An Analysis of Canadian Business Risk Management Programs and Potential Program Enhancements

By

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Abstract

Agriculture is an important industry in Manitoba. The Canadian government recognizes the risk associated with Manitoban and Canadian farms through income support programs known as Business Risk Management Programs. In recent years, the Business Risk Management Programs (BRM) have undergone changes and many producers believe that the programs are less effective. Canadian agricultural producers have issues with the timeliness, predictability, responsiveness, and clarity of the margin insurance component of the BRM, known as AgriStability (AAFC, 2017).

The announcement of the most recent federal-provincial-territorial agricultural policy framework, the Canadian Agricultural Partnership, included a commitment to review the BRM suite of programs during the upcoming framework period. The goal of the review is to analyze and develop solutions to the issues identified with the BRM programs, while considering maintaining cost neutrality of program changes and respecting Canada's obligations to its trading partners.

The purpose of this study is to propose a program enhancement and new program and to measure the value to producers of the enhancement and the new program, relative to participation in the current programs and no program use. Monte Carlo simulation is used to simulate a distribution of outcomes for a farm under each of the program scenarios. This study also measures the value of the timeliness of payments to determine the benefit. Ultimately, the proposed cost of production insurance program provides the most value to producers. However, issues with the structure of the model make it unfeasible in practice. It favours the commodities with higher cost structures and the program may result in production distortions that would provide the opportunities for Canada's trading partners to file complaints.

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List of Abbreviations

AAFC	Agriculture and Agri-Food Canada
AIDA	Agricultural Income Disaster Assistance
APF	Agricultural Policy Framework
BRM	Business Risk Management
CAIS	Canadian Agricultural Income Stabilization
CAP	Canadian Agricultural Partnership
CCA	Canadian Cattlemen's Association
CDF	Cumulative density function
CE	Certainty Equivalent
CFIP	Canadian Farm Income Protection
GF	Growing Forward
GF2	Growing Forward 2
GRIP	Gross Revenue Insurance Program
IPI	Individual Productivity Index
MARD	Manitoba Agriculture and Resource Development
MASC	Manitoba Agricultural Services Corporation
NISA	Net Income Stabilization Account
NPV	Net Present Value
PDF	Probability density function
PM	Program Margin/Production Margin
RM	Reference Margin
RML	Reference Margin Limit
URAA	Uruguay Round Agreement on Agriculture

Chapter 1

Introduction and Objectives

1.1 Farm Revenue and Agricultural Policy

Agriculture is an important industry in Manitoba. In 2018, the Manitoba primary agricultural sector contributed approximately 5% of Manitoba's GDP (Manitoba Agriculture and Resource Development, 2018), while cropping activities in Manitoba covered 13% of Canada's total cropped acres (Statistics Canada, 2019a). Farming is a risky enterprise for its participants, with a high degree of variability in both production and prices faced. Blank, Carter and McDonald (1997) observe that net income variability is largely a function of output prices, yields and input costs; government support programs therefore exist to help protect producers from these downside risks, and exist in part as a response to political pressures from farmers for government intervention in the agricultural sector (Liu, Duan and van Kooten, 2018; Hedley, 2017). Politicians recognize the need to assist producers in mitigating downside risk, while allowing producers to maximize upside profits when available (Janzen, 2008).

In the earliest years of confederation, the Canadian government attempted to take a *laissez-faire* approach to agriculture and only intervened with public goods, including defense, and maintaining the integrity of Canadian currency (Hedley, 2017). However, low grain prices in the 1920s led to increased government involvement in the agricultural industry, including the creation of the Canadian Wheat Board in 1935 (Hedley, 2017). The types of agricultural income stabilisation programs that Canadian farmers use today have their origins in the 1950s and 1960s, which is further discussed in the section 2.2 below.

While many developed countries have provided their primary agricultural production sectors with supports and subsidies in the past, such measures have frequently become obstacles to international trade over time (Liu, Duan and van Kooten, 2018). Agricultural subsidies were a contentious issue during the Uruguay Round (1986-1994) negotiations of the General Agreement on Tariffs and Trade (GATT), with an Agreement on Agriculture being reached that permitted and classified certain types of subsidies (Liu, Duan and van Kooten, 2018). The Agreement on Agriculture provided guidelines for government involvement in agriculture based on three pillars: 1) domestic support, 2) market access and 3) export subsidies. Domestic support is the pillar of interest in this paper; such supports are categorised according to three boxes: 1) amber box – production-enhancing programs that distort trade, 2) blue box – production limiting programs and 3) green box – subsidies with minor distortionary impacts on trade (WTO, 2020).

Countries participating in the agreement agreed to reduce/eliminate aggregate measure of support (AMS) under amber box and modify blue box policies over time, while green box policies are exempted from trade reduction commitments (Liu, Duan and van Kooten, 2018). For a support to be considered a green box policy, farm-level supports must be decoupled from production or market prices (WTO, 2020). Annex 2, Paragraph 7 of The Uruguay Round Agreement on Agriculture (URAA) specifically identifies government financial participation in agricultural income insurance and safety net programs as green box policies, which meet the following criteria:

1) the insurance protects against income shortfalls, relative to a reference period;
2) the payments are based on income and do not relate to the type or volume or production, the prices applied or the factors of production used; and
3) the income loss is more than 30 percent and the amount of the payments compensate for less than 70 percent of the producer's income loss (WTO, 2020).

Canada's primary agriculture farm income safety net program, AgriStability, meets these criteria, as explained in section 2.1 below. In the three previous reportings to the WTO, Canada paid out approximately 15% of its bound AMS to amber box programs (excluding AgriStability) (WTO, 2019).

1.2 Problem Definition

Despite the adherence of AgriStability to Canada's international trade obligations and its nature as a farm income safety net program, the program has been subject to criticism and calls for change in recent years (Briere, 2019). These criticisms and changes serve as the driver for the discussion of Canada's Business Risk Management (BRM) suite in this thesis, particularly AgriStability (margin-based deficiency payment) and AgriInsurance (production insurance) and these programs' abilities to contribute to farm-level outcomes. Additionally, the discussion surrounding AgriStability program review and enhancement serves as a basis for recommending changes to the BRM suite going forward.

Of all BRM programs, AgriStability is perceived as the most problematic: producer participation in the program has declined over time and producers have expressed dissatisfaction for the program in surveys. In a 2017 survey by AAFC's Office of Audit and Evaluation, producers were asked questions about how they perceived the timeliness of benefits received, the responsiveness of the program to market conditions, the producers' predictability of benefits and complexity of BRM programs (AAFC, 2017). Producers were asked to assign a score to each aspect of the program, based on a scale of 1 to 5, with 5 being optimal. Of the three core BRM programs, AgriStability was found to be the least popular program, while AgriInsurance is the most popular, as shown in Table 1.1 below.

Table 1.1 - BRM Programming Average Producer Rating

Criteria	**AgriStability**	**AgriInsurance**	**AgriInvest**	**BRM Average**
Timeliness of Benefits	2.79	3.77	3.65	3.40
Responsiveness of Program	2.56	3.55	3.47	3.19
Predictability of Benefits	2.58	3.61	3.58	3.26
Clarity of Program	2.70	3.76	3.62	3.36
Program Average	**2.66**	**3.67**	**3.58**	**3.30**

Source: AAFC, 2017

As the table shows, producers perceive AgriStability as being slow to respond to losses, especially compared to the other BRM programs. Slade (2020) notes that a large percentage of AgriStability payments are received in October following the year of payment, such that some producers may not be compensated until 10 months after the end of the year in which the loss was incurred. This also describes some of the issues with responsiveness; the program is delayed in responding to losses that producers incur. Predictability is problematic with AgriStability because of the structure of the program. Going into a program year, producers have a general idea of the level of coverage to which they are entitled; however, the support to which the producer is entitled is only calculated after the producer submits their fiscal year data once the year is complete, based on production reported in that fiscal year. This is referred to as "structure change", which is the mechanism for accounting for changes in the farm's size that adjust the values of previous years' margins to standardize them to the current year's level of production. Because of structure change that happens *ex post*, producers find the program to be unpredictable and complex, with the structure change calculation using dollar values for standardization that only the AgriStability administration may access.

The program is also sometimes viewed as cumbersome, given that participants must supply income and expense data, as well as crop and livestock production and inventory, to calculate payments. This results in high administration costs that are often viewed to exceed the benefits of participating in AgriStability (Atmos, 2021). Whether producers choose to have an accountant file their AgriStability data or do so themselves, there is a perception among farmers of significant direct and indirect costs to participating in AgriStability. Atmos Financial Services (2021) explains that there are significant fees associated with having an accountant file the necessary documentation for AgriStability. Even if the producer chooses to do the paperwork themselves, there are also administrative costs associated with record keeping and the time spent to ensure the information provided is accurate. Atmos (2021) also notes that there are likely follow up questions from the AgriStability administration, which results in further producer-level administrative costs of participating in the program.

AAFC officials have indicated that they believe the program to be effective at achieving its outcome of income stability (Del Bianco, 2018; AAFC, 2017). For example, 75% of AgriStability participants that triggered payments in 2014 had their program margin restored to at least 55% of their reference margin, which is considered a success by key performance measurement standards (Del Bianco, 2018). Additionally, at a 70% support level, the payment trigger resulted in $1.1 billion in AgriStability payments between 2013 and 2016 (Del Bianco, 2018).

Despite the success of the program from a program performance measurement and evaluation perspective, only 33% of producers were participating in the program in 2014, which covered 55% of sector market revenues (Del Bianco, 2018; AAFC, 2017). This falls below the AAFC-defined targets of 50% participation by producers that account for 65% of total market revenues (AAFC, 2017). Enrolment in the program also continues to decline year over year, indicative that an increasing number of producers do not see a benefit to participating in AgriStability. Declining participation is believed to be due to the complexity of the program, limited transparency and predictability in the calculation of benefits, issues with the timeliness of payments, the strength of the sector and commodity prices (which would reduce the need for the programs) and reduction in payments due to support reduction with each policy framework (AAFC, 2017).

AAFC has noted that the decline in producer participation in AgriStability is more accelerated than the decline in the market revenues covered by the program, indicative that the program is more popular with larger producers (AAFC, 2017; Poon, 2013). In the 2017 Office of Audit and Evaluation report, AAFC indicated that approximately 50% of Canada's agricultural producers with revenues between $500,000 and $1 million and 56% of producers with revenues greater than $1 million participate in AgriStability. This suggests two problems with the AgriStability program. First, the program is viewed by producers as insufficient and ineffective in supporting smaller producers (less than $500,000 in annual revenues). Only one-third of Canada's producers reporting revenues less than $500,000 participate in AgriStability, despite making up 82% of the total number of producers in Canada (AAFC, 2017).

Second, reduced participation in the ongoing BRM programming has the potential to increase the need for *ad hoc* programming to help stabilize farm revenues during disasters and exposes the industry to increased risk (AAFC, 2017). While Schmitz, Furtan and Baylis (2002) discuss the desire of government to maximize producer uptake in production insurance as a means of not having to fund expensive *ad hoc ex post* disaster assistance programs, the discussion can be extended for uptake of AgriStability to pre-emptively insure farm margins rather than quickly create programs to top up margins after a disaster has been identified.

For the reasons identified above, producers have called for changes to the AgriStability program (Briere, 2019; Del Bianco, 2018). AAFC is currently exploring options for enhancing the BRM suite, through a BRM review that is currently ongoing, as agreed to with the signing of the Canadian Agricultural Partnership (CAP) by AAFC and its provincial/territorial counterparts (Del Bianco, 2018). In December 2019, small changes to AgriStability for the 2020 program year were announced by the federal/provincial/territorial agriculture ministers, while the Minister of AAFC indicated that the BRM review was still ongoing, set to be completed by mid-2020 (Fraser, 2019). This discussion of the BRM Review is woven throughout this document, which provides analysis of existing BRM programs used in various combinations, while also proposing enhancements to BRM programs and evaluating these enhancements relative to existing programs.

1.3 Thesis Overview, Objectives and Organization

Given the discussions surrounding the effectiveness of BRM programming, especially AgriStability and the interest in enhancing BRM programming to provide greater value to farmers, this thesis attempts to identify potential changes to BRM programming which would increase value to farmers, while complying with Canada's trade obligations and being within the budgetary constraints of federal/provincial/ territorial governments.

To accomplish this objective, the existing AgriStability and AgriInsurance programs are analysed given that they cover production, revenue, and expense risk on-farm. Monte Carlo simulation is used to simulate a distribution of outcomes for a Manitoba grain and oilseed farm producing three crops: canola, wheat and soybeans. The analysis on the existing programs analyzes mean profit per acre and the standard deviation of profits without any BRM programs and AgriStability and/or AgriInsurance.

The results of this analysis are compared to two suggested BRM program enhancements to compare the farm's distribution of outcomes to existing programming. These two programs are a combined margin and production insurance hybrid and a cost of production insurance model. The WTO green-box compliance is relaxed, given that Canada uses only approximately 15% of bound AMS in a year, and therefore has some flexibility to design alternate programs (Rude, 2020). This analysis also considers the new programs' ability to address the traditional BRM markers of timeliness, predictability, accuracy and simplicity as they relate to Table 1.1, above. Equity is another point of discussion that AAFC considers; however, this is not be considered in this study and is considered a limitation of the study. This is because this study uses grains and oilseeds sector average data for Manitoba and therefore is not representative of equity across all sectors and regions in Canada; nor does it adequately quantify differences in support for below average or above average grain and oilseed producers in Manitoba. Equity is an analysis that likely requires access to individual producer data and simulating the impacts for each producer; this type of data was unavailable for use in this study.

The remainder of this thesis is organized into five chapters. Chapter 2 outlines the role of agriculture in the Manitoba economy and provides context of the importance of agricultural support programs to the health of the rural economy. This chapter also provides a brief overview of the history of government-subsidized business risk management programming in agriculture, including the long-term FPT cost sharing structures. The current structure of the BRM programs is reviewed in greater detail, with a focus on AgriStability and AgriInsurance, as the production and margin insurance components of the BRM suite. The on-going BRM review and discussions to date are discussed and serve as a framework for the evaluation of objectives in this study.

Lastly, Chapter 2 discusses COVID-19 and its effects on the agricultural economy for the 2020 production year.

Chapter 3 describes this study's proposed enhancements to BRM programs, which are included as part of the alternatives evaluated in terms of the uptake of programs providing the most value to agricultural producers. This chapter provides an overview of two models: a Combined Margin-Yield Insurance Model and a Revenue Insurance Model. After that, the fourth chapter contains a literature review defining risk, including in the context of agriculture, along with expected utility theory and its applications for agricultural decision-making. Additionally, a review of BRM literature to date is provided, to understand the findings on the effects and efficacy of the programs to date.

Chapter 5 explains the methodology applied for Monte Carlo simulation of the farm-level distribution of outcomes. This includes modelling the current and proposed BRM programs, while also providing structures for simulating profit per acre, based on historical prices and yields and Manitoba Agriculture and Resource Development costs of production for grain and oilseed crops. This chapter also lists the data applied to the simulation and its sources and identifies the assumptions inherent in the model. Chapter 6 discusses the results of the simulation, while the seventh and final chapter provides discussion on the results and conclusions, including limitations of this study.

Chapter 2

Background: History and Relevance of BRM Programs

2.1 Overview of Agriculture in Manitoba

Manitoba is Canada's third-largest cropping province by area, having approximately 13% of Canada's cropped acres on average; third behind Saskatchewan with 47% and Alberta with 29% (Statistics Canada, 2021a). The Manitoba agricultural sector represents approximately 5% of Manitoba's total gross domestic product (GDP), generating almost $3.2 billion in 2012 (Manitoba Agriculture and Resource Development, 2018). Crop production alone generates almost $2.5 billion (4%) of Manitoba's GDP across all industries; agriculture also employed 3.7% of Manitoba's workers in 2017.

In terms of farm area, 17.6 million acres were devoted to agricultural activity in Manitoba, according to the Census of Agriculture (Statistics Canada, 2021b). Of this, 11.5 million acres were used for cropping – representing 65% of Manitoba's agricultural area. By harvested area, the most-grown crops in Manitoba in 2019 and 2020 were canola, wheat, soybeans, oats, corn, barley and dry beans (Statistics Canada, 2021c). Farm cash receipts in Manitoba show that canola is typically the "cash crop" for Manitoba farmers. Of $4.3 billion in crop farm cash receipts in 2020, canola receipts totalled $1.6 billion (37%), while wheat accounted for $1.1 billion (26%).The farm cash receipts for all major crops by area is shown in Table 2.1 below.

Table 2.1- Manitoba Farm Cash Receipts for Major Field Crops (x1,000,000)

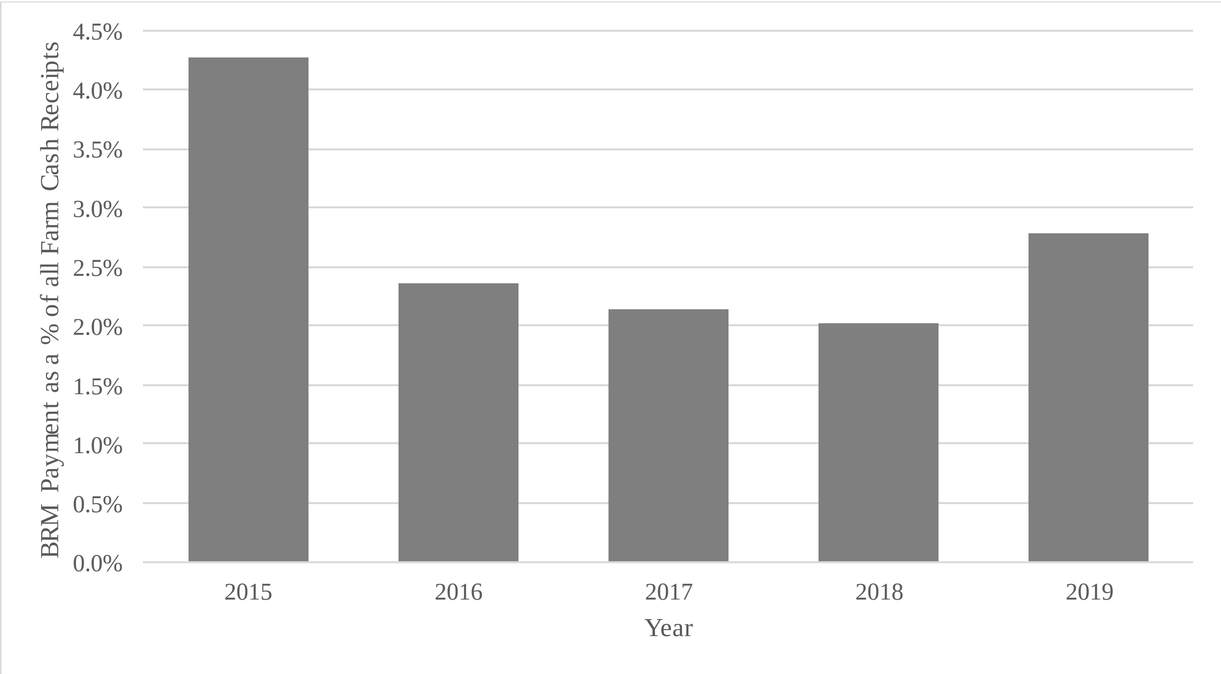
Crop	2019	2020
Canola	$1,315	$1,622
Wheat	$1,128	$1,133
Soybeans	$434	$513
Oats	$150	$169
Corn	$173	$160
Barley	$70	$68
Dry beans	$69	$118

Source: Statistics Canada, 2021c

From 2015 to 2019, direct payments to producers averaged $227 million, or 2.6% of the average total farm cash receipts received by Manitoba producers (Statistics Canada, 2020b).

