The Impact of Additional Safety Net Programming on the Value of Production Insurance

by

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A Thesis submitted to the Faculty of Graduate Studies of
The University of Manitoba
in partial fulfilment of the requirements of the degree of
MASTER OF SCIENCE

Department of Agribusiness and Agricultural Economics
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submitted by

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ABSTRACT

Safety net programs are an important component of agricultural policy. This study attempts to calculate the benefit derived by Canadian farmers from the available portfolio of safety net programs and impact of additional programming on the longstanding production insurance program. In addition to insurance programs, this analysis considers the Canadian Agricultural Income Stabilization program and the Spring Price Endorsement and Revenue Insurance Coverage programs available in Alberta. A stochastic budgeting approach is used to consider the effects of government payments on income for a typical farm in Manitoba that produces wheat, canola, and oats. Each scenario of program use is compared using a stochastic efficiency criterion, specifically a certainty equivalent value of the payment being analyzed. It is found that additional programs have mixed impacts on production insurance. Governments may be to improve the value of production insurance by associating additional benefits to the purchase of insurance with other programs.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AAFC	Agriculture and Agri-Food Canada
AFSC	Alberta Farm Services Corporation
APF	Agricultural Policy Framework
CAIS	Canadian Agricultural Income Stabilization
CARA	Constant Absolute Risk Aversion
cdf	cumulative distribution function
CE	Certainty Equivalent
CFIP	Canadian Farm Income Program
CWB	Canadian Wheat Board
DARA	Decreasing Absolute Risk Aversion
EUM	Expected Utility Model
FPC	Fixed Price Contract
FSD	First –degree Stochastic Dominant
IPI	Individual Productivity Index
KOV	Key Output Variable
MAFRI	Manitoba Agriculture, Food, and Rural Initatives
MASC	Manitoba Agricultural Services Corporation
NISA	Net Income Stabilization Account
pdf	probability density function
RIC	Revenue Insurance Coverage
RP	Risk Premium
RRAC	Relative Risk Aversion Coefficient
SDRF	Stochastic Dominance With Respect to a Function
SERF	Stochastic Efficiency With Respect to a Function
SPE	Spring Price Endorsement
SSD	Second-degree Stochastic Dominance
Std. Dev.	Standard Deviation
U.S.	United States of America

CHAPTER 1

INTRODUCTION AND OBJECTIVES

1.1 Farm Income Risk and Agricultural Policy

The business of production agriculture is risky. The farmer faces variability in many aspects of his operation, as well as the possibility of extreme events that may drive him to exit the industry. The presence of variability and downside risk in farm incomes, two elements of risk acknowledged by Hardaker et al. (2004a), have lead some to conclude that farm incomes are periodically too variable and too low. If farms are to remain financially viable enterprises they require stability and the promise of adequate returns on investment.

To achieve these conditions and counter risk, farm businesses can employ a wide variety of risk management tools and strategies.[1] Some of these strategies are initiated by the farmer. For example, farmers may save earnings from profitable years to draw on in lean ones. Some strategies involve the transfer of risk to other private interests; futures markets and forward contracts allow farmers to transfer price risk to other market participants. In Canada and many other developed countries, private, market-based options are deemed inadequate. The agricultural media has dubbed this the "farm income problem." In response, government has been called upon to directly intervene.

Politicians understand that merely reducing farm income risk is not politically feasible. Farmers want to remain free to capture high returns when the market offers them. One solution is known as a farm income safety net. A safety net connotes assistance or support when accidents, injuries, or downturns occur. In the case of agriculture, safety nets

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[1] For a thorough review of income risk management strategies used by farmers, see Moreddu (2000).

are the provision of financial support to farmers when income determining events fall below predefined thresholds. Often these thresholds are some proportion of longer term averages. It is important to note that because safety net programs inject taxpayer funds into farm businesses and provide these funds when incomes are generally low, they tend to both reduce risk and redistribute income.

For government to create a safety net program, the situation of loss must be defined.[2] Taking the analogy of the net, this is process of setting the height at which the net is suspended. If the income of a crop farm can be simply defined as:

$$(1.1)\ \text{Income} = \text{Price} \times \text{Yield} - \text{Cost}$$

then income risk can be thought of as the cumulative risk in its component parts: price, yield, and cost. For farms that grow multiple crops, income risk is a function of risks in a larger number of price, yield, and cost variables. In the past, safety net programs have been designed to compensate farmers for 'loss' situations in overall farm income, but also with relation to each of these variables individually, both on a whole-farm and crop specific basis. The variable that triggers the payment defines the program (Barnett and Coble 1999). The level at which the safety net is placed defines the level of coverage. It is quite apparent that safety nets have adopted similar terminology to that of insurance. Economists recognize, going back to the first Canadian safety net type program in the late 1930s, that these programs are not necessarily insurance. Rather, they are often "an attempt to substitute

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[2] Government can also provide assistance in cases of wide spread losses on an *ad hoc* basis after losses have occurred. This type of *ex post* support was paid to Western Canadian grains and oilseeds farmers in 2004 and 2005, where farmers received fixed payments based on the value of previous production because of widespread agronomic and market adversity. While such support may play much the same role as pre-defined or *ex ante* programs, it is considered not part of the safety net in this analysis because the safety net ideal implies that there is some level of income that is to be covered or protected. For an interesting discussion of the relative merits of *ex ante* and *ex post* support programs, see Innes (2004).

an adaptation of the insurance principle for direct relief... as the basic method of dealing with crop failures and depressed prices" (Britnell 1940). Safety net programs can be structured as insurance programs, operated on an actuarial basis or as various forms of pseudo-insurance, merely borrowing elements from insurance programs.

In the past twenty years, Canadian agricultural policy makers have adopted the safety net as the dominant paradigm for providing government subsidies to farmers, especially in the grains and oilseeds sector. Western Canadian crop agriculture has seen a vast array of government programs delivered under the rationale of risk management. The latest incarnation of the Canadian agricultural safety net for grains and oilseeds farmers was initiated in 2003 with the adoption of the Agricultural Policy Framework (APF). This was an attempt to create a unified agricultural policy for Canada rather than delivering government programming in a piecemeal approach. The centrepiece of the APF is the Canadian Agricultural Income Stabilization (CAIS) program. It provides payments when net income declines below a farm specific average.

CAIS also allows for provincial-specific programs to address perceived gaps in CAIS coverage; various programs of such a nature exist. For example, all provinces operate a program of crop or production insurance. These programs have been available since 1959, making them the most long-lasting program in Canada's safety net portfolio. Insurance premiums charged by these programs, which cover yield losses for crop producers, are subsidized by federal and provincial governments. These yield risks are often driven by biological and weather events that are seen as unique to crop agriculture. Moreover, due to a lack of profitability and the potential for large, concentrated losses, private markets are unwilling to provide insurance, so this specific risk is deemed to require special coverage from government. Furthermore, individual provinces have seen fit to provide additional safety net programs to provide further direct support to farmers and farm businesses.

1.2 Problem Definition

Choosing to cover various risks through programs of insurance or pseudo-insurance for farmers is complex. Among farmers, government and economic analysts, there is not consensus on an optimal strategy. Hart, Hayes, and Babcock (2006) point out that insuring individual risks, especially on a crop by crop basis, "runs counter to the traditional risk management practice of diversifying across several enterprises." They argue that insuring whole-farm revenues provides government support more efficiently. On the other hand, Coble (2000) points out that any safety net scheme that "subsumes multiple risks" (of crop yield and crop price, for example) obscures the complexity of the underlying system and that apparently simple solutions may have unintended consequences.

This study is motivated by the potential for such unintended consequences in Canadian farm safety net program design. While each safety net program plays a role in covering farm risk, extending coverage to many risks means that multiple program payments flow to individual farms in any given year. Yet for all the efforts to create a unified set of programs to address farm risk, little is known about how they impact farm incomes when used in concert. The amount spent on these programs suggests that they raise farm incomes on aggregate, but the impacts at the farm level are unclear. Moreover, with multiple payments flowing to individual farms, it is not known if the implementation of one program changes the benefits farmers derive from others. In the case of Western Canadian farms, it is not known if new programs such as CAIS will alter the value of the production insurance coverage farmers have been purchasing for some time.

Estimating the impact of government safety net programs and the effectiveness of layered program offerings is important for Canadian government. Unlike the United States or the European Union, safety net programs comprise the bulk of Canadian agricultural spending. In 2005-2006, the federal government spent \$2.6 billion (all figures in Canadian dollars) on "business risk management" programs for agriculture, out of \$3.4 billion in total agricultural spending (Agriculture and Agri-Food Canada (AAFC) 2006a). As part of this spending, CAIS, production insurance, and other provincial risk management programs made up nearly half of all agricultural spending by the federal government. Safety net programs also consume a large share of provincial agriculture budgets. In the province of Manitoba, Risk Management, Credit, and Income Support program spending was nearly \$195 million in 2005-2006, or over half of total provincial agricultural spending (Manitoba Agriculture, Food, and Rural Initiatives (MAFRI) 2006). The vast majority of this money went to the CAIS and production insurance programs. Programming can also be a major source of budget overruns, because it is difficult to forecast government's liability to farmers through safety programs *a priori*.

Assessing the impacts of safety net programs is also important to farmers. While past experience is an indicator of future program performance, it is unclear how programs will perform over the wide range potential market and production outcomes, especially for individual farms. Moreover, if the decision to participate in the program is seen as the purchase of an input, then farmers need to know the implications of that decision on their profitability. This analysis examines a representative farm business, in this case, a grains and oilseeds farm in southern Manitoba and its preferences for the farm income results provided by available safety net programs.

1.3 Objectives and Organization

The two objectives of this study are to measure the impact of Canadian safety net programs on net farm income in an environment of price and yield risk and to assess the magnitude of the benefit of each program under different scenarios of program use for farmers of varying preferences for risk. Specifically, the study will determine the extent to which various program payments correlated and the degree to which CAIS program payments alter the value of using production insurance. In the process of making this determination, the optimal course of action for the farm facing a distribution of risky returns can be found. It allows for comment on the effectiveness of safety net programming and specifically whether using all available programs is optimal for the farmer.

To accomplish these objectives, this study encompasses five sections that investigate safety net program use as a decision making process for a farmer. Chapter 2 reviews the economic literature on modeling decision making under risk. It discusses how risk is represented, the representation of the decision maker's preferences, and how risky decisions can be analyzed in cases where the preferences of decision makers are heterogeneous or unknown. It also reviews how these concepts have been applied in the past in relation to safety net programming and government risk management policy.

Chapter 3 provides a brief background of the market and agronomic environment in Western Canada that determines farm incomes. It also presents the mechanics of the government safety net programs. The fourth chapter presents the methodology and data sources used in this study. The main tool used in this analysis is a stochastic budgeting model of a representative farm. Monte Carlo simulation is used to perform the actual analysis. Data sources necessary to create such a model are also reviewed. The results derived from the simulation model are presented in Chapter 5. A discussion of these findings follows in Chapter 6.

CHAPTER 2

LITERATURE REVIEW: DECISION MAKING UNDER RISK

This study will model the operation of a sample farm with income subject to risk and a set of government programs that alters these outcomes. The model must quantify the impact of these programs for numerous scenarios across a wide range of outcomes. This impact is relevant farmer decision making regarding program use and an economic framework must be developed that can logically represent farmer risk preferences. This chapter outlines previous work on the sources of risk in agriculture and how they might be represented in an economic model. Economic theory on how preferences for such risk can be expressed both qualitatively and quantitatively is reviewed. Finally, previous empirical work on the impact of safety net programs is examined to understand the products and pitfalls of these analyses.

2.1 Definition of Risk

Economic analysis of farm firm decision making is incomplete unless risk is incorporated. For this study, the impact of government program use cannot be completely modeled without including the conditions of uncertainty that are used to justify such programs. What is not straightforward is the nature of risk present in agricultural production and the means by which economists can incorporate such risk into economic models. For example, the assertion that agricultural production is subject to greater risk than other sectors of the economy is common, however little empirical work has been done to substantiate this claim. Within agriculture, there is significant heterogeneity of risk with respect to geography, production technology, and firm size. In addition, economists have yet to agree upon a theory of the firm under risk that adequately represents the underlying decision making process. While it will not cover all of the advancements made in this field,[3] this chapter will broadly review the progress made in analyzing firm decision making under risk with particular attention to agricultural crop production and outline a set of tools for performing such analysis.

2.1.1 Decision Making and Risk: Vocabulary

To analyze farm business decisions in the presence of risk, a common language is essential. Hardaker et al. (2004a) present a set of terms that ably describe business decision making. When the farm business faces decisions with risky consequences, the combined notion of the decision and its outcomes can be called the *risky prospect*. The person charged with making the decision and accepting its outcome is the *decision maker*; in agricultural analyses, this person is often the farmer. The outcomes faced by the decision maker are risky because of *events* or states of nature over which the decision maker has no control. For the farm decision maker, commodity prices are a generally cited example. The consequences or payoffs that result from choices made and the occurrence of a risky event or events are generally expressed in terms of a single output variable, such as profit or wealth. Finally, the decision maker possesses some measure of preference over the possible set of payoffs and a procedure for ranking these payoffs. Economic models of risk try to accurately depict the nature and scope of the risky prospect by incorporating as many events and as much knowledge about the preferences of the decision maker as is feasible.

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[3] See Just and Pope (2002) and Hardaker, et al. (2004a) for a summary.

2.1.2 Defining Risk

The search for a definition of risk can be traced to Knight's 1921 work *Risk, Uncertainty, and Profit*. His lasting contribution was the attempt to clearly delineate the difference between risk and uncertainty. Risks, asserted Knight, were those variables not known with certainty but where the probabilities of possible outcomes were known *a priori*. Uncertainty, in contrast, is a lack of knowledge regarding probabilities. This interpretation is less than satisfying; if one can admit that future events cannot be foretold with certainty, it is difficult to argue that one can know the probability of future events with certainty. From the perspective of the economic modeler, it is difficult to model events for which no prior knowledge exists. While the distinction between risk and uncertainty is important and oft-cited, the nomenclature has not at all been adhered to in subsequent research where the terms often appear interchangeably. For example, Moreddu (2000) defines risk as "uncertainty (i.e. imperfect knowledge or predictability because of randomness) in outcomes that might involve adversity or losses." The reality is that economists have come to no agreement on the meaning of the terms "risk" and "uncertainty."

A better approach is to identify and classify actual risks. Agricultural risk can be categorized in many ways. Given that agricultural risk can only be broadly defined, any system of classification should be considered illustrative, not comprehensive. Hardaker (2004a) outlines five types of risk with relevance to agricultural production. One is yield risk, the variability in production due to weather and biological factors. The second is market risk which refers to price levels, including the price of inputs and outputs as well as the value of currencies. Third are personal risks, encompassing a wide assortment ranging from workplace safety to employer/employee relations. Fourth are institutional risks. These might include changes in the nature of government intervention and also in relationships between the farm business and its suppliers and customers, that is, complications of industrial organization. Last are financial risks including interest rate fluctuations and changes in the availability of credit. Together these various risks are termed “business risk.” Economic analysis generally represents business risk by changes in the level of wealth possessed by the decision making firm or individual or in measures of gain or loss resulting from a decision made. Measures of gain or loss might include profit or net income.

To identify areas of focus for economic research, many studies have tried to gauge which of these risks is most important. A strong degree of consequence and quantitative tractability are necessary if these risks are to be incorporated in economic models. Surveys of farmers have consistently shown price and yield risks to be of greatest concern. This is appears to be true in both Canada (AAFC 1998) and elsewhere (Coble, et al. 1999). Unlike other risks, especially personal and institutional risks, price and yield variability can be readily quantified.

2.2 Representing Risk

As identified in the previous section, the farmer faces decisions with risky consequences. The risky prospect represents both opportunity and threat for the farmer, referred to as “speculative risk” in the insurance literature (Rejda 2005). The uncertain consequences of the risky prospect give the farmer the potential to reap higher profits or suffer greater losses. The insurance literature generally prefers to deal with risks where only losses are possible, often called “pure risk.” Agricultural risks, especially market and yield risks that are addressed by government policy and programming are almost always speculative risks. This becomes an issue when one attempts to mathematically represent risk for analysis.

Risk in a mathematical or statistical context is application of probability.[4] In the case of certain pure risks, it is easy to represent risk in a discrete sense. For example, the probability that a rare infection or disease is discovered in a given animal in Canada might be 1 in 1,000,000. Such discrete probabilities are less useful when analyzing speculative risks. The expected wheat yield for the farmer is not an either/or scenario but a continuous series of all possible outcomes and their related probabilities of occurrence. This information is contained in a continuous *probability density function*, or pdf. A discrete statement of probability does not adequately describe the risky prospect and does not allow the decision maker to adequately assess the relative merits of his available choices.

Young (1984) observes that the representation of risk is driven by the decision rule one wishes to employ in assessing preferences for that risk. To utilize expected utility theory, a framework outlined in the following chapter, risk is to be represented by "a vector of (potentially all) moments of the probability distribution." The complete vector is a Taylor series expansion of the pdf. If fewer moments of the pdf are available, for example only the mean and variance, restrictive assumptions such as the normality of returns must be made. The literature provides "sufficient evidence" that such assumptions are not justified (Turvey 1992). To analyze the outcomes presented by the risky prospect, complete pdfs for each alternative are necessary.[5]

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[4] For a review of basic statistical concepts relevant to risk analysis, see Vose (2000), Chapter 3.

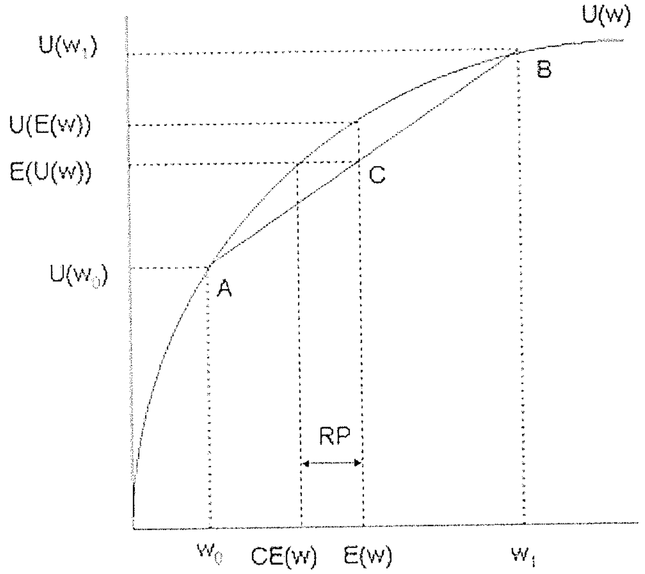
[5] The probability distribution function can also be expressed as a cumulative distribution function or cdf. For a random variable x, the cdf C(x) represents the probability of occurrence of all events less than or equal to x.

2.3 Expected Utility: A Framework for Analysis

Once the nature of the risky prospect is characterized, a framework to evaluate the presented risky alternatives is required. It is often assumed that the farm decision maker attempts to maximize profit, or expected profit, in the case of risk. As early as 1738, Bernoulli realized that real life decision makers may require a more nuanced decision rule. Instead of profit maximization, he proposed that decision makers assigned what he called a "moral expectation value" to uncertain outcomes, what is currently called utility. This allows the decision maker to express varying levels of marginal utility over the range of possible outcomes. Accordingly, a function exists that relates a given outcome variable - usually wealth, profit, or income- to this measure of wellbeing called utility. For example, it allows the decision maker to place greater importance on the first dollars of income than on higher levels of income.

In the presence of risk, the idea that different levels of income are valued differently by the decision maker gives credence to the idea that rational decision makers may have incentive to avoid risk. If the decision maker faces two uncertain outcomes of equal probability, there may be a certain value less than the weighted average of these two uncertain possibilities that gives the decision maker the same level of utility, called a *certainty equivalent* (CE). Its existence suggests that the individual prefers more risk to less. Figure 2.1 gives a graphical example of the determination of the CE value for a decision with two equally probable outcomes, w_0 and w_1, and a utility function $U(w)$. The risky prospect has an expected value of $E(w)$ which has a level of utility corresponding to point C where $E(w)$ intersects the chord between points A and B. At this level of utility, outcome $CE(w)$ gives the same level of utility as the risky prospect. The difference between the CE

Figure 2.1 Graphical Example of Certainty Equivalent



Source: Adapted from Robison and Barry (1987)

and the expected value of the risky prospect is called the *risk premium,* shown as "RP" in Figure 2.1. It represents the maximum that the decision maker would be willing to pay to avoid the risky prospect. For decision makers who are risk-neutral, the risk premium is zero.

