Economic Analysis of the Standard Reinsurance Agreement

Dmitry V. Vedenov, Mario J. Miranda, Robert Dismukes, and Joseph W. Glauber

Abstract

An economic analysis is presented of the Standard Reinsurance Agreement (SRA), the contract governing the relationship between the Federal Crop Insurance Corporation and the private insurance companies that deliver crop insurance products to farmers. The paper outlines provisions of the SRA and describes the modeling methodology behind the SRA simulator, a computer program developed to assist crop insurers and policy makers in assessing the economic impact of the Agreement. The simulator is then used to analyze how the SRA affects returns from underwriting crop insurance. The results are presented in aggregate and also at the regional and individual company levels.

Key words: crop insurance, policy analysis, risk modeling, Standard Reinsurance Agreement

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This research was supported through a cooperative agreement with The Ohio State University, University of Georgia, and USDA. The views expressed are the authors' and do not necessarily reflect those of the USDA.

Risk sharing between private insurance companies and the government has been an integral part of the federal crop insurance program since 1981. The Federal Crop Insurance Act of 1980 encouraged the Federal Crop Insurance Corporation (FCIC) to privatize functions of the crop insurance program "to the maximum extent possible." A key component of the 1980 legislation was the enlistment of private insurance companies to not only sell and service crop insurance policies, but for the first time to share the risks on the policies they write. By 2001, crop insurance companies were writing policies with a total premium of almost $3 billion and retaining risks on almost $2.4 billion in premiums through the Standard Reinsurance Agreement (SRA) with the FCIC (Glauber and Collins, 2002).

From the outset, the role of the private sector in risk sharing has been controversial. Despite underwriting losses on crop insurance policies totaling $2.3 billion between 1981 and 1990, reinsured companies recorded underwriting profits in 7 of the 10 years, contributing to the total of $110 million in underwriting profits over the period (U.S. General Accounting Office, 1992). Reinsured companies argued that the poor actuarial performance of the program during the 1980s was, in part, due to inadequate premium rates set by FCIC, and they were reluctant to share in risks over which they felt they had little control. However, criticism by the U.S. General Accounting Office and others prompted Congress to require reinsured companies to bear more risk through the SRA. The 1992 SRA and subsequent reinsurance agreements have exposed the reinsured companies to substantially more risk, but also have allowed a greater

sharing of underwriting gains (Glauber and Collins, 2002).

Net underwriting gains[1] to the reinsured companies totaled almost $1.5 billion over 1997 through 2001, or about 16.6% of retained premium (Glauber and Collins, 2002). While the size of the net underwriting gains in this period can be largely attributed to the amount of premium and to the nearly ideal crop growing conditions in most regions of the United States, the gains have attracted criticism from watchdog agencies such as the U.S. General Accounting Office and the USDA's Office of Inspector General. In its fiscal year 2003 budget proposal, the Bush Administration concluded that the crop insurance companies had "experienced a windfall," and proposed capping underwriting gains at 12.5% (USDA, 2002, p. 28). Crop insurance companies responded by claiming the proposal "demonstrated a lack of understanding about how crop insurance works" (Shey, 2002) and predicted the proposal would cripple the crop insurance delivery system (American Association of Crop Insurers, 2002).

The most recent version of the Standard Reinsurance Agreement (the 2005 SRA) has been renegotiated and went into effect in 2004, although the structure of the agreement and its major provisions remained largely unchanged from the previous 1998 version.

While there has been much research on the federal crop insurance program, most of the focus has been on how insurance affects producer-level risk and the demand for crop insurance. Research on the reinsurance agreement has focused largely on the use of contingency markets such as futures and options as alternatives to traditional reinsurance (Miranda and Glauber, 1997; Mason, Hayes, and Lence, 2003; Turvey, Nayak, and Sparling, 1999). An exception is a study by Ker and McGowan (2000) who investigate the ability of crop insurance companies to adversely select against the FCIC. Using a stylized model of the SRA which considered wheat yield distributions in 57 Texas counties, they demonstrated that companies could increase expected underwriting gains by ceding more risk to the FCIC in those years where ex ante projections of wheat yields suggested potential crop insurance losses. Yet, while their research provides insight into how companies may increase underwriting gains through the SRA, their empirical findings are limited in scope.

Crop insurance companies typically write policies in more than one state, and several operate nationwide. Expected underwriting gains depend on the underlying crop yield distributions across commodities and regions and also on the structure of the SRA. Changes in the latter can have significant effects on the distribution of underwriting gains and implications for how companies can best maximize returns.

In this paper, we develop a simulation model of the SRA. Using historical data on yields and insurance losses for each crop reporting district, crop, and insurance product, we construct distributions of returns on the book of business resulting from underwriting crop insurance. The effect of SRA on underwriting gains and losses[2] is then analyzed by comparing rates of return at various levels of aggregation before and after SRA is applied.[3] In particular, an attempt is made to quantify changes in expected gains and variability of return due to SRA

[1] *Gross* underwriting gains, or simply underwriting gains, are the amount by which premiums collected exceed indemnities paid. In this article, *net* underwriting gains are gains adjusted according to the SRA.

[2] Underwriting losses can be defined as negative underwriting gains.

[3] For purposes here, the terms "before (or without) SRA" and "after (or with) SRA" refer solely to situations before and after provisions of SRA are applied to realized gains/losses, respectively, in a given reinsurance year. We do not attempt to make a comparison between the current situation and the ones where SRA does not or did not exist.

first for the whole book of business, and then in selected individual states and for individual companies. We also attempt to identify factors that affect the magnitude of these changes at the individual company level.

