Developing Area-Triggered Whole-Farm Margin-based Safety Nets

by

Abram Iskander

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University of Alberta

Abstract

The objective of this project was to consider the feasibility of possible alternatives to the current Agri-Stability program. These alternatives consist of customizable area-based whole-farm program where payments are based on a regional trigger. Problems, associated with designing a simple index, based on revenues across relevant commodities in a region, are considered and alternative strategies to implement the alterative program are developed. The analysis is both conceptual and backed up with stochastic simulations that test alternative approaches and consider trade-offs. Results show that there is a relatively high false negative probability of payouts due to spatial, design, other covariate, and idiosyncratic basis risks. The persistence of basis risk means that the uptake of an area-triggered program will be limited. Reducing basis risk will improve uptake, but this requires addressing design risk and spatial basis risk.

Acknowledgements

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Introduction

Agriculture businesses face complex risks from many different sources. Production risks drive yields of farms and can translate to catastrophic net incomes for farmers. Weather plays a large part in how a farm will operate and succeed each year. Crops need rain during root production and hot sun days when trying to grow out foliage. If the end of a season is too wet, crop harvests can be delayed because their machinery cannot get into the fields, and drying products for shipping requires extra processing costs. More recently, the world has experienced how labour constraints, due to a global pandemic, can bottle-neck harvests and value-added processing, increasing inventory carrying costs across supply chains. Some of these risks can be managed by new innovations such as crop genetics, or slaughterhouse automation, however, technology cannot perfectly predict the hazards or reduce the risks associated with agriculture. Risks in agriculture can also come from markets. Canadian producers compete in global markets, so exchange rates, trade disputes, tariffs, global supply and demand, can all affect profitability of farms in Canada. In 2019, canola produced in Canada was banned for export to the Chinese market, resulting in depressed prices for Canadian canola producers due to high inventories, until trade was restored or other export markets were realized.

Dealing with production and market risks are a part of any business, but agricultural businesses have relatively high levels of exposure to uncontrollable natural risks such as weather, diseases, and pests. Volatile operating incomes effects farm livelihoods since on-farm incomes are directly dependent on farm profitability. Agricultural producers take measures to reduce the level of risk exposure their business has by hedging losses using market instruments, investing in new technology, or by participating in income support, and insurance programs. In Canada, there are public and private income support programs in place to support farm income levels over time and to stabilize the income variability that many producers face. The focus of this study is on Canadian government (public) income support programs and to propose an alternative that could improve the mechanism, in Canada.

The Farm Income Problem

What makes agricultural incomes so unique that it warrants government support over other industries? Freshwater and Hedley (2005) suggest that previously it was the fact that farm income levels were much lower than other occupations and there was a push to close this income gap. As the income gap began to close between off-farm and farm incomes, the farm income problem became one of variability, and rate of return on farm investments. The authors suggest that even as income level increased over time, large income fluctuations year over year decreased a farm family's standard of living. The idea is that since there is a higher risk of return there should also be higher possible returns to average out the variability in incomes, compared to a less variable non-farm income. To address this issue either higher returns are made possible, or variability is reduced. Support programs in Canada, have shifted from a long-term focus of increasing farm income levels, to the short- and medium-term focus of stabilizing incomes. A survey of Agri-Stability participants, a government income support program (discussed in Section 0), indicated the primary benefits are managing income losses and even out income flows (Agriculture and Agri-Food Canada 2017).

There are two broad reasons to intervene in agricultural markets. The first is to redistribute income into agriculture. The second broad reason relates to addressing a market failure – in this case the absence of contingency markets to deal with excess risk. The concept of business risk management (BRM) seems to imply that the reasons for interventions revolve around risk management and missing markets. The exact objective is not explicitly stated and these programs are frequently viewed as income support (e.g. Lester (2018), OECD PSE). At best, there is confusion as to whether the programs are to support incomes or to bridge missing markets to manage risks. Producer groups typically ask for both stability and adequate incomes, which demonstrates a lack of clarity about the main objective of the program (Agriculture and Agri-Food Canada 2017). The lack of clear objectives leads to a violation of a fundamental principle, known as Tinbergen's rule. With this rule, efficiency requires that the number of policy instruments must equal the number of objectives. With a single policy instrument, and two policy objectives (income support and stabilization) there are bound to be trade-offs leading to suboptimal solutions. When the number of objectives exceeds the number of instruments not only is the policy not efficient, but the participants can never be satisfied. The history of safety-net reform since 1992, is one where whole-farm margin-based programs are designed, deemed to be inadequate, re-designed to essentially the same type of instrument, and the cycle goes on. Why does safety net program history keep repeating itself and why does the eventual new program become some version of an existing whole-farm income margin-based deficiency payment? The source of this continual producer dissatisfaction and resulting policy churn is a lack of clear objectives.

Canadian Support Programs

The current Canadian support programs are offered under the Canadian Agricultural Partnership (CAP) policy framework, which is an agreement between provincial and federal governments. Through CAP, the government offers BRM programs to manage production risks due to market volatility or disasters. The BRM programs and their objectives are as follows:

- **Agri-Stability** offers a whole farm income support program to farmers when they experience short-term, large margin declines from their historical incomes

- **Agri-Invest** functions as a savings account that encourages producers to save and have cash available income declines. A participant can contribute up to 100% of their Allowable Net Sales into the account, and the government matches 1% of the Allowable Net Sales.
- **Agri-Insurance** provides coverage of production losses caused by natural hazards. The program functions as a multi-peril crop insurance program. When a participant experiences production loss, from perils such as drought, flooding, wind, excessive rain, snow, disease, etc., the participant receives an indemnity
- **Agri-Recovery** helps producers with the costs of recovery after natural disaster events.

This paper focuses on the Agri-Stability program design, since it targets farm income support. The program is designed to reduce short term variability by comparing a farm's income to their own 5-year moving average income.

A benefit of the Agri-Stability mechanism is that indemnities can be accurate due to the direct income information that participants provide. Some costs with direct income information are administrative costs, transparency to farmers, and time costs between income shocks and indemnity payments. Payment amounts are not always transparent to farmers. The program evaluates incomes using accrual accounting methods which includes account receivables and payables, and inventory adjustments. Many farmers use cash accounting methods to track incomes which only recognizes revenues and costs when it changes hands. For example, a contract could be signed today to deliver product in 30 days and receive payment upon delivery. An accrual accounting record of today takes the payment as revenue received, since it is obligated through a contract, and the balance sheet would record the payment under accounts receivable. A cash accounting record of today would not record the revenue because technically no money has been received. In the cash accounting ledger, the owner has taken on the cost of production, and has not received any revenue, so has a loss on the product. Changing the reported financials from cash to accrual accounting takes time and usually requires the producer to hire an accountant. After accrual accounting adjustments are made, farm incomes can be different than expected by the farmer based on cash accounting practices. Variables used in the indemnity calculations are not transparent to farmers and can be difficult to track. Among the current suite of BRM programs, producers are the most dissatisfied with Agri-Stability (Agriculture and Agri-Food Canada 2017). Their criticism is that the program is complex, with payments that are difficult to predict and slow to be paid.

Problem Definition

The complaints raised by Agri-Stability participants are related to the individualized nature of the program, and the indemnity trigger mechanism. The current Agri-Stability program requires Canada Revenue Agency (CRA) tax-filer records to determine payouts. Using tax-filer records creates a one-year lag associated with filing taxes, but there are additional delays. If producers report revenue and expenses on a cash basis to CRA, then the program year margin must be adjusted for changes in purchased inputs, crops and livestock inventories and accounts payable. This adjustment process requires additional farmer provided information (and accounting expertise) so it adds time to the process of calculating program year margins (and ultimately payouts). This of course is the basis for the criticism that the program is not *"timely"*. The time lag is built-in to the design of the program. The accrual adjustment process also contributes to the criticism that Agri-Stability is "*unpredictable*" and "*complex*." This raises the question: Are there alternative mechanisms to trigger program payments that are not based on individual tax records, yet are representative of the individual's financial situation?

The primary objective of this study is to examine the feasibility of using regional area-based trigger mechanisms to determine Agri-Stability payouts rather than the current individualized trigger mechanism. Each alternative approach involves trade-offs. In fact, the basic question is

– given the data limitations are the alternative approaches even feasible? While area-based data may be available, and its application may speed up the calculation of the payment, the outcomes may not be any more predictable, the process may be equally complex, and the trigger mechanism may be no more transparent than the one for the current program. More importantly, an effective alternative should offer an income risk reduction that is greater than not participating in the program altogether, to keep with the overall objectives of BRM programs.

One alternative mechanism would be to apply the current margin based whole farm approach to a program that determines indemnities with a regional trigger mechanism. The question is whether regionally representative data is available to calculate this margin. If it is not, or if it is not strongly correlated to individual producer revenues and expenses, then an alternative more limited approach must be pursued. In each case where an area trigger is employed, basis risk would be introduced through differences between individual and area risk factors. Effectively the risk is that farm-level variables will not fluctuate in the same manner as county-level variables. Further potential trade-offs include possible reductions in producer welfare and uncertainties about indemnities caused by such factors as year-to-year changes in regional commodity mixes, within year output price variations from the regional average, cost structures relative to the situation of the individual producer, and accounting for inventory adjustments to determine realized incomes.

The alternative proposed consists of customizable area-based whole-farm program where payments are based on a regional trigger. Problems associated with designing a simple index based on revenues across relevant commodities in a region are considered, and alternative strategies to implement the alterative program are developed. The analysis is both conceptual and backed up with stochastic simulations that test alternative approaches and consider trade-offs.

The following chapter discusses the history of agriculture support programs in Canada and how program designs have been influenced. A description of current Agri-Stability is provided and then compared to alternative programs available, primarily private options. Following is an overview of the literature on agriculture area and index insurance policies and the challenges and trade-offs associated, especially basis risk. 0 then provides a theoretical framework for the area-based program design and Agri-Stability, and a description of the data used in the analysis. The performance of each program is then compared and results are presented in 0. Finally, a discussion of results and conclusions including limitations and suggested future studies are provided in the final chapter.

Literature Review

The following chapter will take a closer look at the history of agriculture support programs in Canada, and how they influenced the mechanisms that are seen today in the current BRM programs. Private insurance and income support program designs will also be examined and compared to Agri-Stability. This will lead the discussion into the literature surrounding regional and index insurance mechanisms studied in the agriculture sector around the world. The paper will review common issues of basis risk that appear in the literature and what previous studies have suggested to improve index insurance designs.

History of Agriculture Support Programs in Canada

The Canadian government has offered support to agricultural industries dating back to 1887 with the establishment of the Experimental Farm Stations Act which was designed to research production methods and values of crops and livestock (Experimental Farm Stations Act 1985; Hedley 2015). The federal government wanted to avoid programs that offered direct support to producers. Western Canadian producers struggled to market products and paid high premiums to ship out east. Accordingly, the Crows Nest Pass Agreement (1897), was struck, between the federal government and Canadian Pacific Railway, resulting in a subsidy being paid to the railway in order to reduce high transportation costs being paid by western grain producers.

By 1939, western Canadian farmers had access to the beginnings of a crop insurance program through the Prairie Farm Adjustment Act. The purpose of the Act was to support farmers for yield and crop failures especially during these times when drought was prevalent. Participants in the program paid a one percent levy of their grain sales into a pooled fund used to pay indemnities. Indemnities were dependent on wheat prices, area yields and total cultivated area, although the trigger mechanism was based on yield reductions. Through the

Act, cost sharing of program administration and funding began to appear between farmers and governments. Price support based programs emerged in 1944 with the Agricultural Prices Support Act. A designated board set prescribed prices for commodities (excluding wheat) and bought and sold agricultural products. Policy objectives outlined in the Act include maintaining stable returns in agriculture to those from other occupations. The board could pay the difference between prescribed prices and average market prices when the market price was lower (Booth 1951).

The post-wartime era saw lower commodity prices and farm incomes began to decline. Current programs could not adequately deal with low prices since the price support programs had to maintain a no loss strategy when buying and selling commodities (Hedley 2015). Canada developed the Agricultural Stabilization Act (ASA) in 1958, that would offer farmers a direct payment that would be triggered by low prices in named commodities outside the Canadian Wheat Board's (CWB) areas. When the annual average price of one of the commodities fell below 80 percent of the 10-year average price, an indemnity was triggered. The objective of the ASA was specifically to stabilize prices and not the income of farmers.

The Canadian Wheat Board was first established in 1919 but was quickly abolished due to lack of provincial legislative support. In 1935, the CWB was re-established with more success than before with initial prices of wheat guaranteed by the federal government. The CWB controlled the import and export of all wheat and wheat products for Canada. Advance payments started with the CWB through the Prairie Grain Advance Payment Act, 1959. During this time, farmers required permits to deliver grains to the CWB elevators, leading to longer wait times to deliver farm-stored grains. The Act allowed the CWB to pay advances to farmers for their farm stored wheat, oats, and barley, before elevator delivery dates. In the same year, the federal government established the Crop Insurance Act which would provide funding for provinces to administer insurance programs in each province. Crop insurance was largely based on area average coverage and not yet specific to an individual's farm. By this point, all agriculture income support was offered indirectly through price supports, and yield coverage/crop insurance.

With grain markets seeing large surpluses, prices continued to decline during the 1960s. Inflation rates decreased the support offered by programs that were generally tied to a rolling average of prices. Amendments were made to the ASA program (1975) to offer higher coverage levels of 90 percent of average market prices, instead of the 80 percent offered before, and calculated average price over 5 years instead of 10. The ASA amendments also began to define cost-sharing parameters between provincial and federal governments as increasing pressures from provinces arose regarding equitable treatment and program spending.

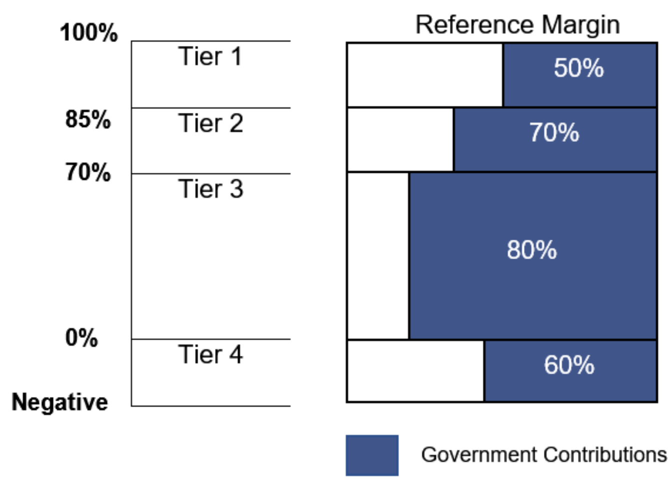
The Western Grain Stabilization Act (WGSA), created in 1976, was the first defined price and income support program for a composition of commodities. Before the WGSA, support programs were commodity specific and did not account for a producer's margin. The WGSA offered producers supports on margins but limited eligible sales to target family farms instead of large corporations (Hedley 2015). These limits attempted to ease concerns over large payouts from the federal government to operate the program. The WGSA offered a 90 percent coverage of the previous 5-year area average net income compared to a current year's net income, familiar to the current Agri-Stability program. Participants paid a levy of 2 percent of eligible sales into a fund, matched by a 4 percent levy by the federal government, that would be used to operate the program.

