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**Managing the Agricultural Revenue Risk in Brazil: Implications for Developing a Crop  
Insurance Program**

**Andréia C.O. Adami<sup>1</sup>  
Vitor Augusto Ozaki<sup>2</sup>**

<sup>1</sup>Center of Advanced Studies on Applied Economics (CEPEA) – ESALQ/USP

<sup>2</sup>University of São Paulo – Risk and Insurance Research Group – GESER/Brazil

*Selected Poster prepared for presentation at the 2013 AAEA & CAES Joint Annual Meeting,  
August 4-6, 2013, Washington, D.C.*

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## Introduction

Adverse weather events may significantly reduce the production, causing serious economic losses for the producer and the regional economy. It can significantly reduce income in circulation in the city or even in the state as a whole. Strong reductions in prices can also drastically reduce farm income. In Brazil the crop insurance emerges as an important risk management tool. Taking this fact into account the Federal Government approved in 2003 the Premium Subsidy Program, to reduce the premium paid by the farmers. Up to 2009, all the products covered only the rural loan. In this year, one insurance company started to offer the so called revenue insurance for the soybean producers in the Parana state. This product protected famers against reductions in price and yields at the same time. This study has the objective to analyze the viability of implementation of the revenue insurance contract in the Parana State (South region of Brazil).

## Objectives

- Set up the availability of Brazilian Revenue Insurance Contract ;
- Pricing revenue risk;
- Calculate the cash flow (premium – indemnity) considering a set of scenarios;
- Verify the viability of the revenue insurance in the South Region of Brazil;

## Data

The soybean farmer crop-yield data (bags by hectare) is provided by COAMO, a Brazilian agri-cooperative, from the West Region of the Parana state.

There total sample is equal to 585 farmers for the period of 2001 through 2011.

The market prices are the daily average prices in February, for March contracts of soybean traded on the Chicago Exchange Futures Market. The prices are traded in USD and were converted to R\$ by the average ptax exchange rate of February.

## Statistical Method

Accurate pricing of crop insurance policies requires accurate estimation of the conditional revenue densities. The insurance premium rate, from now on skew-normal rates (SN), represents expected payouts as a proportion (or percentage) of total liability. In the simple case where a proportion, known as the level of coverage, of the expected farmer crop-yield ( $y^e$ ) and guarantee futures-price at harvest time (PG) are used to form the basis of revenue insurance and defined when the contract is closed (on September) the premium rate is given by:

$$SN = \frac{F_{yp}(\lambda y^e PG).E_{yp}[\lambda y^e PG - E(YP / py < \lambda PG y^e)]}{\lambda y^e PG} = \frac{\int_0^{\lambda y^e PG} (\lambda y^e PG - yp) f(yp) dyp}{\lambda y^e PG}$$

where  $E$  is the expectation operator,  $p$  is the futures-price at the harvest at which losses will be paid,  $y$  is the yield at the harvest time and,  $f$  is the probability density for revenue ( $yp$ ), and  $F$  is the cumulative distribution function of revenues ( $yp$ ).

Azzalini (1985) proposed a method for constructing skewed distribution based on any symmetrical ones. Let  $f$  be a probability density function ( $p.d.f.$ ) symmetric about 0, and  $G$  an absolute continuous cumulative distribution function ( $c.d.f.$ ) such that  $g=G'$  is symmetric about 0. Then,

$$2f(x)G(\theta), \quad x \in R \tag{1}$$

is a p.d.f. for any . From equation (1), the Skew-normal (SN) distribution, with location parameter , parameter and shape parameter , is defined by the following p.d.f.:

$$\phi(x / \theta, \mu, \sigma) = \frac{2}{\sigma} \phi\left(\frac{x-\mu}{\sigma}\right) \Phi\left(\frac{\theta(x-\mu)}{\sigma}\right), \tag{2}$$

where and are the p.d.f. and the c.d.f. of a standard normal random variable, respectively. We can measure the degree of skewness of the Skew-normal distribution given in equation (2) by:

$$\gamma = \sigma^3 \left[ \frac{4}{\pi} - 1 \right] \left[ 1 - \frac{2\sigma^2}{\pi} \right]^{-3/2} \sqrt{\frac{2}{\pi}} \tag{3}$$

$(\theta \rightarrow \pm\infty)$

where and -0,99527< <0,99527 with limiting cases being half-normal distributions. In fact, we use the approach of Henze (1986), representing the Skew-normal distribution as a mean-variance mixture of a normal and a half-normal distributions. Genton (2004) shows more details on multivariate Skew-normal distribution and other skewed distributions.