The Standard Reinsurance Agreement (SRA)

Overview

The FCIC provides reinsurance to private companies that deliver crop insurance products under the terms of SRA, which applies uniformly to all insurance companies. The Risk Management Agency (RMA) administers crop insurance and reinsurance programs on behalf of the FCIC. The SRA is periodically renegotiated, although there is no preset renegotiation schedule. In the past, the renegotiation timeframe has been mandated by acts of Congress. In particular, the 2000 Agricultural Risk Protection Act (ARPA) provided for FCIC to renegotiate the SRA at least once during the 2001 through 2005 reinsurance years. Therefore, FCIC renewed the 1998 SRA through the 2004 reinsurance year (which ended June 30, 2004), and initiated negotiations of a new agreement in early 2004. The final version of the new SRA was approved in June of 2004, and went into effect for the 2005 reinsurance year on July 1, 2004.[4]

At the time the research reported in this paper was conducted, no data were available for 2005 or subsequent reinsurance years. Our research has been based on historical data through 2001 and models the SRA then in existence, i.e., the 1998 version. However, the presented results also apply to the 2005 SRA, since the 1998 SRA structure remained essentially unchanged. The major provisions of the 2005 SRA, as well as differences between it and the 1998 SRA, are presented next, along with a discussion of how these changes might affect our results.

Major Provisions

Reinsurance under the SRA comes in two forms: proportional and nonproportional. The proportional reinsurance allows the companies to cede a proportion of their liability in exchange for an equal proportion of the associated premiums, by transferring a share of their business to the FCIC. Nonproportional reinsurance is then applied to the remaining or *retained* portion of companies' business.

A company operates under the SRA by allocating each of its crop insurance policies[5] into one of seven reinsurance funds: a single Assigned Risk Fund (ARF) and Developmental and Commercial Funds, each of which is further subdivided according to insurance product class (CAT,[6] Revenue, and All Other Plans[7] Funds). The reinsurance funds differ in the required minimum retention rates—the proportion of total premium a company must retain through the proportional reinsurance—and in the nonproportional shares of gains and losses received or paid by the companies on retained business.

Under the 2005 SRA, the ARF has the lowest required retention rate (15% to 25%) and the smallest shares of potential gains and losses on retained business, which makes it the primary designation for high-risk contracts. The SRA also establishes limits on the maximum proportions of a company's business that can be allocated to the ARF. Depending on the particular state, these "cession limits"

[4] The text of the 2005 SRA is available online from the RMA website (www.rma.usda.gov).

[5] While companies are allowed to allocate policies on an individual basis, they may choose to make allocation decisions at higher levels of aggregation, e.g., allocate all policies in a county in the same fund. SRA does not regulate or limit such allocation decisions by individual companies.

[6] Catastrophic coverage level: 50% of expected yield indemnified at 55% of expected price.

[7] All other plans are mainly "additional" or "buy-up" yield insurance with coverage levels greater than CAT.

are set to 75%, 50%, or 25% of the company's business in a state. Under the 1998 SRA, the cession limits to Assigned Risk Funds varied from 10% to 75%, while the required retention rate was set to 20% for all states. While these changes potentially may lead to different patterns of policy allocation across reinsurance funds in the future, they do not change the effect of nonproportional reinsurance, which is the main focus of the current investigation.

The Developmental and Commercial Funds have higher minimum retention requirements (35% and 50%, respectively) and allow companies to retain up to 100% of the premiums in return for higher potential net underwriting gains and losses. The parameters of these two funds remained the same under both the 2005 SRA and the 1998 SRA.

The nonproportional shares of gains and losses are outlined in Table 1. The shares of losses paid by the companies and paid by FCIC vary according to the loss ratio[8] of the companies' retained business calculated at the state level. As the loss ratio increases, FCIC assumes a larger fraction of a company's losses up to 100% of the portion of losses in excess of 500% of total retained premium (stop-loss provision). In the case of underwriting gains (loss ratio less than 1), FCIC claims a larger fraction of the gains as the loss ratio decreases.

The shares of gains and losses are structured so that for the same absolute values of gains/losses, the companies keep a higher share of gains than losses. This is illustrated in Figure 1, which shows the net (after SRA is applied) versus gross (before SRA is applied) loss ratios for the All Other Products Funds. For example, if the realized loss ratio in Commercial Fund for all other products is 0.70 (realized gain of 30%), the company keeps 94% of gains, i.e., its net gain after SRA is 28.2%. At the same time, if the realized loss ratio in the same fund is 1.3 (realized loss of 30%), the company is responsible only for 50% of the losses, i.e., its net loss after SRA is 15%. The same holds true for other ranges of loss ratios (see Table 1). Thus, the SRA's nonproportional reinsurance effectively transforms the loss ratio of the company on its retained business. Furthermore, the decreasing shares of gains kept and losses borne by the companies result in narrowing of loss ratio distributions (as demonstrated in Figure 2 later in the paper).

The shares of gains and losses, which are the key components of this analysis, remained the same under the 2005 SRA as they were under the 1998 SRA, allowing our results to be extended to the new version of the Agreement.

The 2005 SRA also added a "retained net book quota share" form of reinsurance under which each company is required to cede to FCIC 5% of its cumulative underwriting gain or loss defined as net underwriting gains or losses in all states after the proportional and nonproportional reinsurance provisions of the SRA are applied. While this provision was not modeled under the 1998 SRA, its effect on the results would be fairly straightforward.

Modeling Methodology

The objective of the SRA model is to simulate distributions of rates of return[9] from underwriting crop insurance. The realized rates of return (i.e., before the SRA is applied) are driven by gross underwriting gains or losses defined for modeling purposes as the difference between the premiums collected and indemnities paid. The rates of return after the SRA is applied are determined by particular realizations of companies' loss ratios at the state level and the SRA parameters (retention rates, breakpoints, and shares). Therefore, in order to analyze the effect of SRA on the rates of return, it

[8] Loss ratio is indemnity divided by premium.

[9] Rates of return are defined as the ratios of underwriting gains (losses) to gross premiums.