The next decade saw many *ad hoc* programs emerge from both federal and provincial governments to respond to climate and economic pressures. The various programs made it clear that the safety nets in place did not adequately cover the losses felt across the agriculture sector. By the late 1980's the programs were at risk of countervailing duties from the USA on Canadian agricultural products. The Farm Income Protection Act (FIPA) repealed commodity specific programming, and the WGSA, in 1990. Two new programs were created under the Act: the Gross Revenue Insurance Program (GRIP), focused on comparing whole farm gross revenues to a rolling 15 year historical average; and the Net Income Stabilization Account (NISA) that encouraged producers to save a portion of their income for use in reduced income years. A major criticism of GRIP was as the prices continually dropped over time, so did the support levels – a similar criticism to the current Agri-Stability program. Under NISA, producers could contribute up to 3 percent of eligible sales to the account, and receive a matched contribution by the federal government, similar to the current Agri-Invest program. A farmer could withdraw funds from NISA accounts when net income was below their 5-year average, or when household income fell below a threshold level. Over time, complaints arose of accounts not being withdrawn from, even during years of negative returns.

The World Trade Organization (WTO) Agreement on Agriculture in 1995 heavily persuaded future designs of support programs in Canada. The agricultural provisions in the agreement (WTO Agreement on Agriculture Annex II Paragraph 7) set criteria of what program designs were not subject to reduced support. The agreement outlined a producer is eligible for payments after 30 percent losses of average gross or net incomes, based on the preceding 3 years or an Olympic 5-year average. It also outlined less than 70 percent of the shortfall should be paid out by a program. Payments should not be related to the producer's volume of production. Programs following the outlined criteria fall under "green box" programs and could not be countervailed. The Agricultural Income Disaster Assistance (AIDA) program, in 1998, closely followed the WTO criteria listed previously. A similar program, the Canadian Farm Income Protection (CFIP), would be established as the new whole farm income support program in Canada, in 2001.

After the designs outlined by the WTO, the next major changes to agricultural support programs came from discussions between federal, provincial and territorial governments on the cost sharing for these safety nets. The 2002 Agricultural Policy Framework outlined the cost sharing provisions by governments, the objectives, and performance measures of agricultural policy. The Canadian Agricultural Income Stabilization (CAIS) program came into effect the following year replacing CFIP. The program aimed at providing income protection to farmers that experienced large and small declines. The trigger mechanism followed similar principles of CFIP where current program margins were compared to historical reference margins from a 5 year Olympic average. The coverage levels were based off a tier system. Each of the tiers represented a percentage of shortfall from the reference margin and within each tier a coverage amount was set, seen in Figure 0-1.

Figure 0-1 CAIS Benefit Coverage



Source: Agricorp (2007)

By 2007, the suite of agricultural support programs became more familiar to the current business risk management (BRM) programs. Although NISA had been terminated in 2002, a similar program, Agri-Invest, became available to producers with less restrictions. Participants in Agri-Invest could now withdraw funds regardless of a trigger or losses and their contributions would still be matched by government. In 2018, Agri-Invest participants could contribute the full 100% of net allowable sales into the account and the federal government would match 1 percent of eligible sales. The CAIS program was replaced with Agri-Stability under the Growing Forward 1 policy framework. Most of the program mechanism and structure were similar, with major differences in the coverage calculations. The initial 15 percent decline from the reference margin would be covered by Agri-Invest, encouraging the producer to use those savings to cover smaller income losses. Tier 2 and 3 coverage and levels remained the same as the CAIS program, however tier 4 was eliminated from coverage. The next agricultural policy framework, Growing Forward 2, removed the tier structure completely in 2013. The program was now triggered when the program year margin declined more than 30 percent of the reference margin. The reference margin limit was also introduced, which limited the reference margin used in calculations to be the lower of the 5-year Olympic average margin, or the average allowable expenses of the same years used to calculate the reference margin. The next policy framework, the Canadian Agricultural Partnership (2018), carried forward the same trigger mechanisms and coverage levels as the previous Agri-Stability program. The new framework limited the reference margin limit to 70 percent of the reference margin. Currently the programs being offered are the Agri-Stability, Agri-Invest, Agri-Insurance, and Agri-Recovery program, until the CAP framework ends in 2023.

Support Program Design

The OECD (2011) proposed the following economic principles for good design of risk management programs:

- Do not blunt market signals
- Different levels of risk require different levels of responses and different instruments to address the risks.
- Effective policy requires attention to interactions and trade-offs among:

i. Politically acceptable safety nets and minimizing distortions and,

ii. Between different policies.

Given these principles, we can consider alternative programs, but before we consider alternative trigger mechanisms, consider the pressures and constraints that have driven the evolution of Canadian BRM policy. At least four considerations have driven the evolution of Canadian safety-nets and can be identified (Freshwater and Hedley, 2004):

- Concerns about government deficits and debt
- Pressures to harmonize federal and provincial programs
- The desire not to mask market signals or affect production decisions
- Disciplines of international trade agreements and threat of trade remedy actions

The first two constraints apply regardless of whether an individual or area trigger mechanism is applied. However, if the very nature of the risk management program must be changed to accommodate an area-based income insurance program, then the third and fourth considerations can come into play.

Preserving market signals is both fundamental to good policy design and an objective of Canadian governments. Distorting market signals creates fundamental problems both in terms of the efficient allocation of resources within agriculture and with respect to complaints by international trading partners. Whole farm margin insurance pools all price and production risks of one farm into a single insurance policy at a lower cost compared to commodity-specific programs. As result, these contracts are considerably more efficient risk management tools than portfolios of well-designed enterprise specific contracts (Hennessy, Saak, and Babcock 2003). This type of program is best tailored to the financial circumstances of individual producers. By insuring whole farm activities, portfolio diversity increases, premiums/subsidies needed are reduced, and producers capture higher coverage levels because of reduced potential for moral hazard (Hart, Hayes and Babock 2006).

Whole farm margin-based programs also minimize the potential for farmers to *farm the programs*. If it is difficult to predict payments, then there is less room to farm the program, and more incentives for farmers to follow market signals. Stabilizing around whole-farm net income (revenue less costs) creates several trade-offs which makes predicting indemnities more challenging and hence reduces the potential to farm the program. For instance, stabilizing broad based revenues allows for situations where revenues from one activity are decreasing revenues from other activities can increase to off-set the loss (either through higher prices, higher sales or a combination). Not only is this approach more efficient, because of natural diversification, but these offsetting effects reduce the potential to predict and influence indemnities. Further off-setting effects are introduced by considering cost adjustments which can off-set revenue losses.

The whole-farm aspect of current Canadian programs also has trade policy implications in terms of contingent protection measures. Canadian policy makers have always been conscious of the threat of countervailing duties (especially from the U.S.). Whole farm programs that are deemed *generally available* are not considered to be countervailable under US trade law. Furthermore, paragraph 7 of Annex of the WTO Agreement on Agriculture identifies the conditions for whole-farm margin based programs to not be subject to WTO reduction commitments. Consequently, these trade considerations are part of the justification for whole farm BRM programs in Canada.

Given the considerations discussed above, an individual whole-farm net margin is the first best option for business risk management. However, given producer concerns about timeliness and predictability, it is worthwhile to consider alternative trigger mechanisms that may speed the indemnification process up and make it more transparent.

Agri-Stability Design

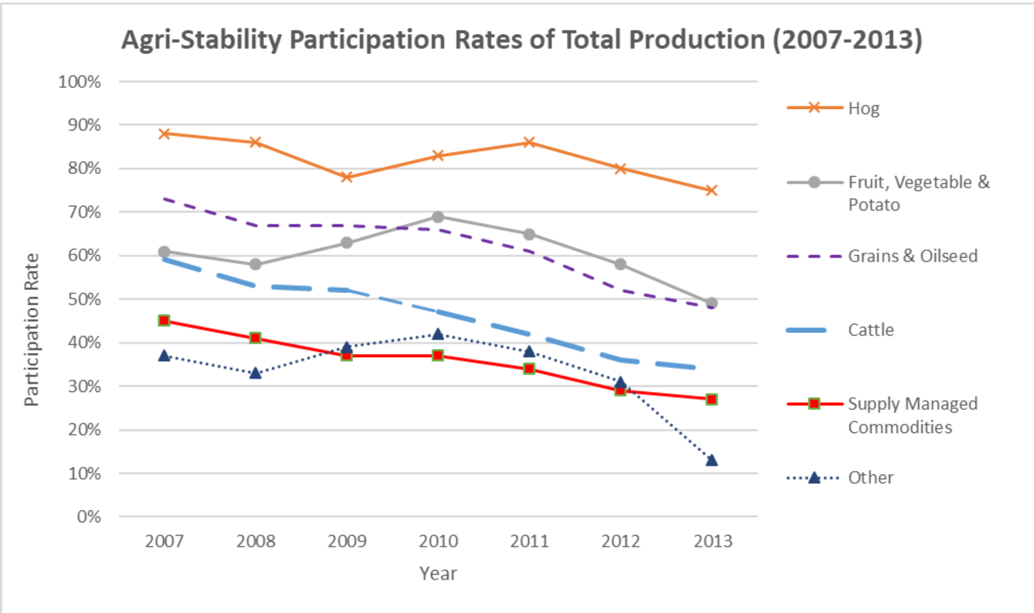
Currently, Agri-Stability is based on whole farm margins, where payments are triggered when the farmer's current margin falls below a 70% threshold of their reference margin. The reference margin is a 5-year moving Olympic average of the farmer's historical income. The highest and lowest incomes are removed, leaving the reference margin to be an average of 3 years. The program has a reference margin limit, which calculates a participant's average expenses over the historical years used, and takes the lesser of the reference margin or the average expenses. The reference margin limit cannot be lower than 70% of the reference margin. A farmer's current program margin is calculated by subtracting allowable expenses from allowable income and making accrual adjustments. The shortfall in income during a program year is the difference between the 70% reference margin threshold and the current margin during a program year. Payments to farmers are 70% of the shortfall in income calculated for a program year. A detailed equation for Agri-Stability indemnity calculations is given in section 0.

To participate, farmers provide information about their operations including income of previous years, and approximate production expectations. To be eligible for the program, participants must have conducted farming activities for 6 consecutive months and completed a production cycle. There is an annual fee for the program which is a fixed administrative fee plus a proportion of their reference margin as a levy.

Participation rates in Agri-Stability have continuously declined since program inception in 2007, at a faster rate than the overall decline in farm numbers in the industry from 2007-2014

(AAFC 2017). From 2007 to 2014 participation rates dropped from 57% to 33% of total agricultural producers in Canada.

Figure 0-2 Agri-Stability Participation Rates 2007-2013

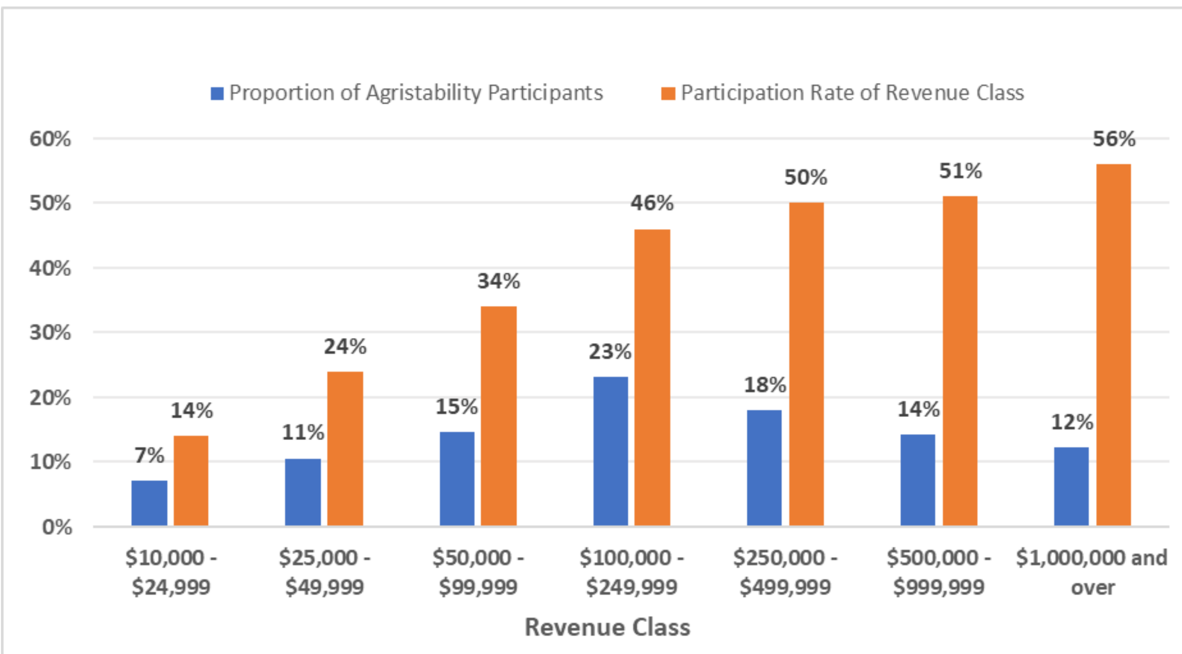


Source: AAFC (2017)

The largest commodity group participant in Agri-Stability has traditionally been hog producers (75%), however there is a downward trend in participation across all commodities. The increase in hog participation between 2009 and 2011 was likely driven by a number of factors including increasing feed prices due to droughts in 2008, a strong Canadian dollar increasing export costs, country of origin labelling (COOL), and consumer preferences changing due to the H1N1 virus (Statistics Canada 2014). The largest decline in participation from 2007-2013 has been in cattle production, speculated to be from the sharp increase in cattle prices during this period. Agri-Stability is one of the major products to insure catastrophic losses in livestock production, but high prices for cattle could have reduced the demand for an insurance product. Criticisms also point to the challenges faced by producers with low-allowable expenses in relation to allowable revenues, like cow-calf operations (Agriculture Financial Services Corporation 2021). The reference margin limit forces low cost producer's trigger thresholds lower requiring them to experience far greater losses than 30% in income to benefit from the program.

The majority of participants (23%) had market revenues of $100,000 - $249,999, during 2013. The $1,000,000 and over revenue class is highly represented in the program with 56% participation in the program (Figure 0-3). There are high volumes of smaller farms, by revenue class, participating in the program. However, as a proportion of total farms in the country, larger farms are more represented in Agri-Stability with 56% of farms over $1 million in revenue participating in the program (2017). Though participation rates have been declining over the years, Agri-Stability still maintains stable administrative costs – a trend that has been the point of program evaluations of efficiency (AAFC 2017). Essentially, it is costing more for administrators to maintain a program that is benefiting less participants.

