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Optimal Climate Crop Insurance Strategy: Contrasting Insurer and Farmer Interests

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Abstract

Predictability of seasonal climate variability associated with El Niño Southern Oscillation (ENSO) suggests a potential to reduce farmer and insurer risks by selecting best crop insurance products conditioned to expected seasonal climate forecasts. This study finds out the best crop insurance products conditioned to ENSO phases from the stand point of view of an insurer, and contrast them with those of farmer's best options. This study addresses synergies and conflicts of interest between insurer and farmer and how climate information would make them more alike or more different. It was found that farmer and insurer have a high degree of discrepancy in their selections. Nevertheless, their choices tend to converge when contracts are 75% yield coverage (APH) for both cotton and peanut, and 75 revenue coverage (CRC) for cotton and catastrophic coverage (CAT) for peanut. Additional synergetic contracts (cotton-peanut) are: for El Niño years 75%APH-70%APH, for La Niña years 75%APH-CAT, and for Neutral years 80%CRC-70%APH, 75%APH-CAT, and 75%APH-65%APH.

Key Words: ENSO, Risk Management, Interest Conflict, Subsidy, Government Farm Programs

Introduction

Risk management tools such as crop insurance and ENSO-based forecasts are best used as part of a coordinated strategy. Farmer's optimal crop insurance contracts according to El Niño Southern Oscillation (ENSO) phases have been identified (Cabrera et al., submitted). This study finds out insurer's optimal crop insurance contracts and contrasts them with farmer's. Crop insurance products are mechanisms to help farmers attain economic stability as stated in the mission of the USDA Risk Management Agency (www.rma.usda.gov). However, long term optimal crop insurance selection of farmers can differ of those of insurers who might look for self sustainability through minimization of losses or through control of losses to a manageable level. Once a farmer buys crop insurance, he or she may have an incentive to engage in risky behavior. Moral hazard is this pervasive concern for insurers that can be addressed by contrasting farmer and insurer interests.

A few studies have investigated the relationship of some type of climate or weather information and farmer crop insurance selection. Schneider and Garbrecht (2003) found crop insurance programs could profitably use seasonal precipitation forecasts. Leigh and Kuhnel (2001) used El Niño Southern Oscillation (ENSO) based hail forecast together with hail insurance in Sidney applied to financial and risk modeling; and Martin et al. (2001) proposed an algorithm to select crop insurance according to an indemnity function that takes into consideration weather-based precipitation derivatives in a cotton farm in Mississippi. Only Cabrera et al. (submitted) included a systematic approach to optimize farmer's crop insurance products according to ENSO-based climate forecasts.

Some studies have addressed insurer's point of view, but without climate interaction. Menrad and Hirzinger (2005) compared insurer versus farmer crop insurance impacts under the scheme of genetically modified plants recommending reduced premium rates for transgenic plants as they will result in reduced indemnity payments. Wang and Zhang (2003) studied the feasibility of private crop insurance contrasting farmer and insurer perspectives revealing high possibility of non-subsidized, private crop insurance. Turvey et al. (1999) presented a model that evaluates insurer risks and an approach to computing actuarial reinsurance premiums. Abbaspour (1994) presented a Bayesian risk methodology to help crop insurers cope with uncertainty and risk.

Climatologists and insurers can and need to work together to effectively bring understanding and wise consideration of climate conditions and their fluctuations. Climatologists can help insurers to mitigate losses and assess risks (Changnon et al., 1999).

The main aim of this study is to analyze insurer's impacts because of ENSO-based crop insurance selection and contrast those with farmer's best options. We hypothesize that synergies between farmer and insurer regarding crop insurance contracts exist and are impacted by climate variability. Our analysis does not include a spatial dimension because we have chosen to study on-farm decisions more closely and give emphasis to farm-level details and farmer's incentives.

Materials and Methods

Representative Farm

In order to contrast farm and insurer strategies, the same case study as Cabrera et al. (submitted) was used. Analyses were conducted on a hypothetical 40 ha (100 ac) non-irrigated farm in Jackson County, Florida (30.774N, 85.226W) that grows 50% peanut (Arachis hypogaea L.) and 50% cotton (Gossypium hirsutum L.). A dominant soil type used for agriculture in the region, Dothan Loamy Sand, was assumed for the farm.