BRM payments account for approximately 75% of the value of direct payments. Figure 2.1 below shows the percentage of Manitoba farm cash receipts accounted for by BRM programming by year, from 2015 to 2019. BRM payments account for approximately 2 to 5% of farm cash receipts each year, but BRM programs account for a lower percentage of the farm cash receipts in years where producers experience better conditions (e.g. weather, prices, etc.).

Figure 2.1 - Manitoba BRM Payments as a Percentage of all Farm Cash Receipts (2015 – 2019)

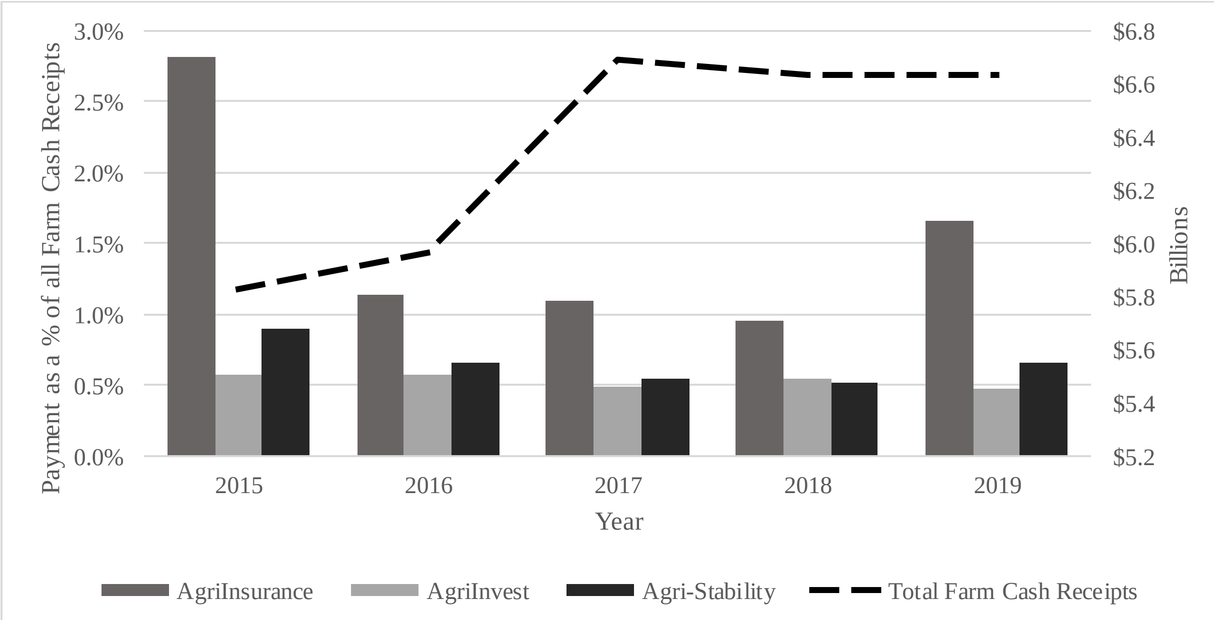


Source: Statistics Canada, 2021c

Of the main BRM programs, AgriInsurance accounts for the largest percentage of payments to producers (Statistics Canada, 2021c). Figure 2.2 below shows that AgriInsurance is also the more volatile program, in terms of payments from year to year, but there is likely a relationship between farm cash receipts and AgriInsurance payments – the higher the total farm cash receipts in a year, the lower the AgriInsurance benefits needed.

AgriStability payments are also volatile from year to year, which could be explained by an inverted relationship with total Farm Cash Receipts – ultimately, in years with good conditions, producers are less likely to need money from BRM programs. AgriInvest BRM payments are relatively constant as a percentage of the total farm cash receipts; this suggests that producer contributions are consistent relative to the farm cash receipts received in a program year and therefore, government expenditures also remain constant relative to farm cash receipts.

Figure 2.2 - BRM Program Payments by Program, as a Percentage of Total Farm Cash Receipts (2015 – 2019)



Source: Statistics Canada, 2021c

Table 2.2 below shows the BRM payments in Manitoba over the course of the Growing Forward (GF), Growing Forward 2 (GF2) and Canadian Agricultural Partnership (CAP) frameworks. Overall BRM program payments have decreased, with AgriInvest remaining consistent and AgriStability payments declining. The decrease in payments could be accounted for by changes to the programs under each framework, but also good conditions in recent years. During the GF framework, AgriInsurance was 47% of total BRM payments, on average, while AgriStability and AgriInvest were 34% and 14%, respectively. AgriRecovery averaged 6%, with larger payments in 2010 and 2011 disaster years. During GF2, AgriStability payments were lower, indicating reduced significance of AgriStability. AgriInsurance payments increased to an average of 55% of total BRM payments during this period, while AgriStability fell to 27%. AgriInvest increased slightly to 18% of total BRM payments. AgriRecovery was less active during the GF2 period.

Table 2.2 - Manitoba BRM Payments by Program (x 1,000)

Framework - Year	AgriInvest	AgriRecovery	AgriStability	AgriInsurance	Total BRM
Growing Forward					
2008	$40,446	$121	$89,447	$78,241	$208,255

2009	$50,103	$18,845	$133,693	$127,958	$330,599
2010	$38,304	$43,932	$92,005	$158,852	$333,093
2011	$55,633	$26,542	$75,246	$307,478	$464,899
2012	$43,085	$16,451	$179,139	$203,949	$442,624
Growing Forward 2					
2013	$47,830	$174	$125,093	$164,251	$337,348
2014	$34,424	$138	$49,630	$122,699	$206,891
2015	$33,189	$3,342	$52,013	$164,339	$252,883
2016	$33,968	$32	$38,967	$68,289	$141,256
2017	$32,873	$0	$36,917	$73,777	$143,567
Canadian Agricultural Partnership					
2018	$36,022	$0	$34,371	$63,488	$133,881

Source: Statistics Canada, 2021c

2.2 History of Government-Provided Business Risk Management Programs in Canada

The Canadian government has a long history of involvement in Canadian agricultural sector stabilization programs, dating back to the mandatory, commodity-specific *Agriculture Stability Act* of 1958 (Rude and Ker, 2013). Crop insurance was first introduced in Manitoba under the *Crop Insurance Act* in 1959; this was the first legislation that included federal-provincial-territorial (FPT) cost sharing provisions – the federal government agreed to contribute funding to provincial crop insurance programs, so long as the provinces adhered to the conditions of receiving federal funds (Hedley, 2017).

Over the next 30 years, income stabilization programs evolved into the *Western Grains Stabilization Act*, in place from 1975-1990, which is the first example of "pooled" commodity coverage (Rude and Ker, 2013). In 1991, the *Farm Income Protection Act* (FIPA) was signed, which provides the basis for FPT cost-shared programs (Hedley, 2017). With FIPA, a new voluntary commodity-specific revenue-based program called the Gross Revenue Insurance Program (GRIP) was implemented. The simultaneous introduction of the Net Income Stabilization Account (NISA) in 1990 is the first example of a Canadian margin-based approach to income stabilization (Rude and Ker, 2013; Hedley, 2017).

NISA remained in place from 1990 until 2002, but GRIP was replaced by the whole farm, margin-based Agriculture Income Disaster Assistance (AIDA) in 1998. AIDA was the first program to target severe drops in net income based on average farm-level net income (Hedley, 2015), marking the shift from commodity-specific to whole farm programs to align with obligations to the World Trade Organization in providing Annex II-based agricultural policies coming out of the 1995 URAA, to prevent countervailing measures by trading partners. That is, these are programs where agricultural payments must be related to income declines relative to a producer's reference-period income, while decoupling payments from the volume or type of agricultural production (WTO, 2020). The AIDA program was a rapidly designed and implemented program to respond to sudden drops in hog and grain and oilseed prices, so the program was not included in the 1995 cost-shared program funding envelope (Hedley, 2015). In 2000, a new three-year farm income safety net agreement was signed, with AIDA becoming the Canadian Farm Income Protection (CFIP) program, which continued to provide historical, net income-based support for whole farm income declines (Hedley, 2015).

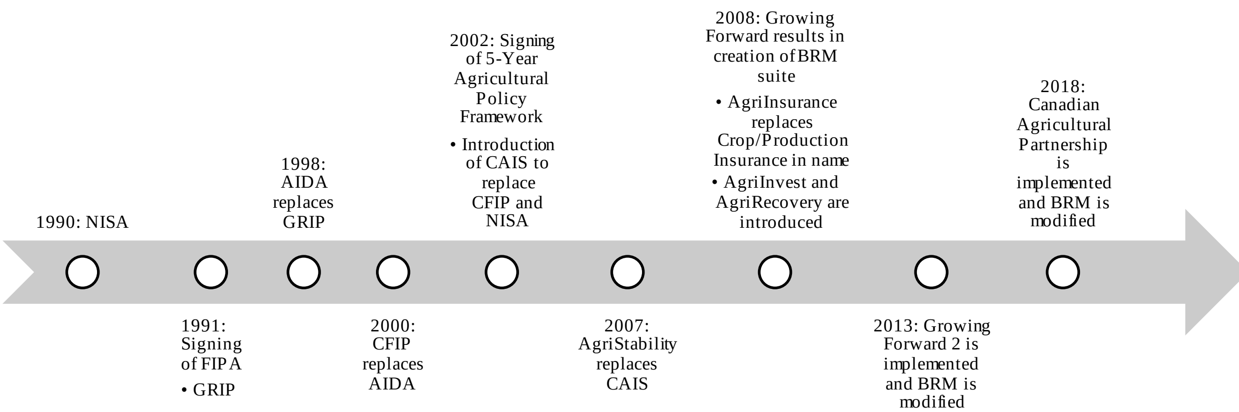
The Whitehorse Accord was signed in 2001, which is the most recent significant development in FPT agreements on agricultural policy (Hedley, 2017). The Whitehorse Accord provides the basis for the 60%/40% cost-sharing agreement between the FPT governments for the premium subsidization and administration of cost-shared agricultural income programs. This agreement holds true with the most recent Canadian agricultural policies (AAFC, 2018c). The Whitehorse Accord also contained goals, objectives and performance measures in the areas of risk management, renewal, environment, food quality and science (Hedley, 2015). This accord served as a framework for the Agricultural Policy Framework (APF) signed in 2003 by FPT governments.

In 2002, CFIP and NISA were replaced by the Canadian Agricultural Income Stabilization (CAIS) Program as part of the first five-year FPT Canadian policy framework, the Agricultural Policy Framework (Turvey, 2012; Rude and Ker, 2013; Hedley, 2015). CAIS was designed to provide whole-farm revenue insurance in the form of deficiency payments, providing payouts based on the entire farm's margin in a program year, relative to a reference margin (Turvey, 2012). CAIS provided tiered coverage, where differing indemnities were paid out depending on the tier determined by the degree of program year margin decline relative to the reference period margin. Overall, indemnities could not exceed 70% of the shortfall below the reference margin (Turvey, 2012).

Following the expiration of the Agricultural Policy Framework, the FPT governments implemented the Growing Forward (GF) policy framework, in place from 2008 until 2013

(AAFC, 2008). The GF framework first introduced the Business Risk Management (BRM) suite of safety net programs, consisting of AgriStability, AgriInvest, AgriInsurance and AgriRecovery (each of these is described below) (AAFC, 2008). The objective was to provide producers with tools to manage business risks of farming beyond their control, such as disasters, reduced production and low prices (AAFC, 2008). Growing Forward 2 (GF2) followed for the 2013-2018 period (AAFC, 2013a) and the Canadian Agricultural Partnership (CAP) for the 2018-2023 period (AAFC, 2018a). These agreements maintained the BRM programming, with minor parameter changes that have affected the whole farm stabilization support levels for AgriStability and AgriInvest, by modifying trigger levels and compensation rates. AgriInsurance has remained largely unchanged through the various frameworks. Figure 2.3 below shows a timeline of government support in Canadian agriculture since NISA was introduced in 1990.

Figure 2.3 - Timeline of Canadian Agricultural Support Programs since 1990



Source: Hedley (2015) and Hedley (2017)

2.3 BRM Programs under the Canadian Agricultural Partnership

Since the introduction of the BRM under GF, there have been minor changes to the structures of the programs with each new policy framework. These changes are related primarily to the trigger points and compensation levels for the AgriStability and AgriInvest programs, while the AgriInsurance program has remained relatively untouched. The CAP framework's structure of the two programs of interest in this study, AgriStability and AgriInsurance, is outlined in the sections below.

2.3.1 Overview of AgriStability

Like AIDA, CFIP and CAIS before it, AgriStability is a margin-based deficiency program targeting income stabilization by providing payments to producers whose program year margin declined below a defined percentage of the reference year income (AAFC, 2008; Hedley, 2015; AAFC, 2018b). Currently, the program provides a support level of 70% of the historical reference margin (AAFC, 2018b). The margin is comprised of the allowable revenues minus the allowable expenses, adjusted for accrued receivables, payables and purchased inputs (AAFC, 2013b; AAFC, 2018b). The allowable revenues and expenses are generally those directly related to production and do not include revenues and expenses generated from other farming activities (e.g. purchase of equipment or rental of land) (Rude and Ker, 2013). The purpose of this is to minimize moral hazard associated with making "spin-off" farming decisions with the intent to trigger a payment (Rude and Ker, 2013). Additionally, in the interest of equity across sectors, only allowing revenue and expenses directly related to production ensures that highly capital-intensive sectors do not trigger payments versus those with lower capital requirements.

Under GF, AgriStability was a two-tiered program, with a stabilization component and a disaster component (AAFC, 2008; AAFC, 2017). The stabilization portion would cover declines between 15-30% of the reference, with payment covering 70% of the decline. If a producer qualified in the disaster layer - that is, their program year margin was between 0-70% of the reference margin - the producer would receive payment of 80% of the loss in the 0-70% reference margin range and 70% on the portion of losses between 70-85% of reference margin. Special consideration for negative production margins provided payment of 60% of the lesser of the absolute value of the program year margin or the margin decline.

Under GF2, the stabilization layer of AgriStability was removed. Program payments were triggered when the production margin declined by a minimum of 30% of the reference margin – that is, the trigger level was set at 70% of the reference margin (AAFC, 2013b; AAFC, 2017). In addition to the lowered trigger level, AgriStability also introduced a reference margin limit (RML), which capped the reference margin at the lower of the average program year margins during the reference period or the average allowable expenses over the same period (AAFC, 2013b). This provides lower reference margins to farms with lower cost structures, which raised questions surrounding equitable treatment of producers by lower coverage for low cost production types (CCA, 2017). Negative margin benefit was modified from the 60% payment rate on margin declines, increased to 70% under GF2 (AAFC, 2017).

The implementation of CAP has modified the AgriStability parameters, reducing the impact of the RML. The trigger for AgriStability remains at 70% of the reference margin, while the RML is capped at 70% of the average reference year margin, such that reference margins cannot be reduced by more than 30% (AAFC, 2018b). This move was welcomed by groups such as the Canadian Cattlemen's Association (CCA), which noted that cow-calf producers lost coverage under the previous framework due to the low-cost nature of their operations (CCA, 2017). The negative margin benefit parameters are the same as those under GF2. However, CAP has introduced a floor on AgriStability payments, such that calculated payments of less than $250 fall below the minimum government payment.

Rude (2020) notes that as a whole farm margin insurance product, AgriStability should in many ways be an ideal product. As a program that involves margins (revenue minus costs), AgriStability is harder to manipulate than a program that exclusively deals with revenues. Additionally, costs to participate are lower for AgriStability because all commodity revenues and expenses are pooled, resulting in diversified risk for the insurer (i.e. FPT governments). As well, in terms of accuracy and specificity of the benefits for each producer, each producer's coverage is tailored to their farm's history; it is not based on the regional circumstances, neighbours' performance, etc. Therefore, a high-performing producer may have higher margins than their neighbours and could receive a higher benefit than their neighbours producing similar commodities, based on the production margin decline relative to the reference margin. Accordintly, he program should theoretically reward good performers while providing appropriate tailored coverage to all participants.

However, AgriStability does not function as smoothly as it perhaps should. Producers have indicated issues with the timeliness, accuracy and predictability of benefits, as well as the simplicity of the program. Payments are often not considered to be timely because they are received up to 10 months after the year of loss. The predictability of benefits is low because the actual coverage applied for the program year is calculated *ex post* because of structure change calculations being done using the program year's reported production and the administration's benchmark per unit (BPU) values known only by the administrator (see section 2.3.1.1 below for an explanation of structure change). The program is also quite complicated due to the considerable data requirements and record keeping necessary to participate. This was discussed in the *Problem Definition* section of Chapter 1.

2.3.1.1 Structure Change and AgriStability

Structure change is a method that the administrators of AgriStability apply to determine whether a farm has experienced a significant change in the operation's potential profit (AAFC, 2018b). The administrator always calculates a reference margin with and without considering the program year's reported productive quantities (i.e. number of acres farmed). If the difference between the Reference Margin with structure change and without structure change is at least $5,000 and 10%, then the administration "structures up" or "structures down" the farm operation, to ensure that changes in the farm operation do not drive payments or conversely, result in zero payment situations when the farm is entitled to payment.

Structure change adds to AgriStability complexity and unpredictability. The administration calculates a set of margins for the program year and reference years using commodity benchmarks per unit (BPU) created by the administration. The administration then compares the ratios of the production margins and reference margins to determine whether the difference is significant. Producers receive this information as part of their payment calculation, but cannot calculate this themselves to predict payments.

