CROP INSURANCE SAVING ACCOUNTS

by

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(Under the Direction of Octavio A. Ramirez and Gregory Colson)

ABSTRACT

Crop insurance is a critical risk management tool for farmers to protect against yield and revenue losses, smooth income over time, and remain a viable operation in times of catastrophic farm losses. However, despite the benefits of crop insurance programs, current crop insurance policies require significant subsidization from the government in order to achieve broad participation. This study proposes a novel alternative design to traditional farm insurance program - Crop Insurance Savings Accounts (CISAs). Our proposed CISA system enables farmers to annually deposit pre-tax income in a personal savings account and draw an indemnity from their accounts when there is a qualified loss. The design has a number of additional advantages including a reduction of farmer moral hazard and adverse selection problems in addition to insurers no longer have to price risks, thus eliminating the associated premium rating problems that weaken actuarial soundness.

INDEX WORDS: Crop insurance, Actuarial performance, Government subsidies, Adverse selection, Crop Insurance Saving Accounts

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DEDICATION

To my devoted parents Changxing Fu and Congdi Hu,

And to my husband, Xiaofei Li, who supported each step of the way.

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CHAPTER 1

INTRODUCTION

Crop insurance is a critical risk management tool for farmers to protect against yield and revenue losses, smooth income over time, and remain viable operations in times of catastrophic farm losses. The U.S. Federal Crop Insurance Program, also known as the Multiple Peril Crop Insurance (MPCI) program, has evolved from a government-run yield insurance program for wheat farmers to a public-private partnership that provides a variety of yield and revenue insurance products to producers of over 100 different crops (Barnett 2000). Created in 1938 and developed through the decades, the MPCI has played a dominant role in agricultural risk management.

While tremendous progress has been made in improving programs, designing federal crop insurance instruments that simultaneously achieve broad participation among farmers at a low cost to taxpayers has proven formidable. The asymmetric information problem – adverse selection and moral hazard – inherent to agricultural insurance markets is cited as the major reason. Moral hazard occurs when policy-holders engage in behaviors that significantly increase the probability of loss and/ or the magnitude of loss. Perfect information and monitoring, even if possible, is too costly to pursue. Therefore, high premiums or high copayments are required to reduce moral hazard problem. However, higher copayments imply lower protection levels and higher premiums discourage participation. The root of adverse selection is the inability of insurers to accurately assess and price the insured's true risk exposure (Goodwin 1994; Ramirez, Carpio, and Rejesus 2011). When the insurer charges a premium that does not reflect each potential insured's actual risk, farmers with high risks tend to participate in the insurance program and those with low risks are not willing to participate. As a result, the program adversely selects farmers whose actuarial risks are higher than their premiums and excludes out those whose expected indemnities are less than the premiums. In order to encourage participation, the government has to heavily subsidize the program. As a result, achieving broad participation in federal crop insurance programs has proven costly to taxpayers. Currently, eighty percent of the planted acres eligible for crop insurance are insured by farmers. These high levels of participation, however, have only been reached after the government subsidized approximately 60% of the effective premiums. Since 2007, government subsidies for crop insurance have averaged about $5.6 billion per year, representing one-third of total expenditures on income transfers and other government payments for program targeted directly to farmers. Total government costs of the crop insurance program, ranging from $3.5 billion in 2002 to $11.3 billion in 2011, sums up to $48 billion just for the past decade (USDA, RMA, 2011).

As will be further detailed later in the literature review, in the last twenty years numerous studies have been conducted with the objective of improving the actuarial performance of the federal crop insurance program through several different avenues. Some have considered alternative insurance forms such as area yield insurance and revenue insurance. Others have focused on developing improved methods for Risk Management Agency (RMA), the program administrator agency under USDA, to accurately assess and price yield and revenue risks. While those studies have shown some promise for improving crop insurance program performance, many of the recommendations are impractical or difficult to implement and, as previously noted, the need for high government subsidies remains. In addition, the most recent work by Ramirez and Carpio (2011) suggests that only marginal improvements are possible even under optimal and seemingly unrealistic conditions.

Given the escalating Federal budget deficit and the pressing need to bring it under control over the next decade, it might be difficult to continue to justify agricultural subsidies of this magnitude. In short, after 20 years of serious but unfortunately unsuccessful efforts to reduce the heavy dependence of the US crop insurance program on government subsidies, it is perhaps time to explore alternatives that can provide an effective safety net for agricultural producers at a much lower cost to the taxpayers. The goal of this research is thus to explore a different insurance design that could be an effective risk management tool for farmers, achieve broad participation, minimize the well-known adverse selection and moral hazard problems inherent in insurance markets without perfect information and monitoring, and drastically reduce the need for taxpayer subsidization.

Specifically, this study proposes an alternative design based on the establishment of crop insurance savings accounts (CISAs). Our proposed CISA system, which has similarities to programs for health insurance (Health Savings Accounts) and unemployment insurance (Unemployment Insurance Savings Accounts)[1] enables farmers to annually deposit pre-tax income in an interest-bearing personal savings account and draw an indemnity from their accounts when there is a qualified loss. If in a given year a farmer's account is exhausted, the government lends money to the account to cover the indemnity. The proposed design reduces the moral hazard and adverse selection problems inherent to the current program. As well, under the CISA system, farm-level risk no longer has to be priced, thus eliminating the premium rating

[1] See Feldstein and Altman (2007).

difficulties that weaken actuarial soundness. In addition, administrative costs are likely to be substantially lower.

The remainder of this thesis is organized as follows. The next chapter introduces the federal crop insurance program in three aspects: MPCI history, product designs and the risk sharing mechanism. Chapter 3 summarizes the program's empirical performance and its associated problems. Chapter 4 presents literature review on crop insurance and summarizes the efforts made to address its problems. In Chapter 5 a detailed design of the proposed CISA system is presented. Chapter 6 describes the methodology and data used to simulate CISA performance for corn growers in the state of Illinois and peanut producers in the state of Georgia. Chapter 7 presents CISA simulation results for Illinois corn and Georgia peanut respectively. Chapter 8 presents sensitivity analyses relating the viability of the CISA system. Finally, Chapter 9 concludes.

CHAPTER 2

THE FEDERAL CROP INSURANCE PROGRAM

The Federal Crop Insurance Program or Multiple Peril Crop Insurance (MPCI) program is a public-private partnership program that provides producers with various risk management tools to address crop yield and/or revenue losses on their farms. Federal Crop Insurance Corporation (FCIC) was created in 1938 to deliver the federal crop insurance program on an experimental basis. Several legislations throughout the 1980s to 2000s developed the program into the current critical farm safety net. The current program is administered by the U.S. Department of Agriculture's Risk Management Agency, and 16 approved private insurance companies sell and service the policies. In purchasing a policy, a producer growing an insurable crop selects a level of coverage and pays a portion of the premium – or none in the case of fully subsidized catastrophic (CAT) coverage – which increases as the level of coverage rises. Currently, the federal government subsidizes about 60% of the total premium. The private entities' losses are reinsured and their administrative and operating (A&O) expenses are reimbursed by the federal government.

The main features of the program are (1) the RMA designs or approves the underwritings of crop insurance policies and rates the premiums ; (2) 16 approved private insurance companies sell and service the policies; (3) Insurers are required to accept all applicants; (4) farmers' Participation is not mandatory expect for those who receive certain program benefits; (5) Premiums paid by farmers are substantially subsidized; (6) the federal government reinsures the insurance companies' losses and reimburses their administrative and operating (A&O) costs (for a more detailed overview see Barnett 2000; Ker 2001; Ramirez, Carpio, and Rejesus 2011; Shields 2010).

2.1 MPCI History [2]

Multiple Peril or "all-risk" [3] Crop Insurance was first introduced by private companies in 1899 and continued to experiment throughout the 1920s. However, these private efforts to provide crop insurance were all failures. This was due, in large part, to "the systemic nature of many crop perils" (Miranda and Glauber 1997; Barnett 2000). Government interference was thus believed to be necessary to address the issue of insuring against farming risks. American agricultural policy underwent a major shift during 1930s in that direct government assistance was thereafter implemented (Kramer, 1983). The Federal Crop Insurance Act of 1938 created the Federal Crop Insurance Cooperation (FCIC), an agency within the U.S. Department of Agriculture, to implement the Multiple Peril Crop Insurance (MPCI) as an experiment to address the effects of the Great Depression and crop losses experienced in the Dust Bowl (Shields, 2010). Initially, the program was started as an experiment and crop insurance activities were mostly limited to major crops (wheat and corn) in the main producing areas. However, several management follies (including allowing local farmer-based committees to determine expected yields) and an inherent adverse selection problem resulted in substantial losses (Smith, 2011). As a result, the program was discontinued in 1941. However the suspension did not last long and by 1944 the FCIC was back in the business of offering MPCI yield contracts to some farmers in some counties for wheat, corn, and cotton.

[2] This detains in this section are heavily drawn from USDA, RMA, 2012a.

[3] Although referred to as "all risk", early private policies and federal crop insurance insured against named perils only. The coverage of perils has increased gradually since the foundation of Federal Crop Insurance Cooperation.

Crop insurance remained an experiment until the passage of the Federal Crop Insurance Act of 1980, which developed the program into a private-public partnership and expanded the program with the goal to effectively substitute for other forms of federal crop disaster assistance. The Act broadened the MPCI in the number of commodities and coverage insured, and removed annual limits on expansion. If sufficient actuarial data were available, the FCIC was permitted to insure any agricultural commodity grown in the United States. And for the first time, premiums were explicitly subsidized to achieve higher participation levels –premium subsidies of up to 30% were instituted. Another important change brought about was a move toward more individualized coverage. Before 1980, insurance yields were based on area (county) average yields, under which all farmers in a county were offered yield coverage options based on the same insurance yield (i.e. county-average yield). The 1980 Act mandated a pilot program using individualized yield guarantees based on the insured farm's yield experience. By 1982, farmers with at least three years of yield data were allowed the choice of insurance based on individual yield calculation (IYC) or the area yield. Subsequently, the IYC procedure was replaced with the approved production history (APH) method for calculating the insurance yield on most crops. In crop years before 1995, the APH yield was based on ten years of yield experience. If farmers provided fewer than 10 years of yields, county-level yields were used.

Although more producers participated in the crop insurance program after the passage of the 1980 Act, the participation rate did not achieve the level Congress had hoped for. And the goal of replacing other disaster reliefs was not achieved. After a major drought in 1988, ad hoc disaster assistance was authorized to provide relief to needy farmers, since participation in crop insurance was not large enough to allow insurance indemnity to relive farmers' loss. A second and a third ad hoc disaster bill was enacted in 1989 and 1992, respectively. An extremely wet and cool growing season in 1993 caused more losses and led to the passage of another ad hoc disaster bill.

Dissatisfaction with the annual ad hoc disaster bills that were competing with the crop insurance program led to the enactment of the Federal Crop Insurance Reform Act of 1994. This Act legislated mandatory participation for farmers to be eligible for deficiency payments, certain loans, and other farm program benefits. Because participation was mandatory, catastrophic (CAT) coverage was created. CAT coverage compensated farmers for losses exceeding 50 percent of an average yield paid at 55 percent of the price established for the crop for that year (called 50/55). The premium for CAT coverage was completely subsidized by the federal government. Producers must pay a $300 administrative fee (as of the Food, Conservation, and Energy Act of 2008 – "2008 Farm Bill") for each crop insured in each county and can buy up the coverage by paying a premium. The Reform Act of 1994 also increased the level of subsidies for higher-level coverage, called "buy-up" or additional coverage.

In 1996, Congress repealed the mandatory participation requirements due to the producers' complain about compulsory enrollment, but farmers who accepted certain other benefits were required to purchase crop insurance or otherwise waive their eligibility for any disaster benefits that might be made available for the crop year. These provisions are still in effect. And nowadays, many banks require farmers' participation in the program for loans. In the same year of 1996, the Risk Management Agent was created to administer FCIC programs and to conduct research on crop insurance.

Participation increased significantly after the enactment of the 1994 Reform Act, which however did not stop the need for more subsidies. In 2000, Congress passed the Agricultural Risk Protection Act (ARPA) which further increased premium subsidies for coverage levels above CAT to encourage purchase of higher level insurance and encouraged development of new types of insurance products. This Act expanded the role of the private sector allowing entities to participate in conducting research and development of new insurance products and features. Despite large gains in participation, Congress continues to pass ad hoc disaster legislation. Two years after ARPA, Congress passed supplemental disaster assistance to cover 2002 crop losses.

The 2008 Farm Bill encouraged expansion to cover more commodities and increased subsidies for insuring at the more aggregate enterprise unit level. Congress chose to revise the legislation in the 2008 Farm Bill to achieve budget savings and to supplement crop insurance with a permanent disaster payment programs (Shields, 2010). In addition, the 2008 Farm Bill required purchase of crop insurance for farmers who wanted to be eligible for the new Supplemental Revenue (SURE) standing disaster aid program for crops.

In summary, the Federal Crop Insurance Program, commonly known as MPCI, has been offered to U.S. farmers since the 1930s. Originally available only through the federal government, the program has been operated since 1981 as a private-public partnership. Thereafter three legislations (the 1994 Reform Act, ARPA of 2000 and the 2008 Farm Bill) have encouraged expansion of the program in terms of scope (commodities insured and regions available), premium subsidy levels, and arrays of insurance plans. Now the Federal Crop Insurance Program is a critical farm safety net insuring 262 million acres with liabilities of $ 223 billion. Currently over 80 percent of the planting acres eligible for crop insurance is insured by farmers.

2.2 MPCI Products

The MPCI program provides an array of insurance products, which basically fall into two categories, yield-based and revenue-based crop insurance. The traditional MPCI product is a farm-level, multiple-peril, crop yield insurance policy called the Actual Production History (APH), which insures against yield losses due to adverse weather and unavoidable perils such as insects and diseases. When purchasing APH policy, a producer is assigned a “normal” crop yield based on the producer’s actual production history (APH). A producer is required to present 4 to 10 years of continuous yield records. The simple average of these records yields the producer’s APH. If a farmer cannot provide adequate records of at least 4 years of data, he or she is assigned a transition yield (T yield) for each missing year of data, which is based on the county average yield of the crop (Cobel et al. 2010). The yield-based policies protect against yield losses and trigger an indemnity if the realized yield is below a guaranteed yield based on APH yield. When a yield loss occurs, the indemnity is calculated as the value of the yield loss at the selected price level (USDA, RMA, 2012b):

(1) $Imdenity = price\ selection\ \times max[0, (yield\ guarantee - realized\ yield)]$.

Where $guaranteed\ yield = coverage\ level\ \times APH\ yield$; And $price\ selection = (1 - copayment) \times established\ price$; The established price is the crop price set annually by RMA prior to planting, based loosely on future prices. The price selection is essentially a percent of the established price.

The Catastrophic (CAT) policy created by the 1994 Reform Act provides a 50 percent coverage level at 55 percent of the established price per unit of production (bushel, pound, etc). This implies a 45 percent copayment. The premiums for CAT are fully subsidized by the federal government but require farmers to pay an administration fee of $300 (as 2008 Farm Bill) per crop per county. CAT policies provide insurance protection at the “basic unit” level. A basic unit covers land planting the insured crop in one county with the same tenant/landlord. Share-rented acreage is divided by share-partners.

Farmers can select to buy additional coverage with higher coverage level and price selection. The producers can elect to buy up to a coverage level 75 percent (and in some areas to 85 percent) by 5 percent increment of their APH yields. Meanwhile, they can, and generally do, choose to reduce co-payment to 0 percent. Farmers are charged premiums on all buy-up policies. The premium rate varies by crop, region, practice, and choice of coverage level and price selection. But higher coverage generally receives more subsidies. With buy-up policies, farmers are allowed to subdivide basic units into smaller optional units according to certain guidelines. This increases the probability of triggering an indemnity on any given insured unit. Those who choose to forgo optional units receive a 10 percent premium discount. The premium rating procedures of APH essentially take two steps. In the first step, the historical loss cost experience for a crop in a county is used to develop county base rates. Then in the second step, these county-level base rates are then adjusted to form individual rate using the producer’s APH record and factors such as coverage level, unit format, crop type, and crop practice (Cobel et al., 2010).

APH plan accounts for 90 percent of the yield-based policies sold. Besides CAT coverage and APH plan, there are three additional yield-based policies, which are based on the same insurance design of APH plan, but have some differences in insured unit and/or the reference to trigger indemnity payment. Yield Protection Insures producers in the same manner as APH polices, except a projected price is used to determine insurance coverage. The projected price is determined based on daily settlement prices for certain futures contracts. Dollar Plan provides protection against declining value due to damage that causes a yield shortfall. The amount of insurance is based on the cost of growing a crop in a specific area. Group Risk Plan (GRP) insures against widespread yield loss of a crop in a county and uses a county yield index as the basis for determining loss. Coverage levels are available for up to 90 percent of the expected county yield. GRP involves less paperwork and costs less than plans of insurance against individual loss. This insurance is primarily intended for producers whose crop yields typically follow the average county yield. Not all policies are available for all crops. For example Actual Production History (APH) coverage is no longer offered for barley (includes malting type), canola and rapeseed, corn, cotton, grain sorghum, rice, soybeans, sunflowers, and wheat since 2011.

Revenue-based policies were introduced after yield-based plans, in mid-1990s, to protect against revenue losses resulted from yield loss, price decrease, or both. The basic form, Actual Revenue History (ARH), first introduced in 1997 as a pilot buy-up option for major crops, has many parallels to the APH plan, with the primary difference being that instead of insuring historical yields, the plan insures historical revenues. For revenue insurance policies, indemnity is triggered by shortfall in revenue:

(2) $Imdenity = max\ [0, (revenue\ guarantee - realized\ revenue)]$.

Where $guaranteed\ revenue = coverage\ level \times (APH\ yield \times estalished\ price)$. The established price is typically a pre-planting monthly average of closing futures prices on the harvest contract; and $realized\ revenue = realized\ yield\ \times harvest\ price$. Harvest price is harvest-time monthly average of closing futures prices on the harvest contract.

There are also different revenue insurances in addition to Actual Revenue History (ARH), according to insured unit and/or reference to trigger indemnity. Adjusted Gross Revenue (AGR) and AGR-Lite insure revenue of the entire farm rather than an individual crop by guaranteeing a percentage of average gross farm revenue, including a small amount of livestock revenue. Group Risk Income Protection (GRIP) insures against widespread loss of revenue from the insured crop in a county. GRIP policies use a county revenue index (based on the estimated county yield) as the basis for determining a loss. This insurance is primarily intended for producers whose crop yields typically follow the average county yield and wish to insure that the combination of yield and price result in a particular level of revenue. Group Risk Income Protection – Harvest Revenue Option (GRIP-HRO) is a supplemental endorsement to the GRIP Basic Provisions. The Harvest Revenue Option changes the trigger revenue to be the result of multiplying the expected county yield by the greater of the expected price or the harvest price and by the producer chosen coverage level percentage. Revenue Protection insures producers against yield losses due to natural causes, and revenue losses caused by a change in the harvest price from the projected price. The producer selects the amount of average yield he or she wishes to insure from 50-75 percent (in some areas to 85 percent). The projected price and the harvest price are based on daily settlement prices for certain futures contracts. The amount of insurance protection is based on the greater of the projected price or the harvest price. Revenue Protection With Harvest Price Exclusion Insures producers in the same manner as Revenue Protection polices, except the amount of insurance protection is based on the projected price only (the amount of insurance protection is not increased if the harvest price is greater than the projected price).

With the goal to simplify the insurance process for agents and promote better understanding of the options available for producers, the RMA issued the “COMBO” rule in late March 2010 to consolidate several crop insurance plans into a single “Common Crop Insurance Policy” beginning with the 2011 crop year (USDA, RMA, 2010). The biggest change is the consolidation of several previous revenue products (Crop Revenue Coverage, Income Protection, Indexed Income Protection and Revenue Assurance) into the above mentioned single revenue product called Revenue Protection and its companion, Revenue Protection with Harvest Price Exclusion.

Since 2003, acres insured under revenue-based policies have exceeded those under yield-based plans. More than two million crop insurance policies were sold in 2011, with revenue-based policies accounting for 58.6% of the total. On a premium basis, revenue policies account for three-quarters of all policies (USDA, RMA, 2012c).

2.3 Private-Public Partnership

The federal crop insurance program is a private-public partnership. The RMA rates the premiums and designs or approves the underwritings of crop insurance policies. 16 approved private insurance companies sell and service crop insurance policies. The private companies are required to accept all applicants eligible for crop insurance. The federal government insures the private insurance companies' losses and reimburses their A&O costs. So, premiums paid by farmers are shared between the federal government and the private companies. Indemnities are also shared according to a complex agreement – Standard Reinsurance Agreement (SRA) – whereby the RMA reinsures the private companies' loss exposure. The current SRA was completed in summer 2010.