Optimization Data

Consistent with Cabrera et al. (submitted) we used 65 years (1939-2003) of daily weather to simulate crop yields, which were classified by ENSO phase (JMA, 1991). A stochastic generator was used to expand the yield records to 990 by ENSO phase. In similar fashion, synthetic prices were generated by simulating multivariate distributions respecting price covariance between cotton and peanut. Contemporary local costs of production were incorporated. For more details, see Cabrera et al. (submitted).

Crop Insurance Products

The most common crop insurance products in Jackson Co., FL were included: CAT or Catastrophic coverage and 65, 70 and 75% APH or Actual Production History (also called MPCI Multi-Peril Crop Insurance) for peanut and cotton; and 65, 70, 75, 80, 85% CRC or Crop Revenue Coverage for cotton. Different from Cabrera et al. (submitted), the premiums received by the insurer for these crop insurance contracts included the subsidized portion in addition to the farmer's payment. Premiums were calculated using the premium calculator at the USDA Risk Management Agency Website (http://www3.rma.usda.gov/ apps/premcalc/).

Minimum Losses of Insurer

A stochastic non-linear whole farm model was used to study the role of climate forecasts in decision making and to estimate the impact of farmer crop insurance choices on the insurer losses. The model was systematically solved to identify optimal planting dates to yield annual insurer minimum losses for all combinations of ENSO Premiphases and available crop insurance products. The model assumed farmer requires selecting at least some type of crop insurance contract for each crop.

Optimal farm decisions

The model selected optimal planting date for cotton and peanut, having 50% of the land devoted to each crop. This procedure was repeated for each combination of peanut and cotton crop insurance product. The model minimized losses (L) for one year planning horizon, Equations 1 and 2.

$$\min_{x} E\{L\} = \sum_{n=1}^{N} \sum_{j=1}^{2} X_{m,i,j} IY_{i,j} PB_{i,j} - X_{m,i,j} \Pr_{i,j} / N \text{, for } i\text{=1 to 4; m=1 to 13} \qquad (1)$$

$$\sum_{m=1}^{9} X_{m,j} = 0.5 \text{, for } j\text{=1; } \sum_{m=10}^{13} X_{m,j} = 0.5 \text{, for } j\text{=2; } X_m \geq 0 \qquad (2)$$

where i is the ENSO phase and all years (1=El Niño, 2=Neutral, 3=La Niña, 4=All Years), j is the crop (1=peanut, 2=cotton), m is the planting date (1 to 9 for peanut [16 April, 23 April, 1 May, 8 May, 15 May, 22 May, 29 May, 5 June, 12 June] and 10 to 13 for cotton [16 April, 23 April, 1 May, 8 May]), and N is the year for each optimization (1 to 990 for each ENSO phase, and 1 to 2970 for all years); IY is indemnity yield, compensation farmer receives to cover losses below insured yield or income, for insurance purposes. PB is price base or price election for insurance purposes, Pr is insurance premium, and X is land allocation for every crop planting date.

The MINOS5 algorithm in GAMS (Gill et al., 2000) was used along with a randomized procedure to alter starting values and assure global maxima solutions. Every solution identified planting date that minimized expected loss.

Conditional Value-at-Risk (CVaR)

Minimization of conditional CVaR (Liu et al., 2006; Rockafellar and Uryasev, 2002) was used to evaluate insurer risk along with minimization of expected loss, Equation 3.

$$CVaR_{\alpha}[L(x,\theta)] \leq v \quad (3)$$

where $L(x,\theta)$ is the stochastic insurer loss distribution for a combination of farm crop insurance contracts, v is a range of maximum losses to a defined probability α. CVaR is a hedging portfolio to reduce risk that finds the best combination of crop insurance contracts that have a defined risk (α) to have a loss inside a defined range (v).

Farm simulation and net income calculation

We constrained the farm model to optimal planting date allocations to simulate net margins for every ENSO phase (990 for each ENSO phase) and for all years (2970 years) using all synthetic yields and prices. This procedure was repeated for each combination of crop insurance for selected CVaR levels. Net income for each year was estimated and compared across ENSO phases and crop insurance products.

