ABSTRACT

BUSINESS RISK MANAGEMENT PROGRAMS AND RISK-BALANCING BEHAVIOR

IN ONTARIO HOG SECTOR

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Agri-food sectors in Canada are supported through safety net programs. CAIS/BRM programs were designed to help producers reduce BR by mitigating negative income shocks and reducing income variability. Nevertheless, according to the risk-balancing hypothesis, farms may take more FR in response to a reduction in BR as a result of program payments. If we find evidence of such behavior, risk-reduction efforts of CAIS/BRM programs may not generate intended outcomes. This thesis employs OFID tax-filing data over the 2003-2014 period to estimate the extent of risk-balancing in the Ontario hog sector as a result of AgriStability payments under CAIS/BRM. We find that AgriStability payments were effective in reducing BR for medium and large farms but not small farms. Controlling for other determinants of financial risk, our log-log fixed-effects regression provides evidence of risk-balancing for medium and large farms in Ontario hog sector.
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LIST OF ABBREVIATIONS

APF: Agricultural Policy Framework
BR: Business Risk
BRM: Business Risk Management
CAIS: Canadian Agricultural Income Stabilization
CI: Crop Insurance
CV: Coefficient of Variation
FCC: Farm Credit Canada
FR: Financial Risk
GFI: Growing Forward I
GFII: Growing Forward II
MAD: Median Absolute Deviation
NOI: Net Operating Income
OMAFRA: Ontario Ministry of Agriculture, Food and Rural Affairs
TR: Total Risk
VIF: Variance Inflation Factor
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1 CHAPTER 1: INTRODUCTION

1.1 Background

1.1.1 Agriculture: an industry characterized by growing uncertainty and volatility

The biological basis of agricultural production makes farms prone to uncertainty with respect to yield. All farms are exposed to production risks, regardless of their sizes. Yield loss of field crop farms may come from natural hazards and/or the prevalence of insects and diseases. For livestock farms, however, losses caused by infectious diseases or adverse weather conditions are not uncommon. More importantly, losses from a contagious disease outbreak may strike a myriad of farms, large or small, and hit production of the entire sector very hard.

Changes in global climate may induce additional variability to farm production and farm income. Due to climate change, rainfall could become more erratic in terms of volume and timing and temperatures could swing wildly. Both changes may lead to more frequent weather calamities like severe storms, flash flooding and droughts. Due to these conditions, agricultural production could become seriously affected.

Closely associated with production uncertainty is the risk of price fluctuations. Price uncertainty has long been a major issue in farming because expected prices could vastly differ from actual prices due to the time gap between the decision to produce and the realization of final production. Farm commodity prices have fluctuated dramatically in recent years. For example, global price of corn experienced large swings in recent years, which influenced not only the corn sector but also adversely impacted poultry, beef and hog sectors. In particular, corn prices doubled from around $2 per bushel in 2006 to about $4 per bushel in 2007 and surged to $8 per bushel in the summer of 2012. Corn prices have since fallen back to $4 per bushel.
Being affected by both production and price fluctuations, farm income has become more variable in recent years than in the past. Figure 1 depicts Canadian farm income from 1980 to 2016. As can be noted from the graph, farm income has become more volatile during the last ten years compared to the previous decade.

![Net farm income - aggregate across all farms, Canada, 1980 - 2016](image)

**Figure 1. Net farm income - aggregate across all farms, Canada, 1980 - 2016**

*Source: Statistics Canada CANSIM Table 002-0009: Net farm income*

Figure 2 reveals similar pattern related to farm income in Ontario during the same period.

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1 Net farm income in this table is real income (government payments included). Real net farm income is calculated based on Canadian Consumer Price Index with 2002 as base year.
The agricultural sector continues to confront inherent risks caused by production and market volatilities, which are accentuated by the growing impacts of global climate change. Therefore, the need for government safety net programs would be even greater in the future to assist farmers to cope with higher income variability and to enhance the long-term sustainability of farm business in Canada.

The following section casts a glance at the Canadian Farm Business Risk Management suite, the core component of Canadian policy tool kit in agricultural risk-management.

1.1.2 The Canadian Farm Business Risk Management programs

Business risk management has been the central focus of Canadian agricultural policy. Growing Forward II framework reinforces this theme (AAFC, 2012). Being a

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2 Net farm income in this table is real income includes government payments. Real net farm income is calculated based on Ontario Consumer Price Index with 2002 as the base year.
whole farm-based income stabilization policy, the Canadian Farm Business Risk Management (BRM) pillar target risks of all sizes and types of farms in Canada.

Under the current Growing Forward (hereinafter referred to as GF) (2013-2018), AgriStability payment is triggered when the Program Year Margin falls below 70 percent of the Reference Margin. Calculation of the Reference Margin for a given year is based on an Olympic average\(^3\) of the preceding five years’ production margins. Starting in the 2013 Program Year, AgriStability payment will be calculated based on the Reference Margin or the average Allowable Expenses in the years used to calculate the RM, whichever is less (AAFC, 2011). For instance, if Reference Margin is $80,000 and the average Allowable Expenses is $50,000, Reference Margin limit of $50,000 is applied to calculate program payment. Besides, Reference Margin is also adjusted in order to reflect any structural change that occurred on the farms. For instance, changing of commodities, up or downsizing of farming operations. In these cases, historical margins are adjusted, and Reference Margin is re-calculated using these adjusted figures. In addition to this Tier of payment, Negative Margin is covered by the government at 70 percent of the portion of margin decline that is below zero, provided it does not exceed the maximum program payment of $3 million per farm.

When the Program Year Margin loss is less than 30 percent of the Reference Margin, farm operators are expected to manage such margin loss through a self-managed producer – government saving account supported by AgrilInvest. This is a savings account built upon annual deposits based on a percentage of farms’ Allowable Net Sales with matching contributions from federal, provincial, and territorial governments. Farm operators can deposit up to 100 percent of their Allowable Net Sales annually and receive matching government contribution on 1 percent of ANS. Matching government contributions is capped at $15,000 per year, corresponding to a maximum ANS of $1.5 million. Also, farms must have ANS of at least $7,500 to make a

\(^3\) An arithmetic average of the previous 5 years’ margin are calculated, with the highest and lowest margin years dropped.
deposit and receive matching government contribution. Farm operators can withdraw from AgriInvest account at any time for risk mitigation or for investment purposes. Both AgriStability and AgriInvest are based on tax information.

Figure 3, Figure 4 and Figure 5 illustrate the structure of AgriStability payment scheme under the Canadian Agricultural Income Stabilization (hereinafter referred to as CAIS), GF I (2007-2012) and GF II (2013-2018), respectively. Under CAIS, AgriStability had 4 Tiers of payment, under which Tier 1 representing the smallest income decline of up to 15 percent of the Reference Margin is covered. Moving to GF I policy frameworks, this Tier is covered under AgriInvest. Notably, AgriInvest supports farm operators when the program year margin loss is up to 30 percent of the Reference Margin. Furthermore, under GF II, negative margins are protected by AgriStability payment at 70 percent while the protection level was at 60% under CAIS and GF I.

![Figure 3. Layering and cost sharing of AgriStability payment under CAIS](image)

*Source: Agricorp – Canadian Agricultural Income Stabilization Handbook*
1.1.3 Risk-balancing behavior in Canadian farming industry: an overview

While AgriStability program intends to mitigate farm income fluctuations, this risk-reducing program modifies the distribution of farm revenue and income and therefore, has the potential to amend the production decisions and risk management strategy of farmers.

An illustration of how BRM programs potentially impact farm’s production is depicted in Figure 6. The theory of production under risk and uncertainty informs us that risk-averse producers reduce their input usage and production in the presence of risk,
meaning the supply curve shifts upward. If risk-reducing policies are effective in mitigating the risks faced by producers, the supply curve would shift downward, resulting in an increase in total production.

Figure 6. The effects of risk-reducing policies on farm’s production

Note: Supply is at farm level. MR stands for marginal revenue

Some analysts argue that a reduction in income variability generates responses in farm’s diversification strategies which could net off or even negate the intended risk-reducing effects of government’s safety net payments. For instance, using data for a representative farm in Manitoba and a simulation analysis, Turvey (2012) finds that programs like CAIS, AgriStability and Agrilnvest create incentives for farmers to specialize in riskier crops in their portfolio choice that generate higher returns.

Another channel through which risk-reducing programs might lead to unintended outcomes of farmer’s risk management behavior and thus, fail to mitigate farm risk is through risk-balancing. The risk-balancing hypothesis maintains that a shock that affects farms’ level of business risk may induce farmers to make offsetting adjustments in its financial decision, which brings about a rise (fall) in financial risk in response to a
fall (rise) in business risk (Gabriel & Baker, 1980). This could lead to an increase (decrease) rather than decrease (increase) of overall farm risks.

A limited number of empirical studies have explored the risk-reducing effects of BRM programs taking into account risk-balancing behavior. Employing cross-sectional data for 13,629 farms in the United States in 2011, Ifft et al. (2015) investigated the impacts of Federal Crop Insurance (FCI) programs on farm debt use. The authors found that FCI participation is associated with an increase in short-term debt use but does not have a statistically significant impact on long-term debt. One of the limitation of this study is that using cross-sectional data does not allow for examining dynamic relationship between FCI participation and farmer’s debt use decisions.

De Mey et al. (2014) explored the strategic adjustments of financial risk of European farmers in response to changes in business risk, using cross-sectional and time series data on EU-15 farm sector for the 1995-2008 period. The analysis result was that 54% of observations show strategic adjustments of financial risk upon changes in the level of business risk. Besides, this adjustment was slow process, the extent of which differs across countries and farm types. However, there was a lack of comparison and explanation about the different results obtained from the two approaches employed in the research.

Ueza et al. (2014b) studied the effects of Canadian Farm Business Risk Management (BRM) programs in reducing farm risks using panel annual data on Ontario field crop and beef farms from 2003 to 2011. It was concluded that BRM payments reduce business risk for beef farms but not for field crop farms. Moreover, a decrease in income variability induces farmers in both sectors to take on more debts. Remarkably, correlation coefficient analysis approach has limitation because it ignores other potential influential factors influencing the financial risk decision.

Employing Survey data of 400 farm households in Shaan Province, Yangling district, China in October 2007, Turvey and Kong (2009) looked into the relationships
between business risks and credit choices of rural farm households in China. Findings were that farmers’ credit choices are related to expected production risk, risk aversion and expected farm income. Also, farmers facing higher production risks reduce financial risks with lower credit demand. A point to note, the paper did not give sufficient explanation of the different results obtained from the four regressions.

Escalante and Barry (2003) explore the strength of trade-offs between business risk and financial risk using panel farm-level dataset of 80 farms over the 1982-1998 period in the United States. The authors concluded that 50% of farms showed strategic adjustment of capital structure when the level of business risk changes. Also, amount of crop insurance coverage, farm tenure position and crop diversification are determinants of the strategic capital adjustments. This paper provides motivation for investigating the extent of risk reduction realized under a more integrated risk management approach, given the compatibility between risk balancing and alternative strategies demonstrated in this study.

A critical review of the existing empirical literature on risk-balancing behavior will be provided in Chapter 3 – Literature Review. In this chapter, specific questions pertaining to each empirical study will also be addressed, including but not limit to: whether the authors use an appropriate analytical framework and whether the empirical analysis is adequate; any limitations in the econometric methods used and how could those be improved; gap(s) highlighting and how those gaps could be bridged in this thesis.

1.2 Economic problem, economic research problem and motivation for the study

The following section presents economic problem, economic research problem and specifies the scope of this study.

1.2.1 Economic problem

Previous literature has identified that the risk-reducing effects of government programs may lead to an upward adjustment of financial leverage position for farms. Such
responses, if present, may offset the desirable benefits of BRM programs and may make
the program ineffective in the long run. This could also adversely affect the long-run
sustainability of farming in Canada.

This research will investigate the risk-balancing behavior of farmers in the Ontario hog
sector as a result of AgriStability payments under CAIS/BRM programs. Therefore, its
result could be of interests to the administrators of BRM programs, who are to review and
make necessary adjustments to these programs upon the expiration of Growing Forward
II in 2018 so that the intended objective of mitigating farm risks could be attained. Put
differently, the findings of this research on the effectiveness of BRM programs in reducing
farm risks, taking into account the possible risk-balancing behaviors of farmers, would
encourage the government at federal, provincial and territorial level\(^4\) to either continue
mitigating farm risks for the Ontario hog sector through this channel or consider making
necessary amendments to these programs or even explore other policy change to reduce
farm risks.

1.2.2 Economic research problem

It is not known from the existing empirical literature if Canadian farm BRM
programs reduce business risk for Ontario hog farms. Furthermore, the ways business
risk was measured varies across studies, and each way has its own pros and cons.
Besides, it is not known whether this reduction in business risk leads to an increase in
financial risk and possibly, a higher level of overall risk for farm operations. Additionally,
against the current background of increasing farm consolidation, a question of interest
has arisen on whether the extent of risk-balancing differs among farms of different size
categories.

In addition, there is more than one channel through which farmers may perform
their risk management behaviors that may crowd out the risk-reducing effects of BRM

\(^4\text{Growing Forward 2 is a five-year policy frame-work (2013-2018) for Canada agriculture and agri-food sector based on the investment of federal, provincial and territorial governments.}\)
programs. Findings from Escalante and Barry (2003) suggest that if risk-reducing policies reduce farmer's incentive to buy Crop Insurance, insurance-protection plans could be considered as an alternative to risk-balancing. This means that instead of making offsetting adjustment in farm's leverage position by taking on more debt, farmers may respond to the reduction in business risk level as a result of government's financial aid by purchasing less Crop Insurance. This could generate a higher level of overall risk for farm operations. However, little is known from the current literature on whether or not this behavior is prevalent among hog farm operators in Ontario. Put differently, it is not known whether Crop Insurance and BRM/ AgriStability are substitutes or complements in program participation.

This research builds upon the theoretical framework conceptualized by Gabriel and Barker (1980) and Collins (1985).

This economic research problem falls under the category of a policy evaluation. BRM programs are under the umbrella of Growing Forward, an agricultural policy framework subject to evaluation and revision every five years in Canada. The scope of this study is limited to the Ontario hog sector for the 2003-2014 period.

1.2.3 Motivation for the study: why Ontario hog sector?

Ontario continues to hold a strong position in the Canadian agri-food landscape. The province ranks 3rd following Saskatchewan and Alberta in terms of farm cash receipts over years and accounts for more than 20 percent of farm cash receipts of Canada. Figure 7 demonstrates farm cash receipts by province from 2007 to 2017 and Figure 8 depicts provincial distribution of total farm cash receipts in 2014. Besides, Ontario farm cash receipts followed a consistent upward sloping trend during the study period (Fig. 9).
Figure 7. Total farm cash receipts by province

Source: Statistics Canada, Table 32-10-0045-01 (x1,000)

Figure 8. Provincial distribution of farm cash receipt in Canada – 2014

Source: Statistics Canada, Table 32-10-0045-01 (x1,000)
Concerning farm numbers, Ontario accounts for over one-quarter of all farms in Canada. Figure 10 and Figure 11 illustrate provincial distribution of agricultural operations by farm numbers in 2006 and 2016, respectively. In addition, one-fifth of the national gross farm receipts were generated by Ontario agricultural operations in 2015.
Figure 11. Provincial distribution of agricultural operations by farm numbers, 2016

Source: Statistics Canada. Table 32-10-0407-01. Tenure of land owned, leased, rented, crop-share, used through other arrangements or used by others every 5 years.

The agri-food sector in Ontario today is a highly diverse sector in terms of the size of operations, commodities produced, level of equity and indebtedness as well as access to market and technology. These factors have significant bearing on farm incomes and on the long-term sustainability of farming as a business. Figure 12 illustrates the fluctuations of net farm income in Ontario from 2003 to 2014, with an upward sloping pattern from 2009 till the end of the period. The BRM programs in Ontario attempts to reduce farm business risks through reducing income variability and enhancing farm income.

In addition, Ontario is among the provinces that has received substantial government payments over years. Figure 13 depicts net government payments by provinces from 2007 to 2017.
Hog production is a vital component of Canada’s agricultural economy. Based on hog statistics from Canadian Pork Council, the hog industry brings in $9.8 billion annually. Also, the hog sector ranked 4th in Canada in terms of cash receipts, after canola, dairy and cattle in 2011. In addition, hog receipts have increased for the past five years due to strong hog prices, especially in 2014 (Brisson, 2015).

However, the hog sector has had significant fluctuations in returns. In particular, the rates of return on assets and equity have declined recently, as farm asset and

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**Figure 12. Net farm income in Ontario 2003 – 2014**

*Source: Statistics Canada. CANSIM Table 002-0009. Net farm income (x1,000)*

**Figure 13. Direct net government payment by province, annual (’000)**

*Source: Statistics Canada, Table: 32-10-0106-01: Direct payments to agricultural producers*

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equity values have increased faster than net incomes. Increased asset values partly reflect the general increase in the size of hog farms across provinces in Canada.

Most importantly, Ontario is among the three provinces that dominates hog and pork production in Canada. Sectoral highlights in the province will be presented and elaborated with key facts and feature under section 2.6 in the next chapter.

1.3 Purpose and objectives

The purpose of this study is to investigate whether farmers in the Ontario hog sectors take on more financial risk when business risk decreases as a result of AgriStability payments under CAIS/BRM programs.

The specific objectives of this study are as follows:

i. To estimate the effects of CAIS/BRM programs in reducing business risk for Ontario hog farms.
ii. To explore the extent of risk-balancing behaviors in Ontario hog farms, if any.

In order to realize the above-mentioned objectives, corresponding null hypotheses are established in the study as below:

i. CAIS/BRM programs did not reduce business risk for Ontario hog farms
ii. Hog farmers in Ontario did not take on more financial risk in response to a reduction in level of business risk.

1.4 Chapter outlines

This thesis is organized as below:

Chapter 1, Introduction, provides background covering real-world and academic context of the research topic, identify the economic problem and economic research problems as well as presents the motivation and the objectives of this thesis.
Chapter 2, *An overview of farm safety-net programs in Canada and Ontario hog sector*, presents the evolution and description of Farm Safety Net Programs in Canada together with key facts and figures of the Ontario hog sector.

Chapter 3, *Literature Review*, provides a review of the theoretical literature of the risk-balancing hypothesis as well as a chronological review and critical assessment of the relevant empirical studies. Most importantly, it aims to identify the gaps in the literature and discusses the ways to bridge one of those gaps.

Chapter 4, *Analytical Framework*, presents the conceptual framework that this study builds upon. It narrows the focus of the project and use theory and economic reasons to identify factors important to the selected model. In particulars, this chapter builds an analytical framework to explore factors influencing farmers’ financial risk decisions. In addition, an attempt was made to incorporate Crop Insurance into the theoretical analysis of risk-balancing.

Chapter 5, *Data, variable measurement and descriptive statistics*, describes data sources and features and define the variables used in the investigation of risk-balancing behavior in Ontario hog farms. The chapter also provides descriptive statistics of the key variables and explain different alternatives of risk measurement to be employed in the empirical analysis.

Chapter 6, *Research methods and empirical results*, presents the empirical approaches employed to assess the effectiveness of CAIS/ BRM and to explore the risk-balancing behavior in Ontario hog sector. Besides, the chapter presents model specification, estimation methods and provides an analysis and discussion of the empirical results obtained in the study.

Chapter 7, *Conclusion*, summarizes the methods used and key findings and discusses policy implications. It also identifies contributions and limitations of the thesis and suggests recommendations for future research.
2 CHAPTER 2. AN OVERVIEW OF CANADIAN FARM SAFETY-NET PROGRAMS AND ONTARIO HOG SECTOR

2.1 Chapter introduction

Canada is a small exporter and is considered a price taker on the world agricultural market. Large share of market generated income is subject to local as well as global market fluctuations. Farm Safety Net programs have been designed primarily to minimize the negative impacts of market fluctuations on farm income. Farm safety-net programs in Canada have followed a distinct path of evolution and there have been significant changes in the design and operation of Canadian farm safety net programs since its inception in 1958.