2.3.2 Overview of AgriInsurance

AgriInsurance is designed to provide producers with insurance against crop production and quantity losses caused by natural disasters and perils that are beyond the control of the producer (MASC, 2020). The program provides a yield guarantee based primarily on the geographic region in which the insured crop is being grown, adjusted slightly for the producer's past performance growing the crop. AgriInsurance coverage provides a dollar value for coverage, set by the administration, but does not provide price insurance, nor does it provide insurance against producer management decisions (MASC, 2020). The program is administered by a designated provincial organization, with the federal government providing financial support to the programs that are tailored to provide varied coverage by province/territory (AAFC, 2008; MASC, 2020). In this province, the Manitoba Agricultural Services Corporation (MASC) administers AgriInsurance.

AgriInsurance is offered to over 60 crops in Manitoba, with three levels of coverage: 50%, 70% or 80% of probable yield (MASC, 2020). Producers participating in the program must insure all acres of a crop (i.e. crops cannot be insured on a field-by-field basis) and once a producer is granted a contract, the contract is automatically renewed year-to-year unless cancelled by the producer or MASC. Premiums are cost-shared between the participant, the provincial government and the federal government, which pay 40%, 24% and 36% of the calculated premium, respectively.

AgriInsurance coverage provides participants with multiple benefits, including financial assistance when reseeding of crops is required due to natural perils without paying additional premium (MASC, 2020). Additionally, participants are entitled to Excess Moisture Insurance (EMI), which provides insurance against unseedable acres to due to excess moisture from either flooding or rainfall. Producers have the option to buy up additional coverage. In addition to the basic AgriInsurance program, MASC also provides producers the option to purchase Crop Coverage Plus, which is a 90% coverage, whole farm crop production insurance program (MASC, 2020). Forage and livestock producers can also purchase forage insurance, forage establishment insurance, pasture insurance and forage restoration insurance; however, given that the interest of this study is strictly crop production, the forage/pasture insurance products are not included in the formal analysis.

AgriInsurance did not undergo any program changes from GF to GF2 because a 2014 AAFC review of the program concluded that the program had been successful in terms of production loss management for both producers and FPT governments, and moreover was considered to be both predictable and bankable by governments (AAFC, 2017). That is, producers enter the growing season with coverage (both yield and dollar) established *ex ante*; this is unlike AgriStability, where the reference margin can be modified *ex post* at the time the year's production data is submitted, depending on whether it is necessary to apply structure change (AAFC, 2018c).

2.4 BRM Review Discussion

Part of the agreement between AAFC and the provincial/territorial agriculture counterparts for CAP was to undertake a review of BRM programs to assess the effectiveness of the programs as well as their impact upon growth and innovation (AAFC, 2018c). The purpose of this review is to examine AgriStability, AgriInvest and AgriInsurance programs to address producer concerns of timeliness, simplicity, and predictability of the programs (AAFC, 2018c; Del Bianco, 2018).

Producers and industry groups have raised several concerns with AgriStability, one of which pertains to the program's ability to aid sector recovery from market events when only one-third of Canadian agricultural producers participate (Del Bianco, 2018). A limit placed on the reference margin first introduced for the GF2 framework, also known as the RML, was having a significant impact upon sectors with low allowable expenses – reducing equitable treatment between sectors. Consultations with producer groups and industry have also indicated the desire to reimplement the stability component (85% reference margin coverage) that was previously available in the CAIS and the GF version of the AgriStability programs. While the AgriStability RML issues were somewhat addressed by introducing a limit on the limit, FPT ministers also agreed on reducing contributions to AgriInvest to offset increased AgriStability payments – to keep framework changes "cost neutral" for governments (Del Bianco, 2018).

In December of 2017, a panel of 11 "industry experts" was announced, that included producers, academics and other experts which represented a wide range of commodities and farming expertise. The panel presented recommendations to the FPT ministers at their annual meeting on July 20, 2018, suggesting the following areas of improvement (AAFC, 2018c):

- developing management tools to cover risks not targeted by the BRM suite
- addressing challenges with AgriStability, including complexity, timeliness and predictability
- examining approaches to improve program equity
- maintaining AgriInvest
- modernizing AgriInsurance premium setting
- improving risk management communication and education.

AAFC and provincial/territorial governments have expressed a renewed interest in continuing to consult with the industry while work continues with the BRM review leading up to the next framework (AAFC, 2018c). While there are many points to be addressed by the comprehensive BRM review, this thesis primarily examines the challenges relating to AgriStability, while also demonstrating the ability of the AgriStability and AgriInsurance programs to achieve BRM policy objectives. The analysis ignores AgriInvest, does not consider AgriInsurance premium methodologies, and does not consider education and communication for BRM programs.

At the July 2019 FPT ministers' annual meeting, FPT ministers announced a commitment to make program changes to AgriStability for the 2020 Program Year (April 2020 implementation), although the extent of the changes was unknown at the time (Briere, 2019). These changes are not a substitute for an overhaul of the BRM programs because of the review;

rather, officials intend to examine proposed changes for quick program enhancements to meet producer and industry calls for AgriStability improvements (Briere, 2019).

2.4.1 Interim Changes to AgriStability

Following the FPT agricultural ministers' meeting in November of 2020, it was announced that AAFC's Minister Marie-Claude Bibeau was proposing an increase in the compensation rate for AgriStability from 70% to 80% (Fraser, 2020). That is, for every dollar of loss compensated by AgriStability, 80 cents would be returned to the producer, rather than 70 cents. Additionally, RMLs would be removed from AgriStability, increasing support to farmers by over 50% (Fraser, 2020).

The impacts of this announcement upon the present study are limited. The Prairie provinces did not accept the proposal to increase the compensation rate from 70% to 80%, but did agree to the removal of RML (Briere, 2021). Within this thesis, RML was being ignored anyway, as detailed below in Chapter 5, and accordingly the announced changes to AgriStability do not affect the results of this study.

2.5 COVID-19 Impacts and BRM Programming

The spring of 2020 saw the introduction of the novel coronavirus causing the COVID-19 disease, which was declared a pandemic by the World Health Organization (WHO) on March 11, 2020 (WHO, 2020). The global spread of this disease caused regional outbreaks that resulted in lockdown measures and closure of businesses to reduce the spread and protect the populations most vulnerable. The agriculture industry was not immune to these closures, with several sectors facing disruptions to their usual business activities. For example, an outbreak of COVID-19 at the Cargill beef processing plant forced a two-week closure of the plant and therefore, a temporary cessation of beef cattle slaughter (Glen, 2020).

Many sectors called for support from the federal government during this time, with relief coming to farmers in various forms, from expanding existing loan programs (Ker, 2020) to providing additional funding for producers to access through AgriRecovery (Real Agriculture, 2020). Farmers were also encouraged to use the existing BRM programs at their disposal (Ker, 2020), including an existing $2.3 billion in fund balances currently in AgriInvest accounts (White, 2020). Despite repeated calls from grain and oilseed producing groups to supplement the funding available under BRM, AAFC Minister Marie-Claude Bibeau encouraged producers from their AgriInvest accounts, before additional programming would be considered (White, 2020).

Literature on initial beliefs regarding of the impacts of COVID-19 on the grains and oilseeds markets and related AgriStability payments indicates that it is unlikely the grains and oilseeds sector should experience losses significant enough to trigger an increase in the number or value of AgriStability benefits. Ker (2020) analyzed the potential impacts of COVID-19 on AgriStability uptake and benefits to producers and concluded that unless the border closes or restricts exports, it is unlikely that prices should change in a significant manner to trigger an increase in AgriStability payments. He also suggested that AAFC could revert the margin decline trigger to 15% to begin triggering AgriStability payments, but indicated that it is economically unnecessary to maintain a stable and affordable food supply for Canadians, but also concluded that farmers should be able to absorb modest losses from the impact of COVID-19.

Brewin (2020) indicated that Canadian supply chains for grain and oilseed products are robust and should not experience lengthy closures or disruptions as a result of COVID-19. Additionally, he noted that increasing commodity prices relative to the world price, due to a weakened Canadian dollar at the onset of COVID-19, should result in minimal changes to seeded acres, and input usage and yields are anticipated to be similar to those of 2019. Therefore, Canadian grains and oilseeds production is likely to be near-normal and does not suggest an increased likelihood of AgriStability payments, from either an income or expense perspective. Given the opinions of Ker (2020) and Brewin (2020), the simulation in this study does not explicitly take account of any potential impacts of COVID-19, and simulates the BRM programs as though there was no on-going pandemic.

Chapter 3

Proposed BRM Program Enhancements

This thesis proposes two alternatives to the current BRM suite of programs. The first alternative combines the AgriStability and AgriInsurance Programs into a single insurance product that provides dual coverage for margin and production declines, improving timeliness and predictability concerns. The second enhances the AgriStability program only, by changing the program to a revenue-insurance model that establishes coverage at the start of the program year.

3.1 Combined Margin-Yield Insurance Model

Combining AgriStability and AgriInsurance would create a single insurance product that provides protection against both yield and margin (income and expense) risks. While current BRM programs do not have common denominators for coverage, it is not difficult to find commonalities for coverage for crops. AgriInsurance coverage is per-acre based by crop, so in the analysis AgriStability reference margin coverage is reduced to a per-acre basis by crop, as well.

Producers enrolled in this program would initially be granted a 30% support level relative to their historical reference margin per acre by crop, to insure against revenue or expense impacts. If a producer were to opt into a new crop for the program year, the historical reference margin per acre assigned could be proxied to the administration-calculated BPU for a proxy crop. Under this program, the overall margin per acre would need to decline by at least 30% to trigger a payment. The producer would then also select a coverage level (50%, 70%, or 80%) for the yield portion of the insurance, which would use the expected yield per acre multiplied by the individual producer productivity index.

To receive a payment, the producer would submit yield, income, and expense data, as well as productive capacities, to the administration. All yield declines below the coverage level would be indemnified. Then the margin-based insurance would recalculate the margin per acre including the yield-based indemnity to determine if a margin-insurance top-up is required (that is, if the margin decline is still greater than 30% with the yield shortfall indemnity).

While this is similar to the separate programs being used in tandem, there are a few key differences that would address some of the issues with AgriStability. First, producers may notice an increase in predictability, by essentially guaranteeing margins on a per-acre basis, rather than on a whole farm basis. Producers could easily calculate their historical margin per acre by crop and determine the averages, to determine their individual coverage level. Provided that producers know their individual coverage for crop yields, they could calculate yield indemnity per acre and plug the value into their program year margin per acre to determine where the program year margin sits, relative to the reference margin. Structure change is not required to be calculated, which can complicate predictability from the perspective of producers when they do not know the BPUs used by AAFC (or their provincial administration) to estimate structure change. This also suggests that simplicity in terms of producer knowledge of calculation inputs may be enhanced under this structure.

The disadvantage of such a program would be that timeliness is not directly improved. Data requirements from producers to program administrations would be virtually identical; therefore, tax filer data would still be required. This may worsen the timeliness for the production insurance portion of payments. While producers may be able to more easily determine the indemnity to which they are entitled under this structure, streamlining the AgriStability and AgriInsurance programs would likely require streamlining administration of the programs to an extent, and having single payments being sent to producers to cover margin and yield declines combined would slow the turnaround time from claim to indemnity. A solution would be to provide interim payments for the yield insurance portion of the decline, as it is known before year end (assuming a December 31st year end) and margins would not be determinable yet.

An additional limitation to the proposed structure is that complexity is not reduced, for two reasons. First, the data requirements are still extensive and the program indemnity calculations are likely to be considered even more complicated through a merging of both AgriInsurance and AgriStability indemnity calculations. Second, the per acre margin is not necessarily easy to calculate if the producer has multiple production types, given that it is not easy (or necessarily correct) to allocate proportions of expenses to various production activities. This would likely result in guessing of what expenses belong to which activity, which could reduce accuracy. The model would also need to consider livestock production; while not the subject of this thesis, the application of a margin-yield insurance per productive unit would need to be considered for a program like this to be implemented. Furthermore, this model likely does not work on farms with multiple types of production (such as crops and livestock), because of difficulty in attributing the values of certain expenses that can be attributed to each type of farming activity. Therefore, this makes the calculation of benchmarks per productive unit virtually impossible.

Another limitation is that, structurally, this model is similar to the existing AgriStability-AgriInsurance model (see 5.1.1.3 BRM Modelling of the Whole Farm), where the coverage is provided as a reference margin per acre, which already has the AgriInsurance "revenue" portion of the calculation included in the AgriStability indemnity. Producers may not view this program as an enhancement; rather, it is a streamlining of administration.

3.2 Cost of Production Insurance Model

The second alternative BRM program considered in this thesis is the Cost of Production Insurance Model, which would be intended to replace the current AgriStability program. This insurance provides a guaranteed revenue per acre based on the anticipated cost of production for the crop in the upcoming program year. The program therefore uses cost of production data established at the start of the growing season on a per crop basis to determine a cost per acre). The cost of production insurance price per unit is equal to the marginal cost of production. At the end of the calendar year, the cash commodity price multiplied by yield per acre is compared to the guarantee and if there is a shortfall between the cost value and the commodity value, the producer is entitled to an indemnity equal to the difference in the two prices.

The Cost of Production Insurance Model replacing AgriStability moves this component BRM suite out of the green box categorization, by the WTO definition outlined in Chapter 1. However, Canada's amber box expenditures are approximately 15% of the bound AMS set out by the WTO (WTO, 2019), and therefore Canada has some flexibility in program design without a need to worry about violating trade obligations under the WTO. The other trading consideration is the possibility of countervailing tariffs in response to modified/increased supports; however, given that this program would be generally available, countervailing measures would not be legal under US Trade Law, diminishing the threat of US countervail against Canada (Rude, 2020).

In terms of the BRM performance indicators, the program is simple, because the calculation of indemnity is a straightforward calculation, and timely, because the determination of indemnity is not reliant on tax filer data and can therefore be issued at any time the administration chooses following harvest. Realistically, it would likely be at the producer's fiscal year end, because the timing of grains and oilseed harvest may differ from the end of the production cycle for other commodities, such as livestock production. However, for crop production, yields could be potentially be leveraged from harvested production reporting to AgriInsurance administrations and payments could be automatically calculated and distributed to program participants once their fiscal year end has passed. This would put money in the hands of producers months earlier than the current AgriStability program. While a revenue insurance replaces the existing margin deficiency payment product, costs are inherent to this model through price setting at the marginal cost of production. Unless costs change significantly over the course of the year, producers are guaranteed the expected cost to produce the crop.

The proposed product may not, however, be effective in accomplishing the two other attributes of interest with respect to BRM programming: accuracy and profitability. By using provincial cost of production data, the marginal cost per unit produced on each farm may not be accurately represented. Producers with higher cost structures may still be exposed to risk if the cost of production exceeds the provincial cost estimates. A way to increase accuracy could be to gather cost of production data at a regional level; however, this would increase equity between regions, but not necessarily between individual producers in each region. Additionally, large producers who may have economies of scale and lower costs may experience larger net gains than producers with higher costs. In addition to an accuracy issue, this creates an equity issue and potentially rewards producers with lower costs by increasing their net income relative to a producer receiving the same commodity price, but with higher costs. Furthermore, the potential benefit to producers is not necessarily predictable at the time of enrolment. The price guaranteed is known at the time of enrolment for the year; however, the total yield applied is not known until after harvest and therefore, the producer is unaware of their actual revenue floor until after harvest.

Chapter 4

Literature Review

This study simulates net per-acre profits for a farm, knowing yields and crop prices are uncertain at the time of the decision to take part in government business risk management programs. The study ultimately determines which combination of participation in BRM programs provides the producer with the best value, through a model that quantifies the outcomes over a wide range of scenarios. This section explores the concept of risk and uncertainty on agricultural decision-making and reviews simulation of farm-level outcomes and explores previously applied examples. Lastly, previous studies of the Canadian BRM programs are discussed, with an overview provided of previous study findings on producer well-being and value under BRM programs, as well as comments and academic discussion on the BRM review.

4.1 Defining Risk in Agriculture

Agricultural production is a risky venture (Anderson and Dillon, 1992). Moss (2010) states that economics is a study of choices and how choices ultimately make up consumer demand and producer supply. In the example of agricultural producers, producers use information available to them to produce a profit-maximizing quantity. As entrepreneurs, agricultural producers seek to maximize profit, which is a form of utility maximization (von Neumann and Morgenstern, 1944). However, decision making with complete and perfect information is an unrealistic scenario. In fact, agricultural producers must make decisions about production with imperfect or incomplete information; producers do not know what weather conditions will be experienced over the coming growing season and the prices they may receive at the time of harvest. Blank, Carter and McDonald (1997) note that agricultural production risks are related to output prices, yields and input costs.

Moss (2010) observes that risk and uncertainty ultimately drive production decisions and agricultural economists seek to understand the effects of risk and uncertainty on production. Decisions ultimately arise when there are multiple choices that can affect an outcome and in a perfect world, the decision chosen is the one that maximizes profit. However, since the true outcome is unknown at the time of decision making, producers must make decisions based on the likelihood of outcomes and how the likelihood of each outcome affects the expected profit. Moss

(2010) states that because risk ultimately drives decisions, the effectiveness of agricultural policy is linked directly to agricultural producers' response or ability to respond to risk.

Hardaker (2000) acknowledges that dealing with risk in a systematic manner is not simple for agricultural producers, citing confusion over a clear definition of risk and how to measure it as one of the main obstacles in addressing risk. Even risk experts cannot come to a clear definition of risk; however, according to Hardaker (2000) there are three main concepts involved with risk: the chance of undesirable outcome; the variability of outcomes, and uncertainty.

An example of uncertainty in the context of this study could be a significant yield decrease or a large decline in margin over the course of the production year. Hardaker (2000) represents risk as $P^* = P(X \leq X^*)$, where P is the probability of the undesired outcome, X is the undesired outcome and X* is the threshold for the desirable outcome. For a producer applying to AgriStability, this could be interpreted as the probability of the production margin (X) experiencing a decline below the reference margin (X*). However, Hardaker (2000) notes that defining the threshold for an undesirable event is not always simple.