Synergies and Conflicts between Insurer and Farmer in Optimal Crop Insurance Selection

Farmers and insurers have different risk reduction strategies. They are conceptualized in Figure 1. For farm specific insurance contracts, Figure 1 shows all uncertain, but possible income areas that can occur before the crop insurance is applied. For practical purposes, yield insurance protection policies (APH and CAT) can also be defined as revenue protection as the actual yield multiplied by a defined price election. Farm income is then the market value of crop yields less the farmer share cost of the insurance premiums. The farm income can be positive (greater than zero), zero, or negative (less than zero). A series of connotations can be drawn depending on where the uncertain farm income is located. Please refer to arrows a, b, c, and d in Figure 1.

If farm income is positive (a, falls inside the "gain" area of the farmer and the "same gain" area of the insurer), the situation is of gaining for both farmer and insurer (synergy). Farmer has a gain and insurer has the maximum gain. Insurer keeps the received premiums (which includes farmer payments and government subsidies) because does not pay any indemnities.

If farm income is negative, but higher than the protected income (b, falls inside the "lost" area of the farmer and still the "same gain" of the insurer), the situation is of losing for the farmer and still maximum gain for the insurer (conflict). Because this area of income is not protected, the farmer does not receive insurance indemnities and the insurer, as previously, keeps all the premiums.

Arrows "a" and "b" represent indifferent situations of maximum gain for the insurer and uncertain situations of less gain or lost for the farmer.

If farm income is negative, lower than the protected income, but higher than the value of the premium received by the insurer (c, falls inside the "same lost" area of the farmer and the "less gain" area of the insurer), the situation is of maximum possible lost for the farmer and of less gaining for the insurer (conflict). Because this area of farm income is protected for the crop insurance contracts, the insurer pays indemnities to the farmer to reach the farm income insured level. These indemnities however have less value than the premiums the insurer received.