Under the SRA and cuts specified in the 2008 Farm Bill, the private companies receive A&O cost reimbursements as a proportion of total premiums, for example, for additional coverage under area-based insurance, 18% in 2009 and 12% since 2011 under 2011 SRA[4]. The reimbursement rate varies by insurance product, depending on whether it is a yield-based or revenue-based policy. The 2011 SRA places a cap for A&O reimbursement at $1.3 billion per year (adjusted annually for inflation) and a minimum at $1.1 billion. The maximum is aimed to control government costs when crop prices rise (which directly affects total premium), while the minimum is intended to protect companies against low market prices.

The SRA also defines risk sharing between the federal government and the private companies. The private insurance companies may transfer some of their risk exposure to the government by choosing to allocate policies within a state to two reinsurance pools: the assigned risk fund and the commercial fund (a third fund ceased to exist since 2011). Within 30 days of the sales closing dates for each crop, companies allocate each policy to one of the two funds that are maintained for each company by state. The companies may transfer some liabilities associated with higher risk policies to the government and retain profits/losses from less risky policies. The companies achieve this by deciding what proportion of premium (and potential for losses/gains) to retain within each reinsurance fund. The by-state retention requirements are 20% for the Assigned Risk Fund and at least 35% for the Commercial Fund. The ceded (not retained) portion of premiums goes to the government. Once the polices are allocated to one of the two funds, the gain/loss sharing for a company's retained business is based on loss ratios as established in the SRA. As a general rule, the higher the loss ratio, the lower the company share of gains or losses, and vice versa.

The assigned risk fund is used for policies believed to be high-risk because it provides the most loss protection to insurance companies through overall "stop-loss" coverage that reinsures

[4] The 2008 Farm Bill allows USDA to renegotiate the SRA once every five years starting the 2011 reinsurance year (the 12-month period beginning July 1, 2010).

against state-level disasters. This is intended to benefits crop producers in that the program is extended to all eligible farmers, regardless of risk. As the assigned risk fund only requires companies to retain 20% of their business, the federal government assumes a large portion of liability associated with high-risk policies. The SRA also specifies a 75% limit by state on the proportion of a company's business that may be placed in the assigned risk fund. In summary, the federal government acts as reinsurers in two ways: by providing overall stop-loss coverage, and to some extent, co-payments for losses on each company's aggregate book of business and by accepting most of the risk for policies placed in an assigned risk fund. The commercial fund is for policies that the companies expect to have the greatest opportunity for profit and only a small amount of losses, compared to the Assigned Risk Fund. One concern has been arisen by researchers is that the approved private insurance companies could adverse selection against government via their reinsurance fund allocation (Shields 2010; Coble, Dismukes, and Glauber 2007).

CHAPTER 3

PROGRAM PERFORMANCE

The federal crop insurance program has experienced rapid growth in participation since the late 1990s and is a critical risk management tool for farmers to protect against yield and revenue risks. However, throughout much of its history the program has experienced problems including the failure of crop insurance to replace other forms of disaster payments, the need of a high subsidy to achieve high participation, low operating and cost efficiency, concerns that the private insurance companies are overly rewarded for the risks they share and that the premium is not properly rated, as reflected in the disparities of loss experience across crops, regions, products and insured units. The remainder of this chapter summarizes MPCI participation development and the associated problems mentioned above.

3.1 MPCI Participation

High program participation rates, widely believed to be condition for crop insurance to effectively replace other forms of disaster assistance, has been a priority of policy makers and program administration since 1980. Table 1 shows the growth of the crop insurance program since 1981. Participation in the program grew slowly in the 1980s, reaching only 55.6 million acres insured in 1988, about 25% of eligible acreage (Glauber 2004). Participation reached 40% in 1989 and 1990, largely due to disaster legislation that required farmers who received disaster payment in 1988 and 1989 to purchase crop insurance in the subsequence crop year. By 1993, participation rate had fallen to 32% of eligible area (Glauber and Collins 2002).

Table 1. Selected Participation Indicators 1981-2011

Crop Year	Policies Sold ($1,000)	Acres Insured ($ mil)	Liability ($ mil)	Indemnity ($ mil)
1981	416.8	45.0	5981.2	407.3
1982	386.8	42.7	6124.9	529.1
1983	310.0	27.9	4369.9	583.7
1984	389.8	42.7	6619.6	638.4
1985	414.6	48.6	7159.9	683.1
1986	406.9	48.7	6230.0	615.7
1987	433.9	49.1	6094.9	369.8
1988	461.0	55.6	6964.7	1067.6
1989	948.6	101.6	13535.8	1212.2
1990	894.8	101.4	12828.4	973.0
1991	706.8	82.4	11216.0	955.3
1992	663.4	83.1	11334.1	918.2
1993	679.2	83.7	11353.4	1655.5
1994	800.9	99.6	13608.4	601.1
1995	2034.3	220.5	23728.5	1567.7
1996	1615.2	204.9	26876.8	1492.7
1997	1319.8	182.2	25459.0	993.6
1998	1242.7	181.8	27921.4	1677.5
1999	1288.8	196.9	30939.5	2434.7
2000	1323.2	206.5	34443.8	2594.8
2001	1297.9	211.3	36728.6	2960.1
2002	1259.5	214.9	37299.3	4066.7
2003	1241.5	217.4	40620.5	3260.8
2004	1228.8	221.0	46602.3	3209.7
2005	1190.6	245.9	44258.9	2367.3
2006	1147.8	242.1	49919.5	3503.5
2007	1137.7	271.6	67339.9	3547.6
2008	1149.3	272.3	89896.7	8679.9
2009	1171.9	264.8	79571.9	5226.3
2010	1140.6	256.3	78098.4	4235.1
2011	1148.2	264.2	113533.6	9986.5
1981-2011 total	962.9	4786.6	976659.5	73014.8
1981-1993 average	547.1	62.5	8447.1	816.1
1994-1999 average	1383.6	181.0	24755.6	1461.2
2000-2007 average	1228.4	228.8	44651.6	3188.8
2008-2011 average	1152.5	264.4	90275.1	7032.0

Source: Risk Management Agency, Summary of Business.

The total producer premium and indemnity over the period of 1980-1993 was $ 409.6 million and $ 816.1 million respectively, which indicates that policyholders on average received about $2 for every 1$ premium paid. Then why participation rates were low throughout the 1980s and early 1990s? The most cited reason was adverse selection (Glauber 2004). Adverse selection occurs because farmers have better knowledge of their risks than insurance providers do (Harwood, Heifner et al. 1999; Barnett 2000). When the insurer charges a premium that does not reflect each potential insured's actual risk, farmers with high risks tend to participate in the insurance and those with low risks are not willing to participate. So the program adversely selects the producers with higher risks while opting out producers with lower risks. In addition, farmers use a variety of risk-management strategies to mitigate the risks they face. Empirical studies on crop insurance participation during this period confirmed that many of these alternative risk management tools had negative effects on participation (See Knight and Coble 1997).

By the end of 1980s, it was clear to policy makers that the subsidy level provided under the 1980 Act was not sufficient to achieve 50% participation rate without either making crop insurance mandatory or increasing subsidy level. As described in the section of MPCI history, ad hoc disaster legislation was passed in each year of 1989, 1990, and 1992. And Congress responded by both making crop insurance compulsory and increasing subsidy levels in the Federal Crop Insurance Reform Act of 1994. Though the mandatory enrollment was short lived and repealed in 1996, it introduced more producers to the crop insurance program. The other two reasons for increasing participation rate after the 1994 Reform Act are higher subsidy rates for buy-up coverage and the introduction of fully subsidized Catastrophic (CAT) coverage, which only required producers to pay an administrative fee of $50 per crop per county (the current fee is $300 per crop per county under the 2008 Farm Bill). Over 220 million acres were insured in 1995, over half of which were CAT coverage. Figure 1 illustrates the program development in terms of acres insured (RMA, Summary of Business). The repealing of compulsory enrollment caused CAT participation decline to 647 million acres in 1997. The CAT enrollment continues to deceasing steadily, reaching 532 million acres in 1999, over 300 million in early 2000s, and ending below 200 million acres in 2011. However participation in buy-up coverage continued to increase more sharply, reaching 182 million acres in 1997, and continues to increase to over 264 million acres in 2011, with an average acres of 240 million throughout the early 2000s.

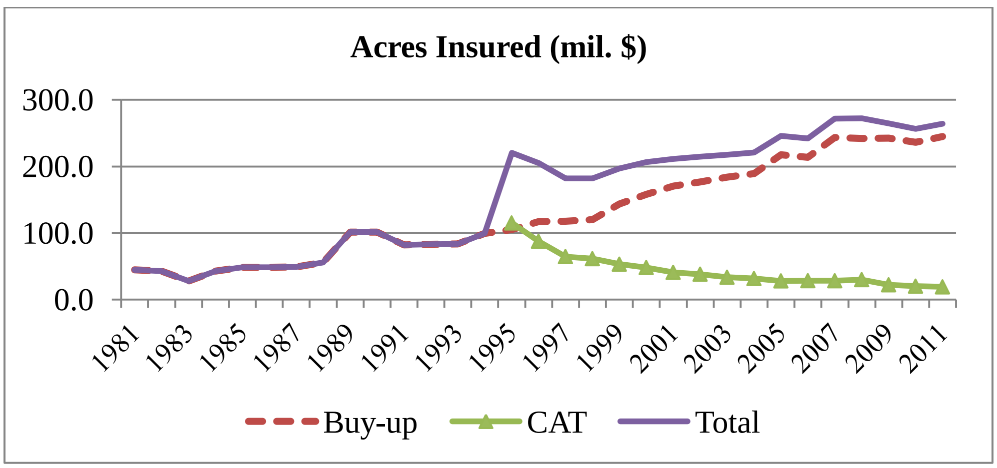

Figure 1. Acres Insured 1981-2011

Insured liability, another indicator of program participation, shows a sharper increase, rising from $6 billion in 1981 to more than $113 billion in 2011 (Figure 2). More acreage, higher crop prices, and increased coverage levels explain the dramatic rise in liability (Collins and Bulut, 2011).

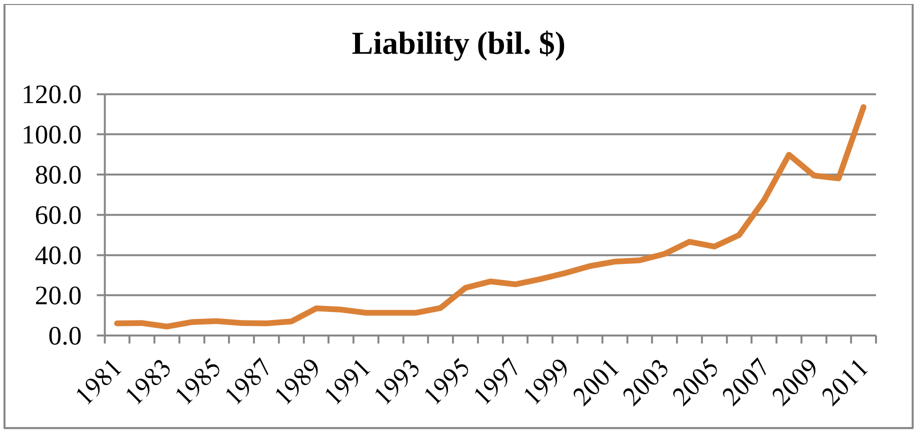

Figure 2. Liability Insured 1981-2011

Since the 1980s, the Federal Crop Insurance Program has played a prominent role in U.S. farm policy and has become a critical risk management tool for farmers to protect against yield and revenue losses. Farmers' participation in the program has increased significantly especially since the 1994 Reform Act. Crop insurance policies are now available for over 130 crops and livestock nationwide, and over 80 percent of the planted acres eligible for federal crop insurance is currently insured by farmers (Smith, 2011).

Several factors account for the participation increase in the crop insurance program. With private sector compensation based on the volume of premium sold, companies and agents have strong incentive to deliver crop insurance to producers. Increases in premium subsidies and government payments for insurance companies have made crop insurance increasingly affordable over time, boosting participation and coverage levels.

Other factors also contributed to the demand increase for crop insurance. Mandatory requirements enacted by the 1994 Act, though short-lived, introduced many producers to crop insurance. Reduction in the level of protection provided by other farm programs and requirements to have crop insurance in order to be eligible for the receipt of hoc disaster payments encouraged participation and higher coverage level. Greater vitality of crop prices and efforts to acquaint producers with crop insurance program may also increase insurance demand.

3.2 Government Costs

The federal government provides explicit and implicit subsidies to support the crop insurance program. The subsidy takes three forms. First, policy-holders receive a premium-rate subsidy, which varies by insurance product and by level of coverage. Second, the private insurance companies are given subsidies as reimbursements for administrating and operating (A&O) expenses. A&O costs reimbursements vary by MPCI product, but for any given product, is defined as a fixed proportion of the total premium associated with each policy. Third, the federal government acts as reinsurer for the private companies' losses.

As discussed above, participation in the federal crop insurance program has grown significantly since the late 1990s; however this growth has been achieved largely by increasing subsidies (Figure 3). Premium subsidies as a percentage of total premium have grown from less than 13 percent in 1981, to 25 percent in early 1990s and to about 60 percent during the past decade since 2001 (Table 2).

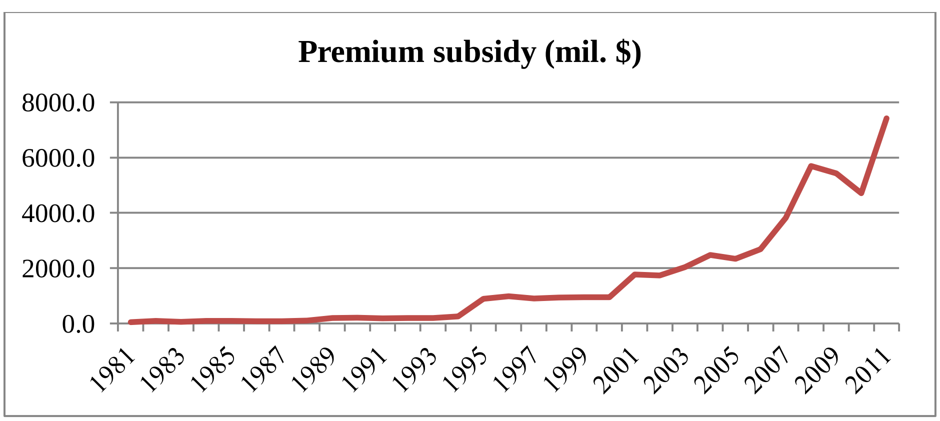

Figure 3. Premium Subsidies 1981-2011

Table 2. Selected Actuarial Performance Indicators 1981-2011

Crop Year	Indemnity ($ mil)	Total Premium ($ mil)	Subsidy ($ mil)	Producer Premium[1] ($ mil)	Net Indemnity[2] ($ mil)	Subsidy rate[3] (%)	Total Loss Ratio[4]	Producer Loss Ratio[5]
1981	407.3	376.8	47.0	329.8	77.5	12.5	1.08	1.23
1982	529.1	396.1	91.3	304.8	224.3	23.0	1.34	1.74
1983	583.7	285.8	63.7	222.1	361.6	22.3	2.04	2.63
1984	638.4	433.9	98.3	335.6	302.8	22.7	1.47	1.90
1985	683.1	439.8	100.1	339.7	343.4	22.8	1.55	2.01
1986	615.7	379.7	88.1	291.6	324.1	23.2	1.62	2.11
1987	369.8	365.1	87.6	277.5	92.3	24.0	1.01	1.33
1988	1067.6	436.4	108.0	328.4	739.2	24.7	2.45	3.25
1989	1212.2	814.3	205.0	609.3	602.9	25.2	1.49	1.99
1990	973.0	836.5	215.3	621.2	351.9	25.7	1.16	1.57
1991	955.3	737.0	190.1	547.0	408.3	25.8	1.30	1.75
1992	918.2	758.8	196.7	562.1	356.1	25.9	1.21	1.63
1993	1655.5	755.7	200.0	555.7	1099.7	26.5	2.19	2.98
1994	601.1	949.4	254.9	694.5	-93.4	26.8	0.63	0.87
1995	1567.7	1543.3	889.4	654.0	913.8	57.6	1.02	2.40
1996	1492.7	1838.6	982.1	856.5	636.2	53.4	0.81	1.74
1997	993.6	1775.4	902.8	872.6	121.0	50.9	0.56	1.14
1998	1677.5	1875.9	946.3	929.6	747.9	50.4	0.89	1.80
1999	2434.7	2310.1	954.9	1355.3	1079.5	41.3	1.05	1.80
2000	2594.8	2540.2	951.2	1589.0	1005.9	37.4	1.02	1.63
2001	2960.1	2961.8	1771.7	1190.1	1770.0	59.8	1.00	2.49
2002	4066.7	2915.9	1741.4	1174.5	2892.2	59.7	1.39	3.46
2003	3260.8	3431.4	2042.0	1389.3	1871.5	59.5	0.95	2.35
2004	3209.7	4186.1	2477.4	1708.7	1501.0	59.2	0.77	1.88
2005	2367.3	3949.2	2343.8	1605.4	761.9	59.3	0.60	1.47

Crop Year	Indemnity ($ mil)	Total Premium ($ mil)	Subsidy ($ mil)	Producer Premium[1] ($ mil)	Net Indemnity[2] ($ mil)	Subsidy rate[3] (%)	Total Loss Ratio[4]	Producer Loss Ratio[5]
2006	3503.5	4579.5	2682.0	1897.5	1606.0	58.6	0.77	1.85
2007	3547.6	6562.1	3823.4	2738.8	808.8	58.3	0.54	1.30
2008	8679.9	9851.3	5690.9	4160.4	4519.5	57.8	0.88	2.09
2009	5226.3	8950.5	5426.7	3523.8	1702.5	60.6	0.58	1.48
2010	4235.1	7593.9	4710.9	2883.0	1352.1	62.0	0.56	1.47
2011	9986.5	11892.4	7412.6	4479.8	5506.7	62.3	0.84	2.23
1981-2011 total	73014.8	86723.1	47695.6	39027.5	33987.3			
1981-1993 average	816.1	539.7	130.1	409.6	406.5			
1994-1999 average	1461.2	1715.5	821.7	893.7	567.5			
2000-2007 average	3188.8	3890.8	2229.1	1661.7	1527.2			
2008-2011 average	7032.0	9572.0	5810.3	3761.7	3270.2			

Notes:

[1]Producer premium is the premium paid by farmers.

[2] Net indemnity is the indemnity in excess of producer premium.

[3] Subsidy rate is the premium subsidy as percent of total premium.

[4] Total loss ratio is indemnity divided by total premium.

[5] Producer ratio is indemnity divided by producer premium.

A subsidy level 0f 60 percent of total premiums indicate that 1.5 dollar was subsidized for each dollar the farmers paid for the crop insurance. CRS estimates that the producer subsidy in 2009 averaged $2,500 per farm, which the calculation including all U.S. farms, not just farms purchasing insurance (Shields, 2010). This high subsidy level on average resulted in a $5.8 billion income transfer per year from taxpayers to agricultural producers since 2007.

The growth of the premium subsidy was due to increased participation and higher subsidy rates throughout the past decades. Table 3 shows the premium subsidy level under four legislations.

Table 3. Increasing Premium Subsidy Level

Coverage Level (%)	Federal Crop Insurance Act of 1980	Federal Crop Insurance Reform Act of 1994	Agricultural Risk Protection Act of 2000	2008 Farm Bill [a] Enterprise units (whole farm units)
55	30.0	46.1	64.0	80(-)
65	30.0	41.7	59.0	80(80)
75	16.9	23.5	55.0	77(80)
85	-	13.0	38.0	53(56)

Notes:
Subsidy rates are for basic and optional units if not otherwise indicated.
[a] Subsidy rates for basic and optional units remain the same under 2008 Farm Bill.
- Coverage level not available.

The 1980 Act set the premium subsidy at 16.9 percent for a policy with 75 percent coverage. The subsidy rate for the same coverage was increased to 23.5 percent by the 1994 Reform Act. To encourage further participation in higher coverage levels, temporary economic loss assistance provided a premium discount for the 1999 and 2000 crop years, which continued until a permanent increase was provided in the Agricultural Risk Protection Act of 2000 (ARPA). ARPA raised subsidies, particularly at the higher coverage levels, with the 75 percent coverage level subsidy more than doubling, reaching 55 percent. The 2008 Farm Bill did not change subsidy rates for individual insurance plans but increased subsidy rates for enterprise and whole farm units to 77 percent and 80 percent respectively for a policy with 75 percent coverage. An enterprise unit covers all land of a single crop in a county for a producer, regardless of tenant/landlord structure. A whole farm unit covers more than one crop.

Numbers in Table 4 illustrate current crop insurance subsidy rates by insured unit and by coverage level. The producer's premium for an insurance policy increases as the levels of yield coverage and price coverage rise, and the premium on buy-up coverage is subsidized at rates ranging from 38% to 80%, depending on the coverage level.

