

THE IMPACT OF FARM-LEVEL VARIABLES ON  
FEDERAL CROP INSURANCE COVERAGE LEVEL SELECTION

by

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A thesis submitted in partial  
fulfillment of the requirements for the degree

of

Master of Science

in

Applied Economics

MONTANA STATE UNIVERSITY  
Bozeman, Montana

April 2019

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## ACKNOWLEDGEMENTS

First, I would like to express my gratitude toward my family and friends for their patience and support while I completed this work. I am sincerely ingratiated to each of you.

Second, I would also like to express my appreciation and acknowledge my employer, Watts & Associates, for the expertise, flexibility, and support they provided throughout my time in graduate school and during the thesis process.

I also owe sincere thanks to my thesis advisor, Professor Belasco, for his guidance, from the idea phase to the final paper, in addition to the opportunities he provided. I would furthermore like to thank and acknowledge my thesis committee members, Professor Atwood, Professor Bekkerman, and Professor Charlton for the insight and comments they provided throughout the process.

Finally, I want to acknowledge the rest of the faculty of the Montana State Department of Agriculture Economics and Economics graduate program, without whom I would not have been able to complete my degree.

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## ABSTRACT

This thesis evaluates the significance of farm-level variables related to cash flow on coverage level selections as a potential explanation for the well-documented behavioral anomaly in producers' federal crop insurance coverage level selection choices. The current crop insurance literature appears to lack a clear explanation of why producers choose to insure at lower or less than economically optimal coverage levels. To inform this question, the relationship between liquidity factors and insurance coverage level selection are estimated empirically using linear and fixed effects models with data from the Agricultural Resource Management Survey, Risk Management Agency Summary of Business, and the Risk Management Agency Actuarial Data Master. Specifically, this research endeavors to evaluate the associations between variables related to cash flow and coverage level selection, as well as isolate the effect of premium rates on coverage selection, in order to provide evidence that constrained cash flow may be the reason for the appearance of nonutility maximization in coverage level selection. The results indicate that variables directly related to cash flow such as higher costs are associated with significant differences in coverage level selection, though the direction of the association is dependent on the type of costs, whether fixed or variable, while higher revenue higher acreage farms insure at higher coverage levels. In addition, higher premium costs are associated with lower coverage level selection, despite subsidy incentives indicating expected cash flow plays a significant role in coverage level decisions.

## SECTION ONE

## INTRODUCTION

The federal crop insurance (henceforth, FCI) program has become the mainstay of U.S. agricultural support and is the single largest agricultural insurance program globally (Woodard and Yi, 2018). In 2015, the FCI program serviced 1.2 million policies, collected 3.7 billion in farmer paid premiums (down from 4.5 billion in 2011 due to crop price declines), and in 2017 covered a total of 100.4 billion (see Figure 1.1) in crop liability.<sup>1</sup> While FCI as a percentage of the total USDA budget remains a relatively small portion (less than 16% in 2017) of the total USDA budget, the Risk Management Agency (RMA) still accounts for a significant total budget of \$7.8 billion.<sup>2</sup> With over 311 million acres insured in the U.S. and participation rates in major crop states estimated to be well over 90% based on National Agriculture Statistic Service (NASS) data, crop insurance is an important economic topic in rural America as well as to taxpayers.<sup>3</sup> The greater crop insurance literature has studied insurance premium rate design, FCI demand elasticities, moral hazard, participation decisions, and the effects of crop insurance on other producer decisions (Sherrick et al. 2004; Just et al. 1999; Goodwin et al. 2004; Woodard and Yi, 2018). Existing research however, appears to lack a clear explanation for why producers choose to insure at widely differing coverage levels, which can be at their own expense given a generous range of utility functions. This outcome is counter to any reasonable

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<sup>1</sup> <http://www.rma.usda.gov/aboutrma/budget/programstatistics.html>

<sup>2</sup> <http://www.obpa.usda.gov/budsum/fy17budsum.pdf>

<sup>3</sup> (<http://www.rma.usda.gov/data/sob.html>) The Summary of Business provides regularly updated federal crop insurance data for the entire RMA book of business down to the county and unit level back to 1989.

utility model predictions given the significantly positive expected return on farmer paid premiums ((Farmer Paid Premium = Total Premium - Subsidy), see column in Table 1.1), where farmers have received \$2.05 in indemnity payments for every \$1.00 paid in premium. Note the standard model of deductible demand under actuarially fair premiums (loss ratio of 1.00) for a risk averse individual results in full coverage even before accounting for the subsidy (Schlesinger H., 2000; Woodard and Yi, 1999).

This is the first study to utilize a national farm level data to examine the associations between farm specific factors including input costs, revenues, assets, and liabilities and coverage level choice differences. This study hypothesizes that producers choose to insure under different coverage levels based on expected or perceived cash flow constraints, while controlling for a number of other factors such as net worth, primary crop grown, and farm size. Based on a precursory review of the United States Department of Agriculture (USDA) Risk Management Agency (RMA) Summary of Business (SOB), higher expected revenue per acre areas in the corn belt (Indiana) appear to insure at higher coverage levels, while lower expected revenue areas such as states in the high plains (North Dakota) insure at lower average coverage levels (Figure 1.2). We postulate that previous approaches employing utility theory to predict farmer choices have failed to accurately explain farmer choices in the past, due to failure to recognize the short term liquidity constraints both real and self-imposed, resulting from widely differing cost and revenue expectations in different growing regions. This study attempts to evaluate whether annual expected costs and revenues (i.e. cash flow) might be influencing these differences in coverage level selection choices, while controlling for

premium rates and other farm level traits potentially correlated with various coverage level selections.

Variables such as higher revenue and higher costs are expected to be positively associated with coverage level selections. Producers are assumed to make expected profit maximizing decisions with risk neutral preferences regarding crop coverage selections. If we assume that a risk-averse producer would choose the highest coverage level available when faced with an actuarially fair premium (Mossin J.,1968) and noting that crop insurance is legally required to be actuarially fair (Refer to Section 3), in addition to the FCI subsidies that result in rates even lower than actuarial fair rates to the point of significant positive returns (see Table 1.1), we can reasonably assert a profit maximizing producer using a generous range of functions would insure under the highest coverage level available. However, despite this assertion, farmers regularly choose lower coverage levels (see Figure 1.2). It thus does seem unreasonable to assume that risk aversion may not be a well-founded assumption.

Producers located in areas with higher production and revenue expectations might be expected to insure at higher coverage levels to cover the higher input costs such as fertilizer, associated with higher yields. Producers may also simply prefer to maximize total subsidy or subsidy received per acre in order to maximize their long run return on premium paid (see Tables 4.2 and 4.3). In either case, realized and expected annual cash flow are hypothesized to influence these decisions. Explicitly, I hypothesize that in the presence of a liquidity constraint, farmers will view variable input quantities and insurance premium as substitutes. Meaning that if variable costs such as fertilizer are

higher, controlling for other variables, farmers will decrease their coverage levels to lower their premium expense. Higher revenue was predicted to reduce the liquidity constraint and thus have a positive effect on coverage level. The hypothesized effect of fixed costs was ambiguous, with the only choice variable annually being insurance premium, assuming fixed costs are fixed for a period of years. For further predictions based on theory, see the Theoretical Methodology and Empirical Methodology Sections.

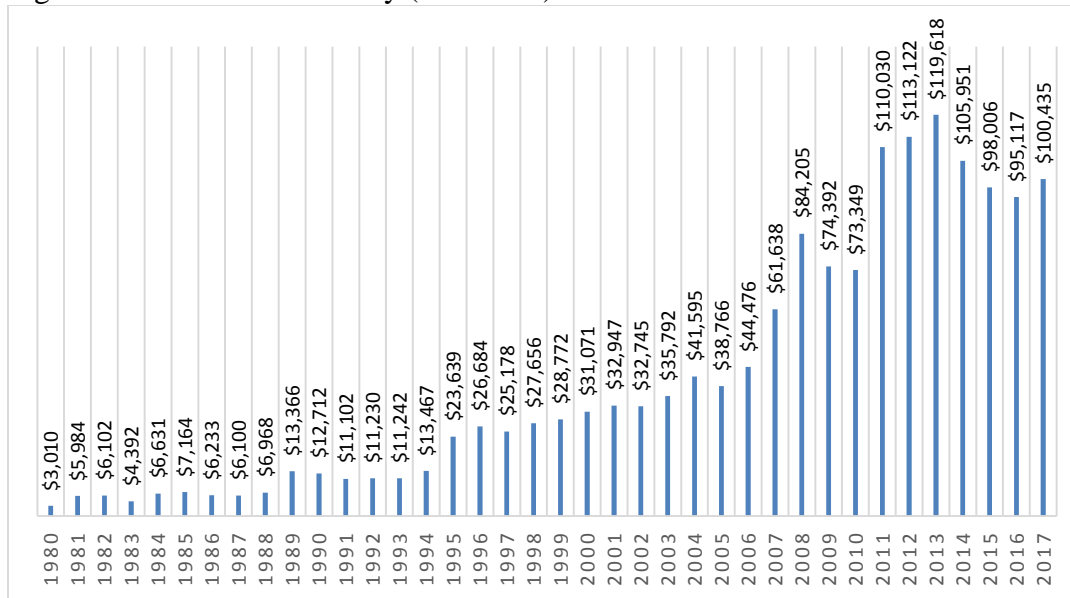
Results show higher variable costs are associated with a decrease in coverage level. This indicates that producers may substitute away from insurance premium, despite the positive long run return, to focus on inputs with a more immediate annual payoff such as fertilizer or chemical. Results for gross revenue per acre and fixed costs per acre show that both variables are associated with higher coverage level selection, even when controlling for premium rates, area, and yield risk. For fixed costs, this indicates that farmers increase their coverage levels to reduce the probability and risk of being unable to meet their financial obligations. For further discussion, see the Conclusion subsection of the Results Section.

Understanding the associations between coverage level selection and farm and producer specific variables has value in regard to agriculture sector policy, as well as determining total FCI program liability levels. In addition, understanding these associations has industry relevance, as it is in the interest of the companies and agents approved to sell FCI to maximize coverage levels and participation rates, thereby maximizing premium and commission collection. Further, the literature suggests FCI decisions have a wide range of effects, including influencing land values, farmer crop

type choices, farm debt levels, environmental health, and input level choices (Goodwin et al. 2004; Young et al. 2001; Atwood et al. 1996; Walters et al. 2012; Mishra et al. 2005).

Thus defining the parameters affecting the total amount of liability farmers choose to insure and specifically the effect of cost and revenue variables, has a variety of implications at the farm and policy level.

Figure 1.1: Total FCI Liability (\$Millions)



Specifically, this thesis sets out to determine if a relationship exists between variable and fixed costs per acre and the coverage levels they choose to insure, while controlling for other farm level financial and production traits. Based on the Risk Management Agency (RMA)<sup>4</sup> summary of business<sup>5</sup> database, geographic differences in

<sup>4</sup> See <http://www.rma.usda.gov/> for an overview of RMA's purpose and directives.

<sup>5</sup> <http://www.rma.usda.gov/data/sob.html>

coverage level selection and preference are shown in Figure 1.2. Farmers in higher average yield states such as Iowa and Indiana, appear to select higher coverage levels, while farmers in lower yielding states such as North Dakota and Kansas, more often select lower coverage levels. Differences in coverage level selections may be due to decision making motivated by expected revenue or input costs or as has been suggested anecdotally by industry participants, influenced by the geographic density of agents and the resulting competition among insurance agents for client business.

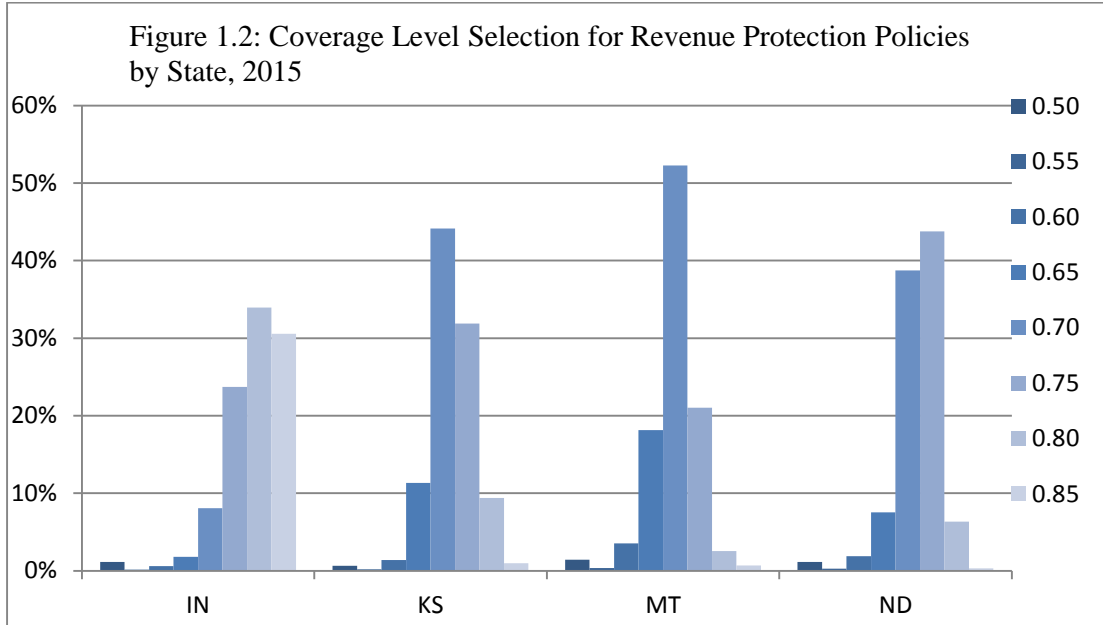
This study utilizes farm level data from the USDA Agricultural Resource Management Survey Data (ARMS) data to isolate the effects of farm level parameters and their association with changes in coverage level selection. Defining which parameters are associated with different coverage selections should provide some insight on how different types of farmers' coverage choices might change in correlation changes in the agriculture economy and agriculture policy changes.

Du, Feng, and Hennesy (2014) employ a mixed logit approach and find that farmers' choices do not appear to coincide with the predictions of standard expected utility maximization framework. Expected utility maximization uses probabilities and utility functions to make a distinction between risk exposure and risk preferences, creating testable models based on known probabilities and assumptions of farmer risk preferences. The standard methodology assumes farmers maximize end of period wealth by choosing input levels, including crop insurance coverage level, subject to a constraint (Sherrick et al. 2004; Smith & Baquet, 1996). A higher return on investment is assumed to increase a farmer's utility depending on the risk level and the farmer's preferences.

Many studies have pointed out the rationale behind selecting the maximum coverage level or subsidy rate in order to maximize subsidy dollar extraction, thereby maximizing utility (Babcock, 2011; Barnett & Coble, 2011). Given an actuarially fair premium<sup>6</sup>, which is mandated by the Federal Crop Insurance Act, a risk neutral profit maximizer subject to no constraints would choose to either maximize their total dollars of subsidy received or the percentage of premium subsidized. A review of the RMA summary of business dataset shows this not to be the case in most areas. Several studies using a variety of methodologies have attempted to explain the anomaly of apparent under-insurance through the selection of low coverage levels (Du, Hennesy, & Feng 2013; Du et al. 2014; Babcock, 2015). This is the first study to utilize a national farm level data to examine the associations between farm specific factors including input costs, revenues, assets, and liabilities and coverage level choice differences. These decisions vary significantly geographically as shown in Figure 1.2 and later in Figures 4.2 and 4.3.

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<sup>6</sup> Rating components include: individual farm risk relative to county, yield, exponent, the coverage level differential, and loads for CAT, RP, PP, and QA; as well as price level, volatility, & correlation for RP. The long run target ratio is 1.00 (actuarially fair) before loading, after which it is around .88.



Source: USDA RMA Summary of Business

It is argued that while crop insurance began as a response to farmer losses during the great depression, it is now regularly seen as a vehicle for income transfer subsidies above and beyond risk management (Goodwin and Smith, 2013). This is largely due to the fact that with a producer loss ratio since 1980 of 2.05 (Table 1.1), which implies that farmers received \$2.05 in indemnity payments for every \$1 paid in premium by farmers. Just, Calvin, and Quiggin (1999) in an attempt to decompose the incentives to participate in federal crop insurance found risk aversion to be a minor incentive, with the farmers who chose not to participate having negative expected returns from insurance.<sup>7</sup> Regardless of whether this is the case, it seems reasonable to assume that producers being profit maximizers are at least partially motivated by subsidies. Why farmers do not

<sup>7</sup> (albeit participation rates have climbed considerably since the publication date of this study)

wholly take advantage of the presence of this income transfer if this is truly the case thus remains a subject of deliberation (Du et al. 2014).

Table 1.1: U.S. FCI Ratios

Year	Loss Ratio	Farmers' Loss Ratio	Earned Premium Rate	Loss Cost Ratio	Effective Subsidy Rate
1980	2.19	2.19	0.05	0.11	NA
1981	1.08	1.23	0.06	0.07	0.12
1982	1.34	1.74	0.06	0.09	0.23
1983	2.04	2.63	0.07	0.13	0.22
1984	1.47	1.90	0.07	0.10	0.23
1985	1.55	2.01	0.06	0.10	0.23
1986	1.62	2.11	0.06	0.10	0.23
1987	1.01	1.33	0.06	0.06	0.24
1988	2.45	3.25	0.06	0.15	0.25
1989	1.48	1.97	0.06	0.09	0.25
1990	1.18	1.58	0.07	0.08	0.26
1991	1.32	1.77	0.07	0.09	0.26
1992	1.23	1.66	0.07	0.08	0.26
1993	2.22	3.02	0.07	0.15	0.26
1994	0.61	0.83	0.07	0.04	0.27
1995	1.02	2.42	0.06	0.07	0.58
1996	0.82	1.75	0.07	0.06	0.53
1997	0.56	1.15	0.07	0.04	0.51
1998	0.90	1.81	0.07	0.06	0.50
1999	1.07	1.80	0.08	0.08	0.41
2000	1.03	1.62	0.08	0.08	0.36
2001	1.01	2.47	0.09	0.09	0.59
2002	1.44	3.51	0.09	0.12	0.59
2003	0.97	2.35	0.09	0.09	0.59
2004	0.76	1.83	0.10	0.07	0.59
2005	0.55	1.34	0.10	0.05	0.59
2006	0.74	1.78	0.10	0.08	0.58
2007	0.55	1.30	0.10	0.06	0.58
2008	0.89	2.10	0.12	0.10	0.58
2009	0.58	1.48	0.12	0.07	0.60
2010	0.56	1.47	0.10	0.06	0.62
2011	0.91	2.42	0.11	0.10	0.62
2012	1.58	4.24	0.10	0.15	0.63
2013	1.03	2.69	0.10	0.10	0.62
2014	0.91	2.37	0.09	0.09	0.62
2015	0.65	1.71	0.10	0.06	0.62
2016	0.41	1.09	0.10	0.04	0.63
2017	0.53	1.43	0.10	0.05	0.63
Total	0.86	2.05	0.09	0.08	

Source: RMA summary of business. Accessed 9/19/18

This research is further deemed policy relevant given the dramatic increases in insured acres and liability since the 1980 Federal Crop Insurance Act, with the total dollar amount of subsidized premiums rising accordingly (RMA summary of business 2017; Johansson et al. 2014). It also provides an opportunity to evaluate the variables affecting farmers' insurance decisions.

Understanding this has value in regard to policy and determining the potential program costs, as well as industry value, as it is in the interest of the companies approved to sell FCI (AIPs) to maximize their insurance sales and premium collected. Further, the literature regarding the effect of FCI on various land values and input decisions indicates that FCI has a wide-ranging impact in rural America. Thus, defining the parameters affecting the level at which farmers choose to insure has a variety of applications important for policy. Finally, little research has been done on whether and to what extent farm level factors affect coverage level selections.

## SECTION TWO

## HISTORY OF THE FEDERAL CROP INSURANCE PROGRAM

The following is a brief overview of the changes to and development of FCI.

Congress first authorized Federal Crop Insurance with Title V of the Agriculture Adjustment Act of 1938 following farmer losses and bankruptcy resulting from the Great Depression and the Dust Bowl (Smith and Glauber, 2012). From this legislation, the Federal Crop Insurance Corporation (FCIC) was created in 1938 to administer the program (RMA 2017). The programs offered were initially designed for only the major crops (mainly corn, barley, oats, sorghum, wheat, cotton, and rice) with participation hovering around 26.6 million acres (12% of all eligible acres were enrolled prior to 1980<sup>8</sup>) for the next several decades (Knight and Coble, 1997). No private companies were involved until 1980<sup>9</sup> (RMA, 2017).

The Federal Crop Insurance Act of 1980 transformed the organization of federal crop insurance in the U.S and is the permanent statutory authority for FCI as it exists today. By removing the previously existing insurance format, the 1980 Act replaced the old format with Multiple-Peril Crop Insurance (MPCI). This new form of insurance covered potential losses at the unit level. In addition to adding many regions and crop varieties, the 1980 Act created a public-private reinsurance agreement that allowed private approved insurance providers (AIPs) to sell insurance products while using the

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<sup>8</sup> [https://www.everycrsreport.com/reports/R45193.html#\\_Toc524363950](https://www.everycrsreport.com/reports/R45193.html#_Toc524363950)

<sup>9</sup> <http://www.rma.usda.gov/aboutrma/what/history.html>

FCIC as a reinsurer. In order to encourage participation, the bill offered premiums subsidized at a rate of 30%, for the 50% and 65% coverage levels. The 75% coverage level subsidy was capped to equal the same total subsidy as the 65% level (Glauber and Collins, 2002; Knight and Coble, 1997; CRS, 2018). The 1980 bill also mandated that a pilot program be implemented in which individual yield history would be used to calculate a farmer's yield guarantee. This was referred to as actual production history (APH) insurance. In addition, disaster assistance was eliminated in counties if crop insurance was available as an alternative in a county (Glauber, 2013).

Allowing private companies with market incentives to sell policies, subsidized premiums, and removing the availability of disaster assistance programs were all steps designed to replace ad hoc disaster bills with crop insurance. Previously congress was obliged to pass ad-hoc disaster relief in order to help rural areas during extreme drought or other causes of extremely low farm income. While crop insurance participation did increase following this bill, it was at a rate much more slowly than expected. As such, beginning again in 1987, congress began passing ad-hoc crop loss disaster assistance bills tending to use low insurance participation rates as justification (Glauber, 2004).

