of LFSP payments. Using a 2% for 1% indemnity schedule, the mathematical expectation is that the benefits in area of LFSP payments outweigh the losses in areas of LFSP payments in 1984, 1985 and 1988.

In 1988, there were relatively few yields or losses that were not in areas of LFSP payments (see Table 5.1). The expected gain in areas of LFSP payments was therefore weighted heavily in the average in the last column of Table 5.5. Despite the large average loss in areas of no LFSP payments, producers overall realized a significant benefit from the LFSP payments.

In 1986, on the other hand, there were few yields in areas of LFSP payments and most losses were in areas of no LFSP payments (see table 5.1). The large benefit expected in areas of LFSP payments did not form a large part of the average in the last column.

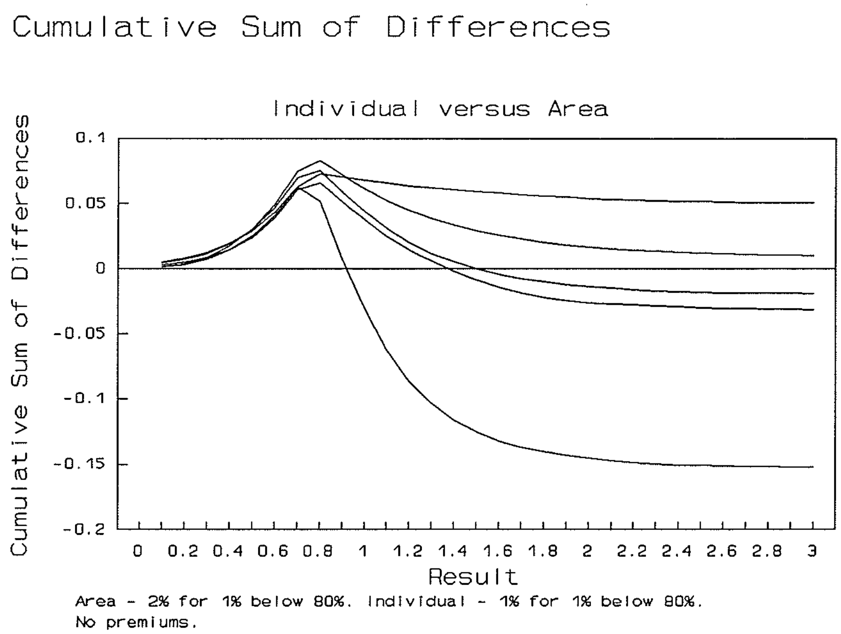
5.3 Second Degree Stochastic Dominance Tests

The results of the second degree stochastic dominance tests for preferences are presented in this section. The question asked is whether the distributions resulting from the individual yield insurance program are preferred over the distributions resulting from an area yield insurance program?

The distributions necessary for these tests were created by expressing each yield as a percentage of the long term average yield and adding the payout made by each of the insurance programs. The costs of the program are introduced by subtracting the premium rate from each producer's yield. The resulting distributions reflect trade - offs between cost, returns from the program and the targeting of returns from the program with producer losses.

The following graphs plot the cumulative difference in the areas under the cumulative density distributions created for an individual yield insurance program and an area yield insurance program. In the first graph (Figure 5.2), the area yield insurance pays 2% for 1%, and the individual yield insurance pays 1% for 1%.

Figure 5.2



The pattern illustrated in Figure 5.2 is typical of the pattern found in the tests of second degree stochastic dominance performed in this study. The cumulative difference rises (favouring individual yield insurance) at first, and then begins to fall (favouring area yield insurance) at higher yield levels. The individual yield insurance dominates area yield insurance at low yields for two reasons. First, it reflects losses in areas of no LFSP payments that were covered by the individual yield insurance program which were not covered by LFSP payments. Second, it reflects losses in areas of LFSP payments that were not completely covered by the LFSP payment. The dominance of the individual yield insurance program is eroded at higher yield levels because the LFSP makes larger payments (relative to individual yield insurance program payments) to producers with yields that were either above the LTAY, or were better than other yields in the area.