In terms of variability, risk is usually discussed in terms of dispersion about a mean, often stated as the variance σ^2 or standard deviation σ. To compare the variance or standard deviation of a distribution, a mean or expected value $E = E[X]$ is established. Alternatively, Anderson and Dillon (1992) define the expected value as the mean or average value of an uncertainty quantity that is expected from many observations of the quantity. Additionally, economic analysis represents risk as standard deviation relative to the expected value, known as the coefficient of variation:

(4.1) $CV = \sigma/E.$

Lastly, Hardaker (2000) defines uncertainty as the result of a distribution of outcomes, with various outcomes having different probabilities of occurrence. A distribution of outcomes for event X as a definition of the risk of event X requires full specification of the distribution of outcomes for the event. This can be represented through a probability density function (PDF) or through a cumulative density function (CDF). Hardaker (2000) notes that CDFs are generally the more convenient function. Overlap exists with the understanding of the variability of the outcomes, with moments of the function determined as measures of risk. Particularly with the normal distribution, the two moments of interest are the first and second moments – mean and standard deviation – which are those observed used when considering risk as dispersion (Hardaker, 2000).

Despite these three points on risk, each has their pitfalls for applying them as the definition of risk (Hardaker, 2000). First, only considering the negative outcomes of a distribution does not fully capture decision making; that is, a risk-averse decision maker may still participate in a risky event when considering that the upside risk of the event is more likely or may be more profitable. Additionally, measuring risk in terms of dispersion may also be misleading; an event that has a higher degree of variability and a higher expected value may still be less desirable to the decision maker than a lower expected value with a lower variability about the expected value. Lastly, the level of risk aversion of the decision maker needs to be known in order to understand whether a lower degree of dispersion/variation in a distribution of outcomes necessarily generates the most desirable expected outcome for the decision maker.

4.2 Simulating Outcomes Under Risk

4.2.1 Expected Utility Theory

Decision analysis for agricultural economics has long relied upon expected utility theory, initially developed by Daniel Bernoulli in the 1700s (Hardaker and Lien, 2009). Anderson, Dillon and Hardaker (1977) summarized Bernoulli's principle for the expected utility theorem and the utility function in terms of three properties: first, for two outcomes a_1 and a_2, if $a_1 > a_2$, then $U(a_1) > U(a_2)$. Second, the utility function is equal to the expected utility value based on the possible outcomes, based on the individual decision maker's subjective distribution of outcomes. Lastly, the scale of utility is arbitrary – i.e. one outcome may be more favourable than the other by providing more expected utility, but this does not necessarily mean that an outcome provides, say, twice the utility.

The principle therefore serves to rank risky outcomes by order of preference, with the decision maker's preferred option being the one with the highest expected utility, based on the assumption that producers seek to maximize their utility (which is in turn assumed to be the outcome that maximizes profit) when making economic decisions. Expected utility theory was revived by von Neumann and Morgenstern (1944), who suggested that by providing a decision maker with a choice of outcomes and the probabilities of occurrence of each outcome, that person's indication of their preferences provides a measure of utility, specifically a measure of the differences in utility. However, von Neumann and Morgenstern (1944) suggested that utility is not necessarily profit, but rather those seeking to maximize their utility are looking to maximize an expected value of a quantity.

The Friedman-Savage utility function proposed in their 1948 paper explains that the curvature of an individual's utility function, as an indicator of their preferences, depends on the individual's wealth. They suggest that the higher an individual's wealth, the higher their tolerance for risk. Conversely, poorer individuals tend to be more risk-averse and more inclined to participate in insurance. In a subsequent paper, the authors further summarize the expected utility theory as a quantifiable measure of the utility, to interpret behaviour or predict individual choices and that the maximization process is a way of designating wise behaviour – it does not suggest a singular convention to measure utility (Friedman and Savage, 1952).

The utility function is a way to assign quantitative utilities to consequences of decisions and expects that a decision maker makes the choice to maximize their utility, based on their expressed preferences (Anderson, Dillon and Hardaker, 1977). Applying the concept of utility, as well as the discussion of risk definition in the previous section, Hardaker (2000) outlines the subjective expected utility hypothesis, initially proposed by Savage (1954) and Anderson, Dillon and Hardaker (1977). The hypothesis is the utility or some other measure of relative preference of risk is equal to the expected utility for the risky prospect (Hardaker, 2000).

4.2.2 Applying the Utility Function to Risk Aversion

The level of risk aversion of the individual can be inferred from the utility function derived from stated preferences. The utility function can be inverted to determine the certainty equivalent (CE), which is in turn necessary to determine the risk premium (Hardaker, 2000; Anderson, Dillon and Hardaker, 1977). The risk premium is the measure of the cost of risk to the decision maker, given as:

(4.2) $RP = E - CE$

where RP is the risk premium, E is the expected value (in this case, expected utility) and CE is the certainty equivalent (Hardaker, 2000). Generally, the risk premium is positive, given that individuals are typically risk-averse over a range of payoffs related to management decisions (Anderson, Dillon and Hardaker, 1977). The utility curve for a risk-averse individual is an upward concave slope, indicating that risk-averse individuals experience diminishing marginal utility from an increase in payoffs, when there is additional risk involved (Anderson, Dillon and Hardaker, 1977). The utility function can be subjected to arbitrary positive linear transformations, which can be problematic because there can exist multiple utility functions that yield the same certainty equivalents (Anderson, Dillon and Hardaker, 1977; Janzen, 2008). An alternative measure for risk aversion, the Pratt coefficient, is in the following paragraphs.

Determining agricultural producers' attitudes toward risk has not been an easy task. As Hardaker (2000) explains, there appears to be bias in the functions toward the interviewers' biases and the framing of questions. An example of this is that producer attitudes toward wealth and income may be different than their attitudes toward gains or losses. Additionally, few people can articulate their risk preference consistently, introducing further bias.

The most plausible utility function, according to Hardaker (2000), is one that evaluates the utility of wealth, $U = U(W)$. The utility of wealth can be used to determine an absolute risk aversion coefficient, $r_a(W)$ (Pratt, 1964), which is the negative ratio of the second and first derivatives of the wealth function, such that,

(4.3) $$r_a(W) = \frac{-U''(W)}{U'(W)}$$

The assumption is that r_a decreases as W increases – that is risk aversion decreases with increases in wealth (Anderson, Dillon and Hardaker, 1977; Hardaker, 2000), consistent with Friedman and Savage (1948). The Pratt coefficient contains the partial derivatives of the utility of wealth, with $U'(W)$ and $U''(W)$ representing first and second partial derivatives, respectively. The second partial derivative is particularly important; it provides the "direction of bending" of the utility function, which Robison and Barry (1987) note is a useful measure for the classification of decision makers.

Modifying the Pratt coefficient further (Robison and Barry, 1987), the relative risk aversion coefficient can be obtained, which represents the elasticity of marginal utility:

(4.4) $$r_r(W) = \frac{-U''(W)W}{U'(W)}$$

The relative risk aversion coefficient allows for comparison of the elasticity of utility by removing endowment effects and differences in gain or loss measures. The example used by Janzen (2008) is that effects on "wealth" caused by differences in currencies are eliminated. The relative risk aversion coefficient is a unitless measure and is not subject to linear transformations, like its absolute cousin. The relative risk aversion coefficient is suggested to be between 0 and 4, with most farmers falling at a coefficient of 2 (Anderson and Dillon, 1992); 0 is extremely risk preferring, and 4 is extremely risk-averse.

Agricultural producers are considered to be risk averse and farmers who are more risk-averse assign higher subjective probabilities of their farms experiencing losses than less risk-averse farmers (Menapace, Colson and Raffaelli, 2013). Friedman and Savage (1948) also hypothesized that risk aversion levels are inversely related to wealth. This property is known as decreasing absolute risk aversion (DARA). DARA is the preference among risky outcomes that are unchanged if a constant amount is added or subtracted from all payoffs and exhibit constant relative risk aversion (CRRA) (Hardaker, 2000). CRRA implies that all preferences are unchanged if all payoffs are multiplied by a constant.

Applying the risk aversion coefficients for analysis purposes, it is often assumed that the utility function has a negative exponential form, which is exhibits a constant absolute risk aversion (CARA):

(4.5) $U = 1 - e^{-cW}$,

Where c is a constant represented by $r_a(W)$. Hardaker (2000) noted the unlikeliness of this scenario, because CARA has increasing relative risk aversion. On the other hand, the DARA scenario, represented by the function,

(4.6) $U = W^c,\ 0 < c < 1$

Or,

(4.7) $U(W) = \frac{1}{1-r_r} W^{1-r_r}$

is more likely and exhibits constant relative risk aversion. When $r_r(W) = 1$, the DARA utility functional form reduces to $U = \ln(W)$.

Given the propensity for risk-averse behaviour by farmers, the DARA scenario is likely the more appropriate representation of farmers' utility. However, as previously indicated, it is difficult to obtain correct and consistent information on risk aversion. Because of this, additional methods should be considered for more flexibility. This methodology is applied as one metric for analyzing the results of this study.

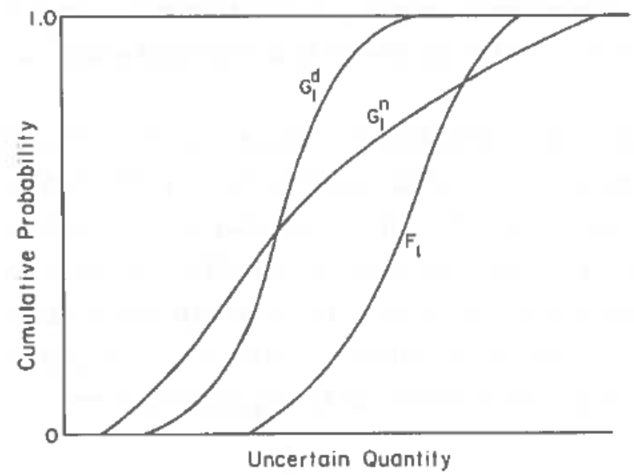
4.2.3 Stochastic Efficiency

Stochastic efficiency analysis is another method of analyzing distributions of outcomes, with the main premise that the process is carried out as long as possible without requiring knowledge of individual decision makers' preferences (Anderson and Dillon, 1992). In stochastic efficiency, first, second, and third-degree stochastic dominance can be studied. The procedure of stochastic efficiency analysis involves studying the CDFs of the probability distributions. Consider two

CDFs F' and G' for discussion purposes; these two CDFs exist over a range R in range [a, b], given by Anderson, Dillon and Hardaker (1977) as:

(4.8) $F'(R) = \int_a^R f(x)dx$ for continuous distributions and

(4.9) $F'(R) = P(x_i \leq R) = \sum_{x_i \leq R} f(x_i)$ for discrete distributions.

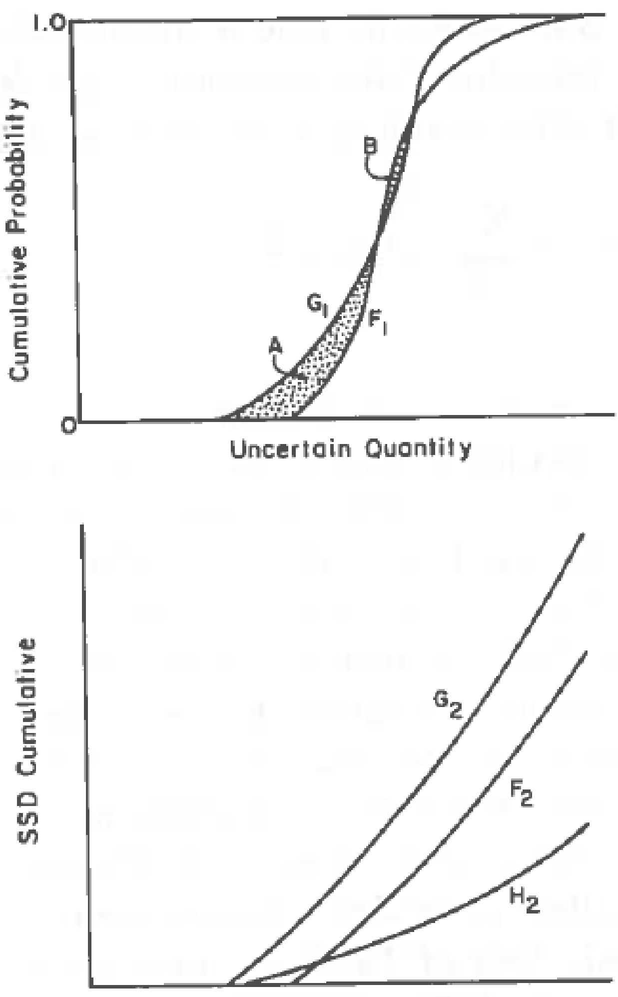


From Anderson, Dillon and Hardaker (1977)

Figure 4.1 - Illustration of First-Degree Stochastic Dominance

First-degree stochastic dominance (FSD) occurs when $F'(R) \leq G'(R)$ for all R in [a, b], and one strong inequality holds (e.g. the $F'(R) < G'(R)$ for at least 1 R between [a, b]) (Anderson, Dillon and Hardaker, 1977). This assumes that the first derivative $U'(x) > 0$. The FSD property is transitive in that, if G' dominates another CDF H' and F' dominates G', then F' must dominate H'. Graphically, the CDF of F' never crosses the CDF of G'. This is shown in the figure 3. Note that in figure 4.1, F' dominates G_1^d. If a CDF meets another, it may be stochastically efficient, but not dominant (first-degree stochastic efficiency). A stochastically efficient set of outcomes, ones where two CDFs follow along the same line, means that all are members of the set are potentially the optimal result, but identification of the utility maximizing point now requires knowledge of decision maker preferences (Anderson, Dillon and Hardaker, 1977). Furthermore, FSD is not necessarily the best method for analyzing alternatives because multiple CDFs may come about from similar decisions, which may create intersecting CDFs; this would yield FSE rather than FSD.

Second-degree stochastic efficiency (SSE) can allow for elimination of distributions based on both FSE and second-degree stochastic dominance (SSD). SSD depends only on the decision maker being risk-averse. Now, in addition to the FSD property that $U'(x) > 0$, $U''(x) < 0$ (Anderson, Dillon and Hardaker, 1977). Graphically, a function F' dominates G' if more of its function lies to the right of G', as shown in the figure 4.2. Figure 4.2 demonstrates that despite F' and G' crossing on two occasions, F' is more to the right of the G' CDF. More simply, area A (where $F' > G'$) is greater than B (where the opposite is true).



From Anderson, Dillon and Hardaker (1977)

Figure 4.2 – Illustration of Second-Degree Stochastic Dominance

An easier way to assess the CDFs is to take the second derivative of the function, so that all curves are upward sloping. This yields the SSD Cumulative curve (Anderson, Dillon and Hardaker, 1977), shown in the lower chart in Figure 4.2. The curve of SSD Cumulative is:

(4.10) $F''(R) = \int_a^R F'(x)dx$

Comparing the SSD cumulative curves allows for a comparison like the FSD conditions. In the case of Figure 4, F'' dominates G'', but not H''. The figure illustrates that the dominant H'' is not the preferred line for risk-averse individuals, because the cumulative probabilities of obtaining the same quantity as G'' and F'' is lower in most instances. The second-degree stochastic efficiency set is made up if the area bound by F'' and H''.

4.2.4 Choosing a Distribution to Model Risk

The simulation of risk outcomes and the comparison of simulations as outlined in the previous sections requires the identification of distributions. Given that there are several types of statistical distributions that exist, it is important to identify an appropriate distribution to model risk accurately. Distributions can be discrete vs. continuous, bounded or unbounded, and parametric vs. non-parametric.

Vose (2000) defines continuous versus discrete distributions. Continuous distributions are ones without breaks in the distribution, with an indefinite number of states possible across a defined domain and/or range (even if that range is infinite). Examples of continuous variables include distance and time, because they are infinitely divisible. Discrete distributions differ from continuous in that they contain a defined set of values or a value in a set range, with a defined probability of occurrence for each instance in the distribution.

Bounded versus non-bounded distributions are also a consideration (Vose, 2000). Bounded distributions are those with upper and lower bounds (maximums and minimums). Non-bounded distributions can theoretically extend from negative infinity to positive infinity and include common distributions such as the normal. Bounds are not necessary

Additionally, there are considerations for the application of parametric vs. non-parametric distributions (Vose, 2000). Parametric distributions are those that are model-based, and their shape is born of the mathematics that describe the theoretical problem. Conversely, a non-parametric, empirical distribution is one that is defined by its required shape, based on the data inputted into the model. The application of a parametric distribution requires a solid understanding of all underlying assumptions, in order to properly justify the use of these distributions. Alterations to the model are difficult if new information becomes available.

Vose (2000) also considers the use of univariate versus multivariate distributions for modelling risk. Univariate distributions are used to model a single variable that is not probabilistically related to any other variable. Conversely, the multivariate distribution describes several parameters that are linked to each other. The multivariate distribution is most applicable in this scenario, given that yield and commodity prices are linked, and that there are correlations between yields of different crops produced in the same geographic area.

Based on the information above, a multivariate empirical (MVE) distribution is appropriate for the simulation problem in this thesis. Richardson et al. (2000) provide a methodology for applying the multivariate empirical distribution to a simulation of farm-level returns for risk assessment and farm policy. The key advantage to the MVE model is that actual data are used to create the form of the distribution. This type of distribution incorporates the inter-and-intra-temporal correlations between yields and/or commodity price, allowing for control of heteroskedasticity over time (Richardson et al., 2000). The MVE model simulates the stochastic portion of each simulated variable and incorporates an intra-temporal correlation matrix of the variables, to incorporate the true relationships over time (Richardson et al., 2000).

While the MVE is the most relevant distribution to this type of simulation, there are other considerations that render this distribution ineffective for modelling the problem. Particularly in the scenario of yields, the data available for the yields is limited (see *Section 5.1.1*) and therefore limits the possibilities for output of yields by the MVE. Instead, a multivariate normal distribution can be used to simulate the yield variables while also preserving the intra-temporal correlations between the yields of the three crops. As the normal distribution is non-bounded, there is the potential that the distribution could generate negative results. Addressing these limitations is discussed in Chapter 5.

4.3 BRM Literature Review

Schaufele, Underschultz and Nilsson (2010) studied normal and catastrophic price risks for cow-calf producers in Alberta, determining that AgriStability is a highly subsidized program. This study also determined that as risk aversion levels in the simulated population increased, gains from participating in AgriStability increased overall. This suggests that AgriStability does have a role in farm business risk management (Schaufele, Underschultz and Nilsson, 2010). However, it is noted that risk-neutral producers benefit almost equally as much as their risk-averse counterparts from AgriStability, which suggests that AgriStability may a better income subsidy than risk management program in this case. The authors concluded that regardless of a producer's level of risk aversion, the risk-efficient decision is to participate in AgriStability, because the program appears to have a role in mitigating both normal and catastrophic price risks.