The purpose of this chapter is twofold: first, it aims to provide a historical overview of farm safety-net programs in Canada and to furnish a deeper understanding of the current safety net programs and its evolution path. The focus of this section is on the two most important components of Canadian agricultural support programs, i.e., the Business Risk Management programs and Crop Insurance. Secondly, this chapter provides an overview of the Ontario hog sector with some highlighted facts and figures.

2.2 Historical overview of farm safety net programs in Canada

While several ad-hoc support programs had previously existed, the federal government launched the Agricultural Stabilization Act in 1958 for all Canadian farmers. This first major stabilization program marked the first milestone in agricultural safety-net programs in Canada. The second major stabilization program was the Western Grain Stabilization Act of 1976. Based on Schmitz et al (2010), this act was adopted to assist Prairie farmers to stabilize their crop income. Both of these stabilization efforts were managed by the Federal government of Canada.

The second milestone in Canadian agricultural support programs was marked by the introduction of the Farm Income Protection Act in 1991. This act eliminated all
previous farm programs and introduced two brand new programs called the Gross Revenue Insurance Program (1991-1995), the Net Income Stabilization Program (1994-2003) and Crop Insurance, and brought about an important shift to Federal – Provincial partnership in farm safety-net programs in Canada.

In 1998, the Federal government introduced the Agricultural Income Disaster Assistance program (AIDA) as a temporary farm income support program based on WTO guidelines. However, the program was replaced by the Canadian Farm Income Program (CFIP) in 2001 due to major design flaws that made it unacceptable to most farm groups (Schmitz, 2008).

The Canadian Agricultural Income Stabilization program (CAIS) was developed in 2003 under the Agricultural Policy Framework to replace NISA and the previous two ad hoc programs available to producers, i.e., the Farm Income Disaster Program and the CFIP.

Beginning in 2007, federal, provincial and territorial ministers of agriculture agreed to adopt Growing Forward, a new market-driven vision for Canada’s Agricultural and Agri-food industry. These new business-risk management programs (BRM) under Growing Forward framework replaced the Canadian Agricultural Income Stabilization Program.

**The Agricultural Stabilization Act (1958 – 1975):** the first major stabilization program introduced in Canada was the Agricultural Stabilization Act (ASA) in 1958. It was fully funded by the Canadian Federal Government. ASA was a commodity-based and price stabilization program, where farmers receive per unit subsidies when a particular commodity price fell below 90 per cent of the previous three-year’s moving average price. Thus, the ASA was designed to protect producers against downside risks, and producers received payments only when price fell below the floor price of named commodities. Commodity coverage of the ASA includes grains and livestock commodities for all provinces.
It is interesting to note that Crop Insurance programs have been a part of Canadian agricultural policy since it was launched under the Canadian Insurance Act in 1957 and it co-existed with the ASA for most the period.

**The Western Grain Stabilization Act (1976-1991):** according to Schmitz et al (2010), the Western Grain Stabilization Act (WGSA) was proposed to stabilize aggregate net cash flow for special grains. Thus, together with the crop insurance, which was to even out yield, these two programs were designed to stabilize income. By design, the support level under WGSA was calculated using a 3-year moving average of market returns. The sharp decline in world grain prices in 1985 triggered a large payout under the WGSA. As a result, the program could not be maintained in an actuarially sound manner after five years of implementation. It was dismantled under the Farm Income Protection Act (hereinafter referred to as FIPA) in 1991.

FIPA had three components: the Gross Revenue Insurance Program (GRIP), the Net Income Stabilization Account (NISA) and Crop Insurance (CI). The introduction of the FIPA made a significant change in Canadian agricultural policy (Schmitz, 2008). Under FIPA, provinces were required to contribute their part to the funding of the farm-income support programs.

**Gross Revenue Insurance Program (1991-1995):** launched in 1991, the Gross Revenue Insurance Program (GRIP) was a commodity-specific program that operated through a tripartite-funding scheme. GRIP was designed to protect crop farmers against the negative effects of yield or price shortfalls by guaranteeing a per acre gross return. However, GRIP had two major problems that led to its downfall starting in 1992 by the withdrawal from the program by Saskatchewan government. (Schmitz et al, 2010). These authors argued that GRIP was expensive. In particular, given the large portion of cost born by the provincial government relative to the previous programs, it was hard for provinces with large land base and sparse population to afford this tripartite program. Moreover, GRIP has the potential for moral hazard and adverse selection. Put
differently, the program could not remain actuarially sound due to its design and was finally dismantled after five years of operation.

**The Net Income Stabilization Account (1990-2003):** introduced under FIPA, the Net Income Stabilization Account (NISA) was the first safety-net program with whole-farm approach. NISA had a three-party funding calculation, with cost-shared 50-50 between government (federal and provincial combined) and producers. According to Schmitz *et al* (2010), NISA established special saving accounts where producers could deposit up to 2 percent of their eligible net sale and receive a matching contribution from the government. Participating farm operators were also paid a 3 percent interest premium over the prevailing market rates.

Producers could make withdrawals from NISA accounts under two conditions. The first condition was if farm income fell below 70 percent of the previous 5-year average. The second condition was if the farmer’s net farm income fell below CAD10,000, or CAD 20,000 for farmers with dependents. These thresholds were later increased to CAD20,000 and CAD35,000, respectively (Anton, Kimura & Martini, 2011).

The drawbacks of NISA were two-fold: firstly, farmers found it wasteful to have a large part of their capital tied up in the program; secondly, from the government’s perspective, the large balances held in NISA accounts suggested that those funds were not utilized to stabilize income as originally intended. These factors led to NISA being replaced and embedded with some changes later on in the Canadian Agricultural Income Stabilization program.

**The Canadian Agricultural Income Stabilization program (2003-2007):** based on AAFC (2005), Agriculture and Agri-Food Canada and all provinces and territories signed the five-year Agricultural Policy Framework (APF) agreement in 2003 to realize the objective of making Canada the world leader in food safety, innovation and environmentally-responsible production. The introduction of APF was an attempt by the federal government and provinces to generate a more integrated approach to
agricultural policy against the background of a growing number of programs operating at all levels of government.

Introduced under the APF, CAIS was designed as a whole farm based program to protect farming operations from both small and large drops in income. The program formed the central risk-management program and was based for the first time on net margin. In particular, payments depend on current versus reference margin equal to five-year Olympic average. When the margin fell below the reference margin, producers receive program payments depending on the size of the shortfall relative to the reference margin and coverage level. Figure 3 illustrates the structure of AgriStability payment scheme under CAIS.

Program payments cannot exceed 70 percent of the total margin decline and is capped at $3 million for a given program year. Also, CAIS was modified in 2004 to include coverage for negative margin to compensate for losses as well as reduction in income. Under this modification, the requirement for producers to deposit one-third of the insured amount was eliminated.

The main difference between NISA and CAIS was that the matching government contribution to the account under CAIS was not made at the time of deposit, but when the funds were withdrawn. This was intended to address the accumulation of large account balance as one of the drawback of NISA (Anton, Kimura & Martini, 2011).

The Canadian Business Risk Management programs under Growing Forward framework: in 2007, federal, provincial and territorial ministers of agriculture agreed to adopt Growing Forward (GF), a market-driven vision for Canada’s agriculture and agri-food industry. The GF framework is an evolution from the APF in the sense that the former “eliminated the provincial ‘companion’ programs institutionalized when NISA was established and allowing provinces to supplement federal-provincial initiatives if desired…” (Anton, Kimura & Martini, 2011, p. 24). Also, it defines the current set of
policies in Canada and attempts to define different layers of public response to risk in agriculture and includes the following four components:

**AgriInvest**: being the successor of NISA, AgriInvest is a producer savings account that was designed to stabilize year-to-year small fluctuations in income as well as support investment to mitigate risk and improve income. AgriInvest account builds as producers make annual deposits based on a percentage of their Allowable Net Sales (ANS) and receive matching contributions from federal, provincial, and territorial governments. Program details, including coverage levels, pricing options, commodity coverage varies by province, and administration of the program is primarily done at the provincial level.

**AgriStability**: this whole farm and margin-based component evolved out of CAIS. Under this component, participating producers are eligible for an AgriStability payout if their Program Margin, i.e., eligible revenue minus eligible expenses, falls below a Reference Margin. The Reference Margin is a historical average of Program Margins. An Olympic average is used to calculate the Program Margin. Under AgriStability, individual information is gathered from tax files and complemented with additional information from farmers. This process takes a great deal of time and could create delays and uncertainty about the timing and amount of the payout.

Both AgriStability and AgriInvest are comprehensive in terms of the risks and sources they cover, meaning these components cover risks that are normal but are also available when risks become more catastrophic. The authors maintained that normal risks and catastrophic risks can be defined based on the frequency and type of events occurring. In this light, the standard layer refers to frequent and small events while rare and large events belongs to catastrophic layer.

Figure 14 illustrates different risk layering covered by Canadian risk management programs. As can be seen from this diagram, coverage under AgriStability from layer 2 to layer 4 proves to be quite comprehensive in addressing both normal and catastrophic
On the other hand, AgriInvest, by its design, provides a precautionary saving account to be utilized during the rainy days and as such, can help producers mitigate the impacts of income-reducing risks, for whatever type and frequency of event occurrence.

**AgrilInsurance**: being a subsidized multi-peril crop insurance program, this component includes existing crop insurance and production insurance. Unlike AgriStability, AgrilInsurance is commodity specific and yield based. The parameters used to define indemnities and subsidies under AgrilInsurance are individual yields, which are compared with a reference yield and the frequency of occurrence of events affecting yields, which is measured in terms of percentile. Layering of loss covered under the program includes standard layer and catastrophic layer. AgrilInsurance payments are included as allowable income in reference margin calculations for AgriStability so as to avoid double compensation. On a side note for this production insurance component
under BRM suite, Ontario is one of the provinces where AgriInsurance also includes livestock price insurance.

**AgriRecovery**: this is a disaster-relief framework designed to provide direct payment in the event of a large-scale farm income disaster (Vercarmmen, 2013). This component under BRM suite is aimed to cover catastrophic risks and supposed to be the main catastrophic risk management instrument in Canada. AgriRecovery is structured with a disaster layer for natural events that affect production and support is decided on by provincial and federal governments over consultation process.

### 2.3 BRM program under Growing Forward II (2013-2017)

While there were no significant changes to either AgriInsurance or AgriRecovery under GF II, AgriStability and AgriInvest parameters were changed and reflected a reduction in government support.

Regarding AgriInvest, the rules governing producer deposit and matching contributions from government changed. In particular, starting with the 2013 program year, producers can deposit up to 100% of their annual ANS, with the first 1% matched by governments. Matching government contributions was capped at $15,000 per year compared to $22,500 under GF I (AAFC, 2017). Also, the maximum account balance limit including matching deposits, government contributions and interests earned was increased from 25 percent of historical average ANS to 400 percent of ANS. According to Jeffrey (2015), these changes brought about greater flexibility for producers in reserving funds for future withdrawals to cope with income shortfalls. Simultaneously, they reflect reduced government support under the form of matching contributions.

With respect to AgriStability, there were four changes under GF II. Firstly, the degree of decline in the Program Year Margin required to trigger a payout was increased from 15 percent to 30 percent, meaning that there was no payout until the Program Year Margin fell to 70 percent of the Reference Margin. Secondly, the coverage level no longer depended on the degree of decline; AgriStability payouts were
equal to 70 percent of the eligible decline. Finally, calculation for the Reference Margin used to determine eligibility for an AgriStability payout was now the lesser of the historical average Program Margin and the historical average of allowable expenses (Jeffrey, 2015). Finally, negative margin are protected by AgriStability payment at 70 percent under GF II while the protection level is 60 percent under CAIS and GF I.

Notably, a decline in the program year margin relative to the Reference Margin is not required for producers to withdraw from their AgrilInvest account. In particular, when the program year margin falls less than 15 percent of the Reference Margin under GF I or less than 30 percent of the Reference Margin under GF II, program payment is not triggered and thus, producers may withdraw from their AgrilInvest accounts as a source of self-risk managing.

Overall, the changes in parameters of the AgriStability component had different directional impacts on the likelihood and amount of the program payouts but likely resulted in reduced capacity to support and stabilize farm incomes.

In a nutshell, being the core of Canadian agricultural policies, BRM programs covers a large set of measures for risk reduction, mitigation and coping that are aimed to smooth income from farming. Besides, while some of the components under BRM suites are ex ante measures, some others are payments triggered ex post. For instance, AgrilInsurance and AgrilInvest are considered as ex ante measures while countercyclical payouts under AgriStability are triggered ex post by government using tax record. In a similar vein, as support under AgriRecovery is decided over consultation process and based on non-defined specific criteria, they are considered as payments decided upon ex post.

Agriculture faces risks of several sources and that all of these sources of risk eventually translate or manifest into farm income risk. The policy priority for BRM programs is, therefore, to help stabilize farm income (Anton, Kimura & Martini, 2011). In this regard, AgriStability, the successor of CAIS remains the center of Canadian
agricultural risk management strategy and AgriStability payouts will be examined and incorporated into analysis in this research.

2.4 Crop Insurance Program

The government of Canada introduced and passed the Crop Insurance Act in 1959. It provided enabling legislation for provincial governments to establish crop insurance programs that obtained financial support from the federal government. Since its inception, crop insurance has remained a joint federal-provincial program. According to Schmitz et al. (2010), Crop insurance is available to individual producers based on individual farm yields, and covers grains, pulses, oilseeds, and forages. The payouts from crop insurance vary from year to year, since price coverage varies according to market conditions.

Since insurance coverage decreases as commodity prices fall, Crop insurance cannot support farm income to any major degree during periods of depressed prices. Remarkably, Crop Insurance in Canada has always been a government program with no involvement of specialized private insurers and it is managed like a program of payments to farmers rather than an insurance business, even if farmers have to contribute with part the premium (Anton, Kimura & Martini, 2011, p.39). The authors also maintain that government and their agencies have continually refined policies to increase commodity coverage and increase the share of the premium paid by the government.

Participation rate has always been an important consideration in the design of crop insurance programs. The main vehicle by which the government can control participation rates is the extent to which the premium is subsidized. Participation rates vary by province as well as regions within the provinces. Farmers in regions with high yield variance had a higher rate of participation as they expect to receive a more frequent payout.

In 1966, the Federal Crop Insurance Act was amended in an attempt to increase farmer participation in the program. Since 1966, the insurance yield coverage level available to farmers has been increased from 60 per cent of the long-term, average-area yield to 80 per cent of the long-term, average-area yield. Also, federal contribution of
premiums increased from 20 percent to 25 percent. In 1970, minor amendments were made to allow for the expansion of crop insurance coverage to include all losses resulting from a farmer’s inability to seed a crop due to weather conditions (Schmitz et al, 2010).

2.5 Concluding remarks on the evolution of safety-net programs in Canada

Over the course of evolution, safety-net programs in Canada have evolved from a commodity-based to a whole-farm based program. The focus also changed from price stabilization to income stabilization. Commodity-based programs started with ASA back in 1958 and ended partially with FIPA and fully with the demise of GRIP in 1999. Subsequently, NISA came into place as the first whole-farm programs. This tendency continued with CAIS and AgriStability components under BRM suite till the present. One of the driving factors of the evolution of income support programs has been the need for WTO compliance and avoidance of trade countervail problems with the United States (Anton, Kimura & Martini, 2011).

Despite the operational problems with NISA, the idea of a producer-directed savings program remained attractive to policy makers and was reflected in AgriInvest. This component of BRM suite replaces the “top tier” of support under CAIS for small income losses with a NISA-style savings account but with higher withdrawal flexibility. Unlike NISA, there are no triggers required for producers to access their funds. This additional flexibility was designed to prevent the accounts from continually growing as they did under NISA.

From CAIS to AgriStability, surviving elements were the whole farm approach and net margin as the basis of payment. Specifically, program payouts depend on current versus reference margin equal to five-year Olympic average. What changed overtime was that, under CAIS, AgriStability has 4 Tiers of payment, under which Tier 1 representing the smallest income decline of up to 15 percent of the Reference Margin is covered. Moving to GF policy frameworks, this Tier is covered under AgriInvest.
Going from GF I to GF II, changes were made in BRM suite with respect to parameters of the two components: AgriStability and AgriInvest, which reflects reduced government support.

On a final note, the common thread that runs through all these Safety-net programs is the short life-span of these programs, except the ASA (1958-1975), and the stabilization of some element with respect to some threshold. In particular, the ASA was based on guaranteeing an average price, the GRIP was based on average revenue per acre, and subsequent programs have been based on net margin, except for NISA, a program of subsidized saving accounts intended to be utilized during rainy days.

2.6 **Ontario hog sector at a glance**

Ontario has been the leading province in terms of hog numbers and farms reporting hogs over censuses of agriculture from 2001 to 2016 (Fig.15 & Fig.16). Total hog numbers in Ontario accounted for more than 30 percent of the hog numbers in Canada (Fig.17).

![Ontario hog sector graph](image)

**Figure 15. Hog numbers by province from census 2001 to 2016 (x1,000)**

*Source: Statistics Canada. Table 32-10-0155-01: selected livestock and poultry, historical data*
Furthermore, hog steadily ranked among top commodities in terms of market receipts in Ontario through census 2001 to 2016, as summarized in Table 1.
Table 1. Top commodities in terms of market receipts ($ million)

<table>
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<tbody>
<tr>
<td>Dairy products</td>
<td>1,369</td>
<td>1,591</td>
<td>1,895</td>
<td>1,975</td>
</tr>
<tr>
<td>Vegetables (including greenhouse)</td>
<td>738</td>
<td>987</td>
<td>1,272</td>
<td>1,621</td>
</tr>
<tr>
<td>Soybeans</td>
<td>449</td>
<td>937</td>
<td>1,077</td>
<td>1,664</td>
</tr>
<tr>
<td>Corn</td>
<td>388</td>
<td>868</td>
<td>1,338</td>
<td>1,250</td>
</tr>
<tr>
<td>Cattle and calves</td>
<td>1,252</td>
<td>846</td>
<td>1,028</td>
<td>1,314</td>
</tr>
<tr>
<td>Floriculture and nursery</td>
<td>755</td>
<td>634</td>
<td>784</td>
<td>796</td>
</tr>
<tr>
<td>Poultry</td>
<td>612</td>
<td>547</td>
<td>891</td>
<td>977</td>
</tr>
<tr>
<td>Hogs</td>
<td>946</td>
<td>454</td>
<td>902</td>
<td>1,119</td>
</tr>
<tr>
<td>Eggs</td>
<td>211</td>
<td>292</td>
<td>301</td>
<td>391</td>
</tr>
<tr>
<td>Wheat</td>
<td>102</td>
<td>213</td>
<td>315</td>
<td>234</td>
</tr>
<tr>
<td>Fruit</td>
<td>224</td>
<td>192</td>
<td>203</td>
<td>263</td>
</tr>
<tr>
<td>Potatoes</td>
<td>72</td>
<td>178</td>
<td>103</td>
<td>117</td>
</tr>
<tr>
<td>Dry beans</td>
<td>22</td>
<td>90</td>
<td>70</td>
<td>77</td>
</tr>
</tbody>
</table>

*Source: Omafra, Statistical Summary of Ontario Agriculture*

In addition, Ontario hog farms share the same national trend of farm consolidation. Specifically, while the number of hog farms in Ontario consistently decreased from 2,500 to approximately 1,200 farms from census 2001 to census 2016, farm size continued to increase substantially, with the national average rising to 1,720 hogs per operation in 2011 and 3,000 hogs per operation in 2016. Figure 18 depicts hog
and hog farm statistics between the two censuses. As can be gleaned from Figure 18, while farm number decreased consistently, hog number seemed to follow a cyclical fluctuation around the number 3.5 million during the period.