Table 2.1: U.S. FCI Statistics

Year	Policies Earning Premium	Total Subsidy (\$millions)	Acres Insured (\$millions)	Premium (\$millions)	Total Liability (\$millions)	Effective Subsidy Rate	Applicable Farm Bills
1980	268,196	NA	26.28	\$156	\$3,010	NA	1980 Federal Crop Insurance Act
1981	416,798	\$47	45.01	\$377	\$5,984	0.12	
1982	383,495	\$91	42.29	\$394	\$6,102	0.23	
1983	310,179	\$64	27.96	\$287	\$4,392	0.22	
1984	389,928	\$98	42.69	\$435	\$6,631	0.23	
1985	414,707	\$100	48.56	\$440	\$7,164	0.23	
1986	406,989	\$88	48.68	\$380	\$6,233	0.23	
1987	433,954	\$88	49.15	\$365	\$6,100	0.24	
1988	461,032	\$108	55.59	\$437	\$6,968	0.25	
1989	946,305	\$201	101.35	\$800	\$13,366	0.25	
1990	892,484	\$213	101.16	\$827	\$12,712	0.26	
1991	704,546	\$187	82.17	\$726	\$11,102	0.26	
1992	661,788	\$194	82.93	\$749	\$11,230	0.26	
1993	677,323	\$197	83.54	\$745	\$11,242	0.26	
1994	798,779	\$251	99.40	\$936	\$13,467	0.27	1994 Crop Ins. Reform Act
1995	2,032,397	\$886	220.33	\$1,535	\$23,639	0.58	
1996	1,612,292	\$976	204.69	\$1,828	\$26,684	0.53	1996 Farm Act (CRC Added)
1997	1,316,318	\$894	181.91	\$1,759	\$25,178	0.51	
1998	1,238,796	\$938	181.61	\$1,862	\$27,656	0.50	
1999	1,283,174	\$929	196.63	\$2,276	\$28,772	0.41	
2000	1,311,738	\$896	206.05	\$2,458	\$31,071	0.36	2000 Agricultural Risk Protection Act
2001	1,286,083	\$1,704	211.07	\$2,877	\$32,947	0.59	
2002	1,247,227	\$1,660	214.56	\$2,811	\$32,745	0.59	
2003	1,228,955	\$1,957	217.12	\$3,322	\$35,792	0.59	
2004	1,217,662	\$2,388	223.91	\$4,081	\$41,595	0.59	
2005	1,178,421	\$2,245	248.75	\$3,831	\$38,766	0.59	
2006	1,136,154	\$2,622	245.85	\$4,497	\$44,476	0.58	
2007	1,126,608	\$3,714	275.38	\$6,412	\$61,638	0.58	
2008	1,138,537	\$5,592	275.84	\$9,717	\$84,205	0.58	2008 Food, Agriculture, Conservation, and Trade Act
2009	1,162,296	\$5,342	268.11	\$8,836	\$74,392	0.60	
2010	1,131,015	\$4,630	260.04	\$7,484	\$73,349	0.62	
2011	1,143,988	\$7,390	266.07	\$11,871	\$110,030	0.62	
2012	1,166,039	\$6,909	283.06	\$11,019	\$113,122	0.63	
2013	1,216,305	\$7,222	296.18	\$11,701	\$119,618	0.62	
2014	1,198,987	\$6,142	294.59	\$9,966	\$105,951	0.62	2014 Agricultural Act
2015	1,196,569	\$5,988	296.07	\$9,623	\$98,006	0.62	
2016	1,151,368	\$5,733	290.32	\$9,132	\$95,117	0.63	
2017	1,116,104	\$6,208	311.70	\$9,858	\$100,435	0.63	
Total		\$84,894		\$146,810	\$1,550,887		

Source: RMA summary of business. Accessed 9/19/18

In 1994, congress passed the Crop Insurance Reform Act. This act introduced completely subsidized 50% coverage yield insurance (CAT) for a small administrative fee. The 1994 Act also added additional subsidy assistance for buy-up yield coverage levels greater than 50%. Combined with making crop insurance compulsory, by 1995 participation rates on eligible acres had reached 80%, with 50% of these acres being covered under CAT (Glauber, 2013; RMA 2017). Largely due to the mandate, FCI liability rose from \$13.5 billion in 1994 to \$25.2 billion in 1995 (Knight and Coble, 1997). This act also introduced a new pilot authorities program under Section 508(h) which allowed private firms to develop new crop insurance policies. Once submitted, these policies can be approved by the FCIC Board of Directors. This makes them eligible for expense reimbursements, premium subsidies, and government reinsurance. Once approved, these policies are added to the general FCI portfolio and can be sold by any of the AIPs agents (Glauber and Collins, 2002).

Along with repealing the unpopular mandatory coverage requirement from the 1994 farm bill, the most notable change of the 1996 Farm Act was to add a revenue coverage insurance option as an alternative the standard yield insurance (Note Table 2.1). This insurance functioned by using the futures market to set a projected price, which could be multiplied by a farmer's APH or average per acre yield to establish a per acre expected revenue, which would be the basis for guarantees (RMA, 2017).

Over the next several years' congress continued to add to crop insurance incentives by increasing subsidy rates and passing the Agricultural Risk Protection Act in the year 2000, which further increased buy-up (coverage levels above the 50%

catastrophic coverage level) coverage level subsidies. This resulted in further increases in farmer participation rates among buy-up coverage levels (Glauber, 2013). This increasing trend in participation rates has continued up into recent years with the 311 (Table 2.1) million acres of the National Agricultural Statistics Service's estimated 319 million total 2017 U.S. crop acres insured (NASS Quickstats<sup>10</sup>). In addition, farmers have steadily adopted revenue coverage insurance in place of yield coverage over time since its introduction in the 1996 farm bill (Adhikari, 2010).

The 2000 Agriculture Risk Protection Act (ARPA) also allowed RMA to enter into contracts with producer groups for the development and research of new crop insurance products, while prohibiting the FCIC from conducting research and development on its own. Private firms were also enabled to submit unsolicited proposals to develop policies to the FCIC board for approval (RMA 2018)<sup>11</sup>. To add additional incentive for new policy development, ARPA also contained provisions allowing for the reimbursement of research and development costs associated with creating the policies approved by the FCIC and developed by private firms (Glauber and Collins, 2002). This change led to many new crop-specific insurance products being developed for commodities with smaller market share as well as specialty crops (RMA, 2017).

The Agricultural Act of 2014 complicated the interaction between the programs available through the RMA and the FSA, by introducing new shallow loss programs. A brief overview is provided (Bradley et al. 2016):

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<sup>10</sup> [https://quickstats.nass.usda.gov/?source\\_desc=CENSUS](https://quickstats.nass.usda.gov/?source_desc=CENSUS)

<sup>11</sup> <https://www.rma.usda.gov/aboutrma/what/history.html>

“The new programs created by the 2014 Farm Bill were implemented in late 2014. A major difference from prior programs involved the underlying “triggers” that activated payments. Agriculture Risk Coverage, or ARC, became the revenue-based program. A payment could be triggered for the ARC program based on a combination of yield and price shortfalls relative to historical averages. The yields could be based off the county’s historical productivity, known as ARC-CO, or the program could be based off the individual’s production history (ARC-IN). The alternative commodity program was the price-triggered program known as the Price Loss Coverage (PLC) program. Payments for this program are triggered when the commodity market year average price falls below the established program price.”

With the meshing of Farm Service Agency (FSA) transfer payment programs and FCI, producers were forced to choose between ARC and PLC, each with a different set of incentives. These programs work with crop insurance, with some insurance options being dependent on your selection of ARC or PLC. ARC as a “shallow loss” program, may take the place of the upper coverage levels of crop insurance, while PLC is determined separately based on price changes if national marketing year average prices fall below legislated reference prices. The current state of FCI and the various aspects of the policies as they exist after the 2014 farm bill are discussed further in Section 3.

Note Knight and Coble (1997) and Glauber (2013) each compiled an overview of the history of FCI and summarized relevant research findings conducted during that history respectively. Both of these papers serve as excellent references to the temporal changes in FCI.

## SECTION THREE

## MECHANICS OF FEDERAL CROP INSURANCE

Currently, crop insurance policies can be divided into four overarching groups or types, Revenue Protection (RP), Yield Protection (YP), Area Revenue Protection (ARP), and Area Yield Protection (AYP). Revenue Protection insurance guarantees a certain level of revenue rather than a percentage of yield. It hedges risk from declines in the product of crop prices and individual yields. The guarantee is based on market prices and on a producer's actual farm yield. Revenue Protection uses CME futures market prices and the producer's average production history (APH) yields to compute their revenue coverage and guarantee. A harvest price is determined by averaging the new crop futures prices during October for both corn and soybeans. The final revenue guarantee is computed by multiplying the higher of either the projected price or the harvest market price by the APH yield for the producers' farm and by the producers' chosen coverage level (50 to 85 percent).<sup>2</sup>

Yield policies function similarly, though an indemnity is only paid in the event of an actual yield loss. Yield Protection is yield insurance covering yield losses for a farm or unit. YP is the longest running crop insurance coverage type, previously known as Actual Production History (APH). YP makes payments when actual yield is below a yield guarantee. The yield guarantee equals the APH yield times a farmer-chosen yield election. Yield elections range from 50 to 85 percent of the APH yield in 5% increments. Area policies are based on county average yields and are triggered in the event a county's

average yield is lower than the county's expected yield. The same revenue and yield protection indemnity framework differences apply to area policies as well (RMA, 2017).

In addition, for each type of policy, there is a harvest price exclusion (HPE) option. Normally in the event of a yield loss, the projected price would be multiplied by the actual yield and subtracted from the expected revenue. Standard revenue policies allow the harvest price to replace the projected price if it is greater than the original projected price, thus increasing the expected revenue. If a producer selects the HPE option, the revenue guarantee is determined solely by the February futures prices and does not increase even if the futures price rises by harvest (RMA, 2017).

Policies are further broken down by units. Each land parcel for which APH yields are tracked and premiums are calculated is called a "unit". There are three unit types, basic, optional, and enterprise. The insured automatically qualifies for basic units without exception. A basic unit (BU), unless otherwise specified in the crop provisions or special provisions, is all insurable acreage of the insured crop in the county on the date coverage begins for the crop year in which the insured has a share in the crop. A premium discount may be applicable as provided in the actuarial documents for certain crops when basic units are not divided into optional units.<sup>12</sup>

Optional units (OU) allow producers to insure smaller parcels and are therefore higher risk. Land that would otherwise be one basic unit may be divided into optional units according to the definition contained in the crop insurance Basic Provisions (applies to all crops), Crop Provisions (applies to a specific crop) and/or Special Provisions

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<sup>12</sup> [https://www.rma.usda.gov/handbooks/18000/2016/16\\_18010.pdf](https://www.rma.usda.gov/handbooks/18000/2016/16_18010.pdf)

(applies to specific crops and counties). Optional units are not available for crops insured under CAT.<sup>13</sup>

The third unit type, enterprise units (EU), consists of all insurable acreage of the same insured crop in the county in which the insured has a share on the date coverage begins for the crop year. An enterprise unit may not be further divided except as specified in the insurance provisions (for example: irrigated and non-irrigated corn). In general, the acreage for an enterprise unit must be located in any combination of two or more sections, section equivalents, or FSA FNs, if more than one of these is the basis for optional units.<sup>14</sup> The main difference between basic and enterprise units is whether a producer owns or has shares in particular fields. Enterprise units combine all the acres of a given crop within a county in which a producer has a financial interest regardless of whether they are owned, rented, or have multiple landlords.

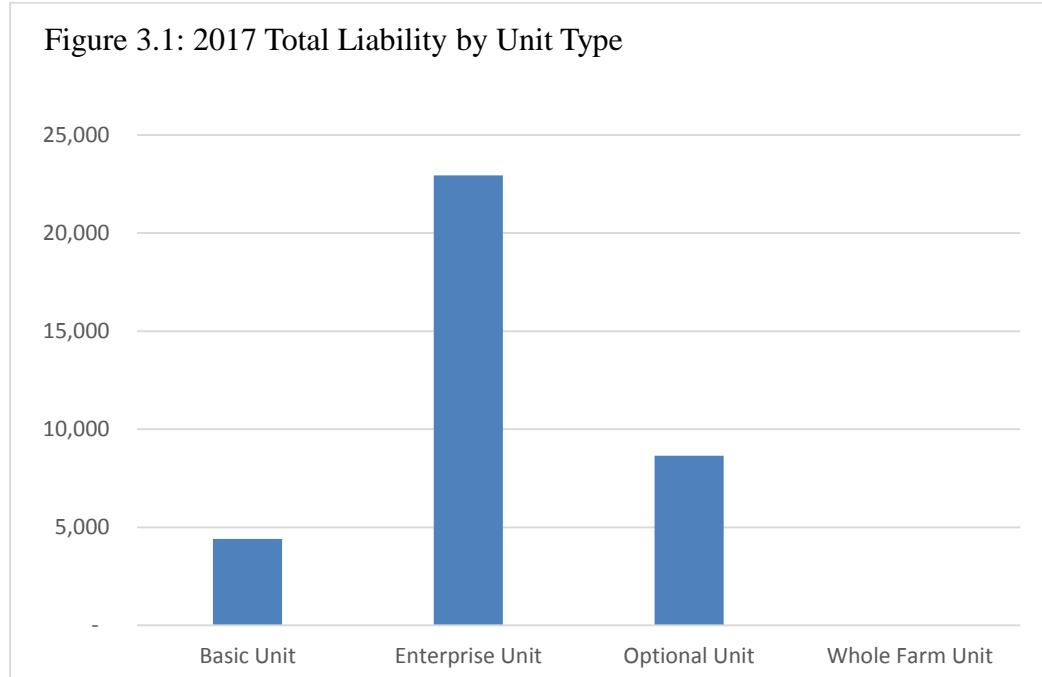
Due to enterprise units typically being larger than the basic or optional units, yields tend to be less variable, decreasing the likelihood of an indemnity trigger. Thus enterprise units are subsidized at higher rates, which tends to encourage higher coverage level selection. Figure 3.1 displays the 2017 distribution of corn policies liability by unit type.

Whole farm units are also available for whole farm plans, but are thus outside of the scope of this study, given the lack of available data from the Agricultural Resource and Management Survey (ARMS) on whole-farm plans.

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<sup>13</sup> [https://www.rma.usda.gov/handbooks/18000/2016/16\\_18010.pdf](https://www.rma.usda.gov/handbooks/18000/2016/16_18010.pdf)

<sup>14</sup> [https://www.rma.usda.gov/handbooks/18000/2016/16\\_18010.pdf](https://www.rma.usda.gov/handbooks/18000/2016/16_18010.pdf)



Source: <https://www.rma.usda.gov/>

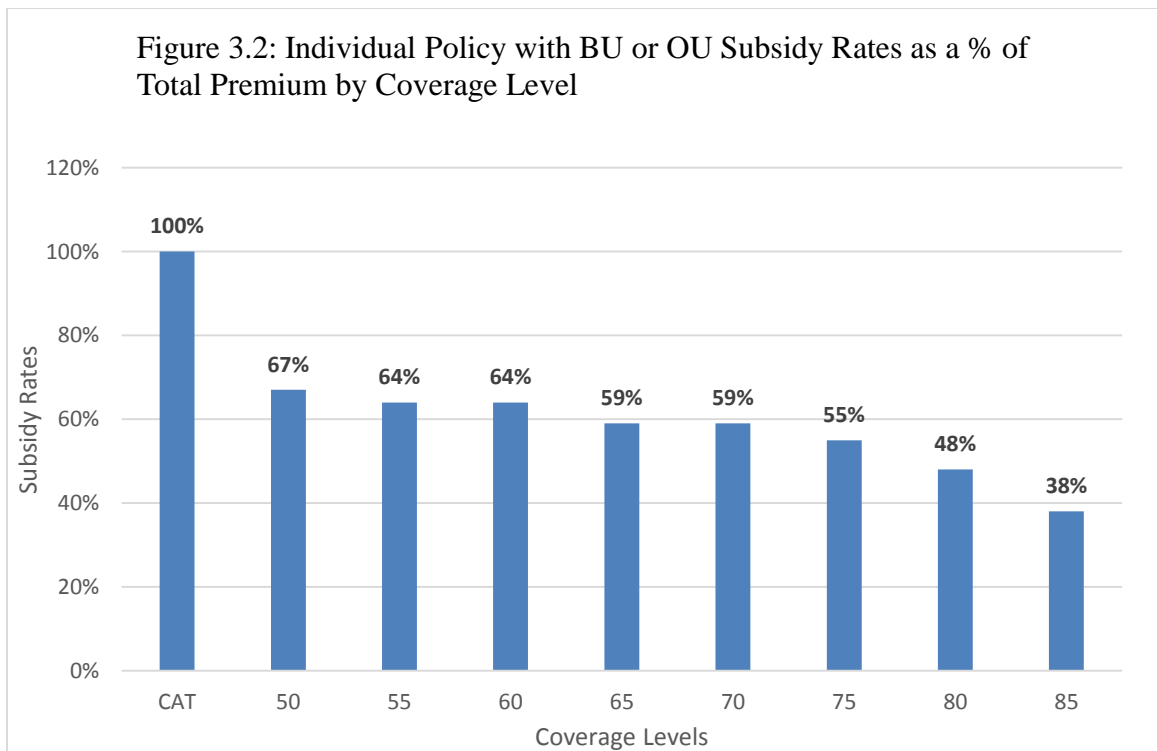
### Subsidy Rates and Coverage Levels

With the amendments to the Federal Crop Insurance Act made by the Agriculture Risk Protection Act of 2000, the USDA was authorized to offer catastrophic (CAT) coverage for an administrative fee (\$300) to producers who grow an insurable crop. For an additional premium, farmers can buy additional coverage beyond the CAT level. This additional coverage comes in the form of insuring a selected percentage of projected revenue in increments of 5 percent typically up to a maximum of 85 percent for individual yield history policies and 90 percent for area yield policies.

By selecting a coverage level, producers can effectively choose their deductible. Thus making the expected revenue calculation:

$$(1) \text{ Revenue Guarantee} = \text{Projected Price} \times \text{Expected Yield} \times \text{Coverage Level} \%$$

Choice of coverage level affects the premium paid and the percentage of subsidy received. Figure 3.2 displays the effective subsidy rates for each coverage level available under the individual RP and YP plans. For both yield and revenue insurance, the choice of coverage level determines the premium subsidy rate, as can be seen, the rate falls as coverage level increases. This means that while the total dollar amount of subsidy increases as coverage level rises due to the increase in premium cost, the percentage of that premium that is subsidized declines.



Premiums for FCI are required to be set at actuarially fair rates (i.e. a loss ratio of 1.00<sup>15</sup>), but opportunities to choose coverage level, as well as between yield and revenue insurance contracts, and area or individual plans create regional differences in subsidies paid per expected bushel covered for a given crop.<sup>16,17,18,19</sup> The 2018 breakdown of policy types selected in three selected states is displayed in Figure 3.3. These states were selected as being relatively representative of their respective regions. As shown, RP is by far the most popular policy type in all states, as producers have increasingly switched from yield protection to gain the additional price decline coverage.

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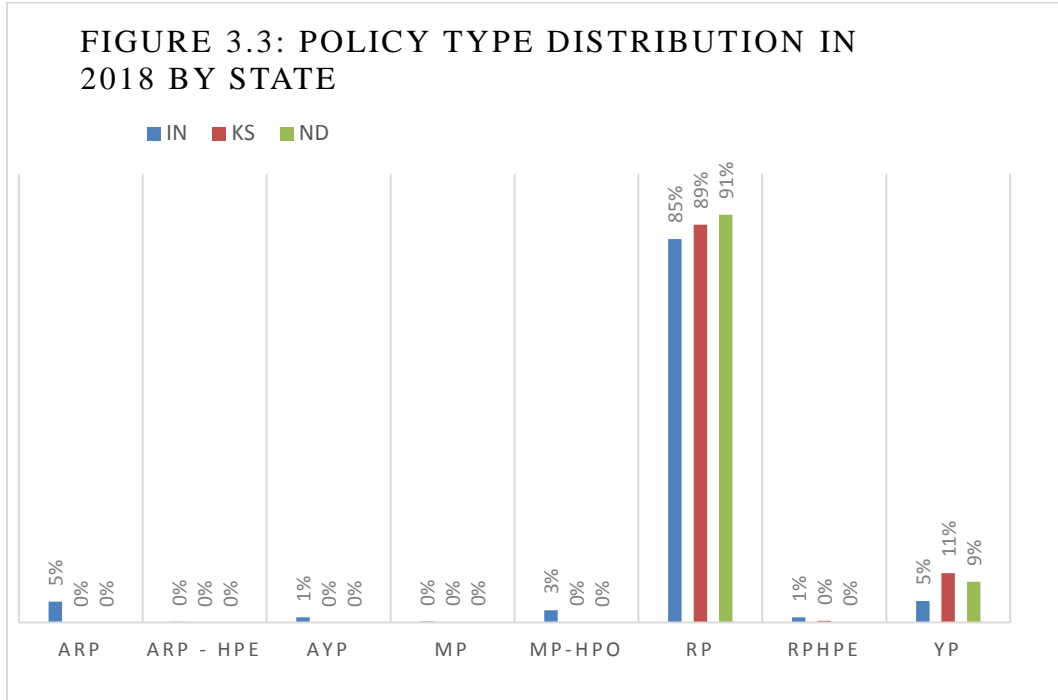
<sup>15</sup> For a discussion of loss ratios, refer to the Data Analysis and Discussion Section under the Federal Crop Insurance Experience Data subsection.

<sup>16</sup> The Act requires that the FCIC set premium rates at a level which it determines to be “actuarially sufficient” to attain a given ratio of anticipated loss claims to the premiums expected to be collected for the entire crop insurance program each year. 7 U.S.C. § 1508(d)(1).  
<https://caselaw.findlaw.com/us-8th-circuit/1443428.html>

<sup>17</sup> The Federal Crop Insurance Reform and Department of Agriculture Reorganization Act of 1994 (P.L. 103-354, Oct. 13, 1994) required that USDA achieve a target loss ratio no greater than 1.10. I.e. insurance rates were to be set to generate revenue from premiums to cover at least 91 percent of the anticipated claims payments—termed 91 percent adequate. The Reform Act required the USDA RMA to achieve a target loss ratio no greater than 1.075, or 93 percent adequate.