Table 1. Companies' Shares in Underwriting Gains and Losses Under SRA

Reinsurance Fund	Gains, by Insurance Plan			Losses, by Insurance Plan		
	CAT	Revenue	All Other	CAT	Revenue	All Other
	– Loss Ratio Between 65% & 100% –			***– Loss Ratio Between 100% & 160% –***		
Commercial	75.0%	94.0%	94.0%	50.0%	57.0%	50.0%
Developmental	45.0%	60.0%	60.0%	25.0%	30.0%	25.0%
Assigned Risk	!!!!!!!!!!	15.0%	!!!!!!!!!!	!!!!!!!!!!!	5.0%	!!!!!!!!!!
	– Loss Ratio Between 50% & 65% –			***– Loss Ratio Between 160% & 220% –***		
Commercial	50.0%	70.0%	70.0%	40.0%	43.0%	40.0%
Developmental	30.0%	50.0%	50.0%	20.0%	22.5%	20.0%
Assigned Risk	!!!!!!!!!!!	9.0%	!!!!!!!!!!!	!!!!!!!!!!!	4.0%	!!!!!!!!!!!
	– Loss Ratio Less than 50% –			***– Loss Ratio Between 220% & 500% –***		
Commercial	8.0%	11.0%	11.0%	17.0%	17.0%	17.0%
Developmental	4.0%	6.0%	6.0%	11.0%	11.0%	11.0%
Assigned Risk	!!!!!!!!!!!	2.0%	!!!!!!!!!!!	!!!!!!!!!!!	2.0%	!!!!!!!!!!!

Note: FCIC keeps the portions of underwriting gains or assumes the ultimate net losses in excess of companies' shares as determined in the table. In addition, FCIC assumes 100% of the amount by which companies' retained losses exceed 500% of the retained net book premium in a given state and fund for a given reinsurance year.

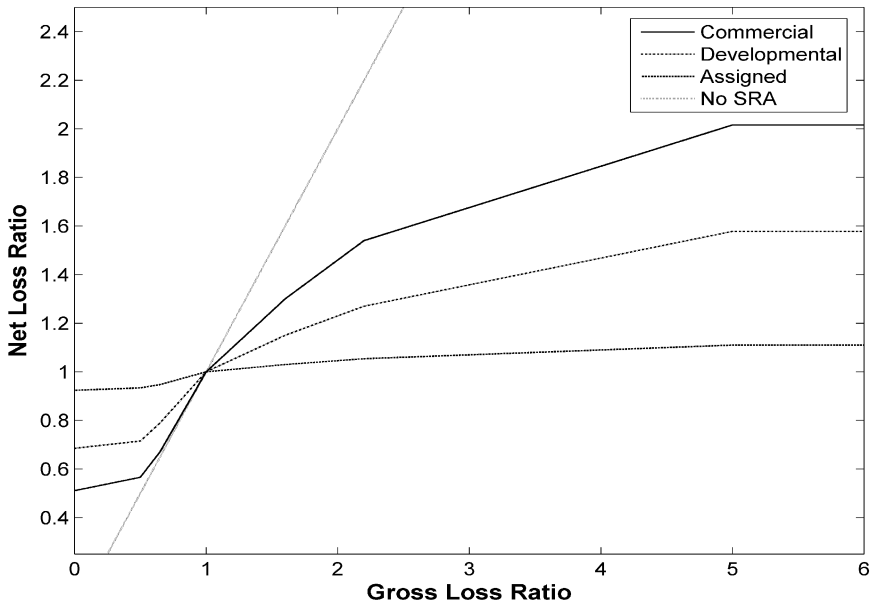

Figure 1. Net (after SRA is applied) vs. Gross (before SRA is applied) Loss Ratios by Reinsurance Fund (commercial and developmental funds are shown for "all other plans")

is necessary to model the distribution of loss ratios by state and fund for each company reinsured by the FCIC.

The straightforward approach to deriving distributions of loss ratios from historical series of indemnities and premiums is not applicable due to the changing nature of the crop insurance program and data limitations. First, the number of contract types available under the crop insurance program has increased dramatically since 1980, with a large portion of products introduced in or after 1994. Therefore, historical loss data are simply not available for many contracts prior to 1994. Second, program participation has also increased over the last two decades both in terms of the acreage insured and coverage levels selected by the producers. This in turn led to a broader pool of insured risk and decreasing variation in indemnities. Third, composition and geographical distribution of contracts in participating companies' books of business have changed over time. The companies have also changed allocation of their books of business across reinsurance funds. Finally, premium rates[10] have changed over time, thus affecting historical realizations of companies' gains and losses. Instead, it was assumed that the loss costs by crop reporting district,[11] crop, and insurance product observed over the historical period (1981–2001) were generated by stationary data-generating processes which are uniform across companies and reinsurance funds.

Historical loss costs at the district level are available for 1981–2001 for selected Actual Production History (APH)[12] yield contracts but only in aggregate, thus providing no information about the distribution of loss costs for specific APH yield contracts, or other contracts such as CAT and revenue products. The loss costs for individual products, however, can be recovered or simulated from data on yields and prices.

The distributions of district-level yields can be derived from historical yield data. However, the aggregate yields are not necessarily representative of yields experienced by insurance buyers. Therefore, distributions of individual yields within each district are also modeled by imposing a parametric distribution with the parameters calibrated so as to match the historical insurance experience reflected in the aggregate loss costs data. The calibrated individual yield distributions along with price models then allow one to simulate distributions of loss costs for all individual products included in the model.

The simulated distribution of loss costs for each district, crop, and insurance product can be combined with the data on liabilities and premium rates for the base year (2001) and aggregated to derive distributions of loss ratios for each company by state and reinsurance fund. The derived distributions of the loss ratios can then be used in combination with the SRA parameters to compute expectations and standard deviations of the rates of return by company, state, and/or reinsurance fund.