Table 4. Premium Subsidy Rates under 2008 Farm Bill

Yield coverage level (%)	CAT	50	55	60	65	70	75	80	85
Premium subsidy (%) for most policies (including basic and optional units)	100	67	64	64	59	59	55	48	38
Premium subsidy (%) for enterprise units		80	80	80	80	80	77	68	53
Premium subsidy (%) for whole farm units					80	80	80	71	56

Source: 2008 Farm Bill

The subsidy rate declines as the coverage rises, but the total premium subsidy in dollars increase because the policies with higher coverage are more expensive. Under the 2008 Farm Bill, a higher subsidy rate is provided for policies using an enterprise unit. An enterprise unit covers all land for a single crop in a county, regardless of the tenant/landlord structure. A premium discount is given for policies using enterprise units because the combined unit has greater geographic diversity and thus is less risky. Because the premiums are lower for enterprise units, a higher subsidy rate provides for an equal dollar amount of premium subsidy regardless of the type of unit used. Current years experience a shift to policies using enterprise units by some farmers.

Since 2007, government subsidies for crop insurance have averaged about $5.8 billion per year, representing one-third of total expenditures on income transfers and other government payments for program targeted directly to farmers. Premium subsidy in 2011 fiscal year reached the historical high of $7.4 billion. With another $1.4 billion A&O expense reimbursement, total government costs reached a historical high of $11.3 billion in 2011 fiscal year. Table 5 presents the government cost for the Federal Crop Insurance from 2002 to 2011. The program costs, increasing from $3.5 billion in 2002 to $11.3 billion in 2011, sums up to $48 billion for the past decade. Given the escalating Federal budget deficit and the pressing need to bring it under control over the next decade, the huge cost of the Crop Insurance Program is now under heavy scrutiny and criticism in preparing the 2012 Farm Bill.

Table 5. Government Costs 2002-2011 (million dollars)

Fiscal Year	Indemnity	Underwriting Losses or (Gains) [a]	Premium Subsidy	Private Company A&O[b] expense reimbursements	Other costs	Total costs
2002	4,114	1,182	1,513	656	115	3,466
2003	3,768	822	1,874	743	149	3,588
2004	2,828	(305)	2,387	900	143	3,125
2005	2,796	(293)	2,070	783	139	2,699
2006	3,585	(32)	2,517	960	125	3,570
2007	3,493	(1,068)	3,544	1,341	123	3,940
2008	5,024	(1,717)	5,301	2,016	137	5,737
2009	8,416	108	5,198	1,602	131	7,039
2010	2,759	(2,523)	4,680	1,371	143	3,671
2011	13,429	2,392	7,376	1,383	144	11,295
Total	50,212	(1,434)	36,460	11,755	1,349	48,130

a. Program underwriting loss (gain if negative) is the amount of claims paid in excess of premium collected and other income.
b. A&Q: Administrative and operating

Source: U.S. Department of Agriculture, Risk Management Agent.

3.3 Trends in A&O Costs and Underwriting Gains

While farmers clearly receive regular and substantial income transfers from the program, the private insurance companies and agricultural insurance agents also receive significant benefits. As discussed earlier, premiums and indemnity are both shared between the government and the private insurance companies. However, private companies could transfer some risks to the government through the reinsurance. Since 2003, the loss ratios of the federal crop insurance program were relatively low (less than 1.0) and therefore resulted underwriting gains both for the government and the private companies.

Smith (2011) illustrates by source of income how private insurance company incomes have increased since 1981. In the early 1980s, total company incomes averaged $37 million. By the late 1980s and early 1990s, annual company incomes had increased by 800 percent to $227 million, solely because of increases in A&O expenses subsidies (as the companies on average experienced underwriting losses between 1988 and 1992). From 1994 to 2001, underwriting gains became increasingly positive. 2000 APAR further encourages participation through higher subsidy level, inherently reducing adverse selection and further increasing expected underwriting gains. Subsequently, total underwriting gains accruing to the companies were positive and, apart from 2002, increasingly substantial. Therefore, a major consequence of the 1994 and 2000 legislations was a massive increase in company incomes from both A&O reimbursements (because of higher participation and coverage level) and underwriting gains. Annual average company incomes increased from $200 million between 1993 and 1996 to $780 million between 1997 and 2000, $1.087 billion between 2005 and 2009. Essentially, private insurance company incomes rose by over 1,200 percent over the 17-year period from 1993 to 2009.

As a Congressionally authorized insurance program subsidized by the U.S. Treasury, FCIC and RMA have the responsibility for ensuring that the profitability of the MPCI program is reasonable in relation to the financial risk retained by the participating insurers. In addition, the government has a duty to taxpayers to ensure that the program is delivered to insured farmers in a cost effective manner. The 2008 Farm Bill allows the government to negotiate the Standard Reinsurance Agreement every the other 5 years since the 2011 crop year. With concern over the cost of the program, the RMA and the crop insurance industry negotiated the terms of the Standard Reinsurance Agreement during later 2009 and the first half of 2010. These changes became effective on July 1, 2010, the start of the 2011 reinsurance year. "The major changes included a reduction in underwriting gain potential in certain states, modest changes in gain and loss potential in other states, and the introduction an upper limit on the amount of A&O reimbursements to be paid to the companies participating in the program" (Grant Thornton, LLP. 2011). These changes are expected to reduce the program cost; however, the efficacy is left to be tested over time.

3.4 Program Performance Disparities

The actuarial performance of the crop insurance program is generally measured by loss-ratio - indemnities divided by premiums. A loss-ratio that is less than 1 means the program balance off in that indemnity paid equals to the premium collected. And one that is greater than 1 indicates poor actuarial performance by indemnity exceeding premium collected. As Figure 4 (and Table 2) illustrates, the overall actuarial performance has been improving since late 1990s. The total loss ratio – indemnity divided by total premium (including subsidy) –had never been below 1.0 until 1994. The loss ratio averaged at 1.53 over the period of 1981-1993. In contrary, only 5 out of the 18 years since 1994 experienced an excess of indemnities over premiums, with the loss ratio averaging at 0.83. The program loss ratios have been well below the statutory maximum of 1.0 for many years since 2003. However, it is important to note that this actuarial improvement is achieved largely by increasing premium subsidies and that loss ratio experienced much sharper volatility among regions and crops. The disparity of loss cost experience is reflected in the asymmetric distribution of distribution of participation, subsidies and indemnities among geographic regions, crops, and insured units.

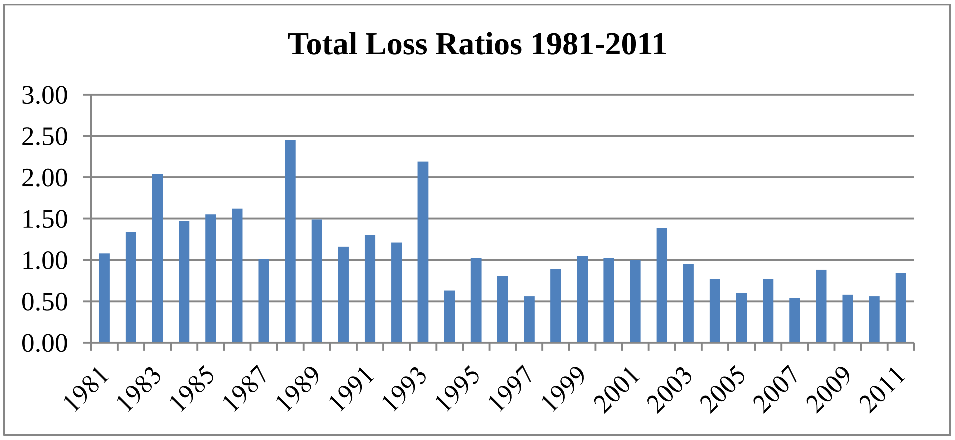

Figure 4. Total Loss Ratio 1981-2011

With widespread participation in crop insurance program by farmers producing main crops (corn, cotton, soybeans, and wheat), the geographic distribution of acreage enrolled mirrors that asymmetry. The four main crops account for three-quarters of total acres insured. And crop premium subsidies and indemnities follows the same pattern, but with indemnity emphasis on producing area with less rainfall and more variable crop-weather conditions.

By crop, the bulk of subsidies and indemnities are for the four main crops – corn, cotton, soybeans, and wheat. Figure 5 (corresponding to Table 6) visualizes the disparities among crops in terms of 2007-2011 annual average premium subsidies and indemnities.

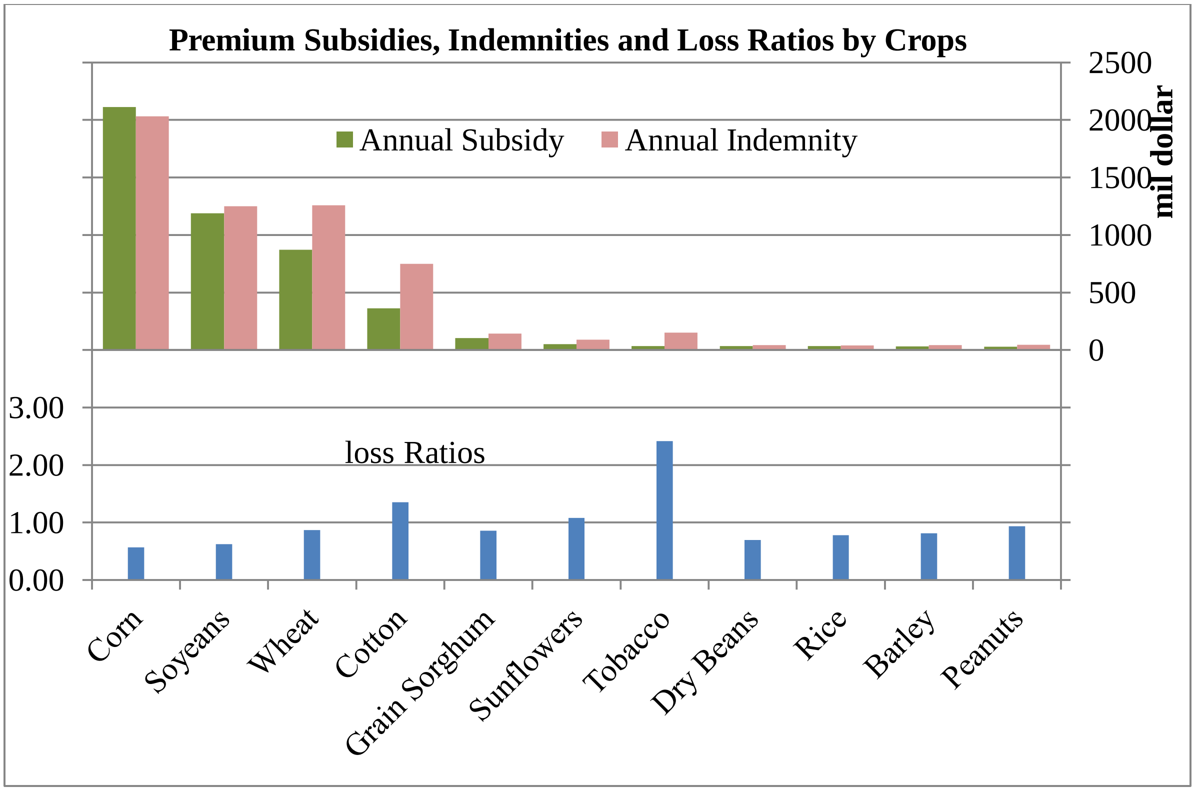

Figure 5. Premium Subsidies, Indemnities and Loss Ratios by Crops, 2007-2011 Average

The annual average premium, subsidy and indemnity for the four major field crops are 7.6, 4.5 and 5.4 billion dollars, respectively – more than 80% of total, while those for the fifth item grain sorghum only accounts for less than 2% of total (Table 6).

Table 6. Premiums, Subsidies, Indemnities and Loss Ratios by Crops, 2007-2011 Average

Crop	Acum. LR	Annual Premium ($ mil)	Annual Subsidy ($ mil)	Annual Indemnity ($ mil)
Corn	0.57	3585.44	2111.53	2030.59
Soybeans	0.62	2003.47	1188.17	1251.20
Wheat	0.87	1451.50	871.51	1257.48
Cotton	1.35	554.30	361.94	750.44
Grain Sorghum	0.86	165.74	102.74	141.97
Sunflowers	1.08	82.90	51.38	89.71
Tobacco	2.42	62.61	35.57	151.26
Dry Beans	0.69	59.45	35.32	41.25
Rice	0.78	49.57	35.27	38.57
Barley	0.81	54.04	32.14	43.89
Peanuts	0.94	47.45	28.19	44.38

Source: Risk Management Agency, Summary of Business

By state, premium subsidies are the greatest in states where these major crops are grown, primarily across the Great Plains, Corn Belt, and parts of the South. Figure 6 (corresponding to Table 7) illustrates subsidies and indemnities for the top 20 states in 2011 crop year. Relatively high indemnity payments were made in the Great Plains, a region with generally low but variable rainfall. In other years, the distribution of indemnity is similar, especially with respect to payments across the Great Plains. However, the concentration of payments varies within major producing areas, primarily depending on the local weather conditions. In addition, the loss ratios vary dramatically across states.

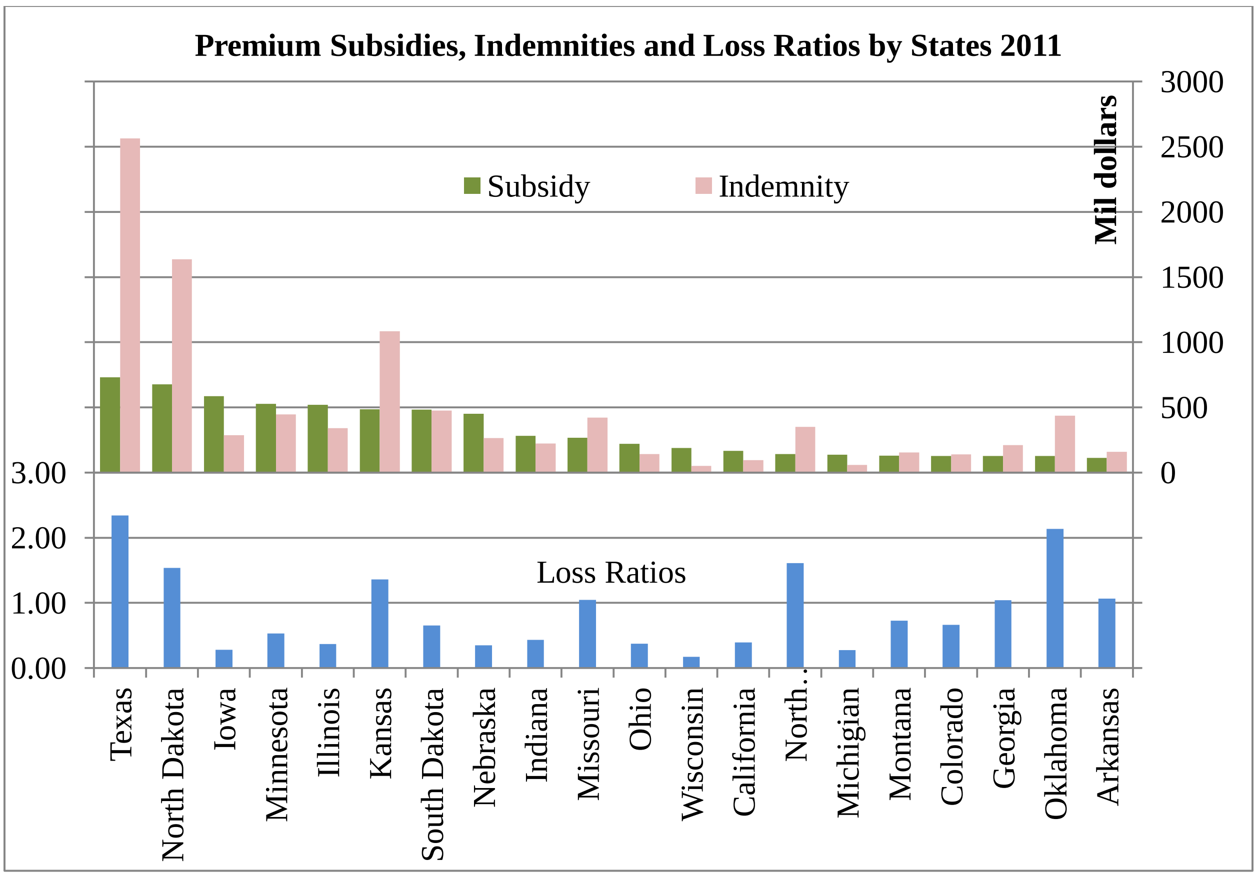

Figure 6. Premium Subsidies, Indemnities and Loss Ratios by States in 2011

Table 7. Premiums, Subsidies, Indemnities and Loss Ratios by States in 2011

State	Total Premium ($mil)	Subsidy ($mil)	Indemnity ($mil)	Loss Ratio
Texas	1,096	730	2,564	2.34
North Dakota	1,065	677	1,635	1.54
Iowa	1,030	587	288	.28
Minnesota	844	526	447	.53
Illinois	928	519	341	.37
Kansas	797	487	1,083	1.36
South Dakota	725	482	475	.66
Nebraska	760	451	265	.35
Indiana	516	283	223	.43
Missouri	404	267	422	1.05
Ohio	379	222	142	.38
Wisconsin	296	188	50	.17
California	246	167	97	.39
North Carolina	218	142	351	1.61
Michigan	211	138	58	.28
Montana	214	130	155	.73
Colorado	213	128	141	.66
Georgia	203	128	211	1.04
Oklahoma	204	128	436	2.14
Arkansas	150	114	160	1.07

Source: Risk Management Agency, Summary of Business

Compared to small farmers, larger operations have greater crop liability, which increases the total costs of insurance and value of the government premium subsidy. "Based on the distribution of insurance costs from USDA's Agricultural Resource Management Survey (ARMS) and actual premium subsidies from RMA ($5.4 billion in 2009), CRS estimated that the producer subsidy in 2009 averaged $2,500 per farm (over all U.S. farms, not just those purchasing crop insurance). However, subsidy per farm varies across farm size. The calculated average subsidy ranged from $400 per farm for operations with less than $100,000 in sales to $32,000 for farms with more than $1 million in sales. Farmers in the largest sales category accounted for an estimated $1.6 billion or 29% of the total premium subsidy in 2009. Unlike other commodity programs, subsidies received under the crop insurance program are not subject to payment limit" (Shields, 2010).

Program loss ratios vary sharply among regions, raising the question whether the rating system suitably accounts for program improvement over time. The asymmetric loss experience implies that premium rates do not reflect the actual underlying risks and that program benefits are not being distributed equally, in conflict with a stated objective of the Federal Crop Insurance Act.

3.5 Asymmetric Information

The most cited reason for the poor actuarial performance arises from problem of asymmetric information. Farmers know more about their risk exposure than insurers do (Harwood, Heifner et al. 1999;Barnett 2000). This asymmetry of information creates both adverse selection and moral hazard problems. Moral hazard occurs when policy-holders engage in behaviors that significantly increase the probability of loss and/ or the magnitude of loss. Studies on moral hazard suggests crop insurance participation to some extent has unfavorable effects on input use and farm output (e.g. Horowitz and Lichtenberg 1993; Quiggin, Karagiannis, and Stanton 1993; Ramaswami 1993; Smith and Goodwin 1996; and Babcock and Hennessy 1996), and induces higher expected indemnity in years with excess loss (Cobel et at. 1997). To combat moral hazard, insurance contracts typically include mechanisms such as deductibles and co-payment provisions where losses are shared between the insurer and the insured. However, relatively high deductibles or high premium costs are required to sufficiently reduce moral hazard problem, either of which reduces producer demand for insurance and thus participation level.

Adverse selection occurs when insurers fail to accurately assess the risk of potential insured. Those who tend to benefit from this mistake are more likely to purchase insurance, which eventually increases underwriting losses. As a result, those whose expected indemnity is higher than the premium cost will purchase crop insurance, while those whose expected indemnity is lower than the cost drop out of the problem. A rich body of econometric studies of crop insurance participation incentives strongly indicates that other things being equal, farmers with higher expected indemnities, higher income risk or larger yield variability are more likely to participate, implying the existence of adverse selection in current crop insurance program (Nieuwoudt et al. 1985; Gardner and Kramer 1986; Just and Calvin 1990; Goodwin 1993; Barnett and Skees 1995; and Coble et al. 1996). That adverse selection is a primary reason for the poor actuarial performance is widely held among researches. Analyzing adverse selection in crop insurance and its reduction for improved program actuarial performance have been explored extensively in the literature. A thorough review is presented in the following chapter.