<sup>18</sup> <https://www.gao.gov/assets/90/81372.pdf>

<sup>19</sup> The 2008 Farm Bill modified Section 1506(n) of the Act to: The Corporation shall take such actions as are necessary to improve the actuarial soundness of Federal multi-peril crop insurance coverage made available under this subtitle to achieve, an overall projected loss ratio of not greater than 1.0.  
<https://www.rma.usda.gov/pubs/2010/organics.pdf>



Source: USDA RMA Summary of Business, March 2019.

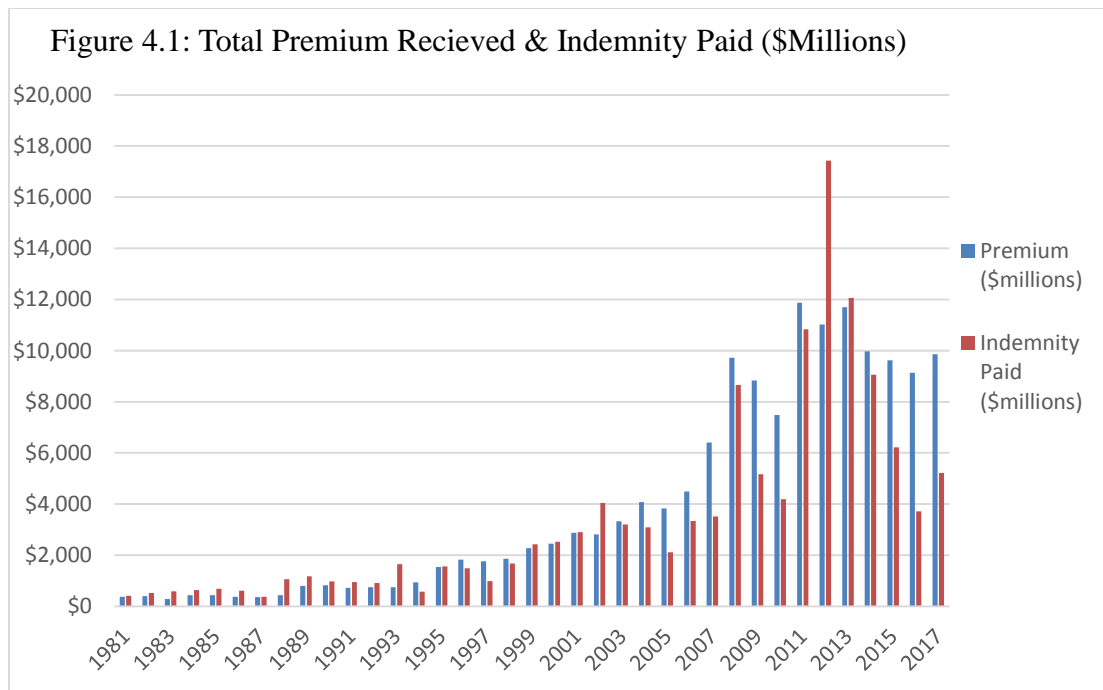
## SECTION FOUR

## LITERATURE REVIEW

Given the importance of the FCI program to agriculture, the accumulation of economic research related to crop insurance has been significant. Yet while the ever changing insurance environment has been the subject of substantial research, literature on the most recent iteration of crop insurance since coverage and participation levels hit their peak is more scarce. Researchers have studied various applications of mechanics and effects regarding crop insurance from the appropriateness of rating methodology and the potential for moral hazard to the effects on farm profitability and land values to the decision making criteria of farmers. Knight and Coble (1997) noted there have been a significant number of studies regarding participation rates, predicting further research faces diminishing returns on further studies. Moral hazard and adverse selection have also been studied extensively, though research addressing the actual scope or magnitude of these behaviors is limited, the existence of the potential is well documented within the literature. Knight and Coble (1997) concluded the amount of research regarding the producer decision making and actuarial soundness of new products should be expanded.

This section sets out specifically to review research relevant to factors motivating farmer decision making criteria in the selection of crop insurance coverage level. The question of whether crop insurance is an income transfer or a tool for risk management is an unswerving topic of debate in the economic literature. The subsidies intended to induce producers to insure are also a form of transferring money from tax payers to

producers (Goodwin & Smith, 2013). The increases in participation rates since 1980 closely followed the increase in subsidy rates mandated in the subsequent farm bills (Glauber, 2004). Goodwin and Smith (2013) show that average adjusted subsidy rates have increased with relative consistency from 12% in 1981 to 62% in 2010. Loss ratios calculated using actual premium paid have averaged 2.05 (Refer to Table 1.1), meaning that producers have on average received \$2.05 for every \$1.00 paid in premium. Full premium paid (including subsidy) and indemnity paid by year are shown in Figure 4.1. The all FCI loss ratio from 1980 to 2017 is 0.86.



The main justification given for these subsidies in FCI lies in the assumed inability of the private market to provide equivalent risk protection due to systemic

weather patterns (Miranda and Glauber, 1997; Glauber and Collins, 2002). Legislators from state economies that rely on crop and agriculture production tend to support these subsidies. Previous to the advent of subsidized crop insurance, *ad-hoc* disaster assistance was common in times of extreme crop or revenue loss for these economies. As the premium subsidies partially disguise the income transfer, they are generally considered more politically viable by crop industry groups due to the less obvious income transfer.

Goodwin (2001) concluded that due to the considerable degree of systemic risk inherent in crop insurance, private offerings would likely be of considerable cost. The amount of subsidy required to bring crop insurance participation rates to their current levels likely supports this assessment (Goodwin and Smith, 2013). Glauber and Collins (2002) results suggested the costs of increasing participation rates from 50 to 75 percent would be considerably higher than the cost of increasing participation from 25 to 50 percent, implying an increasing marginal cost of enrolling additional acreage.

Woodard & Yi (2018) examined FCI demand elasticities finding they are elastic when accounting for the endogeneity of premium rate calculations using an IV model. This is contrary to the findings of previous research (Knight & Coble 1997), which found crop insurance is generally inelastic with respect to premium rates, though per Woodard, other studies have not accounted for potential endogeneity issues.

Bekkerman et al. (2018) utilized farm-level data from the Agricultural Resource Management Survey to evaluate a legislative proposal to implement a subsidy cap based on gross farm income. Since agricultural safety net programs are concentrated among the

largest (highest decile) farms, such caps would have little effect on the majority of farmers and could result in substantial tax payer savings.

Paulson et al. (2014) modeled the effect of imposing a dollar per acre subsidy cap. The model predicts a reduction in subsidy expenditures exceeding 40%, noting the impact being the most severe on the highest revenue crops. This proposition would likely significantly change incentives with low revenue crops receiving the advantage as the percentage of subsidy received would be less affected.

#### Effects of Rating in FCI

Perhaps the greatest area of focus in the broader crop insurance literature has been an ongoing evaluation of the actuarial fairness and the potential for moral hazard based on the accuracy of crop insurance rating. This literature has resulted in changes to the actual rating structure of federal crop insurance. Sherrick et al. (2004) found a producer's yield history average (APH) is not reflective of the best predicted yield due to the consistent increase in per acre yields over time. The influence of this finding had been analyzed previously; as a result, trend adjusted APH calculations were made available as an option to producers (Just et al. 1999).

Other contributions have been made in the area of moral hazard. Atwood, Robison-Cox, and Shaik (2004) developed a methodology useful for flagging farms potentially engaging in yield switching; when farmers relocate or "switch" yield from one unit to another to create the appearance of an indemnifiable loss for one of their insured units. Bekkerman, Smith, and Watts (2012) showed that some FSA programs are likely to

impact producer participation when it results in increased likelihood to receive indemnities and thus exploit moral hazard opportunities.

The RMA uses what is known as a loss cost ratio ratemaking methodology (Joseph et al. 2000). This approach is based directly on historical experiences, where aggregate rates are created by averaging individual loss rates for individual experiences. The historical loss cost ratio methodology used by RMA derives rates by averaging loss cost ratios at each point in time at the county level for individual producers (Woodard et al. 2011). Coble et al. (2010) reviewed the RMA's loss experience based rating system, concluding that a loss driven methodology is the only way to assure actuarially fair rating. Sherrick et al. (2004) found that RMA rates tend to be higher than those implied from estimated farm-level distributions in Illinois. Woodard et al. (2011) concurred using farm level data for Illinois corn found loss cost ratio methodology exaggerates actuarially fair rates, which results in rate estimation bias.

Claassen and Just (2011) discuss the complications spatial and temporal heterogeneity in their analysis of yield distributions. Additional literature regards the ability to predict likely yields, using linearity and accounting for technological innovations.

### Explaining Coverage Level Selection

The question of what factors affect coverage level selection decisions beyond subsidy remains indefinite. Most of the considerable body of research on U.S. crop insurance has focused on issues related to product design, rate-setting, farmers'

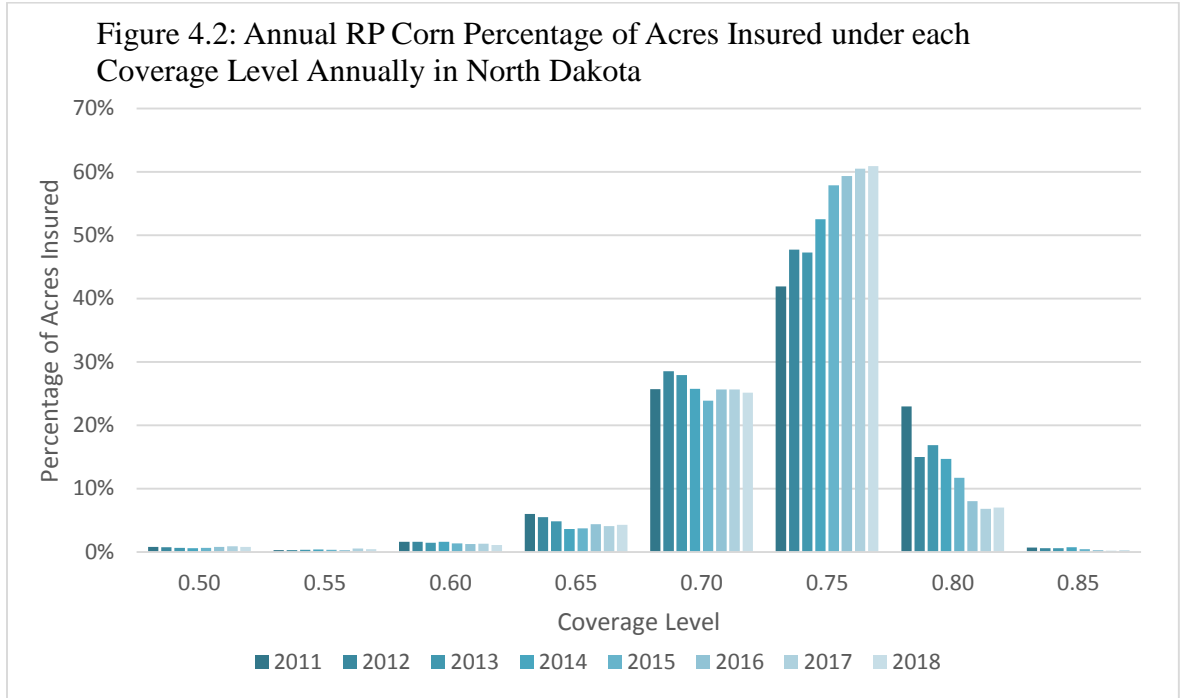
participation decisions, and their choice of which product to buy. However, limited research has been done to investigate the significant disparities in coverage level selection geographically, nor the potential farm level variables and constraints affecting coverage level choices. While some macro associations have been established (Du et al. 2013), whether coverage selections are influenced by decreasing or increasing debt, input prices, education, or symptoms of an adoption curve remains understudied.

Expected utility maximization is an important part of the more general insurance literature and has historically been applied to crop insurance. In this setting the utility maximization framework can be constructed to model a number of choices related to FCI. Whether or not to insure, which policy type to purchase, and finally the level of insurance. The framework for the third choice would be constructed to analyze the tradeoff faced by a producer of higher percentage subsidy payments or higher risk coverage. With subsidies offered as a percentage of premiums dependent on coverage level as shown in Table 4.1, it might be expected that farmers would try to maximize their subsidy per acre or the percentage of premium subsidized (Du et al. 2014). Given a significant positive return on every dollar of premium invested into crop insurance (\$2.05, Table 1.1), the return over the long run is invariably positive. One might then assume that producers would take advantage of this available return or income transfer by maximizing the coverage level at which they insure (i.e., minimize their deductible).

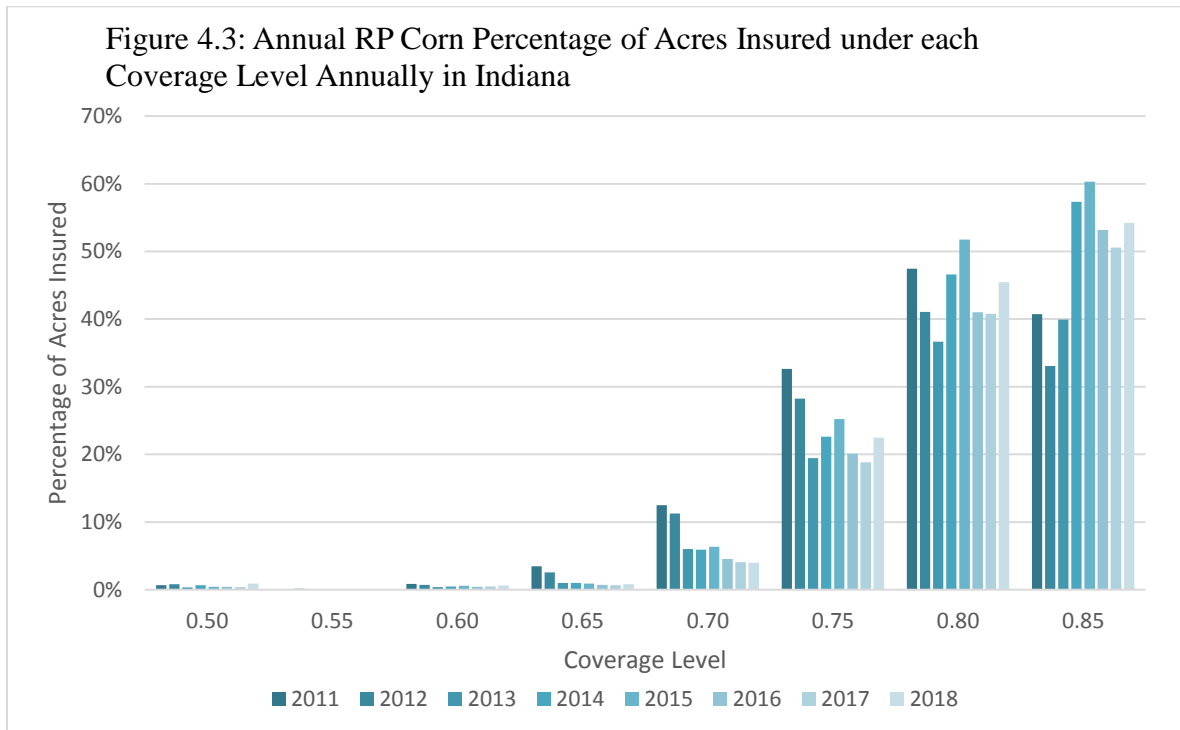
Coverage Levels	CAT	50	55	60	65	70	75	80	85
Subsidy Rate % for most policy types (including those using basic and optional unit plans)	100%	67%	64%	64%	59%	59%	55%	48%	38%
Subsidy Rate % for enterprise units	n/a	80%	80%	80%	80%	80%	77%	68%	53%
Subsidy Rate % for area plans (yield)	n/a	n/a	n/a	n/a	n/a	59%	59%	55%	55%
Subsidy Rate % for area plans (revenue)	n/a	n/a	n/a	n/a	n/a	59%	55%	55%	49%
Subsidy Rate % for whole farm units n/a	n/a	80%	80%	80%	80%	80%	80%	71%	56%

Source: <https://fas.org/sgp/crs/misc/R40532.pdf>

A review of the RMA summary of business shows this not to be the case. Figure 4.2 below, displays corn revenue protection policies earning premium (PEP) (PEP as opposed to policies sold but not earning premium, meaning they are inactive, which the RMA also reports) in North Dakota and aggregates them over the coverage level at which they were taken out. As is distinguishable from Figure 4.2, the most popular coverage level selections in North Dakota during the past six years have held relatively steady at the 0.70 and 0.75 levels. In light of previous discussion, this seems surprising. In contrast, producers in Indiana select the 0.80 and 0.85 coverage levels more frequently and increasingly did so temporally before pulling back slightly following 2016, as shown in Figure 4.3. Note that, subsidies have not changed considerably in the past decade, yet coverage selection has changed considerably as shown in the figures.



Source: USDA RMA Summary of Business, December 2018



Source: USDA RMA Summary of Business, December 2018

Du et al. (2013) noted the geographical inconsistencies in crop insurance policy and coverage selection. They note associations between areas with high yields and less volatile yields and revenue policy selection along with higher coverage. Whether these are more specifically associated with other producer traits, farm-level financial variables, or cost and revenue expectation differences remains unexplained.

In the broader insurance literature, a preference for what can be considered over-insurance rather than underinsurance has been well documented (Pashigan et al. 1966; Snyder, 2010). This is found most generally among consumers choosing a low or zero deductible insurance policy, despite the expected value being lower for lower deductible policies (Shapira and Venezia, 2008), making the seeming underinsurance in FCI all the more peculiar.

Tables 4.2 and 4.3 display estimates of the total premium paid under coverage level for producers insuring non-irrigated corn under Revenue Protection (RP) with optional units in De Kalb county Indiana and McLean county North Dakota. The premium rates assume a 100-acre field with 160-bushel actual production history (APH) for the producer. These tables are provided as an example of the effect the declining subsidy rates have as coverage level is increased. Comparing the two tables, it is apparent that producers in the two counties face a different set of incentives if subsidy maximization is their goal. In De Kalb county Indiana, a producer wishing to maximize their total dollars of subsidy received would insure at the 85% coverage level, while a producer wishing to maximize their subsidy as a percentage of liability would insure at 80% coverage level. In McLean county North Dakota, a producer wishing to maximize

their total dollars of subsidy received would insure at the 80% coverage level, while a producer who wished to maximize subsidy as a percentage of total insured liability would insure at the 75% coverage level.

Referring back to Figures 4.2 and 4.3, it does appear that the most popular coverage levels in Indiana and North Dakota are those in which subsidy as a percentage of liability insured is maximized; indicating that the subsidy rate may have some effect on their risk. Reviewing the Figures however, it is also apparent that a significant number of acres are insured under other coverage levels indicating effects from other possible determinants of coverage level, though they are clustered where subsidy/liability is highest.

Cov. Level	85%	80%	75%	70%	65%	60%	55%	50%
Liability	\$53,856	\$50,688	\$47,520	\$44,352	\$41,184	\$38,016	\$34,848	\$31,680
Total Prem.	\$7,614	\$5,876	\$4,682	\$3,669	\$2,813	\$2,140	\$1,604	\$1,177
Prod. Prem.	\$4,721	\$3,056	\$2,107	\$1,504	\$1,153	\$770	\$577	\$388
Subsidy	\$2,893	\$2,820	\$2,575	\$2,165	\$1,660	\$1,370	\$1,027	\$789
Trigger (Bu.)	136	128	120	112	104	96	88	80
Subsidy/Liab.	5.4%	5.6%	5.4%	4.9%	4.0%	3.6%	2.9%	2.5%
Subsidy Rate	38%	48%	55%	59%	59%	64%	64%	67%

Source: RMA Cost Estimator<sup>20</sup>

<sup>20</sup> <https://ewebapp.rma.usda.gov/apps/costestimator/Estimates/DetailedEstimate.aspx>

Table 4.3: McLean County North Dakota RP Corn Premium Information by Coverage Level

Cov. Level	85%	80%	75%	70%	65%	60%	55%	50%
Liability	\$53,856	\$50,688	\$47,520	\$44,352	\$41,184	\$38,016	\$34,848	\$31,680
Total Prem.	\$14,820	\$12,389	\$10,600	\$8,998	\$7,571	\$6,285	\$5,126	\$4,114
Prod. Prem.	\$9,188	\$6,442	\$4,770	\$3,689	\$3,104	\$2,263	\$1,845	\$1,358
Subsidy	\$5,632	\$5,947	\$5,830	\$5,309	\$4,467	\$4,022	\$3,281	\$2,756
Trigger (Bu.)	136	128	120	112	104	96	88	80
Subsidy/Liab.	10.5%	11.7%	12.3%	12.0%	10.8%	10.6%	9.4%	8.7%
Subsidy Rate	38%	48%	55%	59%	59%	64%	64%	67%

Source: RMA Cost Estimator<sup>21</sup>

Du et al. (2014) addressed the question of producer coverage level choice by attempting to model farmers' choices using an expected utility maximization framework. Hypothesizing a rational farmer would maximize either the per acre subsidy or the percentage of premium subsidized. Using a mixed logit model on a 2009 unit-level RMA data set, they found that a majority of farmers do not maximize subsidy payment received or coverage level, and suggest among several potential motivations, that farmers prefer low out of pocket premium expenses. More specifically, farmers with less yield variability and larger farms tend to insure at higher coverage levels, but not to the level expected if they were maximizing subsidy extraction. Overall, their study proved inconclusive stating:

“Economic theory suggests that individuals exposed to risk should take up actuarially fair insurance if risk averse. When contracts are heavily subsidized and subsidy transfers increase with extent of coverage then uptake should tilt toward the contracts providing the greatest dollar subsidy. We find that farmers turn down contracts that transfer comparatively more subsidy and retain comparatively

<sup>21</sup> <https://ewebapp.rma.usda.gov/apps/costestimator/Estimates/DetailedEstimate.aspx>

less risk in favor of contracts transferring less subsidy and retaining more risk” (Du et al. 2014).

Due to the variety of insurance types and coverage level choices available to farmers, Johansson et al. (2014) advocate for the use of a multinomial model in lieu of a multivariate probit approach to examine the effect of premium rate changes on coverage level selection. Their results confirmed that a higher subsidy rate does, in some cases, increase the likelihood producers will insure at higher coverage levels, while higher premiums reduce the level of coverage selection.

