Journal of Agricultural and Resource Economics 31(1):57–73

Portfolio Allocation and Alternative Structures of the Standard Reinsurance Agreement

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

This paper examines how insurance companies participating in delivery of crop insurance would change patterns of portfolio allocation across reinsurance funds in reaction to the 2005 Standard Reinsurance Agreement. The returns of insurance companies under the SRA are calculated using a simulation model. An heuristic allocation rule is introduced in order to imitate portfolio allocation strategies of participating companies. The main conclusion of the analysis is that the bulk of changes in portfolio allocations are likely to be caused by the introduction of "retained net book quota share" reinsurance rather than adjustments in the cession limits and retention requirements for the Assigned Risk Fund.

Key words: crop insurance, portfolio allocation strategies, reinsurance funds, Standard Reinsurance Agreement

Introduction

An integral feature of the federal crop insurance program is the Standard Reinsurance Agreement (SRA) between the U.S. government and the private insurance companies that deliver yield and revenue insurance to crop producers [U.S. Department of Agriculture/Risk Management Agency (USDA/RMA), 1997, 2004]. Risk sharing is a unique aspect of the federal crop insurance program that distinguishes it from other federally backed programs such as flood insurance, where the federal government assumes all underwriting risks. Through the SRA, crop insurance companies share underwriting risks in exchange for a share of potential underwriting profits. The reinsurance provisions of the SRA allow companies to decrease their risk exposure by transferring (*ceding*) some liability to the Federal Crop Insurance Corporation (FCIC) and selectively allocating the remaining (*retained*) portions of their portfolios among several reinsurance funds.

The ability of companies to place policies into separate reinsurance funds with distinct risk-sharing characteristics (Ker and McGowan, 2000) is an important feature of the SRA. Under the SRA, if a private company chooses to write crop insurance policies

---

Dmitry V. Vedenov is assistant professor, Department of Agricultural and Applied Economics, University of Georgia; Mario J. Miranda is professor, Department of Agricultural, Environmental, and Development Economics, The Ohio State University; Robert Dismukes is an economist with the Economic Research Service, U.S. Department of Agriculture; and Joseph W. Glauber is Deputy Chief Economist, U.S. Department of Agriculture. This research was supported through a cooperative agreement with The Ohio State University, the University of Georgia, and the U.S. Department of Agriculture. The views expressed are the authors' and do not necessarily reflect those of the USDA.

Review coordinated by T. F. Glover.

in a state, it must offer crop insurance products to any farmer in that state. Moreover, insurance companies must accept the premium rates and underwriting guidelines established by the Risk Management Agency, which administers crop insurance and reinsurance programs on behalf of the FCIC. Thus, crop insurance companies may face large potential risk exposure without recourse to raising premium rates or declining to offer coverage to high-risk individuals. Therefore, the SRA allows companies to place high-risk business in the Assigned Risk Fund where the government assumes most of the risk. Less risky business, on the other hand, can be placed in funds where companies pay more of the underwriting losses but also keep more of the underwriting gains. Underwriting returns thus are related to how well a company classifies its risks and manages its portfolio.[1]

In 2004, a new SRA was negotiated and went into effect for the 2005 reinsurance year (which began on July 1, 2004). It replaced the previous SRA, which was adopted for the 1998 reinsurance year and renewed virtually unchanged in subsequent years. The bulk of differences between the new (2005 SRA) and previous (1998 SRA) versions of the Agreement mostly affect companies' ability to allocate business to the Assigned Risk Fund (see discussion below). Other provisions of the SRA, in particular shares of gains kept and losses borne by the companies, remained unchanged (USDA/RMA, 1997, 2004). As of the time of this writing, no data were available on actuarial performance of the crop insurance programs under the new SRA. However, one can assume that the most direct effect of the new agreement would be different allocation of crop insurance portfolios among reinsurance funds. The purpose of the current study is to model such potential changes in the portfolio allocation that may be implemented by insurance companies in response to the new SRA.

The federal crop insurance program has been extensively discussed in the literature (Kramer, 1983; Gardner, 1994; Goodwin and Smith, 1995; Glauber and Collins, 2002; Glauber, 2004). However, the analysis of portfolio allocation under the SRA has received little attention. Ker and McGowan (2000) used a stylized model of the SRA to demonstrate that companies could adversely select against the FCIC by ceding more risk in years with ex ante projections of yield shortfalls, but their empirical analysis was limited to wheat production in 57 Texas counties. Ker and Ergün (2004) searched for empirical evidence that policy allocations by insurance companies reveal private information available to the companies. In particular, they found the policies placed in the Commercial Fund are more likely to be profitable, while those placed in the Assigned Risk Fund are less likely to be profitable. However, they do not discuss possible allocation strategies the companies may use.

In this study, we take a slightly different approach to the analysis of portfolio allocation. Instead of an econometric model, the paper builds on the recent work of Vedenov et al. (2004) who construct an SRA simulation model based on historical yield data and composition of crop insurance portfolios of individual companies. Using a similar model, we examine the allocation patterns present in the portfolios of insurance companies that participated in delivery of crop insurance products in the base year (2001). We then attempt to model companies' allocation decision-making process by introducing a simple

[1] Company's profitability here is restricted to underwriting profits and does not explicitly examine administrative and operating (A&O) expenses. Under the SRA, A&O expenses are subsidized by the government at a fixed percentage of premiums.

heuristic rule. The latter dictates allocation decisions based on the historical loss ratios for each crop reporting district and crop.

The efficiency of the suggested allocation rule in replicating companies' returns is first evaluated by comparing heuristic allocation generated under the 1998 SRA with the actual allocation for the base year (2001). The rule is then used to generate heuristic portfolio allocations under the 2005 SRA. The changes in the allocation patterns are analyzed at the company and state levels.

The remainder of the paper is organized as follows. First, an overview of the Standard Reinsurance Agreement is presented, highlighting differences between the 1998 and 2005 SRAs. The SRA simulation model used in the analysis is then briefly described. The next section introduces the heuristic allocation rule and compares heuristic and actual allocations for the base year (2001). This is followed by a presentation of heuristic portfolio allocation generated under the new SRA and a discussion of changes in allocation patterns between the 1998 and 2005 SRAs. Concluding remarks are offered in the final section.