Figure 0-3 Agri-Stability Participation Rates by Revenue Class



Source: AAFC (2017)

As previously stated, operations that are subject to the reference margin limit have a hard time triggering a payment since their reference is based on average expenses. A low-cost operation could see extreme variability in their top line, but since the trigger is largely reflective of their low expenses, they would need to experience close to a 50% drop in revenues before the indemnity was triggered. Conversely, as the margins become slim for operations, the indemnity trigger is more sensitive to variabilities in revenues or expenses since they are so close in absolute values.

Agri-Stability indemnities could also be biased towards undiversified operations. Diversified operations face less income variability by having multiple revenue streams, or integrating input production into their operations. Risk reducing management efforts are not necessarily rewarded through the program with higher income coverage levels, or reduced premiums, that would be seen in a standard insurance program. Diversified lower risk operations are offered the same coverage and premium structure as a mono-crop operation that has no rotational, or managed risk practices, even though the high-risk operation will likely trigger more indemnities on average.

The last criticism that will be discussed is the overall coverage a participant receives continually decreases as their farm profitability decreases. Because Agri-Stability references a moving average of historical incomes, if the farm continues to experience enough low income years, through production or market risks, the reference itself can be too low to provide adequate support to recover from multi-year income declines (Hedley 2015).

Alternative Support Products

In addition to the BRM programs currently offered by the federal and provincial governments, there are also several private and unique provincial insurance products available to producers. Each product offers a unique coverage and mechanism targeted to business risks. The following is a summary of some of the program designs and comparisons with the Agri-Stability mechanism.

Global Ag Risk Solutions (GARS)

Global Ag Risk Solutions (GARS) is a company based in Saskatchewan that offers production cost and revenue insurance for crops. While GARS is a crop insurance program, it is more comparable to Agri-Stability than Agri-Insurance; Agri-Insurance covers producer losses associated with yield whereas the GARS program covers cost and revenue losses related to factors beyond yield impacts. Participation in GARS, just like Agri-Stability, requires accrual accounted financial statements to calculate payments (GARS 2020). This insurance product is offered as a whole-farm crop program and is generally structured as follows:

- if revenue in a given year is below total insured production costs, a producer is eligible for a payment (Minogue 2018)
- production costs are calculated as fertilizer, seed, and chemical costs per acre plus an additional per acre amount for fixed costs
- producers have the flexibility to increase input costs within a year up to 140% of a 3-year average input expense while maintaining the original policy premium. The flexibility of input cost increases allows producers to react to variable conditions while maintaining coverage
- revenue is calculated as actual yields and actual sale prices in that year. Any inventory maintained from a policy year beyond May 1 of the following year is calculated as sold at the average price in the area

The primary difference between GARS and Agri-Stability is how the indemnity is triggered. While the GARS program compares realized revenues to insured production costs, Agri-Stability looks at the shortfall between actual and historical margins. If a producer faces continuous declines in margins over the years, the Agri-Stability total coverage will decrease as the reference margin continues to decline (GARS 2020). Through the GARS product, participants do not face similar issues since the coverage is dependent on current insured production costs.[1] Another difference is what costs are accounted for in each program. Allowable expenses included in Agri-Stability go beyond the three highest input costs for crops that are included in the GARS program. The margin calculation of Agri-Stability includes more costs that are exposed to management decisions, such as salaries and commodity futures losses/fees. GARS pays out inventory stores of yields since they are not accounted for in the following year's policy. Agri-Stability performs inventory adjustments on income every year before calculating benefits. It is also important to point out that GARS is strictly a crop product, while Agri-Stability offers margin protection for livestock and other agricultural producers.

Ag Right Risk Management (ARRM)

Ag Right Risk Management (ARRM) is a crop revenue insurance product offered by Just Solutions Agriculture. The product is focused on delivering guaranteed incomes to farmers and is structured as follows:

- a policy holder is given a range of revenue per acre where they will receive coverage. The indemnity is triggered when a producer's realized revenue per acre falls below the upper bound of the range of revenues set in the policy (Minogue 2018)
- a producer's realized revenue per acre is calculated as the actual yields (grade adjusted) multiplied by a commodity price index based on November prices
- the indemnity paid per acre is always the difference between the upper bound and the realized revenue with a maximum of the revenue range itself. Significantly low realized revenues below the range of revenues are subject to the maximum indemnity

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[1] GARS also offers fixed cost coverage which covers a portion of historical margins, but this is supplement to the main input cost coverage.

Compared to AARM, Agri-Stability is a more comprehensive support product offering relatively more coverage to producers. Agri-Stability is a whole farm product not just covering crop revenues but also expense side impacts. However, Agri-Stability cannot compete with the timelines offered by AARM. The AARM program offers price support using a price index, unlike Agri-Stability which uses individualized information. As a result, Just Solutions Agriculture acknowledges the tradeoff between accurate, high coverage indemnity payouts that may take longer to calculate, and more immediate payouts with lower coverage. Used in conjunction with other products, a producer can receive immediate cash from AARM for short term expenses while waiting for a larger indemnity from a more comprehensive insurance policy.

Risk Management Program (RMP)

In Ontario, the crown corporation Agricorp offers a program called the Risk Management Program (RMP) to cover losses in commodity pricing and production costs (Agricorp 2020). RMP is available for cattle, grains and oilseeds, hog, sheep, edible horticulture, and veal. The program is structured as follows:

- for livestock, indemnities are paid if market prices drop below a producer's support level. Support levels are determined from the coverage level chosen by a producer and the industry average cost of production, calculated by Agricorp
- different categories of livestock production will face different payment calculations to better represent the variability in production types (e.g. wean hogs on a per-head basis, and grower hogs on a per weight gain basis)
- grains and oilseed indemnities are calculated based on a producer's average farm yield, acreage, and the difference between their support level and the market price. Support level is based on a target price which is an average cost of producing a specified crop

- any payments from RMP are counted towards a producer's provincial portion of Agri-Stability payments

As compared to Agri-Stability, the support levels and coverage offered by RMP are commodity specific, while Agri-Stability offers a standardized program design for all commodities and farm types. Conversely, the RMP program accounts for the variability in production types during payment calculations. Agri-Stability does not offer different payment calculations based on production types, which has seen a criticism when low cost producers must absorb extreme income declines before triggering a payment.

Peril Based Insurance

Many private insurance companies or other financial institutions offer a policy for peril-specific crop insurance or bundled perils. A common example is a hail insurance policy that will trigger an indemnity when there has been significant hail damage to crop yields beyond the deductible. It is structured like most other insurance policies, where an indemnity is only triggered if the specific peril occurs. An example of a peril-based provider is Western Financial Group. Western Financial Group offers hail insurance for a variety of crops. Their premiums are based on crop type and acres planted (Western Financial Group 2020).

Private and Public Evaluations

Privately provided support products have the flexibility to target specific issues without external pressures or bureaucratic influence. Public programs tend to have efficiencies through risk preferences, information access from other government programs, and a lower required return to capital (Ker et al. 2017). This section evaluates the tradeoffs between different support program design choices, primarily focusing on the BRM suite of programs and the alternatives discussed. The following are benefits to various program designs choices:

- Government funded programs, such as Agri-Stability and Agri-Insurance, are relatively low cost in terms of producer participation fees, making these products accessible to a wide range of producers. The subsidized programs offer relatively lower fees and premiums to encourage more participation and reduce sector risks, while being competitively priced with privately offered products.
- Privately offered agricultural support products, like the GARS program, offer premiums that are adjusted for producer risk and coverage choices. Different premium and coverage rates can reflect the inherent risk in production, while encouraging participants to mitigate risks through production practices to capitalize on lower premium levels. For example, a mixed farm that is diversified across commodities might have a lower premium because they have less exposure to individual markets and are therefore considered less risky as compared to farms focused one commodity. Conversely, mixed farms may benefit from higher coverage as a result of being a low risk operation.
- Whole farm margin program designs, like Agri-Stability and GARS, reduce the insurer's exposure to single commodity volatilities and moral hazard. As the insurance portfolio diversity increases, it reduces the level of premiums/subsidies needed, and allows the participant to capture higher coverage levels because of less moral hazard issues (Hart, Hayes, Babock 2006).
- Programs involving relatively high-level (less complex) margin calculations, such as the GARS program, can be effective at capturing much of the risk and associated income volatility that lie outside of a producer's control. Indeed, management decisions are largely the cause of the variation between the most profitable and least profitable producers regardless of commodity, operation size, or geography (Martin 2020; Mussell et. al. 2007). By simplifying the allowable income and expense categories covered in a support

program, producer's can acquire income support for truly external factors while still adjusting their management choices to maximize the efficiency of their operation.

While there are benefits associated with the various agricultural support programs, each program design has associated tradeoffs. The objectives of each program or product should guide which tradeoffs are necessary in order to efficiently achieve the program objective. The following are critiques of various program designs choices:

- Though government subsidized programs like Agri-Stability offer low-cost income support options for producers, these programs are funded through taxpayer dollars, creating a complex political component to the program design and delivery.
- Standardized premiums and coverage levels offered by the Agri-Stability program has been argued to cause inequitable coverage among different producer types. Participants have different production risk levels and market exposures, which are accounted for under programs like GARS or RMP. Indeed, standardized program fees and coverage levels can mean that high volatility producers receive the same coverage and participation fees as less risky producers, yet the indemnity is not equally triggered.
- Although whole farm and margin designs offer great coverage for participants, it often comes at the expense of timely payments. Accrual and inventory adjustments add complexity to the program and can require more time to process and collect information from participants. Programs like ARRM are not as comprehensive as whole farm, margin-based programs, but it offers a faster payout for farmers who are in need of immediate cash or support.
- Support programs that require complex margin calculations (like Agri-Stability) include a wide variety of allowable expenses over which the farmer has control. The more costs that are included in margin calculations, the more complex it becomes to delineate what

shocks are truly outside a participant's ability to manage. Martin (2020) shows that the most efficient and profitable producers are the ones that manage costs effectively, regardless of farm types, geography, size. Therefore, Agri-Stability has the potential for management decisions to strongly drive margin calculations.

Conceptually, whole-farm net margin programs should be the least production distorting alternative safety net. Whole farm margin insurance pools all the price and production risks of one farm into a single insurance policy at a lower cost compared to commodity-specific programs. Since it would be difficult to predict payments, there is less room for producers to farm the program, and more incentives for farmers to follow market signals. Whole farm contracts are best tailored to the financial circumstances of individual producers because they are considerably more efficient as risk management tools than portfolios of well-designed, enterprise specific contracts (Hennessy, Sask, and Babcock, 2003). By insuring whole farm activities the portfolio diversity increases, it reduces premiums/subsidies needed, and can allow producers to capture higher coverage levels because of less potential for moral hazard (Hart, Hayes, Babock 2006). Certainly, a product specific revenue assurance product is easier to administer than a whole farm program. However, whole farm margin or revenue insurance pools all the price and production risks of one farm into a single insurance policy at a lower cost compared to commodity-specific programs. So, a product specific policy does not have the diversification advantages of a whole farm product. Unfortunately, the trade-offs of having efficient, non-distortionary programs are the complaints raised by producer groups: complexity, unpredictability, and slow payouts.

Area and Index Insurance

Area insurance is not a new concept to Canada. In 1939, western Canadian farmers first had access to crop insurance through the *Prairie Farm Adjustment Act*. Participants in the program paid a 1 percent levy of their grain sales into a pooled fund used to pay indemnities. Indemnities were paid based on a trigger mechanism constructed from area yields (Booth 1951). The 1976 Western Grain Stabilization Act (WGSA) was the first margin based support program for a bundle of commodities. WGSA offered a 90 percent coverage level for the previous 5-year average *area* based per unit net cash flow compared to a current year's net cash flow. The only individualized aspect of the program was the participants' levy contribution to the overall fund (Congressional Budget Office 1984). Both the Prairie Farm Adjustment Act, and WGSA used area data to calculate indemnities. When the WGSA program ultimately failed, the cause was not the basis risk associated with the area trigger, but a redesign of the trigger mechanism to make the program payout more money, which ultimately compromised the financial viability of the program (Schmitz, Baylis, and Furtan, 2002).

Programs currently offered by the USDA Risk Management Agency (RMA) offer additional insight into potential alternative trigger mechanisms. These county level programs include an area-based yield insurance (AYP) product, an area-based revenue insurance (ARP) product, and a margin protection program. For ARP and AYP, the baselines are the county's expected values and are compared to actual country values to determine indemnities. When the area revenues or yields fall below the expected revenue or yields, farmers within that region receive an indemnity based on the coverage level they choose. Margin protection triggers payments use expected area revenues minus expected area operating costs. The participation rate for the area revenue and area yield programs has only been about 1% of total acres insured (U.S. Department of Agriculture Risk Management Agency; Chalise *et al.* 2017). The low level of demand appears to be a result of basis risk (Chalise *et al.* 2017; Barnett *et al.* 2005). Index insurance tends to give the highest risk reduction benefits to producers that are exposed to less idiosyncratic risks and more systemic risks, so it is important to identify which risk-type of producers that the index insurance targets (Jensen *et al.* 2016).

Background to Basis Risk

Basis risk is defined as the possibility that the behavior of the index does not match what is happening at an individual level. When there is low correspondence between the individual and the index, there is low efficiency in the indemnity payments. Technically, basis risk is defined as the variance of the conditional distribution of the policyholder's losses given a specific value of the index. Since sufficient data are generally not available to estimate this conditional distribution, practitioners tend to measure basis risk as to the linear correlation between the index and a policyholder's losses (Coble *et al.*, 2020).

A typical example of basis risk is found in the application of weather index insurance. For example, a farmer may pay into a drought insurance product that is triggered when rainfall measurements at a weather station fall below a certain level. The drought for all farmers in an area is indexed by one weather station in the middle of the area. Rain typically does not fall uniformly over the area that the weather station is indexing so a farmer within the area may not experience the same amount of rain that is occurring at the weather station. Downside basis risk occurs when the farmer experiences a drought, but the weather station rainfall amount does not trigger a payment. Upside-basis risk occurs when the farmer receives a payment when there was a drought at the weather station but not on their farm. The same principles apply to programs indexing incomes, margins, or production levels on an area basis. Peril basis risk, or *design risk*, occurs when the index is not designed properly to capture the aggregate shock. In the weather index example given above, consider a region that experiences severe pest infestations in a year, causing significant yield losses. Since the indemnity is only triggered by a drought, the payment will not be triggered because the specific weather peril has not occurred even though program participants suffer a production loss.

An example of design risk comes when an index is used as a proxy for a large aggregation of production shocks. In India, rainfall indexes have been used as a proxy for aggregate shocks in average yields (Negi and Ramaswami, 2018). The issue with the proxy index is that average yields depend on rainfall as well as other factors, such as disease or pests, not captured by the rainfall index. For example, in the U.S. ARP program, the revenue index does not capture outside shocks such as production costs. Because other factors, beyond revenues, affect farm profitability, design risk can result in too narrow a definition for the trigger mechanism.