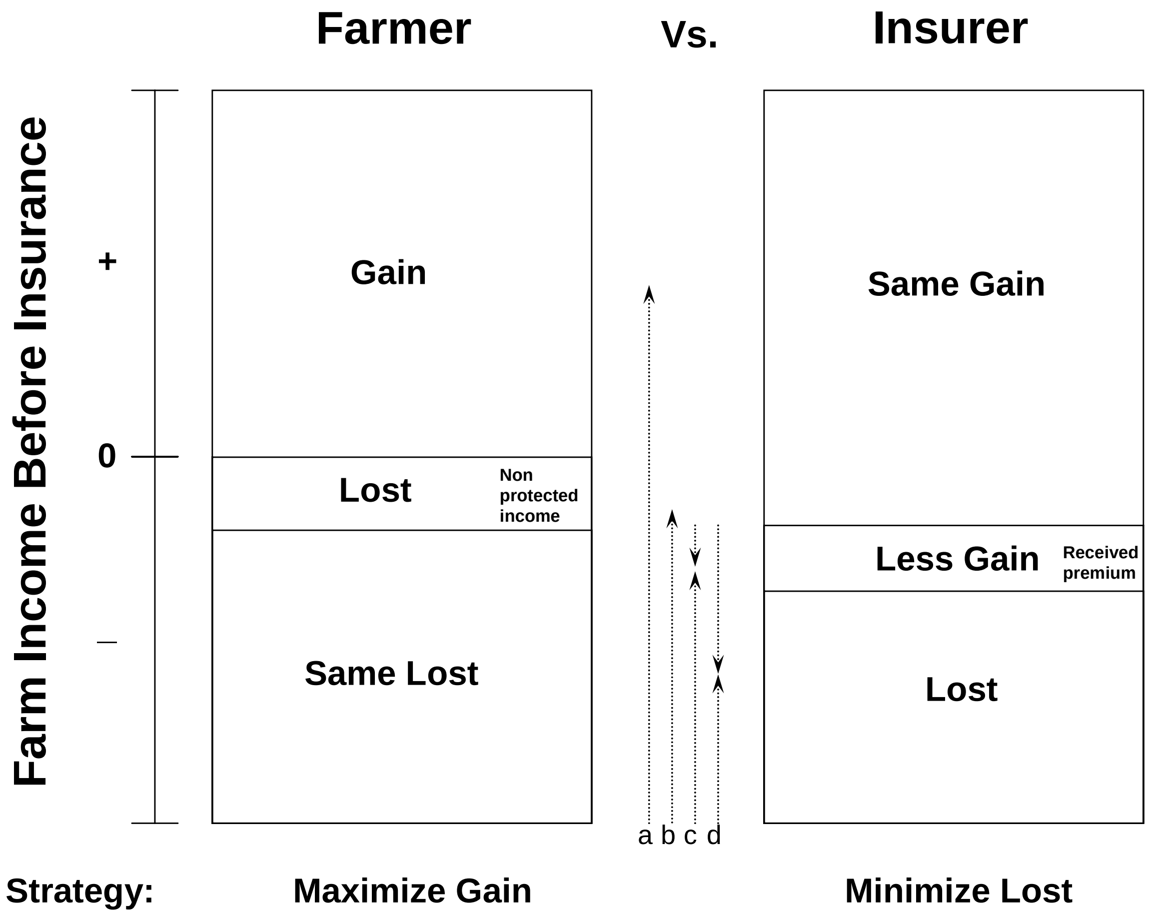

Figure 1 Conceptualization of gains, losses, and risk strategies for determined crop insurance contracts of farmer versus insurer. Note: upside arrows are farm incomes and downside arrows are indemnity payments.

If farm income is negative and lower than the value of the premium received by the insurer (d, falls inside the "same lost" area of the farmer and the "lost" area of the insurer), the situation is of same maximum lost for the farmer and loosing for the insurer (conflict). The insurer has to pay a higher value than the received premium as indemnities for the farmer to reach the protected level.

Arrows "c" and "d" represent indifferent situations of maximum lost for the farmer and uncertain situations of less gain or lost for the insurer.

It can be conjectured that income risk strategies are different (though not opposite) for the farmer and the insurer. The farmer would look forward to maximize gains (Cabrera et al., submitted), while the insurer would look forward to minimize losses. This paper contrasts these two strategies under different ENSO-based seasonal climatic scenarios.

We implemented these synergies or conflicts of interest by comparing farmer's maximum gains versus insurer's minimum losses for a crop insurance contract under determined ENSO phase as relative proportions of their maximums.

Loss Ratios by Optimal Crop Insurance Contracts

Crop insurance products being part of federal farm programs with the purpose to minimize risk in farm income, may not have the aim of minimize insurer losses, however, long term sustainability of these programs would be to maintain losses to a manageable level. Optimizing or minimizing losses would help in this goal. For example, a low loss ratio (paid indemnity / premium received) of 1.075 (G. Hatcher, personal communication) is a target pushed by federal agencies as a desirable index. Following this rationale that crop insurance is a non-profit business analyses were performed assuming insurer loss ratios between 1 (indemnity is equal to premium) and 1.075 (7.5% beyond premium loss) as a desirable range.

Results and Discussion

Minimum Losses or Maximum Gains of Insurer

Average gain of insurer ranged from \$23 to \$258 ha/year. Minimum gain occurred for a contract CAT for cotton and 70%APH for peanut for La Niña and El Niño years, whereas this was CAT for cotton and peanut for Neutral years. Maximum gain occurred for 85% CRC for cotton and 75%APH for peanut for La Niña and Neutral years, whereas 85%CRC for cotton and 65%APH for peanut gave the maximum gain for El Niño years. Figure 2 shows all the gains by insurance contracts and ENSO phase. The lines cross over in several points indicating different climate impacts by insurance contract.

Highest Gain by Risk Levels

Table 1 shows the crop insurance contracts with maximum gains that 90, 95, or 99% of the time (risk level) have more gain than a value (risk value). The contract 85%CRC-65%APH was the best for El Niño years, however if the insurer wants to have higher than \$4000 of gain (or \$100/ha) 95% of the time, 75%APH-CAT would be the best contract. Likewise, the best contract for El Niño years to have 99% of the time higher than \$2000 (or \$50/ha) would be 75%APH-CAT. There was no contract available that 99% of the time had a gain greater than \$4000.