The Standard Reinsurance Agreement

This section presents a general overview of the Standard Reinsurance Agreement and a summary of changes between the 1998 and 2005 SRAs, particularly as they relate to the portfolio allocation decisions. Additional discussion and information on the SRA can be found in Ker (2001); Ker and Ergün (2004); Vedenov et al. (2004); and USDA/RMA (1997, 2004).

Portfolio allocation under the SRA is a two-stage process. First, each contract may be allocated in one of three reinsurance funds—Assigned Risk Fund, Developmental Fund, and Commercial Fund—which differ by the degree of risk sharing between the insurance companies and FCIC. Second, each company has to decide on the proportions of premiums it wishes to retain within each reinsurance fund subject to the required minimum retention limits of individual funds.

The ceded (i.e., not retained) portions of the book of business are completely written off from the companies' balances. The FCIC receives all the associated premiums and also assumes full responsibility for the associated underwriting losses on the ceded business.[2] The underwriting gains and profits on the retained portion of business are then shared between the companies and FCIC in the proportions determined by the SRA.

The Assigned Risk Fund (ARF) has the lowest required retention rate of all three funds as well as the lowest shares of losses the companies must pay on the retained business. These provisions make ARF an attractive destination for the more risky business. In order to avoid concentration of the whole book of business in ARF, the maximum cession limits are established for each state. Under the 1998 SRA, the maximum cession limits ranged from 10% to 75% of the book of business in a given state. The required retention rate was set to 20% for all states. The 2005 SRA established maximum cession limits at 25%, 50%, or 75%, and adjusted required retention rates to 25%, 20%, and 15%, respectively. The maximum cession limits and required

[2] Note that unlike the fund allocation decision, the premiums and liabilities are ceded as a proportion of the entire fund rather than on an individual contract basis. In other words, each company retains at least some liability on every policy it underwrites.

retention rates for the Assigned Risk Fund under both the 1998 and 2005 SRAs are summarized in table 1 by state. For example, under the 2005 SRA, a company underwriting in Iowa can place up to 25% of its book of business in the state in the ARF. The company then must cede 75% of the premiums and liabilities associated with policies placed in the fund to FCIC and retain the remaining 25% on its balance.

The Developmental Fund requires the companies to retain at least 35% of the premiums as well as the associated liability. There is no limit on how much business can be allocated to the fund. Within the Developmental Fund, contracts are further designated into a CAT Fund, Revenue Insurance Fund, or All Other Plans Fund, depending on the type of insurance policies. The retention percentages for these three funds may differ across states, but cannot be lower than 35%. A company may elect to retain more than 35% of its premium and associated liabilities. In this case, the retention level can be chosen in 5% increments up to 100%. The provisions of the Developmental Fund remained the same under the 2005 SRA as in the 1998 SRA.

Finally, designation of a contract to the Commercial Fund requires a company to retain at least 50% of the liability and associated premiums. There is also no cession limit associated with the Commercial Fund. As with the Developmental Fund, the Commercial Fund is further subdivided into CAT, Revenue Insurance, and All Other Plans funds. A company may select a retention rate higher than 50% in 5% increments up to 100%. The 2005 SRA provisions of the Commercial Fund also were unchanged from the 1998 SRA.

The responsibilities of the companies for the underwriting losses as well as their shares of the underwriting gains from the retained business depend on the realizations of loss ratios of each company in a given state for a given reinsurance year.[3] The schedules of shares under different realizations of the loss ratios are shown in table 2 for all reinsurance funds. For each loss ratio range, the percentages in the tables apply to the fraction of each company's loss (gain) within that range.

The general principle is that the higher the loss ratio above one (underwriting loss), the higher the portion of losses assumed by the FCIC (up to 100% of the portion of losses exceeding 500% of the retained premiums). Conversely, the lower the loss ratio below one (underwriting gain), the higher the portion of premiums kept by the FCIC. The degree of sharing is the highest for the Assigned Risk Fund and the lowest for the Commercial Fund. The shares of gains and losses remained the same under both the 1998 and 2005 SRA.

The 2005 SRA also added a "retained net book quota share" form of reinsurance which did not exist under the 1998 SRA. Under this provision, each company is required to cede to FCIC 5% of its cumulative underwriting gain or loss. In other words, once all other provisions of the SRA are applied and each company calculates its net gain or loss (aggregated over all states and funds), this final amount is reduced by 5%, with FCIC receiving the difference.

The SRA Simulation Model

In order to examine the effect of portfolio allocation decisions on rates of return of participating companies, we use an SRA simulation model (implemented as a computer

[3] A loss ratio is defined as indemnity paid divided by premium collected (including premium subsidies).

Table 1. Maximum Cession Limits and Retention Requirements Under the 1998 and 2005 SRAs

	1998 SRA		2005 SRA	
State	Maximum Cession Limit	Required Retention Rate	Maximum Cession Limit	Required Retention Rate
Alabama	50%	20%	75%	15%
Arizona	55%	20%	75%	15%
Arkansas	50%	20%	50%	20%
California	20%	20%	50%	20%
Colorado	20%	20%	75%	15%
Delaware	30%	20%	50%	20%
Florida	40%	20%	50%	20%
Georgia	75%	20%	75%	15%
Idaho	45%	20%	50%	20%
Illinois	20%	20%	25%	25%
Indiana	20%	20%	25%	25%
Iowa	15%	20%	25%	25%
Kansas	20%	20%	50%	20%
Kentucky	25%	20%	50%	20%
Louisiana	50%	20%	75%	15%
Maryland	20%	20%	50%	20%
Michigan	50%	20%	50%	20%
Minnesota	20%	20%	25%	25%
Mississippi	50%	20%	75%	15%
Missouri	20%	20%	50%	20%
Montana	75%	20%	75%	15%
Nebraska	20%	20%	25%	25%
Nevada	75%	20%	75%	15%
New Jersey	50%	20%	50%	20%
New Mexico	55%	20%	75%	15%
New York	40%	20%	50%	20%
North Carolina	20%	20%	75%	15%
North Dakota	45%	20%	75%	15%
Ohio	25%	20%	25%	25%
Oklahoma	50%	20%	75%	15%
Oregon	30%	20%	75%	15%
Pennsylvania	25%	20%	50%	20%
South Carolina	55%	20%	75%	15%
South Dakota	30%	20%	50%	20%
Tennessee	35%	20%	50%	20%
Texas	75%	20%	75%	15%
Utah	75%	20%	75%	15%
Virginia	30%	20%	50%	20%
Washington	30%	20%	50%	20%
West Virginia	75%	20%	75%	15%
Wisconsin	35%	20%	50%	20%
Wyoming	35%	20%	75%	15%