Likewise, when the rainfall on the farmer's land is not strongly associated with rainfall at the weather station design risk is a consideration because the program assumes that all producers in an area face a uniform aggregate shock (Negi and Ramaswami, 2018). The alternative proposed regional design should consider smaller more uniform regions where all participants are more likely to face uniform risks. Ideally, the region should be small enough that the producers are relatively homogenous, so that the trigger mechanism will be representative of all farmers in the area (Shen and Odening, 2013). The homogeneity condition should include similar production practices, and regional climate and physical attributes all of which can help reduce basis risk (Miranda, 1991). However, this homogeneity requirement entails a large volume of regional information. Greater data requirements can increase the accuracy of the indemnities paid and reduce basis risk, but this also has higher administrative costs, potentially also increasing timelines for claim processing (Skees, Black, Barnett 1997).

In Alberta, the Agriculture Financial Services Corporation (AFSC) assigns risk areas across the province that have similar factors of production, methods of productions, and risks to production. These areas would be ideal in the province to administer a region-based program, however, as discussed below, sufficient data was not available for these risk areas.

It is possible to partially correct for difference between farm and regional level yield variability (which has been averaged out in the aggregation process). Marra and Schurle (1994) employed Kansas wheat yield data to correct the variance at the county level to estimate the volatility at the farm-level. Their adjustment employed elasticities to raise farm-level yield volatility for a percent difference between the county acreage and the average farm acreage (Marra and Schurle 1994). They employed observations for farm-level yields, and the corresponding county yields and estimated the following function:

Standard deviation farm yield= f (standard deviation of country yields, farm acreage, average country rainfall and dummy variables to remove common trends).

The equation was estimated as a double log functional form. The coefficient for the standard deviation of the county yield provides the adjustment elasticity, which is the percentage change in standard deviation of farm yields for every percent in total acres. Upward adjustment of volatilities allows for a more direct comparison between an individual and area yields and should aid in reducing the basis risk. Jeffrey *et al.* (2017) applied the same technique to adjust Alberta yield variances to simulate farm-level environmental management decisions when farms participate in BRM programs.

A practical approach to relate county information to farm level variables is by employing multivariate joint distributions. If regional margins and farm-level margins exhibit similar tail dependent behavior, then the regional program might be better targeted for extreme shocks in incomes. Negi and Ramaswami (2018) identified that basis risk tends to be lowest at the extremes of catastrophic loss. Using a rainfall index and average yields, they find that there is high tail dependence between the rainfall index and the average yield. Their approach employs a copula. A copula is a multivariate cumulative distribution function which stitches together marginal probability distributions, using correlation coefficients, for each variable and is used to describe the dependence between random variables. Using maximum likelihood estimation techniques, Negi and Ramaswami determined marginal distributions for each variable, and the dependence between the two variables.

An alternative program based on extreme values to capture tail dependence also falls in line with current BRM objectives to help farmers when they experience catastrophic losses in income. The definition of a catastrophic loss is usually left to policymakers (Morsink *et al.*, 2016), and in the literature has usually been 70 percent of a reference. Agri-Stability follows the same definition of a catastrophic loss, of 70 percent. Any alternative program should have a mechanism sensitive enough to capture these catastrophic losses, while not introducing a large degree of upside basis risk.

A perfect association between individual and regional systemic risks does not eliminate basis risk. So even if homogenous regional prices and outputs are available, and whole-farm approaches were employed to implement a regional trigger mechanism, this approach does not completely reduce basis risk because high levels of idiosyncratic risks will still create overall basis risks. The more elements that are included in the trigger-mechanism, the more of these associated random shocks that will be covered. Jensen et al. (2016) examined sources of idiosyncratic risk for Kenyan livestock index insurance, and found that very little of the variation between households could be explained by household characteristics or local fixed effects. The more elements that are included in the regional trigger, the more seemingly random effects drive basis risk. Any area product that involves a number of moving parts is more likely to create basis risk than a very simple product, and higher basis risk is a deterrent to participating in a regional program.

Practical Considerations for Regional Triggers

From a practical perspective, the region must be an existing administrative unit where it is possible to easily obtain prices and production records. While crop district, or county level, price and yield data may be available, representative data for regional allowable expenses is difficult to acquire. There is considerable heterogeneity among producers' costs because farm cost structures vary according to the size of the enterprise, differences in managerial ability and heterogeneity of land qualities. For instance, Martin (2020) found that the least efficient producers have expenses that are 1.8 times as high as the expenses of the most efficient producers.

Fixed costs play a large role in determining cost heterogeneity between farm types. Land rents are the largest component of these fixed costs. When profitability increases, most of those profits are bid into the land values. Farmers who have higher proportion of rented land can have much higher cost structures than farmers who produce on primarily owned land.

Canadian farms with sales under $50,000 were found to have insufficient operating farm income to service their debts (Martin and Stielfelmeyer 2011). Farms with sales under $100,000, consistently rely on off-farm income as a large proportion of household income showing the need for non-operating incomes to service enterprise debts. Higher debt ratios for smaller farms can be explained by both idiosyncratic efficiencies and scale economies. If smaller farms face higher income risks that are driven by costs, then the appropriate indemnity trigger mechanism should account for scale differences among producers. Furthermore, there is not only cost heterogeneity across enterprise sizes but also within groups of similar sized enterprises. Typically, the most efficient producers have proportionately lower costs rather than have proportionately higher revenues, relative to their counterparts.

Regional data on costs of production are reported on a per-acre and per-commodity basis and this data does not account for farm efficiencies or enterprise size considerations. The challenges are considerable in gathering regional indexes of expenses to determine a regional production margin. The more expenses that are included in the margin calculation, the more management decisions that have to be accounted for.

Methodology

Proposed Program Objectives

The purpose of the proposed program is to examine an area-based alternative to Agri-Stability that calculates indemnities for shortfalls in margin. A major assumption is that the delay in Agri-Stability, is primarily from understanding the magnitude of margin shortfall that a participant experienced in the program year and adjusting for accruals and inventory. Comparing the program year shortfall to a farm's historic margin should not be the complex process. The magnitude of margin shortfall that a farm experiences can be proxied with the magnitude of shortfall of an area's average margin in the same year. Issues with using the proxy between the farm and area is in the margin variability, and correlation. The area's margin shortfall should show strong correlation with an individual's shortfall for the program to perform well.

The proposed methodology starts with a calculation of margin shortfall to first identify the loss that was experienced by an individual in the program year. Afterwards, indemnity payments for Agri-Stability and the proposed area-based program are calculated. The indemnity payments are then compared to one another and to the actual shortfall to see the difference of the payments from the margin risk experienced. The last section describes the data used and how the analysis is performed.

Theoretical Model

The margin shortfall experienced starts with total revenues that are calculated for farm f, in program year t, for all crop commodities i as:

(0-1) $$R_{ift} = P_{ift} * Y_{ift} * A_{ift}$$

$$R_{ft} = \sum_i R_{ift}$$

The expected total revenues are revenues for the five prior years available for farm f :

(0-2)

$$E(R_{ft}) = \sum_i E(R_{ift})$$

Total expenses, C , are then calculated as the sum of eligible expenses, c_j, in program year t. Expected expenses are for the five program years prior to the current year:

(0-3) $$C_{ft} = \sum_j c_{jft}$$

(0-4) $$E(C_{ft}) = \sum_j E(c_{jft})$$

Now current margins and expected margins for farm f can be calculated as:

(0-5) $$\pi_{ft} = R_{ft} - C_{ft}$$

(0-6) $$E(\pi_{ft}) = E(R_{ft}) - E(C_{ft})$$

where expected margins are the Olympic average (excluding the highest and lowest) of the prior five years. The margin shortfall in farm f is then the difference between the margin in the program year and what was expected, where $\pi_{ft} < E(\pi_{ft})$, with superscript NP indicating no program:

(0-7) $$Shortfall^{NP} = \begin{cases} |\pi_{ft} - E(\pi_{ft})| \ , if \ \pi_{ft} < E(\pi_{ft}) \\ 0 \ , if \ \pi_{ft} \geq E(\pi_{ft}) \end{cases}$$

Agri-Stability Model

Basis risk will determine if an area-based margin trigger is feasible. To determine the degree of basis risk, a model of a representative farm is constructed for census agricultural region (CAR) two. Indemnities are calculated with an Agri-Stability-like formula.

The variables required for Agri-Stability indemnity calculations are:

- **Farm level production margin** is the farm margin in the current year:

$$\pi_{ft}^{PM} = Eligible\ Revenues - Allowable\ Expenses$$

- **Farm level reference margin** is the expected margin for the Olympic 5-year average margin:

$$Reference\ Margin^{AS} = E({\pi_{ft}}^{PM})$$

- **Reference margin limit (RML)** limits the reference margin to a participant's average expenses of the years used in the reference margin (whichever is lower):

$$RML^{AS} = min\left[Reference\ Margin^{AS}, E(C_{ft})\right]$$

- **adjusted RML** that ensures the RML cannot reduce the reference margin more than 30%:

$$Adjusted\ RML\ ^{AS} = max(RML^{AS}\ , Reference\ Margin^{AS} * 0.7)$$

- **applied reference margin** is the lower of the reference margin and the adjusted RML

$$Applied\ Reference\ Margin^{AS}\ =\ min\ (Reference\ Margin^{AS}\ , Adjusted\ RML\ ^{AS})$$

The indemnity payment for Agri-Stability can now be calculated as:

$$\eta_t^{AS} = max\left(support\ level * Applied\ Reference\ Margin^{AS}\ -\ \pi_{ft}^{AS}\ , 0\right) * 0.7$$

Support and coverage levels are set at 70% for the current Agri-Stability program. Support level is the trigger for the insurance mechanism to pay an indemnity, while the coverage level is the proportion of shortfall that is paid to the producer. In the case of Agri-Stability, the participants' margin must fall below 70% of their reference margin. The coverage level (70%) dictates that if the indemnity is triggered, the participant receives $0.70 for every $1.00 below the trigger point capped at a total payment of $3 million dollars. Although negative production margins are covered by Agri-Stability, for the purposes of this study negative production margins were ignored.

The area Agri-Stability indemnity uses the same insurance mechanism of current Agri-Stability, but substitutes all individual information for regional averages. Yields and prices are stochastic variables that are simulated from CAR #2 averages and a covariance matrix. Areas and expenses are fixed to the same averages used in the individual calculation. The indemnities show what the payout would be as yields and prices in the region vary.

Implementation of the individual and area-based programs requires stochastic price and yield data, for the individual representative farm and region, which are drawn from a joint normal distribution using Monte Carlo simulation methods. (See section VI for a derivation of the parameters for the joint distributions). For the representative farm, a simulation of 500 states of nature was created based on individual farm data (2012-2017) from census agricultural region 2. Area yields and prices were drawn from the joint distribution for three commodities – canola, spring wheat and feed barley. An Agri-Stability indemnity was then calculated for each of the individual representative. The same Agri-Stability mechanism was used for the area model with regional yields and prices instead of individual yields and prices. An alternative scenario was considered with an 80% coverage level.

Comparison of Models

The comparison of insurance products can be examined by simply looking at the difference between margin shortfall experienced, and the indemnities paid by each insurance program.

(0-8)
$$Shortfall^{NP} = \eta_t^{AS}$$
$$\mathrm{Shortfall}^{\mathrm{NP}} = \eta_t^{\mathrm{area}}$$
$$\eta_t^{\mathrm{AS}} = \eta_t^{\mathrm{area}}$$

The difference between the shortfall and each indemnity examines how well the insurance program covers margin risks experienced on a farm. Optimal coverage levels for will be based on the value that reduces the variability of the difference between shortfall and indemnity and brings the value closest to zero. Likewise, a comparison between Agri-Stability and the proposed program indemnities can show how closely the proposed area-based program performs to the individual-based program.

Data Description

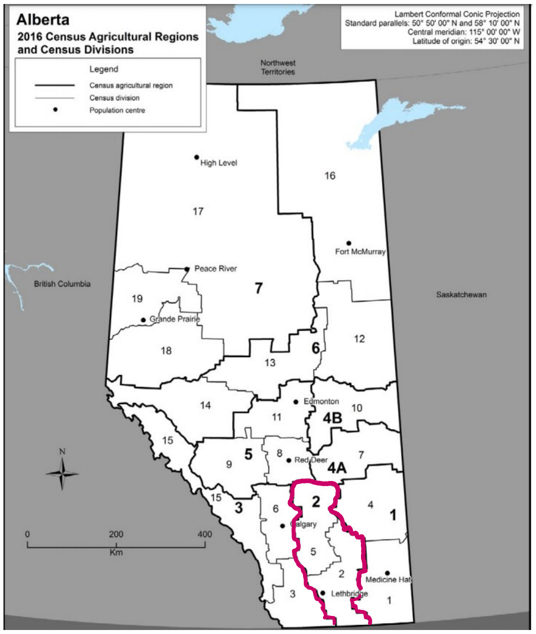
To test the feasibility of introducing an *Agri-Stability-like* area triggered program, the analysis employed tax filer data that was provided by Agriculture and Agri-Food Canada. The data is accessed through the “BRM Program Administrative Tax Database” through the “Canadian Agricultural Dynamic Microsimulation Model (CADMS).” The tax filer data is originally derived from Statistics Canada’s *Whole Farm Database Taxation Data Program*.

The dataset is a panel of Agri-Stability program participants grouped into census agricultural regions (CAR) in Alberta between the years 2008 and 2017. CARs vary in size and definitely are not representative of homogenous producers, or producers with similar risk profiles. Potentially the first best source of data would be from *risk areas* designated by Alberta AFSC, however there is no concordance between this risk area yield data and the program data (revenues, cost and indemnities) available from the “BRM Program

Administrative Tax Database" so we reverted to the more aggregated dataset. The year 2017 was chosen as the representative program year. We have chosen not to make the model dynamic across years since the time-series would only include 10 observations – the years 2008-2017. Observations are further reduced since the analysis only focused on 2012-2017 years. The focus on years after 2012 is in line with Agri-Stability's use of a 5-year average and accounts for data reporting procedures changing in 2012. The data examines the entire CAR and considers the sales class of $500 thousand to $1 million in annual sales. The higher sales limit attempts to isolate the effects of the new program on commercial farms and not complicate the analysis with farms that are more reliant on off-farm income.

As a large province, Alberta has diverse agricultural regions. These regions may be defined in terms of climate, vegetation, and/or soils (e.g., AAF 2015). Cropping activities are most prevalent in the Black and Dark Brown soil regions. CAR #2 consists of seven quite diverse counties, which include black and dark brown soil zones (see Figure 0-1). It is not possible to identify a representative county in CAR # 2, but the region is quite a diverse region reaching from just south of Red Deer, east of Calgary, and south to the Canadian border.

Figure 0-1 Alberta Census Agricultural Regions



Although the “BRM Program Administrative Tax Database” includes all commodities eligible for Agri-Stability, we have only chosen to consider wheat, canola and barley, since they are the most representative crops grown in the region and simplify our approach. The database includes total revenues for each crop, but comparable data for individual yields, acres, and prices are not available. Nonetheless, with some manipulation we can obtain appropriate data for a representative farm.