Though the basic ideas of the utility function and differing attitudes towards risk were first made known long ago, they were not formally incorporated into economic literature until Von Neumann and Morgenstern (1947) laid out the foundations of an axiomatic framework for what is now called the Expected Utility Model (EUM). Robison and Barry (1987) identify four key axioms that decision makers must obey in order to formulate a utility function that represents his preferences. The first, ordering, suggests that for two choices x and y, the decision maker must prefer one to the other, or be indifferent between them. The second axiom, transitivity, states that if x is preferred to y and y to z, then x must be preferred to z. The third, substitution, says that if x is preferred to y and there is a risky prospect with two alternatives, $px + (1\text{-}p)z$ and $py + (1\text{-}p)z$ where p is the probability of x or y, the first alternative is preferred to the second. Finally, the certainty equivalent axiom states, as identified above that a certainty equivalent value y exists between two risky outcomes x and z where the decision maker is indifferent between the risky prospect and the certain value. If the decision maker adheres to these axioms, there exists a utility function that represents his preferences.

The utility function and the individual decision maker's expectations about the risky prospect are needed to analyze decisions under risk. Remember that the risky prospect is represented by pdfs of each alternative. With these two pieces of information inside the axiomatic framework, the utility of the risky prospect can be expressed as its expected utility, the probability-weighted sum of all possible outcomes. Assuming that x_j is the jth outcome of a risky prospect x and $P(S)$ is the cdf corresponding to the likelihood of all possible outcomes j, then the expected utility can be expressed mathematically as:

$$(2.1)\quad U(x_j) = \int_0^1 (x_j \mid S) P(S) dS \, .$$

The utility given by the above formula is defined up to a positive linear transformation. It is a unitless measure allowing only for rank comparisons of utility values; it can only be said that one choice is preferred to another, not that it is 20% better, for example. Still, the EUM gives a robust criterion for ranking risky alternatives.

2.3.1 Risk Attitudes

Any decision rule derived from EUM criteria is critically dependent upon the utility function used in analysis. However, one cannot use the utility function itself to categorize the risk attitude of the decision maker. Because the utility is subject to linear transformations as mentioned above, different utility functions can yield identical certainty equivalent results. Robison and Barry (1987) identify the bending rate of the utility function as a unique measure to classify decision makers. The second derivative of the utility function can be used to represent the "direction of bending" of the utility function. It is negative for the risk averse, zero for the risk neutral, and positive for the risk preferring decision maker. However, the value of the second derivative is not comparable amongst decision makers, again because the utility function is subject to linear transformations. To combat this problem, Pratt (1964) and Arrow (1965) separately introduced the absolute risk aversion coefficient, given as:

$$(2.2)\ R_a(x) = \frac{-U''(x)}{U'(x)},$$

where $U'(x)$ and $U''(x)$ are, respectively, the first and second partial derivatives of the utility function with respect to the outcome measure, x. The Pratt-Arrow coefficient can adapted to give a measure of the elasticity of marginal utility, called the relative (or partial)[6] risk aversion coefficient (RRAC):

$$(2.3)\ R_r(x) = \frac{-U''(x)x}{U'(x)}.$$

The RRAC allows risk aversion to be compared across problems where decision maker wealth endowments or measures of gain and loss are different. An example is wealth expressed in different currencies, or from different time periods. The values of these coefficients are unitless; positive values correspond to risk averting behaviour and negative values correspond to risk preferring behaviour.

Most studies regarding decision making under risk makes the assumption that decision makers are risk averse. The nature of this risk aversion can take on a number of forms (Makki, Somwaru, and Vandeveer 2004). The main difference centers on how risk aversion changes as the payoff measure changes, especially when the payoff measure is

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[6] $R_r(x)$ is called a relative risk aversion coefficient when x is wealth and a partial risk aversion coefficient when x is defined in terms of gain or loss (Robison and Barry 1987).

wealth. Intuition suggests that risk aversion is decreasing for $U(w)$, if w represents wealth; the wealthier decision maker is less risk averse because they can "afford" to take on occasional losses. This is called *decreasing absolute risk aversion* or DARA. A DARA utility function inherently exhibits the additional property of constant relative risk aversion (Hardaker et al. 2004a). In the past, it has been computationally efficient to ignore changing levels of risk aversion. Utility functions with fixed risk aversion levels are said to exhibit *constant absolute risk aversion*, or CARA.

2.3.2 Functional Forms, Risk Aversion Coefficients, and Choice Variables

Economists have been less than successful in translating the above understanding of utility into solid empirical procedures. Hammond (1974) outlines three general difficulties encountered in empirical work: it is difficult to estimate the preference curve, estimated preferences may pose analytical difficulties, and analyses are of unwieldy size. Put more plainly, it is difficult to choose a functional form for the utility function; the functional form consistent with assessed risk preferences may not be mathematically tractable; and the large number of risks to be included in the model may further complicate the analysis. The first two difficulties are discussed below.

With respect to the first point, there has been no solid consensus that real-world decision makers possess a given type of risk preference. Makki, Somwaru, and Vandeveer (2004) summarize seventeen empirical studies of farmer risk preferences. The majority of these studies find that most farmers exhibit risk averse behaviour, but the degree of risk aversion is unclear. The majority of studies that attempted to define this risk aversion further found evidence of DARA on aggregate (for example, Chavas and Holt 1996).

However, for individual primary producers, clear evidence of DARA was not found. When attempting to match algebraic specifications of the utility function with elicited or expected risk preferences for real-world decision makers, it has been found that functional forms with very different properties have comparable goodness of fit (Hardaker et al 2004a).

In addition, empirical work must consider the degree of risk aversion present. Again, no available research has definitively found a level of risk aversion for agricultural producers as a group. Anderson and Dillon (1992) propose a rough guide to classifying producers by their relative risk aversion coefficient, R_r. They speculate that R_r lies between one and two for most risk averse farm decision makers. An R_r of 0.5 would indicate hardly any risk aversion and an R_r of four would indicate extreme risk averse behaviour. It is likely instructive to look at a broad spectrum of preferences for risk.

Even if a functional form and its applied properties are assumed to be characteristic of the decision maker and a level of preference for risk is applied, a further complication is that argument of the utility function is not yet specified. Anderson and Hardaker (2002) state that the same risk attitudes should apply regardless of whether outcomes, previously expressed by the variable x, are expressed as wealth, income, or gain and loss. While wealth is most commonly considered, questions have been raised as to how accurate attempts to ascertain the correlation between risk aversion and wealth are (Lybbert and Just forthcoming). Moreover, accurate data on wealth may be difficult to obtain or prescribe to individuals (Hammond 1974).

Assuming CARA preferences has been one method of dealing with this problem. Hammond (1974) showed that the assumption of CARA could be used in applied risk studies as proxy for decision makers with nonconstant risk aversion. In summary, Hammond said that for two risky choices, adjusting payoffs by a constant measure of wealth or some other "asset position" would only change preferences at a single asset position. Because of the preponderance of "situations where decisions are insensitive to asset position", constant absolute risk aversion may be assumed. This assumption was maintained in the work of Kramer and Pope (1986) and McCarl (1988). Another approach was offered by Anderson and Hardaker (2002), who drew upon Friedman's (1957) permanent income hypothesis to draw equivalence between relative risk aversion coefficients if the payoff measure is wealth or income. Given the range of opinion on the matter, utilizing multiple approaches if at all possible and conducting sensitivity analysis seems sensible.

The most commonly used functional forms for the utility function are either CARA or DARA and utilize both relative and absolute risk aversion concepts. A negative exponential function of the form:

$$(2.4)\ U(x) = 1 - \exp(R_a x)$$

is often used; it is mathematically convenient, but exhibits CARA, which is not necessarily desirable. Two types of utility functions that are DARA are often employed. These are the logarithmic and power. They take the following forms:

$$(2.5)\ U(x) = \ln(x) \text{ and,}$$

$$(2.6)\ U(x) = \frac{1}{1-R_r} x^{1-R_r}\ .$$

When R_r is approximately one, the logarithmic function is often used in place of a power function to eliminate the problem of division by zero. Without consensus on optimal empirical technique for using models of expect utility, it is best to choose methods that allow for flexibility and comparison of alternative approaches. The stochastic efficiency methods outlined in Section 2.4 do this.

2.3.3 Alternatives to the Expected Utility Model

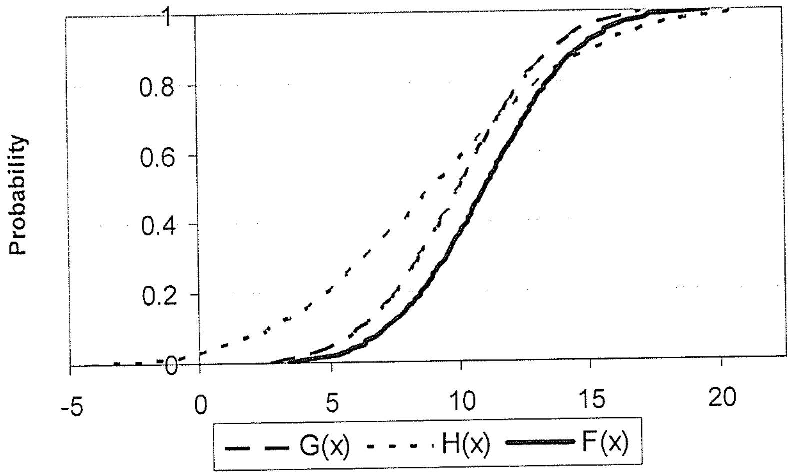
Though it is widely used in economic analysis, the EUM, as a behavioural theory of decision making under risk, has come under considerable criticism. Most commonly, it is asserted that decision makers do not behave in a manner consistent with the EUM and that in fact, real-world decision makers have systematic biases that prevent them from exhibiting expected utility maximizing behaviour. The work of Kahneman and Tversky (1979) is an oft-cited example. Further to this, expected utility theory may impose implausible risk aversion characteristics on decision makers where the stakes of the risky prospect are modest (Rabin 2000). Another criticism is that a number of the assumptions or axioms necessary to prove the EUM are too restrictive (Starmer 2000). In response, economists have developed numerous models of so-called "non-expected utility." Starmer (2000) provides an excellent review of the systemic inconsistencies found in the EUM and the many models proposed to replace it. However, no single alternative model has any consensus behind it. Furthermore, so long as the axioms can be regarded as suitable guides for rational decision makers, it is possible to "(interpret) Expected Utility Theory *normatively* as a model of how people ought to choose and *prescriptively* as a practical aid to choice" (Starmer 2000). The following section outlines procedures for the prescriptive use of the EUM in decision analysis at the farm level.

2.4 Stochastic Dominance in Risk Analysis

If the goal of risk analysis is to rank risky alternatives, then the EUM is an excellent prescriptive tool. However, it forces analysts to make certain assumptions that are problematic. An EUM requires a utility function, an exact representation of preferences. As covered above, it is difficult if not impossible for researchers to ascertain an individual's exact preferences. Moreover, preferences are unique to individuals and no single utility function can be said to represent the preferences of a range of individuals.

King and Robison (1984) identify the use of "efficiency criteria" as a means to overcome the problems inherent in choosing a utility function. An efficiency criterion can rank (at least partially) choices given "specified restrictions on preferences and, in some cases, on probability distributions of feasible alternatives." It separates risky alternatives into efficient and inefficient sets. Efficient sets are said to "dominate" inefficient ones. The optimal course of action for the decision maker lies within the efficient set, so long as two conditions hold: first, that the individual's preferences are consistent with the assumptions made about the nature of the utility function in deriving the risk-efficient set; and second, that he individual's subjective probability distributions for outcomes are identical to those assumed for the analysis (Hardaker et al. 2004a).Generally, the more specific the restrictions become, the more powerful the efficiency criterion and the smaller efficient set. However, imposing more restrictions potentially excludes individuals. Obviously, this presents the problem of a potential trade-off between what King and Robison (1984) call "discriminatory power and potential applicability." Such a trade-off can be seen in two of the most simple efficiency criteria, first-order and second-order stochastic dominance (FSD and SSD). Hanoch and Levy (1969) and Hadar and Russell (1969) introduced these criteria independently. The only restriction necessary to apply FSD is that the decision maker have positive marginal utility, i.e. that $U'(x) > 0$. For two cumulative distribution functions (representing two risky alternatives) shown in Figure 2.2, $F(x)$ and $G(x)$, $F(x)$ is FSD if at every point along the distribution, it has a higher value than $G(x)$.

Figure 2.2 Graphical Example of Stochastic Dominance



Source: Adapted from Richardson et al (2007).

Graphically, this means that the cdfs of the two alternatives being compared cannot cross. Of course, most risky prospects are not so simple, especially when the decision maker must simultaneously consider many alternatives, so FSD has little discriminatory power. If the two distributions being compared happen to cross, SSD may be used provided that the decision maker conforms to more restrictive risk attitudes. SSD requires that the decision maker is risk averse, that is having a utility function of positive but decreasing slope ($U'(x) > 0$ and $U''(x) > 0$). To compare two alternatives by SSD, the cumulative area under the cdfs are compared. The dominant alternative is the one for which the cumulative area under the cdf $F(x)$ is always less than area accumulated under the alternative $H(x)$ as one examines increasing values of x. This can be seen mathematically as

$$(2.7) \quad \int_0^1 F(x)dx \le \int_0^1 H(x)dx,$$

and graphically in Figure 2.2. It is important to note that the distribution which first begins to accumulate area can never be dominant by SSD. This is because the SSD criterion incorporates the risk preferences of all risk averse decision makers. Those with extreme levels of risk aversion, what is sometimes called *loss aversion*, are included in this set. It is unlikely that many decision makers exhibit this behaviour. This phenomenon, called the left-tail problem, is one example of the limitations of basic stochastic dominance criteria (Robison and Myers 2002).

2.4.1 SDRF and SERF

The difficulty with FSD and SSD is that they are not very discriminatory and result in large efficient sets. These methods consider a wide range of risk preferences. If one can assume that the measure of risk aversion falls within given bounds smaller than those inherent in SSD, smaller more applicable efficient sets can be obtained. Meyer (1977) provided this breakthrough, outlining a stochastic dominance procedure that assumed lower and upper bounds on the absolute risk aversion function. In practice, one could also assume bounds on relative risk aversion function and convert. This technique also required assumptions about the shape of the utility function. Thus the procedure has come to be known as *stochastic dominance with respect to a function* or SDRF.

SDRF measures the differences in utility between two distributions *F(x)* and *G(x)*. A utility function is assumed and bounds are placed upon the risk aversion coefficient. The following expression is sequentially evaluated for each bound

$$(2.8)\quad \int_0^1 (G(x) - F(x))U'(x)dx\,.$$

If the minimum of the above expression for both values of the risk aversion coefficient is positive, then decision makers unanimously prefer *G(x)* to *F(x)*, or *G(x)* dominates *F(x)* (Meyer 1977). If the expression is not positive, then the terms can be switched and reevaluated by the same process. This is a pair wise comparison: dominated alternatives drop out of the efficient set and remaining alternatives are evaluated against each other until no more such eliminating can take place. It is important to note that FSD and SSD are special cases of SDRF where the bounds on the risk aversion coefficient are $(-\infty, \infty)$ and $(0, \infty)$ respectively.

Making additional assumptions about risk preferences can eliminate the problems with previous methods, such as the "left-tail problem," but it necessarily turns attention to the measurement of decision maker's preferences. Assuming a form for the utility function presents a number of issues dealt with in Section 2.3. Sorting decision makers into categories based on risk aversion bounds may be problematic, but most analyses have overcome this by performing some type of sensitivity analysis with respect to the risk aversion bounds. There are also computational limits to SDRF: the pair wise comparisons are cumbersome and may not result in the smallest efficient sets and the data points for each distribution must be specified over the same set of probability values (Robison and Myers 2002).

A recent improvement to SDRF makes this type of analysis more computationally efficient and the output easier to comprehend for those who are not familiar with the methodology. In their seminal paper, Hardaker et al. (2004b) describe a method they call *stochastic efficiency with respect to a function* (SERF). Like SDRF, SERF utilizes an assumed utility function and bounds on the risk aversion coefficient. SERF improves upon SDRF by allowing for simultaneous comparisons of risky alternatives at all levels of risk aversion, even inside the specified bounds. It does restrict data to certain probability fractile values. But perhaps most importantly, it "provides a cardinal measure of the decision maker's conviction for preferences among alternatives at each risk aversion level" by representing utility in the form of certainty equivalent values and the difference between CE values as a premium that can be attributed to any difference in alternatives (Hardaker et al. 2004b). This represents the output of the analysis in terms that are easier to explain and permits the analyst to ascertain the relative significance of each alternative in question.

Once cumulative distribution functions for each risky alternative have been obtained, the procedure for performing the SERF analysis contains the following steps: first, the values of x, the outcome variable, are converted to their corresponding utility levels using an assumed utility function and assumed risk aversion coefficients. Second, each finite utility value is multiplied by its associated probability to arrive at a weighted average of utility of outcomes. Repeating this process for a sufficient number of discrete points of the risk aversion coefficient can describe the relationship between utility and risk aversion for each alternative. This allows one to see how the efficient set changes as the risk aversion coefficient is changed. The utility levels provided have corresponding certainty equivalent values that can be found by taking the inverse of the specified utility function. The key output of the SERF process is a graph illustrating the relationship between the level of risk aversion and the CE for each alternative. Such a graph shows clearly the stochastically efficient alternative or alternatives for a range of decision makers.

2.5 Previous Studies

Many studies have incorporated Expected Utility and Stochastic Dominance methods in modeling government program usage at the farm level, especially programs of production or crop insurance. A common approach is to select a representative farm for a given region; the data necessary to do this are the cash flows that characterize farm profitability, namely revenues and costs. *Stochastic simulation* methods are often used to generate the distribution of these cash flows, with price and yield data for the region incorporated to form some estimation of risks present. The vast majority of such studies have looked at farms in the United States; Corn Belt farms most commonly receive attention. The first studies in this area compared various crop insurance and disaster assistance program designs against each other. The rationale for much of this analysis was the elimination of the U.S. Disaster Assistance Program and the renewal and expansion of the U.S. crop insurance program through the Federal Crop Insurance Act of 1980.

Kramer and Pope (1982) determined the optimal pattern of multiple peril crop insurance use on continuous corn cropping Virginia farms. They looked at a range of price and yield coverage options, simulating net returns for nine scenarios. Second degree stochastic dominance was used to rank the alternatives, with the high coverage option found to be most advantageous.

King and Oamek (1983) examined a sample of ten continuous cropping dryland wheat farms in Colorado, using SDRF to ascertain crop farmers' likelihood of selecting crop insurance in the absence of the disaster assistance program. SDRF criteria determined that crop insurance options were dominated by benefits previously available under Disaster Assistance Program. In their concluding remarks, King and Oamek recognize that the results of these studies have limited application to other farm types. The analysis is further limited by aggregation problems resulting from assumed heterogeneity among farmers in a given enterprise.

Government program options were also analyzed using multi-year whole farm financial models in a number of published papers. These models create a more detailed financial picture of the model farm; balance sheet information is assumed to allow for analysis of net worth and possible bankruptcy. Lemieux, Richardson, and Nixon (1982) considered crop insurance participation, disaster assistance payments, and non-participation over a ten year planning horizon on Texas cotton farms. The effect of these payments on ending net worth was analyzed by stochastic dominance with respect to a function. High coverage levels dominated all other alternatives. Mapp and Jeter (1988) performed a similar analysis for mixed-farms in Southwestern Oklahoma, adding the option of receiving loan deficiency program payments, another type of safety net program providing price supports. Though they used Expected Value-Variance decision rules, rather than stochastic dominance, the authors concluded that crop insurance was too costly to be beneficial to Oklahoma producers; despite including a variety of crop insurance options in their analysis, non-crop insurance options dominated.