Other studies have examined farmers’ preference for insurance type. Adhirki et al. (2010) examined the effect of geographical heterogeneity on a farmer’s choice between revenue and yield insurance. Noting through the use of a spatial random effects model the amount of risk borne by farmers and the crop insurance product selected was not necessarily consistent even within a given area, leading them to conclude that external factors such as agent marketing strategies likely influence farmers’ risk management selections.

Smith and Baquet (1996), using farm-level data from Montana wheat farmers, examined the factors that influenced participation in crop insurance, as well as coverage level. They modeled the decision as two-stage estimation procedure; the first stage being whether a farmer decides to purchase insurance and (assuming they did) in the second stage chooses a coverage level. The results indicated that education, perception of yield variability, and debt levels, increased the probability of participation, while increased premium rates decreased coverage selection but not participation. In addition, farmers’

choices of coverage levels were influenced by whether their expected returns from crop insurance was positive or negative.

In the 2014 farm bill, a significant change to shallow coverage levels was made with the introduction of Supplemental Coverage Option. A heavily subsidized option offered through the FSA that allows producers to cover an additional 15 % of their expected revenue, up to 90 %. Bradley et al. (2016) examined the effect of this change on several major crop producing states and they found that the introduction of SCO and the removal of direct payments correlated with higher coverage level selections.

The literature appears to provide an insufficient explanation of the amount of variance in coverage selection between areas, specifically at the producer and county level. Seeming differences in production potential and total input costs, as well as factors such as agent density across states might provide some insight into these geographical inconsistencies. The annual Agriculture Resource Management Survey (ARMS), which provides information on producer level financial condition, production practice, and resource utilization and coverage level selection, combined with RMA summary of business data may provide additional statistically significant parameters effecting coverage level selection differences. Prior to the 2014 ARMS, coverage level selection data was not surveyed and thus associations between coverage levels and farm level variables could not be examined with the observational robustness that is provided by the ARMS.

### Prospect Theory

In response to the lack of empirical evidence supporting their expected utility hypotheses, Du et al. (2014) suggested prospect theory as a potential superior explanatory framework for coverage level decisions made by producers. In prospect theory, as opposed to expected utility, values are allocated to (whereas utility is derived from) potential gains and losses rather than to final assets. Meanwhile, the objective probabilities that are used in utility theory are replaced/transformed with decision weights (Kahneman and Tversky, 1979; Kahneman and Tversky, 1992). Prospect Theory as a model for decision making is supported by substantial laboratory evidence (Barberis, 2013). It is considered relevant by Du et al. (2014), as they believe growers may anchor their reference outcome near potential yields. This is easier noted than applied however, as stated by Barberis (2013), “while prospect theory contains many remarkable insights, it is not ready-made for economic applications.”.

Babcock (2015) followed up on their work by calibrating the prospect theory models using Tversky and Kahnemen’s weighting functions to the same 2009 FCI conditions used by Du et al. (2014). Babcock (2015) found that prospect theory predicts optimal coverage choices consistent with observed coverage selections, but only when a stand-alone investment is used as the reference point, otherwise the predictions relatively match those of expected utility. This could be due to a producer tendency to overweight low probability extreme events (Bocquého et al. 2014; Kahneman and Tversky, 1979). Thus, resulting in a coverage level selection that is lower than expected utility would

predict is optimal. The results of Bougherara and Piet (2014) from a sample of French farmers also indicate that this may explain producer's tendency to underinsure or opt out of insurance altogether.

The consensus from the prospect theory literature appears to agree there is a need for additional study regarding how producer's frame or view their decision making. While prospect theory may indeed offer a better framework for modeling producer choices, the literature is limited by small samples, difficult application, and limited study breadth.

#### Conclusion of Literature Review

While the crop insurance literature is relatively extensive, research regarding coverage level selections appear to be understudied. With the latest changes brought by the 2014 farm bill, which includes the merging of farm programs to crop insurance in the form of ARC, PLC, and SCO, the variables affecting farmer decision making regarding coverage levels are increasingly complex. The question as to why farmers in some situations and areas choose not to maximize coverage level selection in order to maximize subsidy dollar extraction and thus expected profits remains. Understanding the farm level associations between producer and farm traits and coverage level choices has value in regard to policy and determining the potential program costs, as well as industry value, since it is in the interest of the companies approved to sell FCI (AIPs) to maximize their insurance sales and premium collected.

The incentives resulting from subsidy and rating effects are well documented within the literature, though with continued changes to FCI, they will likely continue to be reviewed in future studies. Further, the literature regarding the effect of FCI on various land values and input decisions indicates that FCI has a wide ranging impact on rural America. Thus, defining the parameters affecting the level at which farmers choose to insure has a variety of applications important for measuring policy effects.

## SECTION FIVE

## THEORETICAL METHODOLOGY

The framework most commonly employed in evaluating crop insurance decisions is expected utility (EU) maximization, where production factors, including coverage level, are chosen subject to physical and technical constraints (Smith and Baquet, 1996). This framework has been called into question increasingly in its application to farmer decision making however, with inconsistent levels of risk aversion depending on the amount being risked (Bocquého et al. 2014; Rabin, 2000). Further, based on the models that have been constructed to evaluate farmer insurance decisions under EU framework; the highest coverage levels would be chosen in order to either maximize subsidy dollars as a percentage of liability or maximize total subsidy by maximizing coverage levels (Du et al. 2016). These choices do not appear consistently in practice, which gives the appearance of underinsurance on the part of the producers. While the EU framework is in many cases justified, we also point out that farms are profit maximizing firms, separate from utility maximizing individuals, thus in addition to the added simplicity, we believe it is not inappropriate to evaluate producer decision making under a profit maximization framework. Risk preferences are not known at the farm level; thus these preferences are not assumed or incorporated into the model. In addition, crop insurance is associated with both lower risk and higher expected returns, which would be unambiguously preferred regardless. Producers are assumed to make asset and input allocation decisions in order to

maximize expected profit subject to a cash budget constraint. Equation (1) is intended to represent the expected profit maximization problem of a typical producer.

Under a profit maximization framework, the utilization of a higher coverage level involves exchanging a costlier fixed premium expense for a higher yet indeterminate conditional indemnity. The balance of real or self-imposed liquidity constraints and debt obligations are accounted for in this model, as it may constrain the farm from increasing its coverage level even if the expected return from doing so would be positive. The payment of a higher premium due to a higher coverage level selection is a definite shift of the revenue distribution downward by the amount of the premium minus subsidy; the upward shift due to an indemnity receipt is based on a producer's given yield probability distribution for a given crop.

While a profit maximization model is utilized for this thesis, characteristics from ARMS such as education and operator age are also considered, as well as other household and demographic characteristics. In addition, alternative income sources are considered as these are likely to affect the cash constraint and perceived revenue risk of the producer, thus off-farm income earned by both the producer and other household members is considered. The degree and type of farm indebtedness in addition to other potential determinants would also likely affect the producers' perceived risk. Part of the purpose of this thesis is thus to evaluate the effect these characteristics have on coverage level decisions.

The signs of many of these variables are theoretically ambiguous. For example, older producers might have a higher likelihood of being risk averse and therefore, may be

more likely to purchase high coverage levels. However, older producers are also likely to have higher equity and thus more likely to self-insure or insure under the lowest coverage levels. It is well-known many agricultural lenders will only offer credit if farmers are enrolled in FCI, which likely influences participation decisions; however, it is unknown how lenders might influence coverage level selection.<sup>22</sup> The producers who are required to insure, may enroll in lower coverage levels unless forced to select higher ones by their lender. Farm size might also affect crop insurance decisions due to more professional management among larger farms, more motivated agents pitching to larger farms due to higher commission potential, and/or lower transaction costs per insured acre. Education level also may have an ambiguous effect, with an increased awareness of risk management tools such as futures and options potentially lowering purchase incentives, while the likely greater understanding of insurance and premium subsidy potentially increasing coverage level selection.

Historically, increases in subsidy levels have increased participation and it follows that an increase in subsidy across all coverage levels would increase the expected return and encourages higher insurance coverage levels. Rating changes meanwhile are still ambiguous due to the distortion caused by the subsidy. Since subsidy is offered as a percentage of premium rates, a higher premium rate results in increased subsidy transfer to the farmer, while also increasing farmer premium costs. Since crop insurance is rated to be actuarially fair however, this should mean that farmers can expect a higher indemnity in correlation with the higher premium.

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<sup>22</sup> 7 CFR § 762.123 Insurance and farm inspection requirements.  
<https://www.law.cornell.edu/cfr/text/7/762.123>

The amount of crop insurance/coverage level purchased seems likely to be affected by mean yield and yield distribution in a particular area. *Ceteris paribus*, producers with wider/more variable yield distributions are likely to receive an indemnity at lower coverage levels, thus we acknowledge they might have comparatively less incentive to purchase higher coverage levels. (Note however, that due to the positive expected payout from crop insurance, that high yield variance farmers still have significant incentive to buy up in coverage.) The coverage level purchased however, might be inversely associated with yield dispersion measures. Farmers with smaller yield distributions who purchase insurance may well buy higher levels of coverage, as measured by maximum indemnities, than farmers with more variable yields simply because they require higher yield coverage levels in order to have the same likelihood of receiving an indemnity, especially if shallow losses are typical in their area.

Consider two farms, one in the Midwest and one in the High Plains, each having the same average corn yield of 160 bushels per acre. In addition, the distribution of the high plains farm ranges from 80 to 240 and the Midwest farm's yield distribution ranges from 140 to 180. A coverage level of 50% provides the High Plains farm, assuming the distribution is somewhat uniform, coverage for a much greater potential loss than does a 50% coverage election for the Midwest Farm. In order to have an equal probability of receiving an indemnity, the Midwest farm must thus opt for a higher coverage level.

Now consider a profit maximization framework subject to a liquidity constraint. Producers are assumed to maximize the expected profit at year end by choosing the number of acres of each crop type and input levels including the coverage level of their

crop insurance policy. Once the decision to enroll under a particular policy is made, producers make farm level, policy, coverage level, and type decisions simultaneously. Crop yields and prices are stochastically determined in this model and if the producer is not risk neutral, then the optimal input choices will be sensitive to price and yield distributions in their area.

Expected profit is equal to the discounted value of the difference between revenue and costs from period  $t$  to the terminal time  $T$ , where  $E$  is the expectation operator.

Mathematically,

(5.1)

Max  $\pi =$

$$E \left[ \sum_{t=1}^T a_{it} \left( \sum_{i=1}^I P_{it} Y_{it} + I_{it} [Y_{it}^b, Y_{it}, P_{it}^b, P_{it}, L_{it}] - \theta_{it} [Y_{it}, P_{it}, L_{it}, s_{Cit}, F_{it}] - \sum_{j=1}^j w_{it} X_{it} - C_i \right) - \lambda_1 \left[ \theta_{ij} [Y_{it}, P_{it}, L_{it}, s_{Cit}, F_{it}] + \sum_{j=1}^j w_{it} X_{it} + C_i - M_t(\pi_{t-1}, B_t(E_t)) \right] + ARC_{it} + PLC_{it} \right]$$

where the subscript  $t$  denotes year and the subscript  $i$  denotes the crop. The harvest price of the  $i$ -th crop at time  $t$  ( $P_{it}^b$ ) is intended to be reflective of the market price for crop  $i$  during harvest. The projected (expected) price is denoted by  $P_{it}$ . Since the projected price is denoted from the futures price, the farmer's expectation and the RMA projected price are assumed to be the same. Yields are denoted by (i.e. the harvest yield)  $Y_{it}^b$ , planted acres by  $a_{it}$ , the expected indemnity to be received from crop insurance by  $I$ , and crop insurance premium by  $\theta_{it}$ . Crop insurance indemnity  $I_{it}$  is a function of a producer's actual production history (APH) yield (expected yield) for individual crop insurance  $Y$ ,

the projected price  $P_{it}$ , the harvest price  $P_{it}^b$  (which is assumed to be the same for both the insurance price and the price actually received by the producer), and the coverage level  $L_{it}$  the producer selects, which is our choice variable of interest.

Crop insurance premium expense  $\theta_{it}$  is a function of APH/expected yield  $Y_{it}$ , price  $P_{it}$ , coverage level  $L_{it}$ , subsidy rate  $s_{C_{it}}$  (which is a function of coverage level and unit selection), and  $F_{it}$ , a vector of county, farm, and unit specific coefficients.  $X_{it}$  is the quantity of inputs and the  $w_{it}$  is the associated cost.  $C_i$  is the respective summed fixed cost associated with each crop type, we assume fixed cost are fixed over a number of years, hence the single subscript  $i$ . Other revenue may be received in the form of additional supplemental options through the farm service agency, including Area Revenue Coverage (ARC) and Price Loss Coverage (PLC). They enter the profit maximization model as additional income in each period.

The liquidity constraint is included in the  $\lambda$  term. In the constraint, the profit maximization equation is subject to an available cash constraint where premium costs, other variable input costs, and fixed costs must be covered by the available liquid capital the farm has at its disposal;  $M_t(\pi_{t-1}, B_t(E_t))$ , where  $M_t$  is liquid assets as a function of the previous year's profit and the amount the farmer is willing or able to borrow against their equity  $B_t(E_t)$ .  $B_t$  is assumed to be a potentially binding constraint based on the financial position of some producers, such as those that have insufficient collateral to borrow sufficient funds to purchase optimal input quantities. It should be noted that it may be the case that the credit constraint faced by a farmer might be better considered a maximum willingness-to-borrow or an unwillingness to increase their debt-to-asset ratio

due to risk aversion (see Atwood et al., 1996). After all it is reasonable to assume some producers insuring at lower coverage levels may nonetheless have sufficient equity in their operation to borrow additional working capital to maintain the optimal quantity of inputs. For further discussion, see the conclusion of the Results section.

In this model, our choice variables are; coverage level  $L_{it}$ , planted acres  $a_{it}$ , and the quantity of inputs  $X_{it}$ , of which coverage level is our variable of interest. All other variables are considered exogenous parameters for the purpose of this study.

Solving equation (1) for crop insurance coverage level leads to the optimal insurance coverage level, expressed as exogenous variables. Where  $L_{it}$  is a function of  $(P, Y, s_c, Y^b, F, w, C)$  and  $a_{it}$  is a function of  $(P, Y, s_c, F, w, C)$ . How producers respond to changing subsidy rates depends on the functional form of each equation, which is dependent on farm specific traits and characteristics and on their expectation of the first and the higher instances of prices and yields or their amalgamation in the form of revenues and costs, hence the inclusion of the other variables.

Our variable of interest, the coverage level selection, enters into the model as a function of indemnity and premium. The first order condition for our variable of interest is  $\frac{\partial \pi}{\partial L} = E\left[a \left[ \frac{\partial I}{\partial L} - \frac{\partial \theta}{\partial L} + \frac{\lambda \partial \theta}{\partial L} \right] \right] = 0$ , where the sign is dependent on the functional form of the premium and indemnity calculation. We interpret this to mean a producer will on the margin increase their coverage level subject to the liquidity constraint. The  $\frac{\partial \theta}{\partial s} < 0$  as expected. In addition, while not a direct derivation from the model, considerable aggregated evidence in the literature indicates  $\frac{\partial L}{\partial s} > 0$ , meaning increased subsidy rates result in higher coverage level selection (O'Donoghue, 2014).

As shown in the model, coverage level decisions enter the model as functions of expected indemnity payments and known premium cost. It should be noted  $L_{it}$  is technically a discrete choice variable, which for individual level plans (RP and YP) has eight options,  $L_{it} = (.50, .55, .60, .65, .70, .75, .80, .85)$ . However, the ARMS data requests that producers take the average of their coverage levels, in the case they are insuring under more than one policy, this means that many observations are averages between these discrete choices. The producer is likely presented with the options of different premium costs at different coverage levels by their agent, in addition to having the option to estimate their premium at each coverage level using online calculator available from the AIPs and RMA. The profit maximizing producer would choose the coverage level based on the likelihood of indemnity vs. premium expense as well as likely taking cash flow constraints into account. As participation rates in crop insurance for principle crops were over 89 percent in 2015 and even higher in major crop regions, the option of not choosing a coverage level is not considered.<sup>23</sup> Note in the ARMS data analysis, we exclude operations that did not participate or note their coverage level selection.

It should be noted that while most producers are likely to have a positive return on investment from FCI (see Table 1.1), some farms with especially low risk or that only experience very shallow losses, such as rice growers, may not see a positive return, though their premium rates should be extremely low. In fact, farms with negative

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<sup>23</sup> <https://legacy.rma.usda.gov/pubs/2017/portfolio/4.html>

expected returns may make their crop insurance decisions in systematically different ways from those with positive expected returns.

In the model it should be assumed different producers calculate their willingness to pay premium on their deductible risk under their own unique operating, financial, and business setting, thus recognizing that the effects of crop insurance on a firm's profit maximization expectations is specific to each firm. The producer then compares each coverage level and its associated premium and selects the level that results in the highest return on investment. While overtime we believe that to be the maximum coverage level available due to subsidy incentives, from year to year that level may vary due to the farm level factors previously discussed.

Although the first order conditions from the model yield mostly ambiguous predictions about the direction of the effects of these variables on coverage level selection, the profit maximization model provides a realistic framework in which to view how a business would make such decisions. In addition, the model as constructed suggests that coverage level choice is likely influenced by farm level variables. In particular, the variables affecting the cash constraints faced by the farmer and their willingness to increase their debt-to-asset ratios in the event of increased costs.

The FOCs for both the input quantity and coverage level choices indicate that farmers will increase both s.t. the liquidity constraint, with coverage level being maximized s.t. the liquidity constraint and inputs being optimized. However, the results are ambiguous in regard to how producers will choose between the two options in the presence of a constraint. If the price of variable cost inputs rise, will a producer choose to

decrease their coverage level and retain their current fertilizer and chemical application levels or vice versa. The return on both assumed to be positive, with the difference being long term (multiple years) versus short term (1 growing season) payoff. Our empirical model and variables of interest provide some insight into these decisions and farmers' choices between substitutes.

This thesis thus endeavors to provide empirical evidence of the associative effects of farm level variables related to liquidity and costs on coverage level selection decisions. Broadly, we seek to find an estimation of the variables informing producer's farm level management decisions, focusing on their coverage level decision.

## SECTION SIX

## DATA ANALYSIS AND DISCUSSION

This thesis utilizes summary of business (SOB) data from the United States Department of Agriculture (USDA) Risk Management Agency (RMA), Federal Crop Insurance (FCI) area plan rating data from the RMA Actuarial Data Master files (ADMs) and the Agricultural Resource Management Survey data (ARMS). The SOB is a publically available data set spanning all crop insurance programs administered by the RMA.<sup>24</sup> It includes farm premium and indemnity payments, which are used in this research to proxy for production risks. It also includes premium, subsidy, unit, and indemnity data at the county level used to calculate loss ratios used in this research. Data from the SOB are nationally available and aggregated by policy sold in each county back to 1989. The ADM data is made up of premium base rates for particular crops, policies, practices, and types, in addition to policy and crop specific differences. These are the base insurance rates used to price policies by multiplying the rate by total dollars of liability before any loading factors are added. This research utilizes this data as a proxy for premium costs for crop insurance.<sup>25</sup> The ARMS is a national farm level survey conducted annually by NASS and the USDA ERS. It is utilized in this research to determine associations between farm-level variables related to coverage level selection decisions.<sup>26</sup>

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<sup>24</sup> <https://www.rma.usda.gov/SummaryOfBusiness>

<sup>25</sup> <https://legacy.rma.usda.gov/FTP/References/>

<sup>26</sup> <https://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices.aspx>

### Federal Crop Insurance Rating Data

Crop insurance premium calculations involve numerous input variables with the rating of individual plans based upon a producer's unique Actual Production History (APH) (the ten year history of production for a particular crop and unit on a producers farm), the county of the farm, the loss history and amount of data available in that county, the coverage level selected, RMA's detrended yield estimate, the projected price, price volatility factor for revenue insurance, and heteroskedasticity adjustments.<sup>27</sup> Area-based insurance policies are also affected by these factors with the exception of the use of APH, which utilize county yields in the place of a producer's individual yield history. This research utilizes Area Yield Protection (AYP) base rates for individual coverage levels as a proxy for the cost of insurance in a particular county as well as a measure of risk with higher base rates being associated with higher likelihood of crop loss. Individual farm-level yields are more variable than county yields, thus rates are higher for individual plans. However, the county level base rates provide a useful approximation of the relative variance in premium rates across counties.<sup>28</sup>

The RMA ADM data includes base rates for insurance plans by coverage level, county, and year for the variety of crop insurance plans available from the RMA. ARP base rates were pulled from the RMA online database for 2014 and 2016 for the four main crops. Base rates differ for the respective crops depending on type and practice. The

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<sup>27</sup> Note: volatility factors and heteroskedasticity adjustments are only utilized in pricing revenue plans

<sup>28</sup> An online premium estimator is available on the RMA's website, which allows users to examine premium differences across policies

most common and representative type and practice for each crop was used. These are displayed in Table 6.1.<sup>29</sup>

Table 6.1: ADM Crop and Type Specifications

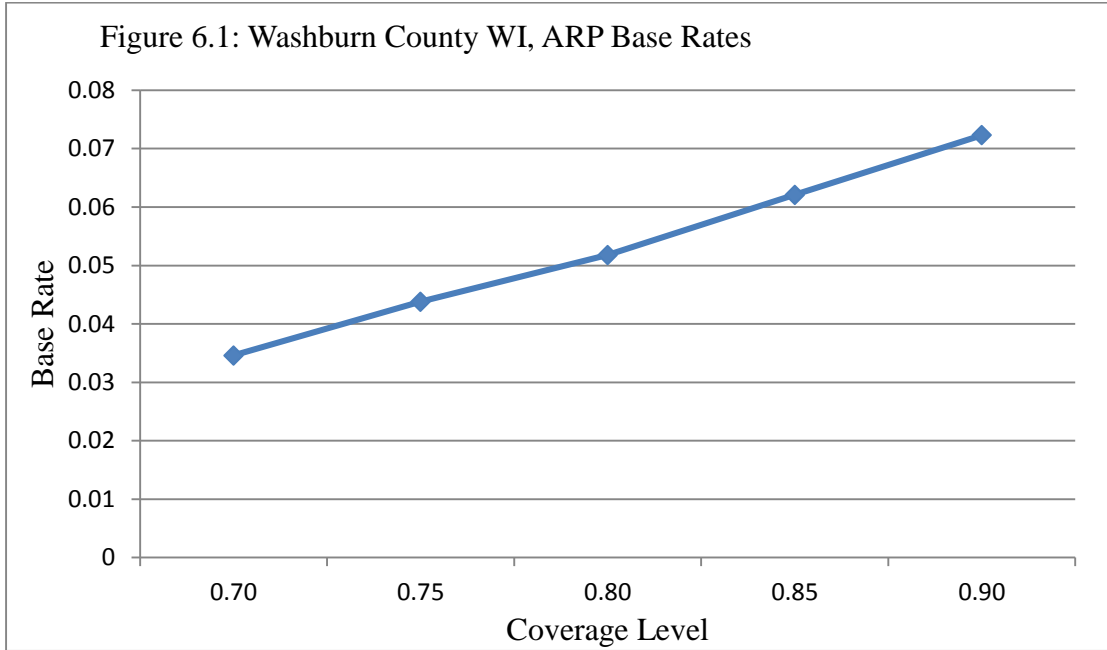
<b>Commodity</b>	<b>Type</b>	<b>Practice</b>	<b>NASS Practice Code</b>
Corn (41)	Grain (16)	Non-Irrigated (3)	nonirr (2), all practices (9)
Soybean (81)	No Type Specified (997), Commodity (91)	Non-Irrigated (3)	nonirr (2), all practices (9)
Cotton (21)	No Type Specified (997)	Non-Irrigated (3)	nonirr (2), all practices (9)
Wheat (11)	Spring (12)	Non-Irrigated (3)	nonirr (2), all practices (9)

*Source: RMA Actuarial Data Master*

While base rates differ across coverage levels, the shape and slope of base rates differ by county and crop. Some counties exhibit more of an exponential shape in their coverage levels, as opposed to a linear shape in others as shown in Figures 6.1 and 6.2 below. In order to account for this difference, which has the effect of making the higher coverage levels relatively more expensive compared with midrange lower coverage levels in counties with an exponential function curve shape, a binary indicator variable was constructed representing whether a producer's farm is located in an exponential or linear shaped base rate county. This shape was determined by defining whether the average of the .90 and .70 coverage level base rates (plus .0075 to account for slight nonlinearities<sup>30</sup>) is greater than or less than the .80 coverage level base rate. Indicating whether a county's base rates increase in a linear or exponential fashion as coverage level rises.