Individual Representative Farm Data

Within the BRM database, 6615 farms reported production information. Of the total farms 6383 (96%) provided information on volume of crops produced, and acres where yields were then calculated for all crops. Areas for the representative farm are assumed to equal the average reported areas for each crop within CAR #2. Individual crop area is fixed and treated as a constant variable in all the simulations. Inventory prices are not truly representative of prices received, so individual commodity prices were disaggregated from total commodity revenues using reported yields and acres.

Representative-farm crop yields and prices, for each crop were modeled as stochastic variables that are drawn from a joint normal distribution. Stochastic yields and prices used in the simulation analysis were linked using correlation coefficients obtained from individual's data. Only those farms that reported yields and areas were used to assemble parameters to form the joint distribution. The joint distributions are constructed with average yields and prices, standard deviations, and correlations between variables. This information is reported as parameters in Table 0-1 and Table 0-2. Each table is further disaggregated into total data for the entire CAR #2 and data for farms with sales between $500 thousand and $1 million in sales.

Table 0-1 Sample Descriptive Statistics

	Total Census Agricultural Region 2		**$500-999K in Sales**	
	Mean	**C.V.**	**Mean**	**C.V.**
Wheat Farm Yield	46.53	0.33	53.48	0.18
Wheat Area Yield	48.10	0.10	53.71	0.08
Barley Farm Yield	66.32	0.27	71.23	0.17
Barley Area Yield	65.93	0.11	76.49	0.08
Canola Farm Yield	38.84	0.27	44.73	0.16
Canola Area Yield	39.61	0.10	39.96	0.12
Wheat Farm Price	8.50	0.21	7.99	0.23
Wheat Area Price	6.31	0.12	6.31	0.08
Barley Farm Price	4.47	0.32	4.23	0.32
Barley Area Price	4.11	0.17	4.59	0.12
Canola Farm Price	12.04	0.22	13.21	0.20
Canola Area Price	10.36	0.13	10.36	0.14
Fixed Variables				
Wheat Acres	172.80	1.84	802.50	0.58
Barley Acres	130.00	2.29	515.00	1.29
Canola Acres	160.00	2.95	651.50	0.42
Wheat Expense	4.31	-	4.31	-
Barley Expense	3.69	-	3.69	-

	Total Census Agricultural Region 2		$500-999K in Sales	
	Mean	C.V.	Mean	C.V.
Canola Expense	6.91	-	6.91	-

Notes: Yields (bushels/acre), Price ($/bushel), Expense ($/bushel), Commodity Area (acres)

Table 0-2 Sample Correlations

Total Census Agriculture Region 2	Wheat Farm Yield	Barley Farm Yield	Canola Farm Yield	Wheat Area Yield	Barley Area Yield	Canola Area Yield	Wheat Farm Price	Barley Farm Price	Canola Farm Price	Wheat Area Price	Barley Area Price	Canola Area Price
Wheat Farm Yield	**1.00**											
Barley Farm Yield	-0.21	**1.00**										
Canola Farm Yield	-0.04	0.08	**1.00**									
Wheat Area Yield	0.07	0.04	0.05	**1.00**								
Barley Area Yield	0.06	0.02	0.05	0.87	**1.00**							
Canola Area Yield	0.05	0.02	0.04	0.47	0.77	**1.00**						
Wheat Farm Price	0.66	-0.30	-0.15	-0.03	-0.02	0.00	**1.00**					
Barley Farm Price	-0.13	0.69	0.07	-0.02	-0.05	-0.06	-0.16	**1.00**				
Canola Farm Price	-0.07	0.04	0.81	0.02	0.00	-0.05	-0.12	0.09	**1.00**			
Wheat Area Price	0.06	0.02	0.03	0.81	0.66	0.23	0.00	-0.01	0.03	**1.00**		
Barley Area Price	0.03	0.03	0.03	0.64	0.42	0.07	-0.01	0.02	0.04	0.86	**1.00**	
Canola Area Price	0.04	0.04	0.02	0.70	0.33	-0.04	-0.02	0.03	0.03	0.81	0.83	**1.00**

$500-999K in Sales	Wheat Farm Yield	Barley Farm Yield	Canola Farm Yield	Wheat Area Yield	Barley Area Yield	Canola Area Yield	Wheat Farm Price	Barley Farm Price	Canola Farm Price	Wheat Area Price	Barley Area Price	Canola Area Price
Wheat Farm Yield	**1.00**											
Barley Farm Yield	0.18	**1.00**										
Canola Farm Yield	0.17	-0.04	**1.00**									
Wheat Area Yield	-0.06	0.06	-0.11	**1.00**								
Barley Area Yield	-0.14	-0.02	0.05	0.62	**1.00**							
Canola Area Yield	0.19	-0.02	0.13	-0.11	0.14	**1.00**						
Wheat Farm Price	0.70	0.08	0.10	-0.25	-0.25	-0.02	**1.00**					
Barley Farm Price	0.20	0.77	0.03	0.03	-0.18	-0.13	0.24	**1.00**				
Canola Farm Price	-0.09	-0.24	0.73	-0.02	0.08	-0.14	-0.04	-0.14	**1.00**			
Wheat Area Price	-0.22	-0.04	0.03	0.51	0.90	-0.13	-0.25	-0.15	0.18	**1.00**		
Barley Area Price	-0.26	-0.01	-0.05	0.59	0.75	-0.53	-0.21	-0.07	0.18	0.89	**1.00**	
Canola Area Price	-0.28	-0.05	0.02	0.23	0.66	-0.48	-0.16	-0.12	0.23	0.88	0.91	**1.00**

Eligible expense data is shown as a fixed parameter at the bottom of Table 0-1. Although individual expense data are available for each farm, it is difficult to disaggregate current year expenses from input inventory expenses. Since the expense inventories are not accrual adjusted in the data, margins can be artificially deflated on farms that purchase excess inputs to production for future use. For simplicity, these expenses were not used to draw correlations between expenses and yields because using this data could misrepresent true relationships and farm profitability. A regional expense per yield was used in the analysis instead. Alberta Agriculture and Forestry (2020) reports annual variable expenses for common commodities in varying soil types in the province, through the Agri-Profit reports. Variable expenses included in Agri-Profits are:

- seed and seed cleaning;
- fertilizer and chemicals;
- crop insurance;
- trucking and marketing;
- fuel, irrigation fuel and electricity;
- machinery and building repairs;
- utilities and custom work;
- operating interest
- paid labour and benefits; and
- unpaid labour and benefits

The expenses in Agri-Profit reports do not directly align with allowable expenses in the Agri-Stability program. Specifically, marketing, machinery repairs, building repairs, and operating interest expenses are not allowable expenses under Agri-Stability. The inclusion of the non-allowable expenses in the analysis are assumed to have minimal to no impact since expenses per bushel are held constant while yields are the main driver of expense. Once representative farm yields and prices are simulated, yields can be multiplied by a fixed expense per bushel to establish a farm margin. The 2017 black soil zone Agri-Profit report was used to establish a variable cost per bushel of spring wheat, feed barley, and canola.

The Agri-Stability mechanism compares current margins to historic performance. To create expected values of income for a farm, an average was taken for yields and prices for all commodities from years 2008-2016. Acres and expenses were held constant to the same acreage allocation, and expense per acre as the current program year (2017). Expected values for the region were calculated in a similar way, by averaging the regional yields for each program year.

The year 2017 was used as the program year, and farms in CAR #2 were used to simulate yields. All commodities eligible through Agri-Stability were provided however only wheat, canola and barley were used for simplicity. Total revenues for each commodity are available, while some farms provide yields, acres, and beginning and ending inventory prices. Because inventory prices do not truly represent prices received, commodity prices were disaggregated from total commodity revenues using reported yields and acres. Only farms that reported yields and acres were used to examine the yield basis risk between farm and area.

Regional Area Data

Table 0-1 and Table 0-2 present averaged area data for establishing mean, standard deviation, and correlations that enter the joint distribution for regional behavior. Provincial average monthly price data was provided by AFSC for eligible Agri-Stability commodities. An average yearly provincial price was used for each commodity as the regional price. It is assumed that provincial prices are an acceptable proxy for a region's price. The province, and largely the country, are price takers for crops. Prices are set by port prices minus transportation costs to a region or grain elevator. These prices also vary by crop quality, variety, and timing of sales within the year. Variability in prices was not directly examined in the analysis. The yearly averages remove the timing of sale variability.

Regional yields were calculated as the median farm yield for a crop each year for census agricultural region two. Acres in the region are the median acres of each crop for farms that seeded (i.e. commodity acres greater than zero). Expenses for the region were calculated in the same way for an individual, since the expenses used from Agri-Profits are regional representations based on soil type. Regional expenses for an area with similar soil types can help reduce basis risk.

Methods to Analyze Basis Risk

Elabed *et al.* (2013) define false negative probability (*FNP*) as the probability that an individual farm does not receive an area triggered insurance (program) payout when its realized index value falls below the level at which the individualized program would payout. Applying this FNP probability to area triggered Agri-Stability program the probability of basis risk is:

$$FNP = Prob\ (PM_{area} > RM_{area} \mid PM_{farm} < RM_{farm})$$

Where $RM_{farm}$is the individual reference margin, and RM_{area} is the area-based reference margin (to avoid confusion we set these two triggers to be equal). PM_{farm} is the individual farm program margin, so when $PM_{farm} < RM_{farm}$ the individualized Agri-Stability program should pay. $PM_{area}$is the representative area farm program margin, so when $PM_{area} > RM_{area}$ the area triggered Agri-Stability program would not pay out. In other words, this is the probability that the area triggered index insurance product does not payout when the individualized Agri-Stability program should pay an indemnity.

To operationalize this measure, we first calculate area-based Agri-Stability indemnity and then calculate the individual-based Agri-Stability indemnity. The false negative bias is measured by taking a difference between these two indemnities. Negative values indicate the area-based indemnity underpaid (downside basis risk) compared to the normal individual Agri-Stability. Conversely, positive values indicate an overpayment (upside basis risk) from the area-based program compared to individual Agri-Stability. Values at zero indicate that both programs paid the same, or more likely that they both were not triggered. A probability density function of the indemnity differences show the frequencies of under and over payments as a measure of basis risk. Applying a cumulative density function determines the probability at which a FNP occurs and how often the area-based trigger is not paying out when it should be.

Table 0-3 provides a summary of the assumption employed and steps followed for the analysis to determine basis risk of adopting an area data triggered Agri-Stability like program.

Table 0-3 Analysis Assumptions and Steps

Assumptions
• farms with over $500K in sales and less than $1 million from census agricultural region 2 are examined
• three crops - canola, spring wheat, feed barley – are considered
• each commodity’s area is the median area in Census ag region 2, and the same area is applied to all simulated models

- area yields calculated as the median of individual yields in census ag region 2, with sales over 500k, for each year
- area price calculated as the average monthly price for each commodity from 2012-2016
- individual price calculated from revenues yields and acres
- expenses are calculated using average variable costs per bushel from Agri-Profits black soil 2017. Expenses are held constant even through reference years

Steps of Analysis

1. Construct 12×12 multivariate distribution (individual and area yields and prices) for Monte Carlo simulation
2. Approximate Agri-Stability program payments for individual and area-based triggers, with 500 simulated draws from the joint distribution.
3. Calculate the difference between indemnities between area and individual triggered programs
4. Obtain distribution of differences in program triggered indemnities
5. Using distribution of indemnity differences calculate false negative probability of false negative bias

The analysis focused on commercial operations in CAR #2, through two whole farm sales groupings as follows:

- whole region
- $500K and over but less than $1 million

Since farm prices were disaggregated and used reported farm yields from inventories, some of the data required adjustments for outliers. Any negative values for yields or prices were adjusted to zero. Limits were also applied to high and low reported yields and prices. Price limits were established from cash price frequency tables between 2010 and 2014, available from Alberta Agriculture and Forestry. Because of the three-year gap to the analysis year (2017) price limits were also corroborated with the monthly price data available from AFSC. Yields were limited to 20% above the 10-year average for each commodity in Alberta.

A multivariate normal simulation of 500 representative farm and area yields and prices were created for each sales group, using averages and covariance between farm and regional variables. The simulated yields and prices were then used to calculate revenues using a fixed acreage for both farm and region, as well as total expenses from the variable expense per bushel and total yields for each commodity.

Results

Given the simulation of random yields and price, the second step calculates program payments for each of the current individualized Agri-Stability program and an equivalent area triggered program. A summary of indemnities paid is given in Table 0-1. Results are only shown for the income group with total sales from $500-$999 thousand. The second and third columns of Table 0-1 compare indemnities between the individualized and area trigged programs, which cover producers who experience margin declines greater than 30% due to production loss, adverse market conditions and increased costs and are offered 70% coverage of this loss. The area-triggered mean and median indemnities are roughly 40% lower than the central tendency for the comparable individualized program. Both distributions of indemnities are not symmetric (i.e. mean that exceeds the median and measures of negative skewness). Each of the distributions is skewed to the right with a longer tail for higher indemnities. Furthermore, a negative value for kurtosis indicates fat tails and the potential for more outlier observations.

In November 2020, Minister Bibeau offered to increase the coverage level from 70% per cent to 80%. The indemnities associated with this potential program reform for an area index, are shown in the fourth column of Table 0-1. With the change in policy parameters, increased coverage results in a distribution with a more similar shape to the individual based program, and a larger mean and median. Increased coverage begins to compensate for lower indemnities, but the shape of the distribution of indemnities remains asymmetric with fat tails.