Table 2. Shares of Gains and Losses to Private Insurance Companies Under the 1998 and 2005 SRAs

		Loss Ratio Range						
Reinsurance Fund		< 0.5	0.5 to 0.65	0.65 to 1.0	1.0 to 1.6	1.6 to 2.2	2.2 to 5.0	> 5.0
Commercial	CAT	8.0%	50.0%	75.0%	50.0%	40.0%	17.0%	0.0%
	Revenue	11.0%	70.0%	94.0%	57.0%	43.0%	17.0%	0.0%
	All Other	11.0%	70.0%	94.0%	50.0%	40.0%	17.0%	0.0%
Developmental	CAT	4.0%	30.0%	45.0%	25.0%	20.0%	11.0%	0.0%
	Revenue	6.0%	50.0%	60.0%	30.0%	22.5%	11.0%	0.0%
	All Other	6.0%	50.0%	60.0%	25.0%	20.0%	11.0%	0.0%
Assigned Risk		2.0%	9.0%	15.0%	5.0%	4.0%	2.0%	0.0%

Source: USDA/RMA (1997, pp. 12–14), and USDA/RMA (2004, pp. 12–14).

Note: The shares reflect the portions of underwriting gains kept or underwriting losses borne by the insurance companies, with the remaining portions assumed by the FCIC.

program). The model simulates the distribution of the rates of return from underwriting crop insurance by combining historical data on yields and loss costs with base year (2001) data on companies' liabilities and premium rates.[4] The simulation model treats provisions of the SRA as input parameters, and thus is equally applicable to analysis of both the 1998 and 2005 SRA. The following is a brief description of the model, with some technical details omitted due to space limitations. An expanded presentation can be found in Vedenov et al. (2004).

The model covers six crops—barley, corn, cotton, soybeans, grain sorghum, and winter wheat—which represent 0.6%, 29.1%, 9.0%, 19.0%, 1.4%, and 9.0%, respectively, of the total FCIC liabilities in 2001. Modeled insurance products include Catastrophic Risk Protection, Actual Production History, Crop Revenue Coverage, Revenue Assurance, and Income Protection contracts with all available coverage levels. These represent 10.3%, 34.2%, 32.2%, 4.1%, and 0.9%, respectively, of the total FCIC liabilities in 2001. Together, these combinations of crops and products encompass about 65% of the total 2001 FCIC liabilities. The major portion of the remaining liabilities consists of specialty crops concentrated mainly in California and Florida. Outside of these two states, the proportion of 2001 liability covered by the model is about 75%.

The model is based on the assumption that the historically observed loss costs from 1981–2001 adequately represent distribution of losses faced by insurance companies underwriting crop insurance. Historical loss costs at the crop reporting district level are available for 1981-2001 for selected 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. Therefore, the model simulates loss costs for individual insurance products by using historical yield data and price models.

More specifically, the distributions of district-level yields are first derived from National Agricultural Statistics Service (NASS) historical yield data by using log-linear detrending and kernel density estimators (Goodwin and Ker, 1998; Ker and Goodwin, 2000; Ker and Coble, 2003). The distributions of individual (farm-level) yields within

[4] Loss cost is a ratio of indemnity and associated liability.

each district are then modeled by imposing a parametric distribution around district yield. The parameters of the imposed distributions are calibrated so as to match the historical insurance experience reflected in the aggregate loss costs data. This approach allows us to reflect yield experience of insurance buyers, which may differ from overall yield experience in the district (Mason, Hayes, and Lence, 2003; Schnitkey, Sherrick, and Irwin, 2003).

Once calibrated, the parameters of individual yield distributions are assumed to adequately represent the variability of within-district yields for all products included in the model. Loss costs for revenue products also require distributions of harvest-time prices, which are modeled as:[5]

$$\log(p_h) = \log(p_b) + \alpha\big(\log(y_{nat}) - \log(\bar{y}_{nat})\big) + z,$$

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, α is the elasticity parameter capturing correlation between national yields and prices, and z is a random shock that reflects additional price variability independent of yield variability. The 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). The parameters of the random shocks z are calculated based on sample variance of the national yields and implied volatilities derived from options contracts matching the futures contracts used to derive the base prices.

The calibrated individual yield distributions along with the price models are used to simulate distributions of loss costs for all individual products included in the model. The simulated distributions of loss costs for each district, crop, and insurance product are then combined with data on liabilities and premium rates for the base year (2001) and aggregated to derive distributions of realized loss ratios for each company by state and reinsurance fund.

At the final stage, the shares of gains and losses presented in table 2, as well as data on base-year retention rates by company, state, and fund, are used to calculate the distributions of the post-SRA rates of return at various levels of aggregation. The simulation program can also be adjusted to output some intermediate results such as simulated distributions of loss ratios and portfolio allocation patterns.

Portfolio Allocation

General Considerations

Assuming that the insurance companies participating in the SRA are risk averse, their portfolio allocation decisions should reflect the preference for lower risk exposure and higher expected returns. Given the structure of the SRA, these goals can be achieved by placing contracts with high expected loss ratios in the Assigned Risk Fund, while keeping those with low expected loss ratios in the Commercial Fund. Under this strategy, the Developmental Fund functions largely as a "spillover" fund which companies can use if

[5] The price model approach was chosen over estimation of price distribution from historical series, which are often distorted by nonstationarity, changing farm policies and support programs, inflation, etc. (Zulauf and Blue, 2003).