While there are more than 20 types of products available for more than 100 crops, the lack of adequate data and the limited scope of some programs do not allow us to incorporate all of them into a simulation model. For our analysis, six crops and five major types of insurance products are included in the model. The crops are barley, corn, cotton, soybeans, grain sorghum, and winter wheat.[13] The insurance products are (*a*) CAT; (*b*) Actual Production History (APH) yield insurance, Crop Revenue Coverage (CRC), and Income Protection (IP) (each at 50%, 55%, 60%, 65%, 70%, 75%, 80%, and 85% coverage levels); and (*c*) Revenue Assurance (RA)

[10] The premium rate of a contract is a ratio of its premium to the associated liability.

[11] A crop reporting district (CRD) is a statistical unit intermediate between a county and a state. Each state is typically split into nine or ten CRDs, and each CRD typically includes eight to twelve counties.

[12] APH is the type of farm yield insurance contract with the longest historical series.

[13] These crops accounted for 0.8%, 42.7%, 13.2%, 27.3%, 2.2%, and 13.7% of the total premiums included in the model, respectively.

(at 65%, 70%, 75%, 80%, and 85% coverage levels). Together, these combinations of crops and products encompass about 65% of the total FCIC liabilities in 2001.[14]

District-level yields for the six crops over the historical period are available from NASS. A simple log-linear time trend is fitted for each crop and district:[15]

$$(1)\quad \log(y_t^{tr}) = \alpha_0 + \alpha_1 (t - 1980),$$
$$t = 1981, \ldots, 2001.$$

The district yields detrended to 2001 equivalents are calculated as follows:

$$(2)\quad y_t^{det} = \frac{y_t}{y_t^{tr}} y_{2001}^{tr}, \quad t = 1981, \ldots, 2001,$$

where y_t are the observed yields and y_t^{tr} are the corresponding yield trends. The detrended yield observations are then used to construct an empirical distribution of district yields (Goodwin and Ker, 1998; Ker and Goodwin, 2000; Ker and Coble, 2003) for the base year (2001) by assigning equal probabilities[16] $1/n_y$ (n_y = 2001 – 1981 + 1) to each realization of the district yield y_t^{det} (t = 1981, ..., 2001). Such an approach allows us to capture correlations between yields in different districts and for different crops in a simple and efficient way without imposing additional distributional properties such as positive skewness.

Since indemnities of all insurance products included in the model depend on farm-level rather than district-level yields, the distribution of yields within the district must also be modeled. For a given realization of district yield (y_d), it is assumed the individual farm's yield (y_f) is lognormally distributed[17] around the district yield so that

$$(3)\quad \log(y_f) = \log(y_d) + \gamma, \quad \gamma \sim N(\mu, \sigma^2),$$

where the distribution parameters μ and σ^2 may depend on the district yield (Miranda, 1991). This approach preserves the empirical yield distribution present in the detrended district yield series, but also reintroduces the variability of farm-level yields lost in averaging to the district level (Mason, Hayes, and Lence, 2003; Schnitkey, Sherrick, and Irwin, 2003). Under these assumptions, the loss cost for an APH product with the coverage level θ and APH average yield $\bar{y}$ can be calculated as

$$\mathbf{E}_\gamma \max\left\{0, 1 - \frac{y_f}{\theta \bar{y}}\right\}.$$

For each district and crop, the historical loss costs are available in aggregate for selected products (APH 35% and 50%, 55%, ..., 85%) as well as data on liabilities by individual product. This allows us to calibrate the parameters of the farm-level yield distributions in (3) whereby the loss costs recovered from these distributions and then aggregated with corresponding liability weights match the observed aggregate loss costs as closely as possible. Similar to the approach adopted by Mason, Hayes, and Lence (2003), we attempt to add enough noise to the district-level yields to replicate the observed aggregate loss costs. The calibration is performed individually for each district, crop, and year, so as to reflect possible differences in within-district yield variabilities.[18]

[14] While it may seem that the model leaves out a significant portion of the FCIC portfolio, a major part of it consists of specialty crops concentrated mainly in California and Florida. Outside of these two states, the proportion of liability covered by the model is about 75% for the base year (2001).

[15] Note that this procedure does not impose any distributional assumptions on the residuals but is used only to remove the central tendency.

[16] We recognize that yield series of only 21 years may (and probably do) bias the results to some extent. However, the major limiting factor here is the lack of corresponding loss cost data for crop insurance products, and thus using longer yield series would not improve the simulations.

[17] Weibull and gamma distributions were also used to model the individual yields. The results were similar to those obtained with lognormal distribution; however, lognormal distribution performed better in matching historical aggregate loss costs, i.e., minimizing the criterion in (4).

[18] Variability of farm-level yields does not have to be the same in different districts, or for different crops. In addition, higher realizations of district-level yields tend to be associated with less variability at the individual level, and vice versa, i.e., yield variability may change from year to year.

Formally, for a given district, crop, and year, let $LC_{sim}(i_p \mid \mu, \Sigma)$ be the simulated loss cost for the APH product i_p for the given values of parameters μ and Σ of the distribution of farm-level yields in (3). Further, let LC_{hist}^{agg} be the historical aggregate loss cost, let $B \in \{1, \ldots, n_p\}$ be the index subset of APH products included in the aggregate loss cost data, and let $L_{hist}(i_p)$ be the historical liabilities for products in B. The aggregate simulated loss cost can then be calculated as

$$LC_{sim}^{agg}(\mu, \Sigma) = \frac{\sum_{i_p \in B} L_{hist}(i_p) \times LC_{sim}(i_p \mid \mu, \Sigma)}{\sum_{i_p \in B} L_{hist}(i_p)},$$

and the parameters μ and Σ of farm-level yield distribution in (3) can then be calibrated by solving

$$(4) \quad \min_{\mu,\Sigma} \left| LC_{hist}^{agg} - LC_{sim}^{agg}(\mu, \Sigma) \right|$$
$$\text{s.t.: } \mathbf{E}_{\gamma} y_f = y_d.$$

The constraint in (4) reflects the fact that the district-level yields are simply averages of individual yields within the district.