![Figure 18. Number of hogs and hog farms in Ontario](source)

**Source:** OMAFRA, Ontario Summary of Agriculture

On a side note, 2006-2011 was a period of adversity for Canada hog sector. Ontario was not an exception with pig herd in the province dropped constantly throughout the period\(^5\). From 2011, hog number started to increase, leaving farm number behind with a widening gap towards the end of the period.

Despite continued growth in the size of hog farms in Ontario, the hog sector in the province has experienced wide price fluctuations in recent years. Figure 19 depicts Ontario weekly hog price, averaged for 10 years versus weekly prices updated for year 2017 and 2018.

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\(^5\) Ontario participated in the Hog Farm Transition Program (HFTP) initiated by the federal government in 2008/2009, with 6 percent of farms participating in the program (Brisson, 2015).
In a similar vein, the wide fluctuations of Ontario price for index 100 hogs live weight are illustrated by Figure 20 for the long 1992 – 2017 period and Figure 21 for the study period of 2003 – 2014. The erraticism in hog prices contributes to the variability of Ontario gross and net returns per hog during the study period, as illustrated by Figure 22.

**Figure 19. Ontario weekly hog price**

*Source: OMAFRA, Ontario Commodity price*

In a similar vein, the wide fluctuations of Ontario price for index 100 hogs live weight are illustrated by Figure 20 for the long 1992 – 2017 period and Figure 21 for the study period of 2003 – 2014. The erraticism in hog prices contributes to the variability of Ontario gross and net returns per hog during the study period, as illustrated by Figure 22.

**Figure 20. Ontario price for index 100 hogs live weight (1992-2017)**

*Source: OMAFRA, Livestock and poultry statistics.*
Figure 21. Ontario annual average 100% formula hog price (Can$/100kg)

Source: OMAFRA - Ontario Commodity Prices

Figure 22. Gross and net returns/ hog in Ontario

Source: OMAFRA – Estimated farrow to finish swine enterprise budget summary

Notes: Gross returns = Market hog value – feed costs– other variable costs
Net returns = Market hog value – feed costs – other variable costs – Fixed costs
3 CHAPTER 3: LITERATURE REVIEW

3.1 Chapter introduction

The purpose of this chapter is to first review the concepts of business risk and financial risk in the risk-balancing literature. Second, we provide a chronological review and a critical assessment of the studies relevant to the research questions identified for this thesis. These questions are: i) the effectiveness of BRM programs in reducing business risk for Ontario hog farms; ii) The extent of risk-balancing behavior in Ontario hog farms, and whether this behavior differs across farm size categories. In addition, we extend our review to include some empirical studies addressing the relationship between risk-balancing and Crop Insurance, as the issue has sparked growing interests in the risk-balancing literature.

3.2 The concept of business risk (BR) and financial risk (FR)

Based on Van Horne (1974, p.207-8), BR is defined to be the risk inherent in the firm, in the sense that it is independent of the way it is financed. In the context of risk-balancing, Gabriel and Baker (1980) maintain that BR is generally reflected in the variability of Net Operating Income (NOI) or net cash flow. Sources of BR in agricultural entities stem from both external and internal factors. External factors firstly include market forces that induce price fluctuations for both outputs and inputs as well as uncertain quality of the latter. The second external factor is the biological nature of agricultural production, which makes it more vulnerable to yield volatility. Internal factors that influence the level of BR include management skills, investment decisions and the like.

Under the same context of risk-balancing study, Collins (1985) refers to BR as the variance of return on assets or the rate of return on assets (ROA). Business risk measures the risk that is exogenous to the firm. The probability distribution for the ROA would reflect a mean-variance efficient choice of enterprises.
With respect to financial risk, as mentioned by Barges (1963, p.16), FR is defined to be the added variability of the net cash flows that results from the fixed financial obligation associated with debt financing and cash leasing. In this regard, FR can be measured by firm’s leverage ratio. Also, Van Arsdell (1968) argued that financial risk encompasses the risk of cash insolvency (p. 304).

According to Gabriel and Barker (1980), as BR can be reflected in the variability of either net operating income or net cash flows, FR could also be defined in terms of net operating income or net cash flow. The authors also maintain that in case FR is defined in terms of net operating income, the fixed debt-servicing obligations would involve only interest. In the other case, when FR is defined in terms of net cash flows, the fixed debt-servicing obligations include both interest and principal.

On a further note, Collins (1985) contended that the leverage position chosen leads to variations in the rate of returns of equity that is some multiple of BR. In this light, the magnitude of this leverage multiplier may be regarded as FR.

The following sections provides a critical review of recent empirical studies relevant to the research questions raised this thesis. Gaps in the literature and areas for future research are also identified afterwards.

3.3 Review of recent studies related to the research questions

3.3.1 The extent of risk-balancing behavior

Escalante and Barry (2001) used optimization techniques in a simulation framework to determine the extent of the risk-balancing strategy in reducing risk under an integrated risk-management strategic approach. The authors employed the quadratic programing model developed by Markowitz, which is equivalent to Freund’s formulation, to derive the optimization framework for running the simulation. The objective of this

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6 For the purpose of simplicity, only debt financing is considered in this study as the source of financial risk.
quadratic programing framework is maximizing expected utility of final wealth, i.e the outcome variable. The paper concludes that risk-balancing, as a risk-management strategy, has the potential to form synergistic relationships with other alternative strategies. In this light, the greater appeal of a more diversified plan usually downplays the risk-balancing strategy. A notable limitation of the paper lies in the simulation approach itself. With this approach, results are challenging to validate and thus, should be interpreted with caution.

**Turvey and Kong (2009)** employed theoretical model by Collins (1985) to investigate the relationships between business risk and credit choices of 400 rural farm households in China based on survey data in October 2007. Measure of risk-taking attitude was also constructed from surveyed questions and incorporated into the model as one of the controlling variables. The authors conducted 4 linear regression models using Maximum Likelihood estimators. These regression models differ only in the dependent variables, i.e., financial risk measures. They found evidence of risk balancing, i.e., farmers facing higher production risks reduce financial risks with lower credit demand. This evidence varied across financial risk measures. One limitation of this paper was the employment of cross-sectional data, which failed to capture the dynamic relationship between BR and credit risk decisions. Further, there was insufficient explanation for the different results obtained from the 4 regressions.

Employing correlation coefficient between BR and FR as a measurement of risk-balancing behavior, **Escalante and Barry (2003)** found evidence of risk-balancing for 80 farms in the United States from 1982 to 1998. Using a similar approach, **Ueza et al (2014b)** employed Pearson’s correlation coefficients between BR and FR as a measure of risk-balancing for each farm. This coefficient was calculated over parings between one year lagged BR and current year FR. As risk-balancing hypothesis maintains an inverse relationship between BR and FR, the extent of risk-balancing is measured by the share of farms with negative correlation coefficient. The authors argued that given the short time series of the data (2003-2011), the statistical significance of the coefficients is less
relevant. They also concluded that the extent of risk balancing varied across farm size categories and that larger farms for both beef and field crop farms showed evidenced of risk-balancing of a larger degree compared to farms of smaller size categories.

The paper by De Mey et al (2014) used both correlation coefficient analysis and regression approach to investigate risk-balancing hypothesis for EU-15 farm sector from 1995 to 2008. Findings were that 50 percent of farms showed evidence of strategic adjustment of capital structure in response to a change in the level of BR. Nevertheless, there was a lack of comparison and explanation about the different results obtained from the two approaches employed in the research.

Wauters et al (2015) aims to theoretically introduce the novel framework of farm household risk-balancing by extending the original risk-balancing framework of Gabriel and Baker (1980) to household level. Based on this framework, farm households set a constraint on the total household-level risk and balance farm and off-farm risks. The authors derived equations linking farm activities, consumption and business and private liquidity and argued that risk-balancing behaviour of farmers could be better understood by considering risk at the household level. The framework showed that facing an exogenous change in BR, risk-averse farm households may also respond by a change in household buffering strategies, for instance, increasing their off-farm risk, and not only by initiating a change in their financial position.

In general, the correlation coefficient analysis approach has its own limitation in measuring the extent of risk-balancing as it fails to account for potential factors that could influence financial risk decisions, for instance interests or the expected Net Operating Income. This limitation can be overcome by using regression analysis.

3.3.2 The effectiveness of BRM program – How to measure business risk?

In a paper selected for presentation at Agricultural and Applied Economics Association’s 2014 Annual Meeting, Minneapolis, Ueza et al assessed the impacts of BRM program participation on farm BR across sectors, including beef, field crop, swine,
supply managed and others, by estimating the BR function using both Tobit and quantile regression model (Ueza et al., 2014a). Downside risk, the dependent variable, was measured as the percentage change in gross margin from previous year during the study period from 2003 to 2011. Regression results showed that the coefficients for most program participation states were negative and significant, suggesting that producers who participate in one or more of the programs experienced smaller drops in gross margin than producers who did not participate.

Also, these authors employed longitudinal data from 2003 to 2011 and compared the distribution of BR with and without BRM/AgriStability payments so as to examine the effectiveness of BRM programs in reducing BR for Ontario beef and field crop farms (Ueza et al., 2014b). The authors used two measures of BR, including the standard deviation measure, i.e., standard deviation/average income ratio, and the left-side semi-kurtosis measure, i.e., the thickness measurement of the left tail of Net Operating Income. While the former measure focuses on observations close to the mean, which represents frequent small gains and losses, the latter emphasizes infrequent yet extreme losses. They argued that the use of the left-side semi-kurtosis measure is more relevant as BRM/AgriStability was aimed to provide coverage for large income decline. Findings were that BRM/AgriStability payments reduced BR for beef farms but not for field crop farms.

In a nutshell, downside risks were captured in both papers. Nevertheless, the way it was measured was different across studies. Applying Tobit regression on downside risks represented by the percentage change in gross margin, Ueza et al. (2014a) were able to segregate the drops from the gains in gross margin from previous year for estimating the effects of BRM programs in reducing these drops. In this way of measurement, however, the author cannot capture the downside variations of farms’ gross margin relative to its central distribution, and thus fails to disentangle the extreme but infrequent losses in farms’ gross margin from the small but frequent ones.

With reference to Ueza et al. (2014b), employing the left-side semi-kurtosis to represent BR, the authors were able to capture the magnitude of the extreme but
infrequent losses in net operating income of Ontario beef and field crop farms. However, this measurement did not tell us if the distribution of net operating income was skewed or not, and if it was skewed to the left of to the right. Put differently, it could not be concluded from the study if downside BR outweighed upside BR, and from risk management perspective, this should receive our attention. Another the limitation of the study comes from the lack of Crop Insurance data, which is significant for field crop farms. As such, one of the suggestions for future research is to incorporate Crop Insurance data into analysis so as to deliver a better measurement of business risk.

3.3.3 **Crop Insurance and risk-balancing behavior**

*Skees (1999)* argued that “subsidized insurance will not take the risk out of agriculture” (p. 35) as a result of risk-balancing behaviour. In particular, the author maintained that as farmers recognize the value of crop insurance subsidies, the effects on risk-taking behavior become counter-intuitive. Farmers with subsidized risk management may push harder and faster and take on more risk. They will probably borrow at higher rates as well, meaning they may “take on more and different risks until their risk level returns to the pre-policy intervention level” (p. 36). The author corroborated that when decision makers must pay for risk protection, the risk will be internalized into the decision processes. When they pay less than they will get back in indemnities resulting from insurance subsidies, society is paying people to take on additional risk.

In this context of risk-balancing behavior, we would review some empirical studies that set some ground for the question of whether Crop Insurance purchase matters to the identification and measure of risk-balancing (Table 2). Specifically, factors influencing Crop Insurance demand and the relationship between BRM/AgriStability and Crop Insurance, i.e., they are substitutes or complements, were explored in empirical studies to follow.

*Sherrick et al (2004)* investigated farmers’ decision to purchase Crop Insurance and their choices among alternative products. The authors used a two-stage estimation procedure that considers the decision to purchase or not, and then evaluated the choice.
among alternate Crop Insurance products in cases of use. A survey of farmers in Illinois, Indiana, and Iowa provided the data for the analysis. Factors included in the model were the level of BR, risk management options, debt use (FR), risk attitude, tenure, age and education of farm operator, expected yields, farm size, livestock enterprises, and off-farm income. Producers facing greater levels of business risk are expected to have a stronger demand for Crop Insurance and use more comprehensive insurance products. The paper concluded that farmers who are more highly leveraged, less wealthy, riskier, and operate larger acreages engage more extensively in insurance and are more likely to choose revenue protection versus more specific yield and hail protection insurance. The pattern of results found in this study needs to be tested in other agricultural regions to verify the extent of their applicability.

Given from the previous section review that BRM programs are effective in reducing farm BR along with the conclusion from this study on a significant positive relationship between BR and CI demand, can it be inferred that BRM programs reduce farmers’ incentive to purchase CI? Further empirical analysis would be needed to address this research question.

On account of risk-balancing evidence as revealed from previous empirical studies, which suggest an inverse relationship between BR and FR, the regression model in this paper may exhibit multicollinearity with BR and FR both entering the model as explanatory variables.

**Cabas et al (2008)** explored determinants of farmers’ participation in Crop Insurance schemes, with participation being decomposed into entry and exit decisions. The study employed data on Ontario soybean crop insurance plan, covering the 1988-2004 period for 8 counties in southern Ontario: Chatham-Kent, Elgin, Essex, Haldimand-Norfolk, Huron, Lambton, Middlesex and Perth. Explanatory variables affecting Crop Insurance participation included: premium rate, soybean price, variance of the expected soybean price, yield, variance of county yield, number of farmers qualifying for insurance payout in the preceding year and proportion of total acreage devoted to soybeans at the county level. The study concluded that price variables were particularly important for farmers considering enrolling in crop insurance, while yield
variables and other risk management opportunities were more important for farmers who have been in the program but are deciding to exit.

Iff et al (2015) used data from the nationally representative Agricultural Resource Management Survey to consider how Federal Crop Insurance (FCI) program influences various measures of farm debt use. Findings were that FCI participation was associated with an increase in the use of short-term debt, but not long-term debt. This finding is consistent with risk-balancing behavior and current trend in the farm sector. Besides, the study by Escalante and Barry (2003) looked at the determinants of FR based on Collins (1985). Independent variables included amount of Crop Insurance coverage, farm tenure position and crop diversification. The results revealed that risk-balancing was compatible with crop diversification and insurance protection plans.

Given the compatibility between risk balancing and alternative strategies demonstrated in this study, the findings set good ground and provide motivation for investigating the extent of risk reduction realized under a more integrated risk management approach that takes into account Crop Insurance purchase. Some pending questions may arise from the above studies: Is Crop Insurance an alternative strategy to BRM payments? And as such, do BRM programs reduce farmers’ incentives to purchase Crop Insurance?

Also, the paper by Ueza et al (2014a) investigated the interrelated dynamics of participation in Crop Insurance, AgriStability and Agrilnvest programs. It was concluded that programs tend to be used together rather than independently: the pairwise correlations between the residuals in the multivariate model are positive and significant, with the correlation between participation in Crop Insurance and AgriStability being the strongest. With respect to risk-reducing effects, Crop Insurance did not seem to be able to mitigate downside risk when used independently, but delivered a great effect when jointly used with AgriStability. On account of the author’s argument that two programs are complementary if they mitigate downside risk more when used jointly than when either program is used in isolation, Crop Insurance and AgriStability are complements rather than substitutes.
3.4 Chapter summary

The above review highlights a number of gaps in the existing literature. The purpose of this thesis is to bridge some of these gaps. First, while relevant papers had different ways to measure the downside risks of Ontario grain and beef farms, little evidence has been found for the hog sector in the province. More importantly, little evidence has been found on a conclusive way of measuring downside risk that could capture the magnitude of infrequent but extreme losses while accounting for the skewness property of its distribution. In addition, due to data constraint, Crop Insurance data was not incorporated into calculation of business risk in the previous studies.

Secondly, while a number of papers used pairwise correlation coefficient to measure the extent of risk-balancing in agricultural sectors in Canada, some other studies employed regression analysis to account for other factors that may also have an impact on financial risk decisions. In addition, whether this extent differs among farms of different size class categories and/or across agricultural sectors has not been fully investigated.

Last but not the least, while BRM/ AgriStability and Crop Insurance were proved to be complements in reducing business risk for farms in a previous study by Ueza et al (2014a), whether participation in these programs substitutes or complements each other opens up an area for further research. In addition, the paper by Cabas et al (2008) suggested a novel way of looking at the demand for Crop Insurance decomposed between entry and exit decisions. Altogether, an inspiring question has arisen on the impacts of BRM/ AgriStability payments on Crop Insurance new enrolment and exit decisions.

A summary of selected empirical studies relevant to the research questions identified in this thesis is provided in Table 2.
Table 2. A synoptic review of empirical studies