Table 0-1 Indemnity Summary Statistics

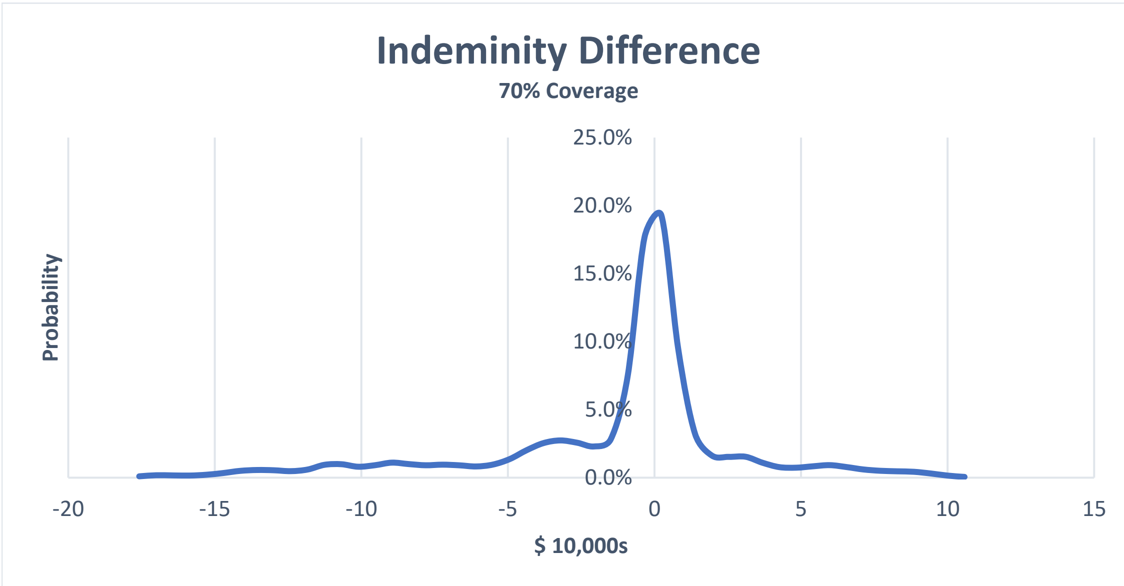
$500K – $1M	***Individual Agri-Stability***	***Area 70% Coverage of 70% Support***	***Area 80% Coverage of 70% Support***
Mean	55,242	32,346	37,196
C.V	0.76	0.81	0.81
Median	41,583	25,810	29,498

Standard Deviation	42,074	26,353	30,110
Kurtosis	-0.32	-0.32	-0.32
Skewness	0.78	0.85	0.85
Range	173,964	95,031	108,606
Minimum	68	18	20
Maximum	174,032	95,030	108,606
Sum	10,164,485	3,905,550	4,463,486
Count	184	120	120

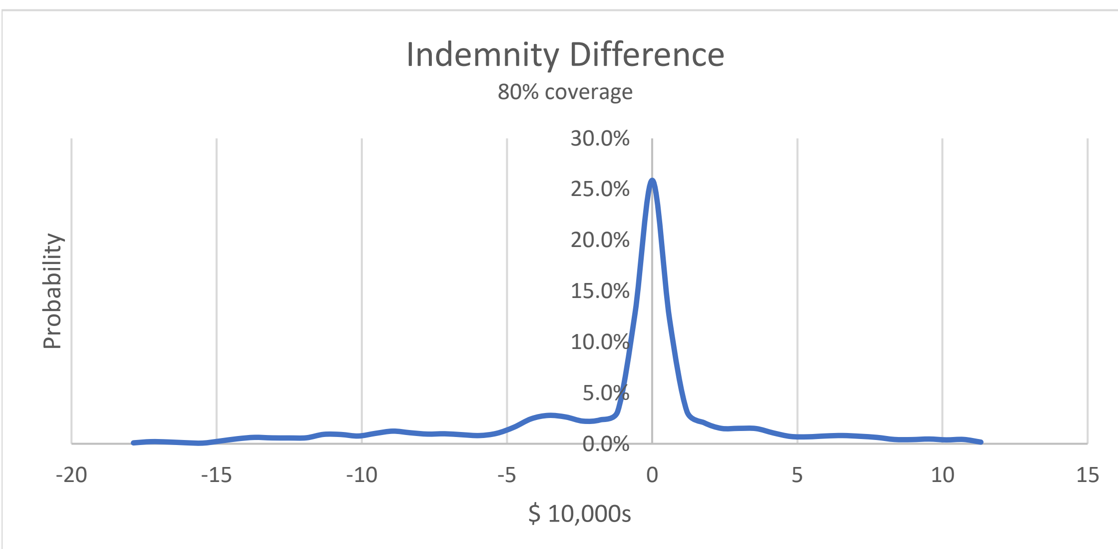
Basis risk is a measure of program effectiveness as a risk management tool and an indication of the predictive reliability of the index insurance product. Basis risk is the probability that the area-based insurance policy does not payout when an individual based policy would have a payout. This is measured as the difference in indemnities associated with the area index less the indemnities associated with the individual based program. Figure 0-1 (panel A) shows the probability of over and under payments for the $500K to $1M sales group, for the difference between the area-based and individual-based indemnities. The differences are skewed to the left indicating a higher overall probability of underpayment when an area-based trigger mechanism is used. This suggests that using area trigger mechanism is not sensitive to all the shocks associated with individual based margin variations.

Panel B of Figure 0-1 shows the impact of increasing the coverage of Agristabilty from 70% to 80% of the covered loss. This adjustment is consistent with recent proposed changes to Agri-Stability. Increasing the coverage of the area program makes the trigger mechanism more sensitive to variability in individual margins. The peak of the distribution, in panel B is higher than in panel A and the density function is somewhat less skewed to the left indicating a reduction in basis risk. This effect is attributable to the fact that increased coverage causes the area trigger mechanism to be more sensitive to individual margin variation (see Chalise et al., 2017).

Figure 0-1 PDF of Indemnity Differences



Panel A



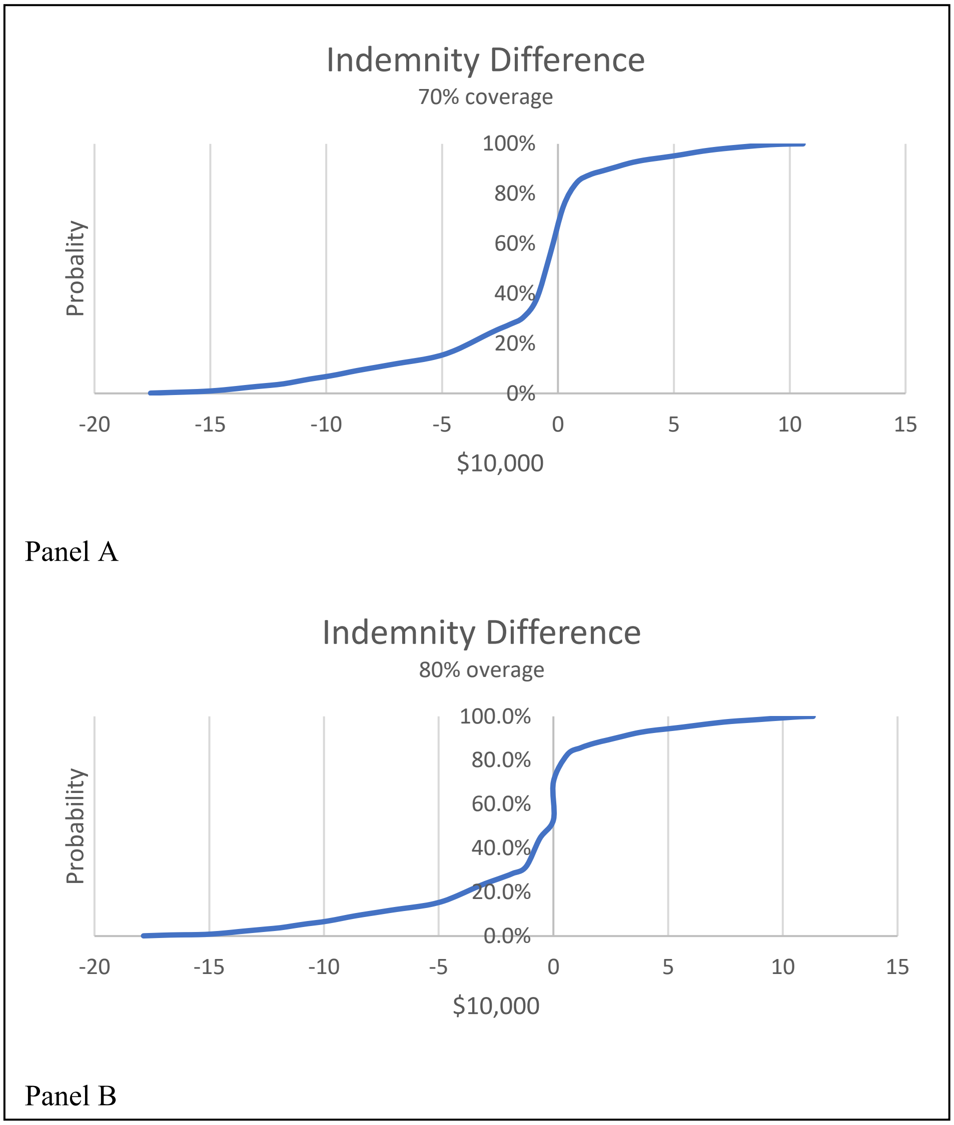
Panel B

Note: Kernel density functions used may display higher probabilities due to data smoothing

The sensitivity of the area trigger sensitivity is best seen in Figure 0-2, which shows the cumulative distribution probalility of a false negative - the probability of no payout occuring when an individual based product would have paid an indemnity. The false negative probability (*FNP*) of down-side basis risk, associated with the area index, can be determined from Figure 0-2. In the case of the current parameters for Agri-Stability, the FNP is 56%. The practical implication for our data set is that while the individual-based Agri-Stability trigger has a 37% probability of paying out, basis risk reduces this probability to 16%. There is an important trade-off between a timelier area-triggered program and the potential loss of risk protection. For producers to find the area-based program attractive, the time value of the delayed payment must exceed the reduced probability of a payout with the regionally triggered program[2]. If the program coverage level is increased to 80% of the loss, then the FNP declines to 44%. The probability of the regional triggered program paying out increases to 21%. Therefore, there is potential to reduce basis risk by increasing the coverage level of the area-based program.

[2] Consider a simple illustration of this trade-off where a producer would receive an identical indemnity in the absence of basis risk for each program. Assuming that the delay in the indemnity payment is a full 24 months, then the *monthly* discount rate at which the two programs would effectively have the same present value of the indemnity is at 2.4%. This is discount is excessively high given the current interest rate structure.

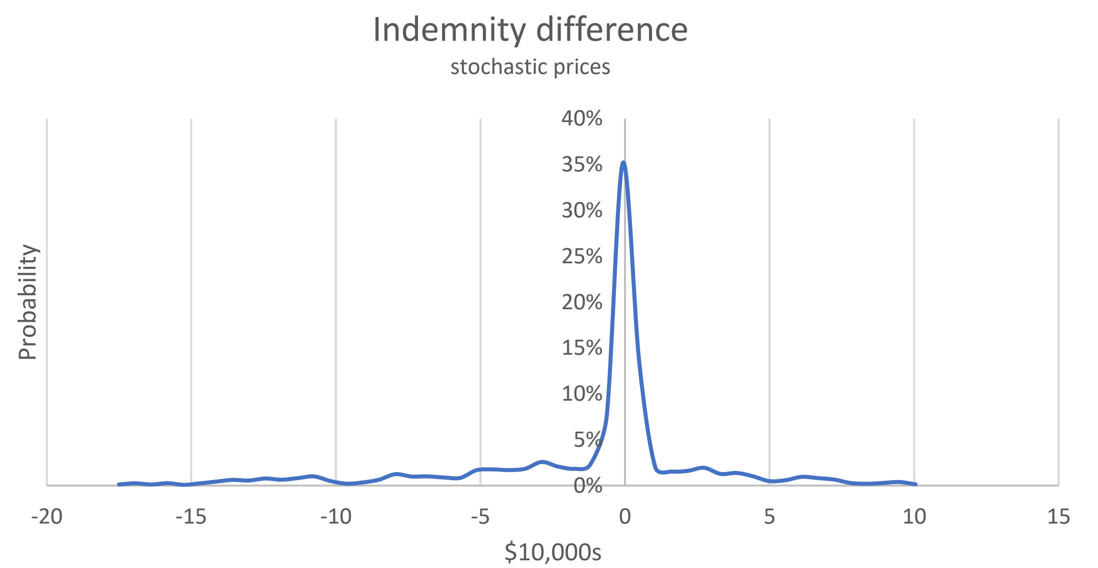
Figure 0-2 CDF of Indemnity Difference



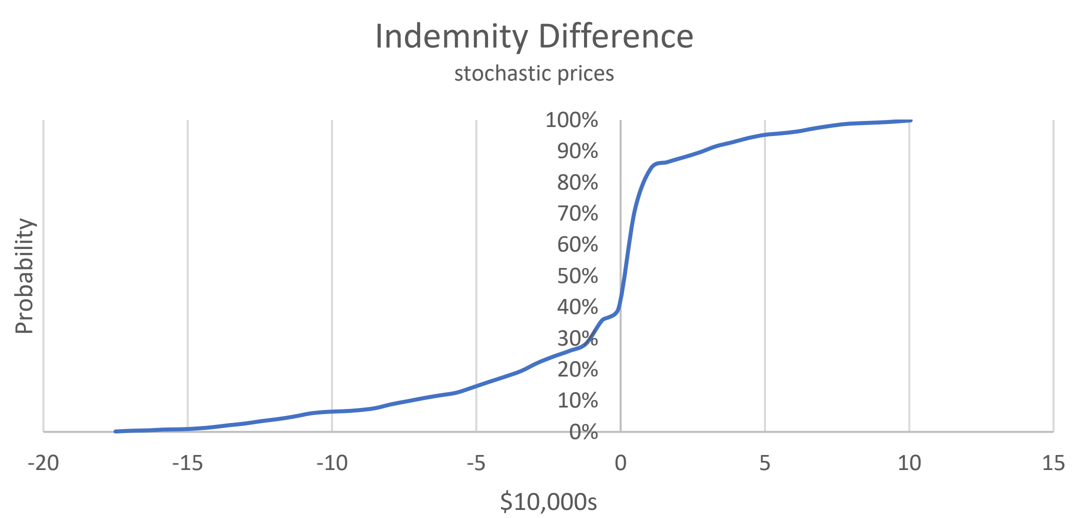
Note: Kernel density functions used may display higher probabilities due to data smoothing

Finally, we consider a scenario where the only stochastic variables are prices and all other variables are treated as deterministic. Since prices are systemic across regions then the potential for basis risk should be reduced. Again, we consider the difference in indemnities between the area-based program and the individualized program. Figure 0-3 describes the difference between indemnities in terms of PDF and CDF functions. Figure 0-3 panel B, shows the cumulative distribution which describes the probalility of a FNP of no payout occuring when an individual-based product would have paid an indemnity. The FNP of downside basis risk, associated with the area index, is 39.6%. As expected, the FNP is quite a bit lower than for the margin-based programs because of the sizable component of systemic risk.

Figure 0-3 PDF and CDF of Indemnity Difference - Price Stochastic



Panel A: PDF function



Panel B: CDF function

The relatively high false negative probability, for the area-based margin instrument, can be related to four sources of basis risk: spatial risk, design risk, other covariate risks and idiosyncratic risks. Spatial risks are conceptually the easiest risks to identify, but from a practical perspective are difficult to address because of severe data limitations. Census regions (e.g. CAR #2) are obviously too broadly delineated, however this region is the narrowest area aggregation associated with individual records made available from the BRM Program Administration Tax Data base. A more granular approach could involve data from AFSC's crop risk areas. For example, CAR #2 encompasses AFSC crop risk areas 2, 3, 5, 7 and 8. However, there is no concordance of data between specific individuals in CAR #2 that matches that the same individual with data from AFSC crop risk area 7. Developing such a concordance is beyond the scope of this project because the procedure would involve intense data comparisons to measure agreement of variables across regions, and in the end may not create a sufficiently homogenous group of farmers to eliminate spatial basis risk. Basis risk is reduced when the administrative area covered by the index is homogeneous both in terms of weather and in terms of farming techniques. However, from a practical perspective representative region must be an existing administrative unit where it is possible to easily obtain, maintain and process price and production records.