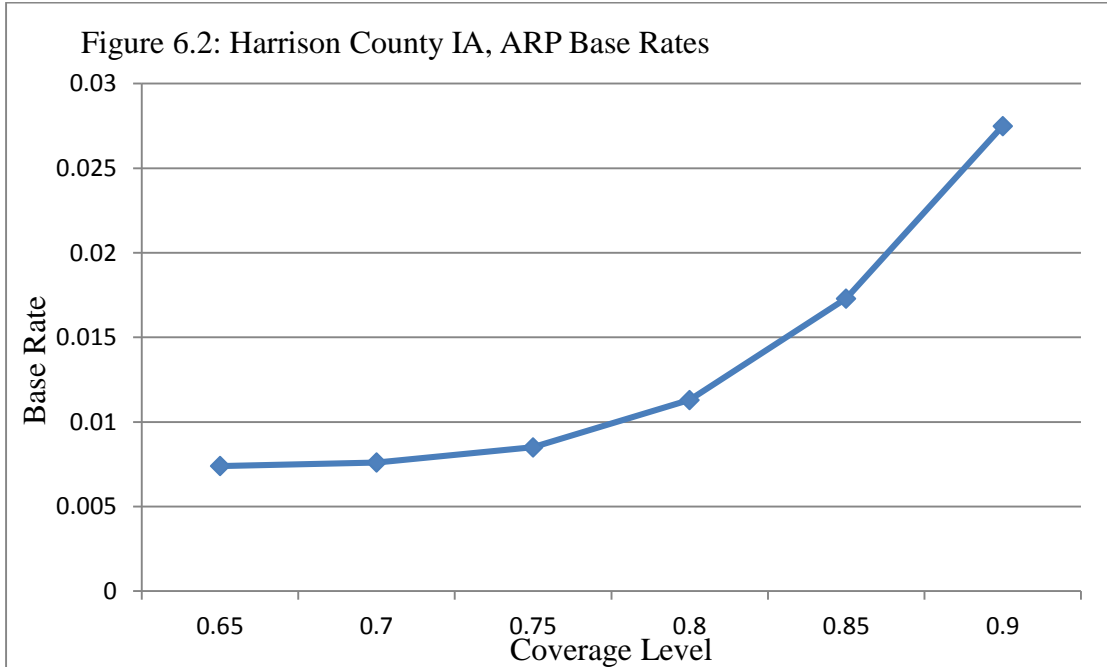
<sup>29</sup> The codes associated with each of these types are defined in the RMA Actuarial Data Master

<sup>30</sup> This number was chosen to account for slight nonlinear variations, which were imperceptible based on visual appraisal.



Source: RMA Actuarial Data Master

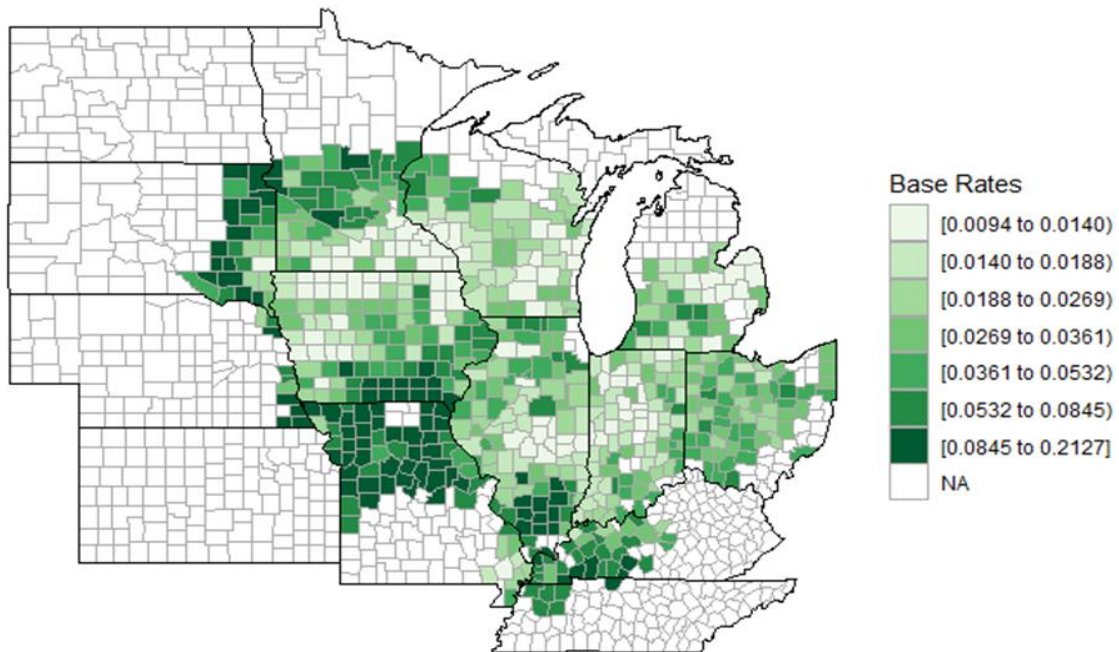
Figure 6.2



Source: RMA Actuarial Data Master

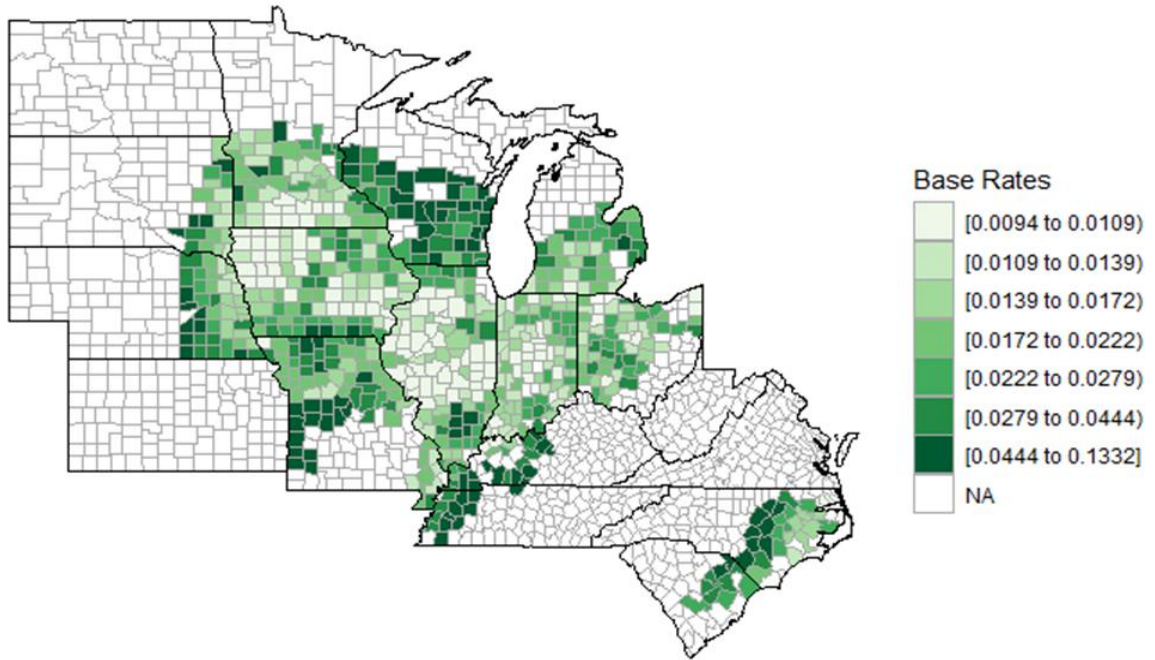
Figures 6.3 and 6.4 display the 2014 AYP policy plan base rates for corn and soybeans. Note that the rates steadily increase the further from the heart of the corn belt a county is located. These counties are rated based on their yield risk potential, thus the counties in the heart of the corn belt having experienced very limited yield loss historically, have significantly lower base rates. These figures also show the limited offer area of the AYP policy, thus limiting our models that include base rates to the counties shown. Base rate observations are not included in the wheat models due to the limited number of observations within the AYP offer area.

Figure 6.3: Corn AYP .80 Coverage Base Rates by County



Source: RMA Actuarial Data Master

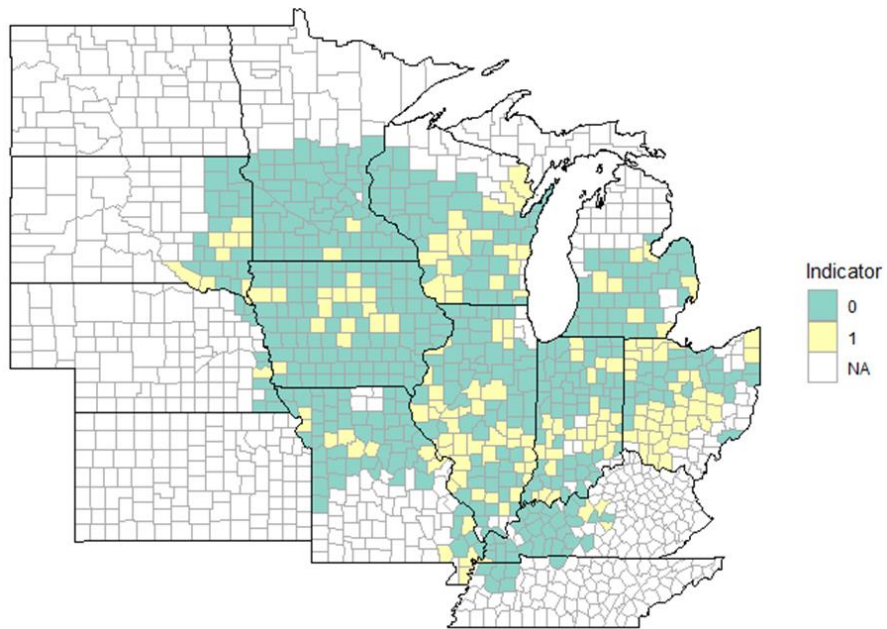
Figure 6.4: Soybean AYP .80 Coverage Base Rates by County



*Source: RMA Actuarial Data Master*

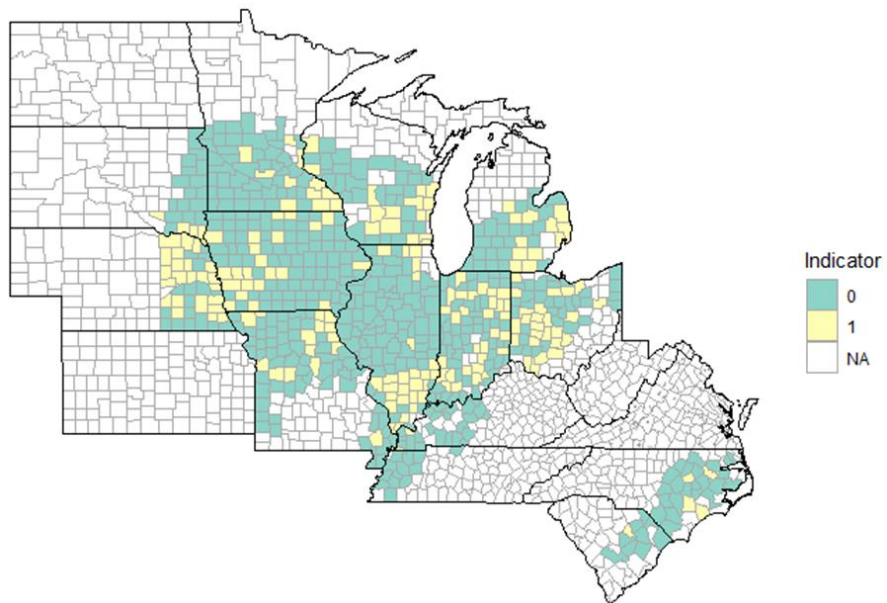
Figures 6.5 and 6.6 display the base rate slope indicator variable, with the number 0 indicating a county where rates increase in an exponential shape as coverage level increase and 1 indicating counties where rates increase linearly. As can be seen, the rates for counties outside of the heart of the corn belt are more likely to increase in a linear shape, particularly for soybean. We hypothesize this is due to low risk counties having a higher probability of shallow losses, thus making the higher coverage levels more expensive relative to lower coverage levels. As opposed to counties outside of the most productive and low risk areas, where a more significant loss is more likely relative to the likelihood of a shallow one, thus the base rates for the lower coverage levels are higher relative to counties with base rates exhibiting an exponential shape.

Figure 6.5: Corn Exponential vs. Linear Cov. Level Base Rate Increases



Source: RMA Actuarial Data Master

Figure 6.6: Soybean Exponential vs. Linear Cov. Level Base Rate Increases



Source: RMA Actuarial Data Master

### Federal Crop Insurance Experience Data

The RMA summary of business contains regularly updated data on all federal crop insurance policies sold. This data includes premium rates, indemnities, subsidies, liabilities, and acres insured, broken down by units and coverage levels down to the county level.

There are three ratios typically used in the evaluation of a policies insurance experience. First the loss ratio is the relationship between benefits and premiums under a policy. The term “loss ratio” means the ratio of all sums paid by the FCIC as indemnities under any eligible crop insurance policy to that portion of the premium designated for anticipated losses and a reasonable reserve, other than that portion of the premium designated for operating and administrative expenses. Second, loss cost ratios (LCR) are a reflection of the actual realized risk in an insurance program, i.e., the percentage of the potential total loss which was actually realized in a given year. Third, earned premium rates (EPR) were derived by taking total premium paid over total liability. This ratio provides a return on total risk from the perspective of the insurance company, while providing the average premium rate paid per dollar of liability from the perspective of the producer.

Loss ratios were calculated by dividing indemnities paid by earned premiums in each individual year for each county. Areas with higher relative production risks tend to correlate with higher relative loss ratios. Premiums and indemnities were aggregated to the county level for a given year and crop and then the ratio of indemnity to premium payments in a given year gives us the loss ratio. As EPR and LCR both have total liability

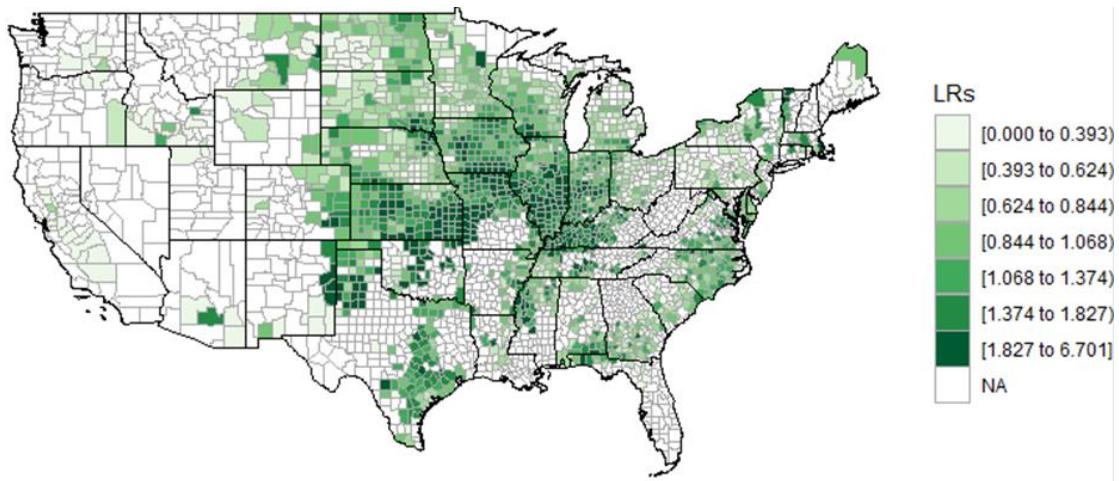
as their denominator, when the LR is 1.00, which means total indemnity and total premium are the same, LCR and the EPR must equal one another. Because of this, given that RMA's all crop long term target loss ratio is 1.00, as mandated by the Food, Conservation, and Energy Act of 2008,<sup>31</sup> over time LCR and EPR should equal one another. EPR is typically a low volatility measurement temporally, as it is a function of the relatively stable measures of total liability and total premium.

For this research, five-year county level loss ratios were utilized to represent the expected return on premium to producers in that county. Figure 6.7 displays the 5-year loss ratios for 2014 by county, relative to other counties in the U.S. As can be seen, insurance experience data exists for a much greater number of counties compared with base rates. It should also be noted that the 2014 5-year loss ratios contain loss data for 2012, which was a record loss year. However, given that the yield losses of 2014 were likely still fresh in operator's memories when making their insurance decisions in 2014 and would be somewhat "watered down" when they made their 2016 coverage decisions, we do not believe this to be problematic.

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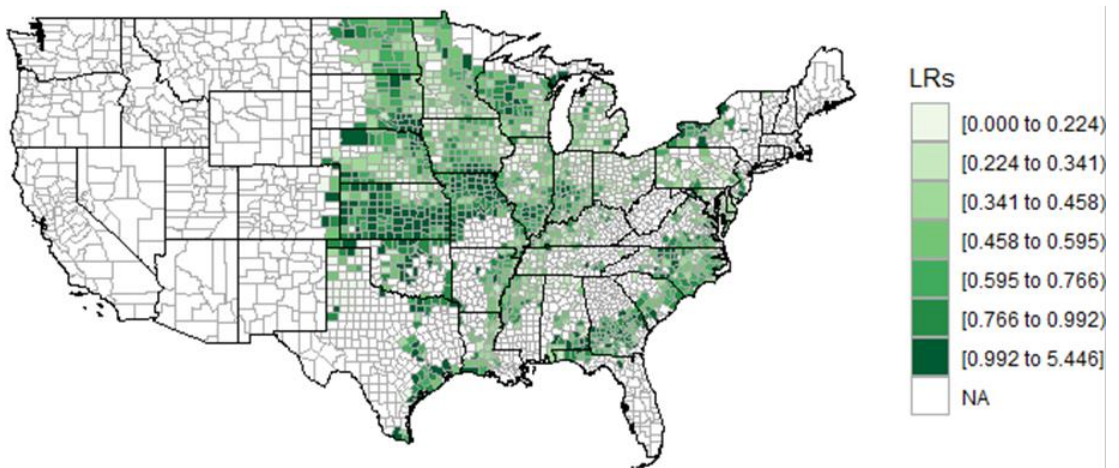
<sup>31</sup> USDA, RMA, Keith H. Coble Thomas O. Knight Barry K. Goodwin Mary Frances Miller Roderick M. Rejesus, 2010, A Comprehensive Review of the RMA APH and COMBO Rating Methodology, Final Report, <http://www.rma.usda.gov/pubs/2009/comprehensivereview.pdf>, accessed May 2015