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Data &amp; type of model</th>
<th>Dependent/outcome variable(s)</th>
<th>Explanatory/ activity variables</th>
<th>Key findings</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. The extent of risk-balancing behavior</strong></td>
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<tr>
<td><strong>Estcalante &amp; Barry 2001.</strong></td>
<td>- Simulation - optimization technique</td>
<td>- Final wealth</td>
<td>- Farm size (acres), cash rented acres, land purchases (acres), equipment purchases ($), net farm income ($), off-farm income ($), return on asset (%), return on equity (%)</td>
<td>The greater appeal of a more diversified plan usually downplays the risk-balancing strategy</td>
<td>- Limitations of the study lie in the simulation method: representativeness of the chosen Illinois grain farm; how to draw inference from the programming results</td>
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<td></td>
<td>- Model: a multi-period quadratic programming model</td>
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<td>- Share rented acres - % of forward contracted - Debt-to-asset ratio, liquidity ratio, unused short-term/long-term credit reserves</td>
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<td></td>
<td>- A representative Illinois grain farm operating under the modified risk environment created by Farm Bill 1996</td>
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<td></td>
<td>- Different iterations illustrate various combinations of risk-management strategies across different classes of risk-aversion.</td>
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<tr>
<td><strong>Turvey &amp; Kong 2009.</strong></td>
<td>- Survey data of 400 farm households in Shaan Province, Yangling district, China in October 2007</td>
<td>FR: - Debt amount - Debt/Asset ratio</td>
<td>BR: - Measure of expected profitability - Measure of risk-taking attitude constructed from surveyed questions.</td>
<td>Farmers' credit choices are related to expected production risk, risk aversion and expected farm income - Farmers facing higher production risks reduced FR</td>
<td>- Lack of descriptive statistics of survey data - Insufficient explanations of different results from the 4 regression</td>
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<td></td>
<td>- 4 linear regression models using ML estimators</td>
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<td>Author(s)</td>
<td>Data &amp; type of model</td>
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| **Estcalante and Barry 2003.**  
The strength of trade-offs between BR and FR | Panel farm-level dataset of 80 farms over the 1982-1998 period in the United States. | Correlation coefficient between financial risk and business risk | N/A | 50% of farms show evidence of risk-balancing behavior, i.e. strategic adjustment of capital structure when the level of business risk changes | Correlation coefficient analysis approach has limitation because it ignores other potential influential factors influencing the financial risk decision. |
| **Ueza et al., 2014b.**  
The extent of risk-balancing | - Panel annual data on Ontario field crop and beef farms  
- 81,153 observations  
- Year: 2003-2011  
- The extent of risk-balancing based on the share of negative BR-FR correlation coefficients | Pearson's correlation coefficients between current year's FR and one-year lagged BR | N/A | The extent of risk-balancing varied across farm size categories and larger farms showed evidence of risk-balancing of a larger degree than farms of smaller size categories | |
| **De Mey et al., 2014.**  
The strategic adjustments of FR of European farmers in response to changes in the BR level | - Cross-sectional and time series data on EU-15 farm sector  
- 124,132 observations  
- Year: 1995-2008  
- i. Correlation coefficient analysis  
- ii. Regression (panel estimator with fixed effects) | Measure of FR (interest paid/net operating income) | Measure of BR (coefficient of variation of rate of return on asset)  
- Cost of debt  
- Farm profitability  
- Farm-type  
- Farm size  
- Farmer's age | - 54% of observations show strategic adjustments of financial risk upon changes in the level of business risk.  
- This adjustment is a slow process, the extent of which differs across countries and farm types | Lack of comparison and explanation about the different results obtained from the 2 approaches employed in the research |
<table>
<thead>
<tr>
<th>Author(s)</th>
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<tr>
<td><strong>Ueza et al., 2014a</strong>&lt;br&gt;The impacts of program participation on BR</td>
<td>- Data: merging of 3 datasets OFID, Agricorp’s CI data and AAFC’s AgriInvest data. Period: 2003-2011&lt;br&gt;-Sample size: 8,721 farms across sectors (Field crops, Beef, Swine, Supply managed and Others)&lt;br&gt;-Model: BR function using quantile regression and tobit model</td>
<td>Downside risk measured as percentage change in gross margin from previous year</td>
<td>-Sector diversification, Crop diversification, farm size dummies&lt;br&gt;-Operating Profit Margin, Operating Expense Ratio, Debt coverage ratio&lt;br&gt;-Payment reliance&lt;br&gt;-BR as CV of revenue/expense of previous 5 years</td>
<td>-Crop Insurance and AgriStability are compliments rather than substitutes in terms of risk-reducing effects</td>
<td>- Drops in gross margin from previous years could be segregated from gains for estimating the effects of BRM in reducing these drops&lt;br&gt;-Cannot disentangle the extreme but infrequent losses in farms' gross margin from the small but frequent ones</td>
</tr>
<tr>
<td><strong>Ueza et al., 2014b</strong>&lt;br&gt;The effects of Canadian Farm Business Risk Management (BRM) programs in reducing farm risks</td>
<td>-Panel annual data on Ontario field crop and beef farms&lt;br&gt;-81,153 observations&lt;br&gt;-Year: 2003-2011&lt;br&gt;-Compare the distribution of BR with and without BRM/AgriStability payments</td>
<td>-N/A</td>
<td>-Measure of business risk (standard deviation/average income) &amp; the frequency of catastrophic loss (left-side semi-kurtosis measure)</td>
<td>-BRM payments reduce BR for beef farms but not for field crop farms</td>
<td>-The use of the left-side semi-kurtosis is more relevant as BRM/AgriStability was aimed to provide coverage for large income decline&lt;br&gt;-Able to capture the magnitude of the extreme but infrequent losses in NOI&lt;br&gt;-Cannot tell if downside BR outweighed upside BR</td>
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<tr>
<td>Author(s)</td>
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<tr>
<td><strong>C. Crop Insurance and risk – balancing</strong></td>
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</table>
| Sherrick et al., 2004  | -Survey data of Midwestern U.S farmers  
-1st stage: Binomial logit model  
-2nd stage: Unordered multinomial logit model | -1st stage: use vs non-use (binomial variable)  
-2nd stage: composed of 3 discrete choices: hail, yield or revenue insurance | - BR level, debt use (FR), risk attitude, tenure, age, education, expected yields, farm size, off-farm income and risk management options | - Midwestern farmers who are more highly leveraged, less wealthy, risker (BR) and operate larger acreages engage more extensively in insurance | - Possible multicollinearity in the regression model between BR and FR as explanatory variables. |
| Cabas et al., 2008     | -Ontario soybean crop insurance plan  
- 8 counties in southern Ontario: Chatham-Kent, Elgin, Essex, Haldimand-Norfolk, Huron, Lambton, Middlesex and Perth  
- Period: 1988-2004 | - Total number of farmers enrolled in the plan  
- The proportion of soybean acres insured  
- The number of farmers enrolling in the plan for the first time  
- The number of farmers cancelling their enrollment | - Premium rate, yield, soybean price, variance of expected soybean price, variance of county yield  
- No. of farmers qualifying for insurance payout in the preceding year  
- Proportion of total acreage devoted to soybeans at the county level | -Price variables are particular important for enrollment decisions of farmers. Yield variables and other risk management opportunities are more important for farmers considering to drop out.  
- New entrants and dropouts are responsive to variable yields. | - Complementing the literature on CI demand  
- Fundamental to CI providers in retaining current clients and encouraging new sign ups |
i. Logit model: Propensity Score Matching  
ii. Regression | Farm debt use  
- Absolute measures: Real estate debt, Non-real estate debt, Short-term debt  
- Relative measures: Current ratio, Debt/asset, Short-term debt/operating expense | FCI participation  
- Farm characteristics: Acres, Sales class, Farm type, Total off-farm income, Ratio of owned to operated area, Farm operator’s age, Farm operator’s education | -FCI participation is associated with an increase in short-term debt use but does not have a statistically significant impact on long-term debt. | Cross-sectional data does not allow for examining dynamic relationship b/w FCI participation and farmer’s debt use decisions |
<table>
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<tr>
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<tr>
<td><strong>Estcalante and Barry 2003.</strong>&lt;br&gt; -The determinants of financial risk based on Collins (1985)&lt;br&gt; -Regression, panel estimator with fixed effects</td>
<td>Panel farm-level dataset of 80 farms over the 1982-1998 period in the United States.</td>
<td>Leverage (debt-to-asset ratio)</td>
<td>-Farm size&lt;br&gt;-Farmer’s age&lt;br&gt;-Insurance expense ratio&lt;br&gt;-Crop diversification index&lt;br&gt;-Enterprise diversification index&lt;br&gt;-Marketing price index</td>
<td>- Determinants of the strategic capital adjustments: amount of crop insurance coverage, farm tenure position and crop diversification&lt;br&gt;-Risk-balancing becomes compatible with risk-reducing crop diversification and insurance protection plans</td>
<td>Provide motivation for investigating the extent of risk reduction realized under a more integrated risk management approach, taking into account CI purchase</td>
</tr>
<tr>
<td><strong>Ueza et al., 2014a</strong>&lt;br&gt; -The interrelated dynamics of participation in Crop Insurance (CI) AgriStability (AS) and AgriInvest (AI)&lt;br&gt; -Multivariate Probit model (estimate factors affecting the participation in CI, AS, and AI) and multinomial Probit model</td>
<td>-Data: merging of 3 datasets OFID, Agricorp’s CI data and AAFC’s AI data. Period: 2003-2011&lt;br&gt;-Sample size: 8,721 farms across sectors (Field crops, Beef, Swine, Supply managed and Others)&lt;br&gt;-CI, AS and AI (“1” if producer participates in the program at time t and “0” otherwise)</td>
<td>-CI, AS and AI (“1” if producer participates in the program at time t and “0” otherwise)</td>
<td>-Sector diversification, Crop diversification, farm size dummies&lt;br&gt;-Operating Profit Margin, Operating Expense Ratio, Debt coverage ratio&lt;br&gt;-Payment reliance&lt;br&gt;-BR as CV of revenue/expense of previous 5 years</td>
<td>- A significant and positive correlation between CI and AS participation confirmed the need for their joint estimation.&lt;br&gt;-Efficient farms are more likely to participate in CI and less likely to participate in AgriStability</td>
<td>-Regression model may exhibit multicollinearity between explanatory variables: Operating Profit Margin, Operating Expense Ratio, Debt Coverage Ratio</td>
</tr>
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4 CHAPTER 4: ANALYTICAL FRAMEWORK

4.1 Chapter introduction

This chapter develops the theoretical model for this study. The first section relies heavily on the conceptual frameworks of risk-balancing introduced by Gabriel and Baker (1980) and later by Collins (1985) to bring out the key analytical issues and the basic relationships among the variables. In section two, the model by Collins (1985) is augmented by incorporating Crop Insurance into it. The augmented model is used to develop the comparative statistic results, which will guide the empirical analysis of this study.

4.2 Theoretical literature of risk-balancing

The total risk faced by a business entity can be considered as a sum of business risk, i.e., risk directly associated with operating the business and financial risk, i.e., risk associated with financial dealings of the business entity. In this sense, financial risk may not be directly linked to the day-to-day business operations.

Gabriel and Baker (1980) developed a conceptual model that links production, investment and financing decisions via a risk constraint. In their model, it is assumed that “the decision maker has identified both firm survival and profit maximization as goals, where firm survival is of primary importance” (p. 561). The decision maker maximizes net returns subject to the constraint that total risk does not exceed the maximum tolerable level.

Defined as the added variability of the net cash flows owing to the fixed financial obligations associated with debt financing and cash leasing\(^7\), financial risk is formulated as follows:

\(^7\) For the purpose of simplicity, only debt financing will be referred to as a source of financial risk in Gabriel and Barker (1980).
Equation 1

\[ FR = \frac{\sigma_2 - \sigma_1}{cx - I} \frac{\sigma_1}{cx} \]

Where \( \sigma_1 \) is the standard deviation of net cash flows without debt financing; \( \sigma_2 \) is the standard deviation of net cash flows with debt financing but before the deduction of debt servicing payments\(^8\); \( cx \) is the expected net cash flows without debt financing; and \( I \) is fixed debt servicing obligations.

As can be seen from equation (1), \( FR \) is reflected by the change in the coefficient of variation of net cash flows or Net Operating Income owing to the debt financing.

Equation (1) can be rewritten to decompose financial risk into its components as:

Equation 2

\[ FR = \frac{\sigma_2 - \sigma_1}{cx - I} \frac{\sigma_1}{cx} - \frac{\sigma_1}{cx} \]

---

\(^8\) Gabriel and Baker (1980) assume that the standard deviation of cash flow with debt financing equals that without debt financing. According to Wauters et al (2015), this assumption may hold in practice, as debt financing is most often used to increase the scale of current operations, rather than removing some of the uncertainty inherent in the current operations. Some farmers, however, take on additional new loans, thereby increasing debt-to-asset ratio, in order to decrease business risk. Indeed, many investments to decrease the risk inherent in normal farm operations require large funds, which most farmers can only acquire through debt financing. For these farmers, this assumption may not hold. If this assumption is relaxed, meaning that there is leverage-induced changes in the level of BR, there will be no inverse relationship between FR and BR, i.e., risk-balancing behavior does not exist.

\(^9\) In case FR is defined in terms of Net Operating Income, the fixed debt-servicing obligations would involve only interest. In the other case, when FR is defined in terms of net cash flows, the fixed debt-servicing obligations include both interest and principal. Under the former definition, accrual accounting method is employed, whereas under the latter definition, cash accounting method applies, and FR encompasses the risk of cash insolvency.
If there is no change in the variability of net cash flow resulting from the debt financing
decision, the first term on the right-hand side of equation (2) \( \frac{\sigma_2 - \sigma_1}{c x} \) = 0 and equation (2)
can be rewritten as:

**Equation 3**

\[
FR = \frac{\sigma_1}{c x} \frac{I}{(c x - I)}
\]

Equation (3) reveals that FR is determined by the degree of BR inherent in the firm
\( \sigma_1 / (c x) \), and the relation \( I / (c x - I) \) which is determined by financial decision for
leveraging.

In case \( \sigma_2 \neq \sigma_1 \), FR is determined by equation (2) and the difference in the variability of
net cash flow compared with the case when there is no change in the variability of net
cash flow owing to debt financing would be determined by the value: \( \frac{(\sigma_2 - \sigma_1)}{c x - I} \). In
particular, in case \( \sigma_2 < \sigma_1 \), meaning the variability of net cash flow declines with the use
of debt financing, FR would be lower than the case of no change in the variability of net
cash flow. In the other case, when \( \sigma_2 > \sigma_1 \), meaning the variability of net cash flow
increases with the use of debt financing, FR would be higher than the case of no
change in the variability.
If there are no leverage-induced changes in the level of BR, then total risk (TR) can be defined as:

**Equation 4**

\[
TR = \frac{\sigma_1}{c x - I} = \frac{\sigma_1 - cx}{c x (c x - I)}
\]

Where \( \frac{\sigma_1}{c x} \) is defined as BR.

Formulated as above, total risk can be decomposed into an additive relationship between BR and FR, i.e.

**Equation 5**

\[
TR = BR + FR
\]

The TR function in equation (4) could be transformed and rewritten as:

**Equation 6**

\[
TR = \frac{\sigma_1 - cx}{c x (c x - I)}
\]

\[
= \frac{\sigma_1 cx + \sigma_1 (c x - I) - \sigma_1 (c x - I)}{c x (c x - I)}
\]

\[
= \frac{\sigma_1}{c x} + \frac{\sigma_1 c x - \sigma_1 c x + I \sigma_1}{c x (c x - I)}
\]
\[
\frac{\sigma_1}{c} + \frac{I \sigma_1}{c \times (c \times -1)}
\]

Where \(\frac{\sigma_1}{c}\) represents BR and \(\frac{I \sigma_1}{c \times (c \times -1)}\) represents FR.

If the decision maker maximizes net returns subject to the constraint that total risk does not exceed a specified level, say \(\beta\), this means that an upper limit can be placed on total risk as below:

**Equation 7**

\[
TR = \frac{\sigma_1}{c} + \frac{I}{c \times (c \times -1)} \leq \beta
\]

When a change only occurs in \(\sigma_1\), the ratio FR/TR\(^{10}\) is invariant to changes in level of BR. However, FR as a percentage of TR might change when there are investment or financial responses to this changes in BR level.

Suppose there is an exogenous rise in \(\sigma_1\), leading to an increase in BR. FR will also increase as revealed by equation (6), which forces a subsequent risk adjustment so as to keep the upper limit of total risk unchanged. This adjustment may involve a production decision, an investment decision or a financing decision or a combination of the three.
The other approach to represent the risk-balancing hypothesis is based on a structural model of the overall debt–equity decision by a farm operator, for instance Collins (1985), Featherstone et al (1988). This model assumes that the decision-maker chooses the debt level that maximizes the expected utility of wealth (net equity), given his/her attitude towards risk, i.e., risk-averse, risk-neutral or risk-lover. This results in an optimizing behavior that balances increased expected return to equity against the additional risk inherent in leveraging. The objective function is the rate of return on equity (ROE) with FR defined as the degree of Debt-to-Asset ratio \( \delta = \frac{D}{A} \) and BR as the variance of the rate of return on asset (ROA).

The set of assumptions used in this model are: (a) the proprietor’s objective is to maximize the expected utility of the rate of return on equity; (b) the utility function of wealth is negative exponential; (c) the rate of returns on asset is normally distributed; and finally (d), taxes do not matter for the expected utility maximization.

Arguing that the leverage choice of the business operator affects both the expected ROE and its variance, the author employed Dupont Identity to capture the relationship between the rate of return on equity, the rate of return on asset and leverage decision as below:

**Equation 8**

\[
\frac{r_p}{E} \equiv \frac{r_p}{A} \cdot \frac{A}{E}
\]

Where \( r_p \) is the net expected return to the portfolio of the enterprise; \( A \) denotes asset; \( E \) denotes equity; \( \frac{r_p}{E} \) is the net expected return on equity; \( \frac{r_e}{A} \) is the net expected return on asset; \( \frac{A}{E} \) is the leverage multiplier, measuring the number of dollars of assets that are supported by one dollar of equity.

Asset is defined as:
\[ A = E + D \]

Thus,

\[ E = A - D \]

And this multiplier can be rewritten as:

**Equation 9**

\[
\frac{A}{E} = \frac{A}{A - D} = \frac{1}{1 - \delta}
\]

Where D denotes debt and \( \delta = D/A \): leverage (debt-to-assets ratio). Using equation (9) to replace \( \frac{A}{E} \), Equation (8) can be rewritten as:

**Equation 10**

\[ \frac{r_p}{E} = \frac{r_p}{A} \frac{1}{1 - \delta} \]

Further, Collins (1985) takes into account two important factors in the leverage choice decision, including interest and anticipated increases in asset values.

With an interest rate of \( K \) and debt of \( D \), the effect of debt on the rate of return on asset is \( \frac{-KD}{A} \) or \( -K \delta \). With \( i \) as the anticipated rate of increase of asset values, the effect of asset inflation on the expected rate of return of assets is \( \frac{-iA}{A} \) or \( i \).

If \( R_e \) is the net rate of return on equity and \( \frac{r_p}{A} \) is the gross return to assets, equation (10) can be rewritten as:
Equation 11

\[ R_E = \left[ \frac{r_p}{A} + i - K\delta \right] \frac{1}{1-\delta} \]

Where the gross anticipated rate of return to assets can be defined as \( R_A = \frac{r_p}{A} + i \) and regarded as a random variable \( R_A \) with mean \( R_A \) and variance \( \sigma_A^2 \). The stochastic anticipated rate of return to equity may be written as:

\[ \tilde{R}_E = \left[ \tilde{R}_A - K\delta \right] \frac{1}{1-\delta} \]

The expected value of rate of return to equity is:

Equation 12

\[ \bar{R}_E = \left[ \bar{R}_A - K\delta \right] \frac{1}{1-\delta} \]

and its variance is:

\[ \sigma_E^2 = \sigma_A^2 \left( \frac{1}{1-\delta} \right)^2 \]

The variance of the rate of ROE represents the total risk facing the firm. It is broken down into two marginal effects. First, BR is captured through the variability in the rate of ROA. Second, because the variance of the ROE is an increasing function of leverage, FR is also captured as the incremental increase in the variability of equity returns due to increases in debt relative to assets.
As most of the business debt is contracted at a fixed interest rate, K can be assumed as non-stochastic. Hence, K is independent of leverage\textsuperscript{11}.

Assuming that the rate of return on assets follows normal distribution, i.e., $R_A \sim N(R_A, \sigma_A^2)$ and employing the negative exponential utility function, Collins (1985) contended that the expected utility-maximizing solution for the rate of return on equity may be obtained by maximizing:

**Equation 13**

$$V(\delta) = \left[ R_A - K\delta \right] \frac{1}{1-\delta} - \frac{\rho}{2} \sigma_A^2 \left( \frac{1}{1-\delta} \right)^2$$

First-order condition for maximizing the expected utility of the rate of return on equity as a function of leverage choice is:

**Equation 14**

$$\frac{dV(\delta)}{d\delta} = \frac{-K}{1-\delta} + \frac{1}{(1-\delta)^2} [R_A - K\delta] - \rho \sigma_A^2 \left( \frac{1}{1-\delta} \right)^3$$

Solving equation (13) for the optimum debt-to-asset ratio yields

**Equation 15\textsuperscript{12}**

$$\delta^\ast = 1 - \frac{\rho \sigma_A^2}{(R_A - K)}$$

The second-order condition requires that,

\textsuperscript{11} Collin argues that although this assumption is in conflict with the theory of finance, it is consistent with agricultural banking practices in the United States in 1980s.

\textsuperscript{12} Specific steps to derive equation (15) are provided in Appendix 1
The second-order condition holds if the farm owner is risk averse. Equation (15) can be rewritten as:

Equation 17

\[
(1 - \delta^*) = \rho \frac{\rho \sigma_A^2}{(R_A - K)}
\]

Where \((1 - \delta^*) = \frac{E}{A}\) is the optimal equity-asset ratio. This model suggests that the degree of FR \((\delta^*)\) depends not only on BR \((\sigma_A^2)\) but also on interest rate, the expected net rate of return to assets and farmers’ attitude towards risk. Differentiating equation (15) w.r.t to \(\sigma_A^2\) yields

Equation 18

\[
\frac{\partial \delta^*}{\partial \sigma_A^2} = -\frac{\rho}{[R_A - K \delta]} < 0
\]

The sign of equation (18) is negative as long as the second-order condition is met, meaning the proprietor is risk averse \((\rho > 0)\)\(^{14}\), and the cost of debt does not exceed the expected rate of return to assets from operations and capital gains. It can be

\[^{13}\text{Specific steps to derive equation (16) are provided in Appendix 2.}\]

\[^{14}\text{The Arrow – Pratt measure of absolute risk aversion } \rho = \frac{u'(x)}{u(x)} > 0.\]
revealed from equation (18) that, ceteris paribus, a change in the level of BR ($\sigma_A^2$) (i.e., the variance of the rate of return to assets) leads to a change in financial leverage ($\delta$) in the opposite direction. Put differently, this model supports Gabriel and Baker’s assertion of an inverse relationship between BR and FR.