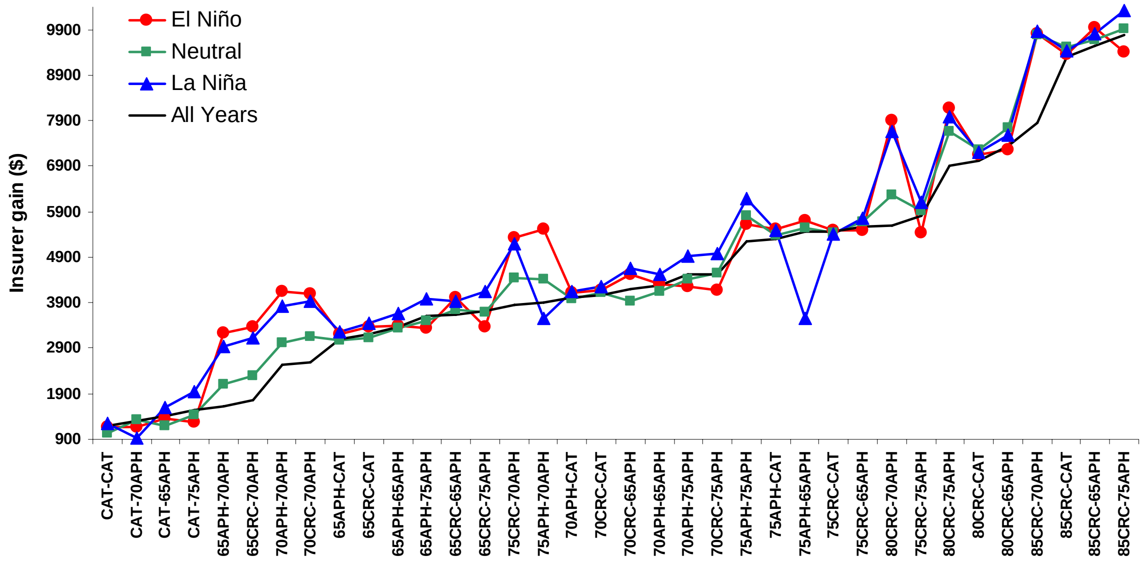

Figure 2 Average gain of insurer per crop insurance contract and ENSO phase in a 40 ha cotton-peanut farm. Note: Crop insurance contracts (%) are for cotton-peanut combinations; APH is yield, CAT is catastrophic, and CRC is income coverage.

Table 1 Best crop insurance contract according to risk values and risk levels.

		Risk level		
	Risk value	90%	95%	99%
El Niño	<-4000	85CRC-65APH	85CRC-65APH	85CRC-65APH
	-4000-2000	85CRC-65APH	85CRC-65APH	85CRC-65APH
	-2000-0	85CRC-65APH	85CRC-65APH	85CRC-65APH
	0-2000	85CRC-65APH	85CRC-65APH	85CRC-65APH
	2000-4000	85CRC-65APH	85CRC-65APH	75APH-CAT
	>4000	85CRC-65APH	75APH-CAT	NA
Neutral	<-4000	85CRC-75APH	85CRC-75APH	85CRC-75APH
	-4000-2000	85CRC-75APH	85CRC-75APH	85CRC-75APH
	-2000-0	85CRC-75APH	85CRC-75APH	85CRC-75APH
	0-2000	85CRC-75APH	85CRC-75APH	65APH-CAT
	2000-4000	85CRC-75APH	85CRC-75APH	75APH-CAT
	>4000	85CRC-75APH	75APH-CAT	NA
La Niña	<-4000	85CRC-75APH	85CRC-75APH	85CRC-75APH
	-4000-2000	85CRC-75APH	85CRC-75APH	85CRC-75APH
	-2000-0	85CRC-75APH	85CRC-75APH	85CRC-CAT
	0-2000	85CRC-75APH	85CRC-75APH	70APH-CAT
	2000-4000	85CRC-75APH	85CRC-75APH	75APH-CAT
	>4000	85CRC-CAT	85CRC-CAT	NA
All years	<-4000	85CRC-75APH	85CRC-75APH	85CRC-75APH
	-4000-2000	85CRC-75APH	85CRC-75APH	75APH-65APH
	-2000-0	85CRC-75APH	85CRC-75APH	65APH-CAT
	0-2000	85CRC-75APH	85CRC-75APH	75APH-CAT
	2000-4000	85CRC-75APH	85CRC-CAT	NA
	>4000	85CRC-CAT	NA	NA

Note: NA means not available insurance contract for those conditions. Crop insurance contracts (%) are for cotton-peanut combinations; APH is yield, CAT is catastrophic, and CRC is income coverage.