Whole farm insurance compromised of AgriStability and AgriInvest was the subject of Turvey's 2021 paper, which served as the initial motivation for this study. He developed a dynamic stochastic programming model to determine how Canadian safety net programs, including but not limited to AgriStability and AgriInvest, affect crop choices. Turvey (2012) also contemplated the green box nature of BRM programs in relation to programs such as GRIP, and studied the impacts of subsidization on Whole farm insurance policies to determine whether subsidization incrementally increases wealth effects that may be distortionary for markets. He concluded that while the whole farm programs are not specific and appear to be decoupled, homogenous risk aversion levels of producers can results in producers optimizing decisions in a similar way as coupled insurance, which could create distortionary effects and result in complaints at the WTO level.

Vercammen's 2013 study addressed the discussion of BRM program timeliness by using a partial adjustment model to estimate the income protection losses incurred on Canadian government federal direct payments due to delays in payment. He determined that a one-dollar loss in market net farm income results in 27 cents of payment in the year of loss, while a remaining 57 cents is the loss in short-run income attributed to payment delays. This analysis underscores the need for timelier BRM programming to rapidly assist producers with income declines.

Rude and Ker (2013) analyzed transfer efficiency for AgriStability, developing a quantitative model for estimating quantity and price impacts of the program, in addition to modelling welfare effects. The authors concluded that AgriStability results in higher farmland rents with limited effects on other farm-owned inputs and therefore provides the greatest welfare benefit to those who own land. Liu, Duan and van Kooten (2018) studied the impacts of changes in the AgriStability program as the framework graduated from GF to GF2 and determined the impact on cropping activities. Using positive mathematical programming, they calibrated farm management models using Alberta data. The study concluded that the initial introduction may have caused farmers to plant riskier crops with the potential for higher returns, but changes to AgriStability in GF2 shifted cropping decisions to be based more on the producers' level of risk aversion.

Janzen (2008) examined the impacts of safety net programs (CAIS) on the production insurance program (pre-GF programming). He was interested in determining if "simple" safety net programs that cover multiple risk have unintended consequences. It was determined that participation in government programs provides clear benefits to all producers, regardless of producer risk aversion levels. He also found that CAIS was less effective as a risk reduction tool because the likelihood of triggering CAIS payments was very high and provided the largest transfer to producer. Knowing that the support levels of AgriStability have since lowered, this may no longer hold. Additionally, the use of CAIS and production insurance together increased the overall value derived from production insurance by up to 50%, except for the most risk-averse farmers (Janzen, 2008).

Slade (2020) surveyed BRM programming and provided a summary of the objectives and appropriate directions for this programming post review. The paper discussed issues with equity in BRM programming, discussing shortfalls in coverage for livestock and horticulture producers

– these sectors lack support from AgriInsurance, and the AgriStability program does not close the gap in coverage. The author suggested that the review must consider distribution of payments by farm size, farm type, location and other demographic information. This study does not address equity in terms of the payments received across sectors, but provides discussion on how equity may be impacted for producers within the same sector. The timeliness of AgriStability in addressing margin declines was also examined, and it was found that the reliance on the collection of tax data for processing AgriStability payments results in the average payment to producers being sent ten months after the end of the tax year.

Chapter 5

Methods, Data & Assumptions

This chapter outlines the methodology for stochastic budgeting applied to a Monte Carlo simulation. Monte Carlo simulation generates distributions of outcomes based on uptake of various combinations of programs. Applying the risk aversion methodologies outlined in the previous section, the distributions are compared to determine which combination of programs (or possible if no program) leaves the producers "better off". Data Sources

5.1.1 Data for Random Variable Simulations

Argentine canola, red spring wheat and soybean mean yields and standard deviations are provided by soil zone for AgriInsurance risk area 12 in Manitoba from 2010 to 2019 (Pascal, 2020; Wilcox, 2020). The yields and summary statistics are shown in Table 5.1 below.

Table 5.1 – Yield Statistics (tonnes/acre) by Year for AgriInsurance Risk Area 12, Soil Zone D

	MEAN YIELD			**STANDARD DEVIATION**		
Year	**Canola**	**RSW**	**Soybeans**	**Canola**	**RSW**	**Soybeans**
2010	0.644	1.099	0.914	0.348	0.429	0.251
2011	0.573	0.979	0.704	0.259	0.391	0.228
2012	0.712	1.645	1.018	0.137	0.259	0.171
2013	1.109	1.785	1.109	0.213	0.274	0.165
2014	0.977	1.654	0.947	0.279	0.381	0.196
2015	0.977	1.657	1.089	0.220	0.293	0.204
2016	0.878	1.488	1.179	0.266	0.362	0.286
2017	1.223	2.140	0.913	0.159	0.279	0.174
2018	1.116	1.829	0.806	0.165	0.299	0.205
2019	1.072	1.747	0.710	0.177	0.304	0.208
Mean	0.928	1.602	0.939	0.222	0.327	0.209
Std Dev.	0.209	0.325	0.156	0.062	0.056	0.036
CV	0.225	0.203	0.166	0.281	0.170	0.172
Min	0.573	0.979	0.704	0.137	0.259	0.165
Max	1.223	2.140	1.179	0.348	0.429	0.286

Periods (T)	10

Adapted from: Wilcox (2020)

Risk area 12 and soil zone D were selected as the AgriInsurance areas of interest for this study because this area is the largest AgriInsurance area in Manitoba. In 2019, 2.1 million acres were insured in risk area 12, representing 21.7% of total insured acres in Manitoba. The importance of this risk area in terms of the crops grown is highlighted in the insurance coverage provided; in 2019, risk area 12 crops had a combined insured value of approximately $685 million, representing 24% of MASC's total liability (Pascal, 2020). Canola, red spring wheat, and soybeans represent approximately 65% of the acres in risk area 12, with soil zone D containing most of the acres, as shown below. As shown on the map in Appendix A; risk area 12 is an agriculturally rich area in south-central Manitoba.

Table 5.2 – 10-Year Average Acres by Risk Area 12 Soil Zones

Soil Zone	Canola	Red Spring Wheat	Soybeans
A	0	0	0
B	4,654	4,147	6,422
C	121,905	84,836	125,027
D	210,367	154,085	227,911
E	129,581	94,476	142,887
F	18,508	11,726	15,407
G	3,767	2,571	2,007
H	2,496	1,275	696
I	2,490	1,671	697
J	2,246	685	512
Total	**496,014**	**355,472**	**521,566**

Adapted from: Wilcox (2020)

The nature of the data does create a notable limitation of this study and disqualifies the use of the MVE distribution for modelling. The yields at the risk area level are aggregated and do not necessarily represent the yield distribution that the individual producer faces. For example, the possibility of facing a zero yield is likely not included in the distribution (Janzen 2008). While individual yields are the solution to this problem, it was not possible to obtain the values at the farm level. Returns experienced by the model farm are more reflective of the area's returns and not necessarily those faced by individual producers in risk area 12. Because of this, a multivariate normal (MVN) distribution is used, as it still incorporates the correlations between yields of the different crops and does not require a highly granular dataset. This representation of yield (shown in Equation 5.2) is based on a mean centered on the average yield for the soil zone in the risk area; however, the standard deviation of the yields presents a challenge. Using only the standard deviation of the average yields over the 10-year period, the standard deviation becomes reflective of the deviation about the area's average, and not the individual producer-level standard deviation. To address this, the farm-level standard deviations of yields in each year by risk area and soil zone were also obtained. A mean farm-level standard deviation is calculated, as shown in Table 5.1 above. This standard deviation is applied to the normal distribution.

While the MVE would have been the ideal distribution for modelling the yields, a MVN is used for this study due to data limitations. While limitations of yield means and standard deviations were discussed in the paragraph above, the covariance of yields and crop prices has yet to be considered to ensure that the relationships between these values is not being omitted from the distribution, which would result in a misspecification of the model. To test this, an intra-temporal correlation matrix was created that compared the correlations between all three crops' yields and the commodity price for each crop at the time of harvest (October) – with the commodity prices divided by the Canadian Consumer Price Index (CPI) to remove inflationary correlations. The results are shown below, along with their corresponding t-statistic below:

Table 5.3 – Intra-Temporal Correlation Matrix and t-statistics of Correlation for Commodity Yield and Price

	Canola Yield	**Red Spring Wheat Yield**	**Soybean Yield**	**Canola Price**	**Red Spring Wheat Price**	**Soybean Price**
Canola Yield	1	0.914	0.106	-0.591	-0.658	-0.389
		6.380*	0.301	2.075	2.469*	1.194
Red Spring Wheat Yield		1	0.193	-0.312	-0.455	-0.122
			0.556	0.929	1.446	0.348
Soybean Yield			1	0.130	-0.254	0.276
				0.372	0.742	0.813
Canola Price				1	0.819	0.922
					4.037*	6.748*

Red Spring Wheat Price					1	0.660 2.487*
Soybean Price						1

*Denotes statistical significance at the 95% confidence level

Because of the low correlations between the yield and harvest-time commodity prices, the covariance of the two can be ignored. Results shown in the table are in accordance with expectations, given that Manitoba commodity production should have limited influence on the global pricing of commodities, as it relates to supply and demand.

Historical prices were obtained from Statistics Canada, dating back to January 2009. These were the average monthly farm-level prices for canola, wheat, and soybeans in Manitoba. These prices are then used to calculate the log normal returns from month to month to apply for the calculation of the volatility term σ and drift term μ shown in the formula for simulating price, Equation 5.3.

5.1.2 Cost of Production Data

Manitoba Agriculture and Resource Development's Cost of Production estimates for the 2015 - 2020 crop years (Manitoba Agriculture and Resources Development, 2020) are used to carry out the farm's cost per acre calculation, as well as to determine the farm's reference margin per acre for AgriStability benefits. For the purposes of determining net profit per acre, MARD's Cost of Production spreadsheet is modified to only include expenses eligible for AgriStability. A summary of allowable income and expenses for AgriStability is found in Appendix C. Expenses deemed eligible are directly attributable to the production of allowable income, such as crops and livestock. (AAFC, 2013b).

Non-allowable expenses are excluded from the AgriStability equation because they are equally done on all farms or can be the result of management decisions; ultimately, these costs do not contribute directly from the production of a commodity. For example, the decision to purchase a new piece of equipment and the resulting capital cost allowance is the management decision an individual producer may make; however, it is not a cost directly resulting from deciding to produce a commodity generating an eligible income. Rather, it is a decision that the individual has made; including these types of expenses in the AgriStability calculation can create moral hazard by allowing producers to manipulate their expenses to decrease their program margins relative to the reference margins.

It should be noted that the Cost of Production Insurance Model applies expenses not eligible for AgriStability (land expenses, taxes, interest, etc). This is because the price guarantee is set at the provincially determined marginal cost per tonne of production and therefore includes an estimate of the total cost of producing a single tonne of each crop. However, for the purposes of comparing the net profit per acre of the revenue insurance model to the other models, the AgriStability-eligible expenses per acre are those considered even for the revenue insurance model.

It is important to note for the purposes of this study that reference margin limit would likely have minimal effects on CAP AgriStability programs, assuming crop production practices and input use are similar across producers of the same commodities. Cost of inputs for crops per acre that are covered by AgriStability (e.g. seed costs, fertilizer, fuel, etc.) would be low in variability from operation to operation. This consistency explains non-production expenses that are highly variable from farm to farm, such as capital cost allowances and machine expenses, are not considered eligible for AgriStability, in order to adhere to the BRM principle of equity across commodities and regions (AAFC, 2008). For reference margin limit to be applied in lieu of reference margin, the average eligible expenses for all crops must be less than the reference margin (average income minus average expenses), meaning that reference margin limit only caps the reference margin when average allowable expenses are low relative to the average allowable income. Therefore, it is assumed that the effects of reference margin limit (and subsequently the need for the limit on the reference margin limit) would be limited for grain and oilseed producers.

5.2 The Model

This study creates a model farm using a stochastic budgeting hybrid model. This model simulates distributions of outcomes for per-acre farm profits over 1000 iterations, using Monte Carlo simulation. Monte Carlo simulation is a common approach to farm problems, where an objective function is defined and input variable values are generated at random based on the mean and standard deviations of distributions of the input variable (Anderson, Dillon & Hardaker, 1977). This simulation is used to generate stochastic price and yield outcomes based on the production of the top three crops in Manitoba in terms of acreage and value of production:

canola, red spring wheat and soybeans (Manitoba Agriculture and Resources Development, 2018). Following Turvey (2012), crop proportions are set at 50% wheat, 25% canola and 25% soybeans, based on agronomic considerations of 4-year rotations of canola. These randomized variables contribute to the overall model output of farm profits.

Net revenue generation for the Monte Carlo simulation was based on the following formulas:

(5.1) $R_{ij} = \sum_{i=1}^{n} \left(Y_{ij}P_{ij} - C_i\right) * b_i$

(5.2) $Y_{ij} = N\left(E(Y_i), cov(Y_i)\right)$

(5.3) $P_{ij} = P_{io}e^{\left(\mu - \frac{1}{2}\sigma^2\right)\frac{7}{12} + \sigma N(0,1)\sqrt{\frac{7}{12}}}$

where R_{ij} is the net revenue per acre, as the sum of crops *i* for iteration *j* multiplied by the proportion of the farm's crop b_i. Y_{ij} is the yield of crop *i* over iterations j, P_{ij} is the price received, and C_{ij} is the AgriStability-eligible cost per acre for crop *i*. The $cov(Y_i)$ term accounts for the covariance in yields between all three crops produced. The process for simulating prices is a Geometric Brownian Motion, proposed by Turvey (2012) in his whole farm insurance study. P_{io} is the price in March of 2020, which is multiplied by a log normal process. The log normal process involves a drift term μ – calculated as the mean of the returns multiplied by mean log return times the number of months (7). The volatility is given as σ, calculated as the standard deviation of the returns multiplied by the square root of 7. A random variant term is also applied assuming a normal distribution with mean = 0 and standard deviation = 1.

The 1,000 iterations to create the distribution of outcomes are repeated four times, to encompass four separate risk management scenarios applying BRM programming: 1) no programs used, 2) AgriInsurance used, 3) AgriStability used and 4) both AgriInsurance and AgriStability used. Additionally, two other scenarios are used to generate revenues: the revenue-only AgriStability model and the hybrid production/margin insurance program. The distributions are compared across all scenarios to determine which programs and combinations thereof contribute to producer targets of profit maximization. Additionally, government expenditures and premiums collected are considered for the various combinations to determine government cost impacts of various programming options.

Several assumptions are applied to the model to simplify the simulation. First, the farm acts entirely within the crop year, with inputs and outputs being entirely acquired or produced and used or sold within the calendar year. The farm sells all of the crop produced in the crop year; that is, the producer does not carry forward any inventory for sale in the following year and does not have any forward or futures contracting for delivery of crops in a year following the year of production. The farm also buys all inputs in the same year of production, so that there are no accrued input costs to consider; the production costs given in the crop year are incurred entirely in the crop year. Second, market revenues are simply calculated as the yield multiplied by the price received; there is no contracting or hedging of prices that occurs in this scenario.

Per-acre costs by crop are deducted from the market revenues received to determine the net revenue per acre. The hybrid model then includes a multiplication of the net revenue by each crop's share of the farm's crop mix, to obtain a single net revenue per acre value, which is then used to determine AgriStability payments due. It is important to note that the expenses considered under the costs are those that are eligible for AgriStability, i.e. costs that are directly associated with the production of the farm outputs and not those resulting from farm managerial decisions, such as land rents and machinery purchases.

5.2.1 Modelling the Existing BRM Programs

Section 2.3 discusses the determination of coverage for both AgriStability and AgriInsurance under the three frameworks featuring BRM programs. This section details the calculations for AgriStability program year margins (PM), reference margins (RM) and reference margin limits (RML). AgriInsurance calculations are also outlined below. This serves as the basis for building the optimization models.

5.2.1.1 AgriStability Modelling

AgriStability payments are based on the program year's margin, relative to the farm's historical margin, referred to as the reference margin. AgriStability program margins are the margins for the program year of enrolment, ending at the farm's fiscal year end as reported to Canada Revenue Agency (AAFC, 2013b). Program margins are equal to the sum of allowable income minus the sum of allowable expenses. Allowable incomes and expenses are those directly attributed to production, reducing the opportunity for moral hazard activities that could trigger payments.

The program margins are adjusted for accruals in purchased inputs, crops and livestock inventory valuation changes and accounts payable and receivable at the start and end of the program year. Purchased inputs are allowable expenses that may be purchased during the current program year, but would be used in the following program year. Crop and livestock inventory valuation changes are the net valuation change of the livestock that the producer reported in starting inventory at the beginning of the year versus at the end of the year. The inventory valuation may change based on the number of animals or quantity of a commodity in inventory and/or the value of the commodity from the start of the year to the end. Accounts payable and receivable are bills where the producer has either purchased or sold an allowable item but has not yet paid or received payment as of the end of the program year. An example of program margin calculation is shown in Table 5.6 below.

Table 5.4 – Example AgriStability Program Margin Calculation

Program Year Allowable Income	$130,000
Program Year Allowable Expenses	($90,000)
Unadjusted Program Margin	$40,000
Accruals - Net Increase (Decrease) in:	
Purchased Inputs	$1,000
Accounts Receivable	($6,000)
Accounts Payable	$4,500
Crop Inventory Valuation	($1,000)
Livestock Inventory Valuation	($3,500)
Program Year Margin	$35,000

Source: AAFC, 2013b

For most producers, the reference margin is based on the program margins for the previous five years, adjusted for structure change, with the highest and lowest margins dropped. Table 5.7 shows a simple example of reference margin calculation. Reference margin limit applies when the average allowable expenses for the three reference margin years is lower than the calculated reference margin. In Table 5.7, the average allowable expenses for the three applied years is $85,000, which is lower than the calculated reference margin. Therefore, the applied reference margin would be capped at the reference margin limit of $85,000 under GF2. The reference margin limit would also be binding under CAP parameters because the reference margin limit reduces the applied reference margin by less than 30%. The applied reference margin is the trigger level, where if program margin falls below the applied reference margin, payment is calculated.