The above techniques have also been used to ascertain optimal strategies for farm decision makers that involve crop insurance use and other farm management decisions. Schoney, Taylor, and Hayward (1994) use simulation methods and second degree stochastic dominance to determine the optimal crop diversification and crop insurance strategies for farmers in the black soil zone of Saskatchewan. They found that when incomes among crops are highly correlated, minimal diversification is best; crop insurance use does not dominate, though this is likely due to the use of the SSD criterion. The authors do find that crop insurance "(reduces but does not eliminate) the economic severity of major crop disasters." It seems likely that a more discriminating efficiency criterion would find that crop insurance was optimal for decision makers with high levels of risk aversion.

While there has been considerable study of the incentives to use crop insurance in its various manifestations, a limited number of papers have looked at crop insurance when used concurrently with programs that are similarly targeted to provide government subsidy when farm incomes are below normal. Two recent works have looked at current U.S. Farm Bill programs and their effect on crop insurance usage. Hauser, Sherrick, and Schnitkey (2004) analyzed corn-soybean farms in Illinois, looking at the relationships between various crop insurance options (traditional multiple peril crop insurance and revenue insurance among them, as well as numerous hybrid products) and counter-cyclical payments, a U.S. program that compensates for price declines on a fixed, historical yield. Using correlation coefficients and sensitivity analysis, the authors found that crop insurance and the counter-cyclical payment program are not substitutes, likely because crop insurance is strongly linked to current price and yield expectations of the farmer, whereas the counter-cyclical program is more "permanent."

Gray et al. (2004) combined much of the previous methodology in this area in examining the value of crop insurance in the face of the entire host of U.S. Farm Bill program payments. Their work studied Indiana farms employing a 50-50 corn/soybean rotation. They utilized SERF criteria to ascertain not only preferred program usage strategies for farm decision makers, but also the degree to which one choice is to be preferred to another, given preferences for risk. For two scenarios, use and non-use of the Crop Revenue Coverage insurance program, the impacts of all U.S. Farm Bill programs were simulated on a per acre basis over 2,000 iterations to produce a distribution of returns. A power function, exhibiting DARA, was used for the certainty equivalent calculations. The authors conducted sensitivity analysis with respect to the coefficient of relative risk aversion; values for the coefficient ranged from zero to four. Unlike past studies, Gray et al. (2004) looked specifically at how the value of other programs is affected by insurance use.

While all programs increased the expected returns to farmers, the more important conclusion was that the presence of an array of farm payments decreased the value of crop insurance and necessitated large subsidies to make the crop insurance program viable.

Together the above papers suggest the following conclusions: first, an analysis of risk management programming should incorporate the stochastic nature of the major determinants of farm income, especially price and yield. Second, expected utility and stochastic dominance are established tools for analysis of decision making under risk. Third, the optimal pattern of government program participation is not the same for all farm types. Similarly, government programs may have very different effects. There is a need to apply these methods to the case of Western Canadian farm safety net programs to provide a more complete assessment of the impacts of these programs on farm profitability and benefits derived by farmers from the safety net as a whole.

CHAPTER 3

CONTEXT: AGRICULTURE AND AGRICULTURAL POLICY IN WESTERN CANADA

To understand the risky prospect presented by the array of government programs available to farmers in Western Canada, the characteristics of crop production and farm management must first be reviewed. This chapter reviews two areas: markets and agronomy, as risks related to these two areas have been identified as very important. Agriculture in Western Canada is dynamic; farmers compete in a global marketplace. The three prairie provinces of Alberta, Saskatchewan and Manitoba exported over $13 billion in agricultural products in 2006, or nearly half of Canadian agricultural exports (AAFC 2006b). The price received by crop producers in Western Canada is driven by global factors that imply complex risks. Similarly, crop production is subject to numerous sources of risk, notably weather. Drought, flood, and frost have all caused significant yield losses in the past few years. The following description points out the key aspects of production agriculture necessary to create a model of farm returns, focusing on sources of risk and the set of simplifying assumptions necessary for a tractable model.

With a solid understanding of the farm management problem, government intervention that is intended to improve farm incomes may be considered. The motivations for safety net programs and relevant economic research regarding various types of programs is reviewed. Finally, this section explains the mechanics of current government programming and how this might be incorporated into the model of farm returns.

3.1 Characteristics of Western Canadian Agriculture

Western Canada has historically been known primarily as a wheat producing region. In each of the three prairie provinces - Alberta, Saskatchewan, and Manitoba - wheat is the crop that covers more of the arable acreage than any other single crop, but most farms are diversified into at least three or four crops depending on the region in which they are situated. The crop mix in each region is determined in large part by agronomic factors such as soil type, climate, and moisture availability, and also by proximity to markets. The analysis in this paper concentrates on a single region in Western Canada, the Red River Valley of the province of Manitoba. This section is intended to outline the characteristics of agricultural production and marketing in the grains and oilseeds sector that are relevant to an analysis of farm income for this region.

3.1.1 Agronomy of the Red River Valley

The Red River Valley of Manitoba includes areas on both the east and west banks of the Red River in an area extending from the United States border north to the city of Selkirk. Manitoba Agricultural Services Corporation (MASC), the provincial crop insurance provider, designates this Risk Area 12, an area that includes all or part of 24 municipalities plus the city of Winnipeg. The geographic location is illustrated on a map of the province in Appendix A. MASC apportions the areas based on similar agronomic and crop yield outcomes. Inside each Risk Area, land is further divided into soil zones, from A to J, based upon the soil's productive capacity or yield potential. Table 3.1 shows how crop land in Risk Area 12 is apportioned by soil zone. Most of the soils in the region are very productive, much of it rich black clay. The downside to this is that these soils also have poor internal drainage. MASC designates such land as "32" soils. These 32 soils make up approximately 70% of crop land in the area (Wilcox 2006).

Table 3.1 Soil Zones in MASC Risk Area 12 (% of total)

Zone	Risk Area 12	Provincial Average
A	0.0	0.3
B	4.7	4.1
C	24.4	9.4
D	29.0	11.6
E	19.5	12.6
F	12.2	9.9
G	2.9	9.4
H	0.2	13.1
I	3.3	14.7
J	2.6	14.0
Uninsurable	1.2	0.9

Source: Adapted from Wilcox (2006)

Soils are one factor influencing the types of crops grown in the Red River Valley; the others are climate and weather. While the growing season is long relative to other areas of Western Canada, it is short compared to many other agricultural regions of the world. Average temperatures are above freezing from April to October. The area receives an average of approximately 1,800 growing degree-days[7] and a frost free period of between 105 and 135 days. Average precipitation amounts to 515 millimetres annually, which often places stress on crops, given poor drainage conditions identified earlier (MAFRI 2006).

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[7] Growing degree-days are a measure of accumulated heat necessary to bring plants to maturity. It uses differences between daily temperatures and a base temperature to gauge heat intensity. The base temperature for crops grown in Western Canada is usually 5 degrees Celsius (Canola Council of Canada 2007).

In terms of causing yield losses, these temperature and moisture concerns are the biggest factors. MASC records the cause of all crop insurance claims. Historical data suggests that excess moisture and drought or heat were each responsible for 36% of insurance claims. Frost, again related to growing season, was the cause of 11% of claims. Other concerns such as hail, disease, and insects made up the remaining 17%. Clearly, weather variability is important in determining yield risk.

Given these agronomic conditions, certain crops are well suited to be grown in the Red River Valley region. Table 3.2 shows the percentage of acreage insured by MASC in Risk Area 12 seeded to various crops. Three crops, red spring wheat, argentine canola, and oats are widely grown. Acres of barley, the one remaining crop grown widely in Manitoba, are mainly concentrated in the western portion of the province. Many other crops comprise small but significant acres in the Red River Valley.

Table 3.2 Percentage Distribution of Selected Field Crops by Area

Crop	Risk Area 12	Provincial Average
Red Spring Wheat	25	33
Argentine Canola	18	28
Oats	16	10
Barley	5	12
Flax	5	5
Winter Wheat	2	2
Sunflowers	5	2
Field Beans	8	2
Soybeans	4	1
Grain Corn	4	1
Canary Seed	3	1

Source: Adapted from Wilcox (2006)

Beyond the three main crops, it is difficult to determine which others might be important for inclusion in a model farm. Some of these crops, especially edible beans and corn are suited to very specific agronomic conditions not predominant in the region. The length of growing season necessary for these three crops is 85 to 88 days for oats, 90 to 100 days for red spring wheat, and 92 to 102 days for argentine canola (MAFRI 2006). This is well within the region's growing season and implies a reduced risk of frost damage.

Information on the performance of various crop rotations in the province of Manitoba suggests that cereal crops such as wheat, oats, and barley should be alternated with non-cereal crops such as canola, flax, and beans. The same dataset also indicates that a wheat-canola-oats crop rotation is commonly used. Canola is most commonly seeded into wheat stubble and wheat is most commonly seeded into canola stubble. The seeding of oats is almost equally split between following wheat and following canola (MMPP 2007). As an approximation to these observed acreage allotments and rotations used, this study will consider a rotation that is 40% red spring wheat, 40% canola, and 20% oats.

3.1.2 Agricultural Marketing in Western Canada

Of relevance to the problem posed in this study is how prices are determined for crops produced in the region. The three main crops are used in both the manufacture of food products and animal feeds. Increasingly, alternative uses such as biofuels are additional source of demand. These varied uses create a lengthy, multifaceted marketing channel or value chain for grains and oilseeds. The chief participants in this marketing channel are farmers, elevator companies, processors, exporters, and end-users. The presence of international markets for these crops and their processed products adds additional complications in price determination (Kohls and Uhl 2002).

For widely traded crops such as the three considered here, price discovery is often conducted on futures exchanges, a transparent mechanism to facilitate trading between all market participants. The crops in question are traded on a number of different exchanges. Red spring wheat is traded on the Minneapolis Grain Exchange, canola is traded on the Winnipeg Commodity Exchange, and oats is traded on the Chicago Board of Trade. The price received by farmers is often determined by these prices, adjusted by a basis factor. The basis represents an adjustment for location and time between the futures price, a price for a given point in the future at a given location for set quality specifications, and the cash price that can be offered to the farmer for grain at his location with his quality attributes in the present (Kolb 1997). Farmers experience variability in both futures prices and basis levels. Canadian farmers also bear additional risk related to currency exchange rates. Because futures prices for spring wheat and oats are quoted in U.S. dollars, the value of Canadian currency also determines in part the price received by the farmer.

Farm price determination for wheat in Western Canada has one additional feature not common to other crops discussed here. In the case of wheat, government has intervened in the market by establishing a collective marketing agency known as the Canadian Wheat Board (CWB). The CWB is responsible for selling on behalf of farmers all wheat destined for export markets or domestic human consumption. It offers farmers a number of unique pricing options not available through the open market. Its traditional method of pricing for farmers is the pooled price. In the pool, all farmers received a crop-year average price for wheat of given quality. The farmer collects an initial payment when grain is delivered equal to a portion of the expected pooled price. Interim and final payments, collected at later points in the end of the crop year cover the remainder.

In the past decade, the Canadian Wheat Board has also begun to offer a number of different pricing options based upon U.S.-based futures contracts. These options allow farmers to bypass the pool and obtain an upfront price for their production. The most widely used is the Fixed Price Contract (FPC), which is based on wheat futures prices from U.S. exchanges. In the case of red spring wheat, the price offered to the farmer is the Minneapolis spring wheat futures price, plus a basis adjustment to make that price comparable to the PRO, which is based on grain in store in Vancouver or St. Lawrence.[8] Normal deductions for freight and handling are applied to arrive at a farm gate price. The producer is paid the full price locked in under the FPC ten days after grain is delivered. Pricing under an FPC is not tied to delivery of grain; rather the farmer delivers grain through normal channels and applies tonnage signed to FPCs to delivered grain (Canadian Wheat Board 2007a).

3.2 Farm Safety Net Programs in Western Canada

Governments in Canada, whether provincial or federal, have implemented some form of income support for farmers in Western Canada since the time of the Great Depression. Agricultural policy in Canada is a shared responsibility of the federal and provincial governments. This has contributed to considerable political uncertainty

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[8] While this describes the essential process of locking in a price for wheat under the FPC other adjustments can serve the complicate the FPC process. A basis "adjustment factor" may be applied that helps the CWB "manage price risk outside the CWB pool accounts" (Canadian Wheat Board 2007b). An "incremental payment" may also be applied to compensate farmers for holding grain while awaiting late season delivery.

surrounding farm policy. Policies are easily changed in the Canadian parliamentary system and the federal government and each province, often with conflicting budgetary realities, must often jointly implement policy. For this reason, Canadian farmers have been subjected to a veritable alphabet soup of farm program acronyms. Many programs are either not generous enough, generating dissatisfaction among the farm lobby or so generous that government cannot maintain funding them. All of these efforts have acknowledged a government role in providing income stabilization and support, but have not built a consensus as to the best method of providing this support.

Safety net programs, the vehicles that distribute government support, are described by two elements which together determine the net benefit to farmers: who provides funding and how are funds distributed. Another way to illustrate these concepts is to look government programs on a cash flow basis: how are funds for the program obtained and how are they dispersed. This section identifies these elements for safety net programs available to western Canadian farmers.

If safety net programs contain elements of stabilization, it is implied that producers provide at least some of the funds necessary to make program payments. The federal government, provincial governments, and producers combining to fund safety net programs have been termed "tripartite funding." Schmitz, Furtan, and Baylis (2002) make a cogent observation about stabilization as a goal of agricultural policy. They ask what it is specifically that is to be stabilized. Stabilization may be interpreted as reducing income fluctuations by holding to an average. If incomes trend downward over time, this average is declining over time as well. This kind of stabilization is unpopular with farmers. However if incomes are declining and policy attempts to stabilize around a fixed base, the liabilities to government increase until the program is no longer feasible. In some sense, agricultural policies are called on not only for stabilization but also for income support.

3.2.1 Key Differences in Safety Net Programs

If stabilization or safety net programming requires farmer contributions to fund payments, generally the magnitude of these contributions is determined prior to the events that might trigger a payment. This requires a calculation of the probability of the occurrence of a loss event. Insurance programs are the textbook example, using actuarial calculations to determine the long run cost of the program and the annual contributions necessary from both farmers and government to meet this cost obligation. Of course, any safety net program, even one entirely funded by government could be run in such an *actuarially sound* manner, with a designated fund is set aside to cover future program liabilities. Yet some government-backed safety net programs draw on general revenues to meet obligations for payment. Large losses in one year do not imply decreased benefits or increased funding obligations for future years. This is a key difference between different safety net programs on the funding side.

The other crucial difference between safety net programs concerns the program trigger, already identified as the defining characteristic of the program (Barnett and Coble 1999). Some program triggers cover very specific risks in single variables. Traditional crop insurance programs, for example, cover crop-specific yield risks. Other programs cover variables that encompass multiple risks. Income risk for most farms is a function of price and yield risks. When considering the impact of one program on the benefits of another, these differences are likely to be the source of these impacts. This section specifically identifies these elements by looking at the funding and provision of payments within western Canadian farm safety net programs.

3.3 Development of Canadian Farm Safety Net Policy

The most recent major change in Canadian agricultural policy came in 2002 with the introduction of the Agricultural Policy Framework (APF). The APF was organized around five pillars. The Business Risk Management pillar contained programs to provide an income safety net. Long-standing provincial crop insurance programs were preserved and the federally designed Canadian Agricultural Income Stabilization (CAIS) program was introduced. To enact the APF, the federal government needed each province to sign on and agree to partially fund the programs. Each province had the option of administering CAIS on its own or using federal administrators. For these reasons, the safety net provided to farmers, even federally designed aspects, varied from province to province. In spite of this asymmetry, there was a conscious effort to create a unified group of programs that worked together (AAFC 2007).

In addition, some provinces chose to add so-called "companion" programs to augment the agricultural income safety net. These programs use federal and provincial funds or may be entirely provincially funded. Examples include Farm Income Stabilization Insurance program in Quebec,[9] and the Spring Price Endorsement (SPE) and Revenue Insurance Coverage (RIC) insurance endorsements available to producers in the province of Alberta. The next section will briefly review these supports and provide an in depth description of the mechanics of each program.

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[9] This program is more widely known by its French acronym, ASRA, or Assurance et Stabilization des Revenues Agricoles.

3.3.1 Production Insurance

The essential characteristics of insurance have long appealed to farmers and others in the agriculture industry as an appropriate way to respond to production risk. Insurance "substitute(s) average loss for actual loss" (Rejda 2006) by transferring risk to insurers, who will indemnify the insured for their losses in exchange for a premium. In the case of crop insurance, yield declines should be indemnified in exchange for premiums. This is referred to as multiple peril crop insurance (MPCI): farmers are covered for yield declines resulting from a variety of conditions, such as drought, excess moisture, insect damage, and others. In the case of actuarially fair insurance programs, the total amount of premiums paid by farmers should equal the money paid out in indemnities. In practice, insurers must be compensated for underwriting expenses so premiums exceed indemnities. Because many potential insured's are risk averse as described in Chapter 2, they are willing to pay such premiums to avoid catastrophic losses. The operation of such a program of insurance has proven difficult, if not impossible; No private insurer has been able to profitably offer multiple-peril crop insurance (Kramer 1983).

This raises the question as to the reasons why MPCI is not offered by private insurers. Perhaps the risks inherent in crop yields are uninsurable. Rejda (2006) identifies the following conditions for an insurable risk: A large number of exposure units, accidental and unintentional loss, determinable and measurable loss, no catastrophic loss, calculable chance of loss, and economically feasible premiums. Crop yields risks generally do not conform to these conditions. Crop yields are not entirely fortuitous. It is difficult to separate yield losses due to outside factors from those resulting from poor management. There can exist without rigorous monitoring a moral hazard problem where farmers can help trigger indemnity payments through changes in farming practices. In that case, premiums must rise causing fewer farmers to purchase insurance.

In some cases, the chance of loss for an individual farmer is not calculable. This gives rise to the problem of adverse selection. If the insurer cannot distinguish between high risk and low risk individuals, it charges an average premium, pricing low risk individuals out of the insurance market. Premiums continue to rise as a result. Finally, catastrophic risks, that is the possibility of yield declines across many farmers, are generally characteristic of agricultural production. Agricultural crop insurance literature refers to this as "systemic risk." Events such as drought lead to yield drops for many producers. If the insurer is unable to spread risk, indemnities owed will exceed premiums and any reserves the insurer has built up and the insurer will go bankrupt. The combined consequence of these conditions is that premiums for actuarially fair crop insurance exceed farmers' willingness to pay (Barnett and Coble 1999).

The solution to this perceived market failure is for government to provide some form of insurance through government backed agencies at a reduced rate to farmers. This government sponsored crop insurance is a variant of true actuarially fair insurance. The first instance of a crude form of insurance in Western Canada was the Prairie Farm Assistance Act of 1939. The program charged farmers a $0.02 levy per bushel of wheat delivered in exchange for payments when yields in a set area dropped below a set threshold. Caps were set on the acreage base on which a farmer could be paid out for under the program. The program made no pretense of being set up in any way that would calculate probabilities of loss or charge premiums that coincided with risk (Britnell 1940).

In an effort to provide insurance coverage for crop yields that could applied to all crop farmers, the federal government passed the Crop Insurance Act of 1959. This program provided federal dollars to cover 20% of the premiums and 50% of the administration costs of a provincially-run insurance scheme. It required the provincial insurers to operate on an actuarially sound basis and ensure that a minimum of 25% of farmer or acreage in a given area were covered in order to spread losses. Since the advent of crop insurance in Western Canada, governments have increased premium subsidies to spur program participation among farmers (Sigurdson and Sin 1994). They have also increased available coverage levels and the number of crops eligible for coverage (Schmitz, Furtan, and Baylis 2002). If more farmers participate in production insurance, government hopes it will not have to fund expensive *ex post* disaster assistance in times of widespread crop losses.