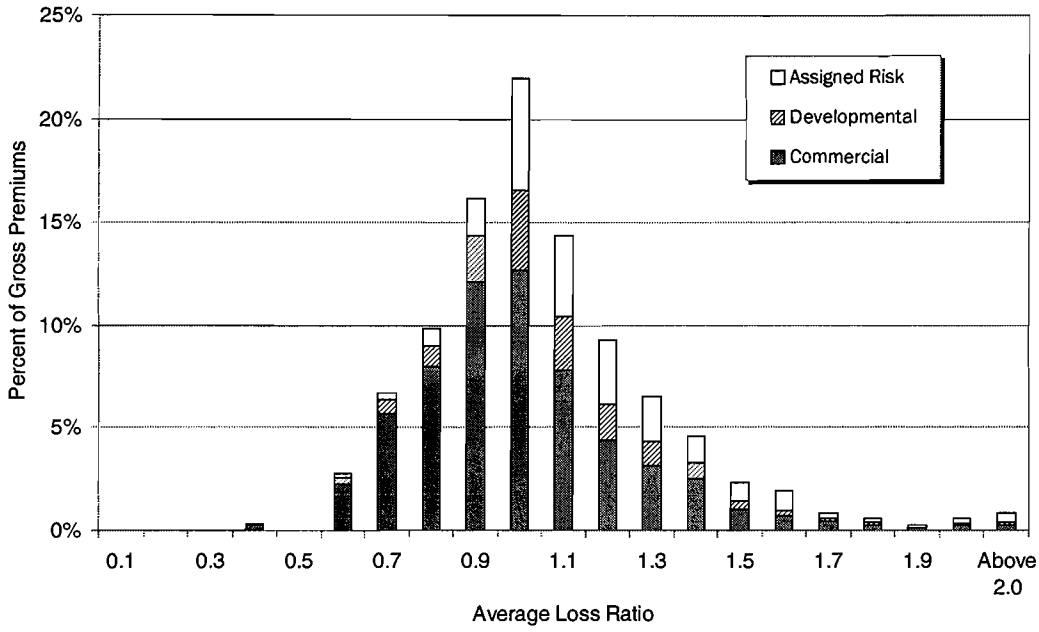

Figure 1. Base-year (2001) allocation of gross premiums across reinsurance funds

they reached cession limit in the Assigned Risk Fund.[6] Figure 1 shows the allocation pattern observed in the 2001 portfolio, which generally conforms to these intuitive considerations. This intuition is also consistent with Ker and Ergün's (2004) finding that the policies placed in the Commercial Fund are more likely to be profitable, while those placed in the ARF are less likely to be profitable.

Practical implementation of this intuitive approach may vary from company to company due to differences in company size, risk attitudes, portfolio composition, and geographical area covered (Vedenov et al., 2004). In addition, loss ratios of individual contracts interact in a nontrivial way when combined in a reinsurance fund due to spatial correlation of underlying yields and prices. Therefore, the expected loss ratio of a fund may be different from the expected loss ratios of individual contracts placed in the fund. The exact magnitude and direction of this aggregation effect is rather hard to predict, as it requires data on loss correlation at the individual policy level—information that even insurance companies themselves may not have.[7]

An alternative approach to portfolio allocation would be to assume that insurance companies are risk-neutral (as is often done in insurance literature) and allocate policies so as to maximize the expected returns only. However, the assumption of risk neutrality

[6] As Ker and Ergün (2004) point out, when companies choose to retain the minimum level (35%) on policies placed in the Developmental Fund, the latter resembles the Assigned Risk Fund.

[7] Since gains and losses from individual crop insurance products are generally accepted to be positively correlated (Miranda and Glauber, 1997), it seems that placing together contracts with similar expected loss ratios would tend to amplify the aggregate loss ratios in the same direction. In other words, if all contracts with the expected loss ratios above a certain threshold are placed in the ARF, the expected loss ratio of the fund will tend to be even higher than the expected loss ratios of individual contracts. Similarly, if all contracts with the expected loss ratios below a certain threshold are placed in the Commercial Fund, the expected loss ratio of the fund will tend to be even lower than the expected loss ratios of individual contracts.

does not appear to be consistent with the empirical evidence. First, if premium rates were actuarially fair, a risk-neutral company would not need reinsurance at all. Even if the need for reinsurance were somewhat justified by distortions present in premiums on crop insurance products, a risk-neutral insurance company would never use the Assigned Risk Fund, which substantially reduces expected returns. Instead, such a company would concentrate all or most of its business in the Commercial Fund. Quite to the contrary, the allocation patterns present in the 2001 portfolio (figure 1) reflect substantial use of the ARF, and thus a certain degree of risk aversion on the part of participating companies.

Heuristic Allocation Rule

Ideally, an optimal allocation rule can be obtained as a solution to a multivariate optimization problem that would determine in which fund to allocate each individual contract and recommend optimal retention rates for each reinsurance fund. Solving such an optimization problem, however, is extremely difficult due to an enormous number of decision variables and nonlinearity of the objective function. Indeed, a typical company underwriting in Iowa may have over 15,000 contracts to allocate across funds. In addition, retention rates need to be chosen for the Developmental and Commercial Funds. Adding more states increases this number even further and makes the computational problem practically impossible to address.

As a more tractable approach, we suggest a simple heuristic rule that companies can use to allocate their books of business. For a given district, crop, and type of product (CAT, Revenue, or All Other Products), the expected loss ratio without reinsurance is computed based on historical data. The heuristic rule states that if the expected loss ratio is higher than a prespecified threshold, all the business in that district and crop is designated "high risk" and placed in the Assigned Risk Fund. If the maximum cession limit to the Assigned Risk Fund is reached in a particular state, the appropriate Developmental Fund is used as an overflow buffer for the remaining "high risk" business. Conversely, if the expected ratio is below the threshold, all the business in the district and crop is allocated into the appropriate Commercial Fund. Once again, such an allocation strategy is consistent with empirical findings of Ker and Ergün (2004) as well as the allocation patterns present in the 2001 portfolio (figure 1).

A "naïve" rule would set the threshold loss ratio at 1.0.[8] However, due to the skewness of losses and asymmetric nature of the SRA (companies' shares of gains are higher than shares of losses), the expected return to companies after the SRA may be positive even though the expected pre-SRA loss ratio is greater than 1.0. Consider a company that must decide how to allocate a contract which may result in a loss ratio of 0.8 with probability of 0.9, and loss ratio of 4.8 with probability of 0.1. The expected pre-SRA loss ratio is 1.2; hence, under the "naïve" heuristic rule, the policy should be placed in the Assigned Risk Fund. However, if the contract were placed in the Commercial Fund, its expected post-SRA loss ratio would be 0.929, i.e., an expected net return of 7.1%.