Also, by sequentially differentiating equation (15) w.r.t the expected rate of ROA, interest rate and risk aversion parameters, one can obtain the following comparative statistics results:

**Equation 19**

$$\frac{d\delta^*}{\partial R_A} = \frac{\rho \sigma_A^2}{(R_A - K)^2} > 0$$

**Equation 20**

$$\frac{d\delta^*}{\partial K} = -\frac{\rho \sigma_A^2}{(R_A - K)^2} < 0$$

**Equation 21**

$$\frac{d\delta^*}{\partial \rho} = -\frac{\sigma_A^2}{R_A - K} < 0$$

Thus, all other factors remaining unchanged, an increase in the expected rate of return on assets will trigger an increase in the use of debt (equation 19); an increase in interest rate will induce a decrease in leverage (equation 20) and the degree of risk-aversion matters as more risk-averse individuals will use less debt than less risk-averse individuals.

By using comparative statistics, the risk-balancing model by Collins (1985) confirms the inverse relationship between FR and BR as proved earlier by Gabriel and
Barker (1980). Further, it is revealed from this model that the financial risk decision has a relationship with other structural variables other than BR, e.g. the expected ROA and costs of debt. As acknowledged by Gabriel and Baker (1980) and emphasized by Ueza et al (2014b) with listed empirical studies as evidence, the risk-balancing hypothesis may not always hold in reality. An upward adjustment of debt use is only one of the strategies farmers choose to respond to an exogenously induced decline in the level of BR. Alternatively, farmer may opt to reorganize production activities, for instance, changing their crop portfolio, or undertake investment activities or a combination of both to bring BR back to the original level. Depending on the extent to which such strategies are pursued by a farm operator, we may not observe a risk-balancing behavior in agriculture. Such coping strategies could vary across sectors and the size of operation within the same sector.

Further, by totally differentiating equation (15) w.r.t \( \sigma_A^2, R_A \) and K and equating to zero yields:

**Equation 22**

\[
d\delta^* = -\frac{\rho}{(R_A - K)} d\sigma_A^2 + \rho\sigma_A^2 (\bar{R}_A - K)^2 d\bar{R}_A - \rho\sigma_A^2 (\bar{R}_A - K)^2 dK = 0
\]

Solving for \( \frac{d\sigma_A^2}{\sigma_A^2} \) we have
Equation 23

\[
\frac{d\sigma^2_A}{\sigma^2_A} = \frac{(d\bar{R}_A - dK)}{\bar{R}_A - K} = \frac{d(R_A - K)}{(R_A - K)}
\]

Where LHS is the proportional change in BR; RHS is the proportional change in the expected rate of ROA over the opportunity cost of capital, i.e., interest rate.

It can be inferred from equation (22) and equation (23) that there would be no change in the leverage position if the proportional change in BR is equal to the proportional change in the expected rate of ROA over the opportunity cost of capital. Therefore, the model revealed the relationship between leverage choice and the relative changes in the model components. Therefore, it is imperative that the risk-balancing hypothesis be investigated under an integrated risk-management approach, taking into account the interactions of other structural variables as well.

In summary, the risk-balancing hypothesis assumes an inverse relationship between BR and FR. The section to follow attempts to incorporate Crop Insurance into Collins’ (1985) conceptual framework, i.e., corroborating the risk-balancing hypothesis with CI coming into play.

4.3 Collins (1985) with Crop Insurance purchase

In the below section, an attempt is made to incorporate Crop Insurance (CI) purchase into the conceptual framework by Collins (1985) for analyzing the risk-balancing hypothesis.

As CI covers production losses and yield reductions caused by insured perils, it is considered as a tool to mitigate production risk. As BR encompasses production risk, CI is supposed to reduce BR (\(\sigma^2_A\)) for producers.
Put $\sigma_A^2$ as the variance of the rate of return on assets with CI purchase. As CI purchasers receive CI indemnities in case their production falls short of the guaranteed value, we expect that $\sigma_A^2 < \sigma_A^2$. In this vein, CI indemnity is a stochastic variable.

On the other hand, since annual risk premium is known from the beginning of the year based on pre-determined factors such as the base premium rate, the guaranteed production based on their chosen coverage level and the surcharge or discount of the proprietor, risk premium can be assumed to be non-stochastic.

Further assume that a proprietor purchases CI as long as the expected net effects $\geq 0$, i.e., expected benefits $\geq$ expected costs, with an annual risk premium $RP$, the effect of risk premium on the rate of return on assets is

$$\frac{RP}{A}$$

Put $R'_E$ as the net rate of return to equity with the purchase of CI, we have:

**Equation 24**

$$R'_E = \left[ \frac{r_e}{A} + i - K\delta - \frac{RP}{A} \right] \frac{1}{1 - \delta}$$

The expected utility maximization function with CI purchase can be expressed as:

**Equation 25**

$$V(\delta) = \left[ - \frac{A}{K\delta - \frac{RP}{A}} \right] \frac{1}{1 - \delta} - \frac{\rho}{2} \sigma_A^2 \left( \frac{1}{1 - \delta} \right)^2$$

Similar to the case without CI being incorporated, solving for 1st order condition yields the optimum leverage to maximize the expected utility of rate of ROE as:
Equation 26

\[
\delta^{*} = 1 - \frac{\rho \sigma^2}{R_A - K - \frac{RP}{A}}
\]

\[
\sigma_{E}^2 = \sigma_A^2 \left( \frac{1}{1 - \delta^*} \right)^2
\]

Where \( \bar{R}_A - K - \frac{RP}{A} \) is the net expected rate of ROA, accounting for the opportunity cost of capital, i.e., interest rate K, and the effect of annual CI risk premium on the rate of ROA.

**Proposition 1**: The proprietor will take a greater leverage ratio (FR) with CI purchase as long as the “scaled variance” of ROA, i.e., the ratio of the variance of the rate of return on assets over the net anticipated rate of return on assets, decreases with CI purchase. This happens when CI is effective in reducing BR for farms, provided that the expected rate of ROA is enough to cover the opportunity cost of capital (K) and the effect of annual CI risk premium on the rate of ROA (RP/A)

**Proof**:

We have the optimum leverage ratio without and with CI purchase as equation (15) and (26), respectively:

\[
\delta^{*} = 1 - \frac{\rho \sigma^2}{(R_A - K)}
\]

\[
\delta^{*} = 1 - \frac{\rho \sigma^2}{R_A - K - \frac{RP}{A}}
\]

Compared the optimum leverage ratio between these 2 cases, we have:
Equation 27

\[ \delta^* - \delta^* = \frac{\rho \sigma_A^2}{R_A - K} - \left( \frac{\rho \sigma_A^2}{R_A - K - \frac{RP}{A}} \right) = \rho \left( \frac{\sigma_A^2}{R_A - K} - \frac{\sigma_A^2}{R_A - K - \frac{RP}{A}} \right) \]

Where:

\[ \frac{\sigma_A^2}{R_A - K} \]

is the “scaled variance” of the rate of ROA without CI purchase;

\[ \frac{\sigma_A^2}{R_A - K - \frac{RP}{A}} \]

the is “scaled variance” of the rate of ROA with CI purchase

As the proprietor is assumed to be risk averse, (\( \rho > 0 \)), it can be inferred from equation

(27) that as long as:

\[ \left( \frac{\sigma_A^2}{R_A - K - \frac{RP}{A}} \right) < \left( \frac{\sigma_A^2}{R_A - K} \right)^{15} \]

Then: \( \delta^* > \delta^* \), meaning the proprietor will take a higher leverage ratio with CI purchase.

**Proposition 2:** As long as the expected rate of ROA is enough to cover the opportunity costs of capital and the effect of CI risk premium on the rate of ROA, ceteris paribus, a decrease in BR will lead to an increase in the leverage ratio (FR).

**Proof:** The second-order condition:

\[ \frac{\sigma_A^2}{R_A - K - \frac{RP}{A}} \]

Implications of this condition: intuitively, as long as \( \sigma_A^2 \) sufficiently decreases and/or interest payment and risk premium are not too big, ceteris paribus, the leverage ratio will increase with CI purchase.
Equation 28
\[
\frac{\partial \sigma^*}{\partial \sigma_A^2} = -\frac{\rho}{\left[ \tilde{R}_A - K - \frac{RP}{A} \right]} < 0
\]

The negative sign of the equation (28) holds, confirming an inverse relationship between BR and FR as long as: \( \frac{RP}{A} + K < \tilde{R}_A \), meaning the expected rate of ROA can cover interest rate and the effect of CI risk premium on the rate of ROA, and that \( \rho > 0 \) (2\textsuperscript{nd} order condition holds, meaning the proprietor is risk averse).

If the individual is risk-neutral (\( \rho = 0 \)), there will be no relationship between BR and the optimum level of FR. If the individual is risk-loving (\( \rho < 0 \)), the 2\textsuperscript{nd} condition does not hold for the maximization problem and there is no risk-balancing behavior.

**Proposition 3**: An inverse relationship exists between the changes in the level of the variance of the rate of ROA (BR) and the magnitude of the changes in the optimum leverage ratio (FR), as long as the proprietor is risk-averse and the net expected rate of ROA is larger than zero, taking into account opportunity cost of capital and CI risk premium.

**Proof**: 

From equation (28), we have the magnitude of the change in the optimum FR between the two cases, with and without CI purchase, w.r.t BR calculated as below:

Equation 29
\[
\frac{d(\sigma^* - \sigma^*)}{\partial \sigma_A^2} = -\rho \frac{1}{\left[ \tilde{R}_A - K - \frac{RP}{A} \right]} < 0
\]
As $\rho > 0$ and as long as $\left( R_A - K \frac{RP}{A} \right) > 0$, equation (29) holds, meaning

$$\sigma_A^2 \downarrow \Rightarrow (\delta^- - \delta^+) \uparrow.$$  

And vice versa.

Whereas Proposition 2 looks at the direction of the FR-BR relationship, Proposition 3 captures the magnitude of the changes in FR responses. Gabriel and Baker (1980) argued that differential magnitudes of the response may be associated with various characteristics as risk aversion, farm size or farm type. The extent of the response for any given farm could be expected to be greater or less than the one displayed in the aggregated model (p. 564).

### 4.4 Chapter summary

For the risk-balancing hypothesis to hold, proprietor is assumed to be an expected utility maximizer with a risk-averse attitude. The more risk-averse the individual is, the more likely he/she will take less financial leverage, all others factors remaining unchanged. Not only BR, possible factors that may induce a change in FR decision should be included in the risk-balancing model. Those are expected ROA together with factors that affect the net expected ROA, including but not limited to cost of debt and risk-premium. Also, in order to have a more accurate measure of BR as well as its “scaled variance” (Collins, 1985), CI should would be included in the model in the calculation of BR as risk-premium and CI indemnities both affect the distribution of ROA. Last but not least, if CI helps to reduce BR for farms, it would bring about an increase in the level of FR, meaning the risk-balancing behavior may exhibit with CI incorporated in the model than the case without CI. Put another way, other factors remaining unchanged, failing to incorporate CI purchase into analysis may lead to an overestimate of BR, and thus, an incorrect estimate of the extent of risk-balancing behavior. On a side note, incorporation of Crop Insurance into risk-balancing analysis is
important for field crops farms, where the majority of farm income comes from field crops proceeds. Yet it may not be that important for hog farms.

Table 3 summarizes the risk variables from the framework by Gabriel & Baker (1980), Collins (1985) and this research.

<table>
<thead>
<tr>
<th>Business risk</th>
<th>Gabriel &amp; Baker (1980)</th>
<th>Collins (1985)</th>
<th>This research</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\frac{\sigma_1}{c \sigma}$</td>
<td>$\sigma_A^2$</td>
<td>$\sigma_A^{*2}$</td>
</tr>
<tr>
<td>Financial risk</td>
<td>$\frac{I \sigma_1}{c x(c x - I)}$</td>
<td>$\delta^* = 1 - \frac{\rho \sigma_A^2}{(\lambda - K)}$</td>
<td>$\delta^* = 1 - \frac{\rho \sigma_A^{*2}}{\lambda - K - \frac{RP}{A}}$</td>
</tr>
<tr>
<td>Total risk</td>
<td>$\frac{\sigma_1}{c x} - \frac{I \sigma_1}{c x(c x - I)}$</td>
<td>$\sigma_{\xi}^2 = \sigma_A^{<em>2} \left( \frac{1}{1 - \delta^</em>} \right)^2$</td>
<td>$\sigma_{\xi}^{*2} = \sigma_A^{<em>2} \left( \frac{1}{1 - \delta^{</em>}} \right)^2$</td>
</tr>
<tr>
<td>Key assumptions</td>
<td>No leverage-induced changes in the level of BR.</td>
<td>-Proprietor: risk-averse expected utility maximizer</td>
<td>-As in Collins (1985)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Expected rate of ROA: sufficiently large to cover cost of capital</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Expected rate of ROA: sufficiently large to cover cost of capital and the effect of CI risk premium on the rate of ROA</td>
<td></td>
</tr>
</tbody>
</table>
5 Chapter 5: DATA, VARIABLE MEASURES AND DESCRIPTIVE STATISTICS

5.1 Chapter introduction

The purpose of this chapter is to describe the data and define the variables used to investigate the risk-balancing behavior in Ontario hog sector. The chapter is composed of two broad sections. The first section describes data features and variable definition. The second section provides descriptive statistics of the key variables and explain alternative risk measurements to be employed in the empirical analysis.\(^{16}\)

5.2 Data and variable definition

5.2.1 Data sources and features

The data used in this study comes from Ontario Farm Income Database (OFID), which is a longitudinal data set compiled from the tax file records of participating farms in Ontario. Data on AgriStability payments under CAIS/BRM programs are also included in this data set. Additionally, we used aggregate data on changes in Ontario farm land value from Farm Credit Canada\(^{17}\).

The original data set consisted of 22,462 observations covering 4,353 farms from 2003 to 2014. From the original dataset, 10,149 observations were excluded from the sample because they have negative interest expenses and are presumed to have measurement errors. Since business risk can influence financial risk only with a lag, farms to be included in this study need to be present in at least two consecutive years during the study period. As a result, 285 observations that did not satisfy this condition were also dropped. As debts show up in the denominator of the Cost of debt variable (interest/debt), 553 observations that have debt value equal to “0” or NAs were excluded from the

\(^{16}\) Crop Insurance is not incorporated into our empirical analysis due to the unavailability of Crop Insurance data at farm-level.

\(^{17}\) Data was obtained from Farmland values report – Historical values (Farm Credit Canada, 2017)
sample\textsuperscript{18}. After removing all these observations, we have a panel dataset of 11,462 observations consisting of 2,036 farms for the 2003-2014 period.

5.2.2 Variable definition and empirical measurement

Risk measures

Following the empirical literature in measuring business risk based on Net Operating Income (NOI) or Return on Asset, we used NOI to construct our risk measures due to the lack of balance sheet.\textsuperscript{19}

Business risk (BR)

The most commonly used measurement of BR in the literature is the coefficient of variation (CV) of either NOI or CV of return of assets. Corresponding to this way of measuring BR, we computed CV of NOI as our initial measure of BR. In particular, 2-year rolling standard deviation over 2-year moving average of NOI was computed to construct this BR-CV measurement\textsuperscript{20}. Notably, the use of CV of NOI as a measure of risk implies that NOI is normally distributed. Also, this measurement cannot tell whether the variable has a tendency for more values to fall in the upper, i.e., the right, or lower, i.e., the left, tail of the distribution.

\textsuperscript{18} Additionally, farms that have revenue equal to $1 are presumed to be input errors and were removed from the sample.

\textsuperscript{19} Besides, we employed Revenue and Arm’s length salary to compute NOI since the majority of Total Operating Revenue showed up with negative values and Cost of Goods Sold for a large number of observations amounted to millions of dollars, which were presumed to be measurement errors.

\textsuperscript{20} Our rationale in choosing the 2-year window is the 4-year time span of CAIS as well as BRM. While a number of previous studies choose a longer time-window for the CV measurement, in our case, a longer time-span would lead to overlap AgriStability payments across different policy regimes. In addition, fewer observations would be retained in the sample if we used a longer window in computing the CV measure. Neither was considered desirable for this study.
Subsequently, we tested if the NOI variable is normally distributed for each farm size category. An attempt was then made to measure BR as rolling skewness\textsuperscript{21} of NOI when the null hypothesis of normal distribution was rejected. By using skewness, we focus on the tails of the distribution, i.e., the infrequent and extreme losses or gains rather than on variations around the mean, which stands for small and frequent gains or losses from risk perspective. Skewness tells us if the distribution of NOI is skewed or not, and if it is skewed to the left, i.e., more downside risks or to the right, i.e., more upside risks.

**Financial risk (FR)**

FR is measured in two ways. First, we followed the empirical model by Gabriel and Barker (1980) in constructing FR measure as the ratio of interest expense to the NOI variable. This is hereinafter referred to as FR-magnitude measurement. Although longitudinal data allows for heterogeneity across individuals and overtime, we tried an alternative way of measuring FR as the CV of Interest expense to NOI ratio on the ground that variations imply uncertainty and risk. In particular, FR-CV measurement was computed as the 2-year rolling standard deviation over the 2-year moving average of the Interest expenses-NOI ratio.

**Explanatory variables**

**Business risk** in the previous year, measured in two ways, i.e., 1-year lagged CV and 1-year lagged rolling skewness of NOI. In each way of measurement, AgriStability payments under CAIS/BRM were incorporated into the computation of risk to compare the risk level with and without program payments.

**Farm diversification**, measured by Herfindahl index\textsuperscript{22} at farm level and ranges from 0 to 1. This index represents revenue allocation among various operations (e.g., beef,  

\textsuperscript{21} Skewness requires a rolling window of at least 3-years for the statistic to be computable.  

\textsuperscript{22} Herfindahl index: \[ H = \sum_{i=1}^{n} (share_i^2) \]
hog, dairy, grain etc.). A lower index value indicates a greater level of diversification for farms and farm diversification could be considered as a risk management strategy. We expect an increase in the level of diversification, i.e., the lower in the index, to be associated with an increase in the leverage taken. Besides, farms with different diversification levels may have different risk-balancing behaviors.

**Cost of debt** in the previous year, measured by interest expense to debt ratio. We would expect farms with a high historical cost of debt to be less likely to take on more leverage in the current period.

**Change in farm land value** in previous year, being Ontario farmland appreciation rates. This variable is included to account for changes in farm land value between years, since relevant information at farm level is not available. As farms may use land as collateral for their loan, changes in the prices of farmland are assumed to affect farm liquidity as credit adjusts to new equity values (Collins, 1985). In this sense, farm land value can be used as proxy for farm asset. However, as hog farming in Ontario is not land intensive, change in farmland value may or may not have a significant effect on farm FR.

Table 4 provides a summary of variables and expected signs in our model estimation.

**Table 4. Variable summary**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definition/ Ways of measurement</th>
<th>Measurement unit</th>
<th>Expected signs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Response variable</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial risk</td>
<td>i. Interest expenses/ NOI</td>
<td>Unit-free</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii. CV of Interest expenses/ NOI</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Explanatory variables**

<table>
<thead>
<tr>
<th>Business risk</th>
<th>The variations of NOI:</th>
<th>Unit-free</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>i. CV of NOI</td>
<td>(-)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii. Rolling skewness of NOI(^\text{23})</td>
<td>(+)</td>
<td></td>
</tr>
<tr>
<td>Farm diversification</td>
<td>Herfindahl index</td>
<td>(-)</td>
<td></td>
</tr>
<tr>
<td>Cost of Debt</td>
<td>The ratio of interest expense over debt</td>
<td>(-)</td>
<td></td>
</tr>
<tr>
<td>Farmland_change</td>
<td>Percentage change in Ontario annual farm land value</td>
<td>(+)</td>
<td></td>
</tr>
</tbody>
</table>

On a further note, farms were originally classified into seven size classes based on annual farm revenue. In order to explore if there are any differences in the risk-balancing behavior across farm size categories, we collapsed them into 3 sizes classes, including Small size (annual farm revenue \(<=\$50,000\)), Medium size ($50,000 < \text{annual farm revenue} < \$250,000$) and Large size (annual farm revenue \(>=\$250,000\)).