Design risk is the margin variation experienced by the individual farm that is not covered by the Agri-Stability program contract. Most existing area-based contracts (e.g. weather insurance) only cover single peril risks. Extending the program coverage to whole-farm margin dramatically increases the number of possible perils. The more dimensions of the margin that are covered, by the contract, the less concordance there is between regional and individual data and the more potential for design risk. Design basis risk is minimized through robust product design and backed by testing of contract parameters and depends on the sources of the risk (production risks, market risks, institutional risk and personal risk). The more risks that are insured the more potential there is for design risk.

Growing empirical evidence suggests that idiosyncratic risk – meaning that one farm's experience is unrelated to its neighbor's but rather to farm specific production processes, management, and other characteristics – exceeds other types of covariate risks (Barrett 2011). In the absence of other risks, basis risks will remain as long as there are idiosyncratic risks. If basis risk persists, the demand for index-based risk management products is limited – especially for risk averse individuals.

Additional Considerations:

The persistence of basis risk means that the uptake of an area-triggered program will be limited. Reducing basis risk will improve uptake, but this requires addressing design risk and spatial basis risk.

Addressing design risk requires simplifying contracts and reducing the number of perils addressed by the assurance program. Current area products (e.g. USDA-RMA area assurance products) typically only address revenue insurance. The advantage is that expenses tend to vary inversely with producer ability and are therefore idiosyncratic. The challenges of determining regional expense indexes are considerable and contribute to overall design basis risk. Furthermore, product specific revenue insurance products are easier to administer than whole farm products. Product specific revenue insurance reduces design risk complications.

While these simplifications should reduce design risks for area-triggered programs, there is a trade-off between design simplicity and minimizing the production distortions from employing a crop-specific revenue product. If policy makers retain a whole-farm approach, then selecting an appropriate weight for each commodity becomes an important issue when designing whole farm, area-based revenue protection. A simple index based on the sum of crop revenues across all commodities produced in the county implicitly assigns commodity weights that reflect the crop mix of the county to every whole-farm, area-based revenue insurance policy sold in that county. As a result, a farm producing a different crop mix may receive poor risk protection. Similarly, an area-based product is more likely to be more acceptable to a group of homogenous producers.

Attempts to minimize spatial risk requires the creation of risk areas that are homogenous with regard to soil and climate. Acquiring appropriate data to implement these homogenous risk regions requires significant development and administrative costs. There is a trade-off between minimizing spatial basis risk and minimizing administrative costs. Risk reduction under an optimal area assignment raises questions about the equity of such a program. If the risk areas are delineated to be homogenous, then non-systematic risk factors would attributable to producer specific factors. An optimal area would decrease systemic risk in the same proportion for all producers, but there would be significant differences between risk areas and among producers with significant differences in managerial ability.

This raises the question of whether producers be free to select the parameters of their program. Because of the potential for moral hazard, individual based programs require a deductible and that coverage levels never exceed 100%. Under area-based insurance moral hazard is essentially eliminated. Lower coverage levels for an area-based product tends to have higher basis risk. So increasing coverage levels will lower basis risk and therefore increase participation. Conceptually coverage levels could exceed 100% (but this would surely bring into doubt the neutrality of the program). Certainly increasing the coverage of any area triggered insurance-based revenue product would require the assessment of a fair premium. Even if the premium is subsided by the government, producers should be informed of the actual size of the fair premium. Producers should then have some flexibility in insuring the risks that are critical to their individual farm enterprises.

The possibility of crop/enterprise specific programs raises the potential for countervailing duties (especially initiated by the U.S.) because the programs are specific to a single enterprise. Another less serious concern is that Canada would not be able to report the expenditures as WTO-Annex eligible and therefore exempt from any reduction commitment. However, “green-box” criteria (i.e. Paragraph 7, Annex II WTO Agreement on Agriculture) are not a meaningful constraint on the development of BRM programs. For the last three notifications to the WTO, Canada’s current measure of Aggregate Measure of Support (AMS) expenditures only amounted to 15% of the bound AMS commitment (WTO, 2019). There is a great deal of flexibility for how Canada must report its domestic support expenditures to the WTO. Reforms to BRM programs are not constrained by the WTO Agreement on Agriculture.

Discussion and Conclusion

The primary objective of this project was to examine the feasibility of using regional area-based trigger mechanisms to determine Agri-Stability payouts rather than the current individualized trigger mechanism. In each case where an area trigger is employed, basis risk would be introduced through differences between individual and area risk factors. Effectively the risk is that farm-level variables will not fluctuate in the same manner as county-level variables. The contribution of this research is that it examines the basis risk that exists in Alberta between an area and individual crop farm, through stochastic simulations.

Risks in farm incomes are both systemic and idiosyncratic. If idiosyncratic risks dominate, the producer is best insured by an individual-based programs such as the current Agri-Stability program. If systemic risks dominate, then developing an appropriate area-based risk management product critically depends on measurement and accounting for all the relevant covariate risks. An area-based risk management program could potentially work, but this requires defining homogenous risk areas, and a design that is sufficiently simplified so that design risk does not dominate. Minimizing design risk likely involves revenue insurance rather than a margin-based program (expenses tend to be more idiosyncratic to individual management techniques). Enterprise specific revenue insurance is the more straightforward design but there is trade-off with potential trade remedy actions.

Producers complain that Agri-Stability is neither timely nor predictable. If basis risk is associated with an area-triggered program, then the program is not predictable. In fact, there is a trade-off between a timely program and a predictable program. Participants surveyed have indicated that the primary benefits of Agri-Stability are managing income losses and even out income flows (Agriculture and Agri-Food Canada 2017). Although the program lacks predictability and clarity, some producer groups indicate they prefer the targeted application of Agri-Stability over an alternative that may alleviate those issues but with a less targeted approach (Agriculture and Agri-Food Canada 2017). These findings could imply that there is a preference for a program that provides a higher direct payment with administrative complications than one that may have reduced payments and a simpler mechanism.

Limitations and Future Opportunities

This study involves a number of limitations. First, our analysis only considered crops, while livestock production and the associated risks are not considered. Mixed farms certainly benefit from increased diversification and off-setting risks. Large intensive livestock operations tend to be subject to more price risks than production risks. Price risks are systemic and region wide. Programs such as the *Western Livestock Price Insurance Program* (WLPIP) tend to fill their need. We have limited our analysis to three major crops (ignoring speciality crops) not because the other crops are not important, but to keep the analysis tractable. The joint distribution employed has to be tractable. We recognize the limitation of using a multivariate normal distribution where the individual marginal distributions may not be normal. An alternative approach would have been to employ a copula-based distribution that does not face this limitation. However, given the data constraints limiting this analysis the choice of functional form on the distribution function is of second order importance. Finally, we are not able to conduct welfare analysis or consider equity implications. This is primarily because we did not account for risk preferences (risk aversion) by producers. This would have required an additional step where the results are incorporated into an expected utility framework such as a certainty equivalent model. Although producer welfare considerations are important, the additional step is not necessary to ask our initial questions about the feasibility of area insurance and basis risk.

The temporal risks associated with using an area-based program were not evaluated in the study. The dataset used lacked a long enough time-series of production and income to properly examine intertemporal relationships. Systemic risks are maximized during extreme weather, or production events and during these moments basis risk is significantly reduced (Negi and Ramaswami 2018). Even by examining 2008-2017, the analysis presents a snapshot of the true relationships between individual and area incomes. Systemic production and income risks can occur over longer time horizons. In previous studies, scale factors were applied to adjust for higher individual farm volatilities than areas (Miranda 1991; Marra and Schurle 1994; Jeffrey, Trautman and Unterschultz 2017; Chalise et al. 2017). Implementing a scale factor could reduce basis risk observed.

Implementing an area-based support program could improve timeliness of program payouts, but due to basis risk the trade-off to participants is an accurate payout and inconsistent risk reduction. The study examines some implications of using an area-based mechanism in an Alberta setting, however not all factors were addressed in creating an appropriate area-based income support program.

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Appendix A - Covariance Matrix

Census Agriculture Region 2	Wheat Farm Yield	Barley Farm Yield	Canola Farm Yield	Wheat Area Yield	Barley Area Yield	Canola Area Yield	Wheat Farm Price	Barley Farm Price	Canola Farm Price	Wheat Area Price	Barley Area Price	Canola Area Price
Wheat Farm Yield	582.2	-164.4	-16.9	7.5	11.1	4.5	59.5	-7.5	-9.9	1.1	0.6	1.5
Barley Farm Yield	-164.4	1101.0	50.0	5.8	5.4	2.9	-36.8	54.7	8.5	0.4	0.7	1.8
Canola Farm Yield	-16.9	50.0	380.5	4.4	7.5	3.1	-10.7	3.4	94.5	0.5	0.4	0.6
Wheat Area Yield	7.5	5.8	4.4	22.1	30.6	9.1	-0.6	-0.2	0.6	2.9	2.1	4.5
Barley Area Yield	11.1	5.4	7.5	30.6	55.6	23.7	-0.5	-0.8	0.2	3.7	2.2	3.3
Canola Area Yield	4.5	2.9	3.1	9.1	23.7	16.9	-0.1	-0.6	-1.3	0.7	0.2	-0.2
Wheat Farm Price	59.5	-36.8	-10.7	-0.6	-0.5	-0.1	13.8	-1.4	-2.7	0.0	0.0	-0.1
Barley Farm Price	-7.5	54.7	3.4	-0.2	-0.8	-0.6	-1.4	5.7	1.3	0.0	0.0	0.1
Canola Farm Price	-9.9	8.5	94.5	0.6	0.2	-1.3	-2.7	1.3	36.2	0.2	0.2	0.2
Wheat Area Price	1.1	0.4	0.5	2.9	3.7	0.7	0.0	0.0	0.2	0.6	0.4	0.8
Barley Area Price	0.6	0.7	0.4	2.1	2.2	0.2	0.0	0.0	0.2	0.4	0.5	0.8
Canola Area Price	1.5	1.8	0.6	4.5	3.3	-0.2	-0.1	0.1	0.2	0.8	0.8	1.9

Appendix B – R Code and Procedure

Individual Data Procedure

1. Using revenues, yields, and acres provided – prices were calculated for each participant
2. Incomes were calculated for each individual using the allowable expenses provided for wheat, barley and canola
3. Expected incomes are incomes before 2017 which is used as the program year.
4. Averages and standard deviations for yields and prices are calculated for the simulation

Regional Data Procedure

5. Area yields and prices for each year are the median of all individuals in a given year.
6. Averages and standard deviations for yields and prices are calculated for the simulation

Simulation and Indemnity Calculations

7. Covariance matrix for yields and prices between area and individuals was calculated and used in the simulation of a multivariate normal distribution. 500 iterations were run.
8. The simulated area and individual prices and yields were then used to calculate indemnities through an Agri-Stability mechanism.
9. Holding yields at the averages, indemnities were calculated for an only price stochastic scenario.