Therefore, our analysis goes beyond the "naïve" rule and takes into account the post-SRA return in determining the threshold loss ratios. For each company, portfolio allocations are generated according to the heuristic rule for threshold values between 0.7 and

[8] Ker and McGowan (2000) utilized this approach in their analysis of Texas wheat counties.

1.3 at 0.01 increments. The generated allocations are then used as data files for the SRA simulator program in order to calculate the corresponding expected values and standard deviations of the rates of return. The "optimal" loss ratio thresholds (LR_{opt}) are chosen for each company by a simple grid search so as to maximize the expected rate of return ($\bar{r}$) while keeping the standard deviation (s) at the same or lower level (s_{2001}) achieved by the company under the actual base-year allocation. More formally,

$$LR_{opt} = \arg\max \bar{r}, \quad \text{s.t.: } s \leq s_{2001}. \tag{1}$$

This approach essentially maximizes expected returns on the set of mean-variance pairs corresponding to various loss ratio thresholds and representing weak Pareto-improvements over the base-year allocation in the mean-variance space. While loss ratio thresholds determined in this way may be somewhat conservative, the advantage of this approach is that it does not require any assumptions about specific risk preferences of individual companies, other than risk aversion.

For practical implementation of the above algorithm, all district/crop/product type combinations within each state were sorted in the decreasing order of the expected pre-SRA loss ratios and placed in the Assigned Risk Fund in that order. This was done to ensure that the districts with higher loss ratios go into the ARF first in case the maximum cession limit is reached in a particular state and the Developmental Fund has to be used as an overflow.

For simplicity, retention rates across all companies and states were fixed at 100% for the Commercial Fund and 35% for the Developmental Fund. For the Commercial Fund, this assumption is consistent with the actual retention elections observed in the 2001 portfolio, where 2,768 out of 2,850 retention rates (or 97.1%) were set to 100%.[9] For the Developmental Fund, the actual 2001 retention elections were generally higher than the minimum 35%. However, these retention elections were made based on actual policies placed in the Developmental Fund and may not necessarily reflect retention rates the companies would elect if allocating according to the suggested heuristic rule. Therefore, we assumed conservative retention rates which are consistent with the intuition behind the suggested heuristic allocation rule (i.e., that the Developmental Fund is used as an extension of the Assigned Risk Fund). Finally, for the Assigned Risk Fund, the retention rates were set to the required 20% for all states under the 1998 SRA (just as in the actual 2001 portfolio) and to the state-specific levels (15%, 20%, or 25%) under the 2005 SRA.

Validation

In order to evaluate efficiency of the suggested heuristic rule in allocating portfolios of insurance contracts among reinsurance funds, we compared the returns generated by the SRA simulation program using the actual 2001 allocation data and the heuristic allocations based on the "optimal" loss ratio thresholds as defined in (1).

Presented in table 3 are the simulated post-SRA rates of return for the actual (2001) and heuristic allocations under the 1998 SRA. The table also reports the loss ratio

[9] The number 2,850 represents the total number of company-state combinations present in either one of three Commercial Funds in the base-year portfolio.

Table 3. Comparison of Actual (2001) and Heuristic Allocations Under the 1998 SRA

	Actual Allocation		Heuristic Allocation					Difference in Premium Allocations			
					95% Confidence Interval						
Company	Expected Rate of Return	Standard Deviation	Loss Ratio Threshold	Expected Rate of Return	Lower Bound	Upper Bound	Standard Deviation	ARF	Developmental Fund	Commercial Fund	% Retained
#1	3.3%	9.1%	1.01	5.7%	4.8%	6.0%	7.5%	7.2%	1.9%	-9.2%	-8.9%
#2	5.4%	10.3%	0.94	6.2%	5.5%	6.7%	7.2%	24.5%	-26.4%	1.9%	-26.5%
#3	6.1%	13.2%	1.14	11.1%	9.9%	12.1%	13.1%	4.5%	-9.1%	4.7%	-1.2%
#4	6.6%	10.9%	1.06	9.3%	8.1%	9.8%	10.9%	9.1%	-19.3%	10.2%	-9.4%
#5	6.7%	10.7%	1.11	9.9%	8.8%	10.5%	10.6%	-8.2%	-5.8%	14.0%	0.7%
#6	6.9%	15.0%	1.14	9.3%	7.8%	10.0%	14.9%	3.1%	-15.3%	12.2%	-2.4%
#7	7.5%	10.7%	1.01	10.8%	9.7%	11.3%	10.6%	1.6%	-9.3%	7.7%	0.8%
#8	8.7%	24.2%	1.08	9.9%	8.2%	11.5%	24.0%	1.1%	-1.5%	0.4%	-0.2%
#9	9.2%	15.8%	1.19	12.0%	10.6%	12.8%	14.0%	5.1%	-5.8%	0.7%	-6.4%
#10	9.5%	14.3%	1.17	12.0%	10.7%	13.0%	13.7%	0.6%	-13.3%	12.7%	-2.3%
#11	10.1%	13.8%	1.06	13.3%	11.9%	14.0%	13.7%	-8.6%	-1.4%	10.0%	6.6%
#12	11.0%	18.2%	1.05	12.4%	11.0%	14.3%	18.1%	12.8%	-22.2%	9.4%	-14.9%
#13	11.2%	17.4%	1.07	13.7%	12.3%	15.1%	17.4%	1.1%	-13.3%	12.1%	-5.0%
#14	14.4%	17.5%	0.96	17.1%	15.6%	18.5%	17.4%	-0.2%	1.8%	-1.6%	1.9%
#15	15.0%	19.9%	1.04	17.0%	15.3%	18.5%	19.6%	2.3%	-13.8%	11.5%	-3.4%
#16	18.7%	27.7%	1.03	21.0%	19.2%	23.3%	26.8%	2.3%	-7.7%	5.4%	-2.0%
#17	19.4%	25.4%	1.04	19.7%	17.6%	20.8%	24.8%	0.9%	0.0%	-0.9%	-0.7%
#18	19.8%	35.5%	1.08	21.0%	19.0%	24.9%	37.2%	4.8%	-20.1%	15.3%	-3.9%
#19	20.2%	32.9%	1.17	21.9%	20.1%	25.1%	30.8%	6.7%	-14.9%	8.2%	-6.8%
All	9.6%	14.0%	N/A	12.5%	11.1%	13.3%	13.4%	0.5%	-8.8%	8.3%	-2.0%