CHAPTER 4

CROP INSURANCE LITERATURE

Economic research on crop insurance can be traced at least as far back as Valgren's 1922 study of private insurance markets. However, the amount of research on crop insurance has increased dramatically since the 1980s, paralleling the growth in the program itself. The Federal Crop Insurance Program has been operating for three decades since 1981 and numerous studies examine issues relating to the program, including (1) explanations of why private crop insurance fails, and (2) studies examine MPCI participation incentives and/or investigate factors affecting farmers' crop insurance decision. Comprehensive literature surveys are found in Gardner and Kramer (1986), Goodwin and Smith (1995), Knight and Coble (1997), and Coble et al. (2002). A rich body of econometric studies of crop insurance participation incentives strongly indicates that other things being equal, farmers with higher expected indemnities, higher income risk or larger yield variability are more likely to participate, implying the existence of adverse selection in current crop insurance program (Nieuwoudt et al. 1985; Gardner and Kramer 1986; Just and Calvin 1990; Goodwin 1996; Barnett and Skees 1995; and Coble et al. 1996).

Various theoretical and empirical studies were conducted as attempt to illuminate the underlying causes of adverse selection and to find solutions to improve the soundness of the actuarial performance of the Federal Crop Insurance Program. Inability to calculate premium rates that reflect the true likelihood of losses is considered to be the root of adverse selection problem (e.g. Goodwin 1994; Ramirez, Carpio, and Rejesus 2011). If premium rates accurately reflected each potential insured's loss risk, adverse selection would not be possible. Hence, studies of adverse selection examine specific contract terms and rate-making practices thought to provide the opportunity for adverse selection.

Recently, a desire to improve participation and reduce adverse selection has led to a number of papers exploding mechanisms to improve insurance designs. Two primary strands of literature has emerged: (1) Alternative insurance designs that are more attractive to farmers, such as area yield insurance and revenue insurance; and (2) Improved methods and techniques for RMA to reflect farmers' risks with more accuracy. Some research that propose alternative policy designs also examine the actuarial rating methods. For clarity, we categorize the literature into two sections. The first section focuses on illustrating the concept of alternative crop insurance designs, while briefly summarizing associated rating methodology. The second section focuses on literature relating premium rating procedures. In addition, various forms of farmer savings accounts (FSAs) were proposed for U.S. farmers. FSAs encourage farmer savings for bad times through deferred tax or/and government subsidy. Our proposed CISA system has some similarities to FSAs, so we give some introduction of FSAs in the third section. However, unlike farmer savings accounts, our CISA system is essentially an insurance design, established on the framework of current crop insurance program and therefore integrates with current administrating and operating system.

4.1 Alternative Crop Insurance Designs

The poor actuarial performance and concern over the costs of insuring individual crop yields has prompted research into alternative insurance contracts including area yield insurance and revenue insurance. Other than crop insurance, alternative risk management tools such as futures contracts and futures options are also explored.

Area yield insurance dates to Halcrow (1949), and has attracted significant attention as a means to avoid the problems of moral hazard, inaccurate rates, and transactions cost associated with individual coverage crop insurance policies (Miranda 1991, Skees, Black and Barnett 1997, Goodwin and Ker 1998, Ker and Goodwin 2000, Bourgeon and Chambers 2003, and Deng, Barnett, and Vedenov 2007). Most agricultural economists agree that strong adverse selection and moral hazard problem as well as high administrative costs are associated with individual yield crop insurance, since the individualized yield records are required. In contacts, information regarding the distribution of the area yield is generally not privately held, and thus available and more reliable than distribution of individual yields, which reduces adverse selection. In addition, area-yield, almost not affected by individual behavior, would also be of less moral hazard problem. Therefore, as listed above, a number of studies explore area-based insurance designs and consider it as an improved design over individual coverage policies in terms of actuarial performance.

Revenue insurance was proposed and examined in 1990s to protect against both yield and price risks. Early studies in 1990s evaluated revenue insurance in comparison to traditional deficiency payment program (e.g. Gray, Richardson and McClaskey 1995; and Hennessy, Babcock, and Hayes 1997). Barnaby (1996) and Stokes(2000) proposed premium rating method for Crop Revenue Coverage, a revenue insurance piloted in the spring of 1996 and integrated into Revenue Protection plan in 2011(Wang, Hanson, Myers and Black 1998; and Coble, Heifner and Zuniga 2000).

Area-revenue insurance, a combination of the advantages of area-yield and revenue crop insurance, was also investigated. In principle, the area revenue triggered commodity program would provide protection against systemic loss events while the farm-level policy would protect against residual, idiosyncratic losses.

Some research turned to alternative risk management strategies other that crop insurance. Economists have long argued that producers of exchange-traded commodities can manage price risk exposure using futures and/or options contracts (See Barnett, 2000 for detailed reference). Some studies suggest combination of revenue insurance, yield insurance and hedging instruments such as futures options and contracts (e.g. Heifner and Coble 1998; and Mahul and Wright 2003).

4.2 Premium Rating Refinements

Literature focusing on developing improved methods for RMA to assess and price yield and revenue risks has examined the issues of (1) using better rate differentials to capture true risks; and (2) identifying appropriate crop yield distributions for risk analysis.

The first string of premium rating studies focuses on developing more accurate and fairer rate differentials to reflect the true individual risk exposure into the producer's premium calculation. These studies focus on deriving premium coefficients that fairly capture rating factors such as coverage level, unit structure, and yield mean and variability. In the mid-1980s, the RMA began to transition from offering the same insurance coverage to all farms in a county to basing coverage on each producer's historical average yield. Initially the same premium was paid regardless of the producer's average yield. Skees and Reed (1986) proposed use of a constant standard deviation in developing premium rates, based on statistical tests of the relationship between average yield and yield variability. Goodwin (1994) also found negative correlation between average yield and relative yield risk. In 1985, the RMA began to offer lower rates for farms with higher average yields. From the mid-1980s through 2000, a fixed rating parameter for each crop was used nationwide to implement these rate differentials based on historical average yields. In 2011, this parameter was adjusted to the county/crop level.

Coverage levels available generally range from 50% to 85% of the historical average yield or historical average revenue for the insured unit. Until 2004, fixed percentage coverage-level differentials were used to adjust rates for alternative coverage levels. Babcock, Hart, and Hayes (2004) examined the statistical validity of these fixed coverage-level differentials and concluded them as not actuarial sound. In 2004, the RMA introduced variable coverage-level rate differentials based on specific risk characteristics of the crop at the county level.

As previously noted, premium rates are also adjusted by unit structure. County base rates are developed at the optional units and tailored into rates for basic unit and enterprise unit. Since 1988, a fixed 10% premium discount has been used for basic versus optional units, as it is believed that lower risks are associated with basic unit. Different discount rates for enterprise units under APH, CRC, and RA were also tailored based on unit structure. Recent studies that addressed the issue of unit structure premium rate differentials are Schurle (1996), and Knight and Coble (1999). Schurle (1996) examined the impact of enterprise size on yield variability and its relationship to actuarially fair premium rates. Knight and Coble (1999) concluded that the current 10% discount for basic unit is generally sufficient to account for higher losses on optional units. However, they recommended additional tailoring of discounts to conform to commodity-level and state-level loss experience. The most recent study by Knight et al. (2010) proposed variable unit aggregate discounts based on observable farm characteristics, and the methods are adopted by the RMA.

A substantial number of econometric studies attempt to improve methods for simulating farmers' yield distributions. Both parametric and non-parametric (e.g. Ker and Goodwin 2000) estimation methods were proposed and examined. Parametric models proposed are generally based on each of the four well-known statistic distributions: the normal, the gamma, the beta, and the inverse hyperbolic since (Gallargher 1987; Nelson and Preckel 1989; Barry, Goodwin and Ker 1998; Moss and Shonkwiler 1993; Ramirez 1997, 2000, Ramirez, Misa and Field 2003, Ramirez, Misra, and Nelson 2003, Ramirez, Carpio, and Rejesus 2009; and Ramirez and Carpio 2011). Assumptions and relaxing of the assumptions on the yield distribution such as normality and heteroskedasticity were also investigated (e.g. Harri et al. 2009 and 2011).

These studies have shown promise for improving the crop insurance program performance and RMA have continuously been implementing refinements of its rating methods. However, many of the recommendations are impractical or difficult to implement and are impossible to eliminate adverse selection entirely; therefore, as previously noted, the need for substantial government subsidies remains.

4.3 Farmer Savings Accounts

Various forms of farmer saving accounts programs have been proposed and are currently used in other countries. Canada implemented a Net Income Stabilization Account program in 1991 and replaced it with the Canadian Agricultural Income Stabilization (CAIS) program in 2003. Under the voluntary program, Canadian producers can make deposits up to 3% of after tax Net Eligible Sales (NES) that is matched by an equal contribution from the government. Net Eligible Sales (NES) are defined as revenue from sales of qualifying commodities and the value of livestock feed for on-farm consumption, minus any purchases of qualifying commodities. Maximum NES is C$250,000 and government matches are capped C$7,500 per producer per year. All contributions earn interest. Tax is only paid on the interest earned and government contributions. Withdrawals can be made when one of the following two triggers are met: (1) when "Gross Margin" – roughly returns after costs – falls below farmers' average net returns over up to five previous years; or (2) when taxable income falls below a fixed level. Farmers may voluntarily leave or rejoin under specific rules (Edelman 2000; Boehlje, Detre, and Gray 2012). A similar program, Farm Management Deposits, is operated in Australia. This program also uses deferred taxes as an incentive for farmer saving, while the specific rules of making deposits and withdraws differ from CAIS.

The concept of farmer saving accounts has been debated in the U.S. Congress since 1996 and several forms of farmer saving accounts program has been proposed for U.S. farmers. The general idea of these proposed programs is to encourage farmer savings for bad financial times. Various designs analogous to CAIS have been proposed, with variations in specific rules for making deposits, accumulating account balances, triggering withdrawal, as well as imposing taxes.

Under the proposal for Farm and Ranch Risk Management (FARRM) Accounts (House Bill proposal "Farm and Ranch Risk Management Act of 2003"), farmers would be allowed to deposit up to 20 percent of "eligible net farm income". Contributions are before tax dollars, while interest earnings are distributed to the farmers at least annually and are taxable. Withdraws are made at the farmers' discretion and are also taxable. FARRM deposits could stay in an account for up to five years, and a 10 percent tax penalty is imposed on FARRM deposits not withdrawn in five years.

The Individual Risk Management Accounts (IRMA) is voluntary and provides incentives of both deferred tax and government matching contribution (Edelman, Monke, and Durst 2000). Similar to FARRM accounts, IRMA accounts deposits are deducible from pretax income. Withdrawals and interest earned are taxable. The difference is that IRMA farmers receive (catastrophic) CAT coverage, and are constrained to purchase only unsubsidized additional crop insurance. The IRMA balances are not allowed to exceed 150 percent of the farmer's three-year average Schedule F Gross Income. Withdrawals are triggered only if current year Schedule F Gross Income falls below 80 percent of the average for the previous three years.

Proposals for Farm Program Payment Reserve (FPPR) Accounts suggest linking and diverting other farm program payments (or AMTA payments) to farmer savings accounts. The AMTA payments, diverted to FPPR accounts in good years, would build up reserves and be available for use in bad times.

The most recent proposal for farm savings accounts, the Farm Income Stabilization Account Act of 2007, suggested government contributions to savings accounts (FISA) to replace government payments to farmers under the Commodity Title of the 2002 Farm Program. Under this proposal, the government would seed FISA accounts through contributions as a percentage of participating farmer's adjusted gross revenue, with percentage declining with higher farmer incomes. The participants make tax-deferred voluntary deposits up to $10,000 and could make withdrawal when the adjusted gross revenue for a year declines to 95 percent of its five-year average.

As will be detailed in the following chapters, our CISA system differs from the above described FSAs in that: (1) CISA is essentially a crop insurance product, integrated in the framework of current crop insurance program, attempting to replace the current program while reducing actuarial problems; (2) CISA system proposes a novel mechanism for contributing to and withdrawing from the saving accounts; and (3) the performance and viability of the CISA system was accessed using simulated long-period of farm-level yields.

CHAPTER 5

CROP INSURANCE SAVINGS ACCOUNTS

In this chapter we formalize the basic framework of our proposed crop insurance savings account system. We present the CISA in language analogous to current revenue insurance instruments, which, on a premium basis, accounts for three-quarters of all policies (Shields, 2010). The following first section describes the program design and the second section explores the feasibility of the CISA design.

5.1 Program Design

Under the system farmers are allowed to annually save a specified fraction of their historic farm revenue in an individually owned crop insurance savings account that earns an interest rate r. We denote the contribution made to a farmer's CISA in period t as $\alpha f(\mathrm{R}_1, \mathrm{R}_2, \dots, \mathrm{R}_{t-1})$ where R_t denotes farm revenue, $f(\cdot)$ is some function of past revenue levels (e.g., a simple average of the farmer's previous five years of revenue), and $\alpha \in [0,1]$ is the proportion of this function of past revenues contributed to the farmer's CISA. These investments are assumed to be with pre-tax income.

Withdraws from the account are made when farm revenues in a given year fall below a specified threshold. Using the language of current revenue insurance programs, we call this threshold revenue level the "revenue guarantee" and denote it as R_t^g. Hence, withdraws from the CISA in a given year are equal to $\max\left(0, \mathrm{R}_t^g - \mathrm{R}_t\right)$. In the event that a farmer's CISA balance is insufficient to cover the withdrawal, the requisite funds are lent to the account by the government at the same interest rate as earned on savings. Given this structure, the periodic balance of an individual's CISA, B_t and their periodic after-tax income from farming, π_t can be expressed as

(3) $$B_t = (1+r)B_{t-1} + \alpha f(R_1, R_2, \ldots, R_{t-1}) - max\left(0, R_t^g - R_t\right),$$ and

(4) $$\pi_t = (1-\tau)\left[R_t + max\left(0, R_t^g - R_t\right) - \alpha f(R_1, R_2, \ldots, R_{t-1}) - C_t\right].$$

Where τ is the tax rate and C_t are farm production costs. Akin to a traditional individual retirement account (IRA), positive balances in CISAs may be withdrawn at retirement age (or bequeathed to heirs in the event of death). Notice that for farmers that have a positive account balance and expect the account to be positive at retirement, participation in the CISA system does not have a distortionary effect on risk taking activities (i.e., no moral hazard) because the cost is fully internalized. This is a distinct advantage of the CISA system over traditional insurance instruments.

For individuals who reach retirement age with a negative CISA balance two alternative policy designs are possible, each with their own distinct advantages and disadvantages. One alternative is for the government to simply forgive the debt. This has two clear disadvantages. First, it would result in not only financial costs to the government to implement the CISA system (i.e., foregone loan repayments), but it would also represent a transfer of wealth from taxpayers to the riskiest of farmers (i.e., those most likely to end with a negative CISA balance). Second, for farmers who expect to have negative terminal period account balances, this creates a moral hazard problem in which they do not face the full consequences of taking on greater risk. On the positive side, if debts are forgiven and participation in the CISA system is voluntary (and where the alternative is no insurance), all farmers would strictly prefer participating regardless of expecting a positive or negative terminal period balance. Hence, full participation would be achieved.

The second alternative approach for managing negative balances upon retirement is to force repayment of the debt. The advantages of this design are two-fold. First, it would result in less financial burden on the government.[5] Second, it would not induce the moral hazard problems described above. However, there are two clear downsides to this approach. Collecting debts upon retirement would not only be highly unpopular, but likely quite difficult. Furthermore, if participation were voluntary, farmers expecting a negative balance would not necessarily choose to participate thus potentially resulting in a system with the reverse of the participation dilemma under traditional insurance instruments - i.e., a CISA system where low-risk individuals participate and high-risk individuals do not.

5.2 Feasibility of the CISA System

The viability of the proposed crop insurance system rests squarely on one issue - the proportion of farmers that will reach retirement with a negative account balance. If for a given revenue guarantee level, R_t^g, and CISA contribution rate, $\alpha f(R_1, R_2, \dots, R_{t-1})$, all farmers expected to reach retirement with a positive CISA account balance, then the proposed system would be strictly superior to traditional insurance instruments. Specifically, the CISA system would (a) not distort farmer incentives (i.e., no moral hazard), (b) achieve 100% voluntary participation because of the tax free savings benefit (i.e., no adverse selection), and (c) reduce the cost to the government (i.e., no subsidies) and eliminate the need for the government to attempt to price farm risk and determine insurance premiums.

However, if not all farmers reach retirement with a positive CISA balance (or expect that it will occur), as discussed earlier, this is where difficulties occur. Regardless of whether debts

[5] Assuming 100% repayment and ignoring administrative costs, the program would cost zero to implement.

are forgiven by the government or not or participation is voluntary or mandatory, incentives for farmers falling in this category are distorted. Furthermore, there are potentially significant costs to the government if debts are forgiven (i.e., subsidies in traditional crop insurance programs are simply replaced by debt-forgiveness). Hence, while the theoretical motivations for the CISA system are enticing, the question remains whether farmers can themselves finance their own crop insurance benefits via saving a reasonable proportion of their own farm income. Specifically, for a reasonable savings rate, what proportion of farmers would fall into this category of having a negative account balance upon retirement? This is the empirical question we focus on in the next chapters.

CHAPTER 6

METHODS AND DATA

In order to assess the performance of the Crop Insurance Saving Accounts system, a long history of farm-level crop yields and prices are required. Therefore, reliable parametric estimates of future crop yield and price are needed to generate long time series of price and yield. We select Illinois corn and Georgia peanuts to evaluate the feasibility of the CISA system. Corn is the number one insured crop in terms of subsidies and indemnities. The peanut is an important cash crop in the southeast, with Georgia being the number one peanut producer in the United States, providing more than 45 percent of the national peanut production each year. The assessment of Illinois corn and Georgia peanut would allow us to compare the CISA performance between different crops, in addition to a within crop assessment.

In the remaining parts of this chapter, we use parametric estimates of farm-level yield records and state-level prices time series to construct the probability distribution function of the yield and price distributions for Illinois corn and Georgia peanuts, respectively. 45 years of yields and prices are then generated using the constructed models for 10,000 Illinois corn farmers and 10,000 Georgia peanut growers, respectively. The CISAs performance analyses are presented in the next chapter.

6.1 Data

The University of Illinois Endowment Farms project has been collecting "representative" corn producers' yield records during the last 50 years. 10 of the 26 "representative" farm-level yields with relatively long span (40-50 years) are used. Average corn farm price received in Illinois for 1960-2011 were obtained from NASS, USDA.

We use a farm-level yield data to simulate the performance of the Crop Insurance Saving Accounts for peanut producers in Georgia. A 31-year (1979-2011 observations, except for 1987 and 1988 which were not recorded) irrigated peanut yield record was obtained from the Southwest Georgia Branch Experiment Station. The Experiment Station established an experimental farm management unit in the 1950s to evaluate production practices and enterprises in a farm-sized operation. "The farm management unit ... is operated as a diversified farm unit with most of the same environmental conditions and influencing factors as privately-owned farms" (Moss and Saunders, 1987). Therefore the peanuts yield data are comparable to farm units operated in a similar manner in this area. Average peanut farm price received in Georgia for 1982-2011was from NASS, USDA.

6.2 Corn Yield and Price Distributions Model

Inverse Hyperbolic Sine (IHS) was used as a flexible probability density function to obtain realistic estimates of the corn price and yield distributions. The IHS can accommodate a wide range of mean-variance-skewness-kurtosis combinations. Ramirez (1997) first utilized IHS for yield modeling and simulation. Subsequent applications of this model involving both yield and price distributions include Ramirez and Somarriba (2000), Ramirez, Misra and Field (2003), and Ramirez, McDonald and Carpio (2006).

In addition to its flexibility, the IHS distribution model is appealing because each of its first four statistical moments can be independently controlled by a parameter or a parametric function of some exogenous variable(s). Specifically, for both the price and yield distributions, the mean is specified as a linear function of time ($B_1 + B_2 t,\ t = 1,2, \ldots, T$) while the variance, skewness and kurtosis are controlled by constant parameters (B_3, B_4, B_5, respectively). In the single variable case, the IHS density is then given by:

(5) $IHS(Y_t) = G_t (2\pi)^{-\frac{1}{2}} exp(-0.5 H_t^2)$.

Where $G_t = [B_3^2 (1 + R_t^2)/J]^{-\frac{1}{2}}$,

$J = [\exp(B_4^2) - 1][\exp(B_4^2) \cosh(-2B_4 B_5) + 1]/(2B_4^2)$,

$R_t = J^{\frac{1}{2}} B_4 (Y_t - B_1 - B_2 t)/B_3 + F$,

$F = \exp(0.5 B_4^2) \sinh(B_4 B_5)$, and

$H_t = ln\ (R_t + {(1 + R_t^2)^{\frac{1}{2}}}\big/{B_4}) - B_5$.