Crop insurance programs vary slightly from province to province. Presented here is an overview of the mechanics of the crop insurance program used in the province of Manitoba. Manitoba was the first province to institute a program of crop insurance and has run a generally actuarially sound program with the highest participation rates in Canada. Over 81% of potential acreage is enrolled in CI in the province of Manitoba. Crop insurance is administered by Manitoba Agricultural Services Corporation, a crown agency that provides insurance and lending services to Manitoba farmers. MASC insures 54 crops and covers all losses resulting from natural perils including drought, excess moisture (rainfall or flood), frost, hail, fire, excess heat, wind, wildlife, disease and pests (MASC 2006). Producers insure on a crop-by-crop basis (they cannot insure individual fields) and select coverage levels of 50, 70, or 80% of expected yields. The yield coverage is valued at a unit price set before planting by MASC. The production insurance coverage provided to Manitoba farmers is calculated as

$$(3.1)\ (\overline{q} * IPI * \lambda) * p_{spring},$$

where λ is coverage level selected by the producer. The area average, $\overline{q}$, is calculated as the lagged ten year moving average of yields in the Risk Area adjusted by soil type. To account for differences in farm productivity, MASC has developed what it calls an *individual productivity index* or IPI. The IPI compares a farm's yield in a given year to the area average yield. This ratio is calculated over ten of the eleven most recent years, with the latest year dropped, then averaged. The formula for IPI for a given crop is

$$(3.2)\ \left(\sum_{t-11}^{t-2} \tilde{q}_t / \overline{q}_t\right) / 10,$$

where $\overline{q}_t$ is the area average yield in time t and $\tilde{q}_t$ is the individual farm yield at time t. The yield coverage that the farm insures for is multiplied by this adjusting factor to give the level of individual coverage. The benefit of including an IPI calculation is that coverage is applicable to the individual but does not vary widely from year-to-year because of large swings in yield (MASC 2007). The producer pays a premium equal to approximately 40% of a percentage of the coverage calculated by MASC.

A farmer triggers an indemnity when the current year crop yield falls below the coverage yield. The indemnity is the difference between these two yield levels, valued at the spring insurance price, or

$$(3.3)\ (\overline{q} * IPI * \lambda - \tilde{q}_t) * p_{spring}.$$

Producers are paid this amount following harvest and confirmation of the yield result. Random audits are conducted to ensure that reported production matches actual production.

3.3.2 Provincial Companion Programs

Yield risks covered by production insurance are not the only risk variable facing farmers. Price risk is the most obvious addition, but input prices are also not known with certainty. Thus farm groups have called for additional government supports. Provinces with the budgetary wherewithal to allocate additional money to agriculture have adopted safety net programming that attempts to address some of these risks. The province of Quebec, for example, has a program of revenue stabilization called Farm Income Stabilization Insurance. This program attempts to explicitly address rising production costs in crop agriculture by offering producers an income guarantee equal to the production cost on a model farm including operators' wages, but excluding returns to equity. Producers are paid the difference between this guaranteed income and production valued at the average price prevailing in the market over the course of the crop year. Producers pay one-third of the cost of running this program, through a system of co-payments or deductions from program benefits (La Financiere Agricole du Quebec 2007).

In Western Canada, governments do not have the fiscal wherewithal or political motivation to provide such rich supports. Only the province of Alberta has seen fit to set up an additional safety net program, which targets price risk. Farmers can choose to purchase this coverage as an "endorsement" on their crop insurance coverage and the program is operated by the provincial insurance agency, Alberta Farm Services Corporation. Though its coverage is tied to the crop insurance program, it provides price support to farmers even when crop yields are strong. The results of this study will look more closely at the implications of adding a program like Alberta's to a farmer's government-provided safety net.

Alberta's price risk management program separates its coverage into two programs, the SPE and RIC.[10] SPE focuses on "within year" price declines. It does so by comparing spring prices to harvest prices. If the harvest price is more than 10% below the spring price, the program pays the difference on each tonne of crop produced up to coverage level the farm has selected under crop insurance. The value of the potential SPE payment is

$$(3.4)\ \max\left[\left(p_{spring}-\tilde{p}_{harvest}\right)*\min\left[\tilde{q}_t,\bar{q}_t*IPI*\lambda\right],0\right]\ \textit{iff}\ p_{spring}-\tilde{p}_{harvest}\geq .1*p_{spring}$$

where $\tilde{q}_t$ is the current period yield and $\bar{q}_t*IPI*\lambda$ is the crop insurance yield coverage level. The spring price set in February and is a forecast of expected average market prices in the coming crop year. The spring price is the same price used to calculate the dollar coverage for crop insurance (i.e. Crop yield multiplied by the spring price). Farmers must pay a premium to be covered under this program, which is subsidized 70% by the Government of Alberta.

Revenue Insurance Coverage is intended to compensate farmers for long term price declines by establishing a floor price. This price is based on "province wide variable input costs, historical relationships among commodity prices, and the provincial government's capacity to provide support" (AFSC 2006). RIC pays farmers the difference between the floor price and the higher of the fall or spring price on tonnage covered under production insurance, less a 30% co-payment. The value of this payment can be expressed as

$$(3.5)\ \max\left[\left(\bar{q}_t*IPI*\lambda\right)*.7*\left(RICflr-\max\left[p_{spring},\tilde{p}_{harvest}\right]\right),0\right].$$

The best description of the RIC floor price is a long term price guarantee. For this reason, some have compared the RIC program to the U.S. Loan Deficiency Payment program, but

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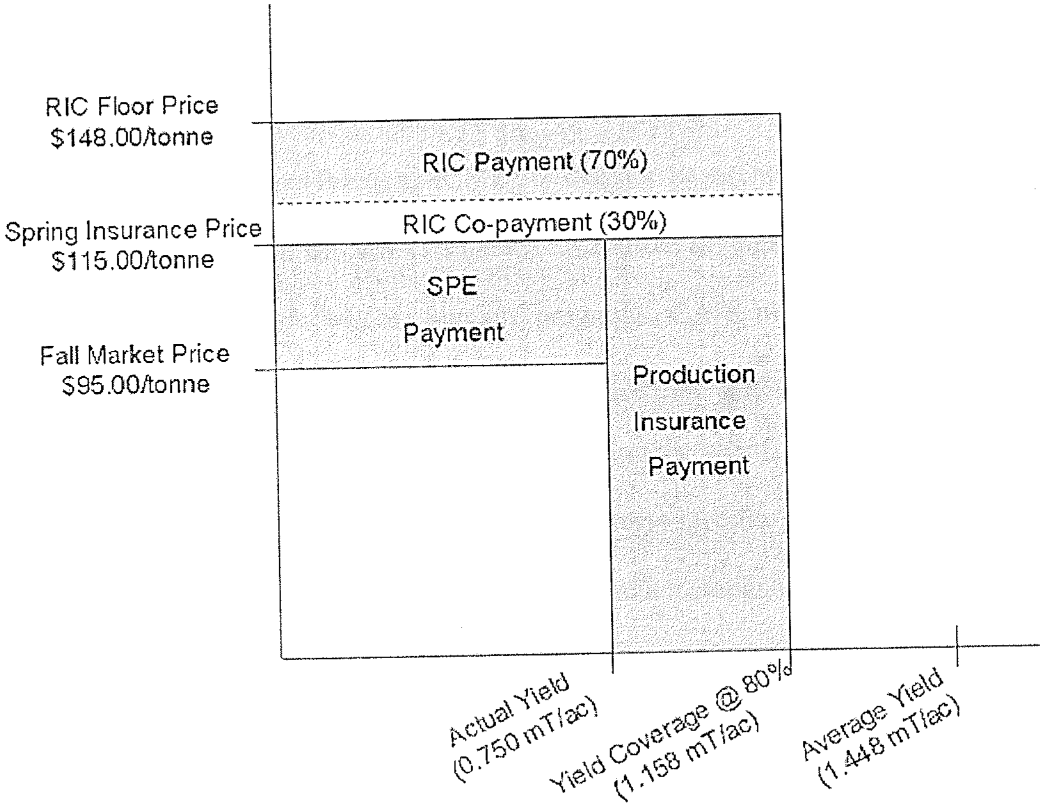
[10] The combined use of these programs is referred to hereafter as "SPE/RIC."

certain restrictions render this association imperfect. Unlike the Loan Deficiency Payment scheme, RIC has a co-payment; farmers do not receive the entire calculated benefit. Second, farmers must purchase the SPE to be covered under RIC. Third, RIC coverage only applies to the yield coverage obtained by the farm under crop insurance.

Combined, SPE/RIC guarantees that the producer will receive minimum revenue equal to the RIC floor price multiplied by the tonnage coverage selected under crop insurance. This can be seen in Figure 3.1, which presents a scenario under which a farmer would receive SPE and RIC payments for oats. SPE covers any tonnes produced that are valued less than the spring price. RIC increases the value of crop insurance covered bushels

Figure 3.1 Example of Potential Provincial Program Payments for Oats



Source: Adapted from AFSC (2006)

to the RIC floor price. In looking at how these two programs are targeted, it is clear that they are meant to assist farmers in times of low prices even if production levels are normal or above normal. However, analysis of Figure 3.1 also shows how the SPE and RIC programs are tied to production insurance in a way that implies a revenue guarantee for the farmer equal to the RIC floor price (less the 30% co-payment) multiplied by the production insurance yield coverage level.

3.3.3 Canadian Agricultural Income Stabilization Program

The Canadian Agricultural Income Stabilization (CAIS) Program is a federally designed program that attempts to provide both disaster assistance (support for large income declines) and income stabilization (small scale compensation for minor income declines). The program is the flagship effort under the Business Risk Management pillar of the APF unveiled in 2002. Originally, CAIS was an amalgam of two previously existing programs, the Canadian Farm Income Program (CFIP), a disaster payments program, and the Net Income Stabilization Accounts (NISA) program, an assisted savings program.

Unlike other current income support programs, CAIS makes no pretense about having any insurance characteristics. CAIS can best be described as a transfer payment program that distributes government money to farmers when income declines occur (Mussell and Martin 2003). The program sets out very specific guidelines as to how to gauge when an income decline has occurred and how much compensation the farmer is due.

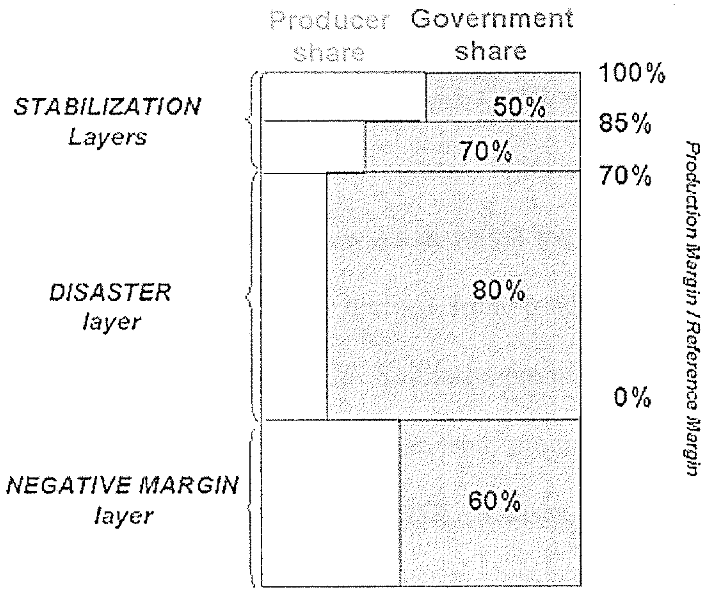
The CAIS program works around the idea of a margin, the difference between a set of allowable income streams and a set of allowable expenses. The margin concept under CAIS is similar to traditional definitions of net income but excludes certain income and expense items to prevent margin manipulation that would trigger payments; the exclusion of certain expenses is intended to discourage moral hazard. The average margin level, what is called a *reference margin* in program jargon, is the Olympic average of the past five years margin levels expressed as

$$(3.6)\ \left[\sum_{t-1}^{t-5}\left(\tilde{p}_t\tilde{q}_t - AC_t\right) - \min_{t-1}^{t-5}\left(\tilde{p}_t\tilde{q}_t - AC_t\right) - \max_{t-1}^{t-5}\left(\tilde{p}_t\tilde{q}_t - AC_t\right)\right]/3,$$

where $\tilde{p}_t\tilde{q}_t$ are revenues and AC_t are allowable costs at time t. An Olympic average is calculated by dropping the highest and lowest margins of the past five year and taking the mean of the median three years. The reference margin, encompassing the past five years, is compared to the current year margin; the difference is the margin decline. In comparing the current year margin to previous years, CAIS administrators attempt to account for changes in the size of the farm operation by performing what is called a *structural adjustment*. Essentially, it adjusts previous year's margin levels to what they would be if the farm had its current year acreage base. Like the nonallowable expenses, it means that farmers cannot trigger payments by drastically reducing their productive capacity, i.e. through cutting acres. It also helps farms that are trying to grow their operations by providing coverage equal to the current status of the farm.

CAIS is designed to provide payments to farmers based on any margin decline. The proportion of the decline that is covered by government payments increases as declines become more severe. The payments are allocated into three tiers, with the percentage of the margin decline covered by government payments defining the differences between tiers. In Figure 3.2, the structure of a CAIS payment is depicted. The current year's production margin can be thought of as a percentage of the reference margin. As the production margin declines, government payments cover an increasing share of the decline, from 50% of the first 15% of margin declines to 80% of the bottom 70% of margin declines. If the production margin is negative, government payments cover 60% of the negative margin portion, if the farm is enrolled in production insurance.

Figure 3.2 Illustration of Tiered Government Contributions to CAIS



Source: Adapted from Rude, Coyle, and Wei (2006)

When the program was first unveiled, it was to have a savings element whereby farmers would have money set aside to cover the portion of margin declines not covered by government money. Eventually these deposits would be mandatory to receive program payments. Under considerable pressure from farm groups who claimed that the deposits were a poor use of scarce financial resources, the federal government ended the deposit requirement and began charging a fee to access the program. This fee is equal to four and a half cents for every $1,000 in reference margin. Both the deposit requirement and the fee should not be interpreted as any form of insurance premium (Mussell and Martin 2005). Neither of these contributions is matched to the cost of the program or the probability of incurring payments.

3.4 Program linkages

Given that farmers are eligible to enroll in all three of production insurance, provincial companion programs, and CAIS, there has been much made of potential "linkages" between the three programs. From a purely mechanical standpoint, there are a number of relatively simple ways in which the programs interrelate. These linkages stem from the fact that benefits derived from production insurance and other programs are allowable income under CAIS. Similarly, premiums paid into such programs are allowable expenses. Thus any benefit derived from production insurance decreases the current year margin by the amount of the benefit. In cases where a producer does not make a claim, carrying insurance actually decreases the current year margin. To eliminate the incentive to stay out of production insurance and let CAIS cover all potential declines, CAIS administration and provincial crop insurers work together to encourage farmers to enroll in both programs.

Two separate mechanisms are available under CAIS to ensure that farmers are not penalized for both purchasing production insurance coverage and enrolling in CAIS. The positive margin linkage applies in the situation where the producer triggers a CAIS payment but his net benefit from production insurance is negative (i.e. premiums exceed indemnities). In this situation, the farmer is not fully compensated for the additional margin decline caused by the premium expense. In response, the CAIS administration issues a positive margin linkage payment that essentially refunds the value of production insurance premiums paid by the farmer. The negative margin linkage creates further incentive for participation in both CAIS and production insurance. This is done by ensuring that losses that could be covered by production insurance are not covered under the 60% negative margin coverage of CAIS. To do this, provincial crop insurers "impute" the net benefits a farm would receive with a 70% crop insurance coverage and deduct this benefit from the negative portion of the current year margin. The farm receives 60% of this reduced amount (MASC 2007b).

Beyond these mechanical linkages, there are more complex interactions between available safety net programs. These linkages exist because the variables that determine whether payments have been triggered and the value of payments under each program are closely related if not identical. For example, production insurance indemnities are triggered if actual yield is below coverage yield. While these values are not relevant in triggering SPE/RIC payments, they determine in part the magnitude of payments under SPE and RIC; SPE payments are paid on actual yield and RIC is paid on coverage yield. This is also true for CAIS, where the program trigger, the reference margin, is a function of price and yield variables that are themselves the trigger variables for the other programs. Assessing the impact of these interrelationships is difficult because the entire spectrum of relevant farm income events must be considered. There are optimistic and pessimistic scenarios for price and yield variables that generate very different responses from farm safety net programs.

CHAPTER 4

METHODS: BUDGETING MODELS AND STOCHASTIC SIMULATION

Chapter 3 outlined the environment in which the farm decision maker operates and the range of government backed safety net programs that he may choose from. To gauge the impact of these programs, a representation of possible outcomes must be placed in a farm decision making framework. This chapter considers farm budgeting methods that allow for the comparison of these outcomes. These methods are combined with statistical tools to create a model capable of comparing safety net program outcomes at the farm level.

4.1 Budgeting and Budgeting Models

4.1.1 Budgets

Budgets are a management tool used to aid in the planning and decision making process of a business. They are used to ensure that planned operations are consistent with the established goals; the goal of the farm decision maker is to maximize economic returns to owned or controlled resources. These resources include land and capital, both owned and borrowed, and the labour of the operator, family, and hired employees. Budgeting provides important oversight before decisions are undertaken by giving the decision maker a means to organize, experiment, uncover previously overlooked elements, and present plans to third parties for consultation. When used effectively, budgets give decision makers the ability to make economically sound decisions with respect to resource allocation that maximize returns.

Doye (2007) outlines three types of budgets relevant to farm business management. A whole-farm budget is a detailed financial picture of all operations. It shows the relationships between the various components of the farm, including resources, constraints, and other technical information. An enterprise budget is a statement of all expected benefits and costs of individual operation of the farm business. One example is a comparison of the profitability of different crop choices. Finally, a partial budget is a listing of only those financial indicators that are impacted by a proposed change in order to ascertain the net economic effects of the change. The method of budgeting used in decision analysis depends on the situation being analyzed, the data available, and the goals of the analysis. No matter what method is used, effective budgets require good source data.

The time period to consider depends greatly on the objective of the analysis. In crop production, most enterprises occur over a single crop year, so this is a common frame of reference for budget analysis. More complex budgets, especially whole-farm models, may look at impact over a longer time horizon. A long time frame is especially important when looking at impacts on debt and equity positions.

The analysis employed by this paper looks at the farm business on an enterprise basis. Separate enterprise budgets are developed for three crops: spring wheat, oats, and canola. These budgets contain detailed revenue and cost figures, necessary to calculate net returns from each enterprise, but also to calculate government program payments. The budget does not look at long-term balance sheet considerations such as debt or equity. The focus is placed on in-year profitability, including government payment options. The enterprise budgets are combined in a pro forma income statement that shows all revenues and costs in summary form.

Compiling budget information can be difficult and time-consuming. For most farm business managers, budgets use fixed-point estimates of production, prices, and financial variables. These figures yield point estimates of financial results. Invariably, real-life outcomes differ from those predicted by these models. Sensitivity analysis can be used to consider a wider range of outcomes, but it is difficult to conduct such analysis beyond changes in one or two variables. Many farm budgeting models would have more risky variables than this. Sensitivity analysis is also limited in that it does not indicate the probability of various outcomes (Lien 2003).

4.1.2 Stochastic Budgeting

The solution is to use budgeting models that incorporate stochastic or random variables. A stochastic budgeting model uses distribution functions rather than point estimates for key risky variables. It then expresses the values of key output variables as distributions through simulation, combining the risk embodied in all stochastic variables. Given that estimating a distribution function requires more information and consideration than given a point estimate or mean value, only the most crucial variables or the most uncertain are made stochastic. Budget elements known with certainty or relative certainty may remain deterministic.

Richardson (2006) establishes a process for building a stochastic simulation model. The starting point is to establish the key output variables (KOVs) that the model should generate. Once the purpose of the model has been established, the KOVs should be apparent. From here, the model builder considers the variables and assumptions necessary to calculate the KOVs. Richardson (2006) breaks these into three types: exogenous variables that are out of managerial control and often constant; stochastic variables that are beyond managerial control and are subject to risk; and control variables that are affected by the decision maker. Generally, the model is sketched out in flowchart form and the interactions between all identified variables are defined. These interactions are generally stated in terms of equations.