Table 5.5 – Example AgriStability Reference Margin Calculation

Reference Year	*Allowable Income*	*Allowable Expenses*	*Accrual Adjustment*	*Reference Margin*	
1	$140,000	$80,000	$20,000	**$80,000**	
2	$90,000	$50,000	($10,000)	$30,000	*Reference Year dropped
3	$140,000	$60,000	$20,000	**$100,000**	
4	$190,000	$65,000	($5,000)	**$120,000**	
5	$200,000	$90,000	$15,000	$125,000	*Reference Year dropped
	Sum Included Reference Margins =			$300,000	
	Reference Margin* =			$100,000	
	Average Allowable Expenses =			$85,000	
	Applied Reference Margin =**			**$85,000**	

**Applied Reference Margin under GF*

***Applied Reference Margin under GF2/CAP*

Adapted from: AAFC, 2013b

Mathematically modelling AgriStability indemnities is as follows:

(5.4) $$AgriStability = 0.70\ x \min\left[0.70K, 0.70K - \sum_{i=1}^{n} R_{ij}, Max\left(0.70\ x\ 0.70K, (C_i)\right)\right]\ x\ Q_{\left(\sum_{i=1}^{n} R_{ij} < 0.70K\right)} + 0.70\ x\ ABS\left[0 - \sum_{i=1}^{n} R_{ij}\right]\ x\ Q_{\left(\sum_{i=1}^{n} R_{ij} < 0\right)}$$

where R_{ij} is the net revenue per acre for the iteration, x_{ij} is the number of acres, C_{ij} is the AgriStability-eligible cost per acre and K is the historical reference margin. (C_i) is the average cost of eligible expenses during the reference (used for the cost generation, above). Q_A is a discrete-state variable that is 1 if the condition A is true and 0 if the condition A is false. That is, if program margin is negative, then Q_A =1 and the second part of the AgriStability equation determines negative margin benefits.

The "max" condition above evaluates the application of the reference margin, the reference margin limit or reference margin limit on limit as the determinant of the support level.

However, given that crop production expenses per acre are high relative to revenues per acre, it is unlikely that reference margin limit and limit on reference margin limit conditions make a significant impact in this study.

The participation fee for AgriStability under GF2 is $3.15 per $1,000 of RM covered multiplied by 70%, plus a $55 administrative cost share fee (Slade, 2020). Mathematically,

$$(5.5) \quad Z = 0.70\left(3.15 * \frac{K}{1000}\right) + 55$$

Another parameter change for AgriStability that is built into the CAP model is a minimum payment of $250, increased from $10 in the previous frameworks.

The modelling of AgriStability requires both current and historical data. The modelling of "current" data is addressed in equations (5.1), (5.2) and (5.3). Modelling of the historic data for AgriStability reference margins combines past price data, historical yield data for the risk area, and the expense information from Manitoba Agriculture and Resource Development. Table 5.8 below summarizes the data applied for the AgriStability calculation, with and without the use of AgriInsurance:

Table 5.6 - AgriStability Reference Margin Data

Without AgriInsurance

Ref. Year	P_{Canola}	Y_{Canola}	C_{Canola}	$Margin_{Canola}$	P_{RSW}	Y_{RSW}	C_{RSW}	$Margin_{RSW}$	$P_{Soybeans}$	$Y_{Soybeans}$	$C_{Soybeans}$	$Margin_{Soybeans}$	Production Margin
2015	$465.95	0.950	$228.96	$213.72	$226.29	1.636	$187.21	$182.98	$370.83	1.08	$172.14	$226.91	$201.65
2016	$467.63	0.855	$239.53	$160.31	$221.02	1.449	$188.55	$131.70	$414.37	1.17	$173.49	$312.56	$184.06
2017	$488.08	1.204	$244.74	$342.94	$257.33	2.089	$185.16	$352.41	$397.23	0.90	$184.95	$174.51	$305.57
2018	$477.19	1.104	$231.86	$294.98	$250.88	1.815	$187.68	$267.66	$409.04	0.83	$185.20	$152.66	$245.74
2019	$443.77	1.047	$248.90	$215.68	$234.57	1.712	$208.71	$192.90	$368.84	0.70	$193.93	$64.65	$166.53
												Reference Margin	$210.49

With AgriInsurance

Ref. Year	P_{Canola}	Y_{Canola}	C_{Canola}	$Margin_{Canola}$	P_{RSW}	Y_{RSW}	C_{RSW}	$Margin_{RSW}$	$P_{Soybeans}$	$Y_{Soybeans}$	$C_{Soybeans}$	$Margin_{Soybeans}$	Production Margin
2015	$465.95	0.950	$250.23	$192.45	$226.29	1.636	$202.02	$168.17	$370.83	1.08	$194.79	$204.26	$183.26
2016	$467.63	0.855	$254.49	$145.35	$221.02	1.449	$200.37	$119.88	$414.37	1.17	$195.80	$290.25	$168.84
2017	$488.08	1.204	$252.85	$334.83	$257.33	2.089	$192.47	$345.10	$397.23	0.90	$198.77	$160.69	$296.43
2018	$477.19	1.104	$239.45	$287.39	$250.88	1.815	$195.20	$260.14	$409.04	0.83	$202.67	$135.19	$235.72
2019	$443.77	1.047	$256.37	$208.21	$234.57	1.712	$216.42	$185.19	$368.84	0.70	$206.59	$51.99	$157.65
												Reference Margin	$195.94

5.2.1.2 AgriInsurance Modelling

AgriInsurance indemnities can be modelled as follows:

(5.6) $AgriInsurance = \left(E(Y_i) * IPI * \lambda - Y_{ij}\right) * P_{io}$

where $E(Y_i)$ is the area average yield, IPI is the individual producer's productivity index, and λ is the producer's selected coverage level (50%, 70%, or 80%). Equation 5.6 represents the shortfall between the expected yield (modified for coverage) minus the actual yield. The AgriInsurance indemnity equals 0 when the formula above evaluates to a number less than or equal to zero, indicating the Y_{ij} exceeds the yield guarantee of $(E(Y_i) * IPI * \lambda$, yielding

(5.7) $AgriInsurance = \max\left(0, \left[(E(Y_i) * IPI * \lambda) - Y_{ij}\right]\right) * P_{io}$

5.2.1.3 BRM Modelling for the Whole Farm

When modelling BRM on a whole farm, it is important to note that AgriInsurance premiums are considered as part of per-acre expenses, and the AgriInsurance indemnity is considered as part of the allowable income, to avoid double-indemnification. Premiums are calculated on a per acre basis (MASC, 2020) and are provided by MASC. Indemnities are calculated based on a shortfall of Y_{ij} relative to the coverage level $E(Y_i)$. Essentially, the new net revenue formula replacing the revenue formula in the *Simulation and Farm Modelling* section above is now for the purposes of AgriStability indemnities:

(5.8) $R_{ij}^1 = \sum_{i=1}^{n}\left(Y_{ij}P_{ij} + AgriInsurance - C_i\right) * b_i.$

The farm's total net profit model per acre, including indemnities for the program year is:

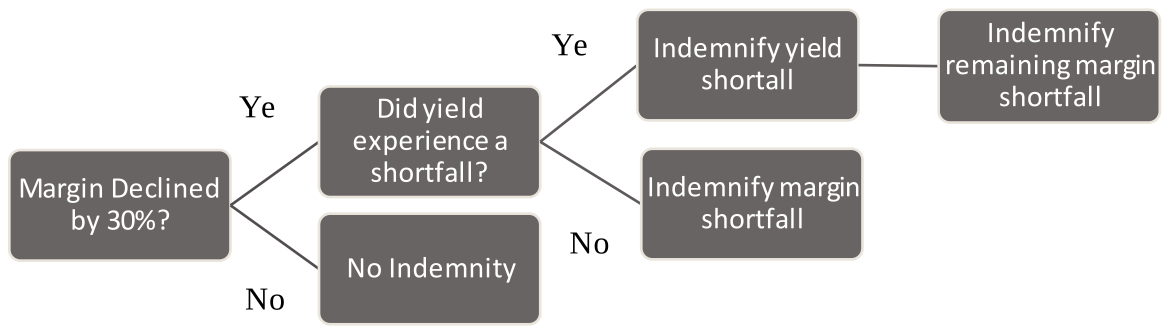
(5.9) $\pi = \sum_{i=1}^{n} (R_{ij}^1 + AgriStability).$

5.2.2 Modelling Proposed BRM Program Enhancements

5.2.2.1 Modelling the Combined Margin – Yield Insurance Model

Recall from section 3.1, that the structure of this model is similar to the existing combination of AgriStability and AgriInsurance participation. However, this model combines both programs into a "single sign-up" model, where participation in revenue insurance forces participation in yield insurance, and vice versa. To trigger a payment under this scenario, the margin must decline by 30%, in which case the yield shortfalls are first considered, followed by the margin shortfalls. The scenario is best represented with the following decision tree:

Figure 5.1 - Decision Tree for Indemnity Calculation of Combined Yield-Margin Insurance Model



Represented mathematically, indemnification can be represented as:

(5.10) $Indemnity_{Yield} = \max\left(0, \left[(E(Y_i) * IPI * \lambda) - Y_{ij}\right]\right) * P_{io} \ x \ Q_{(\sum_{i=1}^{n} R_{ij} < 0.70K)}$,

where Q_A is a discrete-state variable that is 1 if the condition A is true and 0 if the condition A is false. Now the yield indemnity is considered for the remaining margin shortfall, such that:

(5.11) $Indemnity_{Margin} = 0.70 \ x \min\left[0.70K, 0.70K - \sum_{i=1}^{n}(R_{ij} + Indemnity_{Yield}), Max\left(0.70 \ x \ 0.70K, (C_i)\right)\right] \ x \ Q_{(\sum_{i=1}^{n} R_{ij} < 0.70K)}$,

and the final net revenue calculation for the farm under this combined program is as follows:

(5.12) $\pi = \sum_{i=1}^{n}(\mathrm{R_{ij}} + Indemnity_{Yield} + Indemnity_{Margin})$.

5.2.2.2 Modelling the Cost of Production Insurance Model

The Cost of Production Insurance Model compares the expected cost per acre to the market price received per acre and calculates an indemnity on the shortfall. The coverage per acre can be given as,

(5.13) $Coverage_{RI} = \sum C_i$

where the coverage is equal to the sum of all expenses C for crop i in the year. The coverage for the year is based on the estimated cost of production generated by Manitoba Agriculture. Not that there are no program costs associated with participating in this program; actuarial analysis would be required and that is beyond the scope of this thesis.

It is unrealistic to expect that a full coverage program would require a similar BRM funding envelope was what is currently provided to AgriStability. Considering that AgriStability payments can be triggered simply because of large cost increases, a coverage parameter will be applied to the Cost of Production Insurance model:

(5.14) $Coverage_{RI} = MC_i * f = \sum C_i$

Where f is the program parameter for the percentage of the marginal cost that is guaranteed.

The indemnity calculated at the end of the crop cycle is determined as,

(5.15) $Indemnity_{RI} = \max(0, Coverage_{RI} - P_{ij} * Y_{ij})$

The indemnity is a function of the revenue on a per acre basis (price per tonne multiplied by tonnes per acre) and the cost of production per acre. For the purposes of this model, the indemnities are also multiplied by each crop's share of the total farm's production, so that the total indemnity from the revenue insurance model is,

(5.16) $Indemnity_{RI} = \max(0, Coverage_{RI} - P_{ij} * Y_{ij}) * b_i$

5.3 Time Value of Money Analysis

Perceived timeliness of payments is a measure used by AAFC to evaluate producer opinions of the BRM programs (see Table 1.1). To evaluate the value of timeliness of payments, the net present value of receiving the money at an earlier date versus the later date can be determined. This is done by discounting the cash received by a discount rate and determining the difference between the discounted value versus the total value of the "investment", in this case the AgriStability, revenue insurance, or AgriStability-AgriInsurance Hybrid models. The time value of money for these three programs is examined because AgriStability timeliness is a long-cited concern, but there are fewer issues with timeliness surrounding the existing AgriInsurance program. Given that the hypothetical Revenue Insurance and AgriStability-AgriInsurance Hybrid models are being analyzed in this thesis, the time value of money is compared to the time value of AgriStability payments to determine which programs would result in greater benefits in terms of timelier payments.

Net present value is calculated as,

(5.17) $\text{NPV} = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t}$,

where R_t is the cash inflow for the period, i is the discount rate, and t is the time period in which cash flows occur (Fernando, 2020). In this case, NPV represents the January value compared to what the benefit would be worth in October, which is the month that most producers receive AgriStability payments (Slade 2020).

Chapter 6

Results

Based on the results of the simulation, the model farm is likely to have an average year and, as a result, the impacts of program participation are not as beneficial as they would be in a year of below normal prices or yields. The likelihood of payment is less than 50% for all scenarios but one (Cost of Production Insurance), and the means of the simulated variables fall in line with historical average harvest prices and yields. Furthermore, the likelihood of payment from AgriStability-related scenarios is lower due to high reference margins of $210.49 and $195.94 for the scenarios of AgriStability-only and combined with AgriInsurance, respectively, as shown in Table 5.8.

6.1.1 Stochastic Variable Summary

Monte Carlo simulation of these programs required the simulation of all stochastic variables, namely the prices and yields of wheat, canola and soybeans. Table 6.1 below shows the results of the stochastic yield simulation, suggesting that prices in the year following the analysis are anticipated to be close to average and yields appear to be average to above average. This suggests a lower likelihood that the representative farm would receive payments from any of the BRM programs.

Table 6.1 – Summary Statistics of Stochastic Variables, Price and Yield

	P_{Canola}	P_{RSW}	$P_{Soybeans}$	Y_{Canola}	Y_{RSW}	$Y_{Soybeans}$
Mean	$433.12	$238.29	$360.58	0.933	1.620	0.925
Std. Dev.	$35.18	$20.98	$41.90	0.215	0.333	0.337
CV	8.123	8.804	11.620	23.084	20.532	36.419
Skewness	0.093	0.185	0.446	0.191	0.098	0.009
Kurtosis	-0.284	-0.201	0.466	-0.080	-0.039	-0.001

Note: P is price per metric tonne, and Y is yield in metric tonnes per acre

Figures 6.1 and 6.2 below show the 10-year historical harvest price and average yield compared to the 2020 forecast to graphically demonstrate how the average forecasted value fits into the historical values. Figure 6.1 shows that 2020 harvest prices are forecasted using formula (5.3) to be somewhat lower than their 2019 values, and roughly average for the period.

Figure 6.1 - Price History and Forecast by Commodity

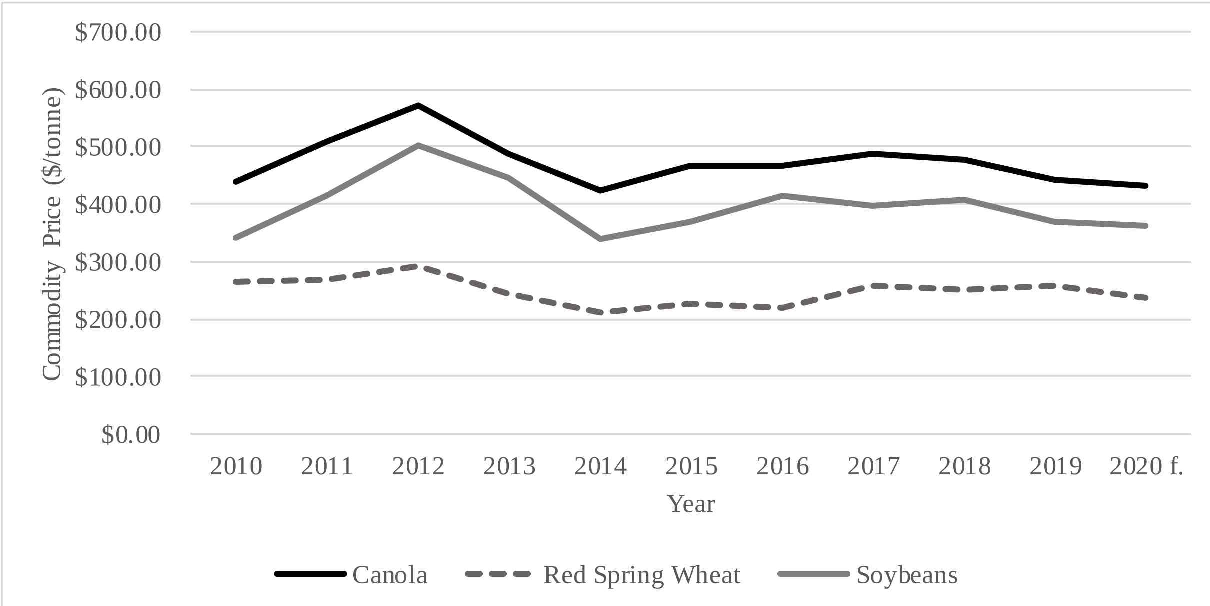
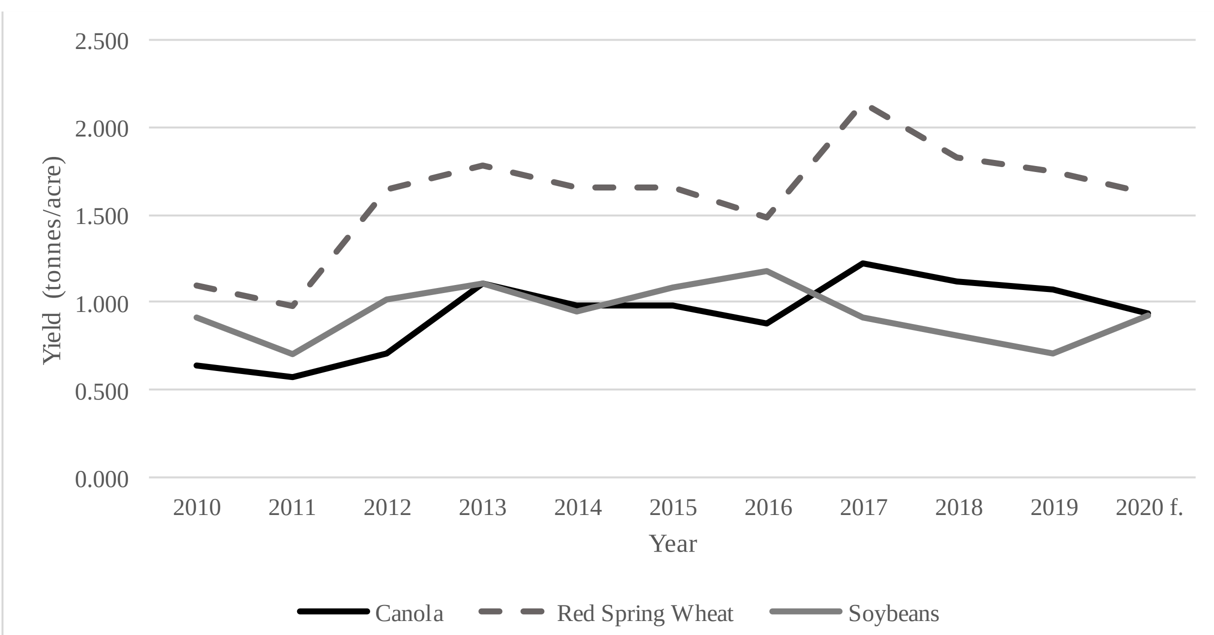


Figure 6.2 shows the average yield per acre and the 2020 yield per acre forecasted for the year, by commodity. The figure shows that yields for canola and red spring wheat are likely to continue their slow downward trend from the 2017 above average yields. The yields do support a continued overall upward trend during the time period. On the other hand, soybeans should see an increase in yield over their 2019 average, to return closer to the 10-year average yield.