As Ramirez, Misra and Field (2003) point out, as B_4 and B_5 approach zero, this pdf becomes a normal density with mean $B_1 + B_2 t$ and variance B_3^2, which facilitates a test for whether or not prices and yields are normally distributed. In addition, if $B_4 \neq 0$ but $B_5 = 0$, the density is kurtotic but symmetric, while a negative (positive) B_5 induces negative (positive) skewness into the distribution. Specifically, the skewness (S) and kurtosis (K) measures of this pdf are given by:

(6) $S = \frac{1}{4} W^{\frac{1}{2}} (W - 1)^2 [W(W + 2)\, sinh(3Q) + 3\, sinh(Q)]/(J{B_4}^2)^{1.5}$, *and*

(7) $K = \frac{\frac{1}{8}(W-1)^2 [W^2 (W^4 + 2W^3 + 3W^2 - 3)\, cosh(4Q) + 4W^2 (W+2)\, cosh(2Q) + 3(2W+1)]}{J^2 B_4^4} - 3$.

Where $W = \exp(B_4^2)\, , Q = -B_4 B_5$.

In short, the IHS model allows for a wide range of skewness-kurtosis combinations (according to the two equations above which only depend on B_4 and B_5) while its mean and variance are determined by $B_1 + B_2 t$ and B_3 only. In addition, Ramirez, Misra and Nelson (2003) show how the IHS density (equation 1) can be modified to allow for autocorrelation. Specifically, all needed is to let $R_t = \left(J^{\frac{1}{2}} B_4 P_t (Y_t - B_1 - B_2 t)/B_3\right) + F$ where P_t is the t^{th} row of a T by T transformation matrix P such that $P'P = \Psi^{-1}$ and Ψ is the error term correlation matrix[6]. Using standard procedures, the concentrated log-likelihood function needed for estimating the parameters of this model can be derived from equation (5):

(8) $\sum_{t=1}^{T} ln\ (G_t) - 0.5 \sum_{t=1}^{T} H_t^2$.

The above function is then maximized in order to obtain estimates for the parameters of a price distribution model with a time-varying mean, constant variance, skewness and kurtosis coefficients, and a suitable autocorrelation process. Maximum likelihood estimation is accomplished using the CML procedure of Gauss 9. The data utilized includes the real (inflation-adjusted[7]) corn prices received by Illinois farmers during the last 70 years (USDA, National Agricultural Statistics Service, 2011). As customary, the price series is first tested and confirmed to be stationary according to both the Dickey-Fuller and the Phillips-Perron tests. The maximum-likelihood parameter estimates and related statistics for this first model are presented in table 8.

First note that real prices have been decreasing over time at a rate of 3.22 cents/year, putting them at a predicted average of $4.085/bushel in 2011. The estimate for the standard deviation of the price distribution stands at $0.618/bushel. A White test is conducted to make sure that the model's variance is constant, i.e. that price variability has not been changing over

[6] For a derivation of P in the case of first and second order autoregressive processes please see Judge et al. (1985, p 285 and 294).
[7] Inflation adjusted by the Producer Price Index for farm products (BLS, 2011).

time. A test statistic of 3.37 does not allow for the rejection of the null hypothesis of homoscedasticity (p-value= 0.185).

Table 8. Maximum-Likelihood Parameter Estimates of Corn Price Distribution Model

	P.E.	S.E.E	T.V.	P.V
B_1	6.3412	0.2144	29.5815	0.0000
B_2	-0.0322	0.0052	6.2110	0.0000
B_3	0.6179	0.0745	8.2948	0.0000
B_4	0.3229	NA*	NA*	0.0106
B_5	20.0914	NA*	NA*	0.0106
B_6	0.7605	0.1091	6.9694	0.0000
B_7	-0.3974	0.1228	3.2354	0.0010

Notes: P.E., S.E.E, T.V., and P.V. stand for parameter estimate, standard error estimate, t-value and p-value respectively. The significance (p-value) of the non-normality parameters (B_4 and B_5) is ascertained through a likelihood ratio test. B_6 and B_7 are the first- and second-order autoregressive parameters.

The maximum value of the concentrated log-likelihood function corresponding to the non-normal price model is -60.37 versus -64.92 for the analogous normal model where B_4 and B_5 are set to zero. As a result, the likelihood ratio test statistic (Ramirez, Misra and Field, 2003) easily allows for rejection of the null hypothesis of normality (p-value=0.01). That is, since both B_4 and B_5 are positive, the distribution of corn prices received by farmers in the state of Illinois is in fact positively kurtotic and significantly right-skewed. Finally it is evident that, over time, prices follow a second order autoregressive process as both parameters in this process (B_6 and B_7 in the transformation matrix P) are highly significant while the Box-Pierce test cannot reject the null hypothesis that the transformed model residuals $\{P_t(Y_t - B_1 - B_2 t)\}$ are independently distributed (p-value=0.978). As described in the next section, this model can be used to obtain draws from the current and future price distributions for the purposes of the CISA analyses.

Farm-level yield models are also estimated using the previously described procedures, assuming that there is no autocorrelation. The maximum-likelihood parameter estimates and related statistics for these 10 yield distribution models are presented in table 9.

Table 9. Maximum-Likelihood Parameter Estimates of Corn Yield Distribution Model

	Farm 1		**Farm 2**		**Farm 3**		**Farm 4**		**Farm 5**	
	N	**NN**	**N**	**NN**	**N**	**NN**	**N**	**NN**	**N**	**NN**
Mean	182.39	193.58	162.14	161.47	179.00	183.10	174.77	173.44	163.47	163.47
B1	100.69	92.60	85.39	84.98	93.38	89.89	88.06	89.57	99.78	99.78
B2	1.542	1.905	1.448	1.443	1.616	1.759	1.636	1.583	1.202	1.201
B3	20.926	21.236	18.005	20.931	22.695	23.477	18.327	25.820	20.301	20.301
B4	0.000	0.914	0.000	0.808	0.000	0.722	0.000	1.258	0.000	0.000
B5	0.000	-0.436	0.000	-0.683	0.000	-0.787	0.000	-0.041	0.000	0.000
Skew	0.000	-2.405	0.000	-2.251	0.000	-1.808	0.000	-1.147	0.000	0.000
Kurt	0.000	28.144	0.000	17.222	0.000	10.416	0.000	306.377	0.000	0.000
White	2.318	2.227	3.741	3.801	2.635	2.456	2.228	2.409	4.831	4.831
-2MV	392.48	375.48	379.24	377.05	390.53	381.57	372.15	363.85	398.67	398.67
LRTS		16.994		2.191		8.965		8.297		0.000
	Farm 6		**Farm 7**		**Farm 8**		**Farm 9**		**Farm 10**	
	N	**NN**	**N**	**NN**	**N**	**NN**	**N**	**NN**	**N**	**NN**
Mean	168.15	181.43	165.97	169.30	186.07	188.71	165.95	171.69	136.04	140.88
B1	114.63	103.19	89.29	86.20	121.66	118.99	128.67	123.16	84.49	80.77
B2	1.010	1.474	1.447	1.568	1.215	1.315	0.704	0.916	0.973	1.134
B3	25.492	27.087	27.705	29.943	21.424	23.122	24.481	26.618	25.454	25.717
B4	0.000	0.418	0.000	0.735	0.000	0.518	0.000	0.725	0.001	0.273
B5	0.000	-15.000	0.000	-0.775	0.000	-9.451	0.000	-0.723	0.000	-15.000
Skew	0.000	-1.394	0.000	-1.876	0.000	-1.832	0.000	-1.717	0.000	-0.856
Kurt	0.000	3.642	0.000	11.257	0.000	6.509	0.000	10.002	0.000	1.330
White	4.846	4.166	2.579	2.252	4.539	4.558	1.494	1.642	3.290	3.493
-2MV	391.21	385.31	398.21	392.61	358.68	348.59	369.35	365.73	409.71	405.69
LRTS		5.907		5.598		10.089		3.621		4.024

Notes:
N and NN stand for normal and non-normal model, respectively.
Skew and Kurt are the standard measures of kurtosis and skewness.
White is the White test statistic
-2MV is minus two times the maximum value of the log likelihood function and LRTS is the resulting likelihood ratio test statistic which, under the null hypothesis of normality, is also distributed as a $\chi^2_{(2)}$ random variable.

First note that all yields are increasing over time, with the average increase rate of about 1.4 bushels/acre per year. The predicted yields for 2011, presented in the first row of the table, average a little over 170 bushels/acre versus about 115 bushels/acre in the early 1970's. The standard deviation parameters of the yield distributions range from 18 to 30 bushels/acre and, as with prices, the White tests statistics (also reported in Table 9) suggest that yield variability has generally remained constant over the last 40 years. The null hypothesis of yield normality is strongly rejected (p-value<0.025) in four cases, rejected (p-value<0.10) in two cases, and cannot be rejected in the remaining four. In contrast to prices, the prevailing negativity in the B_5 estimates suggests that the yield distributions tend to be left-skewed. Two of the non-rejection instances might be explained by the fact that, in both cases, observations were missing for the year 1983 which was characterized by extremely low yields in most other farms. In the other two, it appears that somehow farmers managed to avoid an extremely low yield event during the observation period, which is needed to trigger rejection.

6.3 Corn Price and Yield Simulations

The process of simulating draws from an estimated IHS pdf is simplified by the fact that the IHS random variable is actually defined as a function of a normal (Ramirez, 1997). Specifically, if Z_t is a standard normal, then:

(9) $IHS_t = mean_t\{sig(sinh(\theta(Z_t + \mu)) - F)/(\theta J^{1/2})\}$

where F and J are as defined in equation (3) and, in reference to the models in the previous section, $mean_t = B_1 + B_2 t,\ sig = B_3,\ \theta = B_4,$ and $\mu = B_5$. Thus, once an IHS distribution model parameters have been estimated, random draws from the implied distribution can be easily obtained on the basis of standard normal draws. In addition, contemporaneously correlated draws from several (S) IHS variables can be generated by simply correlating the (1 by S) Z_t vectors used to generate them by the Cholesky decomposition of the desired (S by S) correlation matrix (Ramirez, 1997). Finally, when the estimated IHS model involves autocorrelation, any T draws can be made to follow that process by multiplying a (T by 1) vector of IHS errors ($\{IHS_t - mean_t\} = \{sig(sinh(\theta(Z_t + \mu)) - F)/(\theta J^{1/2})\}$; t=1,…,T) by the Cholesky decomposition of the appropriate correlation matrix $\Psi = (\mathrm{P}'\mathrm{P})^{-1}$ and then adding back the systematic component of the model ($mean_t$).

The above procedures are used in conjunction with the estimated model parameters to simulate random realizations of prices and yields to be experienced by 10,000 hypothetical corn farms in the State of Illinois. It is assumed that the population of 10,000 farms is equally divided into 10 groups, each of which is characterized by one of the 10 yield distributions models detailed in Table 9 (six non-normal and four normal distributions). Forty-five future years of random yields are simulated for each farm assuming correlations of 0.65 across all yield distributions. In addition, 40 years of future state-wide price realizations are simulated assuming correlations of -0.45 with each of the 10,000 sets of yield draws. The 0.65 yield-yield correlation is selected on the basis of the average of the 45 sample correlation coefficients observed across the 10 farm-level yield series underlying the analyses. The -0.45 yield-price correlation is based on the average of the 10 sample correlation coefficients observed between the 10 yield series and the state-wide price data during the period those yields were observed. Using these simulated yields and prices, 40 years of CISA balances are constructed and we present the performance analyses in Chapter 7 and the sensitivity analyses in Chapter 8.

6.4 Peanut Yield and Price Distributions Models

Similar to the analysis of Illinois corn, a yield and price model was first established to simulate a 45-year peanuts yield and price series, and then CISAs balances were simulated correspondingly, followed by performance and sensitivity analyses in Chapter 7 and 8.

Parameters for yield simulation were obtained from an empirical analysis using the 31-year yield data from the Experiment Station. The peanut yield series for the Experiment Station is tested to be normally distributed (Shapiro-Wilk W-statistic=0.968, P-value = 0.4647). The peanuts yield was estimated to be a cosine function of average yield and time trend to capture a systematic trend in the past three decades:

(10) $Y_t = \beta_0 + \beta_1 cos\ (\beta_2 \cdot t)$, where $t = 1$, starting from 1979.

Table 10 presents the maximum-likelihood parameter estimates and related statistics for the peanut yield distribution model.

Table 10. Maximum-Likelihood Parameter Estimates of Peanut Yield Distribution Model

Parameters	Coefficients	t-statistics	p-values
β_0	3877.5608	(47.7385)	<0.0001
β_1	-492.6699	(-4.4721)	0.0001
β_2	-144.0148	(-11,965.5212)	<0.0001
Standard deviation	446.3927	(7.8779)	<0.0001
Loglikelihood value	-204.6474		

A 45-year yield series were predicted using above model. The predicted yield was then used as mean, along with an estimated standard deviation of 446.3927 lbs per acre, to simulate normally distributed yield for 2,000 peanuts producers in Georgia over a 45-year period. A white test was conducted to make sure the model's variance is constant over time. Adjacent farms usually have high correlation in yields. However, we do not have available data to estimate the correlation. We assume farm-level yield correlation of 0.55, lower than county-level yield correlation in Georgia. This assumption is reasonable as aggregate correlation is usually higher than that in farm-level. Considering the robustness of this assumption, sensitivity analyses with respect to different farm-level yield correlations are conducted in Chapter 8.

Peanut prices in Georgia are simulated as a normal distribution with a mean of 0.25 dollar per pound and a standard deviation of 0.05, the mean and standard deviation of the 30-year time series (Figure 7).

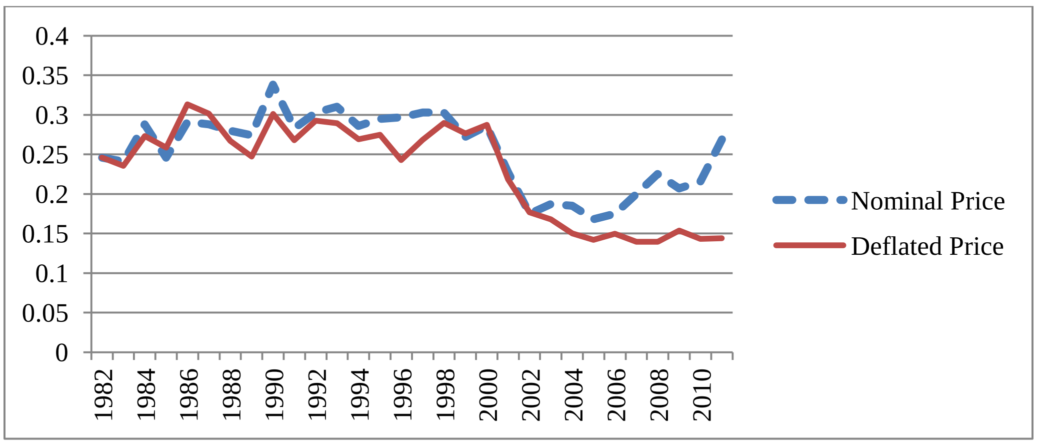

Figure 7. Peanut Price Received in Georgia 1982-2011

Peanuts are in the price support program and therefore we cannot construct a future price model based on the historical records due to possible policy changes. The Agricultural Adjustment Act of 1938 authorized the peanut poundage quotas to regulate the marketing of peanuts consumed domestically for food when production becomes excessive. Under this supply control mechanism, the quota peanuts - peanuts purchased for the edible market (e.g., for peanut butter and snack production) were sold at a support price of $610/ton. Production beyond the quota limits (called additional peanuts) must be crushed for non-edible uses or exported. The

2002 Farm Act replaced the quota support system with the Marketing Assistance Loans and Loan Deficiency Payments, which established a much lower price floor of $314/ton and removed quantity constraints. The average price received by peanut growers in Georgia dropped by 23percent from $0.227/lb in 2001 to $0.175/lb in 2002. Peanut prices were relatively stable during 2003-2006 at around $0.17/lb – $0.18/lb (see Figure 7). The 2008 Farm Act provides loans for crop year 2008 through 2012 for peanut producers. A nonrecourse loan allows a producer with eligible peanuts to store the production and pledge the peanuts as collateral and wait to sell the peanuts when market conditions are more favorable (FAS, USDA, Price Support – Peanut program). Since 2007, peanut price has been rising to a little higher than $0.20/lb. This price level is lower than the average price before the end of quota system ($0.28/lb), responding to the increase in production due to end of quantity constraint.

Figure 7 presents nominal peanut prices and the deflated prices (deflated by farm products PPI from LBS). Nominal price variability has increased in recent years due to the end of government subsidies and price supports. But it is not viable to estimate future price variability based on this historical record because policy changes played an important role in increased variability. Therefore, instead of constructing a price model, we use historical price mean and standard deviation and conduct sensitivity analyses using increased standard deviations.

6.5 Peanut Yield and Price Simulations

Similar to the case of Illinois corn, in each simulation the periodic revenues of a population of 2,000 peanut farmers over 45 years are generated using the above peanut yield model and assumed price. 2,000 iterations are conducted to present the average performance of the CISA system.

CHAPTER 7

CISA PERFORMANCE ANALYSES

This chapter assesses the potential performance of the proposed CISA system for the particular case of Illinois corn and Georgia peanut producers, respectively, with a focus on the four key measures: (1) the proportion of farmers who require loans from the government at some point in time, (2) the proportion of farmers who have a negative terminal balance, (3) the cost of the program to the government, and (4) the affordability of the system to farmers. In each simulation, the periodic revenue of 10,000 corn and 2,000 peanut growers over 45 years is generated respectively using the draws from the yield and price simulations described in the previous chapter. We begin our analysis by considering a simple scheme where it is assumed that the annual CISA contribution by each farmer is a fraction (α) of his/her average revenue over the previous five years. In the next section we will consider a more sophisticated contribution scheme with several distinct advantages over this simple specification. Similarly, we assume that the revenue guarantee (R_t^g) is a fraction (γ) of the farmer's average revenue over the past five years. Hence, the periodic balance of a farmer's CISA is given by:

(11) $B_t = (1+r)B_{t-1} + \alpha\bar{R}_t - max(0, \gamma\bar{R}_t - R_t);\ t = 6, \dots, 45.$

Where $\overline{\mathrm{R}}_t = \frac{1}{5}\sum_{t-5}^{t-1} R_t$ denotes a five year moving average of farm revenue. While in practice it may be beneficial to allow farmers to build up an initial balance in their CISA account before transitioning from a traditional crop insurance program to a CISA system[8], we do not in our simulations (i.e., we assume that the balance at t=5 is zero) in order to deliver a fair assessment

[8] For example, some employers provide employees with seed money to build up new health savings accounts.

of the cost of CISAs to the government and farmers. This absence of a buildup period, as we will elaborate on later, has a number of implications.

7.1 CISA Simulations under Baseline Parameters

Using the estimated model parameters and procedures for simulating future yields and prices discussed in the previous chapter, Tables 11 and Table 12 present summary statistics for the performance of the CISA system over a range of contribution rates and revenue guarantees for corn producers in Illinois and peanut producers in Georgia, respectively. Numbers presented in Table 11 are averages over 100,000 iterations of 10,000 farmers each and Numbers in Table 12 are averages over 2,000 iterations of 2,000 farmers. We consider contribution rates of 3%, 5%, and 7% and revenue guarantee of 65%, 75%, and 85% of the farmers' past five year revenue moving averages. The CISA borrowing and saving interest rate is assumed to be a constant 3%. In terms of performance measures we focus on (1) the percentage of farmers that ever experience a negative CISA balance in at least one year over the 40 years of operation, (2) the percentage of farmers that have a negative terminal CISA balance after 40 years, and (3) the average terminal CISA balance of farmers.

As expected, the performance of the CISA system varies substantially across different contribution rates and revenue guarantees (Tables 11 and 12). For the most logical combinations of contribution rates and revenue guarantees (3% & 65%, 5% & 75%, and 7% and 85%), the percentage of individuals who ever have a negative account balance over the 40-year time horizon is relatively low. For example, at a 5% contribution rate and a 75% revenue guarantee, across all the simulations on average only 18.82% of corn farmers and 27.52% of peanut producers experience a negative CISA balance and require a loan from the government in at least one year.