Figure 6.7: 5-Year Loss Ratios by County for Corn



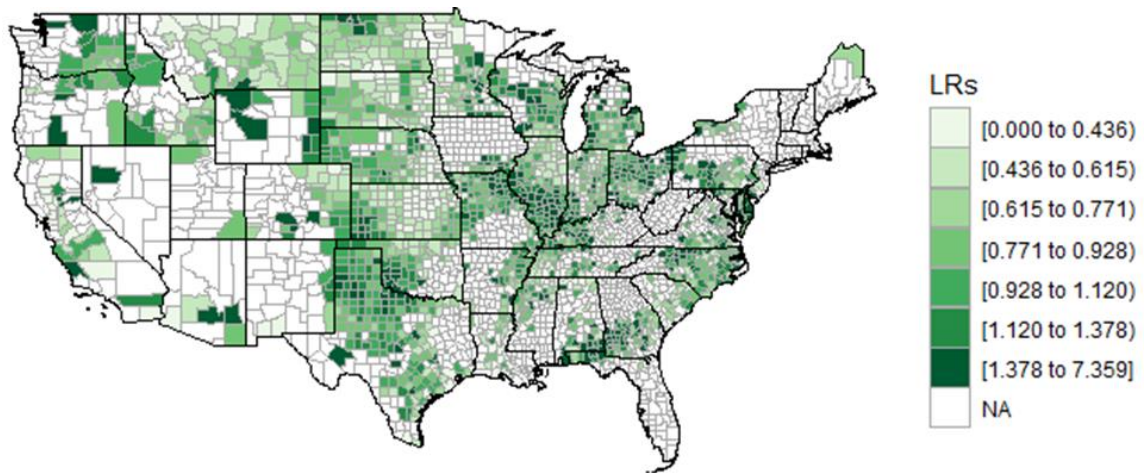
Source: RMA Actuarial Data Master

Figure 6.8: 5-Year Loss Ratios by County for Soybean



Source: RMA Actuarial Data Master

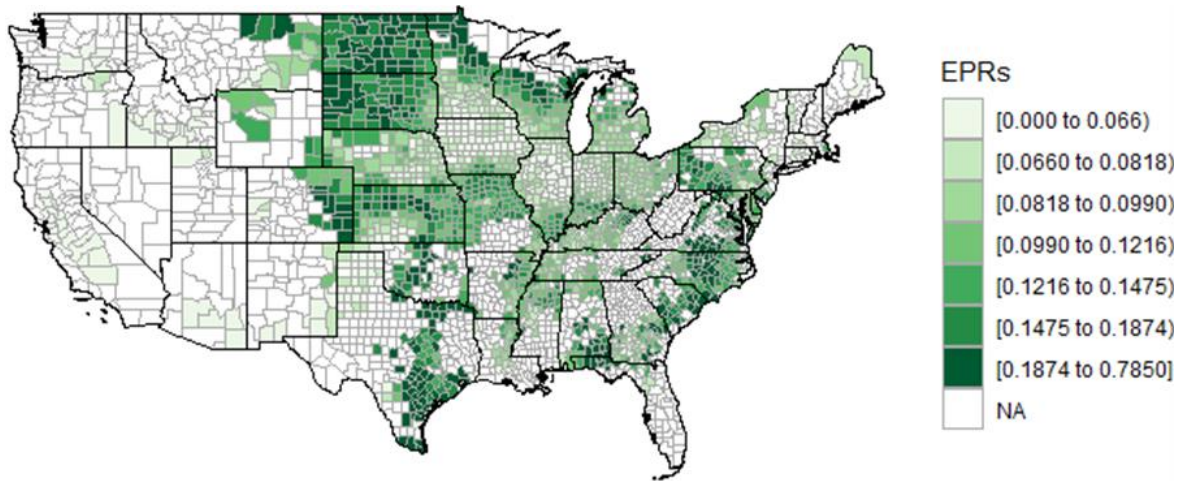
Figure 6.9: 5-Year Loss Ratios by County for Wheat



*Source: RMA Actuarial Data Master*

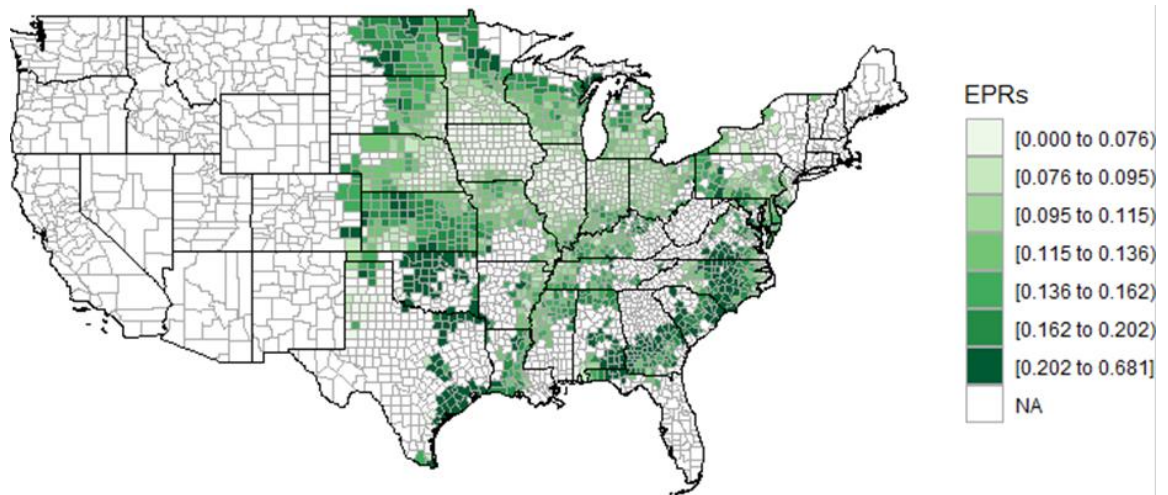
Figure 6.8 displays the 5-year earned premium rates for corn for 2014 by county, relative to other counties in the U.S. As can be seen, the amount of premium paid is far higher outside of the corn belt, particularly in areas such as the high plains and Texas. It should be noted that even if farmers in a particular county were to opt for 55% coverage levels, their liability would be considerably lower along with their premium rate paid, thus changing their earned premium rate only slightly.

Figure 6.10: 5-Year EPRs by County for Corn



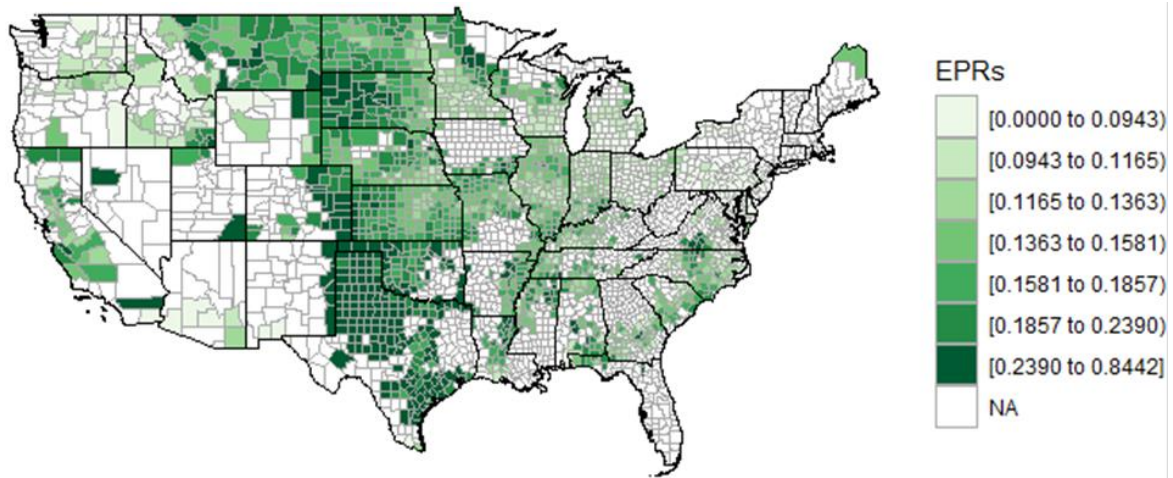
Source: RMA Actuarial Data Master

Figure 6.11: 5-Year EPRs by County for Soybean



Source: RMA Actuarial Data Master

Figure 6.12: 5-Year EPRs by County for Wheat



*Source: RMA Actuarial Data Master*

### Farm Level Data

The Economic Research Service and National Agricultural Statistical Service have conducted ARMS each year since 1996. The ARMS is one of the main sources of information to the USDA for a variety of topics including agricultural resource use, costs, and farm sector financial conditions. The ARMS serves as a valuable source of farm-level data, in part because it asks producers for sensitive information such as debt to asset ratios, income, and ethnicity in addition to being relatively comprehensive. It is conducted in three phases and is the largest nationally representative farm-level survey that is conducted annually. Depending on the version a producer is given, it takes on average from one hour to over one and a half hours to complete (Weber, 2013). The first phase provides complete coverage on general data, such as crops grown and total sales. The second phase surveys production practices and cost reports. The third and final phase

asks for more detailed information on farm finances and household characteristics.<sup>32</sup>

“Operators are selected to assure adequate coverage by state and region and to minimize reporting burden. Strata are based on state, value of agricultural sales and type of farm.”

(NASS, 2018)

The ARMS samples are designed to provide representative coverage for all farms in the 48 contiguous states. The population samples included all businesses that have sold at least \$1,000 of agricultural products in the previous year. The ARMS dataset provides weights to correct for sample selection bias that are based on the probability of being selected and producer response from the national population of farm businesses. This study focuses on the three of the major field crops produced in the United States: corn, wheat, and soybeans. According to the 2012 National Agricultural Statistics Service Census of Agriculture, U.S. corn production accounted for \$64.3 billion in sales, U.S. soybean production accounted for \$35.9 billion in sales, and U.S. wheat production accounted for \$14.2 billion in sales. The ARMS data is thus subsetted down to these crops, which are analyzed individually given that many farmers grow multiple crops.

The ARMS is considered representative of producer decisions regarding crop insurance and coverage level at the national level. Weber (2013) evaluated the significance of the effect of nonresponse bias in ARMS. Using a Probit model, Weber’s findings suggested the nonresponse bias in coefficient estimates have a low magnitude and frequency. Meaning nonresponse bias is predicted to have a minimal effect on econometric models using ARMS. There were no results in which a coefficient estimated

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<sup>32</sup> [https://www.nass.usda.gov/Surveys/Guide\\_to\\_NASS\\_Surveys/Ag\\_Resource\\_Management/index2.php](https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Ag_Resource_Management/index2.php)

from the respondent subsample was outside of a 95% confidence interval. This result was despite data from ARMS and the Census of Agriculture showing non-respondents tend to operate larger farms than producers choosing to respond, even when region, commodity, and household were controlled for. It should be noted that there are obvious input cost and production differences between states, which is partially addressed through the use of a fixed effects model. Since coverage level selection differs significantly in different growing regions, correlation between production factors and coverage level selection would lend evidence toward solving the geographic heterogeneity puzzle.

In 2014 and 2016, the ARMS included additional questions regarding crop insurance choices including coverage for the first time. These included coverage level selection questions for specific crops and plans. Since the ARMS data are an independently pooled cross section, i.e. a different random sample of farms is surveyed each year; we cannot observe how an individual farm's coverage decisions change over a period of years.

This study uses a number of observational variables available through the ARMS including, farm household and operator characteristics, household and farm financial variables, crop and farm inputs, crop insurance selections, farm and household liabilities, asset totals, and financial ratios. These are included to examine the association between these variables and coverage level selection. Table 6.2 contains a summary of these variables and their definitions.

Table 6.2: Summary of Variable Definitions			
	Variable Name	Units	Definition
<b>Financial:</b>			
<b>Revenue:</b>	Off-Farm Income	\$1000s	Off-farm income earned by household
	Gross Farm Income/Acre	100s	Gross farm income per acre
<b>Expenses:</b>	Total VC/Acre	\$100s	Total variable expenses per Acre
	Total FC/Acre	\$100s	Total fixed expenses per Acre
<b>Assets &amp; Liabilities:</b>			
	Debt/Asset Ratio	Ratio	Farm business debt to asset ratio
	Net Worth/Acre	\$1000s	Net worth (equity)
	Total Debt/Acre	\$100s	Total household and farm financial debt per Acre
<b>Acreage:</b>			
	Total Crop Acres	Acres in 100s	Total crop acres operated by farm
<b>Household:</b>			
	Operator Age	Years	Age of Primary Operator
	Number of Owners	Number of Owners	Number of Owners
	Indicator of Operator Education	Four Classes	(1) Less than a High School diploma, (2) a High School diploma, (3) some college including an associate's degree, and (4) at least a four-year college degree

Source: USDA ARMS data 12/11/2018

Household and operator characteristics are included in order to help explain the variation in coverage level selection across farms. These characteristics include operator age, number of owners, and operator education. Operator age is the age of the primary operator. Number of owners is a numerical variable designating the number of owners an operation has. The ARMS classifies education under four indicator categories; (1) Less than a High School diploma, (2) a High School diploma, (3) some College including an Associate's Degree, and (4) at least a four-year college degree. The potential effects of these variables are discussed in later sections.

Farm financial variables related to revenue and expenses are included to help explain a producer's ability to purchase higher coverage crop insurance as well as cover their costs in the event of a loss. On the revenue side, Off-Farm Income is the amount of income earned off of the farm by the household. Gross Farm Income is the total amount of income earned by the farm.

On the expenses side, variables for both fixed and variable costs are included. These are the sum of variable and fixed costs as determined by the ARMS. A number of variables are used to account for a farm's debt and equity. These include the debt to asset ratio, net worth, and total debt (farm and non-farm). Additional variables are used to account for farm size, including total crop acres, as well as the amount of land owned, rented at a fixed rate, flexible rate, and on shares. The number of acres insured is also included. Table 6.3 contains descriptive statistics permitted by the ARMS for the data utilized by this study. Each observation of the ARMS variables discussed above was

individually evaluated for outliers and declined responses (shown as -1s in the ARMS data). Observations with declinations to respond for explanatory variables were removed.

Table 6.3: Summary of ARMS Explanatory & Control Variables

Statistic	N	Mean	Pctl(25)	Median	Pctl(75)
Off-Farm Income	9,262	48,062	0	27,500	56,525
Gross Farm Income	9,493	1,015,212	209,428	510,265	1,113,921
Farm Income to Total Income Ratio	8,003	-1.32	0.28	0.69	0.92
Total Variable Cost	9,493	549,503	109,057	258,454	561,342
Total Fixed Cost	9,493	177,925	31,700	83,200	197,870
Debt to Asset Ratio	9,493	0.24	0.02	0.11	0.28
Net Worth	9,493	3,343,535	823,703	1,938,174	3,940,786
Total Debt	9,262	664,473	99,364	303,732	807,057
Cropland Acres	9,493	1,320	340	800	1,648
Acres Owned	9,493	584	90	288	634
RP Corn Acres	9,493	341	0	100	425
Operator Age	9,493	53.80	47	57	64
Indicator of Operators Education	9,493	2.80	2	3	4
Number of Owners	9,493	1.73	1	1	2
Gross Income per Acre	9,493	983	441	656	946
Total Variable Costs per Acre	9,493	547	224	316	455
Total Fixed Costs per Acre	9,493	149	64	120	199
RE Debt and Interest per Acre	9,493	94	0	32	102.7
Net Worth per Acre	9,493	4,365	1,119	2,672	5,597
Total Debt per Acre	9,262	945	112	420	1,043

Source: USDA ARMS data 12/11/2018

## SECTION SEVEN

## EMPERICAL METHODOLOGY

This study endeavors to empirically measure the associations between cash constraint related farm level variables and coverage level selection. In particular, the differences in size and effects of the associations between different types of costs and revenue on coverage choices are of interest. The following equation characterizes the linear relationship between coverage level selected ( $CovL_{icpt}$ ) by entity  $i$ , for crop  $c$ , under policy  $p$ , in year  $t$ , and the effect of revenue, costs, crop, and farm acreage totals, insurance units, rating, insurance experience, and farmer/household characteristics. As this model utilizes an independently pooled cross section of the 2014 and 2016 ARMS data, the observations are weighted based on the weights provided by the ARMS, which are based on the probability of an operation being selected from the national farm population.

$$\begin{aligned}
CovL_{icpt} = & \beta_0 + \beta_1 OFI_{icpt} + \beta_2 GFacre_{icpt} + \beta_3 VCacre_{icpt} + \beta_4 FCacre_{icpt} + \\
& \beta_5 LR_{cpt} + \beta_6 EPR_{cpt} + \beta_7 BaseRate70_{cpt} + \beta_8 BRslope_{cpt} + \beta_9 DAR_{icpt} + \\
& \beta_{10} NetwAcre_{icpt} + \beta_{11} TotAcres_{icpt} + \beta_{12} Y2016_{icpt} + \beta_{13} NofOwns_{icpt} + \\
& \beta_{14} Oeduc_{icpt} + \beta_{15} Age_{icpt} + u_{icpt}
\end{aligned}
\tag{6.1}$$

The explanatory variables in the above equation are off-farm income earned by household ( $OFI_{icpt}$ ), gross farm income per acre ( $GFacre_{icpt}$ ), total variable expenses per acre ( $VCacre_{icpt}$ ), total fixed expenses per acre ( $FCacre_{icpt}$ ), farm business debt to asset ratio ( $DAR_{icpt}$ ), net worth per acre ( $NetwAcre_{icpt}$ ), the farm's total crop acres

(TotAcres<sub>icpt</sub>), each farm's county base rate (BaseRate70), a dummy variable of whether the county base rates associated with each coverage level increase with an exponential or linear slope (BRslope<sub>cpt</sub>), county average 5-year loss ratio (LR<sub>cpt</sub>), farm's county earned premium rate (EPR<sub>cpt</sub>), number of owner's (NofOwns<sub>icpt</sub>), indicator of operator's education (Oeduc<sub>icpt</sub>), and operator's age (Age<sub>icpt</sub>). In order to control for the upward trend in coverage level, a dummy variable for the year 2016 (Y2016) is included. This controls for the effect that programs such as SCO, which took effect in 2015, may have had.

The end term  $u_{icpt}$  represents the unobservable traits and characteristics influencing a farmer's coverage level selection choice, which are uncontrolled for. Variables that were initially considered and then removed include; ratio of farm household income to total household income (Depend), interest and principal payments per acre (DrintpAcre), total farm operator debt per acre (farm and non-farm) (TotaldebtAcre), total acre leased variables, crop specific acres insured (AcresInsured), alternative or competing crop acres insured (AltCropAcres), and Current Ratio.

The ratio of off-farm income to total farm income was considered but removed due to collinearity with the off-farm income earned by household and gross farm income per acre variables. Since the focus is on cash flow constraints, we believed these two variables more accurately measure the effects of revenue on coverage decision making when evaluated separately. DrintpAcre and TotaldebtAcre were not included as principle and interest payments are already included as part of the fixed cost variable. Other potential acreage control variables were not included due to correlation with the farm's

total crop acres variable. Current Ratio was not included due to a low response rate, decreasing the number of observations.

### Fixed Effects Model

A fixed effects model is included additionally with the linear model to eliminate the potential of unobserved potential bias due to unobserved confounding county-level differences, such as insurance agent density, which might affect coverage level selection, but are not controlled for directly in the model. As discussed previously, the differences in coverage level selection between states are significant, which means the FE model is eliminating a substantial amount of variation if that variation is not accounted for by the explanatory variables. When the fixed effects model is utilized, the parameter estimates are identifying variation between farms within a state. County variables are represented by  $\sum_{i=1}^{c-1} \beta_{24} CF_i$  in equation (6.2), where  $c$  is the number of counties included in the model. Both state and county level fixed effects were considered. Since many counties might have only two or three observations, there was some concern that the majority of the variance would be removed, however when the model is run using either specification, the results stay remarkably consistent. Thus in order to account for differences in growing conditions, premium rates, and agent density, with the greatest precision, county level fixed effects were used. The inclusion of county fixed effects eliminates variation between counties so that the variation in the dependent variables used to identify the parameter estimates is the variation between producers within an individual county.

$$CovL_{icpt} = \beta_0 + \beta_1 OFI_{icpt} + \beta_2 GFlacre_{icpt} + \beta_3 VCacre_{icpt} + \beta_4 FCacre_{icpt} + \beta_5 LR_{icpt} + \beta_6 EPR_{icpt} + \beta_7 BaseRate70_{icpt} + \beta_8 BRslope_{icpt} + \beta_9 DAR_{icpt} + \beta_{10} NetwAcre_{icpt} + \beta_{11} TotAcres_{icpt} + \beta_{12} Y2016_{icpt} + \beta_{13} NofOwns_{icpt} + \beta_{14} Oeduc_{icpt} + \beta_{15} Age_{icpt} + \sum_{j=1}^{S-1} \beta_{24} SF_{icpt} + u_{icpt}$$

(6.2)

### Models without Base Rates

A shortcoming of the inclusion of base rates is the loss of observations outside counties where Area Yield Coverage is offered (refer to maps in the Data Analysis and Discussion Section). Thus the models are also run without the inclusion of the base rate data, which substantially increases the number of county fixed effects in the fixed effects model, in addition to increasing the number of observations.

### Explanatory Variables

Potential influences in coverage level selections choice include cash flow related variables such as total revenue per acre, off-farm income, variable costs per acre, fixed costs, and premium costs. Other influences include farm size and balance sheet variables including; total crop acres, net worth per acre, debt to asset ratio, current ratio, and, total debt per acre, in addition operator/household characteristics. Explanatory variables are included intended to represent each of these.

Off-farm income earned by household (OFI) captures the effect of income diversification and its potential effect on farmer risk aversion. Farm with higher off-farm

income have a more dependable cash flow source, better enabling them to afford premium expenses for the higher coverage leverage levels. Farms with higher off-farm income may also have higher risk tolerances, due to being less dependent on the farm's income to cover costs and thus allowing them to insure at a higher coverage level and cover the expense without the risk.

Gross farm income per acre ( $GFI_{i\text{cpt}}$ ) accounts for the additional financial flexibility provided by additional revenue per acre, allowing for great cash flow flexibility. If farmers purchase lower coverage levels due to income or cash flow constraints, we would expect farms with additional revenue and higher constraints to purchase higher coverage levels when other variables are controlled for.

The other side of the profit and cash flow expectation equation is costs. If farms are reducing their coverage levels in the presence of more significant cash flow constraints driven by lower revenue or higher costs, we might expect higher costs to reduce the average coverage level selected. One idea that has been proposed to explain the differences geographically in coverage level is varying levels of input costs, in addition to revenue expectations. As discussed in previous sections, farms in the high production states tend to insure at higher coverage levels. Higher production per acre is associated with higher expected revenue acre, as well as higher fixed and variable costs per acre. Fixed and variable costs are included separately to account for the different effects they may have on the coverage level choice at the time of the decision.

Consider that fixed costs are a cost and therefore additional downward constraint on cash flow at the time when farmers make their coverage level decision. Since these

costs are already fixed, a producer making variable costs choice including premium expense must take into account that fixed costs must be covered regardless of profit. Thus we predict an ambiguous effect. Higher fixed costs may decrease coverage level choices due to cash flow, however farmers may respond to higher fixed costs by increasing their coverage level in order to insure their expected revenue to the point where they are certain of covering their fixed payments such as real estate or equipment payments.

Many variable cost choices are made around the time of the crop insurance coverage choice selection in early spring. Farmers with higher variable costs may insure at a higher coverage level in order to cover these costs, if they have the flexibility in their cash flow budgets to allow it. However, there is also the potential for farmers to substitute cash flow away from their premium expense and toward other variable costs such as fertilizer, which might result in increased revenue. In this case, we would expect higher variable costs to be associated with a lower coverage level selection.

#### Rating and Insurance Experience Variables

Crop specific Area Yield Protection policy base rates (BR) are included as a proxy of historical yield risk in a county. This variable is the area yield protection base rate before loading at the 70 percent coverage level and is thus uninfluenced by a farm's actual production history, coverage level selection, price risk, or any other loading factors.