Once the parameters of farm-level yield distributions are calibrated, it is assumed that they correctly represent the variability of within-district yields for the specific crop, district, and year, and thus can be used to simulate the loss costs for all other products included in the model. In addition to yields, distributions of harvest-time prices are required to calculate loss costs for revenue products. The distribution of intra-seasonal prices was modeled[19] for each crop as

$$(5) \quad \log(p_h) = \log(p_b) + \varphi\left(\log(y_{nat}) - \log(\bar{y}_{nat})\right) + z,$$

where p_h is the harvest price, p_b is the base (projected) price, y_{nat} is the detrended national yield, $\bar{y}_{nat}$ is the long-term average detrended national yield, φ is the elasticity parameter capturing correlation between national yields and prices, and z is a random shock that reflects additional price variability independent of y_{nat} and is distributed normally with zero mean and some variance Σ^2.

For practical purposes, national yields data were collected from NASS and detrended according to (1)–(2). The values of the elasticity parameters φ were chosen to represent historically observed correlation between national yields and prices. The base prices and the variances of harvest prices were obtained from RMA publications[20] and reflected contemporary market information available prior to the 2001 planting season (Table 2).

By combining distributions of yields (3) calibrated according to (4) with the price distributions in (5), we can derive the distributions of loss costs for all districts, crops, and products included in the model. Data on base year premium rates and liabilities can then be used to aggregate these distributions and arrive at the premium rates and distributions of loss costs by state, company, and reinsurance fund. The provisions of the SRA (Table 1) can then be applied to arrive at the distributions of adjusted rates of returns aggregated by companies, states, and reinsurance funds. A formal presentation of the aggregation procedure and derivation of distributions of rates of return can be found in Vedenov (2001).

[19] Historical series could also be used to estimate variability of prices. However, the historical price series are often distorted by nonstationarity, changing farm policies and support programs, inflation, etc. (Zulauf and Blue, 2003).

[20] The base prices are established and published by RMA prior to beginning of the planting season, and are typically based on monthly averages of corresponding futures prices (USDA/RMA, 1999). The total variances are monthly averages of implied volatilities derived from option contracts matching the futures contracts used to derive the corresponding base prices. Since the random shocks z in equation (5) are assumed to be independent of corresponding yields, the shock variance Σ^2 for each crop can be calculated as a difference between the total variance of the harvest price (Table 2) and the sample variance of the national yield (NASS data).

Table 2. Parameters of Price Models

Crop	Base Price [a] (p_b)	Elasticity (")	Total Variance [b] [Var(p_h)]
Barley	2.07	!0.5	0.0213
Corn	2.44	!0.5	0.0213
Cotton	0.66	!0.5	0.0132
Soybeans	5.23	!0.5	0.0144
Sorghum	2.32	!0.5	0.0213
Wheat	3.41	!0.5	0.0215

[a] Base prices are established and published by RMA prior to the beginning of the planting season and are typically based on monthly averages of corresponding futures prices (USDA/RMA, 1999).

[b] The total variances are monthly averages of implied volatilities derived from option contracts matching the futures contracts used to derive the corresponding base prices. Since the random shocks z in equation (5) are assumed to be independent of corresponding yields, the shock variance F^2 for each crop can be calculated as a difference between the total variance of the harvest price (given in the table) and the sample variance of the national yield (NASS data).

Results

In order to analyze the effect of the SRA on loss ratios and thus rates of return, data on companies' books of business, allocations, and retention rates in 2001 have been used to simulate the distributions of the aggregate loss ratios before and after the SRA is applied.[21] Figure 2 shows these distributions by fund and in aggregate.[22] The distributions of loss ratios within individual reinsurance funds before the SRA is applied (dotted lines) reflect the difference in the level of protection provided by each of them, and thus allocation of business across funds. The Commercial Fund tends to attract less risky contracts, while the Developmental Fund and especially ARF are used for more risky business. The distributions of loss ratios after the SRA is applied (solid lines) are visibly narrower and shifted to the left. Recall that the narrowing effect is caused by decreasing shares of gains kept and losses borne by insurance companies built into the SRA structure (Table 1).

Comparison of distribution moments also indicates that the reinsurance provided by the SRA lowers both the expected values and variability of loss ratios (Table 3). As expected, the reinsurance provisions of the ARF result in the largest decrease in variability of loss ratios (93%) as well as the largest decrease in their expected values (11.8%). The reinsurance provisions of the Developmental and Commercial Funds decrease the variability of loss ratios to a lesser extent, but also result in lower decreases in the expected values.

Since most companies underwrite crop insurance in more than one state, it is important to consider how SRA affects returns at the regional level. Presented in Table 4 are expected underwriting gains[23] before and after SRA is applied for the top 20 states in terms of gross premiums, which together cover about 90% of the total gross premiums included in the simulation. Without reinsurance provided by the FCIC, underwriting of crop insurance would be profitable only in nine mostly Midwestern and Plains states. The SRA significantly improves the expected gains in all 20 states, making all but three of them profitable. Therefore, it comes as no surprise that even the states characterized by high expected losses without SRA attract more than one insurance company.

Increases in the overall expected gains might be achieved by ceding especially risky contracts to FCIC. Analysis of premium retention and fund allocation at the state level (Table 4, columns 4 and 6) confirms that in most cases states with expected losses without SRA tend to have lower proportions of business retained and higher proportions placed in the ARF.

[21] Once again, note that the goal of the present study is to separate the effect of SRA on the rates of return ceteris paribus, rather than make any conclusions about the world where SRA is not available. Such an analysis, however, is within the possibilities of the presented model and may be a focus of future research.

[22] For presentation purposes, empirical distributions have been smoothed using a kernel-smoothing procedure with variable-bandwidth Epanechnikov kernel (Härdle, 1991).

[23] The expected gains are the means of corresponding distributions produced by the simulation model.