The individual yield insurance program dominated the area yield insurance program in 1986 and 1987. The overall expected gain from the LFSP was negative even with the 2% for 1% indemnity schedule in these two years (see Table 5.5). Second degree stochastic dominance of the individual yield insurance program is not established in 1984, 1985 or 1988. The difference between the area under the individual yield insurance program and the area under the area yield insurance program, after the two cumulative density distributions cross, is greater than the difference in the areas under the distributions before the distributions cross. As a result, the lines showing the cumulative sum of differences between the area and the individual cumulative density distribution for these years in Figure 5.2 drop below zero.

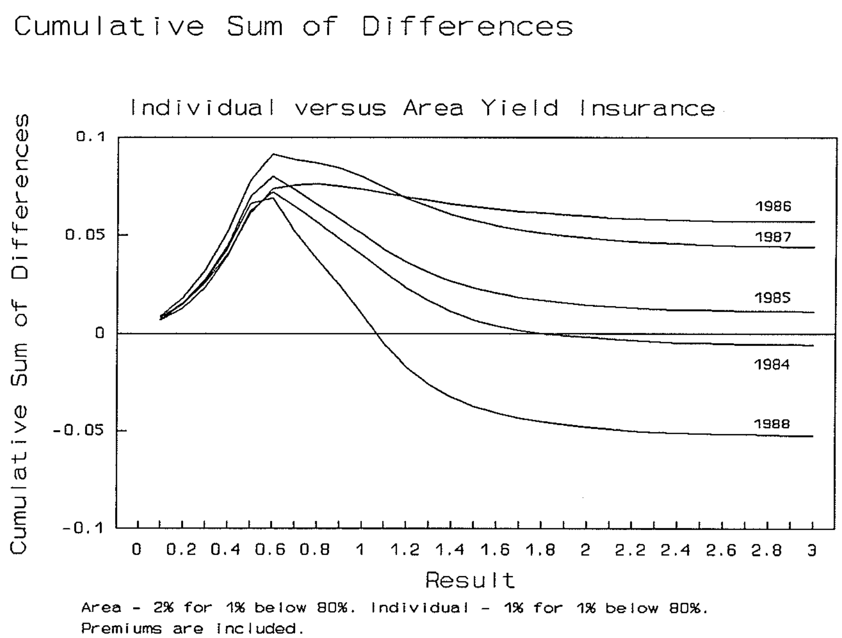
Overall, the individual yield insurance program may be preferred to the area yield insurance program in Figure 5.2, or vice versa. The ability of second degree stochastic dominance tests to establish an overall preference (i.e., not just in a particular year) by all risk averse producers for one program over the other is greatly reduced in a multiperiod study[29] when the dominance of one program can not be

[29] See Jeffrey and Eidman (1992) for a discussion of the conditions necessary for stochastic dominance in a multiperiod framework. Generally, dominance for each variable (year) is necessary and sufficient for overall dominance by FSD or SSD.

established in each and every year of the study.

5.3.1 Including Premiums

Figure 5.3



In Figure 5.3, the costs of the programs have been charged to producers in form of a uniform premium rate[30]. Premium costs add an important new dimension to the problem, since higher payments result in higher premiums which have to be paid each year, not just in the year(s) of higher payouts. All the parameters used for Figure 5.2 are unchanged. The area

[30] Producers are charged the full premium rate. In actual fact the producer pays half of the premium and governments pay the other half. If the premium rates were cut in half the differences in the costs of various options would also be cut in half. If only half of the premium rate were used, the full difference in the cost of the other option would not be reflected in the stochastic dominance tests.

yield insurance used a 2% for 1% indemnity schedule, and the individual yield insurance used a 1% for 1% indemnity schedule.

The costs of the individual yield insurance program and the area yield insurance program are very similar. The premium rate for the individual yield insurance program is 22.6%. The premium rate for the area yield insurance program is 21.7%

With the premiums included, individual yield insurance dominates the area yield insurance program in three out of the five years (1985, 1986 and 1987). In 1984 and 1988, the two years in which stochastic dominance is not established, the difference between the two areas under the area yield insurance and the individual yield insurance narrows compared to the differences in the areas before premiums were included (Figure 5.2).