Loss ratio (LR) is calculated as the total five-year (total indemnity/total premium) loss ratio preceding the year a farmer insures their crop in the county in which a farm is located. This variable is intended to serve as a proxy for a farmer's expectation of losses in the upcoming year and the influence it may have on coverage level selection. Due to the income effect, higher expected loss ratios may provide operations with an incentive to insure at higher coverage levels in order to harvest additional subsidy. The loss ratios can be interpreted as the average return farmers in a county received per dollar paid in premium (including subsidy) over the five-year period preceding the insurance purchase years in the data (2014 and 2016). Corn, soybean, and cotton loss ratios are all positive. Meaning that farmers could expect over a dollar in return for each dollar of premium paid in insurance, in contrast to most other forms of insurance. Wheat farmers received \$0.88 for every dollar of premium paid. However, the actual loss ratios are considerably higher if subsidy is considered, since the subsidy covers on average roughly half of the total premium (refer to previous sections).

Earned premium rate is the 5-year county level earned premium rate preceding the year in which a farmer makes their insurance decision. This variable is included to represent the average cost of insurance (premium/liability) in the county in which a farm is located. A higher earned premium rate indicates a higher average cost of insurance for farmers within a county. Examining Table 7.1, corn revenue protection has a mean earned premium rate of 0.094. Indicating that the average premium paid per dollar of liability insured is \$0.09. Whereas the average premium paid for wheat per dollar of liability insured is \$0.146. The effect of a higher premium rate without subsidy would be

negative due to the income effect, however due to the current subsidy structure a higher premium rate results in additional absolute subsidy, distorting this effect.

Summary statistics for these variables are included in the table below for each crop and policy type. Higher rates for the higher base rate coverage levels represent the increased likelihood of indemnity payout due to shallow losses. Due to the Area Yield Coverage insurance plan only being offered in counties RMA considers to be significant production areas, observations in which base rates were available are limited relative to the SOB loss ratios and earned premium rates. Base Rates are not included for cotton and wheat as there were too few observations in the ARMS data set in the counties for which base rates are available.

Table 7.1 Summary of ADM and SOB Variables

Policy	Crop	Variable	N	Mean	Median	Std. Dev.
RP	Corn	BaseRate70	4306	0.031	0.017	0.037
RP	Corn	BaseRate80	4306	0.044	0.027	0.044
RP	Corn	BaseRate90	4306	0.068	0.050	0.050
RP	Corn	5 Year LR	5615	1.292	1.193	0.667
RP	Corn	5 Year EPR	5615	0.094	0.080	0.042
YP	Corn	BaseRate70	1748	0.034	0.018	0.038
YP	Corn	BaseRate80	1748	0.047	0.028	0.046
YP	Corn	BaseRate90	1748	0.071	0.051	0.052
YP	Corn	5 Year LR	2748	1.210	1.088	0.674
YP	Corn	5 Year EPR	2748	0.102	0.086	0.048
RP	Soy	BaseRate70	2169	0.014	0.010	0.012
RP	Soy	BaseRate80	2169	0.023	0.017	0.019
RP	Soy	BaseRate90	2169	0.043	0.037	0.026
RP	Soy	5 Year LR	5130	0.568	0.496	0.344
RP	Soy	5 Year EPR	5130	0.096	0.085	0.042
YP	Soy	BaseRate70	879	0.016	0.011	0.013
YP	Soy	BaseRate80	879	0.027	0.020	0.020
YP	Soy	BaseRate90	879	0.049	0.042	0.027
YP	Soy	5 Year LR	2423	0.566	0.496	0.338
YP	Soy	5 Year EPR	2423	0.110	0.099	0.051
RP	Wheat	5 Year LR	1958	0.843	0.805	0.408
RP	Wheat	5 Year EPR	1958	0.146	0.135	0.062
YP	Wheat	5 Year LR	1958	0.843	0.805	0.408
YP	Wheat	5 Year EPR	1958	0.146	0.135	0.062

Source: The USDA RMA summary of business and actuarial data master. Accessed September 2018 and June 2018 respectively.

Control Variables:

The debt-to-asset ratio variable (DAR) captures the effect a farm's leverage ratio has on coverage level selection. It is defined as the ratio of total farm debt to total farm assets. Higher asset levels relative to debt would indicate a farm is less likely to become overleveraged or one that has a higher relative net worth relative to debt obligations, meaning greater equity available to borrow against.

Net Worth/Acre is intended to control for production potential under the assumption that more valuable farmland is associated with a higher value, as well as control for higher valued farms ability to either self-insure or insure at higher levels due to greater access to lines of credit which are typically tied to collateral.

Cropland Acres controls for the size of farms, under the assumption that larger farms may be able to better utilize economies of scale, in addition to the higher potential of having professional or and/or educated management.

Age of primary operator (Age) is a personal characteristic that has been shown to affect risk aversion and is correlated with higher equity.

Number of owners (NofOwns) is a farm characteristic controlling for the number of owners, which may impact the insurance coverage decision.

Operator education (Oeduc) is an operator characteristic that may be correlated with knowledge of the mechanics of crop insurance and farm programs, management style, as well as risk aversion.

### The Dependent Variable

The dependent available utilized in this study is coverage level selected, as noted on each survey respondents returned ARMS. As expected only a limited number of individuals responded to this question on the ARMS for each crop and policy type. Thus the data is subsetted for each respective crop and policy type to include only observations where the coverage level selected response is 50 or greater, as that is the minimum coverage level available under each insurance policy type. Responses to coverage level selection over 85 were assumed to be data entry error, or intended to mean maximum coverage, and are thus reduced to 85.

### Correlation Matrices

It is not unreasonable to assume there may be significant correlation among the farm-level variables. For example, larger farm operations may be likely to have more higher revenue per acre or at least lower expenses per acre due to economy of scale advantages. In addition, higher input costs are likely associated with higher revenue, after all, more nitrogen results in higher yields up to a certain point on the yield curve. Further, as just discussed, many of the variables included could possibly be correlated with coverage level selection.

Thus multicollinearity and endogeneity are persistent issues when using farm level variables. Wooldridge (2015) states that the problem of multicollinearity cannot be clearly defined, however all else equal, for estimating coefficients it is better to have less correlation between our variables. The presence of multicollinearity inflates the variance and standard errors of the estimated parameters and can therefore reduce the significance of the coefficients. For a given dataset, multicollinearity can be reduced by dropping independent variables from the model. However, this can introduce bias if the dropped variables belong in our model. In order to counter this, the scope of this thesis was reduced in terms of variables of interest, with the acres leased and several financial variables which exhibited significant correlation with other controls removed. The consistency of the statistical significance of each of the variables of interest proved particularly robust however, for the most part staying consistent regardless of the model specification that was run and the variables that were included. Correlation matrices between each of the variables included in the models are provided in Figures 7.1, 7.2, and 7.3 in order to assist in determining potential multicollinearity concerns.

The variation inflation factors (VIF) for the models were also computed, which serve as an indicator of multicollinearity. A VIF of 8 for a particular variable would imply that the standard errors are 8 factors higher than if there were no multicollinearity between that variable and the remaining independent variables. Commonly a value of 10 is recommended as a maximum (Kennedy, 1992). However lower recommended values can be found in the literature. When the VIF were calculated for each of the final models, the majority of the VIF for both the variables of interest and controls were between 1 and







## SECTION EIGHT

## FINAL RESULTS AND IMPLICATIONS

The results in Table 8.1 include six regression specifications. From left to right, the results in column (1), the OLS BR&SOB (Ordinary Least Squares with Base Rate and Summary of Business data) model, and column (2), the FE BR&SOB (Fixed Effects with Base Rate and Summary of Business data) model, include the two base rate (BR) variables, BaseRate70 and BR slope, as well as the two Summary of Business (SOB) variables, the 5-year loss ratio (LR) and the 5-year earned premium rate (EPR). Column (1) does not include fixed effects, while column (2) includes county fixed effects. The results in columns (3) and (4), the OLS BR (Ordinary Least Squares with Base Rate data) (3) and FE BR (Fixed Effects with Base Rate data) (4) models, do not include the SOB variables LR and EPR, while the results in columns (5) and (6), the OLS SOB (Ordinary Least Squares with Summary of Business data) (5) and FE SOB (Fixed Effects with Summary of Business data) (6) models, do not include the two BR variables.

To clarify, models (2), (4), and (6) are identical to models (1) and (3), and (5) respectively, but include state fixed effects. Models 5 and 6 include additional observations and states, due the larger dataset they are run on, since the first four models include the base rate variables which limit them to counties and states where the Area Yield Protection plan of insurance is offered. Though the AYP counties do account for the majority of the production and thus most of the corn belt, the observations outside of the AYP offer area are not included except in columns (5) and (6) due to the

unavailability of the base rate data. Results are attained across all farms in the annual ARMS sample across the United States for all corn growing states.

### Standardized Coefficients

To allow for ease of interpretation, models with standardized regression coefficients are included. This removes the potential confusion caused by unit size in the interpretation of the magnitude and importance of a variable's effect on coverage level. The standardization method utilized allows for comparison of the size of the association of the dependent variable to coverage level selection and thus for comparison of the relative strength of each variable. Put differently, the greater the absolute value of the coefficient, the more significant is the association with coverage level. The dependent variables in these models were standardized and thus utilize standard deviations as units. This standardization is achieved by subtracting the mean from the variable outcome and dividing by two times its standard deviation. The resulting variables have a mean of zero and a standard deviation of 1 and thus measure the change in coverage level selection given a two standard deviation increase in an independent variable.

The coefficients below are standardized using the methodology discussed in Gelman (2007), in which he recommends standardizing each input variable by dividing by two times its standard deviation. Note that linear rescaling of independent variables does not change the t-statistics or p-values, but can aid the coefficient interpretations. Dividing by two standard deviations allows for coefficients to be interpreted in the same way as binary inputs. The procedure scales inputs to be comparable with binary variables

and be somewhat symmetric with probabilities that fall between 0.3 and 0.7. For further discussion, see Gelman (2007).

The following models are fit to transformed inputs: the binary independent variables have been centered by subtracting their specific mean in the data, while the continuous variables have been rescaled by subtracting the mean and dividing by two standard deviations. Thus the standard z-score formula is applied with the standard deviation multiplied by two as shown in 8.1.

$$z = \frac{x - \bar{x}}{2s}$$

(8.1)

The independent variable is not standardized in the following table, which allows for easy interpretation of the coefficients as coverage level percentages. The independent variables of interest are the first seven (cash flow related) variables included in the model, followed by the controls. Note that the dependent variable, coverage level, is technically a discrete choice set. Though producers were asked to average their coverage level across policies resulting in observations that were not in the discrete set. This means that the interpretations of the coefficients should be considered more as average associative effects on coverage level rather than changes in producers' discrete coverage choices.

Table 8.1: Results for Corn Insured under RP

	Coverage Level						Std. Dev.
	OLS BR&SOB	FE BR&SOB	OLS BR	FE BR	OLS SOB	FE SOB	
	(1)	(2)	(3)	(4)	(5)	(6)	
Off-Farm Income	0.745*** (0.193)	0.579*** (0.187)	0.678*** (0.198)	0.544*** (0.191)	0.444** (0.203)	0.816*** (0.209)	108,772
Gross Farm Income/Acre	1.319 (0.974)	-0.289 (0.951)	1.842* (0.999)	0.562 (0.973)	5.384*** (1.051)	3.447*** (1.009)	2,441
Total VC/Acre	-1.720** (0.795)	-0.619 (0.779)	-2.061** (0.816)	-1.339* (0.796)	-5.939*** (0.847)	-4.466*** (0.818)	1,520
Total FC/Acre	2.353*** (0.351)	2.437*** (0.338)	3.104*** (0.356)	3.069*** (0.342)	2.910*** (0.347)	2.565*** (0.333)	159
yr5LR	1.249*** (0.215)	1.604*** (0.232)	1.278*** (0.220)	1.723*** (0.238)	0.916*** (0.203)	1.121*** (0.205)	.67
yr5EPR	-4.249*** (0.309)	-4.353*** (0.334)			-3.941*** (0.181)	-3.764*** (0.188)	.04
BaseRate70	-2.213*** (0.190)	-1.988*** (0.207)	-3.267*** (0.178)	-3.119*** (0.192)			.04
BR Slope	0.204 (0.259)	0.018 (0.268)	0.126 (0.266)	-0.044 (0.274)			.41
Debt/Asset Ratio	-1.844*** (0.683)	-1.659** (0.664)	-2.341*** (0.700)	-1.987*** (0.680)	-0.986 (0.686)	-0.259 (0.665)	.66
Net Worth/Acre	-3.371*** (0.284)	-1.774*** (0.294)	-3.152*** (0.291)	-1.712*** (0.301)	-1.783*** (0.276)	-0.807*** (0.275)	7,979
Cropland Acres	0.346** (0.175)	0.568*** (0.179)	0.137 (0.179)	0.362** (0.183)	-0.160 (0.110)	-0.045 (0.119)	1,743
y2016	0.370* (0.210)	0.392* (0.206)	0.797*** (0.213)	0.743*** (0.209)	-0.319 (0.201)	-0.242 (0.195)	.50
Number of Owners	-1.745*** (0.187)	-1.219*** (0.186)	-1.650*** (0.192)	-1.128*** (0.190)	-0.629*** (0.160)	-0.634*** (0.163)	1.13
Education	0.626*** (0.196)	0.704*** (0.194)	0.629*** (0.201)	0.764*** (0.199)	-0.027 (0.194)	-0.254 (0.190)	.84
Operator Age	0.822*** (0.229)	0.511** (0.223)	0.806*** (0.235)	0.531** (0.229)	0.302 (0.215)	0.152 (0.213)	11.83
Fixed Effects		County		County		County	
Observations	3,866	3,866	3,866	3,866	5,075	5,075	
Adjusted R <sup>2</sup>	0.213	0.308	0.171	0.274	0.163	0.276	

Notes:

\*\*\*Significant at the 1 percent level.

\*\*Significant at the 5 percent level.

\*Significant at the 10 percent level.

Explanatory Variable Results Discussion

Comparing the results across the six columns in Table 8.1, the majority of explanatory variables of interest that are significant for any model are also significant in the other models. Off-Farm income is significant at the 1 percent level in all six columns, with a two standard deviation increase being associated with a .44 to .81 increase in coverage level. This may indicate off-farm income reduces the cash flow constraint as perceived by farmers, allowing them to increase their coverage selection. The reader might note the standard deviation for off-farm income is particularly large. This is due to the highly skewed distribution of off-farm incomes in the dataset. Interestingly, if off-farm income observations of over \$400,000 are removed, the magnitude of the positive association between off-farm income and coverage level actually increases. Indicating that off-farm income increases coverage level up to a certain level of off-farm income, at which point the incentives facing a producer might change. One postulate that might partially explain this is that outliers in terms of off-farm income (\$400k+), might have an entirely different set of incentives regarding risk and personal attention than an average representative producer with the median off-farm income level for the entire dataset being \$27,500. For example, the sign of coefficient indicates that producers who likely less liquidity constrained due off-farm income are associated with an increase their coverage level regardless of whether outliers or higher levels of outside income are included, as the theoretical model predicts. However, producers with extremely high off-farm incomes near the outlier zone, while not cash constrained, also are likely not at

significant financial risk in the event of a crop loss, in addition to likely having significant personal and financial interests outside of farming, thus potentially warping their insurance incentives. Though I acknowledge this is beyond the sophistication of the model to recognize as it simply predicts that farmers would maximize their coverage in the absence of a constraint.

Gross Farm Income/Acre is significant at the 10 percent level in column (3) and the 1 percent level in columns (5) and (6). When county fixed effects are added into the model in Column 3, the coefficient loses significance as shown in Column (4). Columns (5) and (6) do not include the yield risk (BR) controls and include observations from a much larger area. Unsurprisingly, the coefficients on this explanatory variable are positive in all models for which they are significant, meaning higher gross income per acre is associated with higher coverage level selection, which is consistent with our prediction of a less binding liquidity constraint being associated with higher coverage level selection. The magnitude of this association is significantly larger in columns (5) and (6), with a 2 standard deviation increase in Gross Farm Income per Acre being associated with a 5.39 increase in coverage level in column (5) and a (3.51) increase in column (6) when fixed effects are added in, compared with an increase of 1.92 and 1.81 in columns (3) and (4) respectively.

The estimated association between variable costs per acre and coverage level selection is consistently negative and significant at either the .05 or .01 level across the six columns when state fixed effects are used (see appendix). Columns 2 and 4 lose significance as shown in the Table below when county fixed effects are added, however

Column 6 is still significant at the .01 level, when county fixed effects are added.

Reviewing column (1), the coefficient suggests that at the mean a two standard deviation increase in variable costs per acre is associated with a decrease in coverage level selection from 1.73 to 2.02 in columns (1) and (3), 5.93 in column (5), and 4.3 in column (6). Once again this appears consistent with our cash flow constraint predictions as it may indicate that farmers adjust their coverage levels downward to make up for a more constrained cash flow budget that would be associated with higher variable costs per acre. This association if continually found in future studies may be the most significant contribution to the literature. Referring back to the theoretical model predictions in the Theory Section, the FOCs' were ambiguous regarding producer choices between coverage level and input quantities. When analyzed individually, the model predicts that coverage level will be maximized s.t. the liquidity constraint. Input quantities will be optimized to maximize profit s.t. the liquidity constraint as well. Left ambiguous without knowing the functional forms of premium, indemnity, or input quantity mixes however, is whether in the presence of a liquidity constraint, producers will on the margin choose to increase their coverage level and thereby their premium expense or if they will increase their inputs to be closer to the optimum quantities. The results shown in Table 8.1 present some evidence that producers appear to choose inputs (variable costs) over higher coverage levels (premium costs). This is in spite of the long run positive return to crop insurance premium, indicating that farmers may be focusing on remaining viable in the short term where crop insurance may or may not pay out, particularly if they're liquidity constrained.

An increase of two standard deviations in fixed costs per acre is associated with an increase in coverage level that is significant in all six columns at the .01 level. The magnitude is also relatively consistent ranging from 2.32 in column 1 to 3.30 in column 3. The difference in sign for associated effects between fixed costs and variable costs is likely driven by a combination of cash flow constraints and risk aversion. Since fixed costs are payments that must be made regardless of revenue, profit, or cash flow, it appears that farmers may adjust their coverage level upward in order to ensure their ability to make those fixed expense payments. This is in contrast to variable costs, over which farmers have greater control. If variable costs are increased, it appears that farmers may respond by reducing their premium expense in order to stay within their cash flow constraint. These results support the hypothesis that differences in expected revenue and costs are likely driving some of the differences we see geographically in coverage level selection. Holding other variables constant, a higher revenue per acre farm with lower variable costs per acre will select a higher coverage level.

When the fixed cost variables are removed from the models and loan payments are added in, the sign and magnitude of the two variables are similar. (Note they are not included in the same models due to a high degree of collinearity, resulting in a lack of significance in the total loan payments per acre variable. Note there is also a high degree of collinearity between variable costs per acre and gross revenue per acre, however the signs of these variables stay consistent when either of the correlated variables are removed from the models.

Reviewing the insurance cost and incentive proxy variables, the 5-year loss ratio and earned premium variable signs are consistent with predictions, with each coefficient being significant at the .01 level for both variables. A two standard deviation increase in the average five-year loss ratio is associated an increase from .92 to 1.60 across the 6 models. When premium rate and cash expenses are controlled for, farmers appear to increase their coverage levels in the presence of higher loss ratios, consistent with theoretical predictions in standard economic models.

Coverage level selection appears to be the most responsive to changes in premium rate, regardless of the model specification used. In the presence of controls, farmers reduce their coverage levels by significant magnitudes when premiums are higher per dollar of liability with a 2 standard deviation increase associated with a 3.76 decrease in coverage level in Column 6 and a 4.35 decrease in Column 2. Higher earned premium rates are associated with lower coverage levels despite the theoretically greater probability of payout and therefore higher expected total absolute return under actuarially fair rates. As a higher premium rate results in a greater burden on cash flow at higher coverage levels, this association also appears to fit into that theory.

Farms located in counties with higher base rates are also associated with a lower coverage level. County base rates were included as a proxy representative of yield risk in a county and are theoretically disassociated with any other rating or loading factors, thus the result is to some extent unanticipated. However, higher yield risk does imply higher yield variability which would allow farms to insure at a lower coverage level and still

have a similar probability of an indemnity payout to a low yield risk area as discussed in the Theory Section.

The base rate associations appear to be consistent regardless of whether county fixed effects are included in either model, although when fixed effects are included there appears to be a slight decrease in the coefficients due to the decrease in variance. A two standard deviation increase in the RP corn base rate is estimated to decrease coverage level by 1.99 based on the Column (2) coefficient and 3.12 in Column 4. These results do not support suggested hypotheses that farmers insure at higher coverage levels in order to harvest subsidy through the positive return on each dollar paid in premium.

#### Control Variable Discussion

The debt-to-asset ratio is statistically significant with a negative sign for the first four columns for which base rates are included. An increase in a farmer's debt-to-asset ratio is typically indicative of decreased solvency. However, it should be noted that such an increase may or may not be indicative of worsened financial condition. The magnitude of the estimated coefficients in both cases means that a two standard deviation increase in the debt-to-asset ratio is associated with a 1.66 to 2.34 decrease in coverage level selection in the columns for which the control variable is significant. It is worth noting that the negative sign on the coefficients indicates that despite the requirement of crop insurance by many agricultural lenders in order to provide operating and real estate loans,

it does not appear that higher debt levels are associated with higher coverage level selections.

Higher net worth per acre is consistently associated with lower coverage levels and is significant at the .01 level in all six columns. This may mean that higher net worth farms prefer to self-insure. Note that higher net worth per acre farms are typically associated with higher coverage levels due to the noted tendency of farms located in the high value per acre corn belt to insure at higher levels, which indicates that farms in the corn belt are insuring at higher coverage levels in order to cover their revenue and costs despite their higher net worth per acre. This is consistent with the result of (Sherrick et al. 2004), who found that producers whom owned more acres were associated with greater nonuse of insurance and when they did insure, chose to insure specific risks, such as purchasing hail insurance, more commonly than lower net worth farmers whom more insured under multi-peril options. The magnitude of these coefficients also appears significant in the non-standardized models (see appendix), with a \$1000 increase in net worth per acre being associated with a decrease in coverage level of 2.7 for corn RP models (1) and (2) and 1.3 in model (6).