\(^\text{23}\) For the sake of interpretational consistency, skewness was transformed into relative values for each farm, using its minimum value as the reference value. As a result, skewness values turns into non-negative for the whole medium farms and represents the deviation of the original skewness value from the minimum value at farm level. In this way, an increase in this transformed skewness value suggests a shorter left tail, i.e., less downside risks or a longer right tail, i.e., more upside risk, with reference to the minimum skewness value of each farm. An increase in this transformed skewness, therefore, indicates a reduction in the level of the undesirable BR.
5.3 Descriptive statistics and risk measurements

5.3.1 Outlier detection – the distribution of Net Operating Income (NOI)

Since NOI is employed to calculate BR measures, we explored the distribution of NOI variable for each size group separately. First, boxplot and Kernel density plot are used to visually inspect the distribution of NOI as shown in Figure 23.

![Density plot and boxplots of NOI across farm size categories](image)

Figure 23. Density plot and boxplots of NOI across farm size categories

Density plot of NOI showed a very long right-hand tail for the Large size category. Correspondingly, its boxplot reveals quite a number of outliers above the median value. We applied Median Absolute Deviation\(^ {24}\) approach (MAD) to detect and discard outliers in NOI for large farms. As a result, 1,084 observations were removed, making the Large size group to consist of 6,689 observations after outlier discarded. Our final sample after outlier detection and discard of NOI consists of 10,377

---

\(^{24}\) MAD provides an alternative approach to the 3-sigma rule in detecting outliers. MAD is believed to be better than the latter approach in the way that instead of using the mean value, it uses median, which is not pulled by extreme values, to detect outliers.
observation of 1,975 farms. Figure 24 captures the distribution of NOI of the Large size group after outlier detection and removal with MAD.

Figure 24. Box plot and density plot of NOI – Large size group (after outlier removal)

Figure 25. Density plot of NOI across 3 size categories (after outlier removal)
Subsequently, we investigated the quartile statistics of NOI for each size group, the results are summarized in Table 5.

Table 5. Quartile statistics of NOI - After program payments

<table>
<thead>
<tr>
<th>Farm size($)</th>
<th>Min</th>
<th>1st Qu.</th>
<th>Median</th>
<th>Mean</th>
<th>3rd Qu.</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>179,747</td>
<td>412,619</td>
<td>630,524</td>
<td>781,595</td>
<td>1,033,804</td>
<td>2,306,115</td>
</tr>
<tr>
<td>Medium</td>
<td>29,878</td>
<td>101,108</td>
<td>151,400</td>
<td>153,523</td>
<td>205,068</td>
<td>476,633</td>
</tr>
<tr>
<td>Small</td>
<td>142</td>
<td>15,303</td>
<td>27,612</td>
<td>27,796.34</td>
<td>40,093</td>
<td>109,074</td>
</tr>
</tbody>
</table>

NOI has its median lower than its mean value for the three sizes. This suggests that the NOI variable probably has a right-skewed distribution (Table 5).

The Shapiro-Wilk normality test was subsequently employed as a final step to investigate the distribution property of NOI for each farm size category. Based on the results of Shapiro-Wilk normality test, while we failed to reject the null of normal distribution for the Small and Large farm size group, the null is rejected for the Medium size category at the 5 percent level of significance. This result confirms that for the medium farms, NOI was not normally distributed, which seems to be consistent with its density plot and quartile statistics. As a result, we compute rolling skewness of NOI for as an alternative BR measure for the Medium size category (Table 6).
Table 6. Results of Shapiro-Wilk normality test of NOI across farm size categories

<table>
<thead>
<tr>
<th>Farm size</th>
<th>Shapiro-Wilk normality test</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Null: normal distribution</td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>W = 0.92185, p-value = 0.3016</td>
<td>Fail to reject the Null</td>
</tr>
<tr>
<td>Medium</td>
<td>W = 0.81112, p-value = 0.01257</td>
<td>Reject the Null</td>
</tr>
<tr>
<td>Small</td>
<td>W = 0.95942, p-value = 0.7775</td>
<td>Fail to reject the Null</td>
</tr>
</tbody>
</table>

5.3.2 Descriptive statistics of key variables

Table 7 provides basic summary statistics of the key variables used in the study. In particular, NOI has a higher mean and standard deviation with program payments relative to those without program payments. Measured by CV of NOI, BR had a lower mean value with program payments. Conversely, FR measured by CV of Interest expenses/ NOI exhibited a slightly higher value with program payments compared with the case without program payments.
Table 7. Descriptive statistics for key variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Count</th>
<th>Mean</th>
<th>Sd</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOI_1 ($)</td>
<td>10,377</td>
<td>529,627.90</td>
<td>480,255.80</td>
<td>142.00</td>
<td>2,298,439.00</td>
</tr>
<tr>
<td>NOI_2 ($)</td>
<td>10,377</td>
<td>549,586.00</td>
<td>495,720.10</td>
<td>142.00</td>
<td>2,306,115.00</td>
</tr>
<tr>
<td>BR_1=CV of NOI_1</td>
<td>7,817</td>
<td>0.1770</td>
<td>0.3195</td>
<td>0.0000</td>
<td>16.4324</td>
</tr>
<tr>
<td>BR_2=CV of NOI_2</td>
<td>7,817</td>
<td>0.1677</td>
<td>0.3006</td>
<td>0.0000</td>
<td>17.7790</td>
</tr>
<tr>
<td>Interest ($)</td>
<td>10,377</td>
<td>38,108.18</td>
<td>49,264.36</td>
<td>1.00</td>
<td>1,136,694.00</td>
</tr>
<tr>
<td>FR_1 = Interest/NOI_1</td>
<td>10,377</td>
<td>0.1206</td>
<td>0.6512</td>
<td>0.0000</td>
<td>38.2007</td>
</tr>
<tr>
<td>FR_2 = Interest/NOI_2</td>
<td>10,377</td>
<td>0.1159</td>
<td>0.6492</td>
<td>0.0000</td>
<td>38.2007</td>
</tr>
<tr>
<td>FR_CV_1=CV of Interest/NOI_1</td>
<td>7,817</td>
<td>0.3200</td>
<td>2.6390</td>
<td>0.0000</td>
<td>222.2500</td>
</tr>
<tr>
<td>FR_CV_2=CV of Interest/NOI_2</td>
<td>7,817</td>
<td>0.3207</td>
<td>2.6930</td>
<td>0.0000</td>
<td>226.1700</td>
</tr>
<tr>
<td>Herfindahl index</td>
<td>10,377</td>
<td>0.7861</td>
<td>0.1868</td>
<td>0.3439</td>
<td>1.0000</td>
</tr>
<tr>
<td>Cost of Debt</td>
<td>10,377</td>
<td>0.0521</td>
<td>0.0118</td>
<td>0.0340</td>
<td>0.0710</td>
</tr>
<tr>
<td>Farmland rate change (%)²⁵</td>
<td>10,377</td>
<td>8.1678</td>
<td>5.8650</td>
<td>3.8000</td>
<td>30.1000</td>
</tr>
</tbody>
</table>

Notes: 1 and 2 denotes without and with program payments, respectively.

Descriptive statistics of key variables for each farm size category are presented in Table 8. Large farms account for the largest share in the sample, with almost 65 percent of the farm number during the interval. Small-size farm is the minority out of the 3 size groups, accounting for 6.3 percent. This information reflects farm consolidation trend in the Ontario hog sector. Besides, NOI experienced a consistent increase in its mean and standard deviation from Small to Large size category for both cases, without and with program payments. Furthermore, NOI had a higher mean and also, a higher standard deviation.

²⁵ Percentage change in farm land values is aggregate data at provincial level. As such, this variable varies over years, but not across farms.
deviation with program payments across the three size categories. Notably, Small-sized farms had the highest mean value of BR compared to the Medium and Large-sized farms.

On the contrary, FR measured by CV of Interest/ NOI had a higher mean value with program payments for small-sized farms. Besides, Small-sized farms had the highest maximum value of FR measured as Interest expense/ NOI and Large-sized farms had the highest maximum value of FR measured as CV of Interest expenses/ NOI out of the three size groups (Table 8).
Table 8. Descriptive Statistics by farm size categories

<table>
<thead>
<tr>
<th></th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>sd</td>
<td>min</td>
</tr>
<tr>
<td>NOI_1 ($)</td>
<td>26,042.750</td>
<td>14,147.590</td>
<td>142.000</td>
</tr>
<tr>
<td>NOI_2 ($)</td>
<td>27,948.330</td>
<td>16,111.670</td>
<td>142.000</td>
</tr>
<tr>
<td>BR_1 = CV of NOI_1</td>
<td>0.472</td>
<td>1.098</td>
<td>0.000</td>
</tr>
<tr>
<td>BR_2 = CV of NOI_2</td>
<td>0.465</td>
<td>1.009</td>
<td>0.000</td>
</tr>
<tr>
<td>Interest expense ($)</td>
<td>6,818.730</td>
<td>9,751.590</td>
<td>3.000</td>
</tr>
<tr>
<td>FR_1 = Interest/NOI_1</td>
<td>0.597</td>
<td>2.386</td>
<td>0.000</td>
</tr>
<tr>
<td>FR_2 = Interest/NOI_2</td>
<td>0.581</td>
<td>2.383</td>
<td>0.000</td>
</tr>
<tr>
<td>FR_CV_1 = CV of Interest/NOI_1</td>
<td>0.437</td>
<td>0.364</td>
<td>0.000</td>
</tr>
<tr>
<td>FR_CV_2 = CV of Interest/NOI_2</td>
<td>0.447</td>
<td>0.362</td>
<td>0.003</td>
</tr>
<tr>
<td>Herfindahl index</td>
<td>0.726</td>
<td>0.224</td>
<td>0.343</td>
</tr>
<tr>
<td>Cost of Debt = Interest/Debt</td>
<td>0.053</td>
<td>0.012</td>
<td>0.034</td>
</tr>
<tr>
<td>N</td>
<td>726</td>
<td>2,962</td>
<td>6,689</td>
</tr>
</tbody>
</table>
Concerning Herfindahl index, large farms had the highest mean value, meaning that on average, they are the most specialized out of the three farm size categories.

On a side note, while Interest expense had its highest mean and standard deviation belonging to the Large size category, Cost of Debt hardly varied across the three farm size groups.

In brief, a descriptive analysis of the data sample provides some insight into the variables of concern. Both NOI and FR variables exhibited great variations within and between farm sizes. Notably, medium and large farms account for the majority of the sample\(^{26}\) and small farms just make up the minority of 7 percent (Fig.26)

---

\(^{26}\) This pie chart was drawn employing the number of farms who applied and received AgriStability payments under CAIS/BRM from 2003 to 2014. This does not mean the total number of observation but the number of farms entering into the programs during the study period.
5.3.3 Risk measurements

5.3.3.1 Whole sample: Coefficient Variation (CV) measure of BR

With regards to the measurement of risk, I used Coefficient of Variation (CV) of NOI as a starting point in measuring BR. Financial risk is measured in two ways: i) Interest expenses/ NOI and ii) CV of Interest expenses/ NOI. As for total risk, based on Gabriel and Barker (1980), the concept of total risk is built upon an additive relationship between FR and BR. In this first attempt of employing CV measurement, total risk can be computed by adding BR and FR for individual farms, whereby BR is measured as CV of NOI and FR as CV of Interest expenses/ NOI. Figure 26 depicts total risk averaged across farms under each size category over the study period.

![Graph showing average total risks by farm size categories- CV measure](image)

**Figure 27. Average total risks by farm size categories- CV measure**

As can be gleaned from Figure 27, the difference in total risk with and without program payments are not very different. However, total risk peaked during the years 2009 – 2010 for Small and Medium farms and in 2011 for large farms. This can be...
traced back to the period of adversity for the hog sector when feed costs peaked and brought more volatility in net farm income.

Small farms had the highest and most fluctuated total risk out of the three size groups. Especially in the years 2009 -2010, total risks with program payments exceeded total risk without program payments. For Medium and Large farms, program payments apparently reduced total risk, especially from the beginning of the period to 2010.

Breaking down into component risks, BR and FR were computed and plotted for visual inspection. Figure 28 depicts BR measurement by 2-year window CV of NOI.

![Graph showing average BR by farm size categories - CV measure](image)

**Figure 28. Average BR by farm size categories- CV measure**

Medium and large farms experienced a fairly stable level of BR during the study period. And the story is somewhat different for small farms\(^{27}\). However, we can hardly

\(^{27}\) It was likely that small farms with such a high level of BR could survive during the tough period that this study covers thanks to their off-farm income as a source of income cushion.
tell if there was any distinctive difference between BR with and without program payment. (Fig.28).

Average across farm size of FR as CV of Interest expenses/NOI ratio was also plotted for additional inspection. Figure 29 depicts FR-CV measure averaged across farms for each farm size category.

![Average FR by farm size categories - CV measure](image)

**Figure 29. Average FR by farm size categories - CV measure**

With this way of FR measurement, there was hardly any noticeable difference in the FR level with and without program payments for the three size groups. A similar pattern of FR was shared among the Medium and Large size with its peak in 2009 for Medium farm size and in 2011 for the Large farm size. Besides, large farms had the highest FR level out of the three size classes during the period of study.

Small size farms exhibited a somewhat different cyclical pattern, with its highest peak in the year 2013.
Notably, as Medium and Large farms had a fairly stable BR pattern during the study period, it seemed that their total risk picked its pattern from its FR component.

For the sake of completeness, FR-magnitude measure was also computed and plotted in Figure 30. Medium and Large farms had a stable and much lower level of Interest expenses/ NOI of around 0.2 compared to Small farms during the study period. The latter showed a widely fluctuated and much higher level of FR, which increased to a new high in 2014. It is also worth noting that the level of FR with magnitude measure barely changed with program payments. And this is true for all three size categories (Fig. 30)

![Figure 30. Average FR by farm size categories – magnitude measure](image)

5.3.3.2 Medium size group: skewness measurement of BR

The null hypothesis of normal distribution of NOI being rejected at the 5 percent level of significance for Medium size group, we proceed to compute the 3-year window rolling skewness of NOI as an alternative measure of BR for medium farms. Figure 31 depicts
average BR measured by 3-year rolling skewness of NOI across medium farms from 2003 to 2014.

![Graph showing average BR of Medium farm size category—Skewness measure](image)

**Figure 31. Average BR of Medium farm size category—Skewness measure**

As can be observed from the graph, average BR as skewness of NOI ranged from approximately -0.07 to 0.08. From the year 2005 to 2006, the red line representing BR with program payments lay above zero and above the blue line representing BR without program payments, indicating that on average, farms had a higher degree of positive skewness with program payments. In other words, with AgriStability payments under CAIS, there were gains in NOI compared to the case without program payments for medium farms.

In addition, skewness of NOI displayed its highest positive peak, meaning farms had the largest jumps in NOI, in 2007 and exhibited a somewhat cyclical pattern under BRM programs from 2007 onwards. Notably, the red line was below the blue line for the most parts of the period. This suggests that farms of Medium size category had an either higher degree of negative skewness or a lower degree of positive skewness with AgriStability payments. When both lines are below zero, a lower red line reveals that the
distribution of NOI had a longer left tail, meaning a higher level of downside risk, or farms incurred larger drops in NOI with program payments. When both lines are above zero, a lower red line denotes a distribution with a shorter right tail, i.e., a lower level of upside risk.

5.4 Chapter summary

In this chapter, we provided a descriptive statistics of the sample data for the three farm size categories and defined alternative ways of risk measurements for empirical analysis. BR was measured by CV and skewness of NOI, and FR was measured by Interest expense/ NOI and the CV of this ratio.

Our graphical examination of the risk-measurements for Ontario hog sector suggested that total risk with CV measurement peaked during the years 2009 – 2010 for small and medium farms and in 2011 for large farms. This can be traced back to the period of adversity for the sector when feed costs rocketed and brought more volatility in net farm income. In addition, with BR measured as CV of NOI, small farms had the highest level and most fluctuated pattern of BR out of the three farm size categories.

With BR measured as skewness of NOI, it was revealed that medium farms experienced larger gains in NOI with AgriStability payments under CAIS. Under BRM programs from 2007 onwards, farms exhibited either a higher degree of negative skewness, i.e., farms incurred larger drops in NOI, or a lower degree of positive skewness, i.e., farms incurred a lower level of upside risk, with AgriStability payments.

In a nutshell, our graphical examination of the risk measurements suggests that apparently, there was hardly a conspicuous difference in the risk levels with and without program payments for the three farm size categories during the study period. A formal test would therefore be conducted in Chapter 6 to confirm the risk-reducing effects of CAIS/ AgriStability payments on the hog sector in Ontario.
6  CHAPTER 6: RESEARCH METHODS AND EMPIRICAL RESULTS

6.1  Chapter introduction

The first section of this chapter discusses empirical approaches employed to investigate the effectiveness of CAIS/BRM programs and the risk-balancing behavior in Ontario hog sector for the 2003-2014 period. Two approaches were applied to investigate the risk-balancing hypothesis: the correlation coefficient analysis and the regression analysis. Under the latter approach, model specification and estimation method are further presented. The second sections analyses empirical results based on the discussed approaches.

6.2  Empirical approaches

6.2.1  Effectiveness of CAIS/AgriStability payments

One-tailed paired t-test\(^{28}\) was employed to test for the effectiveness of CAIS/BRM in reducing BR for farms under different size categories. The null hypothesis is no difference in mean BR without and mean BR with program payments. Alternative hypothesis is the difference (mean BR\(_{\text{wo}}\) – mean BR\(_{\text{with}}\)) is significantly greater than zero. While \(p\)-value tells us the significance of the effect, the magnitude of the sample estimate reveal the strength of the effect.

6.2.2  Extent of risk-balancing

6.2.2.1  Correlation coefficient analysis

The first approach employed to investigate the extent of risk-balancing is to analyze the correlation coefficient between the 1-year lagged BR and current year FR.

\(^{28}\) \(Ho: \mu_d = 0\); \(t = \frac{(\sum D_i)/N}{\sqrt{\sum [D_i - (\sum D_i)/N]^2 / (N-1)(N)}}\)
In particular, a negative correlation coefficient suggests that the current year FR level moves in an opposite direction with the previous year’s level of BR, thus providing evidence of risk-balancing. Remarkably, this correlation coefficient approach fails to account for factors other than BR that could potentially influence the FR decision. This limitation could be overcome by the regression approach to be presented in the next section.

6.2.2.2 Regression analysis

Our main approach to investigate risk-balancing in this study is to regress current period FR measure against the historical BR level and other relevant factors.

6.2.2.2.1 Model specification

Given the temporal aspect of the risk-balancing hypothesis, most of explanatory variables in our regression model are employed in lagged form. The econometric model is specified in equation 30:

**Equation 30**

\[
FR_{i,t} = \alpha + \beta_1 BR_{i,t-1} + \beta_2 Herfindahl_{i,t} + \beta_3 CostofDebt_{i,t-1} + \beta_4 Farmland\_change_{t-1} + \epsilon_{i,t}
\]

Where

- \(FR_{i,t}\) is current period FR measure; \(BR_{i,t-1}\) is the 1-year lagged BR measure; \(Herfindahl_{i,t}\) is farm diversification measured by Herfindahl index; \(CostofDebt_{i,t-1}\) is the 1-year lagged ratio of interest expenses over outstanding debt; \(Farmland\_change_{t-1}\) is the 1-year lagged of annual percentage change in Ontario farmland value of the \(year_{t-1}\).

On a further note, as great heterogeneity of key variables across farm size categories was showed in our panel descriptive statistics in the previous chapter, we run separate regressions to investigate the risk-balancing behavior for each farm size class, i.e., the Small, Medium and Large size group.
6.2.2.2 Estimation method

First, pooled OLS was used as a natural starting point to examine the models. If individual effect (cross-sectional or time specific effect) does not exist, OLS produces efficient and consistent parameter estimates.