5.3.2 The Importance of the Indemnity Schedule

The next two figures illustrate the importance of the 2% for 1% indemnity schedule used in the Livestock Feed Security program. The premium rates required are summarized below. Using a 1% for 1% indemnity schedule, the premium rate for the area yield insurance program is quite low. If the Livestock Feed Security Program used a 2% for 1% indemnity schedule, the cost of the area yield insurance program and the individual yield insurance program would be very similar.

Program	Indemnity Schedule	Premium Rates
Area	1% - 1%	12.3%
Area	2% - 1%	21.7%
Individual	1% - 1%	22.6%

Area yield insurance indemnity schedule of 1% for 1%

In Figure 5.4 the indemnity schedule for the LFSP is 1% payment for each 1% loss. With this indemnity schedule, the individual yield insurance program is stochastically dominant over the area yield insurance program in 1988. In 1986, the individual yield insurance program may or may not be preferred to the area yield insurance program.

Area yield insurance indemnity schedule of 2% for 1%.

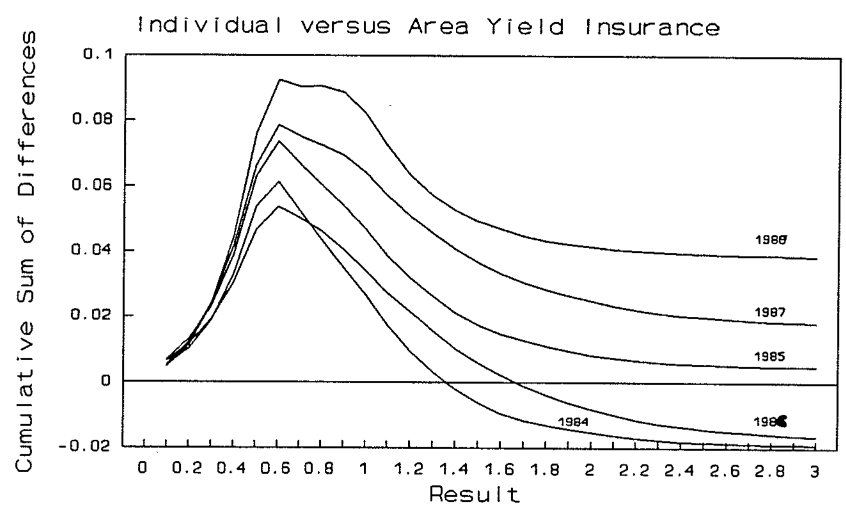
In Figure 5.5 the indemnity schedule used by the

Livestock Feed Security Program paid 2% for each 1%. With the Livestock Feed Security Program using this indemnity schedule, the individual yield insurance program is stochastically dominant over the area yield insurance program in 1986, but not in 1988. Changing the indemnity schedule causes a reversal in the ordering of the area yield insurance program and the individual yield insurance program in 1986 and 1988.

Why does the individual yield insurance program show second degree stochastic dominance over an area yield insurance program that uses a 1% for 1% indemnity schedule in 1988, and not one using a 2% for 1% indemnity schedule? One reason is there is improved coverage of losses with individual yield insurance and second, there is not enough weight (because of lower payments) at higher yield levels to overcome the initial advantage of the individual yield insurance program at low yield levels. When the area yield insurance program uses an indemnity schedule of 2% for 1%, there is enough weight at higher yield levels to overcome the advantage of the individual yield insurance program at low yield levels,