4.2 Simulation

The purpose of a stochastic budgeting model is to generate a distribution for key output variables to give decision makers a better sense of how elements of their operation affect the risk of outcomes. Modeling these risky elements is often done through simulation. Rather than considering a single set of possible variable values in a stochastic budgeting model, simulation runs through a large number of iterations. These iterations can best be understood as a possible actual occurrence. Vose (2000) makes this his "cardinal rule" for modeling risky situations, saying "Each iteration of a risk analysis model must be a scenario that could physically occur." In the case of the model proposed here, each iteration represents the outcomes of a hypothetical 2006-2007 crop year for a model farm.

A simulation model arrives at values for stochastic variables by separating source data on that variable into deterministic and stochastic parts. The deterministic component can be established exogenously or calculated endogenously. Richardson (2007) calls the deterministic portion of a variable its systemic variability, with the stochastic portion representing random variability. One can think of systemic variability as the change in a variable is known *a priori*. For example, crop yields are known to increase over time as agronomic improvements are made. This pattern of growth is not part of observed risk of a single years yield outcome.

Richardson (2007) outlines three ways of separating a single stochastic variable x into its component parts. The first method assumes that x is distributed without a trend. The deterministic component is the mean of historical values, $\bar{x}$. The stochastic component is derived from the residuals from the mean. Second, x is distributed about a trend. The deterministic component is given by a simple linear trend equation, $\hat{x} = \beta_0 + \beta_1(\text{Trend})$. The stochastic component is given by the residuals about the trend line. Third, assume x is distributed about a structural equation that relates x to exogenous variables. The deterministic component is the regression equation, $\hat{x} = \beta_0 + \beta_1 y + \beta_2 z$. The stochastic component is the residual about the regression equation. Once estimated, the deterministic component of a stochastic variable is fixed, save for changes to endogenous variables such as the time trend.

Simulation relies heavily on the use of random numbers to generate the stochastic portion of model variables for each iteration of the model. Because random numbers are often associated with games of chance, stochastic simulation is often referred to as Monte Carlo simulation. Most simulation software uses pseudo-random number generators. These strings of random numbers start with a seed. By using the same seed for multiple simulations, the series of numbers generated by the pseudo-random number generator is unchanged and the results of each simulation can be compared.

Repeated random sampling is the essence of simulation. To simulate any uncertain input variable, a cumulative distribution function for that variable is necessary. The cdf, $F(x)$ gives the probability that the variable X will be less than or equal to a given value, x, or

$$(4.1)\quad F(x) = P(X \le x).$$

Inherently, *F(x)* is a continuous function ranging from zero to one. This cdf and a random number generated from a Uniform distribution with range (0,1) are the two inputs necessary to simulate a single iteration for the variable *X*. The random number, *r*, is fed into an inverse function *G* to arrive at a simulated value,

$$(4.2)\quad G(r) = x\,.$$

If a large enough number of iterations are performed, the distribution of simulated x variables should approximate the input distribution *F(x)*. This procedure is known as Monte Carlo sampling. Its weakness is that it can over and under sample portions of the distribution, because the sampled numbers are purely random. To accurately replicate the input distribution, prohibitively large numbers of iterations may be necessary. A second sampling method exists to combat this problem. Latin Hypercube sampling stratifies the input distribution and draws random numbers in equal amounts from each segment. This greatly reduces the number iterations necessary to accurately simulate input distributions. Meaningful results can be obtained from fewer than 1000 iterations. (Richardson 2006) This study runs 2,000 iterations of the model.

4.3 Distributions

As noted above, modeling risky variables using simulation requires an input distribution. Incorporating risk into an analysis is only practical if that risk can be modeled accurately, so the choice of input distribution is critical to effectiveness of the model. This section will refer to a number of distributions common in agricultural risk analysis, but this reference is by no means exhaustive.

To determine the appropriate probability distribution for the stochastic variables in any model, it is important to understand the range of options available. Vose (2000) posits that categorizing probability distributions allows the modeler to make better choices about the distributions used in a model. To this end, he outlines a number of differences between distributions.

First, the distribution may be discrete or continuous; it may take on a set of distinct identifiable values or it may take any value in a given range. In agricultural models, discrete distributions, such as the binomial and generalized discrete, might be useful in modeling the number of tractors a farm should purchase. Other variables in agricultural problems such as prices or yields are essentially infinitely divisible and should be modeled using continuous distributions, of which the normal distribution is the most common.

A second categorization of probability distributions is unbounded versus bounded. Unbounded distributions have a range that extends from negative to positive infinity. The Normal and Logistic distributions, for example, are both unbounded. Though these distributions are widely used, it is crucial that the modeler account for this characteristic when using these distributions as variables may take on values that would not be found in reality. This may be the case when modeling commodity prices, which cannot take on negative values. Bounded distributions have fixed minimums and maximums. These may be a function of the mathematical properties of the distribution as in the case of the exponential, Chi-squared, or Weibull distributions, all of which are greater than or equal to zero by definition. A distribution may also have a single bound imposed upon it. Some simulation programs provide for user-defined truncated distributions, such a truncated normal. These partially-bounded distributions may be useful where variables must be nonnegative or when policy constraints impose bounds. Richardson (2007) refers to the unbounded and bounded forms as open and closed form distributions.

4.3.1 Parametric and Nonparametric Probability Distributions

Perhaps the most important distinction among probability distributions for applied modelers is between parametric and nonparametric distributions. Vose (2000) describes a parametric distribution is one "whose shape is born of the mathematics describing a theoretical problem." The normal, lognormal, and beta distributions all exhibit this property. Nonparametric distributions allow the required shape (as determined by historical data and/or expert opinion) to define the mathematics. This includes Empirical, Discrete, and Triangular.

Parametric distributions capture a great deal of information. The use of parametric distributions has been aided by diagnostic tools that allow modelers to compare the fit of various distributions to historical or survey data. One commonly used tool is the software program BestFit, (Palisade Corporation 2005) which allows users to import data and perform fitting. It outputs numerous statistical measures of fit that may be used to choose the best parametric distribution.

Perhaps the most flexible nonparametric distribution is the Empirical, provided that there is accurate, relevant data available. Its use allows modelers to let the source data define every aspect of the input distribution. The Empirical cumulative distribution function for a variable x is defined by sorting the historical data from least to greatest and assigning each x a probability $P(x)$.

There are distinct advantages to using each type of probability distribution for analysis of decision making under risk. Nonparametric distributions are favoured by many analysts because they are relatively simple to parameterize, even for those inexperienced in risk analysis. For example, the Triangular distribution can be parameterized with only three simple pieces of information: the mode, high, and low values. In contrast, even simple parametric distributions like the Normal, which requires only the mean and standard deviation, are difficult to parameterize because real-world decision makers are not knowledgeable enough to accurately comprehend the meaning of the standard deviation or predict its value. Vose (2000) also notes that nonparametric distributions are often easier to update if and when improved information becomes available.

4.3.2 Multivariate Probability Distributions

A simulation model that accurately models the behaviour of farm business is complicated by dependencies that exist between variables. The univariate probability distributions described above do not account for these dependencies. As such, the simulation results produced using those distribution may bear little resemblance to real-world outcomes. Crop yields are one variable where one would expect intra-temporal correlation amongst the various crops raised on a given farm. This correlation must be preserved and multivariate distributions are the method by which this is done. If the correlation is not preserved, the mean and/or variance of the output variables that are a function of the model's stochastic variables will be biased. This is because the variance of the output variables is a function of not only the variances of the input variables but also the covariance of the input variables. Proof of this statement is provided by Richardson (2007).

Procedures for maintaining "appropriate correlation" between input variables are outlined in an important paper by Richardson, Klose, and Gray (2000). They introduce the multivariate empirical (MVE) distribution and present a practical example of its use in agricultural modeling. These procedures are reproduced in an instructional format in Richardson (2007). Similar to the Empirical distribution, the MVE distribution uses actual data to determine its form. The random numbers used to generate the stochastic portion of simulated iterations are correlated using an intra-temporal correlation matrix calculated from historic data. Simulated variables from an MVE distribution will then be intra-temporally correlated the same as in past data, in addition to possessing similar mean and standard deviation (Richardson, Klose, and Gray 2000).

4.3.3 Use of Probability Distributions in Agricultural Economics

While simulation models require input probability distributions for all stochastic variables, the majority of efforts to parameterize agricultural distributions have focused on crop yields. The efforts of Day (1965) initiated a longstanding search to find a probability distribution specification that could be applied to the economics of production under uncertainty. The need to accurately specify yields has been particularly acute for economists studying crop yield insurance problems. Many have posited that crop yields are non-normal, but there is no agreement about the nature of this non-normality, for example the direction of skewness in crop yields.

Just and Weninger (1999) present a thorough review of the empirical evidence against non-normality of crop yields and the methodological problems in performing such analyses. They emphasize the importance of differentiating the deterministic component of farm-level yields from both region-wide variability and variation between farms.

But even if one can account for the complexities of available yield data, there are still problems in parametric approaches to estimation. Common tests for fitting candidate distribution forms such as the Chi-squared, Kolmogorov-Smirnov, and Anderson-Darling are "sensitive to different departures of the assumed distribution from the actual distribution" (Zhao 1992). Often they will not yield matching results. Furthermore, because these tests generally consider a large group of distributions, the possibility of failing to reject the hypothesized distribution (Type II error) may be high. If the assumed parametric distribution is wrong, stochastic efficiency analysis may yield poor results. Moreover, using the empirical distribution function compares favourably to parameterized distributions (Pope and Ziemer 1984). For these reasons, the use of the empirical distribution is justified in simulating the operation of the model farm in this study.

4.4 Data Sources

Whether parametric or nonparametric approaches are used to model stochastic variables in a simulation model, data is required. This analysis assumes that historic variability present in stochastic variables gives a reasonable indication of future variability and relies on historic data to incorporate these aspects of risk, namely output prices and yields, into the model. In addition, deterministic components in this model require current and past data. This section names and describes the data sources used for this model.

The major stochastic parameters are yields and prices for each of the three crops, wheat, oats, and canola that are grown on the model farm. Cumulative distribution functions must be specified for each of these variables. Yield data is perhaps the most difficult to obtain. Area yields are made available to the general public by government agencies, but only at the national or provincial level. Government appointed crop insurance providers such as Manitoba Agricultural Services Corporation have made available yield data at the risk area level. The problem with area yields is that they are aggregated. The distribution of area yields does not reflect the true distribution of potential yields faced by individual farmers. To give an extreme example, an area average does not indicate that a farmer might have a yield of zero for a given crop in a given year, as the likelihood that the entire area experiences crop failure is infinitesimal. Thus to accurately simulate yields, individual farm level data is necessary.

For this project, field-level yield data was obtained from MASC for all producers inside MASC Risk Area 12. The data covers the past ten years of crop production in the region. The data was anonymized, but producers were given a unique number so that a farm-level yield could be gleaned from the data. The physical location of each field was unimportant, but it was crucial to group fields common to one operator because the model uses the farm and farm income in evaluation. The yield dataset contains yield records for 2430 farms for wheat, 2280 farms for canola, and 1994 farms for oats. However, yield points are not available for all farms in all crops and years. The data was filtered to include only farms with data for all three crops in all years; reducing the dataset to the resulting 54 farms was necessary to allow for the preservation of farm level correlation between crop yields.

Data on prices was obtained from two sources. Prices for open market crops, oats and canola, were taken from MAFRI's Industry Intelligence Service weekly price publication. This report gives elevator prices for each crop, based on Winnipeg delivery, a reasonable assumption given Winnipeg's location in the centre of the risk area. This data goes back to the 1990-91 crop year (MAFRI 2006). Corresponding data for nearby futures prices were obtained from Agriculture and Agri-Food Canada's Market Analysis Division (Lennox 2007). Where prices were quoted in U.S. dollars, prices were converted to Canadian dollars using exchange rate data from the Federal Reserve Bank of St. Louis (2007).

Price data for wheat is somewhat more problematic as there is no market price or cash price for Hard Red Spring Wheat in the province. The CWB does publish a Pool Return Outlook, a monthly estimate of what they believe will their final price for producers at the end of the year for all classes and grades of wheat. This estimate is a poor indicator of price variability. By definition, it is an average (or an estimate of the average) of sales prices from throughout the year. The absence of a cash price for wheat makes it difficult to assess price variability between planting and harvest. To avoid this complication, variability in futures prices was incorporated using nearby Minneapolis spring wheat futures prices. The farm gate price was calculated by adjusting the futures price as would be done if the farm was using the CWB's Fixed Price Contract pricing option.

Data on costs, both current and past costs was obtained from MAFRI estimates, which are published each spring. These publications give itemized estimates of costs relevant to agricultural production across the province (MAFRI 2007). These estimates were adjusted slightly to account for differences in costs between regions. The assumed value of land was set at $1000 per acre, to be more reflective of land prices in the region under consideration. This means a "land cost" (either rent or returns to farm land) of approximately $40/acre using MAFRI guidelines. Currently, this may be slightly on the low end of cash rents in the area. Costs were re-categorized so that they could be used for CAIS program margin calculations by separating them into allowable and non-allowable categories (AAFC 2006c).

4.5 The Model

The budgeting model used in this project takes a hybrid approach. By assuming that the farm grows only three crops and that all farm revenues are derived from sales of these crops in a given crop year, enterprise budgets can be created for each crop to assess their profitability. Market revenues for each crop are simply the price received multiplied by the crop yield. It is assumed that the entire crop is sold at the crop-year average price. There is no carry over from year to year; the farm does not hold inventories of outputs. Given this price and yield data, revenues from crop specific government programs, crop insurance and the companion revenue program can be calculated. The cost figures for each crop are deducted from these revenues to arrive at a per-acre profit or loss for each crop.

The hybrid approach to budgeting takes the enterprise budgets for each crop and uses figures calculated in that process to calculate a measure of per-acre net farm income. Revenues and expenses are weighted by their proportion in the farm's crop mix. Recalling that wheat and canola each comprise 40% the rotation and oats taking the remaining 20%, the revenue and expense figures are multiplied by these percentages and placed in a pro forma income statement. The figures are also used to calculate any benefits due the farm under the CAIS program.

Expenses are not classified according to standard accounting or economic delineations. For example, expenses are not split into fixed and variable costs. Rather, they are divided into those that are eligible and ineligible for consideration in calculating production margins under the CAIS program. Because the key output variable for the model is net farm income, any expense break down is unnecessary for the purpose of calculating profitability. An expense break down is only necessary to calculate CAIS payments, so expenses remain broken out in that manner.

4.5.1 Specifying Stochastic Variables

Specifying a distribution of stochastic prices requires greater effort than stochastic yields. This difference arises from the level of farmer expectations about end of year outcomes. In the case of yields, farmers, especially those in the Red River Valley, have little or no expectation of what harvested yields might be in the spring time. Though soil moisture levels might give something of a starting point, the variability in precipitation through the crop year means that spring time moisture levels are a poor indicator of future yield. Also, in short-season cropping environments such as Western Canada, adequate heat units, sunlight, and growing degree days are also crucial to crop success. These are difficult to predict in spring. For these reasons, we assume that the farmer makes no predictive assumptions about yield. Therefore the simulated yield values in the model sample equally from all available historical data, preserving the correlation between crops. The distribution used is a multivariate empirical. The distribution is centred on the long term historic average.

The case of prices is different. The presence of forward contracting and futures markets gives the farmer a reasonable expectation of future prices. In addition, the price received by the farmer is not a one-time event, but a weighted average of crop marketing throughout the crop year. Of course, these markets are subject to fluctuations and the end-of-year average price will not equal the spring expectation, but it is unreasonable to think that the distribution of output prices received by the farmer is centred on a long-term historic average.

To establish an expected price that would form the centre of the farmer's expected distribution of output prices for the coming crop year, a simple forecasting model created by Hoffman (2005) is adapted. The model uses futures prices adjusted by historic basis levels to forecast a price for each month of the coming crop year. These prices are then weighted by the percentage of output expected to be marketed in each period to arrive at an average annual price. An example of the calculation of this forecast price is given in Appendix B.

Using this forecasting technique presented a number of additional challenges, mainly arising from a lack of Canadian-based price discovery tools. In the case of canola, the forecast process is relatively straightforward. The basis levels for each month are calculated by comparing cash prices in the Winnipeg area with the nearby futures values. The basis for each month is an average of the values for the past five years. In the case of oats, cash price values must be converted to U.S. dollars so that they may be compared to the value of U.S. oats futures on the Chicago Board of Trade. The resulting basis levels are then converted back to Canadian dollars. The model does not explicitly consider exchange rate risk; exchange rates are only used as a means of expressing all model variables in common terms.

To accommodate the idiosyncrasies of Canadian wheat marketing, the expected farmer price was assumed to be based on the CWB Fixed Price Contract. Under this program, farmers to price their CWB deliveries against U.S. futures adjusted to port position in Vancouver; the CWB deducts freight and handling charges from this price to arrive at the farm price. A common basis for the adjustment to Vancouver of $20/tonne is assumed based upon historic levels published by the CWB.[11] Deductions for freight and handling and storage incentives are also taken into consideration to arrive at a monthly price forecast. Marketing weights were estimated based upon conversations with farmers. It was assumed that oat marketing would be strongly weighted towards the earlier part of the crop year as the bulkiness of oats gives strong incentive not to store. Wheat marketing was assumed to be evenly spread through out the crop year.

The next step was to estimate some measure of in-year price variability. To do this, weekly cash prices in Winnipeg, or nearby futures prices in Minneapolis in the case of wheat, were used. The mean for each crop year was found and the deviations from the mean were calculated.[12] The distributions rendered by this method are approximately symmetric with high peaks, indicating that most of the time the expected price in spring is near the season average price. Of course, if forecast prices are near historic highs (or lows), it is intuitively less likely that they will move higher (or lower). To incorporate this stylized fact into input distribution, truncation points were placed on the price deviation distribution so

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[11] CWB basis levels are difficult to assess given a lack of long-term historic data and lack of transparency as to how the basis is set.

[12] Another attempted method tried to accommodate seasonality of prices by running a simple linear regression over time and using the deviations from the trend as a measure of variability. However, in multiple cases, prices trended downward rather than upward over the year, resulting in some abnormal deviations. It was felt that using deviations from the mean resulted in a more accurate sample of price volatility.

that the simulated season average price would not be substantially above (or below) long term highs or lows. The resulting distribution is simulated as a truncated empirical.

4.5.2 Incorporating Historic Data

Most of the model devised to this point focuses upon at the current period. However the very nature of government programs such as CAIS and production insurance is backward-looking; the prospects of payment in the current year are a function of results in past years. Recall that production insurance requires a comparison of past farm yields to area yields over the past eleven crop years to determine the IPI. This analysis avoids this complication by assuming that the farm's IPI is equal to one; on average, the farms historic yields are equal to those in the Risk Area. This means that the model farm receives published coverage levels that are unadjusted by an IPI. Similarly, the premiums paid by the farm for production insurance and the spring price endorsement are also incorporated into the model using published figures. In reality, the premiums paid by farmers are a function of the coverage level selected and historic yield figures. The insurer attempts to equate expected premiums and expected indemnities over the long run using its knowledge of the probability of yield outcomes. Ray (1981) provides a thorough examination of this process.