Synergies and Conflicts between Insurer and Farmer in Optimal Crop Insurance Selection

Figure 3 combines the farmer net income (Cabrera et al., submitted) and the insurer gains (expressed as percentages of their maximums) by ENSO phase and crop insurance contract. Synergies between insurer and farmer can be found in areas where percentages of insurer gain and farmer net income are alike. Considering 40 to 60% a reasonable area where insurer and farmer would converge their interests, it was possible to find out best crop insurance contracts for both. Those were 75%APH-75%APH and 75%CRC-CAT for all ENSO phases. In addition, 75%APH-CAT for Neutral and La Niña years; 75%APH-70%APH for El Niño years; and 80%CRC-70%APH and 75%APH-65%APH for Neutral years were also synergetic. Neutral years had five common contracts between 40 and 60%, whereas El Niño and La Niña only had three.

The greater conflict of interest between insurer and farmer occurred at the extremes of the graphs in Figure 3. The contract 85%CRC-CAT was the lowest net income generator for the farmer while it brought one of the greatest gains to the insurer. Likewise, contracts such as CAT-75%APH for El Niño and Neutral years and CAT-70%APH for La Niña years had the highest net incomes for the farmer with the lowest gains for the insurer.

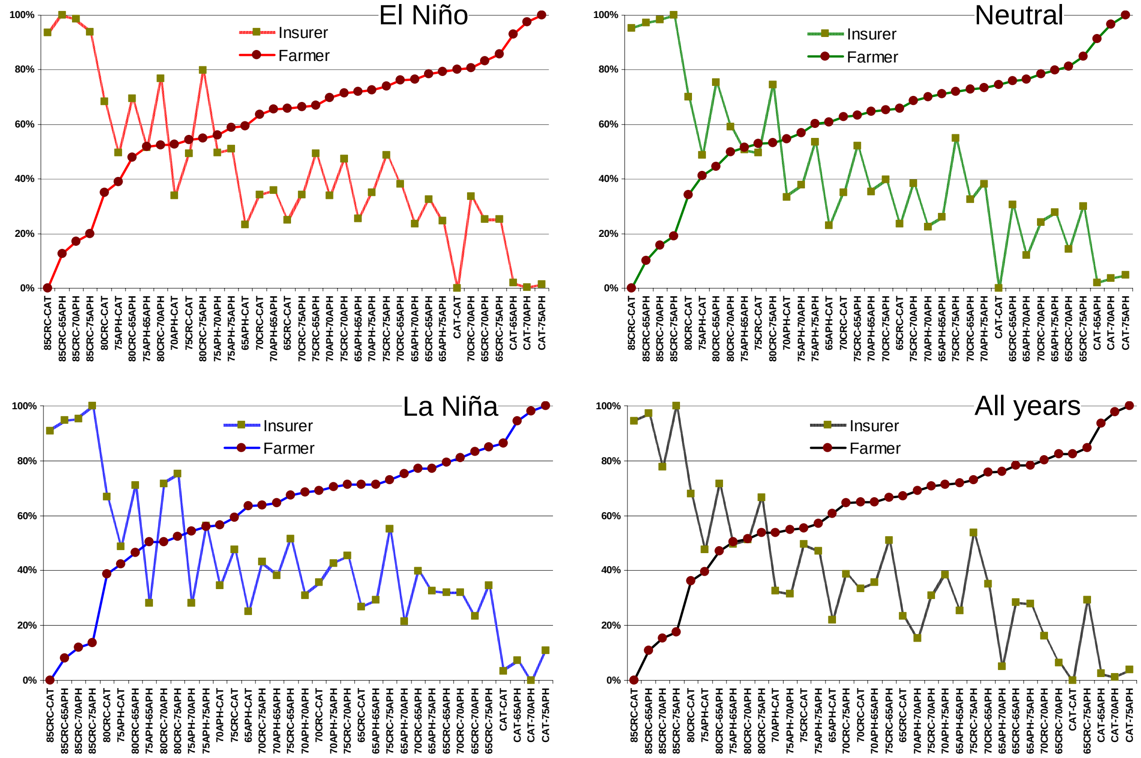

Figure 3 Insurer gain and farmer net income expressed by percentage of their maximums by crop insurance contract and ENSO phase. Note: Crop insurance contracts (%) are for cotton-peanut combinations; APH is yield, CAT is catastrophic, and CRC is income coverage.

Loss Ratios by Optimal Crop Insurance Contracts