Figure 5.4

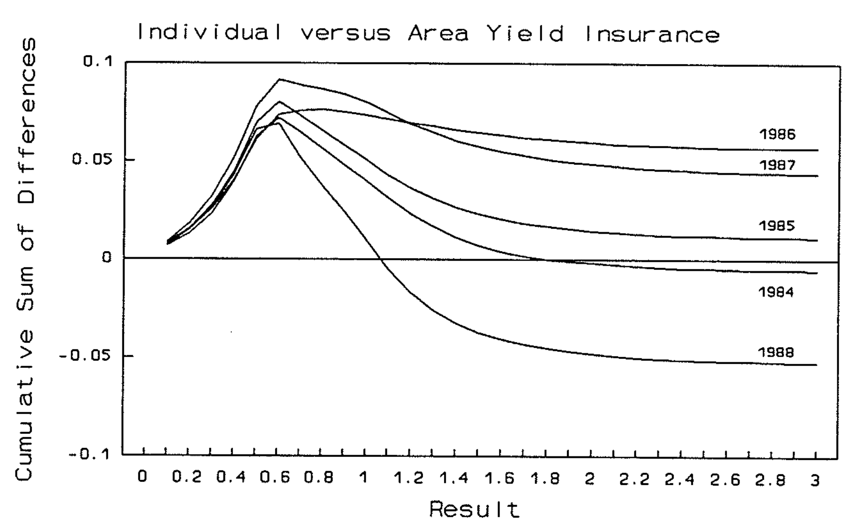
Cumulative Sum of Differences



Area - 1% for 1% below 80%. Individual - 1% for 1% below 80%.
Premiums are included.

Figure 5.5

Cumulative Sum of Differences

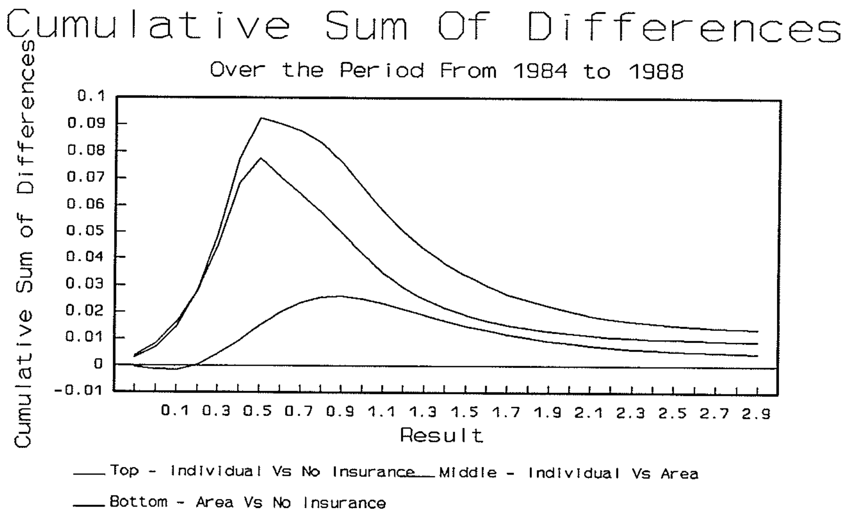


Area - 2% for 1% below 80%. Individual - 1% for 1% below 80%.
Premiums are included.

The higher payouts with a 2% for 1% indemnity schedule are reflected in higher premium costs that affect the stochastic dominance tests particularly in 1986. The increased costs of the area yield insurance program that uses a 2% for 1% indemnity schedule, rather than a 1% for 1% indemnity schedule is reflected in the relative position of 1986 in the two figures. At 2% for 1%, the premium cost of an area yield insurance is almost as large as the premium cost of an individual yield insurance program. There were few areas of LFSP payments in 1986, and most of the losses covered by the individual yield insurance program were not covered by the area yield insurance program. With similar costs and lower payouts, the area yield insurance program was dominated by the individual yield insurance program in 1986.

At 1% for 1%, on the other hand, the premium cost of the area yield insurance program was substantially less than the premium cost of an individual yield insurance program. In 1986, the lower premium cost of an area yield insurance program using a 1% for 1% indemnity schedule adds enough weight at higher yield levels to erode the dominance of the individual yield insurance program at lower yield levels.

Figure 5.6



Area 2% for 1%. Individual 1% for 1%.
Premiums are included.

The stochastic dominance tests have been based on a year by year comparison of two programs. It has not been evident whether overall, one program tends to dominate the other. An alternative to satisfying the criteria for multivariate stochastic dominance may be to combine the multiple attributes into a single outcome and apply a univariate criterion[31]. In Figure 5.6, the five years between 1984 and 1988 are treated as one period. This hides the multivariate nature of the problem by eliminating the temporal separation[32] of yields, payouts and premiums. SSD tests are used to compare the resulting distributions.