Table 11. Performance of Corn CISA

	$\alpha = 3\%$ $\gamma = 65\%$	$\alpha = 3\%$ $\gamma = 75\%$	$\alpha = 3\%$ $\gamma = 85\%$	$\alpha = 5\%$ $\gamma = 65\%$	$\alpha = 5\%$ $\gamma = 75\%$	$\alpha = 5\%$ $\gamma = 85\%$	$\alpha = 7\%$ $\gamma = 65\%$	$\alpha = 7\%$ $\gamma = 75\%$	$\alpha = 7\%$ $\gamma = 85\%$
All Farmers									
% Ever have a Negative CISA Balance	11.29%	36.92%	86.43%	5.94%	18.82%	55.84%	3.73%	11.61%	35.04%
% End with Negative CISA Balance	0.84%	11.90%	73.46%	0.02%	0.85%	23.15%	0.00%	0.05%	3.46%
Ave. Terminal CISA Balance (per acre)	$1208.61	$641.61	$-512.63	$2237.53	$1669.09	$515.48	$3267.49	$2699.87	$1546.62
Ave. Annual CISA Contribution	$18.03	$18.03	$18.03	$30.06	$30.05	$30.06	$42.08	$42.08	$42.08
Ave. Annual CISA Withdraw (per acre)	$4.30	$11.34	$25.26	$4.32	$11.36	$25.28	$4.30	$11.34	$25.26
Ave. # of Withdraws from CISA	2.72	6.14	11.35	2.73	6.15	11.35	2.72	6.14	11.35
Farmers with Positive Terminal CISA Balance									
% Ever have a Negative CISA Balance	10.81%	32.65%	64.47%	5.93%	18.51%	49.91%	3.73%	11.60%	34.24%
Ave. Terminal CISA Balance (per acre)	$1217.03	$725.25	$200.67	$2237.87	$1677.47	$708.95	$3267.51	$2700.50	$1578.21
Farmers with Negative Terminal CISA Balance									
Ave. Terminal CISA Balance (per acre)	$-199.32	$-253.76	$-684.75	$-278.82	$-243.21	$-325.57	$-791.36	$-358.82	$-268.03

Table 12. Performance of Peanut CISA

	$\alpha = 3\%$ $\gamma = 65\%$	$\alpha = 3\%$ $\gamma = 75\%$	$\alpha = 3\%$ $\gamma = 85\%$	$\alpha = 5\%$ $\gamma = 65\%$	$\alpha = 5\%$ $\gamma = 75\%$	$\alpha = 5\%$ $\gamma = 85\%$	$\alpha = 7\%$ $\gamma = 65\%$	$\alpha = 7\%$ $\gamma = 75\%$	$\alpha = 7\%$ $\gamma = 85\%$
All Farmers									
% Ever have a Negative CISA Balance	16.37%	55.36%	96.72%	6.63%	27.52%	75.24%	3.17%	13.30%	46.19%
% End with Negative CISA Balance	0.12%	14.88%	90.32%	0%	0.40%	34.35%	0%	0.0002%	2.62%
Ave. Terminal CISA Balance (per acre)	$1,612.80	$673.59	-$1,127.89	$3,086.45	$2,119.31	$322.01	$4,563.51	$3,579.21	$1,816.86
Ave. Annual CISA Contribution	$25.87	$25.86	$25.86	$43.16	$43.11	$43.08	$60.38	$60.35	$60.41
Ave. Annual CISA Withdraw (per acre)	$6.86	$17.67	$38.59	$6.82	$17.94	$38.72	$6.74	$18.06	$38.59
Ave. # of Withdraws from CISA	3.19	6.66	11.62	3.20	6.74	11.63	3.15	6.71	11.63
Farmers with Positive Terminal CISA Balance									
% Ever have a Negative CISA Balance	53.61%	81.96%	6.63%	27.50%	71.63%	3.17%	13.30%	46.03%	53.61%
Ave. Terminal CISA Balance (per acre)	$771.01	$175.67	$3,086.45	$2,121.76	$646.12	$4,563.51	$3,579.21	$1,837.55	$771.01
Farmers with Negative Terminal CISA Balance									
Ave. Terminal CISA Balance (per acre)	-$91.92	-$197.01	-$1,191.49	Na	-$136.41	-$379.34	Na	-$50.69	-$177.95

As discussed earlier, the most critical factor for the viability of the proposed CISA system when farmer participation is voluntary and negative end-balances are to be repaid to the government is the percentage of farmers that would expect to reach retirement with a negative account balance, as this might be a disincentive to participate. For the lower contribution rate (3%) and revenue guarantee (65%), the simulation results are tremendously positive on this metric (tables 11 and 12): on average, only 0.84% of the corn farmers and 0.12% of the peanut farmers end with a negative account balance after 40 years of operation. The average terminal CISA balance for all farmers is $1208.61 per acre for corn farmers and $1613.33 per acre for peanut farmers, and the average terminal balance for the 0.84% of corn farmers and 0.12% of peanut farmers retiring with a negative balance is just -$199.32 per acre and -$91.92 per acre, respectively, which could be easily managed given land values. In addition, note that if higher percentage contributions are required from farmers who desire higher revenue guarantees (i.e. one has to pay 5% for 75% coverage and 7% for 85% coverage), the terminal balance statistics are similarly favorable. Also note that these results are obtained without assuming a build-up period prior to initiating the CISA system and do not account for the reduction in the amount of yield and price risk that farmers are willing to take if self-insurance is their only protection against that risk.

7.2. Capped Balances with Catch-up Contributions

While the results presented in Tables 11 and 12 suggest that by saving a small percentage of their annual average revenue farmers can self-insure against unacceptable revenue losses with a very low default rate, there are two drawbacks of this simple design. First, by having a constant contribution rate over time regardless of whether a farmer has a large or small positive or negative balance in his/her CISA, there is no differentiation of contribution rates among farmers who at any given time are at a higher or lower risk of ending up with a negative balance. This inevitably results in some farmers building up substantial positive account balances far in excess of what is required to insure against statistically remote deficits. As well, farmers who suffer unusually severe or frequent crop losses and thus accumulate large negative balances, but only replenish their account at a constant rate, α, are at a much higher risk of having to retire owing money to the government.

Given these undesirable consequences of the constant contribution rate scheme, we propose an alternative design that strives to achieve three objectives: (1) minimize the periodical contribution rate (given the desired coverage level) for farmers who are carrying adequate balances in their accounts, (2) prevent the buildup of balances in excess what is needed to provide sufficient funds in the event of catastrophic losses, and (3) more rapidly replenish accounts that are in a deficit to minimize the percentage of farmers ending up with negative terminal balances.

Specifically, we propose the following improvements to our original design. Letting $I\{\cdot\}$ denote an indicator function that equals 1 if it is true and 0 otherwise, when farmers reach or exceed an account balance cap of θ percent of their average revenue (i.e. when $I\{(1+r)B_{t-1} < \theta\overline{\mathrm{R}}_{\mathrm{t}}\} = 0$) they are not permitted to contribute to their CISA in that year. Alternatively, farmers with balances below the cap ($I\{(1+r)B_{t-1} < \theta\overline{\mathrm{R}}_{\mathrm{t}}\} = 1$) continue to contribute at a constant annual rate (α) up until they reach it. Algebraically, this contribution is expressed as $min(\alpha\overline{\mathrm{R}}_{\mathrm{t}}, \max(0, \theta\overline{\mathrm{R}}_{\mathrm{t}} - (1+r)B_{t-1}))$.[9] For farmers with negative balances, we institute

[9] It is also specified that farmers with balances that grow above their cap due to either interest accumulation or a decrease in their cap from a fall in their 5-year moving average of revenue are not permitted to withdraw funds from their account.

"catch-up" payments in addition to their regular contribution, but these are only triggered in years when revenue is above their historical average (i.e., when $I\{(1+r)B_{t-1} < 0\} * I\{R_t > \overline{\mathrm{R}}_{\mathrm{t}}\} = 1$). This contribution is equal to the lesser of either their outstanding loan balance, or the current period revenue in excess of their moving average (i.e. $min(|(1+r)B_{t-1}|, R_t - \overline{\mathrm{R}}_{\mathrm{t}})$). Formally, the evolution of account balances under this specification of a regular contribution (if account balances are below the balance cap) and additional catch-up payments (if balances are less than zero and revenue in that year is above average) can be expressed as:

(8) $$B_t = (1+r)B_{t-1} + I\{(1+r)B_{t-1} < \theta\overline{\mathrm{R}}_{\mathrm{t}}\} * min(\alpha\overline{\mathrm{R}}_{\mathrm{t}}, \max(\theta\overline{\mathrm{R}}_{\mathrm{t}} - (1+r)B_{t-1}, 0)) + I\{(1+r)B_{t-1} < 0\} * I\{R_t > \overline{\mathrm{R}}_{\mathrm{t}}\} * min(|(1+r)B_{t-1}|, R_t - \overline{\mathrm{R}}_{\mathrm{t}}) - max(0, \gamma\overline{\mathrm{R}}_{\mathrm{t}} - \mathrm{R}_{\mathrm{t}}).$$

Tables 13 and 14 presents simulation results of the corn and peanut CISA performance, respectively, under the above described contribution scheme with capped balances and catch-up contributions. The simulations are conducted for regular contributions of 1.5%, 3.0%, and 6.0%, revenue guarantees of 65%, 75%, and 85%, and caps of 65%, 75%, and 85% (i.e., $\theta = \gamma$), respectively. The rationale for letting $\theta = \gamma$ is that this allows farmers to build up account balances to a level where they can fully cover a CISA withdrawal in a catastrophic year with 100% crop losses.

As evidenced in tables 13 and 14, very favorable ending balances are obtained under this design despite the lower annual contribution rates. Across the three revenue guarantee levels (65%, 75%, and 85%), just 0.50%, 0.91%, and 1.03% of corn farmers, and 0.08%, 0.25%, and 0.07% of peanut farmers are expected to have a negative terminal CISA balance. Due to the inclusion of a contribution cap, the average ending account balances of \$434.14, \$511.30, and \$510.72 per acre for corn producers and \$581.30, \$685.70 and \$787.86 for peanut growers are substantially lower than under the previous scheme (tables 11 and 12).

Table 13. Performance of Corn CISA with Capped Balances and Catch-up Contributions

	$\alpha = 1.5\%$ $\gamma = 65\%$ $\theta = 65\%$	$\alpha = 3.0\%$ $\gamma = 75\%$ $\theta = 75\%$	$\alpha = 6.0\%$ $\gamma = 85\%$ $\theta = 85\%$
All Farmers			
% Ever have a Negative CISA Balance	25.37%	37.53%	45.86%
% End with Negative CISA Balance	0.50%	0.91%	1.03%
Ave. Terminal CISA Balance	\$434.14	\$511.30	\$510.72
Ave. Annual CISA Contribution (per acre)	\$8.42	\$15.04	\$27.11
% of Revenue Contributed to CISA	1.41%	2.53%	4.55%
Ave. Annual CISA Withdraw (per acre)	\$4.31	\$11.35	\$25.28
Ave. # of Withdraws from CISA (per acre)	2.72	6.15	11.35
Farmers with Positive Terminal CISA Balance			
% Ever have a Negative CISA Balance	25.16%	37.30%	45.67%
Ave. Terminal CISA Balance (per acre)	\$435.26	\$513.55	\$513.26
Farmers with Negative Terminal CISA Balance			
Ave. Terminal CISA Balance (per acre)	\$-96.36	\$-118.32	\$-166.58

Table 14. Performance of Peanut CISA with Capped Balances and Catch-up Contributions

	$\alpha = 1.5\%$ $\gamma = 65\%$ $\theta = 65\%$	$\alpha = 3.0\%$ $\gamma = 75\%$ $\theta = 75\%$	$\alpha = 6.0\%$ $\gamma = 85\%$ $\theta = 85\%$
All Farmers			
% Ever have a Negative CISA Balance	41.08%	53.44%	60.78%
% End with Negative CISA Balance	0.06%	0.15%	0.11%
Ave. Terminal CISA Balance	\$571.96	\$694.04	\$782.33
Ave. Annual CISA Contribution (per acre)	\$12.95	\$24.20	\$44.84
% of Revenue Contributed to CISA	1.50%	2.80%	5.18%
Ave. Annual CISA Withdraw (per acre)	\$6.81	\$17.59	\$38.70
Ave. # of Withdraws from CISA (per acre)	3.19	6.63	11.66
Farmers with Positive Terminal CISA Balance			
% Ever have a Negative CISA Balance	41.05%	53.40%	60.75%
Ave. Terminal CISA Balance (per acre)	\$572.11	\$694.41	\$782.57
Farmers with Negative Terminal CISA Balance			
Ave. Terminal CISA Balance (per acre)	-\$29.36	-\$34.49	-\$37.59

In addition, for the very small percentage of farmers that are expected to retire with a deficit, their outstanding loan balance is small (-$96.36, -$118.32, and -$166.58 per acre for corn producers, and -$28.14, -$36.49, and -$34.94 per acre for peanut growers) relative to the values of lands.

Because of the cap provision, the actual contributions as a percentage of past revenue required under this more sophisticated scheme average just 1.41%, 2.53% and 4.55% for corn CISA, and 1.49%, 2.83%, and 5.17% for peanut CISA, respectively, and the corresponding per acre contributions are $8.42, $15.04 and $27.11 per year for corn CISA, and $6.63, $17.89, and $38.58 per year for peanut CISA.

As a point of reference, the 2007-2011 average crop insurance premiums paid by grain corn farmers (crop code 0041) purchasing revenue insurance products in the State of Illinois for the same (65%, 75% and 85%) coverage levels, were $10.82, $15.43 and $29.27 per acre[10]. As noted in Table 13, these modest contribution levels are enough to ensure revenue loss protection against events (i.e. withdrawals) that on average occur 2.72, 6.15 and 11.35 times out of 40 years (i.e. 6.8, 15.4 and 28.4 out of 100 years) for corn producers. The 2007-2011 average crop insurance premiums paid by Georgia peanut growers (crop code 0075) purchasing APH insurance for the same coverage levels were $17.48, $29.70, and $60.82 per acre. These insurance costs are much higher than the required annual contributions under the CISA system ($12.95, $24.20, and $44.84 from Table 14). Therefore these current peanut APH insurance costs, used as contribution levels, are enough to ensure revenue loss protection against events

[10] This was obtained by dividing the total premium amount paid by farmers by the number of acres insured at each of the three coverage levels. The selected product is Crop Revenue Coverage (CRC) for 2007-2010 and Revenue Protection (RP) for 2011. From 2007 to 2010, CRC was the top selling revenue insurance plan. Since 2011, CRC and three other revenue-based plans were discontinued and combined into a single uniform RP policy.

(i.e. withdrawals) that on average occur 3.15, 6.68, and 11.59 times of 40 years (i.e. 7.9, 16.7, and 29.0 out of 100 years) for peanut growers, respectively.

7.3 Distribution of Outcomes under the CISA System

While the statistics presented in Tables 13 and 14 offer a promising projection on the potential of CISAs to deliver an effective self-insurance system in the case of Illinois corn farmers and Georgia peanut farmers, it is critical to look beyond average performance and understand the distribution of potential outcomes. In this section we discuss a series of figures illustrating the distribution of the statistics presented in tables 13 and 14 for a CISA system with capped balances and catch-up contributions.

Figures 8 and 9 present, over the range of contribution rates and revenue guarantee levels, a breakdown of all the simulation outcomes (10,000 simulations for corn CISA and 2,000 simulations for peanut CISA) as a function of the percentage of farmers that ever experience a negative CISA balance.

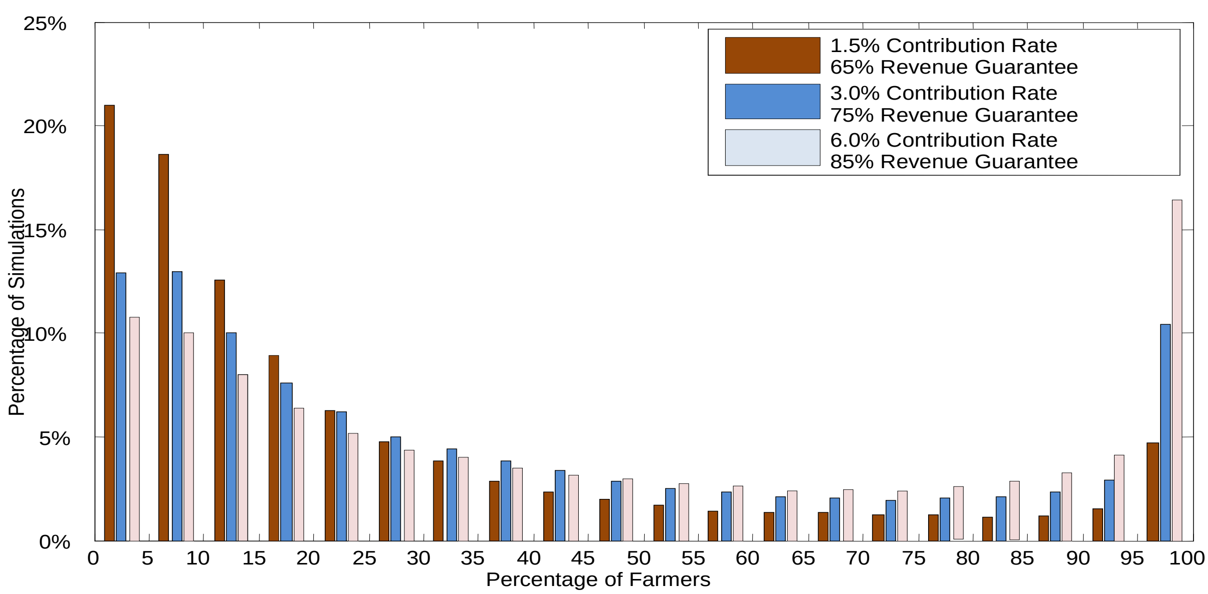

Figure 8. Percentage of Corn Farmers Ever with a Negative CISA Balance

As can be seen, for a significant percentage of the simulations a sizable percentage of farmers at some point will require a loan from the government due to a negative account balance. For example, at the 65% coverage level, in over 20% of the simulations (i.e. there is a greater than 20% probability that) none of the 10,000 corn farmers will ever need a loan. Alternatively, at the 85% coverage level, in over 15% of the simulations 100% of the corn farmers will at some point need a loan. For peanut CISA, at the 65% coverage level, there is over 25% probability that none of the 2,000 peanut farmers will ever need a loan. Alternatively, at the 85% coverage level, there is over 30% probability that 100% of the peanut farmers will need government loan in at least one year. Given the absence of an account buildup period before relying on the CISA as the sole source of insurance, this is to be expected. Including a small buildup period would substantially shift the mass of the distribution in Figures 8 and 9 to the left.

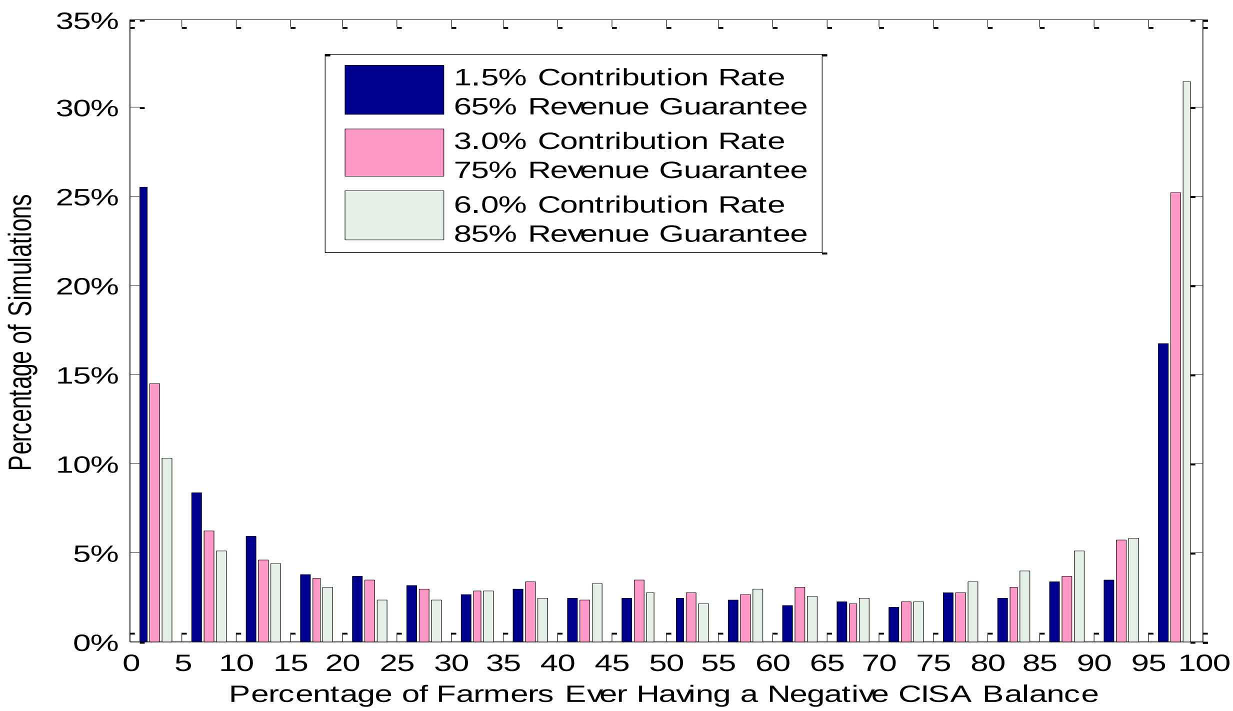

Figure 9. Percentage of Peanut Farmers Ever with a Negative CISA Balance

In regard to the more relevant terminal balance statistic, however, as illustrated in Figure 10 for corn producers and Figure 11for peanut producers, over a farming lifetime virtually all simulations result in a very low percentage of farmers ending with an account deficit. That is, regardless of the selected coverage level, it is highly unlikely if CISA was implemented for Illinois corn farmers and Georgia peanut farmers that more than 5% of them would end up with a negative balance.