Notes: Returns are expressed as percentages of gross premiums. Lower and upper bounds of the confidence interval are computed as 2.5% and 97.5% percentiles of jackknife distribution of the expected returns. Differences in premium allocations are calculated as percentages of gross premiums placed in a corresponding fund or retained under heuristic allocation less the same percentage under the actual 2001 allocation. Companies' identities are replaced by scrambled identifiers due to the proprietary nature of data used in the analysis.

thresholds "optimal" in the sense of (1) and differences in portfolio allocation patterns between the actual and heuristic allocations. Results are reported for the 19 companies reinsured by FCIC in 2001. Due to the proprietary nature of some data used in the SRA simulator program, the individual companies are represented in this and subsequent tables by scrambled identifiers, and all results are expressed as percentages of gross premiums rather than dollar amounts. The gross premiums are not affected by a particular allocation method, and thus provide a convenient basis for relative comparison.

The results indicate that the suggested heuristic rule works at least as well, if not better than, the allocation strategies utilized by companies in 2001. The expected returns of all companies under the heuristic rule are higher than those obtained under the actual allocation, while the variability of returns is lower for all but one company. To further validate the results, 95% confidence intervals for the expected returns are computed for the heuristic allocation by using the jackknife approach (Efron, 1982). For 15 companies, the improvement in expected returns is significant at the 95% confidence level. For the other four companies, the lower bound of the 95% confidence interval is only slightly below the expected returns under the actual allocation. The difference in returns is primarily explained by heavier use of the Commercial and Assigned Risk Funds under the heuristic allocation at the expense of the Developmental Fund. The difference in percentages of retained premiums is explained by fairly conservative assumptions about retention rates underlying the heuristic rule.

Note that the seemingly superior performance of the suggested heuristic rule must be interpreted somewhat cautiously. The rule makes several simplifying assumptions, such as fixing retention rates at the same level for all companies and states, treating all business for a given district and crop as a single allocation unit, using the expected loss ratios for the whole district regardless of product composition, setting a single threshold for expected loss ratios for the whole company, and so on. In addition, the rule completely ignores correlation in losses or gains that may exist between contracts written in adjacent districts or for different crops within the same district.

However, we would like to emphasize that our purpose is not to suggest a better strategy to allocate crop insurance policies so as to extract the maximum profit from the SRA (a topic, no doubt, of great interest to participating companies). Rather, we seek to find an allocation rule that would reasonably replicate portfolio performance for a known portfolio allocation in the hope it will do equally well in simulating portfolio performance in a situation for which actual allocation is unknown—such as the 2005 SRA. From this standpoint, the results in table 3 suggest that the heuristic allocation rule does a fairly good job in approximating companies' allocation strategies, and thus can be used to imitate companies' reaction to the changed structure of the 2005 SRA.

2005 SRA versus 1998 SRA

We now attempt to analyze the changes in allocation patterns and rates of return that may be caused by introduction of the new SRA. Recall that the main difference between the 1998 SRA and 2005 SRA is in the cession limits and retention requirements for the Assigned Risk Fund (table 1) and the introduction of the "retained net book quota share" form of reinsurance, which essentially decreases overall net gains and losses by an additional 5%. The parameters of Commercial and Developmental Funds, as well as shares of gains and losses under the nonproportional reinsurance, are the same under both versions of the agreement.

Table 4. Changes in Post-SRA Returns and Portfolio Allocation by Company: 2005 SRA versus 1998 SRA

		Portfolio Returns		Allocation of Gross Premiums			
Company	Loss Ratio Threshold	Expected Rate of Return	Standard Deviation	% in ARF	% in Developmental	% in Commercial	% Retained
#1	—	-0.5%	-0.8%	11.5%	-11.5%	0.0%	-4.0%
#2	—	-0.4%	-0.5%	3.7%	-3.7%	0.0%	-3.0%
#3	0.06	-0.5%	-0.2%	1.4%	-5.9%	4.4%	1.9%
#4	—	-0.5%	-0.6%	2.4%	-2.4%	0.0%	-1.8%
#5	0.03	-0.3%	-0.1%	0.3%	-5.0%	4.7%	2.1%
#6	—	-0.5%	-0.9%	4.4%	-4.4%	0.0%	-0.6%
#7	0.06	-0.3%	-0.1%	6.6%	-16.0%	9.4%	4.6%
#8	—	-0.5%	-1.2%	0.1%	-0.1%	0.0%	-1.2%
#9	—	-0.6%	-0.7%	2.1%	-2.1%	0.0%	-0.8%
#10	0.02	-0.6%	-0.5%	0.5%	-2.1%	1.6%	0.6%
#11	0.04	-0.5%	0.0%	-1.0%	-2.6%	3.6%	2.2%
#12	0.02	0.0%	0.0%	-0.7%	-4.0%	4.7%	2.7%
#13	0.05	-0.5%	-0.2%	-0.5%	-4.7%	5.2%	3.2%
#14	0.04	-0.3%	0.1%	3.2%	-8.1%	4.8%	2.5%
#15	0.08	-0.4%	0.2%	-1.4%	-3.5%	4.8%	3.2%
#16	0.14	-0.5%	0.5%	-5.3%	-0.4%	5.7%	5.0%
#17	0.06	-0.9%	-0.3%	-2.9%	0.0%	2.9%	2.4%
#18	0.02	-1.0%	-1.8%	-0.2%	0.0%	0.2%	0.4%
#19	—	-1.1%	-1.7%	2.2%	-2.2%	0.0%	0.4%
All	N/A	-0.5%	N/A	0.9%	-4.0%	3.1%	1.4%

Note: The results reported here are presented as changes from the 1998 SRA (table 3) to the 2005 SRA.