The CAIS program requires a five-year Olympic average of program margins to calculate the farm's reference margin. To determine the reference margin for the sample farm, program margins for each of the past five years were taken from the data identified above. Per acre program margins are calculated for each of the three crops, seen in Table 4.1. Price figures are season averages. The yield figures used are average yields for the risk

Table 4.1 CAIS Reference Margin Calculations for Model Farm

Year	P_{wheat}	Y_{wheat}	$Expense_{wheat}$	$Margin_{wheat}$	P_{canola}	Y_{canola}	$Expense_{canola}$	$Margin_{canola}$	P_{oats}	Y_{oats}	$Expense_{oats}$	$Margin_{oats}$	Production Margin
2001	169.14	0.701	119.71	-1.07	315.57	0.500	153.17	4.67	186.92	1.000	90.90	96.11	20.66
2002	200.10	1.193	115.45	123.27	365.51	0.779	145.67	138.94	174.12	1.345	88.64	145.54	133.99
2003	163.02	1.564	125.50	129.49	353.90	0.915	161.82	161.89	123.39	1.757	102.72	114.07	139.37
2004	154.55	1.495	122.53	108.56	278.61	0.794	162.28	58.95	117.63	1.724	99.21	103.62	87.73
2005	143.04	0.348	125.09	-75.38	242.99	0.099	156.60	-132.42	129.00	0.402	102.02	-50.21	-93.16
									Reference Margin (Olympic Average)				80.79

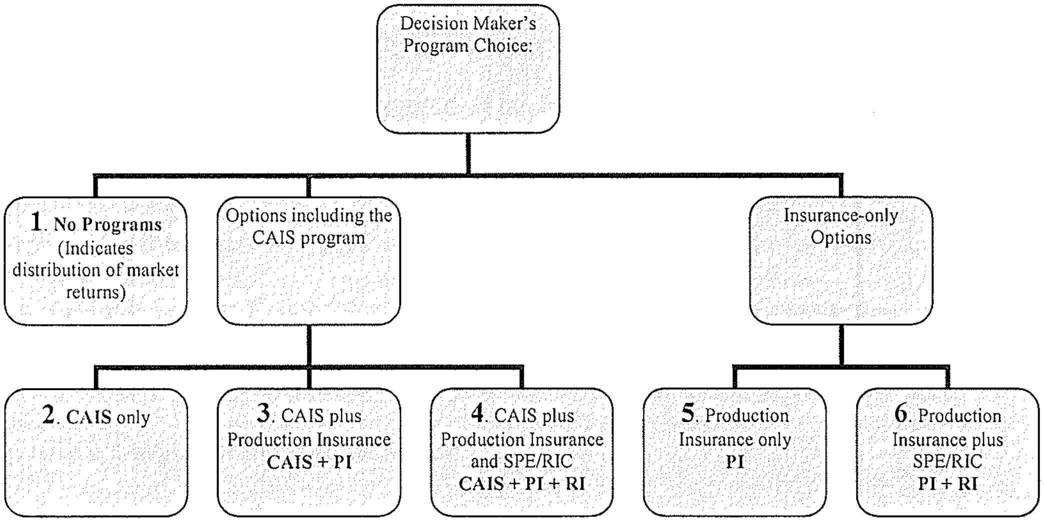
Note: P indicates price, in dollars per tonne; Y indicates yield, in tonnes per acre. Expense indicates CAIS Allowable Expenses.

area in each year. These margins are weighted by the share of that crop in the farm crop rotation to determine the whole farm production margin for a given year. Production margins were positive for four of the five years. When an Olympic average is taken, the farm's per acre reference margin is determined to be $80.79 per acre.

4.5.3 Scenarios

The model utilizes the same random draws, but the outcome of each iteration can take one of six forms based upon a scenario of program use shown in flow chart form in Figure 4.2. The first scenario is considered the base case where the farm operates without government support. This is termed "No Programs." The second, third, and fourth scenarios are all permutations of possible program use involving the CAIS program: "CAIS", "CAIS+PI", and "CAIS+PI+RI", where PI indicates the purchase of production insurance and RI indicates the purchase of SPE/RIC. The final two scenarios include insurance options but not CAIS coverage: PI and PI+RI. It is important to note that the SPE/RIC

Figure 4.1 Flow Chart of Program Choices



program cannot be accessed without first purchasing production insurance. As such, scenarios that include the use of SPE/RIC without production insurance use are not considered.

4.5.4 Model Calculations

The output variable of the model is per acre net income for the farm. The equation for per net income is

$$(4.3)\ \sum_i(\delta_i\tilde{p}_i\tilde{q}_i) + NetGovPayments\ - \sum_i \delta_i C_i\,,$$

where δ_i is the share of crop *i* in the farm's rotation, $\tilde{p}_i$ is the price per tonne of crop *i*, $\tilde{q}_i$ is the per acre yield for crop *i* and C_i is per acre cost for crop *i*. The first term represents all market derived revenue for the farm. The second term, *NetGovPayments* represents the value of production insurance, CAIS, and other program payments expressed on a per acre basis. An example of the calculations necessary to determine these values are given in Appendix C. The first two steps are to sets exogenous parameters and, through the simulation of stochastic prices and yields, determine market revenues. The market revenue calculations include the variables necessary to determine whether production insurance and SPE/RIC payments have been triggered. The calculation of CAIS benefits follows, as it incorporates information about market revenue and other program proceeds. Unlike other programs, the three sets of CAIS calculations are performed, one for each scenario under which farmers access CAIS. Positive margin benefits are calculated first, followed by negative margin benefits. The final step is to compare benefits between scenarios to assess if a positive margin refund is to be issued.

A summary of these calculations is provided in the sample spreadsheet and income statement found in Appendix D. Net income for each scenario for a single iteration of the model is shown. Repeated generation of the stochastic variables through simulation, run through the model to calculate a series of values of net income for each scenario allows for the formation of a cumulative distribution function of net income for each scenario.

4.5.5 SERF Calculations

The distributions are assessed using the SERF method outlined in Chapter 2. Computationally, this method has four steps, as stated in Hardaker et al (2004b). First, probability distribution to be evaluated is divided in a large finite set of values. These values are then expressed in utility terms using an assumed utility function and risk aversion coefficient. This analysis used a power utility function of the form

$$(4.4)\ U(\tilde{x}+\omega)=\frac{(\tilde{x}+\omega)^{1-R_r}}{1-R_r},$$

where $\tilde{x}$ represents the stochastic value derived from the model, ω, a fixed initial wealth parameter, and R_r, the coefficient of relative risk aversion. The initial wealth level is approximated using data on average net worth of Manitoba farms (Statistics Canada 2006). The resulting utility values are then multiplied by their associated probabilities. This expected utility value is converted into a certainty equivalent value in dollar terms by taking the inverse of the utility function at that level. The next chapter presents the results of analysis using these procedures.

CHAPTER 5

RESULTS

This chapter presents results derived from the stochastic simulation model developed in Chapter 4. Monte Carlo simulation methods are used to calculate 2,000 iterations of market revenues, program payments, and net returns for the 2006-2007 crop year on the model farm. Analysis of these results comprises two parts. First, a general statistical overview of the distributions of net income and their constituent parts explains the impact that each program has on farm net income. This statistical analysis looks not only at summary statistics but also calculates the probabilities and correlations of events important to the farm decision maker. Second, stochastic efficiency analysis as described in Chapter 2 is used to quantitatively evaluate farmer preferences in electing to use each program and the impact that additionally programs have on the value of the net benefits derived from production insurance.

5.1 Results Derived from Simulation of Stochastic Variables

Recall from Chapter 4 that the model contains six scenarios of possible farmer use of safety net programs. Common to all scenarios are the calculation of non-government determinants of net income, namely stochastic output prices and yields and deterministic input costs. Table 5.1 shows the summary statistics for the stochastic price and yield variables simulated. These statistics demonstrate of production challenges and profitability of each crop. Table 5.1 shows historically low prices for wheat and canola, indicating that farm net income is likely to be low for the coming crop year.

Table 5.1 Summary Statistics for Model Stochastic Variables

	P_{wheat}	P_{canola}	P_{oats}	Y_{wheat}	Y_{canola}	Y_{oats}
Mean	147.21	280.21	127.89	1.060	0.710	1.450
Std. Dev.	10.44	24.05	15.22	0.420	0.290	0.510
Skewness	1.96	0.48	0.47	-0.340	-0.780	-0.680
Kurtosis	6.82	0.08	1.29	-0.410	-0.160	-0.050

Note: P indicates price, in dollars per tonne; Y indicates yield, in tonnes per acre.

Since the stochastic variables are crucial in deriving an accurate estimate of net income and net income variability, a number of brief validation exercises are conducted to ensure the simulation results follow the historical data and the forecast procedure used to simulate crop prices. T-tests are used to confirm that the mean and standard deviation of the simulated variables match their historic or forecast values. The test determines whether the simulated values are significantly different from the specified value at the 95% level. The null hypothesis that the mean of the simulated series equals the historic mean specified is not rejected in all cases. For example, the simulated canola mean equals $278.55 whereas the forecast value is 278.67. The critical value for the t-test is 1.96 at the 95% confidence level. The test statistic is 0.11. In all cases, the tests fail to reject the null hypothesis.

Because crop yields were simulated using a multivariate empirical distribution, it must also verified that the correlation matrix for the simulated values matches the historic correlation matrix. Given that the correlation matrix is a 3x3, which is relatively small, it is not anticipated there would be any difficulty in replicating the historic correlation matrix over 2,000 iterations. Results of t-tests on each component of the matrix show that in each case between wheat, canola, and oats yields, the tests fail to reject the null hypothesis that the simulated correlation is the same as the historical correlation. Based on these hypothesis tests, it can be concluded that the simulation results are valid.

By combining the market price and farm level yields, an estimate of the expected distribution of net income for the crop year absent government supports can be built. This is the "base case" for this analysis. Net farm income is calculated by subtracting costs and adjusting per acre profit/loss for each crop for its proportion in the farm crop rotation. Summary statistics for this distribution are presented as part of Table 5.4 (found on page 80). The expected value of market returns in this crop year is a loss of $28.22. The second and fourth moments of the distribution, the standard deviation and kurtosis, indicate that there is great variability in market returns. The large standard deviation of 64.63 indicates that the distribution encompasses a very wide range. The kurtosis value of -0.24 shows that the distribution is not highly peaked. Market returns display negative skewness because more extreme values exist on the low end of the distribution.

The expectation for the coming crop year is that the farm will not be particularly profitable. Net income is positive only 36% of the time. The return to farmland, that is revenues less all costs except the standardized cash rent/return to owned land, is positive 62% of the time. The farm is able to cover its variable costs 73% of the time. On a weighted per acre basis, variable costs are equal to $142.35.

It should be noted that this base case represents farm returns without the benefit of many common privately provided producer risk management tools. Price risk may be managed by hedging with futures or forward contracting with grain buyers. Costs may lower than assumed in the model if extreme yield losses occur and farmers can forego certain input expenses.

5.1.1 Results of Program Payment Calculations

For each iteration of market returns generated above, program payments that are triggered by lower prices, yields, or production margin declines are calculated. A summary of production insurance payments, SPE/RIC payments, and CAIS payments is shown in Table 5.2. For production insurance and SPE/RIC, the payments are broken out by crop. The premiums charged for these programs have been deducted so the information available in Table 5.2 can be interpreted as the net program benefit. It is initially apparent is that there is significant money available in government payments under the range of market and agronomic conditions present in this crop year. The expected benefit as expressed by the mean is positive for all programs, including those that charge premiums, namely production insurance and SPE/RIC. This is to be expected, given that a large portion of the actual premiums for these programs are covered by government transfers.

Production insurance has the lowest mean value of payments. The expected benefit for each crop ranges from six to eight dollars per acre. The farm expects to trigger a production insurance payment approximately 25% of the time in the case of each crop. These figures are lower than for the other programs; the benefit of production insurance is seen at the extremes. The maximum payments made over the course of 2,000 iterations were \$94.97 per acre for wheat, \$110.21 for canola, and \$124.65 for oats. Contrast this with the SPE/RIC program; the mean payments are less and the farm triggers some SPE/RIC

Table 5.2 Summary Statistics for Distributions of Government Program Payments, by Program

	PI_{wheat}	PI_{canola}	PI_{oats}	RIC_{wheat}	RIC_{canola}	RIC_{oats}	CAIS	CAIS(+PI)	CAIS(+PI+RI)
Mean	6.40	8.22	7.28	6.32	12.17	10.86	29.48	32.29	27.09
Std. Dev.	22.80	32.11	27.82	4.84	8.73	9.81	25.09	26.36	24.74
Minimum	-4.85	-6.92	-4.95	-4.68	-2.56	-2.76	-0.36	-0.36	-0.36
Median	-4.85	-6.92	-4.95	6.77	12.68	11.12	26.32	30.47	22.19
Maximum	94.97	110.21	124.65	15.51	32.39	57.79	76.78	78.44	74.50
Skewness	1.98	2.07	2.43	-0.55	-0.07	1.20	0.13	0.17	0.33
Kurtosis	2.70	2.87	4.87	0.03	-0.75	3.95	-1.60	-1.44	-1.41

payment in more often. The probability of receiving a SPE/RIC payment is 82% for oats, 86% for canola, and 88% for wheat. The maximum available payments under this program are much smaller. This is because of the possibility of catastrophic or near-total yield declines can mean large production insurance payments; yields can decline to zero, but prices are unlikely to decline so precipitously.

Simulation results for the CAIS program indicate that is consistently more lucrative than other programs from the standpoint of the farmer. Three potential CAIS payment outcomes are presented in Table 5.2, differentiated by the use of other programs. The three scenarios are CAIS alone, CAIS combined with production insurance, and CAIS combined with production insurance and SPE/RIC. The expected returns are highest for the combination when the farmer chooses CAIS plus production insurance and lowest when the farm chooses additionally to buy SPE/RIC. Maximum benefits are achieved under the CAIS plus production insurance scenario because the negative margin coverage available under CAIS is superior when the farm purchases production insurance. Recall that positive margin coverage is capped at 70% of the reference margin. For the model farm, this is approximately $60 per acre. Beyond this point, the farm that purchases production insurance will secure greater benefits. They receive full negative margin coverage, rather than having imputed production insurance benefits deducted from their CAIS payment. This is the maximum CAIS payment for the farmer who purchases production insurance is greater than for the CAIS-only farm, even if the CAIS-only farm has more dramatic margin declines.

Payments from the three programs are then combined to form a revenue stream of program payments under all possible scenarios, net of premiums and fees. For each of the five alternatives shown in Table 5.3, (the sixth scenario of no government payments is not considered for obvious reasons) the expected benefits are greater than zero, indicating that there are definite benefits to purchasing or signing up for these programs. The options that include CAIS payments have significantly greater benefits than those with only the premium-charging programs. The benefits available by combining CAIS and the premium charging programs are even greater. The mean net government payment for the crop year in question is over $40 per acre for these scenarios. In extreme cases, the combination of CAIS and production insurance can reach $185 per acre, or enough to cover all production costs for the farm.

Table 5.3 Summary Statistics for Net Government Payments, by Scenario

	CAIS	CAIS+PI	CAIS+PI+RI	PI	PI+RI
Mean	29.12	40.02	43.66	7.31	16.87
Std. Dev.	25.09	46.07	45.88	23.67	24.24
Minimum	-0.36	-6.06	-9.24	-5.70	-8.88
Median	25.96	26.01	27.26	-5.70	7.10
Maximum	76.42	185.08	190.94	107.00	121.65
Skewness	0.13	1.05	1.12	2.08	1.98
Kurtosis	-1.60	0.28	0.37	3.64	3.41

5.1.2 The Distribution of Net Income

By combining market receipts and government payments and deducting all expenses, net farm income for each scenario is calculated. This represents the returns to management for the farm. The distribution of net returns is illustrated in Figure 5.1, where the cumulative distribution functions for each alternative are plotted. Summary statistics for these distributions are presented in Table 5.4. While the stochastic dominance analysis presented below will describe the properties of these distributions more completely, a number of observations about the range of net farm incomes for the operation can be made.

Table 5.4 Summary Statistics for Distributions of Net Income, by Scenario

	No Programs	CAIS	CAIS+PI	CAIS+PI+RI	PI	PI+RI
Mean	-28.22	0.89	11.79	15.43	-20.92	-11.35
Std. Dev.	64.63	43.34	22.42	23.81	46.25	45.53
Minimum	-203.41	-147.21	-18.32	-15.69	-96.40	-89.83
Median	-18.09	7.87	7.88	8.99	-23.28	-12.93
Maximum	124.63	124.27	118.57	126.49	118.93	126.86
Skewness	-0.47	-0.86	1.58	1.65	0.36	0.35
Kurtosis	-0.24	1.57	3.14	2.82	-0.56	-0.60

For alternatives without the CAIS program, expected mean benefits are negative. Net income falls below zero approximately 73% of the time in the market-only scenario. Mean benefits are also negative in the PI scenario, where the farm cannot breakeven 79% of the time. Moreover, using these programs also does not eliminate the possibility that the farm will be unable to cover its variable costs. These specific thresholds, breakeven and variable cost coverage, are illustrated for all six scenarios in Figure 5.2. The top portion of the bar shows the proportion of iterations where farm net income is above breakeven. The middle portion identifies returns between -65.53 and zero, where variable costs are covered, but fixed costs are not. The bottom portion shows circumstances where the farm cannot cover its variable and fixed costs. Using government programs nearly always reduces the probability of the latter outcome. The bottom portion does not exist for the scenarios where CAIS and production insurance are used in tandem. While this graph does indicate the shifting percentage in each category, it focuses on two particular points along the

Figure 5.1 Cumulative Distribution Functions of Net Farm Income for Six Program Use Alternatives

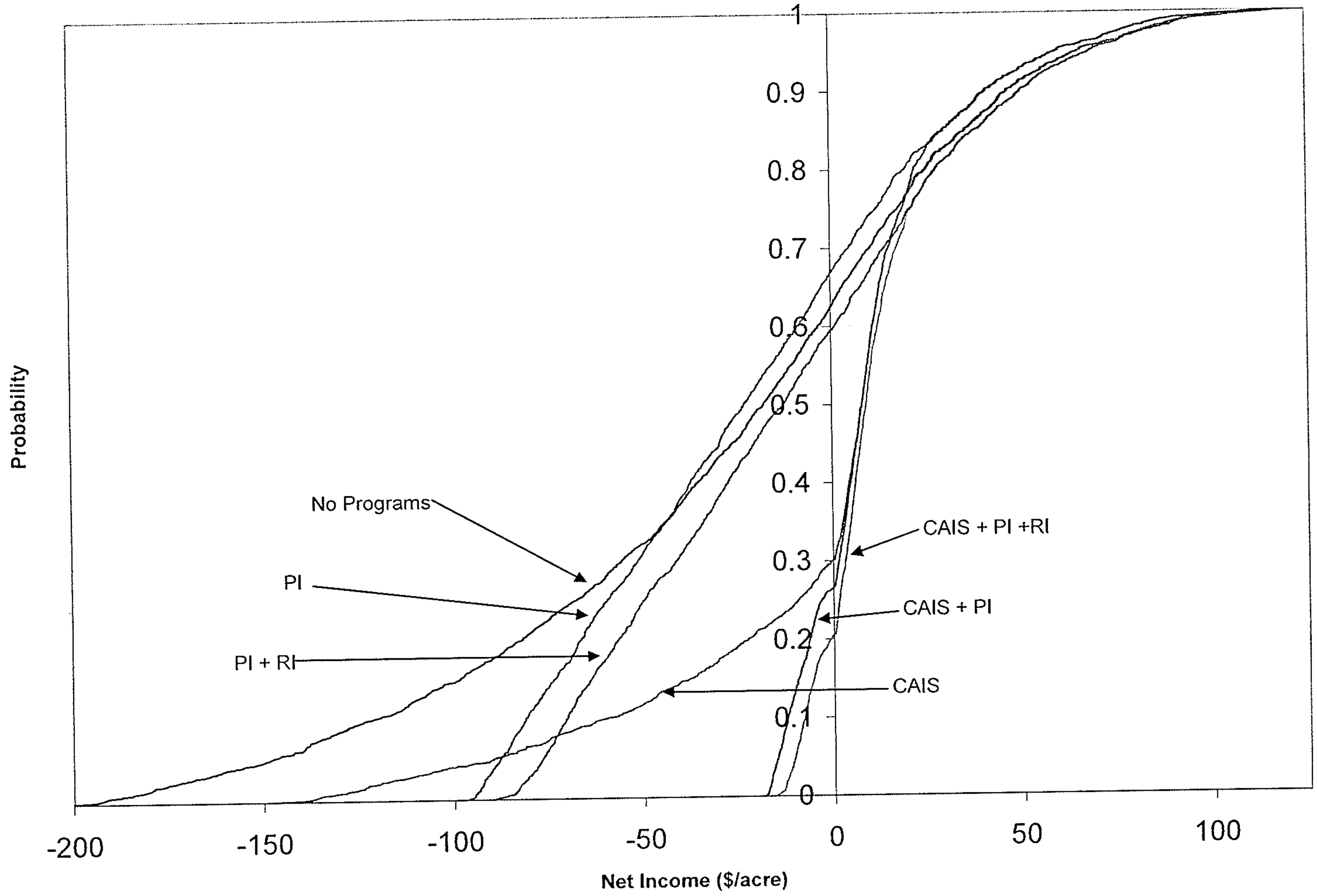
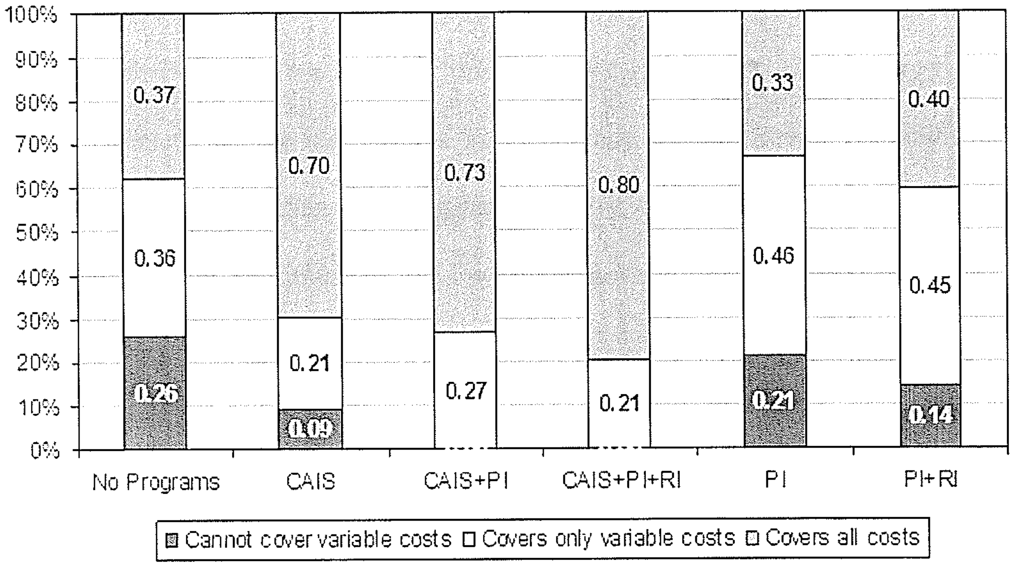


Figure 5.2 Breakeven Probabilities for Six Program Use Alternatives



distribution. Though those points are important, they do not describe the entire distribution. For example, while the crop insurance program actually increases the percentage of cases where net income falls below zero in this crop year, it does decrease the number of iterations where the farm cannot cover variable costs. More importantly, it provides significant coverage in cases where market returns are extremely low.