Subsequently, panel data models of either Fixed Effect Model (FEM) or Random Effect Model (REM) was employed. Fixed-effects are tested by F-test, and random effects are examined by the Lagrange Multiplier (LM) test (Breusch and Pagan, 1980).

Based on Greene (2000), the FEM is generally expressed as:

**Equation 31**

\[ y_{it} = \beta_1 + \beta_2 x_{it} + \beta_3 z_{it} + \ldots + u_{it} \]

The FEM allows each cross-section unit to have its own intercept value, which is denoted by \( \beta_i \). While it is allowed to vary across entities, \( \beta_i \) is time-invariant.

In the random-effects model, the intercept \( \beta_i \) is assumed to be a random variable with mean value of \( \beta_i \) and could be expressed as

\[ \beta_{it} = \beta_i + \varepsilon_i \]

Being a random error term with mean equal to zero and variance \( \sigma^2 \), \( \varepsilon_i \) captures the individual differences in the intercept value of each entity. Therefore, \( \varepsilon_i \) is also referred to as the cross-section or individual specific error component. Under these circumstances, the model could be re-written as:

**Equation 32**

\[ y_{it} = \beta_1 + \beta_2 x_{it} + \beta_3 z_{it} + \ldots + \omega_{it} \]

Where \( \omega_{it} = \varepsilon_{it} + u_{it} \)
It is worth noticing that the REM is based on the assumption of no correlation between the error term and explanatory variables in the model. Which model FEM or REM is more appropriate depends on our assumption about the likely correlation between the cross-section specific error component and the explanatory variables based on our understanding of the data set in use. If they are uncorrelated, REM is more efficient as it reduces the number of parameters to be estimated. Otherwise REM will produce inconsistent estimates.

Taking into account the assumption under REM, this estimation method appears to be more suitable for experimental environment, where variables have random values. Also, FEM seems to be more appropriate to be employed to estimate the variables in our dataset, as all the explanatory variables are time-variant. This reasoning is to be validated by Hausman test, which is used to decide if FEM or REM is more appropriate. The test statistics has an asymptotic chi-square distribution. If the computed chi-square value exceeds the critical chi-square value, the null hypothesis that the two estimates should not differ systematically is rejected and FEM is preferred to REM.

Based on the results of our hypothesis testing of serial correlation, cross-sectional dependence and heteroscedasticity, we computed the heteroscedasticity and/or autocorrelation consistent covariance estimator in order to obtain the appropriate standard errors and test statistics of the corresponding model estimation.

After estimating the model with the selected estimation method and robust standard errors, I conducted model validation by performing F-test (robust) for model overall significance and checking for multicollinearity using VIF and correlation matrix with details to follow.

6.2.2.2.3 Model validation

We validate the econometric model by testing the model overall significance and check for its multicollinearity.
To test the overall significance of a multiple regression, the F-test is used to test the hypothesis:

\[ H_0 : \beta_2 = \beta_3 = \ldots = \beta_k = 0 \]

Given the k-variable regression model

With F-statistics:

\[ F = \frac{\text{ESS} / df}{\text{RSS} / df} = \frac{\text{ESS} / (k - 1)}{\text{RSS} / (n - k)} \]

If the p-value of F computed from the above equation is sufficiently low, \( H_0 \) can be rejected.

As a final step of model validation, we check for multicollinearity to see if there exists a perfect or exact relationship among the explanatory variables by computing correlation matrix and Variance Inflation Factor (VIF).

*Examination of correlation matrix:* large correlation coefficients in the correlation matrix of explanatory variables indicate multicollinearity. If there is perfect multicollinearity between any two explanatory variables, the correlation coefficient between these two variables will approach unity.

*Examination of VIF:* the VIF quantifies the extent of multicollinearity in an OLS regression analysis, which is calculated as:

\[ VIF_j = \frac{1}{1 - R_j^2} \]

Where \( R_j^2 \) denotes the coefficient of determination when \( x_j \) is regressed on all other explanatory variables in the model.

VIF ranges from \( 1 \rightarrow \infty \). \( VIF = 1 \) when \( R_j^2 = 0 \), i.e., the \( j^{th} \) variable is not linearly related to the other explanatory variables in the model. \( VIF = \infty \) when \( R_j^2 = 1 \), i.e., the \( j^{th} \) variable is linearly related to the other explanatory variables in the model.

As multicollinearity is not sensitive to estimation methods, we conduct this check for the respective pooled OLS models.
6.3 Empirical results and discussion

6.3.1 The risk-reducing effects of CAIS/AgriStability

The t-test results are presented in Table 9. As can be concluded from the table, there were no risk-reducing effects of CAIS/AgriStability payments for small farms. For medium farms, BR was reduced by 0.008 units with program payments with CV measure and by 0.009 units with skewness measure. And these effects are significant at the 1 percent and 10 percent level, respectively.

The risk-reducing effect was strongest for the Large farm size category. On an average, BR of large farms was reduced by 0.01 units with program payments, and this effect was also statistically significant at the 1 percent level.

Overall, AgriStability payments under CAIS/BRM were effective in reducing BR for the Ontario hog sector during the study period. On average, BR of farms was reduced by 0.009 units with program payments.

For the sake of completeness, t-test results for total risk with CV measurement are reported in Appendix 3. As the possibility of total risk increasing with program payments could not be ruled out, a two-tailed t-test was used to test for the changes in the total risk level. The test results suggest that while total risk level was not different with CAIS/AgriStability payments for small farms, the program payments reduced the total risk level for medium and large farms.
Table 9. Risk-reducing effects of CAIS/BRM - Business Risk

<table>
<thead>
<tr>
<th>Farm size</th>
<th>Ho: mean(BR wo) - mean(BR w) = 0</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ha: mean(BR wo) - mean(BR w) &gt;0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sample estimates</td>
<td>P-value</td>
</tr>
<tr>
<td>Small</td>
<td>0.007</td>
<td>0.31</td>
</tr>
<tr>
<td>Medium</td>
<td>0.008***</td>
<td>5.36E-10</td>
</tr>
<tr>
<td>Large</td>
<td>0.010***</td>
<td>2.20E-16</td>
</tr>
<tr>
<td>Whole sample</td>
<td>0.009***</td>
<td>2.20E-16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BR = CV of NOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
</tr>
<tr>
<td>Medium</td>
</tr>
<tr>
<td>Large</td>
</tr>
<tr>
<td>Whole sample</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BR = Skewness of NOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
</tr>
</tbody>
</table>

*, **, *** denote statistical significance at the 10 percent level (p<0.1), the 5 percent level (p<0.05) and the 1 percent level (p<0.01), respectively.

6.3.2 The extent of risk-balancing

As the second purpose of this study is to investigate the risk-balancing behavior in Ontario hog sector in the context of CAIS/BRM programs, we calculated FR and BR measures with AgriStability payments incorporated for both Pearson correlation coefficient and regression analysis. For the three farm size categories, FR was measured in two ways: i) Interest expenses/NOI, and ii) CV of Interest expenses/NOI while BR was measured by CV of NOI. Due to the distribution property of NOI for the Medium size category, BR was further measured by the 3-year rolling skewness of NOI for this farm size group.

6.3.2.1 FR-BR Pearson correlation coefficient analysis

Our investigation of risk-balancing in Ontario hog sector was firstly based on Pearson correlation coefficients analysis. Farms were grouped by farm identifier number to compute Pearson correlation coefficients at farm level between the 1-year lagged BR
and the current year FR for each size category. Following De Mey et al (2014), the proportion of farms that had negative correlation coefficient, i.e., the risk-balancers, were calculated. Furthermore, the extent of risk-balancing behavior for each size group could be measured by averaging the negative correlation coefficients across the risk-balancers in the size group.

Table 10 presents the results of Pearson correlation coefficient in terms of the proportion of risk-balancers, the extent of risk-balancing and the overall significance of this FR-BR relationship for the three farm size categories.

As can be revealed from the table, with BR measured as CV of NOI, large farms had the highest proportion of risk-balancers and small farms had the smallest proportion. Notably, all the risk-balancer groups of each farm size class had the average risk-balancing coefficients being statistically significant at the 1 percent level. However, for the whole size group, there was no evidence of risk-balancing for the small and medium size. Evidence of risk-balancing was found for the large farms only. The strength of this relationship is -0.069 and statistically significant at the 5 percent level.

\[ Ho: \rho = 0; \ t = r \sqrt{\frac{n-2}{1-r^2}} : \] t-value for the correlation coefficient, whereby n is the number of observations and r is the correlation coefficient computed.
Table 10. The extent of risk-balancing across farm size category – Pearson correlation coefficient

<table>
<thead>
<tr>
<th>Measure of BR</th>
<th>Farm size</th>
<th>(1) Proportion of risk-balancers (%)</th>
<th>(2) Average correlation coefficient of risk balancers (r)</th>
<th>(3) Average correlation coefficient of non-risk balancers</th>
<th>(4) Correlation coefficient (whole size group)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FR = Interest expense/ NOI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>21.35</td>
<td>-0.644***</td>
<td>0.733***</td>
<td>0.099</td>
<td>t-value = -3.471</td>
</tr>
<tr>
<td>Medium</td>
<td>30.36</td>
<td>-0.671***</td>
<td>0.682***</td>
<td>-0.013</td>
<td>t-value = -8.245</td>
</tr>
<tr>
<td>Large</td>
<td>44.582</td>
<td>-0.51***</td>
<td>0.494***</td>
<td>-0.023</td>
<td>t-value = -11.500</td>
</tr>
<tr>
<td><strong>CV of NOI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>24.72</td>
<td>-0.692***</td>
<td>0.66***</td>
<td>0.077</td>
<td>t-value = -4.287</td>
</tr>
<tr>
<td>Medium</td>
<td>31.43</td>
<td>-0.714***</td>
<td>0.698***</td>
<td>-0.051</td>
<td>t-value = -9.457</td>
</tr>
<tr>
<td>Large</td>
<td>31.53</td>
<td>-0.494***</td>
<td>0.512***</td>
<td>-0.069**</td>
<td>t-value = -11.631</td>
</tr>
<tr>
<td><strong>Skewness of NOI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>27.86</td>
<td>-0.718***</td>
<td>0.677***</td>
<td>0.022</td>
<td>t-value = -8.993</td>
</tr>
</tbody>
</table>

* *, **, *** denote statistical significance at the 10 percent level (p<0.1), the 5 percent level (p<0.05) and the 1 percent level (p<0.01), respectively.
As our correlation coefficient analysis cannot capture factors other than BR that potentially influence the FR decision, we proceed to the regression analysis approach to explore risk-balancing in the Ontario hog sector for the study period.

6.3.2.2 Regression analysis

Before estimating the model, we conducted preliminary inspection of serial correlation based on the residuals of OLS regression. In particular, we computed the autocorrelation of residuals from OLS regression up to lag 2\(^30\) with the results presented in table below.

Table 11. First and second – order autocorrelation of residuals – OLS linear regressions

<table>
<thead>
<tr>
<th>Farm size</th>
<th>BR</th>
<th>FR = Interest/ NOI</th>
<th>FR = CV of Interest/ NOI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lag =1</td>
<td>Lag =2</td>
</tr>
<tr>
<td>Small</td>
<td>CV of NOI</td>
<td>0.698</td>
<td>0.816</td>
</tr>
<tr>
<td>Medium</td>
<td>CV of NOI</td>
<td>0.832</td>
<td>0.787</td>
</tr>
<tr>
<td>Large</td>
<td>CV of NOI</td>
<td>0.788</td>
<td>0.718</td>
</tr>
<tr>
<td>Medium</td>
<td>Skewness of NOI</td>
<td>0.832</td>
<td>0.775</td>
</tr>
</tbody>
</table>

*Note: OLS regressions were run with default standard errors*

Residuals are more serially correlated when FR was measured as Interest expenses/ NOI for the three farm size categories. However, there was a lower degree of serial correlation among the residuals when FR was measured as CV of Interest expenses/ NOI, especially for the small and large farms. Besides, all the three size groups had positive autocorrelation when FR was measured by Interest expense/NOI. With FR measured by CV of Interest expense/ NOI, large and small farms exhibited

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\(^{30}\) Farms had to be present in at least 2 consecutive years over the study period in order to be included in the sample.
negative autocorrelation, which suggests a somewhat alternating pattern of FR overtime, at lag =1 and lag = 2 respectively.

Our econometric analysis was carried out using the statistical package R studio for Windows. All variables were transformed into logarithm form for log-log regression. Table 12 summarizes attempted regressions in this study.

Table 12. Attempted regressions

<table>
<thead>
<tr>
<th>BR= log (CV of NOI)</th>
<th>FR = log (Interest/NOI)</th>
<th>FR = log (CV of Interest/NOI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Medium</td>
</tr>
<tr>
<td>(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To start with, we ran fixed-effects\textsuperscript{32} log-log regressions with default standard errors and conducted hypothesis testing of cross-sectional dependence, autocorrelation and heteroscedasticity for the eight models. In particular, we employed Pesaran CD test for cross-sectional dependence, Wooldridge’s test for serial correlation and modified Wald test for group-wise heteroscedasticity in fixed effect models (Green 2000, p.598) with results summarized in Table 13. Except for model (6), where the null hypothesis of no cross-sectional dependence was rejected at the 5 percent level, the remaining models had no cross-sectional dependence. Concerning serial correlation, models from (2) to (8) had serial correlation, when the null was all rejected at the 1 percent level of significance. In addition, the results of heteroscedasticity testing showed a rejection of the null of

\textsuperscript{31} As taking logarithm would drop observations with negative skewness, we run linear regression with BR measured as 3-year rolling skewness of NOI.

\textsuperscript{32} Fixed-effect estimation was confirmed to be the better choice over pooled OLS and random-effect estimation based on the result of F-test for individual effects and robust Hausman test. The results of these two tests are presented in Appendix 4 and Appendix 5, respectively.
homoscedasticity of residuals for all the estimated models. Consequently, heteroskedasticity and autocorrelation-consistent covariance matrix computed by Arellano (1987)\(^{33}\) was finally employed to re-estimate all these models.

Table 13. Testing of cross-sectional dependence, autocorrelation and heteroscedasticity

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Cross-sectional dependence</th>
<th>Autocorrelation</th>
<th>Heteroscedasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ho: No cross-sectional dependence</td>
<td>Ho: No autocorrelation of residuals</td>
<td>Ho: (\sigma^2(i) = \sigma) (homoscedasticity of residuals)</td>
</tr>
<tr>
<td></td>
<td>z-stat</td>
<td>P-value</td>
<td>F-stat</td>
</tr>
<tr>
<td>1</td>
<td>-0.33</td>
<td>0.741</td>
<td>2.610 (1;25)</td>
</tr>
<tr>
<td>2</td>
<td>0.877</td>
<td>0.38</td>
<td>1.406(1;267)</td>
</tr>
<tr>
<td>3</td>
<td>0.962</td>
<td>0.336</td>
<td>275.41***(1;35)</td>
</tr>
<tr>
<td>4</td>
<td>1.487</td>
<td>0.137</td>
<td>12.584***(1;1107)</td>
</tr>
<tr>
<td>5</td>
<td>-1.299</td>
<td>0.194</td>
<td>17.752***(1;25)</td>
</tr>
<tr>
<td>6</td>
<td>-1.695**</td>
<td>0.09</td>
<td>14.798***(1;267)</td>
</tr>
<tr>
<td>7</td>
<td>-0.262</td>
<td>0.793</td>
<td>123.4***(1;35)</td>
</tr>
<tr>
<td>8</td>
<td>0.082</td>
<td>0.422</td>
<td>8.342***(1;1107)</td>
</tr>
</tbody>
</table>

Notes: *, **, *** denotes statistical significance at the 10 percent level (p<0.1), the 5 percent level (p<0.05) and the 1 percent level (p<0.01), respectively.

Finally, we checked for multicollinearity among the four explanatory variables based on Variance Inflation Factor and Correlation Matrix, the results of which are summarized in Appendix 6 and Appendix 7.

The correlation coefficient between Cost of debt and Changes in farm land value approached unity. Considering that Cost of Debt is farm-specific data, the variable of

\(^{33}\) This covariance estimator allows a fully general structure with reference to heteroscedasticity and autocorrelation (Stock and Watson, 2008).
changes in farmland value was removed from the regression. Consequently, our model estimation consists of 3 explanatory variables.

Estimation results for the entire sample\textsuperscript{34} are presented in Table 14. There is evidence of risk-balancing behavior for the entire sample of Ontario hog sector during the study period with FR measured as CV of Interest expenses to NOI ratio. On average, a one percent reduction in previous year’s BR level was associated with an increase of 0.06 percent in the current year FR, all other factors remaining unchanged (Table 14).

We proceeded to estimate the model separately for each farm size category. Estimation results with BR measured as CV of NOI are presented in Table 15 for interpretation.

\textsuperscript{34} BR measured as skewness of NOI was computed for medium farms only. Therefore, BR measured as CV of NOI was used for whole sample regression
Table 14. Estimation results: fixed-effects log-log regression for whole sample

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>FR = log(Interest expenses/ NOI)</th>
<th>FR = log (CV of Interest expenses/ NOI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>k=3</td>
<td>k=3</td>
</tr>
<tr>
<td>BR_cv</td>
<td>0.007 (0.009)</td>
<td>-0.061*** (0.015)</td>
</tr>
<tr>
<td>Herfindahl</td>
<td>-0.721*** (0.133)</td>
<td>-0.168 (0.151)</td>
</tr>
<tr>
<td>Cost of debt</td>
<td>0.672** (0.056)</td>
<td>-0.103 (0.075)</td>
</tr>
<tr>
<td>Medium</td>
<td>0.393*** (0.088)</td>
<td>0.092 (0.121)</td>
</tr>
<tr>
<td>Small</td>
<td>0.700** (0.219)</td>
<td>0.813** (0.336)</td>
</tr>
<tr>
<td>Observations</td>
<td>5,823</td>
<td>5,823</td>
</tr>
<tr>
<td>Within R²</td>
<td>0.086</td>
<td>0.006</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.085</td>
<td>0.005</td>
</tr>
<tr>
<td>F-statistic (robust)</td>
<td>48.314*** (5; 1283)</td>
<td>5.040*** (5; 1283)</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses. *, **, *** denotes statistical significance at the 10 percent level (p<0.1), the 5 percent level (p<0.05), and the 1 percent level (p<0.01), respectively.
There was evidence of risk-balancing for medium (model 6) and large farms (model 8) in the Ontario hog sector during the study period, with BR measured as CV of NOI and FR as CV of Interest expenses/NOI. Specifically, BR has coefficient estimate valued -0.087 for medium farms and -0.06 for large farms, statistically significant at the 5 percent and 1 percent level, respectively. This indicates that medium and large farms in Ontario hog sector made strategic FR adjustments in line with the risk-balancing hypothesis during the study period. On average, 1 percent reduction in the previous year's BR level was associated with 0.087 percent increase in current year FR for medium farms and 0.06 percent increase in FR level for large farms, ceteris paribus.

Herfindahl index had the expected negative sign for its coefficient for medium farms, with both FR measurements and for large farms with FR-CV measure. In particular, for medium farms, a 1 percent reduction in Herfindahl index, i.e., farms becoming more diversified, would be associated with 0.926 percent increase in the FR level taken and this effect is significant at the 5 percent level. For large farms, the magnitude of FR-HI relationship is approximately 0.75 percent. This indicates that for medium and large farms in Ontario hog sector, the more diversified farms are, the more FR farms would take and vice versa. In this light, farm diversification might have been used as an alternative risk management strategy for large farms. Another possibility was that diversification of farm operations might have helped farms of this size class to have a better credit ratings with large borrowing, and thus, incurred higher financial risk.