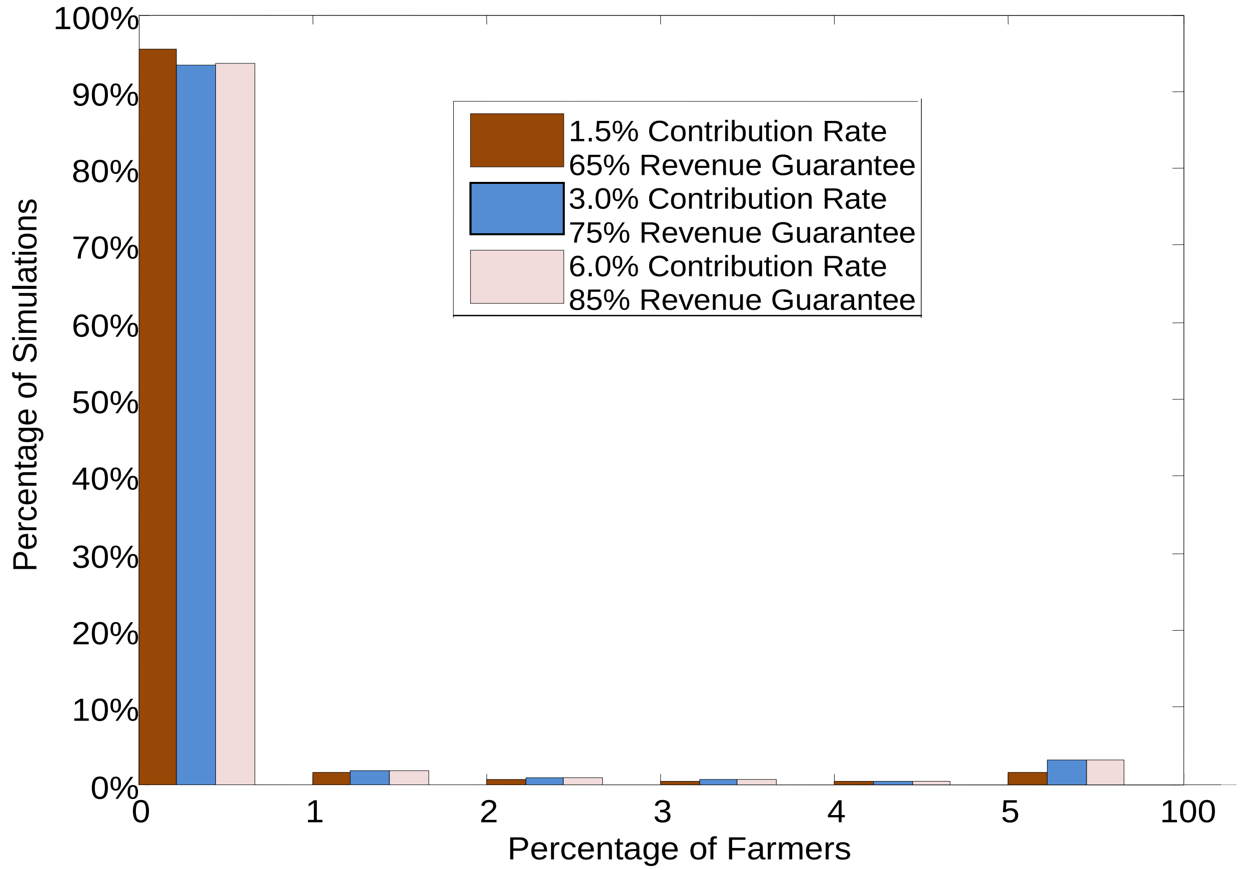

Figure 10. Percentage of Corn Farmers with a Negative Terminal CISA Balance

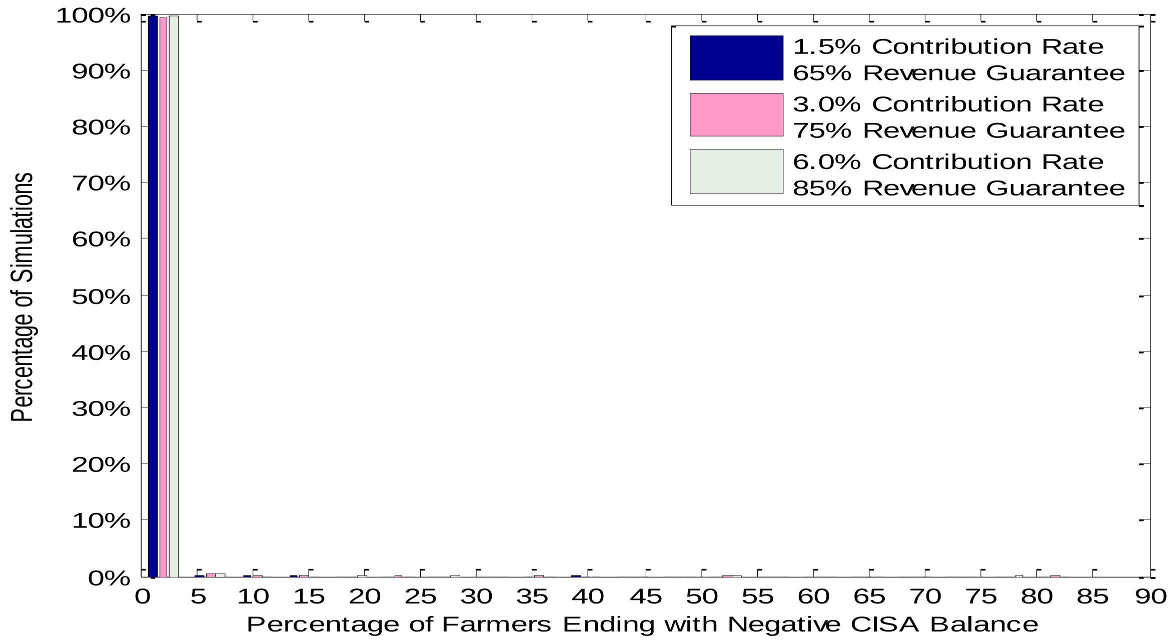

Figure 11. Percentage of Peanut Farmers with a Negative Terminal CISA Balance

Figures 12 and 13 present the distribution of the average terminal CISA account balances across the 100,000 corn simulations and 2,000 peanut simulations, respectively.

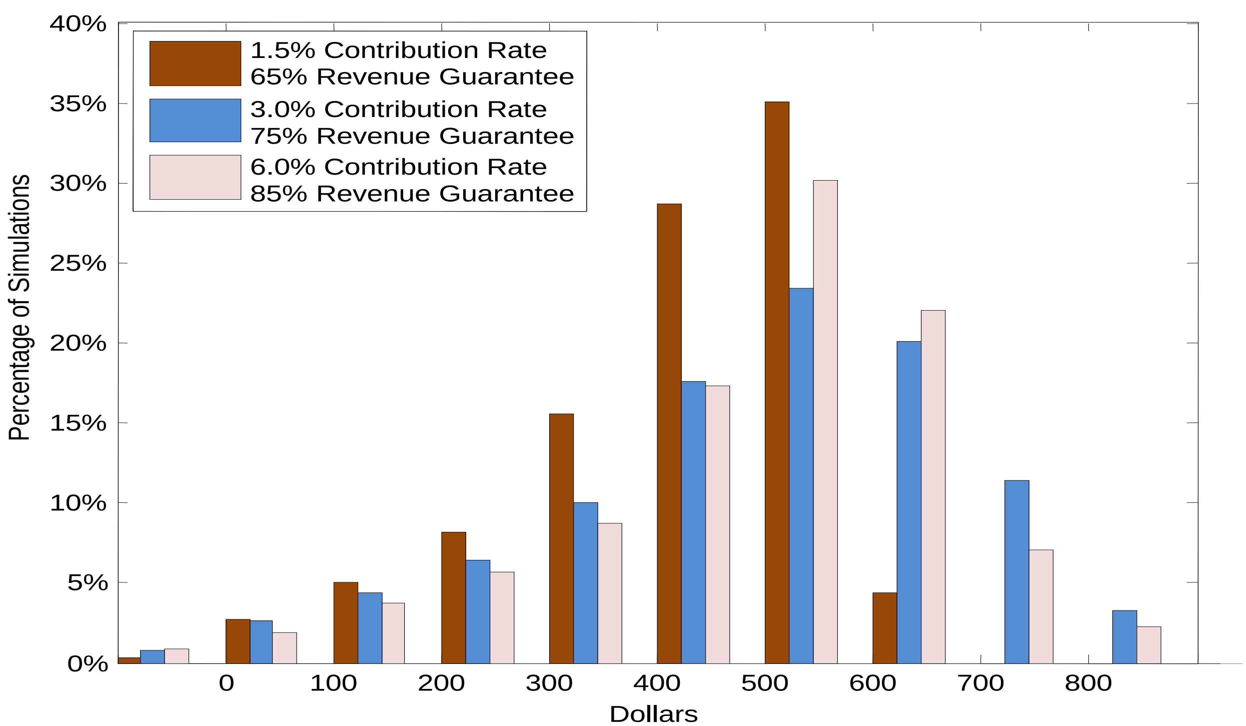

Figure 12. Average Corn CISA Terminal Balance per farmer per acre

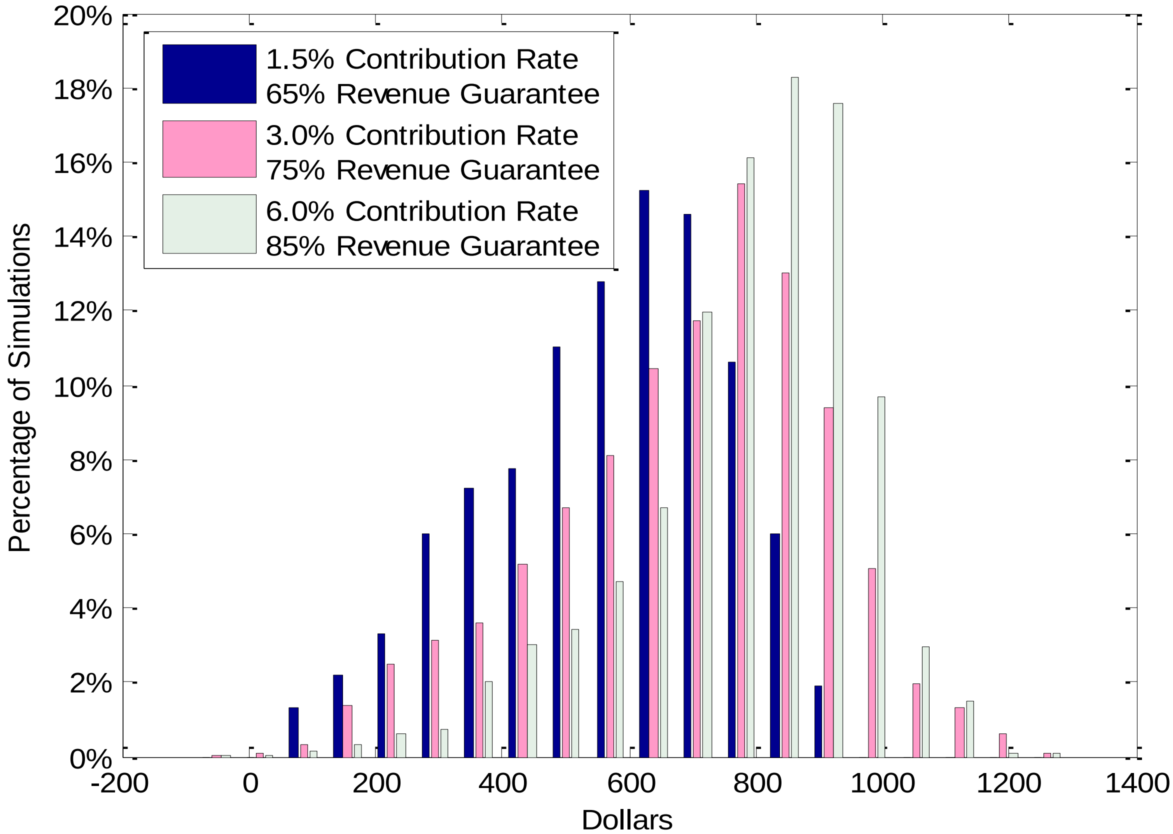

Figure 13. Average Peanut CISA Terminal Balance per farmer per acre

Note that the probability of the average balance for the 10,000 hypothetical corn farmers and 2,000 peanut farmers ending up being negative is negligible. This suggests that if the government chose to forgive the negative account balances of farmers reaching retirement, even in the event of an extremely unlikely outcome, the cost to the government would be relatively small. From tables 13, the expected average cost per acre corn is $0.48 (0.50% of $96.36), $1.08 (0.91% of $118.32), and $1.72 (1.03% of $166.58), for the 65%, 75%, and 85% coverage levels, respectively. From Table 14 the expected average cost per acre peanut is $0.02 (0.06% of $29.36), $0.05 (0.15% of $34.49), and $0.04 (0.11% of $37.59) for the same coverage levels. Therefore, for example, if farmers were "retiring" 2.3 million acres of corn per year (1/40th of the total number of acres planted in the U.S. in 2011) and 57,030 acres of peanut per year (1/20th of the total number of acres planted in the U.S. in 2011), even at the 85% coverage level, the expected loss in loan re-payments to the government would be less than $4 million per year for corn and less than $2281 per year for peanut. As reference, during 2007 -2011, the corn and peanut insurances on average cost the government $556.68 million per year and $25.12 million per year, respectively (operation costs excluded, see Table 6).

CHAPTER 8

CISA SENSITIVITY ANALYSES

Given the robustness of the datasets and the methods used to estimate the price and yield distributions underpinning the previous analyses, we feel fairly confident of the results for the simulated corn and peanut producers. However, it is possible that the performance of the proposed CISA system might not be as strong for farms that are exposed to a substantially higher revenue risk. Considering this possibility, we focus our sensitivity analysis on a scenario where both the price and yield volatility are markedly higher. Specifically, the standard deviation of the price distribution is increased by 25% and the standard deviations of the yield distributions are increased by 50%. In all cases, these increases are the equivalent of adding more than two standard errors to the models' original parameter estimates.

In addition, as we assumed peanut yield correlation of 0.55 and peanut price mean and standard deviation of 0.25 and 0.05, respectively, without empirical estimation, we also conducted additional sensitivity analyses for peanut CISA performance with respect to above two concerns.

8.1 Sensitivity Analysis with Increase Yield and Price Variances

Tables 15 and 16 present summary statistics for the performance of the CISA system under such "worse-case" scenario for corn and peanut producers, respectively.

Table 15. Sensitivity Analysis with Increase Price and Yield Variances for Corn CISA with Capped Balances and Catch-up Contributions

	$\alpha = 2.5\%$ $\gamma = 65\%$ $\theta = 65\%$	$\alpha = 5.0\%$ $\gamma = 75\%$ $\theta = 75\%$	$\alpha = 9.0\%$ $\gamma = 85\%$ $\theta = 85\%$
All Farmers			
% Ever have a Negative CISA Balance	48.01%	53.36%	58.20%
% End with Negative CISA Balance	1.93%	1.98%	1.97%
Ave. Terminal CISA Balance	$398.53	$443.10	$443.03
Ave. Annual CISA Contribution (per acre)	$14.29	$24.37	$40.68
% of Revenue Contributed to CISA	2.43%	4.14%	6.91%
Ave. Annual CISA Withdraw (per acre)	$11.39	$22.55	$40.25
Ave. # of Withdraws from CISA (per acre)	5.08	8.74	13.32
Farmers with Positive Terminal CISA Balance			
% Ever have a Negative CISA Balance	47.44%	52.97%	57.90%
Ave. Terminal CISA Balance (per acre)	$403.75	$448.98	$448.94
Farmers with Negative Terminal CISA Balance			
Ave. Terminal CISA Balance (per acre)	$-98.33	$-130.98	$-168.05

From table 15, note that, in order to maintain the percentage of corn farmers ending up with a negative terminal balance under 2%, the prescribed contributions for the 65%, 75% and 85% coverage levels had to be increased to 2.5%, 5% and 9% of past average revenue. However, thanks to the cap provision, actual contributions as a percentage of past revenue required under this more sophisticated scheme are just 2.43%, 4.14% and 6.91%, respectively, and the corresponding annual contributions are $11.39, $22.55 and $40.25 per acre. Although under this extremely pessimistic scenario the necessary contributions would be higher than what Illinois farmers are currently paying for crop insurance ($10.82, $15.43 and $29.27 per acre), note that on average they would benefit from substantial residual balances ($398.53, $443.10 and $443.03 per acre) at the end of the coverage period.

Table 16 shows that higher contributions (3.0%, 5.5%, and 9.0% for 65%, 75%, and 85% coverage levels, respectively) are required to maintain the percentage of peanut farmers ending with negative terminal CISA balances under 3%. However the actual contributions are just 2.64%, 4.45%, and 7.49% due to the cap provision. Similar to the corn CISA, the required contribution levels ($22.79, $38.45, and $64.81 per acre per year for 65%,75%, and 85% coverage levels, respectively) are a little higher than the current cost ($17.48, $29.70, and $60.82), but the all-farmer average terminal CISA balance are substantial ($656.42, $718.09, and $741.25).

Table 16. Sensitivity Analysis with Increase Price and Yield Variances for Peanut CISA with Capped Balances and Catch-up Contributions

	$\alpha = 3.0\%$ $\gamma = 65\%$ $\theta = 65\%$	$\alpha = 5.5\%$ $\gamma = 75\%$ $\theta = 75\%$	$\alpha = 9.0\%$ $\gamma = 85\%$ $\theta = 85\%$
All Farmers			
% Ever have a Negative CISA Balance	52.37%	55.69%	64.55%
% End with Negative CISA Balance	0.20%	0.25%	0.27%
Ave. Terminal CISA Balance	$656.42	$718.09	$741.25
Ave. Annual CISA Contribution (per acre)	$22.79	$38.45	$64.81
% of Revenue Contributed to CISA	2.64%	4.45%	7.49%
Ave. Annual CISA Withdraw (per acre)	$17.11	$33.75	$60.54
Ave. # of Withdraws from CISA (per acre)	5.66	9.25	13.68
Farmers with Positive Terminal CISA Balance			
% Ever have a Negative CISA Balance	52.29%	55.62%	64.46%
Ave. Terminal CISA Balance (per acre)	$657.07	$718.79	$742.10
Farmers with Negative Terminal CISA Balance			
Ave. Terminal CISA Balance (per acre)	-$43.82	-$54.74	-$56.00

A final observation is that high annual percentage contributions are only required when coverage for events that occur very frequently is desired, which is not really the objective of having insurance. For example, under the scenario where the estimated level of corn price and yield variability is assumed (Table 11), an average annual contribution of $15.04 per acre is needed for 75% coverage, which protects farmers from low revenue events that occur 6.15 out of every 40 years. In contrast, under the increased price and yield volatility scenario (Table 15), the 65% coverage level requires slightly lower annual contributions of $14.29 per acre and ensures farmers against adverse revenue events that take place 5.08 out of 40 years. So, if the objective is to protect farmers from infrequent losses (e.g. those that occur 5 or 6 out of 40 years), it appears that the contribution level is not much affected by how volatile revenues (i.e. prices and yields) are. This suggests that as long as coverage levels are reasonably defined in terms of the frequency of loss they are designed to protect (e.g. 5, 10 and 15 out of 100 years) the proposed CISA system should provide effective coverage at affordable annual contributions regardless of how volatile a crop's revenues are.

8.2 Sensitivity Analysis with Different Peanut Yield Correlations

In section 6.4 we assumed farm-level correlation of 0.55. This level correlation seems reasonable in that it is lower than county-level aggregate yield correlation. However, in order to test the viability of this assumption, we conducted the sensitivity analyses with respect to different peanut yield correlations with two extreme cases – very low farm-level yield correlation (rho=0.10) and very high yield correlation (rho=0.90). Table 17 presents the peanut CISA performances for yield correlations of 0.10 and 0.90. We check the sensitivity by looking at the per acre cost of the peanut CISA ("The percentage of farmers end with negative CISA balance" times "Average Terminal CISA Balance"). Comparison of the performances under correlations of 0.10, 0.55, and 0.90 (Tables 14 and 17) shows that the per acre costs of peanut CISA do not vary significantly across different correlations (for the same coverage level of 65%, 75%, and 85%, respectively, the per acre cost is $0.03, $0.06, and $0.03 with 0.10 yield correlation, $0.02, $0.05, and $0.04 for 0.55 correlation, and $0.01, $0.04 and $0.04 for 0.90 correlation). Therefore, we conclude that the assumption of yield correlation, even incorrect, would not undermine the viability of our assessment of the peanut CISA performances.