Figure 6.2 - Yield History and Forecast by Commodity



Combining the price and yield stochastic simulations with production costs allows for the determination of net income distributions under various choices of risk management program use. To generate the net income, the forecasted harvest price is multiplied by the forecasted yield for each commodity and then the total costs per acre (fixed and variable) are subtracted to obtain the net income on a per-acre basis. The distribution of the net incomes under that various scenarios is explained further in Section 6.1.3.

6.1.2 Program Payment Summary

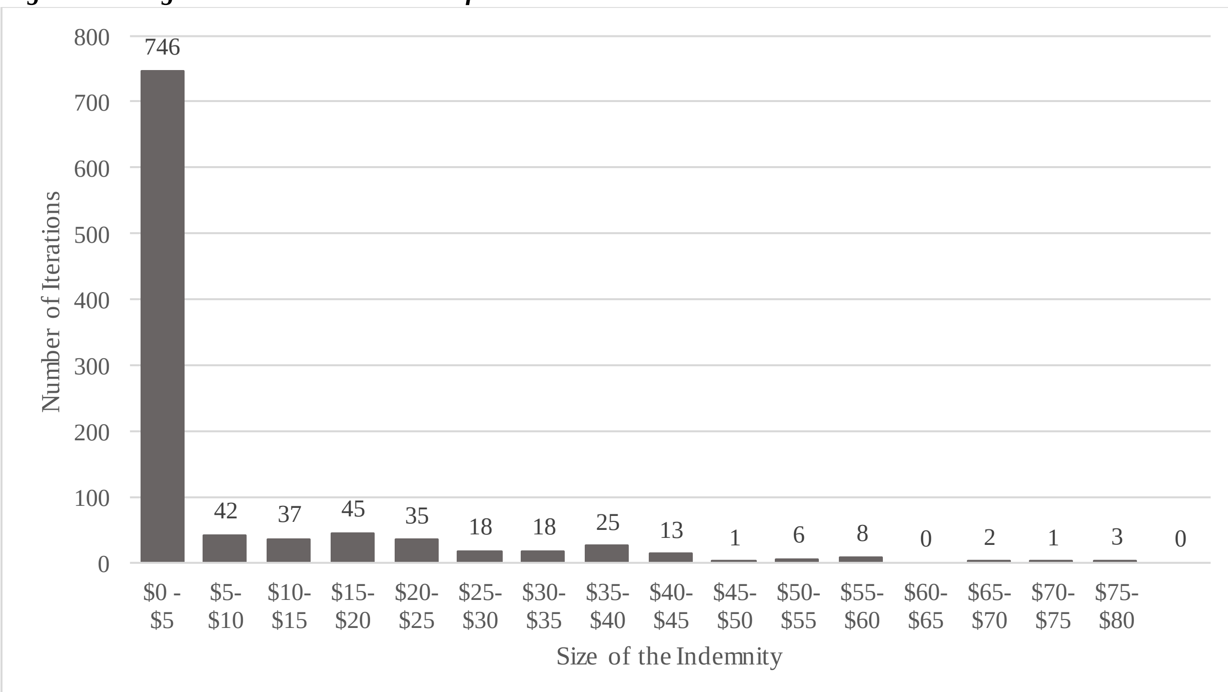
Table 6.2 summarizes the distributions of the payments received by scenario. The AgriInsurance only scenario generates the lowest payment to the farm, on average, while the Revenue Insurance model generates the highest payment. Additionally, the Revenue Insurance model has the coefficient of variation, a measure of standard deviation relative to the mean. This suggests that the model may be overly sensitive to commodities with higher marginal cost structures (lower net profit commodities). This is problematic in that the revenue insurance model may distort production decisions to lower net profit commodities such as wheat because of the high likelihood of payment, particularly if the payment scenario becomes more profitable than growing either canola or soybeans. Incentives are especially present for producers with lower than average cost structures, who would therefore spend less than the average producer to grow the crop and would also benefit from a payment based on the higher cost structure.

Table 6.2 - Summary Statistics of Program Payment Values

	AgriStability	AgriInsurance	AgriStability + AgriInsurance	Cost of Production Insurance	Combined Margin-Yield Insurance
Mean	$9.42	$6.38	$12.74	$45.64	$11.48
Std. Dev.	$17.97	$12.97	$20.98	$35.46	$21.12
CV (%)	190.7	203.2	164.7	77.7	183.9
Min.	$0.00	$0.00	$0.00	$0.00	$0.00
Median	$0.00	$38.29	$0.00	$0.00	$0.00
Max.	$102.91	$75.32	$120.26	$183.55	$120.26
Skewness	2.214	2.476	2.062	0.863	2.163
Kurtosis	4.945	6.365	4.609	0.487	4.888

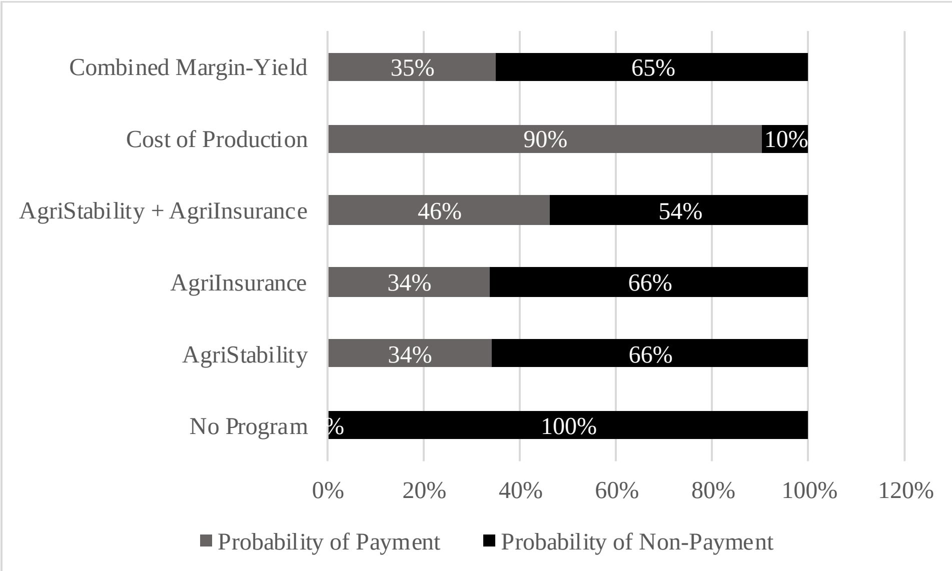
The AgriInsurance scenario has the lowest maximum of all the scenarios, while also showing a distribution with the highest kurtosis and skewness. In all instances, the skewness is positive, but in the AgriInsurance scenario, the skewness is furthest to the right. The kurtosis of the AgriInsurance scenario also suggests that the peak of the distribution is not high, with a lot of values falling into the tails of the distribution. The distribution is also asymmetrical, with most of the iterations falling between $0 and $5/acre in indemnity. The kurtosis implies that there is a high degree of probability of occurrence in the two tails of the distribution. Figure 6.3 models the distribution of outcomes, showing that the highest probability of payment is contained in the tails, which ultimately means that the probability of receiving a large payment is low.

Figure 6.3 – AgriInsurance Distribution of Outcomes



The probability of payment is shown in Figure 6.4 below. The highest likelihood of payment is for the Cost of Production program, which provides payment in 90% of the iterations. This further supports the issues identified with the program throughout this section. The AgriStability-only and AgriInsurance-only scenarios have a 34% chance of payment. The AgriStability + AgriInsurance combination pays out 46% of the iterations, while the Combined Margin-Yield Insurance pays in 35% of scenarios. This also supports that the farm is likely to have an average year, with less than 50% likelihood of payment under most scenarios.

Figure 6.4 - Probability of Payments by Scenario



6.1.3 Net Income Distribution

By combining the simulated harvest price and yield by commodity and subtracting all expenses, a net income per acre distribution is generated for 1,000 iterations over 6 program scenarios. Table 6.4 summarizes the net income distributions by program scenario. Without any risk management program, the expected value of the farm's net income is -$12.23 per acre. The use of AgriInsurance only actually results in a lower expected return per acre, attributable to the average negative returns from canola and red spring wheat policies – yields are anticipated at historical average levels, and this therefore reduces the magnitude of AgriInsurance payments when they are anticipated. Furthermore, the average premium per acre is $10.15, and the magnitude of weighted payments per acre is frequently less than the cost of participating, despite subsidized premiums.

Besides the Revenue Insurance scenario, which is expected to be the most profitable scenario, AgriStability is the closest scenario to a $0 expected value, which would be a breakeven scenario. The standard deviation for the AgriStability scenario is also the lowest of all scenarios, yet creates the largest coefficient of variation, given the mean close to $0.

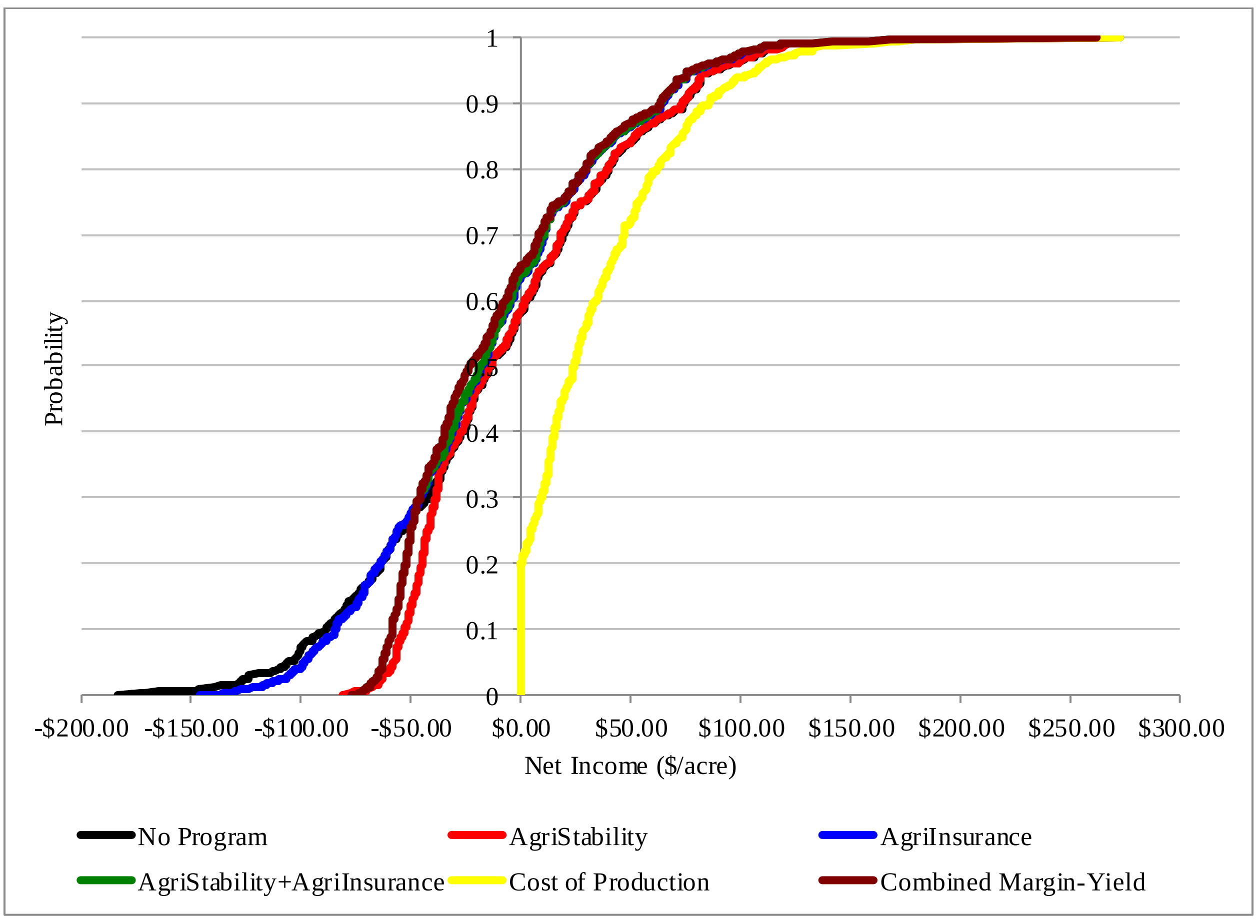
Table 6.3 - Net Income Distribution by Program Scenario

	No Program	AgriStability	AgriInsurance	AgriStability + AgriInsurance	Cost of Production Insurance	Combined Margin-Yield Insurance
Mean	-$10.82	-$1.92	-$14.58	-$8.74	$34.82	-$10.00

Std. Dev.	$61.77	$49.77	$56.21	$48.32	$36.88	$48.34
Min.	- $183.55	-$81.16	-$146.21	-$77.09	$0.00	-$77.09
Median	-$13.51	-$14.03	-$18.28	-$18.80	$24.02	-$23.39
Max.	$272.79	$272.27	$262.64	$262.12	$272.79	$262.12
Skewness	0.27	1.10	0.55	1.16	1.62	1.21
Kurtosis	0.55	1.68	0.82	1.92	4.18	2.01

In the case of no program, this scenario creates a positive return 42% of the time, second only to the Revenue Insurance model, which has a distribution truncated at $0 and has net incomes above $0 for 80% of iterations. AgriStability net income is positive 42% of the time, while the remaining scenarios generate net income greater than $0 less than 40% of the time. These returns are illustrated in the cumulative density function chart in Figure 6.5.

Figure 6.5 - CDFs of Program Scenarios



6.2 Stochastic Dominance and Efficiency Analysis

Until this point, analysis of the program possibilities describes the distributions of each of the program possibilities and the possible net incomes under each iteration for the potential programs used. This section now incorporates producer risk preferences and how this affects the value of the programs considering these producer preferences.

6.2.1 Stochastic Dominance Analysis

Producer risk preferences and their effects upon program value is also an important consideration when comparing programs. After plotting the CDFs of all program possibilities, as shown in Figure 6.4, the areas between the CDFs for each program can be compared to determine which programs are stochastically dominant. Table 6.6 below summarizes the second-degree stochastic dominance, as described in Chapter 4. The scenario considered is summarized in the left-hand column of the table, while the programs in which the considered scenario is being compared is contained in each column header. If the cells are blank, that implies that scenario considered on the right is not dominated by the scenario in the column.

The No Program scenario is the least preferred scenario in all cases except the AgriInsurance only scenario, which is the scenario that is not preferred to any other programs. The Cost of Production Insurance scenario is not dominated by any other scenarios, implying that it is the most preferred program.

Table 6.4 - Second Degree Stochastic Dominance Table by Scenario

	No Program	AgriStability	AgriInsurance	AgriStability+ AgriInsurance	Cost of Production	Combined Margin-Yield
No Program SDD:						
AgriStability SDD:	No Program		AgriInsurance			
AgriInsurance SDD:						
AgriStability+ AgriInsurance SDD:	No Program		AgriInsurance			Combined Margin-Yield
Cost of Production SDD:	No Program	AgriStability	AgriInsurance	AgriStability+ AgriInsurance		Combined Margin-Yield
Combined Margin-Yield SDD:	No Program		AgriInsurance			

6.3 Time Value of Payment Analysis

Assuming an interest rate of 0.20%, which is the interest rate on a Royal Bank of Canada (RBC) business savings account at the time of writing (RBC, 2021), the value of cash flows can be discounted, comparing a January payment to an October payment.

Table 6.5 below shows that the average value of a payment made in January versus October is 2.0% higher. That is, filing AgriStability information for indemnification at the current timing (Slade, 2020) results in a 2.0% loss of value.

Table 6.5 – Time Value of Payments by Program

Program	Value of Payment in January	Value of Payment in October	Percentage Increase by Receiving Payment in January
AgriStability	$9.42	$9.24	2.0%
AgriStability + AgriInsurance	$12.74	$12.49	2.0%
Revenue Insurance	$45.64	$44.73	2.0%
AgriStability - AgriInsurance Hybrid	$11.48	$11.26	2.0%

Because interest rates at the time of writing are so close to zero, a sensitivity analysis was completed to show the difference in values when payment is received in January versus October. The results are shown in Table 6.6 below. The higher the interest rate, the greater the difference in the value of the money when received in January versus when received in October.

Table 6.6 - Sensitivity Analysis of Interest Rates

Interest Rate	Additional Value of Payment Received in January
0.20%	2.0%
0.50%	5.1%
1.00%	10.5%
1.50%	16.1%
2.00%	21.9%
2.50%	28.0%
3.00%	34.4%
3.50%	41.1%
4.00%	48.0%
4.50%	55.3%
5.00%	62.9%

Chapter 7

Discussion and Conclusions

The objective of this thesis was to determine whether potential changes to BRM programming would increase program value to farmers, while adhering to Canada's obligations under international trade agreements and and not increasing support required from federal, provincial and territorial (FPT) budgets. This study examined the current BRM suite of programs and the value that would be provided to a producer by choosing to participate in AgriStability alone, AgriInsurance alone, and both programs. Additionally, two new potential programs/program enhancements were proposed, and the value of these programs was compared to the existing suite of programs.

Monte Carlo simulations were conducted for each of the program uptake scenarios (i.e. no program, AgriStability, AgriInsurance, AgriStability + AgriInsurance, Revenue Insurance, AgriStability – AgriInsurance Hybrid) to create a distribution of returns for each program uptake scenario. These distributions were compared to determine which programs provided the most value to producers, according to the highest net income scenarios. To ensure current FPT budgetary outlays were not increased, a parameter to pay out a percentage of the loss was placed on the revenue insurance model, and optimized to determine what percentage of each dollar of loss compensated would yield the same result as the AgriStability-AgriInsurance uptake model, as a base for what the FPT governments would prefer to maintain for BRM program expenditures.