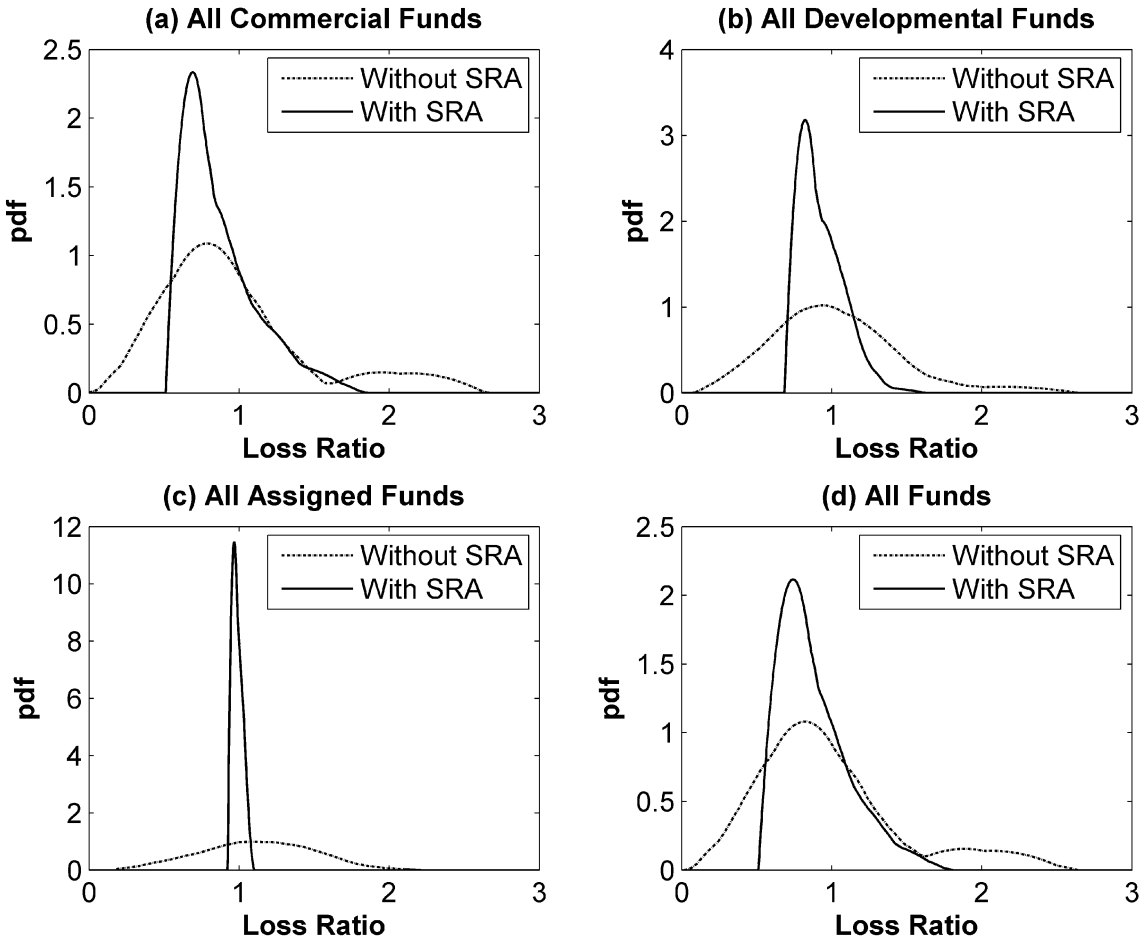

Figure 2. Effect of SRA on Distribution of Loss Ratios for the Aggregated Book of Business: (a) all commercial funds, (b) all developmental funds, (c) assigned risk funds, and (d) all funds

Table 3. Distributions of Aggregate Loss Ratios Before and After SRA Is Applied, Sample Statistics

	Before SRA		After SRA		Percent Change	
Reinsurance Fund	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
All Commercial	0.953	0.468	0.866	0.205	!9.1%	!56.3%
All Developmental	1.025	0.374	0.927	0.100	!9.5%	!73.3%
All Assigned	1.121	0.307	0.988	0.020	!11.8%	!93.6%
All Funds	0.973	0.438	0.882	0.177	!9.3%	!59.6%

A notable exception is Texas, which has a small expected underwriting gain without SRA, yet has a relatively high percentage of business in the ARF. A possible explanation is that due to the variation of growing conditions within a state, underwriting crop insurance may be quite profitable in some areas or for some crops, while unprofitable for other areas or crops. Aggregated at the state level, the losses cancel out most of the gains, but individual companies may have business concentrated mostly in the low-return areas, and thus tend to use ARF to a higher extent.

The net effect of the SRA on expected gains differs significantly by state. The general tendency is the lower the gain before SRA is applied, the higher the change in expected gain due to reinsurance. However, there are several exceptions to this rule on both sides. For example, Oklahoma, Georgia, and Wisconsin experience rather modest increases in the expected gains compared to the levels of gains before the SRA is applied. In fact, Oklahoma is barely profitable even after the SRA provisions are applied. In contrast, changes in expected gains in Kansas and Texas are fairly high, even though their returns without SRA are not nearly as bad. Substantial increases in expected gains are also observed in Minnesota and Illinois, where underwriting crop insurance would be profitable even without the reinsurance.

Expected underwriting gains at the company level are presented in Tables 5 and 6. In particular, Table 5 reports returns from underwriting crop insurance at the company level before SRA is applied. To analyze the effect of geographical diversification on underwriting returns, we calculated two measures of diversification for each company's crop insurance portfolio. The first is the Herfindahl-Hirschman Index (HHI), a commonly accepted measure of market concentration (Tirole, 1988, p. 221) which can also be used as a general measure of diversification. The index was calculated as the sum of the squared shares of a company's premium in each state. The lower the HHI, the more diversified is the portfolio.[24] The second measure is the proportion of each company's gross premiums in regions that we defined based on expected underwriting gains before SRA: Region 1, comprised of states with negative expected underwriting gains before SRA; and Region 2, comprised of states with positive expected underwriting gains before SRA (Table 4).