R Code Used in Analysis

```
> library(dplyr)
> library(tidyr)
> library(writexl)
> library(MASS)
> library(robustbase)
> library(ggplot2)
>
> #iNDIVIDUAL REVENUES and Simulation
> ###############
>
> Rev<-revenue %>%
+   group_by(ID,PRG_YEAR,COM_NAME) %>%
+   mutate(row=row_number())%>%
+   tidyr::pivot_wider(names_from = COM_NAME, values_from = REV_AMOUNT,values_fill=0)
> Rev<-subset(Rev,select=-c(row,CATTLE,HOG,LENTILS,OTHER))
>
> Rev<-merge(Rev,yield_acre,by=c("ID","PRG_YEAR"))
>
> write_xlsx(Rev,"C:/Users/Megan/Documents/Thesis/FINALE/REVENUESbroken.xlsx")
>
> exppivot<-expense %>%
+   group_by(ID,PRG_YEAR,COM_NAME) %>%
+   mutate(row=row_number())%>%
+   tidyr::pivot_wider(names_from = COM_NAME, values_from = EXP_AMOUNT,values_fill=0)
> Exp<-subset(exppivot,select = -c(FEED,row,VET,OTHER_LIV_PURC,CATTLE_PURC,HOG_PURC))
>
> incomeTOT<-merge(REVENUESbroken,Exp,by=c("ID","PRG_YEAR"))
>
> #wheat price limits
> incomeTOT$p_wheat[incomeTOT$p_wheat>0 & incomeTOT$p_wheat<4]<-4
> incomeTOT$p_wheat[incomeTOT$p_wheat<0]<-0
> incomeTOT$p_wheat[incomeTOT$p_wheat>8.5]<-8.5
>
> #barley price limits
> incomeTOT$p_barley[incomeTOT$p_barley>0 & incomeTOT$p_barley<3]<-3
> incomeTOT$p_barley[incomeTOT$p_barley<0]<-0
> incomeTOT$p_barley[incomeTOT$p_barley>6.3]<-6.3
>
> #canola price limits
> incomeTOT$p_canola[incomeTOT$p_canola>0 & incomeTOT$p_canola<8.5]<-8.5
> incomeTOT$p_canola[incomeTOT$p_canola<0]<-0
> incomeTOT$p_canola[incomeTOT$p_canola>14.5]<-14.5
>
> #wheat yield limits
> incomeTOT$y_wheat[incomeTOT$y_wheat>0 & incomeTOT$y_wheat<4]<-4
> incomeTOT$y_wheat[incomeTOT$y_wheat<0]<-0
> incomeTOT$y_wheat[incomeTOT$y_wheat>60.96]<-60.96
>
> #barley yield limits
```

```
> incomeTOT$y_barley[incomeTOT$y_barley>0 & incomeTOT$y_barley<30]<-30
> incomeTOT$y_barley[incomeTOT$y_barley<0]<-0
> incomeTOT$y_barley[incomeTOT$y_barley>81.12]<-81.12
>
> #canola yield limits
> incomeTOT$y_canola[incomeTOT$y_canola>0 & incomeTOT$y_canola<10]<-10
> incomeTOT$y_canola[incomeTOT$y_canola<0]<-0
> incomeTOT$y_canola[incomeTOT$y_canola>47.28]<-47.28
>
>
> income_r2<-incomeTOT[incomeTOT$CENSUS_AG_REGION==2,]
> #filter only wheat, barley, canola, and variable expenses
>
> income_r2_3comm<-subset(income_r2,select = -c(PEAS,
OATS,y_acre_peas,y_oats,ACRE_peas,ACRE_oats,p_peas,p_oats,CROP_HAIL_INS,ELEC,
+                                     HEAT_FUEL,OTHER,WAGES_ROOM_BOARD,REV_SC,EXP_SC,MACH_FUEL))
>
> ####create 500k and 1mill sales groupings
>
> write_xlsx(income_r2_3comm,"C:/Users/Megan/Documents/Thesis/FINALE/region2inc_3comm.xlsx")
>
> #calculated revenues income income per acre, and sepearted out 2012-2017
>
> library(readxl)
> region2inc_3comm <- read_excel("region2inc_3comm.xlsx",
+                         sheet = "2012-2017")
> sample500<-r2_salesgroup[r2_salesgroup$rev_tot_calc>=500000 & r2_salesgroup$rev_tot_calc<1000000,]
>
> sample1mill<-r2_salesgroup[r2_salesgroup$rev_tot_calc>=1000000,]
>
>
> #Create area yields for each year
>
> PRG_YEAR<-c(2012:2017)
> y_wheat_r500<-rep(NA,6)
> y_wheat_r500[1]<-median(sample500$y_wheat[sample500$y_wheat>0 & sample500$PRG_YEAR==2012])
> y_wheat_r500[2]<-median(sample500$y_wheat[sample500$y_wheat>0 & sample500$PRG_YEAR==2013])
> y_wheat_r500[3]<-median(sample500$y_wheat[sample500$y_wheat>0 & sample500$PRG_YEAR==2014])
> y_wheat_r500[4]<-median(sample500$y_wheat[sample500$y_wheat>0 & sample500$PRG_YEAR==2015])
> y_wheat_r500[5]<-median(sample500$y_wheat[sample500$y_wheat>0 & sample500$PRG_YEAR==2016])
> y_wheat_r500[6]<-median(sample500$y_wheat[sample500$y_wheat>0 & sample500$PRG_YEAR==2017])
>
> y_barley_r500<-rep(NA,6)
> y_barley_r500[1]<-median(sample500$y_barley[sample500$y_barley>0 & sample500$PRG_YEAR==2012])
> y_barley_r500[2]<-median(sample500$y_barley[sample500$y_barley>0 & sample500$PRG_YEAR==2013])
> y_barley_r500[3]<-median(sample500$y_barley[sample500$y_barley>0 & sample500$PRG_YEAR==2014])
> y_barley_r500[4]<-median(sample500$y_barley[sample500$y_barley>0 & sample500$PRG_YEAR==2015])
> y_barley_r500[5]<-median(sample500$y_barley[sample500$y_barley>0 & sample500$PRG_YEAR==2016])
> y_barley_r500[6]<-median(sample500$y_barley[sample500$y_barley>0 & sample500$PRG_YEAR==2017])
>
> y_canola_r500<-rep(NA,6)
> y_canola_r500[1]<-median(income_r2$y_canola[income_r2$y_canola>0 & income_r2$PRG_YEAR==2012])
> y_canola_r500[2]<-median(income_r2$y_canola[income_r2$y_canola>0 & income_r2$PRG_YEAR==2013])
> y_canola_r500[3]<-median(income_r2$y_canola[income_r2$y_canola>0 & income_r2$PRG_YEAR==2014])
> y_canola_r500[4]<-median(income_r2$y_canola[income_r2$y_canola>0 & income_r2$PRG_YEAR==2015])
> y_canola_r500[5]<-median(income_r2$y_canola[income_r2$y_canola>0 & income_r2$PRG_YEAR==2016])
> y_canola_r500[6]<-median(income_r2$y_canola[income_r2$y_canola>0 & income_r2$PRG_YEAR==2017])
>
> area2_mean500<-data.frame(PRG_YEAR,y_wheat_r500,y_barley_r500,y_canola_r500)
>
> r2_3comm500<-merge(sample500,area2_mean500,by="PRG_YEAR")
>
> #get regional prices
> aggprice<-price_data[price_data$Year>=2012 & price_data$Year<2017,]
>
> aggprice<-aggregate(aggprice,by=list(aggprice$Year),FUN = mean)
>
> colnames(aggprice)<-paste("preg",colnames(aggprice),sep="_")
> names(aggprice)[2]<-"PRG_YEAR"
>
> r2_3comm500<-merge(r2_3comm500,aggprice,by="PRG_YEAR")
> r2_3comm500<-subset(r2_3comm500,select = -c(preg_Group.1))
>
> #averages for the simulation
>
> avg_y_p500<-rep(NA,12)
> avg_y_p500[1]<-median(r2_3comm500$y_wheat[r2_3comm500$y_wheat>0])
> avg_y_p500[2]<-median(r2_3comm500$y_barley[r2_3comm500$y_barley>0])
> avg_y_p500[3]<-median(r2_3comm500$y_canola[r2_3comm500$y_canola>0])
```

```
> avg_y_p500[4]<-median(r2_3comm500$y_wheat_r500[r2_3comm500$y_wheat_r500>0])
> avg_y_p500[5]<-median(r2_3comm500$y_barley_r500[r2_3comm500$y_barley_r500>0])
> avg_y_p500[6]<-median(r2_3comm500$y_canola_r500[r2_3comm500$y_canola_r500>0])
> avg_y_p500[7]<-median(r2_3comm500$p_wheat[r2_3comm500$p_wheat>0])
> avg_y_p500[8]<-median(r2_3comm500$p_barley[r2_3comm500$p_barley>0])
> avg_y_p500[9]<-median(r2_3comm500$p_canola[r2_3comm500$p_canola>0])
> avg_y_p500[10]<-median(r2_3comm500$preg_wheat[r2_3comm500$preg_wheat>0])
> avg_y_p500[11]<-median(r2_3comm500$preg_barley[r2_3comm500$preg_barley>0])
> avg_y_p500[12]<-median(r2_3comm500$preg_canola[r2_3comm500$preg_canola>0])
>
> stdev_y_p500<-rep(NA,12)
> stdev_y_p500[1]<-sd(r2_3comm500$y_wheat[r2_3comm500$y_wheat>0])
> stdev_y_p500[2]<-sd(r2_3comm500$y_barley[r2_3comm500$y_barley>0])
> stdev_y_p500[3]<-sd(r2_3comm500$y_canola[r2_3comm500$y_canola>0])
> stdev_y_p500[4]<-sd(r2_3comm500$y_wheat_r[r2_3comm500$y_wheat_r>0])
> stdev_y_p500[5]<-sd(r2_3comm500$y_barley_r[r2_3comm500$y_barley_r>0])
> stdev_y_p500[6]<-sd(r2_3comm500$y_canola_r[r2_3comm500$y_canola_r>0])
> stdev_y_p500[7]<-sd(r2_3comm500$p_wheat[r2_3comm500$p_wheat>0])
> stdev_y_p500[8]<-sd(r2_3comm500$p_barley[r2_3comm500$p_barley>0])
> stdev_y_p500[9]<-sd(r2_3comm500$p_canola[r2_3comm500$p_canola>0])
> stdev_y_p500[10]<-sd(r2_3comm500$preg_wheat[r2_3comm500$preg_wheat>0])
> stdev_y_p500[11]<-sd(r2_3comm500$preg_barley[r2_3comm500$preg_barley>0])
> stdev_y_p500[12]<-sd(r2_3comm500$preg_canola[r2_3comm500$preg_canola>0])
>
> stdev_y_p500<-as.data.frame(stdev_y_p500,row.names = names)
> write_xlsx(stdev_y_p500,"C:/Users/Megan/Documents/Thesis/FINALE/standarddevsample500.xlsx")
>
> covmatrix500<-as.data.frame(cov(r2_3comm500[,c(4,5,6,22,23,24,11,12,13,25,26,27)]))
> corrmatrix500<-as.data.frame(cor(r2_3comm500[,c(4,5,6,22,23,24,11,12,13,25,26,27)]))
>
> #Simulation
> set.seed(24171994)
> sim500<-data.frame(mvrnorm(n=500,avg_y_p500,covmatrix500,12,12))
> sim500<-replace(sim500,sim500<0,0)
>
> #wheat price limits
> sim500$p_wheat[sim500$p_wheat>0 & sim500$p_wheat<4]<-4
> sim500$p_wheat[sim500$p_wheat<0]<-0
> sim500$p_wheat[sim500$p_wheat>8.5]<-8.5
>
> #barley price limits
> sim500$p_barley[sim500$p_barley>0 & sim500$p_barley<3]<-3
> sim500$p_barley[sim500$p_barley<0]<-0
> sim500$p_barley[sim500$p_barley>6.3]<-6.3
>
> #canola price limits
> sim500$p_canola[sim500$p_canola>0 & sim500$p_canola<8.5]<-8.5
> sim500$p_canola[sim500$p_canola<0]<-0
> sim500$p_canola[sim500$p_canola>14.5]<-14.5
>
> #wheat yield limits
> sim500$y_wheat[sim500$y_wheat>0 & sim500$y_wheat<4]<-4
> sim500$y_wheat[sim500$y_wheat<0]<-0
> sim500$y_wheat[sim500$y_wheat>60.96]<-60.96
>
> #barley yield limits
> sim500$y_barley[sim500$y_barley>0 & sim500$y_barley<30]<-30
> sim500$y_barley[sim500$y_barley<0]<-0
> sim500$y_barley[sim500$y_barley>81.12]<-81.12
>
> #canola yield limits
> sim500$y_canola[sim500$y_canola>0 & sim500$y_canola<10]<-10
> sim500$y_canola[sim500$y_canola<0]<-0
> sim500$y_canola[sim500$y_canola>47.28]<-47.28
>
> #area averages for commodities
> r2_sim500<-sim500
> r2_sim500$a_wheat<-median(r2_3comm500$ACRE_wheat[r2_3comm500$ACRE_wheat>0])
> r2_sim500$a_barley<-median(r2_3comm500$ACRE_barley[r2_3comm500$ACRE_barley>0])
> r2_sim500$a_canola<-median(r2_3comm500$ACRE_canola[r2_3comm500$ACRE_canola>0])
>
> #average variable costs per bushel from Agriprofits black soil 2017
> #top 1/3 is: Spring wheat=$2.97, barley=$2.97, canola=$4.09
> r2_sim500$expenseperbushel_wheat<-4.31
> r2_sim500$expenseperbushel_barley<-3.69
> r2_sim500$expenseperbushel_canola<-6.91
> ###calculations for income and expected incomes were calculated in excel and then
> #reloaded into R
>
```

R Code Used in Analysis

```
> library(readxl)
> inc_sim500 <- read_excel("r2_sim500.xlsx",
+                     sheet = "Income")
> View(inc_sim500)
>
> #loaded expected values
> library(readxl)
> Expected_inc500 <- read_excel("r2_sim500.xlsx",
+                          sheet = "Expected Values")
> View(Expected_inc500)
>
> #####
> #Indemnity Calculations
> ######################################
> #calculate shortfall, agristability, and area payments
>
>
> inc_sim500$ref_marg<-inc_sim500$E_income_i
> n<-500
>
>
> for(i in 1:n){
+   inc_sim500$RML[i]<-if(inc_sim500$ref_marg[i]>Expected_inc500$expTOT_i){
+     Expected_inc$E_expTOT_i
+   } else{inc_sim500$E_income_i[i]
+   }
+ }
> inc_sim_pos500<-inc_sim500[inc_sim500$income_i>0 & inc_sim500$income_r>0,]
>
> inc_sim_pos500$AS_indemnity<-((0.7*inc_sim_pos500$ref_marg)-inc_sim_pos500$income_i)*0.7
>
> inc_sim_pos500$AS_indemnity[inc_sim_pos500$AS_indemnity<0]<-0
>
> #agri-stability function with regional numbers
> m<-495
> inc_sim_pos500$ID<-c(1:m)
> agstab_reg500<-as.data.frame(inc_sim_pos500$income_r)
> names(agstab_reg500)[1]<-"income_r"
> agstab_reg500$ID<-inc_sim_pos500$ID
> agstab_reg500$ref_marg<-inc_sim_pos500$E_income_r
>
>
>
> for(i in 1:m){
+   agstab_reg500$RML[i]<-if(agstab_reg500$ref_marg[i]>Expected_inc500$expTOT_r){
+     Expected_inc500$expTOT_r
+   } else{agstab_reg500$ref_marg[i]
+   }
+ }
> agstab_reg500$AS_indemnity_r<-((0.7*agstab_reg500$ref_marg)-agstab_reg500$income_r)*0.7
>
> agstab_reg500$AS_indemnity_r[agstab_reg500$AS_indemnity_r<0]<-0
>
> agstab_reg500$AS_indemnity_i<-inc_sim_pos500$AS_indemnity
>
> agstab_reg500$indem_diff<-agstab_reg500$AS_indemnity_r - agstab_reg500$AS_indemnity_i
>
> #agri-stability mechanism with higher coverage levels
> agstab_reg500$AS_indemnity_r80<-((0.7*agstab_reg500$ref_marg)-agstab_reg500$income_r)*0.80
>
> agstab_reg500$AS_indemnity_r80[agstab_reg500$AS_indemnity_r80<0]<-0
> ###price stochastic with yields constant
> ###incomes calculated in excel then loaded into R
>
> library(readxl)
> price_stochastic <- read_excel("price_stochastic.xlsx",
+                           sheet = "Income")
> View(price_stochastic)
>
> price_stochastic$ref_marg<-price_stochastic$E_income_i
> n<-500
>
>
> for(i in 1:n){
+   price_stochastic$RML[i]<-if(price_stochastic$ref_marg[i]>Expected_inc500$expTOT_i){
+     Expected_inc$E_expTOT_i
+   } else{price_stochastic$E_income_i[i]
+   }
+ }
```

R Code Used in Analysis

```
> p_stoch500_pos<-price_stochastic[price_stochastic$income_i>0 & price_stochastic$income_r>0,]
>
> p_stoch500_pos$AS_indemnity<-((0.7*p_stoch500_pos$ref_marg)-p_stoch500_pos$income_i)*0.7
>
> p_stoch500_pos$AS_indemnity[p_stoch500_pos$AS_indemnity<0]<-0
>
> #agri-stability function with regional numbers
> h<-490
> p_stoch500_pos$ID<-c(1:h)
> agstab_price_stoch<-as.data.frame(p_stoch500_pos$income_r)
> names(agstab_price_stoch)[1]<-"income_r"
> agstab_price_stoch$ID<-p_stoch500_pos$ID
> agstab_price_stoch$ref_marg<-p_stoch500_pos$E_income_r
>
>
>
> for(i in 1:m){
+   agstab_price_stoch$RML[i]<-if(agstab_price_stoch$ref_marg[i]>Expected_inc500$expTOT_r){
+     Expected_inc500$expTOT_r
+   } else{agstab_price_stoch$ref_marg[i]
+   }
+ }
> agstab_price_stoch$AS_indemnity_r<-((0.7*agstab_price_stoch$ref_marg)-agstab_price_stoch$income_r)*0.7
>
> agstab_price_stoch$AS_indemnity_r[agstab_price_stoch$AS_indemnity_r<0]<-0
>
> agstab_price_stoch$AS_indemnity_i<-p_stoch500_pos$AS_indemnity
>
> agstab_price_stoch$indem_diff<-agstab_price_stoch$AS_indemnity_r - agstab_price_stoch$AS_indemnity_i
> agstab_price_stoch$AS_r_acre<-(p_stoch500_pos$income_i+agstab_price_stoch$AS_indemnity_r)/1969
> agstab_price_stoch$AS_i_acre<-(p_stoch500_pos$income_i+agstab_price_stoch$AS_indemnity_i)/1969
> agstab_price_stoch$noprogram_i_acre<-p_stoch500_pos$income_i/1969
>
> agstab_price_stoch$r_proportion<-agstab_price_stoch$indem_diff/agstab_price_stoch$AS_indemnity_i
```