Since no data on actual allocations under the 2005 SRA were available at the time this research was conducted, the heuristic allocation rule described in the previous section was applied to the 2001 book of business. Specifically, we attempted to replicate portfolio allocation patterns that might have arisen if the participating companies allocated their 2001 portfolios under the provisions of the 2005 SRA. The generated portfolio allocation was then used as an input for the SRA simulation program in order to calculate expected rates of return and their variability. The results of the simulation in terms of differences from the baseline levels of the 1998 SRA are presented in table 4.[10]

Table 4 suggests the 2005 SRA will result in rather minor changes relative to the 1998 SRA. All companies will experience a slight decrease in expected rates of returns (between -0.02% and -1.1%). At the same time, the variability of returns will also slightly decrease for all but three companies. Given relatively minor differences in provisions of the 1998 and 2005 SRAs, the most probable explanation for these changes appears to be the "retained net book quota share" reinsurance. Recall that this new provision

[10] For adequate comparison, the results obtained under heuristic rather than actual allocation are used as the 1998 baseline.

decreases by an additional 5% the net gains and losses realized after proportional and nonproportional provisions of SRA are applied. Since the expected net returns are positive for all companies (table 3), the companies on average stand to lose 5% of gains more often than to have 5% of losses compensated, which results in a negative net effect on the expected return. The "retained net book quota share" reinsurance also tightens the distribution of returns around 0%, which explains the decrease in variance observed in table 4.

In terms of portfolio allocation, reactions of companies to the 2005 SRA seem to exhibit three distinct patterns. One group of companies (#1, #2, #4, #6, #8, #9, and #19) would use the same loss ratio thresholds for allocation decisions, and only reallocate portions of the business from the Developmental to the Assigned Risk Fund. Since the Developmental Fund is used as an overflow for the ARF under the heuristic allocation rule, these companies appear to underwrite in states with a higher proportion of risky business and would benefit from increased cession limits in those states (table 1).

The second group of companies (#3, #5, #7, #10, and #14) would also reallocate part of their business from the Developmental Fund to ARF, but at the same time increase their allocation to the Commercial Fund (also at the expense of the Developmental Fund). This behavior can be explained as a combination of two factors. First, increased cession limits under the 2005 SRA allow the companies to allocate more business to the ARF in some states. Second, the companies attempt to counteract the decrease in net gains caused by the "retained net book quota share" reinsurance by recapturing a higher portion of the gains in the Commercial Fund.

Finally, the remaining seven companies (#11–#13 and #15–#18) would increase their allocations in the Commercial Fund by reallocating business from both the Developmental Fund and the ARF. These companies seem to underwrite in states where cession limits to the ARF were not binding under the 1998 SRA. Changes in their allocation patterns are explained solely by the reaction to the "retained net book quota share" reinsurance.

To further analyze the effect of changes in cession limits and retention requirements, the changes in allocation patterns between the 1998 and 2005 SRAs aggregated at the state level are presented in table 5 for the top 25 states in terms of 2001 gross premiums. The results once again suggest that the major driving force behind changes in portfolio allocations is the introduction of "retained net book quota share" reinsurance rather than changes in provisions of the ARF. While the cession limits to the ARF increased under the 2005 SRA in 17 out of 25 states, the proportions of premiums allocated to the ARF under the 2005 SRA increased only in six states (Louisiana, Mississippi, Kansas, Missouri, South Dakota, and Tennessee). In two states where the cession limits under the 2005 SRA remained the same (Arkansas and Montana), the proportions of gross premiums in ARF also remain the same. In all other states, the proportions of gross premiums in ARF actually decrease. At the same time, the proportions of premiums in the Commercial Fund increase in all 25 states with additional premiums reallocated from the Developmental and/or Assigned Risk Fund. Changes in retention requirements do not appear to have any consistent effect on changes in allocation patterns.

Table 5. Changes in Portfolio Allocation Patterns for Selected States: 2005 SRA versus 1998 SRA

		Change in:				
State	Gross Premium ($ millions)	Cession Limit to ARF	Required Retention Rate in ARF	% Gross Premiums in Commercial Fund	% Gross Premiums in Developmental Fund	% Gross Premiums in ARF
Louisiana	31.82	25%	-5%	0.2%	-25.1%	24.9%
Mississippi	70.20	25%	-5%	0.3%	-24.1%	23.8%
Kansas	164.43	30%	0%	5.5%	-11.8%	6.3%
Missouri	76.32	30%	0%	4.2%	-9.5%	5.3%
South Dakota	131.83	20%	0%	3.6%	-8.6%	5.0%
Tennessee	18.18	15%	0%	2.2%	-5.9%	3.6%
Arkansas	44.69	0%	0%	6.7%	-6.7%	0.0%
Montana	43.04	0%	-5%	1.5%	-1.5%	0.0%
Iowa	223.80	10%	5%	0.8%	-0.7%	-0.1%
Alabama	23.61	25%	-5%	1.0%	-0.6%	-0.4%
Michigan	23.78	0%	0%	3.5%	-3.0%	-0.4%
Indiana	80.64	5%	5%	3.9%	-3.5%	-0.4%
Colorado	40.81	55%	-5%	1.1%	-0.4%	-0.7%
Ohio	47.24	0%	5%	3.3%	-2.5%	-0.8%
Nebraska	175.98	5%	5%	1.1%	0.0%	-1.1%
Illinois	162.27	5%	5%	1.3%	-0.1%	-1.2%
North Carolina	39.12	55%	-5%	2.0%	-0.7%	-1.3%
Kentucky	18.65	25%	0%	2.6%	-0.7%	-2.0%
Oklahoma	48.66	25%	-5%	5.1%	-3.0%	-2.1%
Minnesota	179.34	5%	5%	2.1%	0.0%	-2.1%
Wisconsin	36.99	15%	0%	7.6%	-5.5%	-2.1%
Texas	297.55	0%	-5%	2.3%	0.0%	-2.3%
Georgia	60.53	0%	-5%	6.8%	-1.5%	-5.3%
North Dakota	134.06	30%	-5%	9.0%	-1.6%	-7.3%
South Carolina	15.86	20%	-5%	7.9%	0.0%	-7.9%
All States	2,283.84	N/A	N/A	3.1%	-4.0%	1.0%

Notes: The table includes the top 25 states in terms of gross premiums (95.9% of all premiums included in the model). The states are ordered by percentage changes of gross premiums in ARF (the last column). The results in columns 3 through 7 are changes from the 1998 SRA to the 2005 SRA.