Table 17. Sensitivity Analyses with Different Peanut Yield Correlations with Capped Balances and Catch-up Contributions

	Low Yield Correlation rho=0.1			**High Yield Correlation rho=0.9**		
	$\alpha = 1.5\%$ $\gamma = 65\%$ $\theta = 65\%$	$\alpha = 3.0\%$ $\gamma = 75\%$ $\theta = 75\%$	$\alpha = 6.0\%$ $\gamma = 85\%$ $\theta = 85\%$	$\alpha = 1.5\%$ $\gamma = 65\%$ $\theta = 65\%$	$\alpha = 3.0\%$ $\gamma = 75\%$ $\theta = 75\%$	$\alpha = 6.0\%$ $\gamma = 85\%$ $\theta = 85\%$
All Farmers						
% Ever have a Negative CISA Balance	41.30%	55.70%	60.47%	41.74%	53.61%	61.49%
% End with Negative CISA Balance	0.08%	0.15%	0.07%	0.04%	0.12%	0.13%
Ave. Terminal CISA Balance (per acre)	$574.94	$686.78	$785.20	$568.30	$695.11	$780.46
Ave. Annual CISA Contribution	$12.96	$24.55	$44.68	$12.99	$24.23	$44.93
% of Revenue Contributed to CISA	1.50%	2.83%	5.16%	1.50%	2.80%	5.19%
Ave. Annual CISA Withdraw (per acre)	$6.77	$17.89	$38.56	$6.88	$17.59	$38.79
Ave. # of Withdraws from CISA	3.20	6.74	11.66	3.19	6.64	11.66
Farmers with Positive Terminal CISA Balance						
% Ever have a Negative CISA Balance	41.28%	55.65%	60.44%	41.70%	53.59%	61.45%
Ave. Terminal CISA Balance (per acre)	$575.18	$687.32	$785.51	$568.35	$695.23	$780.63
Farmers with Negative Terminal CISA Balance						
Ave. Terminal CISA Balance (per acre)	-$35.75	-$42.68	-$44.55	-$26.23	-$33.46	-$25.98

CHAPTER 9

CONCLUSION AND IMPLICATION

Crop insurance is a critical risk management tool for farmers to protect against yield and revenue losses. Current Federal Crop Insurance Program has played a dominant role in agricultural risk management. The Federal Crop Insurance Program currently provides insurance products to over 100 different crops nationwide, insuring 262 million acres with liabilities of $223 billion in 2011, with over 80 percent of the planting acres eligible for crop insurance insured in the program. However, this high level of participation has only been achieved by heavy government subsidy – about 60% of the effective premiums. The disparity distribution of premium subsidy and indemnity as well as loss ratios across crops and states arise concerns that the premium rates do not reflect farmers' actual underlying risks. The most cited reason for this poor actuarial performance is the asymmetric information inherent to agricultural insurance markets.

This study proposes an alternative design called Crop Insurance Saving Account, which enables farmers to annually deposit pre-tax income in an interest-bearing personal savings account and draw an indemnity from their accounts when there is a qualified loss. If in a given year a farmer's account is exhausted, the government lends money to the account to cover the indemnity. The proposed design reduces the moral hazard and adverse selection problems inherent to the current program. As well, under the CISA system, farm-level risk no longer has to be priced, thus eliminating the premium rating difficulties that weaken actuarial soundness. In addition, administrative costs are likely to be substantially lower.

Overall, although we consider this analysis to be just a “test-of-concept,” the results and sensitivity analyses in Chapters 7 and 8 offer a promising outlook on the viability of the proposed CISA system provided that revenue guarantee levels and contribution rates can be appropriately matched to ensure that only a small fraction of the CISA accounts end up with a negative terminal balance and that the farmers can afford the necessary contribution levels. Since, as proposed, CISA’s cost should be much less than what the government is currently spending subsidizing the Crop Insurance apparatus, more favorable terms (such as matching or allowing for an initial buildup period) could be considered in cases when the required contribution levels seem unaffordable.

Another finding from the comparison across Table 11 to Table 17 is that it is more reasonable to base insurance on the “frequencies” of certain losses. The realizations of revenue, regardless of the CISA scheme, determine the number of withdraws made from CISA. For example, Tables 11 and 13 illustrates that the number of withdraws from CISA is the same across CISA scheme (under different contributions rates or with or without caped balances and contribution rates) for the same coverage level; this is because the underlying frequencies of yield falling below the guaranteed yield are the same for given yield distributions. As expected, Table 15 shows more volatility (increased price and yield variances) increases the number of withdraws; and correspondingly, higher annual contributions are required to insure against this increased volatility (Tables 13 and 15).

REFERENCES

Babcock, B.A., C. E. Hart, and D.J. Hayes (2004). "Actuarial Fairness of Crop Insurance Rates With Constant Rate Relativities." *Journal of Agricultural Economics* 86(3):563-75.

Babcock, B.A., and D.A. Hennessy (1996). "Input Demand under Yield and Revenue Insurance." *American Journal of Agricultural Economics* 78: 416-27.

Barnaby, G. A., Jr. (1996). Worksheet for determining premiums. In "Crop Revenue Coverage Policy for Hard Red Winter Wheat, Soft Red Winter Wheat, and Hard Red Spring Wheat." Department of Agricultural Economics, Kansas State University, Manhattan, 1996.

Barnett, B.J. (2000). "The U.S. Federal Crop Insurance Program." *Canadian Journal of Agricultural Economics* 48(4):539-51.

Barnett, B. A. and J. R. Skees (1995). "Regional and Crop Specific Models for the Demand for Federal Multiple Peril Crop Insurance." *Journal of Insurance Issues* 78:416-27.

Bourgeon, J.M., and R.G. Chambers (2003). "Optimal Area-Yield Crop Insurance Reconsidered." *American Journal of Agricultural Economics* 85(3): p590-604.

Boehlje, M., J. Detre, and A. Gray. (2012). "Overview of Farm Savings Accounts (FAS) Alternatives." Purdue Extension EC-746-W. Online available: http://www.extension.purdue.edu/extmedia/EC/EC-746-W.pdf (accessed April 2012).

Cobel, K.H., T. O. Knight, R. D. Pope, and J. R. Williams (1996). "Modeling Farm-Level Crop Insurance Demand with Panel Data." *American Journal of Agricultural Economics* 78(2): 439-47.

____(1997). “An Expected-Indemnity Approach to the Measurement of Moral Hazard Crop Insurance.” *American Journal of Agricultural Economics* 79(1):216-26.

Coble, K. H., R. Heifner, and M. Zuniga (2000). “Implications of Crop Yield and Revenue Insurance for Producer Hedging.” *Journal of Agricultural and Resource Economics* 25: 432-52.

Cobel, K.H., T.O. Knight, B.K. Goodwin, M.F. Miller, and R.M. Rejesus (2010). “A Comprehensive Review of the RMA APH and COMBO Rating Methodology – Final Report.” RMA publication on actuarial methodology. Online available: http://www.rma.usda.gov/pubs/2009/comprehensivereview.pdf

Coble, K.H., R. Dismukes, and J.W. Glauber (2007). “Private Crop Insurers and the Reinsurance Fund Allocation Decision.” *American Journal of Agricultural Economics* 89(3):582-95.

Collins, K. and H. Bulut (2011). “Crop Insurance and the Future Farm Safety Net.” *Choices* 26 (4).

Coble, K.H., Knight, T.O., Pope, R.D., and Williams, J.R. (1996). “Modeling Farm-Level Crop Insurance Demand with Panel Data.” *American Journal of Agricultural Economics* 78:439-47.

Commission on 21st Century Production Agriculture (2001). “Direction for Future Farm Policy: the Role of Government in Support of Production Agriculture.” Report to the President and Congress, January 2001.

Deng, X. H., B. J. Barnett, and D.V. Vedenov (2007). “Is There a Viable Market for Area-Based Crop Insurance?” *American Journal of Agricultural Economics* 89 (2): 508–19.

Edelman, M.A. (2000). “Canadian Net Income Stabilization Accounts and Other Options for Achieving Counter-Cyclical Program Payments with Planting Flexibility”. Economic

Department Staff Paper 333, Iowa State University; Testimony to National Commission on 21st Century Production Agriculture, Whitten Building Washington D.C., January 28, 2000.

Edelman, M.A., J.D. Monke, and R. Durst (2001). “Farmer Saving Accounts.” *The 2002 Farm Bill: Policy Options and Consequences*, publication of the National Public Policy Education Committee, 2001, pp61-74.

Feldstein M. and D. Altman (2007). “The Unemployment Insurance Saving Accounts.” NBER Book Series "Tax Policy and the Economy" ed. J.M. Poterba, MIT Press. Vol.21: 35-64.

Gardner, B. L., and R. A. Kramer (1986). “Experience with Crop Insurance Programs in the United States.” Crop Insurance for Agricultural Development, Issues and Experience, Peter Hazell, Carlos Pomareda, and Alberto Valdes, eds. Baltimore: John Hopkins University Press, 1986:195-222.

Glauber, J.W., and K.J. Collins (2002). "Crop Insurance, Disaster Assistance, and the Role of the Fed-eral Government in Providing Catastrophic Risk Protection."*Agricultural Finance Review* 69: 81-102.

Glauber, J.W. (2004). “Crop Insurance Reconsidered.” *American Journal of Agricultural Economics* 86(5): 1179-95.

Goodwin, B. K. (1993). "An Empirical Analysis of the Demand for Crop Insurance." *American Journal of Agricultural Economics* 75: 425-34.

Goodwin, B.K. (1996). “Premium Rate Determination in the Federal Crop Insurance Program: What Do Averages Have to Say About Risk?” *Journal of Agricultural and Resource Economics* 19 (2): 382-95.

Gray, A.W., J.W. Richardson, and J. McClaskey (1995). "Farm-Level Impacts of Revenue Assurance." *Review of Agricultural Economics* 17:171 - 83.

Grant Thornton, LLP. (2011). Federal Crop Insurance Program, Profitability and Effectiveness Analysis, 2010 Update. Overland Park, KS: National Crop Insurance Services. (http://www.ag-risk.org/NCISPUBS/SpecRPTS/GrantThornton/Grant_Thornton_Report-2010_FINAL.pdf.)

Halcrow, H.G. (1949). "Actuarial Structures for Crop Insurance." *Journal of Farm Economics* 31:41843.

Harri, A., K. H. Coble, A.P. Ker and B.J. Goodwin (2011). "Relaxing Heteroscedasticity Assumptions in Area-Yield Crop Insurance Rating." *American Journal of Agricultural Economics* 93 (3): 703-13.

Harri, A., K.H. Coble, C. Erdem, and T.O. Knight (2009). "Crop Yield Normality: A Reconciliation of Previous Research and Statistical Tests for Normality." *Applied Economics Perspectives and Policy* 31 (1): 163-82.

Harwood, J., R. Heifner, K. Coble, J. Perry, and A. Somwaru. (1999). "Managing Risk in Farming: Concepts, Research, and Analysis." U.S. Department of Agriculture, Market and Trade Economics Division and Resource Economics Division, Economic Research Service: Washington D.C.. Agricultural Economic Report No. 774.

Hennessy, D.A., B.A. Babcock, and D.J. Hayes (1997). " Budgetary and Producer Welfare Effects of Revenue Insurance." *American Journal of Agricultural Economics* 79 (3): 1024-34.

Heifner, R., and K. Coble (1998). “The Risk-Reducing Performance of Alternative Types of Crop and Revenue Insurance When Combined with Forward Pricing.” Report to the Risk Management Agency, USDA, Economic Research Service, December 1998.

Horowitz, J.K., and E. Lichtenberg (1993). "Insurance, Moral Hazard, and Chemical Use in Agriculture." *American Journal of Agricultural Economics* 75 (4):926-35.

H.R. 927--108th Congress: Farm and Ranch Risk Management Act (2003). In GovTrack.us (database of federal legislation). Retrieved April 10, 2012, online available at: http://www.govtrack.us/congress/bills/108/hr927

Just, R.E., and L. Calvin (1990). “An Empirical Analysis of U.S. Participation in Crop Insurance.” In Hueth, D. and W.H. Furtan ed. Economics of Agricultural Crop Insurance: Theory and Evidence. London: Springer London Ltd, 2002, 205-52.

Kramer, R.A. (1983). "Federal Crop Insurance 1938-1982." *Agricultural History* 57 (2 April):181-200.

Ker, A.P., and B. K. Goodwin (2000). “A Nonparametric Estimation of Crop Insurance Rates Revisited.” *American Journal of Agricultural Economics* 82 (2):463-78.

Knight, T.O. and K.H. Coble (1997). "Survey of U.S. Multiple Peril Crop Insurance Literature since 1980." *Review of Agricultural Economics* 19 (1): 128-56.

Knight, T. O., and K. H. Coble (1999). “Actuarial Effects of Unit Structure in the U.S. Actual Production History Crop Insurance Program.” *Journal of Agricultural and Applied Economics31*: 519–35.

Mahul, O. (1999) “Optimum Area Yield Crop Insurance.” *American Journal of Agricultural Economics* 81 (1):75-82.

Mahul, O., and B.D. Wright (2003). "Designing Optional Crop Revenue Insurance." *American Journal of Agricultural Economics* 85 (3): 580-89.

Miranda, M.J. (1991). "Area-Yield Crop Insurance Reconsidered." *American Journal of Agricultural Economics* 73 (2):233-42.

Miranda, M.J. and J.W. Glauber (1997). "Systemic Risk, Reinsurance, and the Failure of Crop Insurance Markets." *American Journal of Agricultural Economics* 79 (1):206-15.

Monke, J. and R. Durst (1999). "Tax-Deferred Savings Accounts for Farmers: A Potential Risk Management Tool." Agricultural Outlook, USDA-ERS. (May 1999):22-24.

Moss, C.B. and J.S. Shonkwiler (1993). "Estimating Yield Distributions Using a Stochastic Trend Model and Non-Normal Errors." *American Journal of Agricultural Economics* 75 (4):1056-62.

Moss, R.B. and F.B. Saunders (1987). "Costs and Returns for Selected Crop Enterprises at the Southwest Georgia Branch Experiment Station, 1984-1986, With Comparisons for the 24-Year Period 1963 to 1986". Research Report 536, the Georgia Agricultural Experiment Stations, University of Georgia, August 1987.

Nieuwoudt, W. L., S.R. Johnson, A.W. Womack, and J.B. BuUock. "The Demand for Crop Insurance." Agricultural Economics Report, Department of Agricultural Economics, University of Missouri-Columbia. No.1985-16.

Quiggin, J., G. Karagiannis, and J. Stanton (1993). "Crop Insurance and Crop Production: Empirical Study of Moral Hazard and Adverse Selection." *Australian Journal of Agricultural Economics* 37:95-113.

Ramaswami, B (1993). "Supply Response to Agricultural Insurance: Risk Reduction and Moral Hazard Effects." *American Journal of Agricultural Economics* 75 (4): 914-25.

Ramirez, O.A. (1997). “Estimation and Use of a Multivariate Parametric Model for Simulating, Heteroskedastic, Correlated, Nonnormal Random Variables: The Case of Corn Belt Corn, Soybean and Wheat Yields.” *American Journal of Agricultural Economics* 79 (1):191–205.

—— (2000). “Parametric Modeling and Simulation of Joint Price-Production Distributions under Non-normality, Autocorrelation and Heteroskedasticity: A Tool for Assessing Risk in Agriculture.” *Journal of Agricultural and Applied Economics* 32 (2): 283–97.

Ramirez, O.A., S.K. Misra, and J. Field (2003). “Crop-yield Distribution Revisited.” *American Journal of Agricultural Economics* 85 (1): 108-20.

Ramirez, O.A., S.K. Misra, and J. Nelson (2003). “Efficient Estimation of Agricultural Time Series Models with Non-normal Dependent Variables.” *American Journal of Agricultural Economics* 85:1029–40.

Ramirez, O.A., and T. McDonald (2006a). “Ranking Crop Yield Models: A Comment.” *American Journal of Agricultural Economics* 88 (4):1105–10.

____ (2006b). “The Expanded Johnson System: A Highly Flexible Crop Yield Distribution Model.” Presented Paper at AAEA 2006 Annual Meeting, 23-26 July, Long Beach, California.

Ramirez, O.A., C.E. Carpio, and R.M. Rejesus (2011). “Can Crop Insurance Premiums be Reliably Estiamted?” *Agricultural and Resource Economics Review* 40 (1): 81–94.

Ramirez, O.A., and C.E., Carpio (2011). “Premium Estimation Inaccuracy and the Actuarial Performance of the US Crop Insurance Program.” Presented Paper at AAEA 2011 Annual Meeting, 24-26 July, Pittsburgh, Pennsylvania.

Royhschild, M., and J. Stiglitz (1976). “Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information.” *The Quarterly Journal of Economics* (November 1976):629-49.

Schurle, B.W. (1996). “The Impact of Size on Yield Variability and Crop Insurance Premiums.” *Review of Agricultural Economics* 18: 415–22.

Shields, D.A. (2010). “Federal Crop Insurance: Background and Issues.” SRC Report R40532 pp2. Online available: www.nationalaglawcenter.org/assets/crs/R40532.pdf

Skees, J.R., J.R. Black, and B.J. Barnett (1997). “Designing and Rating an Area Yield Crop Insurance Contract.” *American Journal of Agricultural Economics* 79 (2):430-38.

Skees, J. R., and M. R. Reed (1986). “Rate Making for Farm-Level Crop Insurance: Implications for Adverse Selection.” *American Journal of Agricultural Economics* 68: 654–9.

Smith, V.H., and B.K. Goodwin (1996). "Crop Insurance, Moral Hazard, and Agricultural Chemical Use." American Journal of Agricultural Economics 78 (2):428-38.

Smith, V.H. (2011). “Premium Payments: Why Crop Insurance Costs Too Much.” Washington, DC: American Enterprise Institute. Available online: http://www.aei.org/paper/economics/fiscal-policy/federal-budget/premium-payments-why-crop-insurance-costs-too-much/.

Stokes, J.R. (2000). “A Derivative Security Approach to Setting Crop Revenue Coverage Insurance Premiums.” *Journal of Agricultural and Resource Economics* 25 (1):159-76.

Thomas O. Knight, T.O., K.H. Coble, B. K. Goodwin, R. M. Rejesus and S. Seo (2010). “Developing Variable Unit-Structure Premium Rate Differentials in Crop Insurance.” *American Journal of Agricultural Economics* 92 (1): 141-51.

Turvey, C.G. (2001). "Weather Derivatives for Specific Event Risks in Agriculture." *Review of Agricultural Economics* 23:333-51.

USDA, Risk Management Agent (RMA), 2010. "RMA releases new common crop insurance policy basic provisions," press release, March 31, 2010. Site: http://www.rma.usda.gov/news/2010/03/combo.html

USDA, RMA (2011). Costs and Outlays, "Fiscal Year Government Cost for Federal Crop Insurance, 2002-11," site: http://www.rma.usda.gov/aboutrma/budget/costsoutlays.html

USDA, RMA (2012a). "A History of the Crop Insurance Program." Site: http://www.rma.usda.gov/aboutrma/what/history.html (Accessed February 2012).

USDA, RMA (2012b). "Crop Policies and Pilots." Site: http://www.rma.usda.gov/policies/ (Accessed February 2012).

USDA, RMA (2012c). Summary of Business Reports and Data. Site: http://www.rma.usda.gov/policies/ (Accessed February 2012).

USDA, National Agricultural Statistics Service. Data and Statistics. Site: http://www.rma.usda.gov/data/sob.html (Accessed September 2011).

U.S. Bureau of Labor Statistics (BLS). PPI databases PPI-Farm Products. Site: http://www.bls.gov/ppi/data.htm (Accessed September 2011).

Vedenov, D.V., and B.J. Barnett (2004). "Efficiency of weather derivatives as primary crop insurance instruments." *Journal of Agricultural and Resource Economics* 29 (3 December):387-403.

Velandia, M., R.M. Rejesus, T.O. Knight, and B.J. Sherrick (2009). "Factors affecting farmers' utilization of agricultural risk management tools: The case of crop insurance, forward contracting, and spreading sales." *Journal of Agricultural and Applied Economics* 41 (1): 107–23.

Wang, H. H., S. D. Hanson, R. J. Myers, and J. R. Black (1998). "The Effects of Crop Yield Insurance Designs on Farmer Participation and Welfare." *American Journal of Agricultural Economics* 80 (4):806-20.

Wright, B.D., and J.D. Hewitt (1990). "All Risk Crop Insurance: Lessons from Theory and Experience." Giannina Foundation, California Agricultural Experiment Station, Berkeley, April 1990.