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[31] See Jeffrey and Eidman (1992), pp, 199. For example, as wealth is a function of income in successive periods, comparisons may be based on the resulting distributions of wealth at the end of the time frame.

[32] Separation by the passage of time from one event (or set of probabilities) to another event (or set of probabilities).

Three pairs of distributions are compared with each other in Figure 5.6. The top line illustrates the cumulative difference between the individual yield insurance program and no insurance. The line in the middle shows the cumulative difference between the individual yield insurance program and the area yield insurance program. The bottom line shows the cumulative differences between the area yield insurance program and no insurance.

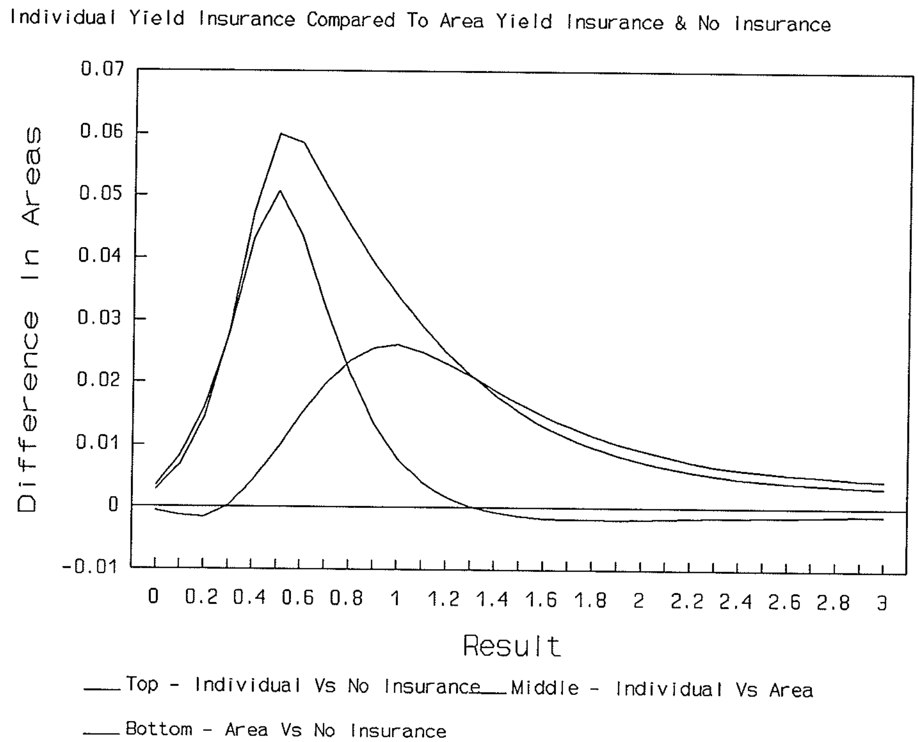
As shown in Figure 5.6, the individual yield insurance program, dominates no insurance and the area yield insurance program. No insurance, on the other hand, has a slight advantage over area yield insurance at very low yield levels.

5.3.3 Accounting For Lower Coverage Levels

Up to this point, it has been assumed that yields are unaffected by increasing the coverage level available under an individual yield insurance program to 80%, from 70%. Advocates of area yield insurance contend that the reduction of program abuse allows increased coverage levels. Increasing the coverage to 80% in an individual yield insurance program may therefore result in increased program abuse, with the result that the necessary premiums are underestimated in this model.

To test the benefits implied in this trade-off, the indemnity schedule of the individual yield insurance program was changed to pay 0.75% for every 1% decline below 70% of the individual's LTAY. The area yield insurance program continued to pay 2% for every 1% decline below 80% of the area LTAY.

Figure 5.7



Area 2% for 1% Below 80%. Individual 0.75% for 1% Below 70%.
Premiums are included.