The impacts of each program on the distribution of returns are also described by plotting the cumulative distribution functions. In Figure 5.1, it can clearly be seen how program payments cause the distribution function to differ between scenarios. In the best 25% of outcomes, the five program payment distributions are nearly identical to the outcomes present when no programs are used. Beyond this point, truncation of the distribution begins to take place. This truncation is most pronounced for scenarios including the CAIS program. The cdf becomes increasingly steep, first as the upper tier CAIS payments kick in, steeper still as the disaster tier payments kick in, offering greater government coverage of margin declines. The central 40% of outcomes differ little between the CAIS program and CAIS plus production insurance. However, the lowest 30% of outcomes exhibit large differences between those scenarios. As the farm's program year margin declines into negative territory, the differences between CAIS and crop insurance become apparent. When the farmer buys crop insurance, the distribution maintains its steep slope; returns do not decline into negative territory. Without crop insurance, negative margin coverage is sharply reduced; the lowest outcomes for the producer using only CAIS are quite low.

Differences in how crop insurance and CAIS truncate the distribution of returns can be seen in the statistical moments of the distribution presented in Table 5.4. Looking solely at the first two moments of the distribution indicates that CAIS has greater risk reducing effects. The mean is greater and the standard deviation lower for the CAIS only scenario compared to the PI only scenario. However, the CAIS program does far less at the extreme low end. The skewness of the CAIS only distribution is negative, in fact more negative than the skewness of the baseline distribution. These distributions have longer left tails, indicating that on the whole, CAIS does not truncate the distribution of returns. If its goal is to provide the bulk of its support at the extreme low end of the distribution, CAIS is unsuccessful. Production insurance, while less valuable in gross terms, provides support at the bottom end of the distribution. When the two programs are combined, they have an extremely strong truncating effect. The skewness of the distribution is 1.58, indicating a long right tail.

Alberta programs provide positive net benefits. These benefits are largely diffused all along the distribution of returns, essentially shifting the entire cdf slightly to the right. The SPE/RIC programs increase mean returns by approximately nine dollars per acre without CAIS and by four dollars per acre with CAIS. However, measures of risk such as standard deviation and skewness remain the same. There are two complementary reasons for this. First, the AB price supports for the RIC portion of the program are set at "long term levels" that do not reflect expected price levels and risk in the crop year. Second, because yields are not strongly correlated with prices for Manitoba crops, the likelihood that SPE/RIC payments will occur most heavily when overall revenues are low or high is less.

If the two components of the price targeted program are separated, it is evident that the Spring Price Endorsement is almost never triggered in the model. This is because the spring prices set by MASC are very low by historic standards for this crop year. This is one weakness of our study; by grafting one provinces program onto another's, events occur in the model that were not originally contemplated when the program parameters were defined. In this case, the farmer might be less likely to purchase the coverage because the probability of a payment is lower or the insurer may set higher spring prices to make such coverage reasonably attractive to farmers.

5.2 Correlation Between Farm Income Determinants

The simulation results presented above describe the distributions of net returns for the model farm. This useful information does not describe on an iteration-by-iteration basis how the programs interact with each other. When one looks at the cumulative distribution functions presented in Figure 5.1, it is easy to assume that a given iteration on one distribution corresponds to the parallel iteration another. However, the manner in which program payments alter the distribution implies that correlation cannot be ascertained simply by visually assessing the cdf. To more accurately and fully describe the interactions that occur in the model, we can calculate the correlation between various events. As in the study performed by Hauser, Sherrick, and Schnitkey (2004), correlations between individual program payments and between program payments and total revenues are examined.

5.2.1 Insurance Indemnities and CAIS Payments

The central question to be answered relates to frequency with which CAIS payments occur when crop insurance indemnities are triggered? High positive correlation could indicate that CAIS and production insurance are overlapping. In this case, it would be reasonable to ask what the point of having two programs would be.

Table 5.5 presents correlation coefficients for the various program payment types. Production insurance indemnities are positively correlated with CAIS payments. Coefficients range from 0.56 to 0.67, depending on the crop covered under insurance and mix of programs the farm uses. This positive correlation indicates that crop insurance and CAIS are triggers in some but not all of the same instances. Obviously, revenue declines and resulting CAIS payments can be triggered by declines in yield, even if prices are strong.

The correlation analysis results for the SPE/RIC program are also shown in Table 5.5. Here it is found that there is very low correlation between crop insurance and SPE/RIC payments. Similarly, Hauser, Sherrick, and Schnitkey (2004) found very low correlations between traditional crop insurance program payments and price support payments in the United States that operate using long-term price averages. The reason for this lack of correlation is obvious: crop insurance payments are triggered solely by yield declines and price support payments are triggered solely by price differences. Correlation coefficients

Table 5.5 Correlation Coefficients For Various Program Payments

	PI_{wheat}	PI_{canola}	PI_{oats}	RIC_{wheat}	RIC_{canola}	RIC_{oats}	CAIS	CAIS(+PI)	CAIS(+PI+RI)
PI_{wheat}	1	0.60	0.62	0.04	0.02	0.02	0.58	0.64	0.67
PIcanola		1	0.54	-0.01	0.03	0.01	0.56	0.64	0.67
PI_{oats}			1	0.01	0.02	0.02	0.49	0.56	0.58
RIC_{wheat}				1	0.00	0.01	0.09	0.10	0.06
RICcanola					1	-0.02	0.13	0.15	0.07
RIC_{oats}						1	0.05	0.06	0.02
CAIS							1	0.98	0.98
CAIS(+PI)								1	0.99
CAIS(+PI+RI)									1

between RIC payments and CAIS payments are generally higher than those between crop insurance, however they are some low, in the range of 0.05 to 0.15.

5.2.2 Revenue Relationships

Using the program payment iteration values incorporated in the previous section, correlation coefficients between these values and revenues for the associated scenarios were calculated. These values indicate how effective or how targeted payments are in relation to revenue or net income declines. Since costs are treated deterministically in the model, the correlation results used here would be essentially the same if net income were substituted for revenue.

Though it is not unexpected, all program payments are negatively correlated with overall revenues, as seen in Table 5.6. However, the correlation coefficients show that the three programs (production insurance, SPE/RIC, and CAIS) are correlated with revenue to very different degrees. CAIS, no matter how it is utilized by the farmer, has the strongest negative correlation with total revenues. Correlation values between CAIS payments and market revenue range from -0.90 to -0.95. Production insurance payments are the next most negatively correlated program type. Correlation between production insurance indemnities and revenue ranges between -0.65 and -0.74, depending upon the crop. These coefficients are generally smaller for indemnities on oats, because oats comprises a smaller share of the farm crop rotation. One should not interpret these results to mean that CAIS is more effective than production insurance.

Table 5.6 Correlation Between Program Payments and Market Revenue

Payment	Correlation Coefficient
PI_{wheat}	-0.74
PI_{canola}	-0.76
PI_{oats}	-0.65
SPE/RIC_{wheat}	-0.09
SPE/RIC_{canola}	-0.13
SPE/RIC_{oats}	-0.05
CAIS	-0.90
CAIS(+PI)	-0.95
CAIS(+PI+RI)	-0.95

Rather, CAIS is simply targeted to revenue declines. Production insurance indemnities are similarly correlated to declines in crop specific revenues. The correlation between wheat indemnities and wheat revenues, for example, is -0.8. Correlations between the SPE/RIC program payments and total revenue are far less than for other programs. RIC payments and revenues have correlation coefficients from -0.05 to -0.13, depending on crop. While this confirms that the RIC program is not well targeted on its own for dealing with large income declines, one should note that its very design ensures this. By using long-term price averages as the program trigger, in-year variability is necessarily ignored. Put in more practical terms, given the program parameters, it appears that the farmer can form a decent estimate of the likelihood of a payment under the RIC program in any year.

These results present a number of inferences that may seem obvious, but should have been tested nonetheless, given the availability of the data. Program payments differ in their applicability to overall measures, but it appears that each type of program is well targeted to declines in the triggering variable in each case. Drawing conclusions about whether payments ought to occur simultaneously based upon correlation coefficients between payments is more difficult. Recalling the cdf curves presented in section 5.1, production insurance and CAIS have something of a complimentary relationship. The magnitude of the correlation between the programs may provide further justification for this idea. They occur together often enough to be complimentary, but not often enough to be considered duplicative.

5.3 Stochastic Efficiency Analysis

Results thus far have amply described the many possible iterations of the model. The next step is to incorporate farmer preferences for risk and assess the value of the program payments in light of these preferences. This allows for conclusive statements as to which program use scenarios are preferred by the farmer and allows for the placement of dollar values on the degree to which programs are preferred.

5.3.1 Results of Stochastic Dominance Analysis

Following the procedures described in Chapter 2, areas between the cdf curves in Figure 5.1 are calculated. By comparing these areas, the optimal course of action for the farm decision maker can be derived. Table 5.7 presents the results of this comparison. It explains which distributions are said to dominate in a pair-wise comparison with other distributions. The left-hand column of Table 5.7 indicates which distribution is being considered and the scenarios named to its right are those dominated. The optimal course of action by stochastic dominance is to use all programs; this distribution is second-degree stochastically dominant over all other alternatives. The market only scenario is never

Table 5.7 Second-Degree Stochastic Dominance Results

Scenario Considered	Scenarios Dominated in Pairwise Comparison					
No Programs						
CAIS	No Prog.				PI	PI+RI
CAIS+PI	No Prog.	CAIS			PI	PI+RI
CAIS+PI+RI	No Prog.	CAIS	CAIS+PI		PI	PI+RI
PI	No Prog.					
PI+RI	No Prog.				PI	

preferred; it is dominated by all other scenarios. The value of the CAIS program is evident in stochastic dominance results as well. Scenarios with use of CAIS dominate all scenarios without CAIS. Scenarios with SPE/RIC also dominate those without. It can be concluded unequivocally that using all programs available is in the best interest of farm profitability. However, additional procedures are needed to draw conclusions about how using all of the programs impacts the value derived from the programs. This is because second-degree stochastic dominance only makes ordinal, pair wise comparisons between scenarios and makes no assumptions about risk preferences other than the presence of risk aversion.

5.3.2 Stochastic Efficiency and Comparisons between Scenarios

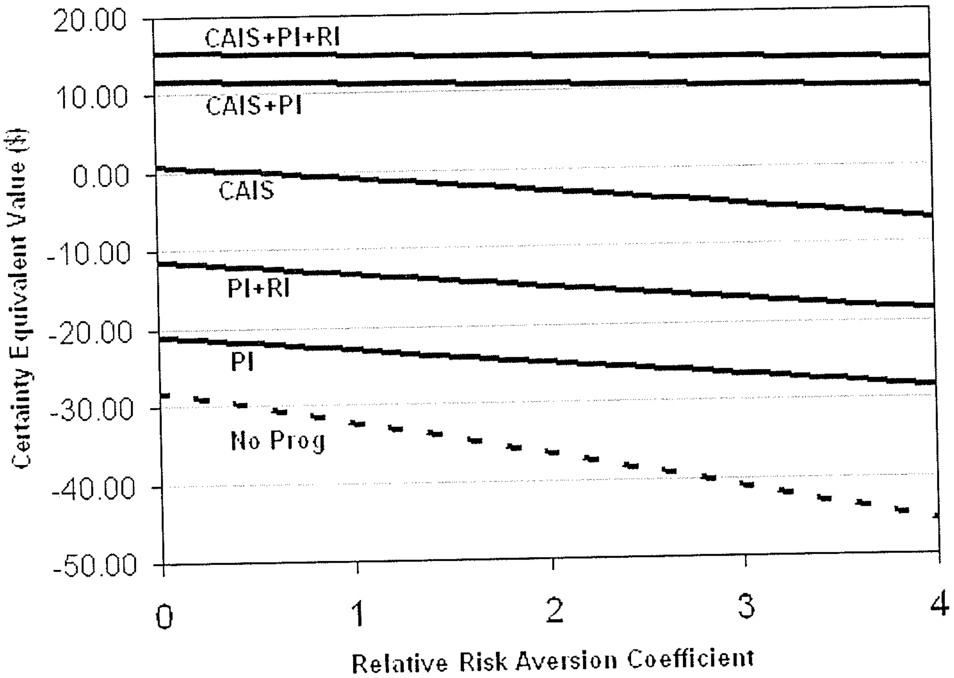
While the optimal program use scenario can be determined unambiguously by second-degree stochastic dominance, more specific quantitative results can be derived from certainty equivalent calculations performed as part of the stochastic efficiency with respect to a function (SERF) procedure originated by Hardaker et al (2004b). As stated previously, preferences under this procedure are assumed to follow a power utility function, with a relative risk aversion coefficient that ranges from zero to four. Certainty equivalent (CE) values for each scenario are calculated. This allows for a dollar value to be placed on outcomes between scenarios. The CE from one scenario may be subtracted from another to provide a measure of program impact. The resulting value is the benefit provided by the additional programming. For example, the benefit of production insurance excluding the use of other programs is the CE value of returns in the PI scenario less the CE from the No Programs scenario. Figure 5.3 and Table 5.8 show how CE values differ between levels of risk aversion and program use scenarios. The risk neutral case, when the relative risk aversion coefficient equals zero, is identical to the summary statistics presented in section 5.1 because the CE values are simply mean values. With risk neutrality, all programs show positive net benefits when compared to the market-only scenario. The benefits of the programs should increase significantly as the farmer becomes more risk averse if the programs have risk reducing effects. This is the case for production insurance and CAIS; whereas production insurance had a $7.31/acre benefit to the risk neutral producer, it has a $17.35/acre benefit to a very risk averse producer. Similarly, the benefits of CAIS relative to the No Programs scenario increase from $29.12 to $39.03. This does not appear to be

Table 5.8 Stochastic Efficiency With Respect to a Function Results

RRAC	No Prog	CAIS	CAIS+PI	CAIS+PI+RI	PI	PI+RI
0	-28.22	0.89	11.79	15.43	-20.92	-11.35
1	-32.27	-0.83	11.38	14.97	-22.83	-13.17
2	-36.54	-2.67	10.98	14.52	-24.71	-14.97
3	-41.03	-4.62	10.59	14.10	-26.56	-16.73
4	-45.72	-6.69	10.22	13.69	-28.37	-18.47

Note: RRAC is the relative risk aversion coefficient.

Figure 5.3 Stochastic Efficiency Results Plotted Across Levels of Risk Aversion



true for the companion SPE/RIC program. Comparing the CAIS+PI and CAIS+RI scenarios and the PI and PI+RI scenarios, the benefits from the SPE/RIC program are calculated under risk neutral preferences to be $3.64 and $9.57, respectively. These values change little in percentage terms as the producer becomes more risk averse. Interestingly, when CAIS is used with SPE/RIC, the value of RI actually declines as the producer becomes more risk averse. This implies that the benefits of this program in a given year have are targeted in such a way that they do provide significant measures of risk management or risk abatement.

When the magnitudes of the benefits of each program are compared individually, it is clear that CAIS presents the greatest benefit to the farmer. Production insurance has smaller benefits, but the value of the benefits increases dramatically as risk aversion increases. At R_r=0, the benefit of production insurance is approximately 23% of the benefit of CAIS. At R_r=4, it is 44%. This points to a strong risk abatement component to crop insurance that is less present in CAIS and almost non-existent in the SPE/RIC program. Similar to results for U.S. programs presented by Gray, et al (2004), program payments become more valuable as producers become more risk averse. This indicates that government programs or subsidies make farming much more attractive for producers who are very risk averse.

The central question of how program benefits change when used in conjunction with one another has not yet been answered. There is a question as to whether the benefits from provincial programs are diminished by the CAIS program. The CE values in Figure 5.3 provide this answer. By comparing the value provided by individual programs in different scenarios, the impact of one program on another is assessed. For example, the benefit of production insurance is assessed both with and without the use of the CAIS program. The difference between these benefits is the impact that CAIS use has on the value of production insurance. These impacts are shown in Table 5.9.

For risk neutral producers, the benefit provided by production insurance when using CAIS is \$10.90/acre. The benefit of production insurance when used alone is \$7.31/acre. If the farmer is moderately risk averse, with R_r=2, the benefit of PI under CAIS is \$13.65/acre, compared to \$11.83/acre without CAIS. However, at levels of risk aversion above 3.6, the benefit of PI is greater when the farmer is not in CAIS. At R_r = 4, the benefit of PI under CAIS is \$16.91/acre, compared to \$17.35/acre without CAIS. This points to a complimentary relationship between CAIS and production insurance. If the farmer is enrolled in CAIS, they can actually increase the value that is derived from production insurance. The value of complimentary relationship is relatively small. At R_r=2, the value of

Table 5.9 Impact of CAIS Program on Provincial Program Benefits

RRAC	Benefit of Production Insurance Without CAIS	 With CAIS	 % Change	Benefit of Prov. Programs Without CAIS	 With CAIS	 % Change	Benefit of SPE/RIC With PI only	 With CAIS+PI	 % Change
0	7.31	10.90	49%	16.87	14.53	-14%	9.57	3.64	-62%
1	9.44	12.21	29%	19.09	15.80	-17%	9.66	3.59	-63%
2	11.83	13.65	15%	21.57	17.19	-20%	9.74	3.54	-64%
3	14.47	15.21	5%	24.29	18.71	-23%	9.82	3.50	-64%
4	17.35	16.91	-3%	27.26	20.38	-25%	9.90	3.46	-65%

Note: "% Change" indicates the increase or decrease in program benefits when the CAIS program is used.
RRAC is the relative risk aversion coefficient.

production insurance is increased by $1.82/acre, or approximately 15% by enrolling in CAIS. Enrolling in CAIS has very different impacts on the value of SPE/RIC and the value of provincial program payments together (ie. Production Insurance and SPE/RIC). Under CAIS, SPE/RIC benefits range from $3.43 to $3.63/acre. Without CAIS, SPE/RIC benefits range from $9.57 to $9.97 per acre. With modest risk aversion, the value of revenue insurance declines nearly two-thirds, from $9.74/acre to $3.54/acre. CAIS has similar, if diminished impact, on the value of provincial programs together, reducing program benefit by 14 to 25%.