Diversification as measured by the HHI does not seem to be directly related to the expected returns from underwriting crop insurance, as companies with roughly the same HHI may have dramatically different returns (e.g., Company 2 and Company 12). Variability of returns appears to be slightly more related to the HHI, with lower HHI corresponding to lower standard deviations of returns without SRA, although not without exceptions (e.g., compare Companies 16 and 19). These results are fairly logical, since the HHI does not take into account returns from individual states or correlation between crop yields across states, but rather reflects overall composition of companies' portfolios.

[24] The actual numbers of states in which companies underwrite crop insurance are withheld to protect the identities of individual companies.

Table 4. Returns for Selected States Before and After SRA Is Applied

State [a]	Number of Companies	Gross Premium [b] ($ mil.)	% Premiums in ARF [c]	Retained Premium [b] ($ mil.)	% Retained	Expected Gain: Before SRA ($ mil.)	Expected Gain: After SRA ($ mil.)	Change ($ mil.)
Mississippi	8	70.2	55.6%	33.7	48.0%	!28.78	!3.77	25.01
Louisiana	7	31.8	40.3%	20.2	63.5%	!27.62	!4.81	22.81
Arkansas	11	44.7	36.3%	29.9	66.9%	!20.29	!3.50	16.79
Montana	13	43.0	36.4%	29.3	68.1%	!15.67	0.06	15.73
S. Dakota	12	131.8	15.5%	111.9	84.9%	!7.51	7.50	15.01
Oklahoma	12	48.7	36.1%	32.6	67.0%	!6.03	0.13	6.16
N. Dakota	13	134.1	36.9%	92.1	68.7%	!4.96	6.82	11.78
Georgia	10	60.5	35.8%	38.6	63.8%	!4.18	1.66	5.84
Wisconsin	9	37.0	7.6%	34.6	93.5%	!3.22	3.39	6.61
Missouri	14	76.3	9.1%	68.2	89.4%	!1.83	6.41	8.24
Kansas	14	164.4	13.5%	141.9	86.3%	!1.81	9.93	11.74
Ohio	12	47.2	9.9%	42.8	90.6%	0.28	4.28	4.00
Texas	10	297.6	43.3%	185.9	62.5%	0.60	13.94	13.35
Colorado	13	40.8	10.5%	37.1	90.9%	3.06	3.90	0.83
Indiana	13	80.6	11.3%	73.0	90.5%	3.79	9.13	5.33
N. Carolina	9	39.1	15.0%	32.3	82.6%	3.91	3.71	!0.20
Illinois	13	162.3	6.3%	152.8	94.2%	15.90	29.49	13.59
Minnesota	14	179.3	8.9%	164.4	91.7%	25.29	39.46	14.17
Nebraska	13	176.0	10.2%	160.8	91.4%	36.43	31.20	!5.23
Iowa	13	223.8	5.1%	213.9	95.6%	49.01	51.55	2.54
All States	19	2,283.9	20.6%	1,853.4	81.2%	0.00	218.70	218.70

[a] States are sorted by the expected gains without reinsurance (column 7). Only the top 20 states in terms of gross premiums are included in the table.
[b] All premiums are calculated as a part of the simulation and are not actual premiums collected and/or retained by participating companies.
[c] ARF is Assigned Risk Fund.

Table 5. Regional Composition of Insurance Portfolios and Returns Without SRA, by Company

Company [a]	Herfindahl-Hirschman Index (HHI)	% Premiums in Region 1 [b]	% Premiums in Region 2 [c]	% Premiums in ARF [d]	% Retained	Expected Rate of Return [e]	Standard Deviation [e]
1	2,259	81.5%	11.1%	35.3%	60.4%	!11.9%	38.9%
2	857	46.8%	44.8%	34.3%	72.0%	!9.0%	36.6%
3	716	40.9%	50.2%	19.5%	76.3%	!8.5%	41.6%
4	4,711	21.8%	75.9%	30.8%	74.8%	!2.6%	35.3%
5	583	39.1%	47.0%	13.2%	89.4%	!1.3%	37.2%
6	2,362	61.1%	38.1%	24.5%	80.3%	!1.1%	30.0%
7	3,019	73.6%	19.1%	14.9%	84.9%	!1.3%	38.0%
8	683	33.8%	53.7%	16.9%	86.5%	!0.3%	38.1%
9	2,268	48.6%	47.0%	14.7%	88.3%	1.6%	62.1%
10	1,134	56.6%	41.4%	25.1%	66.5%	1.7%	33.9%
11	9,897	0.5%	99.5%	22.2%	81.3%	2.3%	48.9%
12	796	27.2%	65.4%	29.6%	73.6%	3.2%	38.1%
13	940	35.5%	58.0%	18.3%	85.3%	3.4%	51.5%
14	1,407	34.8%	61.2%	13.7%	87.7%	9.3%	56.9%
15	1,346	25.3%	69.4%	17.7%	77.5%	10.7%	55.9%
16	9,823	0.0%	99.1%	0.3%	99.7%	11.9%	98.8%
17	3,342	3.6%	96.4%	12.5%	89.8%	14.4%	77.2%
18	7,461	3.0%	97.0%	6.8%	94.5%	15.1%	93.3%
19	10,000	0.0%	100.0%	2.8%	97.1%	20.9%	37.2%
All Companies	629	36.3%	54.8%	20.6%	81.2%	0.0%	39.5%

[a] The dollar amounts of premiums are withheld and companies' names are replaced by scrambled identifiers due to the proprietary nature of data used.
[b] Region 1 (states with negative expected underwriting gains before SRA) includes MS, LA, AR, MT, SD, OK, ND, GA, WI, KS, and MO (see Table 4).
[c] Region 2 (states with positive expected underwriting gains before SRA) includes OH, TX, NC, CO, IN, IL, MN, NE, and IA (see Table 4).
[d] ARF is Assigned Risk Fund.
[e] Expected rates of return and their standard deviations are expressed as percentages of gross premiums.