It was determined that the proposed Revenue Insurance model provided the most value to producers, by providing the most significant payments and generating the highest mean net income. However, this program would be problematic if implemented as outlined in this study. The high rate of payments on wheat may potentially distort production toward wheat (and toward other commodities with higher cost structures) in order to trigger government payments.

Once the considerations for FPT budget constraints are made, the program at a 70% guarantee of marginal costs as a proxy for revenue per acre effectively eliminates the program's significant advantages in terms of net income and payments to producers. This analysis highlights the trade-off that must be made by the governments with respect to value to producers versus expenditures. It is unlikely that governments will be able to significantly increase the value of the BRM programs to producers without also increasing the level of expenditures assigned to BRM programming.

While the analysis shows that using the current BRM programs and the proposed BRM enhancement combining AgriStability and AgriInsurance does not create positive net income scenarios, on average, the use of these programs is still preferable to not using any risk management program at all.

7.1 Limitations of this Study and Areas for Further Research

There are several limitations to this study, particularly with respect to the assumptions required to simplify the representative farm so that it could be easily modelled. First, this representative farm does not employ any form of non-government risk management. The farm is assumed to sell all commodities immediately upon harvest and does not conduct any hedging activities in the forward or futures contracting markets. Many producers employ other risk management options to guarantee prices received, so this limitation potentially increases the likelihood of payment if this simulated producer received lower commodity prices for their crops than other producers employing other methods of price risk management.

It is also assumed that the farm does not grow any other crops other than canola, wheat and soybeans (by acreage, the three most common crops in Manitoba); however, growing a wider variety of crops can have benefits for risk reduction through diversification. Additionally, agronomic yield benefits of crop rotations were not considered in this study; however, it was assumed that farmers would follow agronomic best practices when choosing their rotations of canola, soybeans, and wheat. Producers that do not employ this practice may experience lower yields, that would result in lower revenues per acre and higher payments per acre.

This thesis also focused upon an average grain farm in a single calendar year in Manitoba. Year-over-year considerations are made by incorporating past yield and cost data to build reference margins, but this analysis did not consider how a farm that performs above or below average, in terms of costs of production and commodity marketing, would fare year-over-year. There are several factors that AAFC would need to consider for a new or modified program. First, AAFC would need to consider similar producers in terms of grain production, but how the programs would impact higher cost farms versus lower cost farms. Second, AAFC would need to consider regional impacts to determine whether farmers across various regions in Canada would be treated similarly based on their farming operation. Lastly, AAFC would need to evaluate the programs over the various types of production, such as livestock and mixed operations, and even other types of crop production. For the purposes of simplicity for this analysis, the assumptions about this farm simplified it into a grain farm in Manitoba growing the three most common commodities; however, this represents only a subset of farms in Canada.

Additionally, this study of program impacts on a producer is limited, in that the simulations are limited in quality by the data available for use. A multivariate normal distribution was applied to recognize the relationships between yields of various commodities; however, a multivariate empirical distribution may have been more effective for this type of simulation if a richer data set were available. The lack of real producer data imposes a limitation due to the fact that the crop yields used in the simulation represent averages for the risk area and are not an exhaustive list of yields realized in the area over the previous decade. While farm-level standard deviations were applied, it is unlikely that the simulation provided the truest distribution of outcomes that represented possible risks to this producer.

Ultimately, this thesis examines two potential alternatives to the current suite of BRM programs. Analysis of the Cost of Production insurance model showed that net distribution outcomes could be significantly improved over the current suite of programs; however, the program is too generous at a coverage level of 70% and could incentivize production of higher cost, lower return crops in an attempt to trigger government payments. The Combined Margin-Yield Insurance model provided a distribution of outcomes with a mean that exceed the scenario without any BRM programming applied and the AgriInsurance only scenario, but it did not improve upon the outcomes for the current AgriStability program alone, and AgriStability in combination with AgriInsurance. This thesis contributes to the dialogue surrounding the future of the BRM suite, by providing two examples of programming ideas that are unlikely to be effective replacements to the current programs.

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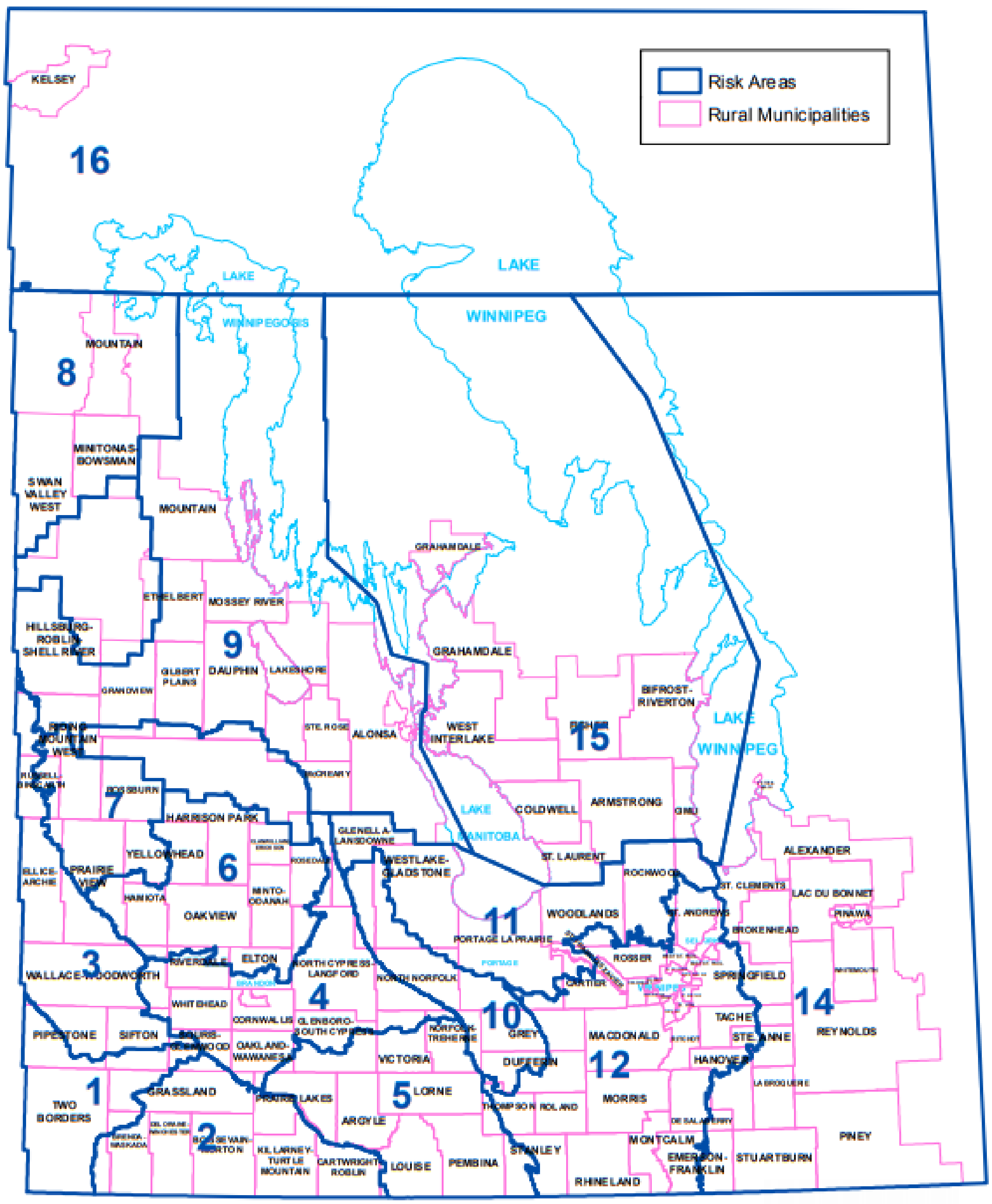
Appendix A:

Map of Manitoba Agricultural Services Corporation Risk Areas

Note: Risk Area 12 (South-Central Manitoba, in the Red River Valley) was the risk area applied for this study because it is a significant risk area in terms of grain crops grown and MASC liability.

RISK AREAS



Appendix B:

Summary of Formulas Used for Simulation

Basic Simulation Formulas:

(5.1) Revenue: $R_{ij} = \sum_{i=1}^{n} \left(Y_{ij} P_{ij} - C_i\right) * b_i$

(5.2) Yield: $Y_{ij} = N\left(E(Y_i), cov(Y_i)\right)$

(5.3) Price: $P_{ij} = P_{io} e^{\left(\mu - \frac{1}{2}\sigma^2\right)\frac{7}{12} + \sigma N\,(0,1)\sqrt{\frac{7}{12}}}$

Existing BRM Programming Formulas:

(5.4) AgriStability Indemnity :

$$AgriStability = 0.70\ x \min\left[0.70K, 0.70K - \sum_{i=1}^{n} R_{ij}, Max\left(0.70\ x\ 0.70K, (C_i)\right)\right] x\ Q_{(\sum_{i=1}^{n} R_{ij} x_i < 0.70K)} + 0.70\ x\ ABS\left[0 - \sum_{i=1}^{n} R_{ij}\right] x\ Q_{(\sum_{i=1}^{n} R_{ij} x_i < 0)}$$

(5.5) AgriStability Participation Fee: $Z = 0.70\left(3.15 * \frac{K}{1000}\right) + 55$

(5.7) AgriInsurance Indemnity: $AgriInsurance = \max\left(0, \left[\left(E(Y_i) * IPI * \lambda\right) - Y_{ij}\right]\right) * P_{io}$

(5.8) Whole Farm Revenue Including AgriInsurance Indemnity:

$$R_{ij}^{1} = \sum_{i=1}^{n} \left(Y_{ij} P_{ij} + AgriInsurance - C_i\right) * b_i$$

(5.9) Whole Farm Revenue Including AgriStability and AgriInsurance Indemnities:

$$\pi = \sum_{i=1}^{n} \left(R_{ij}^{1} x_{ij} + AgriStability\right)$$

Proposed BRM Enhancement Formulas:

Combined Margin-Yield Insurance Model:

(5.10) Yield Portion of the Indemnity:

$$Indemnity_{Yield} = \max\left(0, \left[\left(E(Y_i) * IPI * \lambda\right) - Y_{ij}\right]\right) * P_{io}\ x\ Q_{(\sum_{i=1}^{n} R_{ij} < 0.70K)}$$

(5.11) Margin Portion of the Indemnity:

$$Indemnity_{Margin} = 0.70\ x \min\left[0.70K, 0.70K - \sum_{i=1}^{n}(R_{ij} + Indemnity_{Yield}), Max\big(0.70\ x\ 0.70K, (C_i)\big)\right] x\ Q_{(\sum_{i=1}^{n} R_{ij} < 0.70K)}$$

(5.12) Farm Net Profit Per Acre:

$$\pi = \sum_{i=1}^{n} (R_{ij} + Indemnity_{Yield} + Indemnity_{Margin}) * b_I$$

Cost of Production Insurance Model:

(5.14) Cost of Production Insurance Coverage Level:

$$Coverage_{RI} = \sum C_i * f$$

(5.16) Cost of Production Insurance Indemnity:

$$Indemnity_{RI} = \max\big(0, P_{ij} * Y_{ij} - Coverage_{RI}\big) * b_i$$

Net Present Value of Payments:

(5.17) NPV = $\sum_{t=1}^{n} \frac{R_t}{(1+i)^t}$

Appendix C:

AgriStability Income and Expense Categorizations

AgriStability Allowable and Non-Allowable Income Items

Allowable Income	**Non-Allowable Income**
Agricultural commodity sales	Agricultural contract work
Rebates for allowable expenses	BRM and disaster assistance payments
Wildlife Damage Compensation program	Other program payments
AgriInsurance proceeds	Rebates for non-allowable expenses
Premium adjustment payments	Patronage dividends
CFIA payments	Interest
	Gravel
	Trucking
	Machinery rental
	Leases
	Resale of commodities purchased

Source: AAFC, 2013b and AAFC, 2020

AgriStability Allowable and Non-Allowable Expense Items

Allowable Expense	**Non-Allowable Expense**
Commodity purchases	Machinery repairs
Containers and twine	Agricultural contract work
Fertilizer and lime	Advertising and marketing costs
Pesticides	Building and fence repairs
Insurance premiums for crop production	Other insurance premiums
Veterinary fees, medicine, A.I. fees	Membership/subscription fees
Minerals and salts	Legal and accounting fees
Machinery (gasoline, diesel fuel, oil)	Non-arm's length salaries
Electricity	Office expenses
Freight and shipping	Motor vehicle expenses
Heating fuel	Small tools
Arm's length salaries	Soil testing

Storage/drying	Licenses/permits
Prepared feed	Telephone
Commodity Futures transaction fees	Machinery lease/rental
Commissions and levies	Land clearing and drainage
Trucking	Interest
	Property taxes
	Rent
	Quota
	Gravel
	Purchases of commodities resold
	Motor vehicle interest and leasing costs
	Allowable on eligible capital property
	Capital cost allowance
	Mandatory inventory adjustments
	Optional inventory adjustments
	Any other expenses not listed as allowable

Source: AAFC, 2013b and AAFC, 2020

Appendix D:

Example of Model Used to Simulate Distributions

Modelling 2020 Program Year						
Crop	**Crop Rotation**					
Canola	25%					
Red Spring Wheat	50%					
Soybeans	25%					
Expected Revenue Calculation						
Exogenous Parameters:	Canola	RSW	Soybeans			
PI Spring Price ($/tonne)	$445.00	$235.00	$380.00			
Yield Coverage (tonnes/ac)	0.864	1.492	0.795			
AgriInsurance Cov/Ac	$384.48	$350.62	$302.10			
AgriInsurance Premium	$12.17	$8.58	$11.25			
RI Price (P=MC/acre.)	$422.65	$381.24	$367.31			
Stochastic Parameters		Iteration #	818			
	Canola	RSW	Soybeans			
Harvest Price	$399.47	$228.05	$476.76			
Average Yield	0.662	1.501	1.128			
	Mkt Rev: Canola	Mkt Rev: RSW	Mkt Rev: Soybeans			
Revenue	$264.33	$342.36	$537.87			
Revenue/Acre	$371.73					
AgriInsurance						
Exogenous Parameters:	IPI	1	RA/Soil Zone	D12		
	Coverage Level	80%	Soybean Area	2		
	Yield Coverage	Dollar Coverage	Shortfall	Indemnity/Acre	Wtd Indemnity/Acre	Weighted Premium/Ac
Canola	0.691	$445.00	0.030	$13.13	$3.28	$3.04
RSW	1.194	$235.00	0.000	$0.00	$0.00	$4.29
Soybeans	0.636	$380.00	0.000	$0.00	$0.00	$2.81
Net Benefit/Acre					$3.28	
AgriStability						
	AS Only	AS+PI				
Reference Margin/Acre	$210.49	$195.94				
Revenue/Acre	$302.36	$307.94				
Expenses/Acre	$204.23	$214.38				
Program Margin	$98.13	$93.56				
Benefit	$34.45	$30.52				
Fee	$0.52	$0.49				
Net Benefit	$33.93	$30.03				
Revenue Insurance						
Exogenous Parameters:	Coverage Level	70%				
	Price Received	Price Guarantee	Shortfall	Weighted Cost	Wtd Indemnity/Tonne	
Canola	$275.46	$422.65	$147.18	$0.00	$36.80	
RSW	$309.27	$381.24	$71.98	$0.00	$35.99	
Soybeans	$315.45	$367.31	$51.86	$0.00	$12.97	
Payment/Acre					$85.75	
AgriStability-AgriInsurance Hybrid Model						
Exogenous Parameters:	Yield Coverage	80%	Revenue Coverage:	70%		
Margin Decline Trigger	30%					
Margin Decline:	55%					
Yield Insurance Indemnity Determination:		Y				
	Yield Coverage	Dollar Coverage	Shortfall	Indemnity	Weighted Indemnity/Ac	
Canola	0.691	$445.00	0.050	$22.31	$5.58	
RSW	1.194	$235.00	0.000	$0.00	$0.00	
Soybeans	0.636	$380.00	0.000	$0.00	$0.00	
					$5.58	*$0 if margin decline < trigger
Revenue Per Acre (pre-Yield)	$302.36					
Yield Insurance Top-up	$5.58					
New Revenue/Acre	**$307.94**					
Expenses/Acre:	$214.38					
Program Margin:	$93.56					
Margin Coverage:	$195.94					
Margin Indemnity:	$30.52					
Total Indemnity =	$36.09					

Overview of Program Selections:

	No Program	AgriStability	AgriInsurance	AS+PI	Rev Insurance	AS-PI Hybrid
Per Acre Income	**A**	**B**	**C**	**D**	**E**	**F**
Receipts						
Market Revenue						
Canola	68.87	68.87	68.87	68.87	68.87	68.87
RSW	154.63	154.63	154.63	154.63	154.63	154.63
Soybeans	78.86	78.86	78.86	78.86	78.86	78.86
Insurance Program Payments						
Canola						
Production Insurance	0.00	0.00	5.58	5.58	0.00	0.00
Revenue Insurance	0.00	0.00	0.00	0.00	36.80	0.00
RSW						
Production Insurance	0.00	0.00	0.00	0.00	0.00	0.00
Revenue Insurance	0.00	0.00	0.00	0.00	35.99	0.00
Soybeans						
Production Insurance	0.00	0.00	0.00	0.00	0.00	0.00
Revenue Insurance	0.00	0.00	0.00	0.00	12.97	0.00
Hybrid Insurance	0.00	0.00	0.00	0.00	0.00	36.09
Pre-AS Total						
AS Payment	0.00	34.45	0.00	30.52	0.00	0.00
Total Receipts	302.36	336.81	307.94	338.46	388.11	338.46
Per Acre Expenses						
AgriStability Allowable Expenses						
Canola	59.17	59.17	59.17	59.17	59.17	59.17
RSW	99.01	99.01	99.01	99.01	99.01	99.01
Soybeans	46.05	46.05	46.05	46.05	46.05	46.05
Participation Fees or Premiums	0.00	0.52	10.15	10.66	0.00	10.66
Total Allowable Expenses	204.23	204.75	214.38	214.90	204.23	214.90
Non-Allowable Expenses						
Canola	46.49	46.49	46.49	46.49	46.49	46.49
RSW	91.61	91.61	91.61	91.61	91.61	91.61
Soybeans	45.78	45.78	45.78	45.78	45.78	45.78
Total Expenses	388.11	388.63	398.26	398.77	388.11	398.77
	NoProg	AgriStability	AgriInsurance	AS+PI	RI	AS-PIHybrid
Net Cash Income	-85.75	-51.82	-90.32	-60.32	0.00	-60.32