Cost of Debt exhibits the expected negative sign for large farms, when FR was measured as CV of the Interest expenses to NOI ratio. This suggests that for large farms, a higher cost of debts in the previous year would be associated with a lower variation degree of the Interest expense/NOI ratio and vice versa. On average, a 1 percent increase in last year's cost of debt would be associated with a 0.156 percent reduction in the variation of the Interest expenses/NOI ratio, ceteris paribus. And this effect is statistically significant at the 10 percent level. However, the situation was reverse when FR was measured by the magnitude of the Interest expense to NOI ratio. For both medium
and large farms, a 1 percent increase in historical cost of debt would be associated with an increase of 0.418 percent and 0.738 percent in the magnitude of Interest expense/NOI in the current year for medium and large farms, respectively. One possible explanation is that farms faced tough financial situations and had great demand for borrowing to finance their business operations, taking into account the period of adversity for the hog sector between 2006 and 2011. As a possible result, historical costs of debt may not be negatively related to the current period’s FR decisions.

For Small size category, there was no evidence of risk-balancing behavior, with both FR measures. This is understandable as small farms do not have the same accessibility to credit compared with medium and large farms. However, we can hardly make a conclusive statement for this farm size category as the number of observations retained in the regression is quite low relative to the number of small farms in the sample.

The coefficient of determination $R^2$ is quite low for the estimated models. Nevertheless, this would not be considered as a serious issue since the purpose of this study is not to predict, but to explore the extent of the FR-BR relationship.

Estimation results of linear regressions are summarized in Appendix 8. It is worth noting that linear regressions were run with both BR measures, as CV of NOI and as skewness of NOI for medium farms. Overall, no evidence of risk-balancing was found for the three farm size categories in the case of linear regression (Appendix 8).
Table 15. Estimation results: log-log regression by farm size categories

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>FR = log(Interest expenses/ NOI)</th>
<th>FR = log (CV of Interest expense/ NOI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small (1)</td>
<td>Medium (2)</td>
</tr>
<tr>
<td>BR_cv</td>
<td>-0.017</td>
<td>-0.006</td>
</tr>
<tr>
<td></td>
<td>(0.072)</td>
<td>(0.020)</td>
</tr>
<tr>
<td>Herfindahl</td>
<td>0.938</td>
<td>-0.926**</td>
</tr>
<tr>
<td></td>
<td>(0.803)</td>
<td>(0.305)</td>
</tr>
<tr>
<td>Cost of debt</td>
<td>0.609</td>
<td>0.418***</td>
</tr>
<tr>
<td></td>
<td>(0.529)</td>
<td>(0.121)</td>
</tr>
<tr>
<td>Observations</td>
<td>188</td>
<td>1,334</td>
</tr>
<tr>
<td>Within R²</td>
<td>0.057</td>
<td>0.046</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.042</td>
<td>0.044</td>
</tr>
<tr>
<td>F-statistic (robust)</td>
<td>1.032*** (3; 88)</td>
<td>9.750***(3; 462)</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses. *, **, *** denotes statistical significance at the 10 percent level (p<0.1), 5 percent level (p<0.05) and 1 percent level (p<0.01), respectively.
6.4 Chapter summary

This chapter presents empirical approaches and corresponding results in examining the effectiveness of CAIS/BRM programs and the extent of risk-balancing behavior in Ontario hog sector during the 2003-2014 period.

Our key findings were that with BR measured as CV of NOI, the programs were effective in reducing BR for large and medium farms, but not for small farms. Especially for medium farms, the program payments reduced the variations of NOI around its mean as well as affected its two tails of distribution, i.e., the infrequent but extreme losses or gains of NOI.

Concerning the extent of risk-balancing, evidence of risk-balancing was found for large and medium farms in Ontario hog sector but not for small farms.
CHAPTER 7: CONCLUSION

7.1 Research summary

Agri-food sectors in Canada are supported through safety net programs. Over time the safety-net programs in Canada have evolved from a commodity-based to whole-farm based program. The focus also changed from price stabilization to income stabilization. CAIS/BRM programs were designed to help producers reduce BR by mitigating negative income shocks and reducing income variability. However, according to the risk-balancing hypothesis, farms may take more FR in response to a reduction in BR as a result of program payments. If we find evidence of such behavior, risk-reduction efforts of CAIS/BRM programs may not generate intended outcomes and therefore, may jeopardize the economic stability and viability of the Canadian agri-food sectors.

The literature on risk-balancing indicates that there are different ways to measure BR in agricultural sectors. Yet there is no definitive way of measuring BR that could capture the magnitude of the infrequent but extreme losses while accounting for the skewness property of its distribution. On the other hand, while a number of papers use pairwise correlation coefficient to measure the extent of risk-balancing in agricultural sectors in Canada, some other studies employed regression analysis to account for other factors that may have an impact on the FR decisions. Nevertheless, whether this behavior differs among farms of different size categories has not been fully investigated.

Concerning the analytical framework, our comparative statistic analysis further confirms the risk-balancing model introduced by Gabriel and Barker (1980) and Collins (1985). The latter maintains that for the risk-balancing hypothesis to hold, proprietor is assumed to be an expected utility maximizer with a risk-averse attitude. Besides, potential factors other than BR that may induce a change in FR decision should also be included in the risk-balancing model. Furthermore, in order to have a more accurate measure of BR, Crop Insurance should be included in the model in the calculation of BR since both risk-premium and Crop Insurance indemnities affect the distribution of the farm profit. Our analytical framework demonstrates this.
Regarding our empirical analysis, using OFID tax-filing data over the 2003-2014 period, we investigated the risk-reducing effects of AgriStability payments under CAIS/BRM programs on the Ontario hog sector and estimated the extent of risk-balancing in the sector afterwards. Concerning the effectiveness of CAIS/BRM programs, paired t-test was employed to test for the statistical significance of the mean difference of BR without and with program payments. The result was that CAIS/AgriStability payments were effective in reducing BR for medium and large farms. However, there was no risk-reducing effect for the small hog farms.

Given the effectiveness of CAIS/AgriStability payments, we subsequently estimated the extent of risk-balancing in the sector. Specifically, we first followed the correlation coefficient approach proposed by Escalante and Barry (2003) and subsequently estimated the strength of risk-balancing by using the regression analysis approach employed by De Mey et al (2014).

For our key findings, our correlation coefficient analysis points out that out of the three size categories, large farms had the highest proportion of risk-balancers and small size farms had the smallest. In addition, the evidence of risk-balancing was found for the large farms, with BR measured as CV of NOI and FR measured as CV of Interest expenses/NOI. The strength of this inverse relationship is -0.069, significant at the 5 percent level of significance.

Controlling for other determinants of FR, our log-log fixed-effects regression provides evidence in favor of risk-balancing for Ontario hog farms as a whole, with FR measured as CV of Interest expenses/NOI. Taking into account the heterogeneity of the sample as revealed by our descriptive statistics, we run the log-log regression separately for each farm size category.

Our findings confirmed evidence of risk-balancing for medium and large farms with BR measured as CV of NOI and FR as CV of Interest expenses to NOI ratio. On average, 1 percent decrease in the previous year’s BR level was associated with 0.087 percent
increase in current year FR for medium farms and 0.067 percent increase in FR level for large farms, all other factors remaining unchanged. Consistent with our correlation coefficient analysis, our regression results found no evidence of risk-balancing for the small farm size categories. But again, statement on the evidence of risk-balancing for this farm size is not as conclusive as those for medium and large farms.

In general, our empirical results substantiate previous studies by providing empirical evidence of: i) the risk-reduction effects of AgriStability payments under CAIS/BRM programs; ii) risk-balancing in Ontario hog sector for the large and medium farm size categories during the study period. In view of the fact that findings from the study can set light on the FR-BR relationship in the Ontario hog sector, especially with farm-size group specific results, our research objective was realized and our research questions were answered.

7.2 Policy implications

While CAIS/BRM programs were designed to address BR for farms of all size categories, our empirical results indicate that AgriStability payments under the programs reduced BR for medium and large farms, but not for small farms. On the other hand, our descriptive statistics as well as our visual inspection of risk measures across farm size groups reveal that small farms faced a greater degree of BR compared with the medium and large farm sizes during the study period. If income stabilization is an important goal of these programs, this goal has been achieved for the medium and large farm size categories. As these two farm size classes account for approximately 95 percent of the number of hog farms in Ontario, this goal realization is meaningful for the long-run viability of the Ontario hog sector.

Furthermore, our empirical findings provide evidence of risk-balancing for medium and large farms during the study period 2003-2014. This means that as CAIS/BRM programs reduced BR for medium and large farms, these farms incurred more FR as a result of risk-balancing. Nevertheless, as long as the reduction in BR level was not more than offset by an increase in FR level, the viability of the programs would not be
questioned. This was proved to be the case for Ontario hog sector, as our formal test for the effectiveness of CAIS/BRM programs revealed that the total risk that medium and large farms faced were also reduced during the study period. In this light, the presence of risk-balancing behavior found for the medium and large farms in the Ontario hog sector do not seem to pose any threat to the long-run viability of CAIS/BRM programs and the sustainability of the hog sector in Ontario.

7.3 Contributions of the study

Our study provides the first empirical evidence of risk-balancing in Ontario hog sector for the 2003-2014 period. Apart from bridging this gap, the research also contributes to the risk-balancing literature by making an attempt to measure BR as rolling skewness of NOI. This skewness measurement relaxes the underlying assumption of the Coefficient of Variation measurement that the variable used for computing BR measure is normally distributed. Furthermore, believing that variability implies uncertainty and risk in itself, an attempt was made to employ CV of the Interest expenses – NOI ratio as an alternative way of measuring FR. Last but not least, for theoretical side, Crop Insurance was firstly incorporated into the analytical framework by Collins’ (1985) to model risk-balancing so as to provide a more accurate measurement of BR.

One of the limitations of the study lies in its failure to incorporate Crop Insurance payments into empirical analysis due to data constraint. As corroborated in our theoretical framework, BR might be overestimated and thus, leading to under-estimation of FR in the presence of risk-balancing. However, it would not be a serious issue as our empirical analysis was on the hog sector, for which Crop Insurance is not as important as it is for the field crop sector.

7.4 Suggestions for further research

Given the evidence of risk-balancing in Ontario hog sector, future research could look at the interactions between risk balancing and other risk-management strategies, e.g., farm diversification or strategies to manage off-farm income. As contended by
Wauters (2012), one potential significant risk management strategy could be household buffering such as off-farm income.

Another interesting avenue for further research could be to incorporate Crop Insurance into empirical analysis for a more accurate BR measure, especially for field crops farms where Crop Insurance is important. Taking into account Crop Insurance purchase, future research could extend the present analysis by exploring the relationship between Crop Insurance and BRM programs and answering some relevant pending questions, i.e., Is Crop Insurance an alternative strategy to BRM payments? And as such, do BRM programs reduce farmers’ incentives to purchase Crop Insurance?

On methodological grounds, future risk-balancing research under BRM programs could hopefully make good use of a better dataset to further look at alternative definitions of BR so as to replicate the Program Margin formulated under AgriStability payment scheme. In this way of definition, BR would better reflect the risk-reducing effects of the programs. Also, incorporating risk-attitude in line with the utility-centric risk balancing models by Collins (1985) and Featherstone et al (1988) could be another option for further consideration. Finally, future work could extend present analysis to further measure BR so as to both capture the skewness property of the margin variable and the magnitude of its left tail. In this light, the magnitude of the downside risk can be assessed in relation to the upside risk.
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Statistics Canada. No Date. Table: 32-10-0106-01: Direct payments to agricultural producers (x1,000) https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210010601 (accessed: Jun 16, 2018)


APPENDICES

Appendix 1. First-order condition of the expected utility function

\[ V(\delta) = \left[ \bar{R}_A - K\delta \right] \frac{1}{1-\delta} - \frac{\rho}{2} \sigma_A^2 \left( \frac{1}{1-\delta} \right)^2 \]

Put
\[ \frac{1}{1-\delta} = X \Rightarrow \delta = 1 - \frac{1}{X} \]

\[ V(X) = \left[ \bar{R}_A - K\left(1 - \frac{1}{X}\right) \right] X - \frac{\rho}{2} \sigma_A^2 X^2 \]

\[ = \bar{R}_A X - KX + K - \frac{\rho}{2} \sigma_A^2 X^2 \]

\[ = (\bar{R}_A - K)X + K - \frac{\rho}{2} \sigma_A^2 X^2 \]

\[ \frac{dV(X)}{dX} = (\bar{R}_A - K) - \rho \sigma_A^2 X \]

1st order condition:

\[ \frac{dV(X)}{dX} = 0 \]

\[ \Leftrightarrow (\bar{R}_A - K) - \rho \sigma_A^2 X = 0 \]

\[ \Leftrightarrow X = \frac{\bar{R}_A - K}{\rho \sigma_A^2} \]

\[ \Leftrightarrow \frac{1}{1-\delta} = \frac{\bar{R}_A - K}{\rho \sigma_A^2} \]

\[ \Rightarrow \delta^* = 1 - \frac{\rho \sigma_A^2}{\bar{R}_A - K} \]
Appendix 2. Second-order condition of the expected utility function

We have:

\[
\frac{dV(X)}{dX} = (R_A - K) - \rho \sigma_A^2 X
\]

2\textsuperscript{nd} order condition requires:

\[
\frac{d^2V(X)}{d^2X} = -\rho \sigma_A^2 < 0
\]

As \( \sigma_A^2 > 0 \) \( \Rightarrow \rho > 0 \)

Thus, for the 2\textsuperscript{nd} order condition to hold, the proprietor must be risk-averse.
Appendix 3. T-test results for the risk-reducing effects of CAIS/BRM on total risk

<table>
<thead>
<tr>
<th>Farm size</th>
<th>Ho: mean(ttlrisk_wo) - mean (ttlrisk_w) = 0</th>
<th>Ha: mean (ttlrisk_wo) - mean(ttlrisk_w) != 0</th>
<th>Ha: mean (ttlrisk_wo) - mean(ttlrisk_w) &gt; 0</th>
<th>Ha: mean (ttlrisk_wo) - mean(ttlrisk_w) &lt; 0</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sample estimates</td>
<td>P-value</td>
<td>Decision</td>
<td>Sample estimates</td>
<td>P-value</td>
</tr>
<tr>
<td>Small</td>
<td>-0.160</td>
<td>0.873</td>
<td>Fail to reject</td>
<td>-0.160</td>
<td>0.5635</td>
</tr>
<tr>
<td>Medium</td>
<td>0.01***</td>
<td>0.00E+00</td>
<td>Reject</td>
<td>0.015***</td>
<td>2.20E-16</td>
</tr>
<tr>
<td>Large</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole sample</td>
<td>0.013***</td>
<td>2.20E-16</td>
<td>Reject</td>
<td>0.015***</td>
<td>2.20E-16</td>
</tr>
</tbody>
</table>
Appendix 4. Result of F-test for individual effects

*Pooled OLS regression:*

\[
\text{po.log.8} \leftarrow \text{plm}(\text{logfr_cv_w} \sim \text{laglogbr_cv_w} + \text{logherfindahl} + \text{laglogcostofdebt} + \text{laglogfarmland_change}, \text{data} = \text{large_log}, \text{index} = \text{c("farm_id", "year")}, \text{model} = \text{"pool"})
\]

*Fixed-effects regression:*

\[
\text{fe.log.8} \leftarrow \text{plm}(\text{logfr_cv_w} \sim \text{laglogbr_cv_w} + \text{logherfindahl} + \text{laglogcostofdebt} + \text{laglogfarmland_change}, \text{data} = \text{large_log}, \text{index} = \text{c("farm_id", "year")}, \text{model} = \text{"within"})
\]

*F test for individual effects:*

\[
\text{pFtest(fe.log.8, po.log.8)}
\]

\[
F = 1.269, \ p\text{-val} = 0.000
\]

Alternative hypothesis: significant effects

Conclusion: Reject the null at the 1 percent level of significance.

Decision: Fixed-effects is chosen over pooled OLS
Appendix 5. Results of Hausman test (robust)

form<-logfr_cv_w ~ laglogbr_cv_w + logherfindahl + laglogcostofdebt + laglogfarmland_change

phtest(form, data = large_log, method = "aux", vcov = vcovHC)

Regression-based robust Hausman test:

chisq = 9.5688, p-val= 0.08842

Alternative hypothesis: one model is inconsistent

Conclusion: Reject the null at the 10 percent level of significance.

Decision: Fixed-effects is chosen over random effects
Appendix 6. Variance Inflation Factor of explanatory variables

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Independent variables</th>
<th>BR_cv</th>
<th>Herfindahl</th>
<th>Cost of debt</th>
<th>Farmland_change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1.025</td>
<td>1.006</td>
<td>3.556</td>
<td>3.428</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case 2</th>
<th>Independent variables</th>
<th>BR_skew</th>
<th>Herfindahl</th>
<th>Cost of Debt</th>
<th>Farmland_change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1.042</td>
<td>1.029</td>
<td>6.247</td>
<td>7.195</td>
</tr>
</tbody>
</table>
Appendix 7. Correlation matrix of explanatory variables

BR = CV of NOI

<table>
<thead>
<tr>
<th></th>
<th>Herfindahl</th>
<th>BR_cv</th>
<th>Farmland</th>
<th>Cost of Debt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herfindahl</td>
<td>1</td>
<td>0.049</td>
<td>0.028</td>
<td>-0.054</td>
</tr>
<tr>
<td>BR_cv</td>
<td>0.049</td>
<td>1</td>
<td>0.074</td>
<td>-0.118</td>
</tr>
<tr>
<td>Farmland</td>
<td>0.028</td>
<td>0.074</td>
<td>1</td>
<td>-0.84</td>
</tr>
<tr>
<td>Cost of Debt</td>
<td>-0.054</td>
<td>-0.118</td>
<td>-0.84</td>
<td>1</td>
</tr>
</tbody>
</table>

BR = skewness of NOI

<table>
<thead>
<tr>
<th></th>
<th>Herfindahl</th>
<th>BR_skew</th>
<th>Farmland</th>
<th>Cost of Debt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herfindahl</td>
<td>1</td>
<td>-0.158</td>
<td>0.023</td>
<td>-0.006</td>
</tr>
<tr>
<td>BR_skew</td>
<td>-0.158</td>
<td>1</td>
<td>0.032</td>
<td>0.017</td>
</tr>
<tr>
<td>Farmland</td>
<td>0.023</td>
<td>0.032</td>
<td>1</td>
<td>-0.912</td>
</tr>
<tr>
<td>Cost of Debt</td>
<td>-0.006</td>
<td>0.017</td>
<td>-0.912</td>
<td>1</td>
</tr>
</tbody>
</table>
Appendix 8. Estimation results: linear regressions by farm size categories

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>FR = Interest expenses/ NOI</th>
<th>FR = CV of Interest expenses/ NOI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small (1)</td>
<td>Medium (2)</td>
</tr>
<tr>
<td>BR_cv</td>
<td>-0.191</td>
<td>-0.067</td>
</tr>
<tr>
<td></td>
<td>(0.133)</td>
<td>(0.155)</td>
</tr>
<tr>
<td>BR_skew</td>
<td></td>
<td>-0.0003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.004)</td>
</tr>
<tr>
<td>Herfindahl</td>
<td>0.270**</td>
<td>-0.082***</td>
</tr>
<tr>
<td></td>
<td>(0.122)</td>
<td>(0.020)</td>
</tr>
<tr>
<td>Cost of debt</td>
<td>2.640*</td>
<td>0.519***</td>
</tr>
<tr>
<td></td>
<td>(1.544)</td>
<td>(0.133)</td>
</tr>
<tr>
<td>Observations</td>
<td>210</td>
<td>1,381</td>
</tr>
<tr>
<td>Within R²</td>
<td>0.092</td>
<td>0.049</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.005</td>
<td>0.047</td>
</tr>
<tr>
<td>F-statistic (robust)</td>
<td>1.509(3;99)</td>
<td>3.291***(3,480)</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses, *, **, *** denotes statistical significance at the 10 percent level (p<0.1), the 5 percent level (p<0.05) and the 1 percent level (p<0.01), respectively.