Operator's education is statistically significant at the .01 level in Columns (1) through (4), indicating education is positively associated with coverage level selection. The magnitude of the association is relatively insignificant however with a two standard deviation increase in education being associated with a .63 to .764 increase. Note additionally that there are only four levels of education available to select in the ARMS,

and in non-standardized terms, an additional four years of education adds between 0.242 and 0.388 to coverage level.

Operator age is significant in Columns (1) through (4). An increase in age is associated with a positive effect on coverage level selection. A two standard deviation increase in operator age is associated with an increase of .53 to .82 in coverage level. In the non-standardized model, the association is more relatable where an additional 20 years of age is associated with an estimated increase in coverage level of 0.60. This result is consistent with other studies that have found individuals tend to become more risk averse as they age. It could also suggest that older producers have a greater ability to pay the higher insurance premiums accompanying higher coverage levels, having had more time to accumulate net worth.

#### Soybean Results Discussion

The results for soybeans insured under an RP policy in Table 8.2 are displayed in an identical manner to those of corn in Table 8.1. Comparing the results across the six columns in Table 8.2, it is apparent that the results are relatively similar to those of corn, as might be expected given that the majority of U.S. farmers rotate between the two crops. Given this however, it might be further expected that the results should be nearly identical to corn, but as can be noted reviewing the two tables, there is some difference. Mainly several variables such as Total VC/Acre are not significant in several of the models for soybean, whereas they are in the corn results. There are several potential explanations for this, one being that different types of farms with different crop mixes

may have responded to the ARM survey. For example, the corn surveys may have had responses from farms who grow “corn on corn” repeatedly, which was not uncommon during high crop prices, or from farmers in slightly less temperate climates which might limit them to corn or wheat, such as areas of North Dakota. An alternative explanation to these however, relates to the model predictions and the differing input mixes and costs for the two crops. Consider that a large portion of the variable costs for most corn farms are made up by their fertilizer expense. Soybeans in contrast, being legumes, fix nitrogen. This means that farmers apply nitrogen to soybeans at significantly lower rates<sup>33</sup>, resulting in a lower variable costs per acre. This means that variable costs for soybean are less binding relative to corn in the event of constrained liquidity and is perhaps why the soybean results are not identical to those of corn.

Reviewing the results for Off-Farm Income, an increase in Off-Farm income is associated with a slightly higher coverage level. This is the association predicted by our theoretical model, however the magnitude is small given the large standard deviation. Refer to the discussion of the corn results for a discussion of the size of the standard deviations. The association is significant in four of the six models. The two models in which the coefficient is not significant are the FE models that include base rate data (columns (2) and (4)), meaning the variation measured is within county variation between farms located in the soybean AYP offer area, which is nearly exclusively inside the corn belt.

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<sup>33</sup> [http://www.farmdoc.illinois.edu/manage/actual\\_projected\\_costs.pdf](http://www.farmdoc.illinois.edu/manage/actual_projected_costs.pdf)

Gross Farm Income/Acre is significant at the 1 percent level in columns (5) and (6). Columns (5) and (6) do not include the yield risk (BR) controls and thus include observations from a much larger area. Unsurprisingly, like the corn results, the coefficients on this explanatory variable are positive in all models for which they are significant, meaning higher gross income per acre is associated with higher coverage level selection, which is consistent with our prediction of a less binding liquidity constraint being associated with higher coverage level selection. The magnitude of this association is larger in column (5) than column (6), where, when county fixed effects are included, the magnitude decreases by roughly half.

The estimated association between variable costs per acre and coverage level selection is significant and negative in columns (5) and (6). Which is consistent with the negative association between coverage level and variable costs we see in corn and wheat. This consistency serves as a pseudo robustness check to the postulate put forth in the corn results discussion, providing evidence of the choice producers tend toward when choosing between premium expense and other variable input costs.

The positive association between fixed costs and coverage level is significant at the .01 in all six columns. This association is nearly identical to that found in the corn results and given the level of significance in both, indicates considerable robustness. We interpret this as farmers who have higher fixed costs or financial obligations, such as long term lease agreements or land debt, likely increase their coverage levels in order to ensure their ability to make those payments. In the short term, in the case of a cash constraint, farmers will decrease their coverage level and therefore premium payment in

order to divert resources to other variable cost inputs in order to maintain their debt-to-asset ratios as collateral to fall back on (see conclusion). However, the same farmer, if presented with a required payment in the short term, will opt to increase their coverage level to the point where they can cover their payment obligation and decrease risk of default in the short term. This may even be required by a farmer's agricultural loan officer, considering they require crop insurance participation, it might follow that they would require sufficient coverage level to ensure the farmer meets their annual loan obligations.

Reviewing the insurance cost and incentive proxy variables for RP soybean, the 5-year loss ratio is associated with a slight decrease in coverage level in columns (3) – (6). This surprising outcome is in contrast to the results in RP corn, though the magnitudes in soybean are much smaller. This could be a symptom of multicollinearity between the 5-year loss ratio and the other insurance variables, which each have the expected negative signs associated with higher premium rates.

The sign on the earned premium rate variable is consistent with predictions, with each coefficient being significant at the .01 level for both variables. The coefficients are of relatively large magnitudes, with a two standard deviation increase in premium rate associated with a decrease in coverage level ranging from 3.77 to 4.68. Higher earned premium rates are associated with lower coverage levels despite the theoretically greater probability of payout and therefore higher expected absolute return under actuarially fair rates. However as discussed, this result appears to be driven by the fact that a higher

premium rate results in a greater burden on cash flow and farm liquidity. Thus this association appears to be consistent with the theoretical model.

The BaseRate variable is associated with a decline in coverage levels in each of the four models for which it is included. It is significant at the .01 level in three of the columns and the .10 level in column (3). County base rates were included as a proxy representative of yield risk in a county and are theoretically disassociated with any other rating or loading factors, thus the result is to some extent unanticipated. This could be due to the correlation with premium rate, which has a negative effect on coverage level or as mentioned in the discussion of the corn results; higher yield risk does imply higher yield variability which would allow farms to insure at a lower coverage level and still have a similar probability of an indemnity payout to a low yield risk area.

#### Soybean Control Variable Discussion

Higher net worth per acre is significant at the .01 level in columns (5) and (6). This may mean that higher net worth farms prefer to self-insure. Refer back to the Corn RP results for further discussion. The year 2016 variable is also significant in columns (1) - (4), indicating that soybean farmers in the Midwest increased their coverage levels slightly on average between 2014 and 2016. Since this variable is not significant in columns (5) and (6), this might indicate that this trend was not strong enough across the broader U.S. where soybeans are grown to be picked up by the model.

Operator's education is statistically significant at the .01 level in column (1) and columns (4) through (6) and at the .10 level in column (2), indicating education is positively associated with coverage level selection. The magnitude of the association is relatively insignificant however, with a two standard deviation increase in education being associated with a .63 to .76 increase.

Operator age is only significant in model (5), where it has a positive effect. This result is consistent with other studies that have found individuals tend to become more risk averse as they age. As it is not significant in column (6), the limited number of observations in each county surveyed in the ARMS may mean that this variation was removed.

Table 8.2: Results for Soybeans Insured under RP

	Coverage Level						Std. Dev.
	OLS BR&SOB	FE BR&SOB	OLS BR	FE BR	OLS SOB	FE SOB	
	(1)	(2)	(3)	(4)	(5)	(6)	
Off-Farm Income	0.515** (0.238)	0.261 (0.234)	0.482** (0.243)	0.271 (0.239)	0.911*** (0.207)	0.788*** (0.203)	113,356
Gross Farm Income/Acre	0.285 (1.199)	-0.979 (1.222)	0.692 (1.221)	-0.213 (1.247)	3.518*** (0.859)	1.873** (0.851)	1,548
Total VC/Acre	-0.725 (1.080)	1.011 (1.105)	-0.903 (1.101)	0.424 (1.129)	-4.232*** (0.810)	-2.735*** (0.804)	1,259
Total FC/Acre	2.594*** (0.474)	2.093*** (0.467)	3.118*** (0.480)	2.586*** (0.474)	2.690*** (0.348)	2.266*** (0.341)	154
5 Year LR	-0.345 (0.289)	-0.222 (0.344)	-0.954*** (0.286)	-0.727** (0.347)	-0.631*** (0.193)	-0.599*** (0.200)	.34
5 Year EPR	-4.032*** (0.483)	-4.680*** (0.536)			-3.767*** (0.198)	-4.018*** (0.207)	.04
BaseRate70	-0.956*** (0.290)	-0.650* (0.338)	-1.939*** (0.270)	-1.805*** (0.318)			.01
BR Slope	0.629* (0.354)	0.765* (0.393)	0.778** (0.361)	0.935** (0.402)			.41
Debt/Asset Ratio	-0.381 (1.104)	-0.470 (1.095)	-0.578 (1.126)	-0.587 (1.120)	-0.719 (0.672)	-0.365 (0.659)	.65
Net Worth/Acre	-0.757 (0.522)	-0.367 (0.513)	-0.445 (0.531)	-0.212 (0.524)	-2.839*** (0.293)	-1.512*** (0.304)	7,576
Cropland Acres	-0.433* (0.235)	-0.077 (0.262)	-0.349 (0.239)	-0.073 (0.268)	-0.150 (0.118)	-0.177 (0.123)	1,562
y2016	0.730** (0.297)	0.781** (0.307)	0.924*** (0.302)	0.942*** (0.313)	0.200 (0.201)	0.250 (0.200)	.49
Number of Owners	-1.043*** (0.286)	-0.846*** (0.290)	-1.078*** (0.292)	-0.880*** (0.297)	-0.903*** (0.168)	-0.550*** (0.170)	1.15
Education	0.976*** (0.278)	0.559* (0.292)	1.047*** (0.284)	0.659** (0.298)	0.518*** (0.191)	0.435** (0.190)	.84
Operator Age	0.198 (0.342)	-0.133 (0.344)	0.421 (0.348)	0.125 (0.350)	0.861*** (0.215)	0.340 (0.215)	11.83
Fixed Effects		County		County		County	
Observations	1,924	1,924	1,924	1,924	4,644	4,644	
Adjusted R <sup>2</sup>	0.125	0.232	0.090	0.196	0.161	0.243	

Notes:

\*\*\*Significant at the 1 percent level.

\*\*Significant at the 5 percent level.

\*Significant at the 10 percent level.

Wheat Results Discussion

The final results discussed in this section are for RP Wheat displayed in Table 8.3. Insufficient observations existed in the AYP offer area for wheat, thus the base rate variables are not included, leaving only the model results that would compare with the results in columns (5) and (6) in the corn and soybean results tables.

In Table 8.3 column (1) displays the OLS results for RP wheat for the entire ARMS sample, while column (2) includes county level fixed effects. Reviewing the results for wheat insured under RP, first note the size coefficient on Off-Farm Income in column (2) is significant at the .10 level and of consistent sign with the results for corn and soybean.

The most notable result for wheat are the VC/Acre coefficients, which are also consistent in sign with the results from corn and soybeans. The magnitude of the wheat coefficients however, is significantly larger. This effect while at first surprising, likely stems from the differences in liquidity, expected revenues, and costs faced by wheat producers, compared with those of most corn and soybean farmers. Refer to Atwood et al. (1996) for a discussion of Montana wheat farmers financials, where based on their findings, due to the high yield risk faced by wheat farms of Montana, farmers there maintain lower debt-to-asset ratios relative to their peers in other growing regions. Anecdotally, it also seems likely that liquidity constraints might be somewhat more binding for wheat farmers, especially considering their lower annual cash flow receipts, making them particularly sensitive to increases in variable costs. In the presence of such

an increase, it does not seem unexpected that farmers would lower their premium cost by reducing their coverage level in an attempt to maintain their low debt-to-asset ratios as a risk management strategy.

This line of thought also leads into the possibly initially surprising result that FC/Acre coefficient is not statistically significant in either column (1) or (2). However, using reasoning just discussed, it seems likely that if the low debt-to-asset ratios carried by wheat farms found by Atwood et al. (1996) continue to be the case, fixed costs are likely a small percentage of the total cost per acre faced by wheat farmers and thus relatively insignificant in their decision process. Comparing the size of the standard deviations for the two variables this seems likely.

The 5-Year Loss Ratio variable is significant with a positive effect in column (1), though it loses significance in column (2) when fixed effects are added. Weakly indicating that when premium is controlled for, farmers insure under slightly higher coverage levels (1.8 points) when the average loss ratio over the past 5 years in their county is .82 higher (2 standard deviations).

The Earned Premium Rate coefficient is significant in both columns at the .01 level. The magnitude also appears to be economically significant with a .12 increase in the earned premium rate associated with a 4.8 decrease in coverage level. In dollar terms, a \$12 increase in premium paid per \$100 of insured liability is associated with a 4.8 decrease in coverage level selected. This result is consistent with the results found in corn and soybean. It is also consistent with farmers minimizing their cash expenditure on premium in spite of the positive return on crop insurance premium paid.

Table 8.3: Results for Wheat Insured under RP

	Coverage Level		Std. Dev.
	OLS SOB (1)	FE SOB (2)	
Off-Farm Income	0.456 (0.438)	0.803* (0.436)	50,119
Gross Farm Income/Acre	3.353 (4.884)	-0.013 (4.864)	2,864
Total VC/Acre	-16.560*** (6.067)	-10.954* (6.144)	2,623
Total FC/Acre	-1.198 (0.798)	0.324 (0.803)	100
5 Year LR	1.806*** (0.416)	0.455 (0.474)	.41
5 Year EPR	-4.820*** (0.348)	-4.754*** (0.427)	.06
Debt/Asset Ratio	1.216 (1.249)	-0.038 (1.259)	.52
Net Worth/Acre	-0.464 (0.541)	-0.228 (0.562)	2,517
Cropland Acres	-0.208 (0.187)	-0.581** (0.242)	2,529
y2016	-0.295 (0.459)	-0.132 (0.472)	.47
Number of Owners	-1.260*** (0.427)	-0.534 (0.456)	1.2
Operators Education	-1.339*** (0.429)	-0.759* (0.451)	.84
Operator Age	0.375 (0.460)	0.546 (0.464)	11.7
Fixed Effects		County	
Observations	1,786	1,786	
Adjusted R <sup>2</sup>	0.154	0.291	

Notes:

\*\*\*Significant at the 1 percent level.

\*\*Significant at the 5 percent level.

\*Significant at the 10 percent level.

Summary

The interpretations in the previous results discussions are mostly based on the assumption that farmers are either liquidity constrained or unwilling to increase their debt-to-asset ratio by borrowing more in order to pay their premium expense in the fall. We maintain the assumption made for the theoretical model that farmers are profit maximizers, despite not consistently buying up on their coverage in the presence of what appears to be a significant expected return on each dollar of premium paid. These results do not negate the postulate put forward in recent literature (Du. et al., 2016) that farmers are minimizing expenditures. They do however provide some insight into which types of expenditures farmers are minimizing, in particular crop insurance premium.

We acknowledge that these findings are correlational only, however there appear to be very few reasonable alternative explanations for why higher variable costs might be associated with decreased coverage level selection. Future work should focus on regional differences as well as identifying a source of variation from which causal inference could be made. This will likely be more achievable as additional years of data become available, particularly in the presence of policy changes.

### Conclusion and Implications

This study provides evidence toward a potential explanation of the behavioral anomaly exhibited in farmer coverage choices across differing geographic locations. Of particular interest, the results provide insight in an area where our theoretical model predictions were ambiguous; do farmers substitute away from premium expense and toward direct variable input expenses in the presence of a liquidity constrain, thereby decreasing their coverage level? In addition, it allowed us to study and evaluate the existence of other significant associations between coverage level and farm level characteristics, while controlling for fixed county and year factors.

Across crop and insurance policy types this research suggests a few notable findings. First, higher short term/variable costs are associated with lower coverage levels. Second, long term/fixed costs are associated with higher coverage levels. Third, higher revenue per acre and larger farms in terms of acreage tend to insure at higher coverage levels. Finally, that farmers insuring under RP policy plans, regardless of which of the three crops evaluated are grown, are price sensitive to increases in premium rates, despite strong subsidy incentives and positive long term return expectations that accompany higher coverage levels.

As to the question posed in the literature of why farmer's do not insure at the maximum coverage level given the positive long run expected return; we believe the results of our analysis indicate that liquidity concerns may be creating what is effectively

a constraint on their spending, either affecting farmers' ability to afford the premium cost of the higher coverage levels or reducing their willingness make the expenditure at least in the short term. This appears to be particularly true in areas outside of the corn belt, where revenues are lower. Thus, while a utility maximizing farmer would choose to either maximize their total dollars of subsidy received or the percentage of premium subsidized, they may not choose do so in the presence of an expected or perceived cash flow or liquidity constraint. Adding to the evidence of a constraint, is that nearly every variable included in each successive generation of the empirical model, regardless of crop, that related to liquidity or cash flow, indicated that higher expenses or lower revenue was associated with a decrease in coverage level. These included variables that did not make it into the final model due to multicollinearity concerns, such as acres cash leased, which had a negative effect on coverage level, even though the farmers leasing more acres under a cash lease contract have more risk. Indicating that like wheat farmers, even in the presence of higher financial risk, farmers prefer to lower their coverage level and manage risk by minimizing expenditures than by increasing their coverage level and increasing their short term costs.

It might well be the case that the suggested credit constraint faced by farmers may be better considered a perceived constraint or a "maximum willingness-to-borrow". After all it is not unreasonable to assume some producers choosing to insure at lower coverage levels may nonetheless have sufficient equity in their operation to borrow additional working capital to maintain the optimal quantity of inputs including a higher coverage level on their crop insurance coverage. Evidence of this occurring is limited however. If

anything, producers whom borrow additionally to increase their coverage levels are those with higher fixed costs they wish to ensure their continued pay, which is what our results indicate. Thus we postulate that in the presence of increasing input costs, producers will decrease their input quantities (including insurance premium) to a certain point, rather than borrow the additional working capital required to maintain an optimal yield and or profit maximizing input mix.

This theory is supported by the results found in Atwood et al. (1996), in which they found the high yield risk wheat farms of Montana maintained low debt-to-asset ratios, even in the presence of subsidized insurance. Hence we suggest here that farmers likely have a minimum debt-to-asset they like to maintain at all times, thus reducing their willingness to pay high premium costs in the short term that will likely increase their debt-to-asset ratios in the event they do receive an indemnity; i.e. an unwillingness to trade a definite annual fixed premium cost for a higher conditional but indeterminate/uncertain indemnity, particularly over a short term horizon. Thus, in such a case as supported by our results, we believe farmers choosing to insure at lower coverage levels are attempting to ensure they remain viable over the short term (one to five years) via either a real or self-imposed budget constraint.

Thus the suggestion that there are two types of producers that make the same choice of low coverage levels, the first type is low equity producers that have legitimate cash constraints and the second being producers who are attempting to control their short run financial risk using cash reserves and thus minimize expenditures in the short term, even when presented with the choice of a long term positive investment because it is

likely to reduce their cash reserve in the short term. Therefore, we emphasize that this is likely not an absolute constraint for all producers, but one indicative of how farmers choose to manage risk.

The theoretical model, which predicts both that producers will on the margin, maximize their coverage level s.t. the liquidity constraint and secondly that producers would optimize their input quantities s.t. the liquidity constraint, left ambiguous how farmers would choose between the two choice variables when the constraint was binding. The results provide sufficient evidence to hypothesize that farmers may indeed view direct farm inputs and crop insurance premium as substitutes, where in the short term with the payout of crop insurance uncertain, farmers shift from purchasing additional coverage levels to purchasing direct inputs (such as nitrogen) with direct revenue increasing payoffs in the short term (one growing season). This is despite the long run positive return to crop insurance premium paid.

The findings from this empirical analysis also allow for some insight regarding policy implications, in addition to being intended to improve our understanding of the drivers or at least variables associated with different levels of coverage level selection in the event of financial changes at the farm level. The potential implications of this thesis have several applications and repercussions relevant to farm and FCI policy, particularly as coverage level selection is a major determinant of the total liability outstanding during any given crop year.

More specifically the results indicate that farmers might adjust coverage level selections based on changes to costs depending on the types of cost. Based on these

results, long term increases in variable costs, such as fuel and energy prices might lead to a decrease in coverage levels. While farms with higher fixed costs, such as machinery payments, will insure at higher coverage levels. A major change in the farm economy affecting input costs could thus affect coverage levels depending on whether the effect resulted in changes to fixed or variable costs. Changes in revenue could also affect coverage level selection, along with changes in the relative net worth of farms. These associations should be of interest to agricultural lenders, crop insurance industry participants, as well as the RMA due to the implications that changes in the agricultural economy may have on coverage level and thus the total insurance liability in any given area. While unproven by this study, we believe the results provide evidence of our postulate that farms are attempting to maximize profits by attempting to minimize costs subject to annual cash flow constraints.

As the public spotlight has shifted to the treasury costs of the FCI program and the effect of premium subsidy on farm decision making (Smith and Goodwin, 1996), a debate has emerged on whether farmers are utilizing crop insurance to manage risk or maximize return on investment. Given discussion during the 2018 farm bill negotiations, which noted suggestions to reduce costs through a variety of mechanisms, such as the removal of the harvest price option and the capping of subsidy levels (Bekkerman et al. 2018), a future reduction in subsidy rates appears not completely unlikely. Such a change would result in effectively higher farmer paid premium rates. When premium rates are adjusted upward, the results of this research suggest that farmers' coverage levels will be adjusted downward to account for the increased cost. Thus this research indicates that

despite premium subsidy (Goodwin & Smith 2013), farmers are highly price sensitive, indicating they view crop insurance less as an investment, but rather as a risk management tool for which annual cash flow constraints must be taken into account.

In the future, the pattern of results found across crops in this study needs to be further validated, preferably by exploiting variation due to a policy or rating change. In this, the continued inclusion of crop insurance questions in the ARMS, specifically regarding coverage level selection, would be of valuable service. Future work might also address the differences found in associations between farm level variables and coverage selection for farms growing corn and soybeans, as opposed to farms growing wheat.

As a caveat to these suggestions, it should be acknowledged that based on discussion with crop insurance industry participants and agents, farmers are typically slow to respond or adjust their insurance choices. Whether this is due to the potentially daunting complexity of the modern federal crop insurance program or some other factor is unknown. However, we believe it is not unreasonable to consider crop insurance choices, including coverage level selection, to be “sticky” and thus slow to adjust to incentives. Perhaps this is part of the reason that coverage levels crept upward slowly during the decade of high prices preceding the 2014 farm bill.

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