These results lead to the conclusion that the CAIS program can complement existing programs if it is targeted at different parts of the distribution of net income. Because CAIS begins providing benefits for any margin decline, it covers areas where production insurance payments would be untriggerable. The negative margin linkage between CAIS and production insurance may explain the rest of the complementary relationship. By using production insurance, the farmer triggers a sort of second level of coverage under CAIS. This can provide significant benefits depending upon the farms margin position.

CHAPTER 6

DISCUSSION AND CONCLUSIONS

The objectives of this study were to measure the impact of Canadian safety net programs on net farm income and to assess the magnitude of the benefit of each program under different scenarios of program use for farmers of varying preferences for risk. Considering that the safety net concept now appears to be the dominant paradigm for agricultural policy in Canada and that the presence of multiple programs in this safety net is highly likely, a thorough analysis of the impact of current programs is necessary, especially an analysis that considers the impact using one program may have on the use of another. As was reviewed in Chapter 2, studies with similar objectives have been completed for farm programs in the United States. The contribution of this work is that it considers interrelationships between Canadian safety net programs and applies novel methods to Canadian problems, namely stochastic simulation and stochastic efficiency techniques.

Clearly, the results put forward in Chapter 5 provide conclusive evidence regarding the farm decision making regarding the use of Canadian agricultural safety net programs. The optimal course of action is participation in all available government programs. The programs have clear benefits that make producers with varying preferences for risk better off.

The impacts of individual programs require more complex interpretation. It was found that each of the programs differed significantly in level and nature of benefits provided to farmers. The CAIS program provides the largest transfer to farmers. However, as a risk reduction tool, it is far less effective than insurance programs. This is because the likelihood of triggering payments under CAIS is high. The program pays benefits on any margin decline and the CAIS benefits are not necessarily concentrated in the lowest portion of returns.. Insurance programs covering crop yield risks are more effective at reducing risk and providing benefits when they are most needed by farmers. Safety net programs targeted specifically at price risks are not especially well-targeted to overall income declines. Moreover, some of the coverage they provide is also available from the private sector through the use of futures, options, and forward contracts. Longer-term price guarantees offered by these programs inherently are less concerned about managing in-year risk and more concerned about providing government transfers to agricultural producers.

The more surprising conclusion of this analysis showed that the use of CAIS and production insurance in combination increases the value derived from production insurance for all but the most risk averse farmers. It was found that the CAIS program increased the additional benefit derived by farmers from production insurance by up to 50%. Results of similar analyses for U.S. farm programs would seem to indicate that alternative programs will inherently reduce the value and incentive to use crop insurance, but these results may have biased expectations about the results for this study. The design of the Canadian programs inherently attempts to create large supplementary effects between CAIS and production insurance. By purchasing production insurance, the farmer essentially "unlocks" another level of CAIS coverage for negative margins, without reducing available benefits under positive margin coverage and without incurring further costs under CAIS. Where the results from previous studies were similar was with respect to the benefits of the price-based safety net programs, namely the Spring Price Endorsement (SPE) and Revenue Insurance Coverage (RIC) programs, where similar declines in program benefits were found. The introduction of the CAIS program reduced the derived from SPE and RIC by approximately two-thirds.

More broadly, this study indicates that the CAIS program can yield significant benefits, but that its ability to provide support to the farmer in any and all cases is limited. CAIS is not a catch-all, even if it is not as bad is its detractors would suggest. However, it should be used with a well-targeted production insurance program to be most effective. The additional benefit provided by the SPE and RIC programs, namely as price supports, is minimal and not targeted to income decline situations.

6.1 Limitations and Opportunities for Further Research

There are a number of limitations to this study; the most obvious is a matter of scope. To reduce the analysis to a manageable size, specific assumptions about production practices and farm location were made. The management variables for the farmer were limited: the model farm did not employ any non-government risk management tools to deal with price risk, for example. The analysis was also restricted to a single year with specified market conditions. An expanded analysis that incorporates greater diversity in these areas would bring further insight.

The assumptions made to limit the scope of this work also cause problems related to endogeneity of a number of model parameters. Obviously, the benefits of these programs may change farmer decision making with respect to production decisions. Potential impacts on future price and yield distributions are not taken into account. Similarly, program costs, such as production insurance premiums, are taken as given, rather than being a function of yield data used to generate the distribution of crop yields for the model farm.

A second limitation is that in assessing the value of government programming, some common complaints about the programs were not incorporated into the model. Detractors of the CAIS program have found fault with the timing of payments under the program; their concern is that CAIS program payments are not provided to farmers until well after the income decline has occurred. They have also objected to the accounting and management costs indirectly imposed by the program. This analysis does not incorporate these administrative issues; it may be that significant program drawbacks are not being considered. To address this, farm-level modeling may need to analyze multi-period operation of safety net programs.

A final limitation of this study is that not all farms are average. The results represent a best effort at determining the distribution of net returns for an "average" farm in this region of Manitoba. Some are more profitable than others. Agriculture and Agri-food Canada surveys (2007) suggest that farm revenues per productive unit such as per acre or head of cattle vary little between the most and least profitable farms. Farmers operate in a multi-seller market and are price takers. Costs of production vary greatly between profitable and unprofitable farms. This is somewhat troublesome for this analysis. We have considerably detailed information about farm revenue determinants and rather simplistic information about costs of production.

It is natural to question how this might this effect results. Since costs are treated deterministically, the main effect of differing costs of production would be to change the break-even point. This would mean shifting the breakeven point on the cdf curve of returns to the left or right. In the case of scenarios involving the CAIS program, it could alter the distribution if there was heterogeneity in allowable costs. One would expect that allowable costs would vary less between farms than the non-allowable costs that are often related to financing and debt positions, however some of the CAIS program idiosyncrasies such as the treatment of custom work hired by the farm may cause significant changes. Unfortunately, detailed information about the heterogeneity of costs for specific farm types at this level is not available. Moreover, a detailed cost of production study is beyond the scope of this research.

Building better farm-level models should allow economists to conduct improved analyses of agricultural safety net policy. To this end, this study addresses some, but not all of the elements necessary to create an accurate representation of farm operations and farm decision making.

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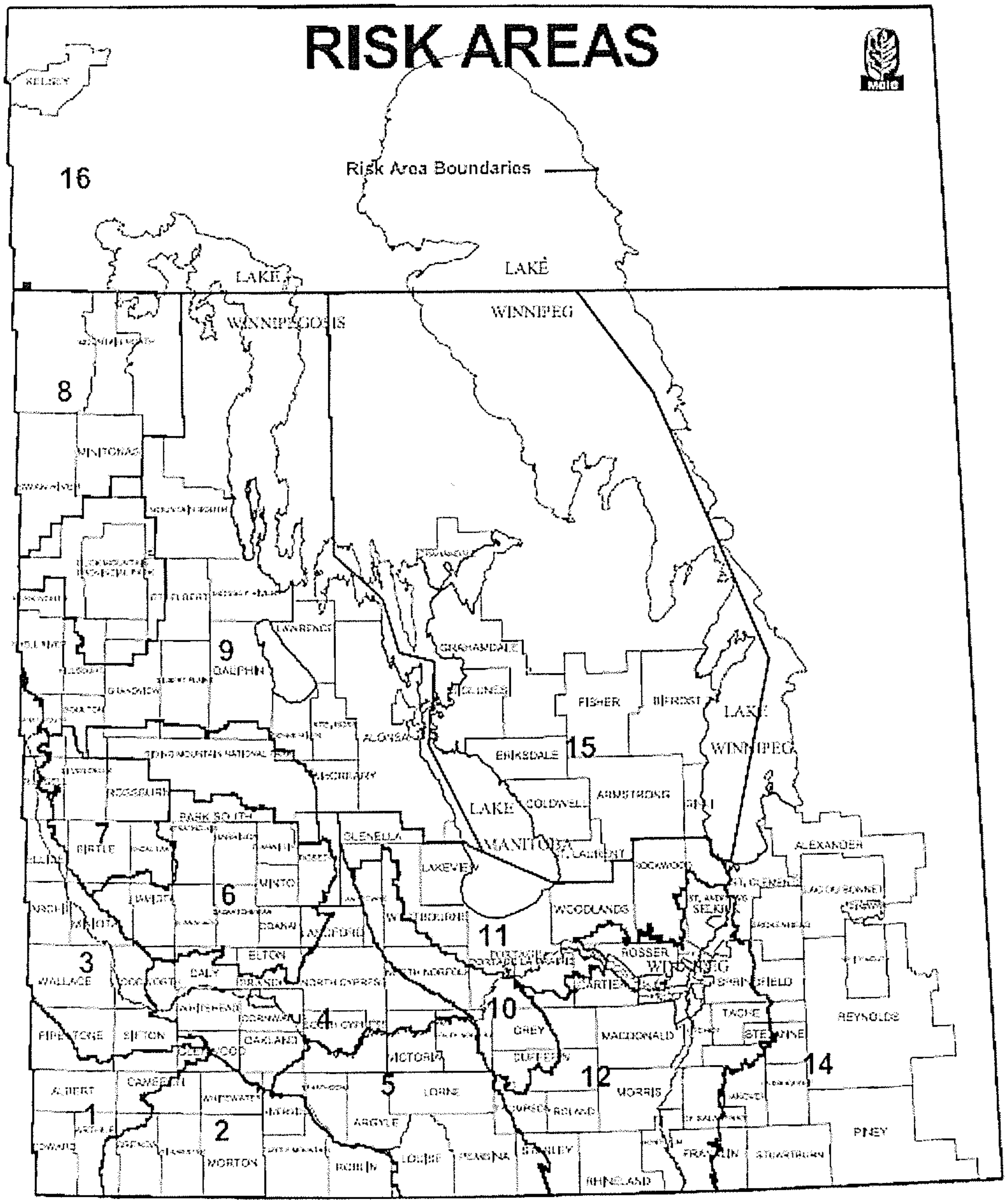
APPENDIX A - MAP OF MANITOBA AGRICULTURAL SERVICES CORPORATION RISK AREAS

Note: Risk Area 12 (bottom centre) is the relevant geographic area for this study.



(Source: MASC 2006)

APPENDIX B – EXAMPLE OF PRICE FORECAST PROCEDURE

Forecast as of: April 30, 2006

Futures model forecast of canola producers' season-average price received, marketing year 2006/07

	Step # 1			Step # 2	Step # 3		Step # 4	
(Col. A) Marketing year month 1/	(Col. B) Current futures price by trading contract 2/	(Col. C) Futures price based on nearby contract 3/	(Col. D) Basis (5-year average)	(Col. E) Monthly farm price forecast	(Col. F) Actual monthly farm price, if available 4/	(Col. G) Composite monthly forecast actual/futures	(Col. H) Monthly marketing weights	(Col. I) Monthly price weight
	--Dollars per tonne--							
February					240.27			
March					255.28			
April					262.88			
May		276.50						
June		276.50						
July	276.50	292.60						
August		292.60	-27.74	264.86	0.00	264.86	10%	26.486
September		292.60	-26.00	266.60	0.00	266.60	15%	39.990
October		292.60	-25.55	267.05	0.00	267.05	15%	40.057
November	292.60	299.80	-23.84	275.96	0.00	275.96	10%	27.596
December		299.80	-18.04	281.76	0.00	281.76	10%	28.176
January	299.80	304.80	-20.58	284.22	0.00	284.22	10%	28.422
February		304.80	-19.60	285.20	0.00	285.20	5%	14.260
March	304.80	307.80	-15.79	292.01	0.00	292.01	5%	14.601
April		307.80	-9.74	298.06	0.00	298.06	5%	14.903
May	307.80	312.80	-13.87	298.93	0.00	298.93	5%	14.947
June		312.80	-18.11	294.69	0.00	294.69	5%	14.735
July	312.80	320.00	-29.93	290.07	0.00	290.07	5%	14.503
November	320.00					Sum of weights =	100%	

Forecast of season-average price received:

Step # 5 Futures model forecast of the season-average price received (weighted average) ($/mT.)	=	278.67

APPENDIX C – FORMULAS FOR PROGRAM PAYMENT CALCULATIONS

Market Returns: $= \sum_i (\delta_i \widetilde{p}_i \widetilde{q}_i) + NetGovPayments \ - \sum_i \delta_i C_i$

Production Insurance Indemnity: $= \max \lfloor (\overline{q} * IPI * \lambda - \widetilde{q}_t) * p_{spring}, 0 \rfloor$

Individual Productivity Index: $= \left(\sum_{t-11}^{t-2} \widetilde{q}_t / \overline{q}_t \right) / 10$

Production Insurance Premium: $= 0.4 * \eta * (\overline{q} * IPI * \lambda) * p_{spring}$

Note: λ = coverage level (50-80%) η is the premium rate (a % of bushel coverage for the crop)

CAIS Payment:

$= .8 * \max[.7 * (RM_t - \widetilde{p}_t \widetilde{q}_t - VC_t, 0)] + .7 * \max[\min[.85 * RM_t - (\widetilde{p}_t \widetilde{q}_t - VC_t), .15 * RM_t], 0]$

$+ .5 * \max[\min[RM_t - (\widetilde{p}_t \widetilde{q}_t - VC_t), .15 * RM_t], 0]$

CAIS Neg. Margin Coverage: $= .6 * \max[VC_t - \widetilde{p}_t \widetilde{q}_t, 0]$ less imputed PI benefit

CAIS fee: $= 0.0045 * RM_t + 55$

CAIS Reference Margin:

$$RM_t = \left[\sum_{t-1}^{t-5} (\widetilde{p}_t \widetilde{q}_t - AC_t) - \min_{t-1}^{t-5} (\widetilde{p}_t \widetilde{q}_t - AC_t) - \max_{t-1}^{t-5} (\widetilde{p}_t \widetilde{q}_t - AC_t) \right] / 3$$

Note: CAIS benefits cannot exceed 70% of RM_t

Spring Price Endorsement: $= \max \lfloor (\widetilde{p}_{spring} - \widetilde{p}_{harvest}) * \min[\widetilde{q}_t, \overline{q}_t * IPI * \lambda], 0 \rfloor$ *iff*

$\widetilde{p}_{spring} - \widetilde{p}_{harvest} \geq .1 * \widetilde{p}_{spring}$

Revenue Insurance Coverage: $= \max \lfloor (\overline{q}_t * IPI * \lambda) * .7 * (RICflr - \max \lfloor \widetilde{p}_{spring}, \widetilde{p}_{harvest} \rfloor), 0 \rfloor$

APPENDIX D – EXAMPLE OF MODEL CALCULATIONS AND INCOME STATEMENT FOR ONE MODEL ITERATION

1. Enter Assumed Crop Rotation

	Proportion
Hard Red Spring Wheat	40%
Canola	40%
Oats	20%

2. Determine Current Year Model Parameters and Calculate Market Revenue

Exogenous Program Parameters

	HRS Wheat	Canola	Oats
PI Spring Price	118.00	218.00	115.00
PI Yield Coverage	1.061	0.714	1.448
RIC Floor Price	165.00	316.00	143.00

Stochastic Model Parameters

	HRS Wheat	Canola	Oats
Farmgate Harvest Price	170.17	289.46	123.19
Farm Average Yield	0.803	0.351	1.377
Market Revenue	136.59	101.69	169.65

3. Production Insurance Calculations

Select Coverage Level (50%. 70%. 80%)	80%

	Bushel Coverage	Dollar Coverage	Yield Shortfall	Indemnity	Premium	Net Payment
Hard Red Spring Wheat	0.849	100.16	0.046	5.45	4.85	0.60
Canola	0.571	124.52	0.220	47.94	6.92	41.02
Oats	1.158	133.22	0.000	0.00	4.95	-4.95
					Net PI Benefit	15.66

Select Coverage Level (50%. 70%. 80%)	70%

	Bushel Coverage	Dollar Coverage	Yield Shortfall	Indemnity	Premium	Net Payment
Hard Red Spring Wheat	0.743	87.64	0.000	0.00	3.42	-3.42
Canola	0.500	108.96	0.148	32.37	5.07	27.30
Oats	1.014	116.56	0.000	0.00	3.51	-3.51
					Net PI Benefit	8.85

4. Revenue Coverage Calculations

	SPE Price Diff	RIC Price Diff	SPE Payment	RIC Payment	Premium	Net RI Payment
Hard Red Spring Wheat	0.00	0.00	0.00	0.00	4.68	-4.68
Canola	0.00	26.54	0.00	10.61	2.56	8.05
Oats	0.00	19.81	0.00	16.06	2.76	13.30
					Net RC Benefit	4.01

5. Canadian Agricultural Income Stabilization Program

	NoProg	CAIS	CAIS+PI	CAIS+PI+RI	PI	PI+RI
	A	B	C	D	E	F
Reference Margin	80.79	80.79	80.79	80.79	80.79	80.79
Current Year Margin	- 18.36	- 18.72	- 3.06	0.95	- 2.70	1.31
Negative Margin	18.36	18.72	3.06	-	2.70	-
CAIS fee	0.36	0.36	0.36	0.36	0.36	0.36
CAIS Payment						
Disaster Tier		45.24	45.24	44.49		
Lower Stabilization Tier		8.48	8.48	8.48		
Upper Stabilization Tier		6.06	6.06	6.06		
Subtotal		59.79	59.79	59.03		
CAIS Negative Margin Coverage		11.23	1.84	-		
Less Payment Cap		3.23	3.23	2.47		
Less Imputed PI Benefit		8.85				
Total CAIS Payment		58.94	58.39	56.56		

6. CAIS-PI Positive Margin Linkage

	NoProg	CAIS	CAIS+PI	CAIS+PI+RI	PI	PI+RI
	A	B	C	D	E	F
CAIS Payment		58.94	58.39	56.56		
CAIS + Prov. Prog. Payments		58.94	74.05	76.22	15.66	19.67
CAIS PI Premium Adjustment			-	-		
Net Government Payments		58.58	73.69	75.86	15.66	19.67

Pro Forma Income Statement

Per Acre Income	NoProg A	CAIS B	CAIS+PI C	CAIS+PI+RI D	PI E	PI+RI F
Receipts						
Market Receipts						
Hard Red Spring Wheat	54.63	54.63	54.63	54.63	54.63	54.63
Canola	40.67	40.67	40.67	40.67	40.67	40.67
Oats	33.93	33.93	33.93	33.93	33.93	33 93
Total Market Receipts	129.24	129.24	129.24	129.24	129.24	129.24
Insurance Program Payments						
Hard Red Spring Wheat						
Production Insurance	-	-	2.18	2.18	2.18	2.18
Revenue Insurance	-	-	-	-	-	-
Canola						
Production Insurance	-	-	19.18	19.18	19.18	19.18
Revenue Insurance	-	-	-	4.25	-	4.25
Oats						
Production Insurance	-	-	-	-	-	-
Revenue Insurance	-	-	-	3.21	-	3.21
Pre-CAIS Total	129.24	129.24	150.59	158.05	150.59	158.05
CAIS Payment	-	58.94	58.39	56.56	-	-
CAIS Premium Adj.	-	-	-	-	-	-
Total Receipts	129.24	188.18	208.99	214.61	150.59	158.05
Expenses						
Crop Allowable Expenses						
Hard Red Spring Wheat	39.78	39.78	39.78	39.78	39.78	39.78
Canola	59.34	59.34	59.34	59.34	59.34	59.34
Oats	15.84	15.84	15.84	15.84	15.84	15.84
Program Premiums and Fees	-	0.36	6.06	9.51	5.70	9.15
General Allowable Expenses	32.63	32.63	32.63	32.63	32.63	32.63
Non-Allowable Expenses						
Hard Red Spring Wheat	23.94	23.94	23.94	23.94	23.94	23.94
Canola	24.48	24.48	24.48	24.48	24.48	24.48
Oats	11.86	11.86	11.86	11.86	11.86	11.86
Total Expenses	207.88	208.25	213.95	217.39	213.58	217.03
	NoProg	CAIS	CAIS+PI	CAIS+PI+RI	PI	PI+RI
Net Farm Income	- 78.64	- 20.07	- 4.96	- 2.79	- 62.99	- 58.98