## Results

Table 1 compares the Empirical Rates (ER) and Skew Normal Rates (SN) for 585 soybean farmers in the West of Parana (Brazil). The estimates were estimated by counties using the coverage levels of 50%, 60% and 70%. The counties are Tupassi, Bragantina, Spiguaçu, O.V.Oeste, N.Sta.Rosa, VilaNova, and DezMaio. As one can note, ER rates sometimes overestimate and sometimes underestimate the SN rates. When ER rates are higher than the SN (ER>SN) the risk is smaller than those accounted fo the insurance companies. However, when ER rates are underestimated (ER<SN), the situation is reversed. At the 70% of coverage level, the difference is smaller than the 50% and 60% coverage level for all counties. For the rest of the West Region, the differences fall when the coverage level increases. For 70% coverage level the ER and SN rates are equal on average (5.4%).

Table 1 – Skew-normal (SN) and empirical rates (ER) for different levels of coverage in the West of Parana (Brazil) aggregated by county.

	LC50%		LC60%		LC70%	
City	ER(%)	SN(%)	ER(%)	SN(%)	ER(%)	SN(%)
Tupassi	3.3	4.3	4.9	5.9	7.1	8.0
Bragantina	1.2	2.4	2.8	3.6	4.7	5.3
Spiguaçu	0.7	1.7	1.9	2.5	4.6	3.8
O.V.Oeste	1.1	1.8	2.6	2.7	5.2	4.1
Toledo	0.6	1.1	1.7	1.9	3.9	3.0
N.Sta.Rosa	3.2	2.3	3.0	3.5	5.0	5.2
VilaNova	1.4	1.9	2.9	2.8	5.2	4.1
DezMaio	0.7	2.0	2.4	3.2	4.7	4.9
West	1.8	2.6	3.2	3.8	5.4	5.4

Table 2 compares insures cash flow for cycle 2009/2010 and 2010/2011 by coverage level in million R\$. The counties analised were Tupassi, Bragantina, Spiguaçu, O.V.Oeste, N.Sta.Rosa, VilaNova, and DezMaio. As one can note, the cash flow increases with the coverage level, i.e, for higher levels of risk insures take higher revenues by counties and for whole West region in these two cycles. For these two cycles, there is no losses for insures, only on crop 2008/2009 there is a city (Bragantina) that presented losses, because of the severe drought in this particular year, but at the regional level the cash flow was positive.

## Results

Table 2 – Cash Flow (premium – indemnity) considered in the selected counties in 2009/10 and 2010/11.

	LC50%		LC60%		LC70%	
City	2009/10	2010/11	2009/10	2010/11	2009/10	2010/11
Tupassi	0.5	0.4	0.9	0.7	1.4	1.1
Bragantina	0.1	0.1	0.3	0.25	0.6	0.5
Spiguaçu	0.02	0.01	0.07	0.05	0.2	0.15
O.V.Oeste	0.01	0.01	0.05	0.03	0.1	0.08
Toledo	0.08	0.06	0.3	0.2	0.6	0.5
N.Sta.Rosa	0.016	0.012	0.023	0.018	0.3	0.25
VilaNova	0.07	0.06	0.18	0.16	0.35	0.31
DezMaio	0.01	0.01	0.06	0.05	0.12	0.09
West	1.0	0.8	2.0	1.7	3.7	3.0

## Conclusions

In this study we address the viability of the revenue insurance contract at the farmer level in the Parana State using an alternative statistical method based on skew-normal distribution of probability. Looking at the results, one can see that at farm-level, there are counties that presented an ER higher than SN and others presented a lower ER rate. This results suggested that some low risk farmers were overcharged and high risk farmers were undercharged. At the county level the low risk areas presented an ER higher than SN and lower in high risk areas. At 70% of coverage level, the premium rates on average in the West of Parana were similar, about 5.4% for both ER and SN rates. Insurers cash flow were estimated for crops 2009/2010 and 2010/2011. The results showed that the cash flow were positive considering the three coverage levels. This study contributes to a better understanding of the dynamic of revenue gains and losses, as well as of their implications for the insurance market and credit agents.

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