The distribution of business between the identified regions, on the other hand, is found to be extremely important in determining the overall rates of return. Indeed, companies with extremely high expected losses have major portions of their business concentrated in Region 1 (states with negative expected returns without SRA) and vice versa. In other words, it is less important in how many states a company underwrites crop insurance than where it does so.

The effects of SRA on returns of individual companies are presented in Table 6. Given the crop insurance portfolios in the model base year (2001), eight out of 19 companies would experience underwriting losses without the SRA, and all companies would face extremely high variability of expected returns. The SRA increases the expected returns of all but one company and also significantly decreases the variability. The magnitude of this effect varies by individual companies; composition of companies' portfolios, once again, appears to be the most probable explanation.

While watchdog agencies and industry groups may disagree on whether the SRA generates excessive returns to companies, our analysis suggests a picture far more complicated than the one reflected in the bottom line. Gross underwriting gains are not distributed equally across states and companies. Rather, they tend to be concentrated in a handful of states where the actuarial performance has been generally good over the time period analyzed. Four states—Illinois, Iowa, Minnesota, and Nebraska—account for about two-thirds of total gross underwriting gains in the model. Companies with business concentrated in states with high returns tend to have higher rates of return than companies that underwrite crop insurance in many states. Still, the SRA provides a means by which companies can deliver insurance in states with poor expected actuarial performance. The results also suggest that any change to the SRA failing to take into account the regional aspects of the program would potentially have differential, and perhaps destabilizing, impacts on the crop insurance industry.

Conclusion

This article presents an economic analysis of the underwriting gains and losses under the Standard Reinsurance Agreement, the contract governing the reinsurance relationship between the Federal Crop Insurance Corporation and private insurance companies that deliver crop insurance products to farmers. A simulation model is developed, using historical data on yields and insurance losses in order to simulate empirical distributions of insurance companies' loss ratios under 2001 composition of their books of business. The crucial assumption is that the historically observed loss costs, or ratios of indemnities to total liabilities, were generated by stationary data-generating processes, and thus correctly represent the true distribution of underwriting losses. A representative farmer model is used to simulate yields for any given district, crop, and year, with parameters of random yield shocks calibrated such that the simulated loss costs match the historically observed ones. The simulated distributions of loss costs are then combined with data on liabilities and retained premiums in order to arrive at distributions of loss ratios aggregated by state, company, and fund for the base year of 2001.

The simulation program is used to analyze the effect of the SRA on the distributions of loss ratios and rates of return at several levels of aggregation. The reinsurance provisions of the SRA result in both higher expected values and lower variability of returns of individual companies, thus providing an incentive to participate in underwriting crop insurance. At the regional level, the SRA makes underwriting crop insurance profitable in most of the major crop-producing states, although the magnitude of the effect varies significantly across individual states. While this analysis was performed under the 1998 version of the SRA, the results are also applicable to the recently renegotiated 2005 SRA, which did not change the provisions of the nonproportional reinsurance.

Table 6. Rates of Return by Company Before and After SRA Is Applied

	Before SRA		After SRA		Percent Change in:	
Company	Expected Rate of Return	Standard Deviation	Expected Rate of Return	Standard Deviation	Expected Rate of Return	Standard Deviation
1	!11.9%	38.9%	3.3%	9.0%	15.2%	!29.9%
2	!9.0%	36.6%	6.6%	10.7%	15.6%	!25.9%
3	!8.5%	41.6%	6.1%	13.2%	14.6%	!28.4%
4	!2.6%	35.3%	5.4%	10.3%	8.0%	!25.0%
5	!1.3%	37.2%	9.2%	15.8%	10.5%	!21.4%
6	!1.1%	30.0%	6.6%	10.9%	7.7%	!19.1%
7	!1.3%	38.0%	6.9%	14.9%	8.2%	!23.1%
8	!0.3%	38.1%	9.5%	14.3%	9.8%	!23.8%
9	1.6%	62.1%	11.0%	18.2%	9.4%	!43.9%
10	1.7%	33.9%	7.5%	10.7%	5.8%	!23.2%
11	2.3%	48.9%	8.7%	24.2%	6.4%	!24.7%
12	3.2%	38.1%	10.1%	13.8%	6.9%	!24.3%
13	3.4%	51.5%	11.2%	17.4%	7.8%	!34.1%
14	9.3%	56.9%	14.9%	19.9%	5.6%	!37.0%
15	10.7%	55.9%	14.4%	17.5%	3.7%	!38.4%
16	11.9%	98.8%	19.8%	35.5%	7.9%	!63.3%
17	14.4%	77.2%	18.7%	27.7%	4.3%	!49.5%
18	15.1%	93.3%	20.2%	32.9%	5.1%	!60.4%
19	20.9%	37.2%	19.2%	25.2%	!1.7%	!12.0%
All	0.0%	39.5%	9.6%	14.0%	9.6%	!25.5%

Notes: The dollar amounts of premiums are withheld and companies' names are replaced by scrambled identifiers due to the proprietary nature of data used. All values in table are expressed as percentages of gross premiums.

The overall effects of the new SRA on underwriting returns remain to be seen. Given the relatively minor nature of changes, the adjustments are also likely to be rather minor. Changes in the session limits to the Assigned Risk Fund (ARF) may result in more business allocated to this fund in states with poor expected returns before SRA is applied. The companies may also be willing to underwrite riskier contracts overall in anticipation of their ability to pass more of the bad risk to the FCIC. Analysis of these effects may be a subject of future research as data on changes in portfolio allocation become available.

Further research may also include analysis of companies' behavior in allocating their books of business across reinsurance funds so as to maximize their underwriting gains, as well as counter-factual simulations of alternative SRA structures and reinsurance provisions.

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