The average loss ratio for all years was 0.32, what is 32% of the premium received was used to pay indemnities. This ratio decreased to 0.27 for El Niño, 0.30 for Neutral, and 0.26 for La Niña years. Figure 4 shows the average loss ratio by insurance contract and ENSO phase. The lowest loss ratios occurred for 65, 70, and 75%APH cotton and CAT peanut contracts for La Niña years; and 75%APH-CAT contracts for El Niño and Neutral years. The highest ratios occurred for CAT-75%APH for El Niño, 65%CRC-70%APH for Neutral, and CAT-70%APH for La Niña years.

Figure 4 shows a great impact of climate variability to the loss ratio represented by multiple lines cross over. This variability is greater for La Niña years. No insurance contract reached on average a loss ratio close to a desirable target between 1 (indemnity is equal to premium) and 1.075 (7.5% beyond premium loss). However, most of the contracts had a probability of reach such a target loss ratio. There was great variability in such frequency. Depending on ENSO phase, the frequency varied from zero (75%APH-75%APH and 80%CRC-CAT contracts) to 65 in Neutral years (65%CRC-75%APH), to 54 in El Niño years (75%CRC-75%APH), and 43 in La Niña years (65%CRC-65%APH) (Figure 5).

There was great impact of climate on the frequency of reaching the target loss ratio by crop insurance contract. The climate impact was maximized for the 65%CRC-75%APH contract when Neutral years had 41% higher and El Niño and La Niña years had 55% lower frequencies with respect to all years.

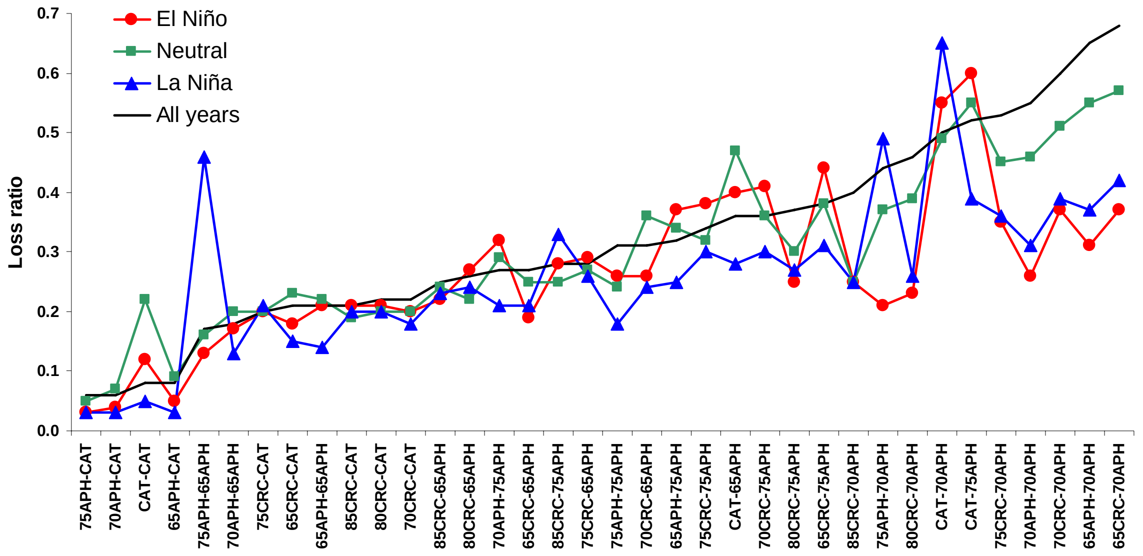

Figure 4 Average loss ratio per crop insurance contract and ENSO phase in a 40 ha cotton-peanut farm. Note: Crop insurance contracts (%) are for cotton-peanut combinations; APH is yield, CAT is catastrophic, and CRC is income coverage.