Conclusion

This paper has examined how insurance companies participating in delivery of crop insurance would react to the introduction of the 2005 Standard Reinsurance Agreement. The analysis concentrates on changes in portfolio allocation patterns across reinsurance funds that may be caused by the new SRA.

The rates of return of insurance companies under the SRA are calculated using an SRA simulation model based on historical data on loss costs and yields. In order to imitate portfolio allocation strategies of participating companies, a simple heuristic allocation rule is introduced. The rule, while not an optimal allocation strategy in the

strict sense, allows for variations in risk attitudes among companies and also takes into account the effect of the SRA on net returns. Comparison of returns calculated under the actual base year (2001) allocation and an allocation implied by the heuristic rule suggests the rule works fairly well as a proxy to the actual companies' behavior, and thus can be utilized to model their reaction to changes in the SRA.

The heuristic rule is then applied to construct portfolio allocations that reflect changes in the 2005 SRA. The allocation patterns along with portfolio returns are analyzed at the individual company and state levels. The main conclusion of the analysis is that the bulk of changes in portfolio allocations are likely to be caused by the introduction of "retained net book quota share" reinsurance rather than adjustments in cession limits and retention requirements for the Assigned Risk Fund. While seven companies do increase the proportion of gross premiums placed in the ARF, the other 12 reallocate gross premiums from the Developmental and/or Assigned Risk Fund into the Commercial Fund. The "retained net book quota share" reinsurance requires companies to cede to the FCIC 5% of gains or losses realized after all other provisions of the SRA are applied. Since the expected returns after all other provisions of SRA are positive for all companies, the companies on average stand to cede 5% of their gains more often than 5% of their losses. Thus the "retained net book quota share" reinsurance tends to decrease the expected returns, and companies attempt to counteract this effect by allocating more of gross premiums into the Commercial Fund, where they can keep higher shares of underwriting gains. At the state level, increases in cession limits result in a higher proportion of gross premiums placed in the ARF in only six out of 25 states reported. At the same time, the proportion of premiums placed in the Commercial Fund increases in all states.

The effect of changes in the 2005 SRA on portfolio returns appears to be rather minor. The expected returns of all companies decrease by less than 1.1%, suggesting the companies should be able to mitigate the effect of "retained net book quota share" reinsurance to some degree.

[*Received June 2004; final revision received January 2006.*]

References

Efron, B. *The Jackknife, the Bootstrap, and Other Resampling Plans.* Philadelphia: SIAM, 1982.

Gardner, B. L. "Crop Insurance in U.S. Farm Policy." In *Economics of Agricultural Crop Insurance: Theory and Evidence*, eds., D. L. Hueth and W. H. Furtan, pp. 17–44. Boston: Kluwer Academic Publishers, 1994.

Glauber, J. W. "Crop Insurance Reconsidered." *Amer. J. Agr. Econ.* 86,5(2004):1179–1195.

Glauber, J. W., and K. J. Collins. "Crop Insurance, Disaster Assistance, and the Role of the Federal Government in Providing Catastrophic Risk Protection." *Agr. Fin. Rev.* 62(2002):81–102.

Goodwin, B. K., and A. P. Ker. "Nonparametric Estimation of Crop-Yield Distributions: Implications for Rating Group-Risk Crop Insurance Contracts." *Amer. J. Agr. Econ.* 80(1998):139–153.

Goodwin, B. K., and V. H. Smith. *The Economics of Crop Insurance and Disaster Aid.* Washington, DC: The AEI Press, 1995.

Ker, A. P. "Private Insurance Company Involvement in the U.S. Crop Insurance Program." *Can. J. Agr. Econ.* 49,4(2001):557–566.

Ker, A. P., and K. Coble. "Modeling Conditional Yield Densities." *Amer. J. Agr. Econ.* 85(2003):291–304.

Ker, A. P., and T. Ergün. "On the Revelation of Private Information in the U.S. Crop Insurance Program." Work. paper, Dept. of Agr. and Resour. Econ., University of Arizona, Tucson, September 2004.

Ker, A. P., and B. K. Goodwin. "Nonparametric Estimation of Crop Insurance Rates Revisited." *Amer. J. Agr. Econ.* 83(2000):463–478.

Ker, A. P., and P. McGowan. "Weather-Based Adverse Selection and the U.S. Crop Insurance Program: The Private Insurance Company Perspective." *J. Agr. and Resour. Econ.* 25,2(2000):386–410.

Kramer, R. A. "Federal Crop Insurance." *Agricultural History* 97(1983):181–200.

Mason, C., D. J. Hayes, and S. H. Lence. "Systemic Risk in U.S. Crop Reinsurance Programs." *Agr. Fin. Rev.* 63,1(2003):23–39.

Miranda, M. J., and J. W. Glauber. "Systemic Risk, Reinsurance, and the Failure of Crop Insurance Markets." *Amer. J. Agr. Econ.* 79(1997):206–215.

Schnitkey, G. D., B. J. Sherrick, and S. H. Irwin. "Evaluation of Risk Reductions Associated with Multi-Peril Crop Insurance Products." *Agr. Fin. Rev.* 63,1(2003):1–21.

U.S. Department of Agriculture, Risk Management Agency. *1998 Standard Reinsurance Agreement.* USDA/RMA, Washington, DC, 1997. Online. Available at http://www.rma.usda.gov/pubs/ra/98SRA.pdf.

———. *2000 Revenue Crop Insurance Plans.* USDA/RMA, Washington, DC, 1999. Online. Available at http://www.rma.usda.gov/pubs/2000/2000rcip.pdf.

———. *2005 Standard Reinsurance Agreement.* USDA/RMA, Washington, DC, 2004. Online. Available at http://www.rma.usda.gov/pubs/ra/05SRA_final.pdf.

Vedenov, D., M. Miranda, R. Dismukes, and J. Glauber. "Economic Analysis of the Standard Reinsurance Agreement." *Agr. Fin. Rev.* 64,2(Fall 2004):119–134.

Zulauf, C. R., and E. N. Blue. "Has the Market's Estimate of Crop Price Variability Increased Since the 1996 Farm Bill?" *Rev. Agr. Econ.* 25(2003):145–153.