Figure 5.7 is identical to Figure 5.6, except for the change in the individual yield insurance indemnity schedule. The top line illustrates the cumulative difference between the individual yield insurance program and no insurance. The line in the middle is the cumulative difference between the individual yield insurance program and the area yield insurance program. The bottom line is again the cumulative difference between the area yield insurance program and no insurance.

Despite the lower coverage, the individual yield insurance program is nearly able to maintain its stochastic dominance over the area yield insurance program. In addition to the better targeting of payouts, the premium rate is much lower for the individual yield insurance program at a lower coverage level (9.9%) compared to the premium rate (21.7%) required for the area yield insurance.

Chapter Six: Conclusion

6.1 Statement of the Problem

The theoretical case for insurance (the basis for a mutually beneficial contract between the insurer and the insured) rests on the ability of an insurance company to reduce uncertainty. To be an effective means of reducing uncertainty, the payments made under an insurance program must be reasonably correlated with changes in the producer's income stream. With an area yield insurance program, like the Livestock Feed Security Program, the correlation of the payments made by the program with changes in the producer's income stream could be a problem.

6.2 Objectives

The objectives of this study were to measure the correspondence of payments made by an area yield insurance program with producer losses, and test whether a preference for an individual yield insurance program could be established over an area yield insurance program for a risk averse producer. If a preference for an individual yield insurance program can be established problems are indicated with the correspondence of the payments made by the area yield insurance program and producer losses.

Payments made by the Livestock Feed Security Program between 1984 and 1988 were simulated and compared with individual yield insurance payments. Stochastic dominance was used to establish producer preferences. Numerical analysis provided additional insight into the relative benefits of the two program designs.

6.3 Results

In a test of area homogeneity, demarcation of areas and the representativeness of the yield measurements, this study found a higher number of losses in areas of LFSP payments than in areas of no LFSP payments, and that losses on average were greater in areas of LFSP payments, than they were in areas of no LFSP payments. Nevertheless, there were a significant number of losses in areas of no LFSP payments.

The study identified the location and magnitude of losses, and compared the payments made by the area yield insurance program with individual losses. The study found that 30% of producer losses were in areas where the LFSP did not pay. In areas where the LFSP did pay about 43% of producer losses were not matched by a LFSP payment if the LFSP used a 2% payout for each 1% of loss. If the indemnity rate was increased to 2% payout for each 1% of loss, the proportion of producer losses not covered is reduced to 20%.

On the other hand, 36% of all the LFSP payments were not matched to a loss[33] when the LFSP used a 1% for 1% indemnity

[33] If LFSP payments exceeded individual yield insurance program payments, LFSP payments were not considered to be matched against producer losses.

schedule, and 54% of the LFSP payments were not matched to a loss when a 2% for 1% indemnity schedule was used.

Even though 20% of producer losses were not covered by payments with a 2% for 1% indemnity schedule, producers in areas of LFSP payments on average could expect much larger payments from the area yield insurance program than they could have expected from an individual yield insurance program. Over all the areas considered, the cumulative payouts made by the LFSP with a 2% for 1% indemnity schedule were about equal to the individual yield insurance payments. This is known because the premium rates were almost the same. Creating an expected gain in areas of LFSP payments given similar cumulative payouts was possible only because producers in areas of no LFSP payments with yield losses were not compensated.

Stochastic dominance tests were used to test the preference for the individual yield insurance program over the area yield insurance program. The pattern of the stochastic dominance tests illustrated the benefits of an area yield insurance program. The individual yield insurance was dominant at low yield levels, but the dominance was eroded at high yield levels due to the area average program's propensity to pay individual producer simply because they resided in a payout area. In other words the area program paid at yields the individual program would not have paid at. levels at which an individual yield insurance program would not pay. The stochastic dominance tests graphically illustrates that an area yield insurance program shifts payouts away from producers with low yields.

If the years between 1984 and 1988 are treated as one period, an individual yield insurance program that offers similar coverage levels to an area yield insurance program is preferred. With a lower coverage level for individual yield insurance, it is not clear which program is preferred.