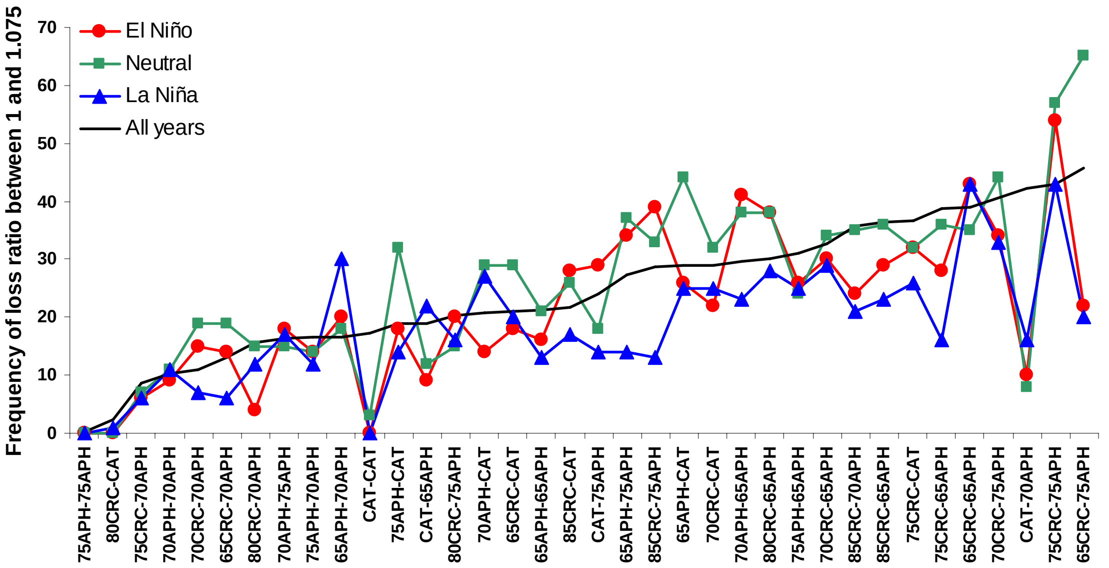

Figure 5 Frequency or number of times the loss ratio was between 1 and 1.075 per crop insurance contract and ENSO phase in a 40 ha cotton-peanut farm. Note: Crop insurance contracts (%) are for cotton-peanut combinations; APH is yield, CAT is catastrophic, and CRC is income coverage.

Conclusions and Discussion

Gains of insurer in the long run were directly related to the amount of received premium, indicating that at higher coverage, although more frequent indemnity payments, the balance of premium less indemnity is greater than with lower coverage. Year to year, ENSO-based climate variability impacts moderately insurer gains according to crop insurance contracts. In addition, at higher risk levels, gains are more stable by decreasing moderately crop insurance coverage.

Insurer and farmer might have conflict of interests regarding crop insurance selection, although best selections are not completely opposite. If both parties are interested in relax their best selections, farmer and insurer can attain long term sustainability. Using ENSO-based climate forecast has an impact on these decisions. However, only the insurer has the capacity to change the underwritten crop insurance policy contracts and the mission to help farmers attain economic stability. Consequently, the insurer would have greater connotation in resolving these potential conflict of interests, even though farmers are not willing to change their best selections.

Insurer loss ratio target of 1.075 (premium received vs. indemnity payment) is substantially higher than what was found in this study of 0.32. This fact indicates that there is room for decreasing subsidies and/or decreasing farmer's premiums and still safely attain the target loss ratio. A voice of caution is that this study only used large temporal distributions. Further study is recommended to include spatial distributions.

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