Nevertheless, an individual yield insurance program was not shown to be preferred to an area yield insurance program at all times. In 1988, for example, the second degree stochastic dominance tests could not establish a preference for the individual yield insurance program over an area yield insurance program that used a 2% for 1% indemnity schedule. This did not result from roughly equivalent targeting of payments compared to an area yield insurance program but rather because the payments made by the area yield insurance program were larger than the payments from the individual yield insurance program. Without the 2% for 1% feature in the area program, individual yield insurance was shown to be stochastically dominant in 1988.

One of the attractions of an area yield insurance program is the possibility that payments may be much higher than would be the case if such payments were calculated on the basis of the producer's own yield loss. Higher coverage levels and an increased level of payments may be essential features if producers are to be attracted to an area yield insurance program.

6.4 Statement of Conclusions

Individual yield insurance has a clear advantage over area yield insurance in targeting payments to producers with low yields. A significant possibility of no payment from an area yield insurance program was found. As a result, it is possible that the lack of correspondence between LFSP payments and producer losses may have been a significant factor leading to the decline in participation in the Livestock Feed Security Program.

Substantial drops in participation emerged at a time when premium rates started to increase and when payouts from the program in 1986 and 1987 were not large enough to create an overall expectation of a gain from participating in the program.

If higher coverage levels and improved benefits are necessary to attract producers to an area yield insurance program who pays for those increased benefits if the producer is less willing to pay the full actuarial cost of the benefits? Problems targeting payments may change the entire framework the decision maker works under from risk reduction to gambling that future windfalls will compensate for the uncompensated losses (i.e, that a higher expected income will compensate for the higher income variance). If the program is actuarially fair in the sense that premiums overall equal payouts, then either some producers must get more than they paid in (if producers get back what they paid in, expected income is unchanged), or the government subsidy is higher, or both.

Savings in program abuse are created by an area yield insurance program because each individual producer is uncertain about the program benefits and hence does the best job possible with the available resources. This uncertainty also means that important advantages of insurance are lost. The possibility of an uncompensated loss under an area yield program could mean that additional steps or costs are necessary to reduce the potential consequences of adverse outcomes. As a result, potential program benefits like lower borrowing costs or improved resource utilization (lower forage inventories) are reduced.

While area yield insurance is one alternative to dealing with program abuse, it is not the only alternative. Adjusting coverage levels and premiums is another possibility that retains individual targeting of payouts.

6.5 Limitations of the Study

Several important assumptions and simplifications were made that place limitations on the analysis in this study. The first is that the calculations using the long term average yields (LTAYs) borrowed from the Cultivated Forage Insurance Program actually reflected the producer's loss. The probability that the LTAYs actually reflected producer losses would increase if they reflected the producer's expected yield, or in other words that the probability of a yield above the expected yield was equal to the probability of a yield below the expected yield.

In the stochastic dominance tests each producer was assumed to have no greater tendency to end with a windfall or a loss than the frequencies of occurrence shown for the province. This assumed that the probability and the magnitude of the payments made by the area yield insurance program were no greater in one area of the province than they were in another. Obviously if the probability of a payment is greater in one area of the province than it is in another then at a less aggregated level the stochastic dominance tests may look somewhat different.

Administrative costs and the costs associated with program abuse are not modeled.

The insurance of native hay yields is an important aspect of the Livestock Feed Security Program. Native hay claims are not modeled and therefore a significant aspect of the Livestock Feed Security Program is not part of this study.

The same premium rate was charged for individual yield insurance coverage across the province. In reality, premium rates will be higher or lower than this uniform rate depending on the area of the province.

The long term average yields calculated in this study for the Livestock Feed Security Program may differ from the actual long term average yields used in the program.

6.6 Further Research

Debates between area yield insurance programs and individual yield insurance programs have been or are based on stories or feelings about the magnitude of the costs associated with program abuse. While the data requirements and specifications necessary to isolate these costs are probably formidable, a methodological or theoretical approach to the problem of quantifying these costs may be very helpful.

Further research is needed on the efficiency and the effectiveness of public expenditures in area yield insurance programs versus individual yield insurance programs.

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