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# Revenue protection for organic producers: too much or too little

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## **Keywords**

crop insurance, organic production, revenue protection, organic agriculture

## **Disciplines**

Economics

# Revenue Protection for Organic Producers: Too Much or Too Little

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## **Revenue Protection for Organic Producers: Too Much or Too Little**

### **Abstract**

*A framework is developed to examine organic crop insurance established by the Risk Management Agency (RMA). Given that RMA links organic and conventional crop prices, the model is calibrated to reflect both markets to illustrate the impacts that pricing has on insurance coverage. Findings indicate that at the 75% coverage level, RMA's fixed price factor implies an effective coverage ranging from 45% to 106% depending on the ratio of planting-time organic to conventional market prices. Results suggest RMA's program is likely to induce adverse selection, because the nominal coverage level is likely to substantially deviate from the effective coverage.*

Keywords: crop insurance, organic agriculture

The Food, Conservation and Energy Act of 2008, which amended part of the Federal Crop Insurance Act, required the U.S. Department of Agriculture to examine currently offered Federal crop insurance coverage for organic crops as described in the organic policy provisions of the 2008 Farm Bill (Title XII of the Food, Conservation and Energy Act, 2008). The provisions established the need to review underwriting risk and loss experience of organic crops and determine whether significant, consistent, or systematic variations in loss history exist between organic and non-organic production. On the basis of the loss history examination, the Risk Management Agency (RMA) is to reduce, eliminate, or increase the 5% premium surcharge for coverage of organic crops that applies to all crops and regions across the U.S. While Federal crop insurance for organic crops does account for some of the idiosyncrasies in organic production, the incorporation of organic production data into the crop insurance rating structure has been limited.

Organic producers are charged an arbitrary 5% premium surcharge over conventional crop insurance. The actuarial fairness of this premium is, at least, questionable (see Singerman, Hart, and Lence 2010). No other adjustments are made to the premium rate to reflect organic production practices. Moreover, in the case of crop failure, organic farmers receive compensation based on conventionally-produced crop prices. Thus, current insurance policy structure does not compensate for price premiums that organic producers are able to obtain in the market for their crops (RMA 2011a).

As a consequence of the 2008 Farm Bill provisions, at the beginning of 2009 RMA contracted for the development of a pricing methodology that would improve the crop insurance policy for organic crops. Based on that research, a pilot program was started during the 2011 crop year that established a separate price election for a few certified organic crops.<sup>1</sup> Under this pilot program, prices of organic corn and soybeans for insurance purposes are the prices of their conventional counterparts multiplied by 1.788 and 1.794, respectively. These ratios are based on minimum ratios of organic to conventional prices observed from January 2007 through September 2009.<sup>2</sup> In this way, the pilot program links price determination of organic crop prices

to their conventional counterparts by a fixed percentage. This change will influence the payouts of both Yield and Revenue Protection products for organic corn and soybeans.<sup>3</sup> But the impact will be greater for revenue insurance products.

By pegging organic prices to their conventional counterparts and using conventional crop futures markets to forecast what organic crop prices will be at harvest time, RMA's pilot program assumes the two markets are affected by the same shocks and they react to those shocks in a similar fashion. Such linking not only contradicts the findings of Singerman, Lence, and Kimble-Evans (2010), which suggest that there is no basis for advocating the existence of a consistent long-run relationship between organic and conventional prices, but also sharply contrasts with observed market dynamics.

Organic crops have historically sold at a premium over their conventional counterparts. Singerman, Lence, and Kimble-Evans (2010) found that the average organic premium from October 2004 until July 2009 for corn (soybeans) across different markets in the U.S. was \$4.17/bu (\$7.41/bu), which translates to a ratio of 2.233 (1.966). In general, one might expect organic crops to sell at a premium because, as argued by Clarkson (2007) and illustrated by Loureiro, McCluskey, and Mittelhammer (2001), some consumers strongly prefer organic products over their conventional counterparts.

Organic price premiums are also expected because organic production involves additional risks (Klonsky and Greene 2005) that help explain the lower yields (Porter 2003; Delate and Cambardella 2004; Singerman, Hart, and Lence 2010) achieved in organic production. McBride and Greene (2008) also found that organic production involves higher per unit costs. Therefore, price premiums act as a major incentive in encouraging conventional producers and processors to switch to organic agriculture, by making organic crop systems competitive with conventional systems. However, since October 2010 organic price premiums for corn and soybeans have been shrinking, due to the rise of commodity prices boosted by increased crop demand via biofuels and simultaneous reductions in supply due to weather-related problems in the Southern hemisphere, while organic prices have been steady. In late February 2011, the time of crop

insurance price determination, prices for organic (conventional) corn and soybeans were \$8.60/bu (\$6.86) and \$18.61/bu (\$13.38), respectively.<sup>4</sup> Hence, the price ratios were 1.25 and 1.39 for corn and soybeans respectively, well below RMA's established price ratios for both organic crops.

The disparity in the behavior of organic and conventional crop prices implies a changing multiplicative relationship between them, making their price ratio larger or smaller depending on idiosyncratic shocks and adding evidence to the idea that the two markets are distinct. Thus, the linking of organic to conventional prices for crop insurance purposes by a fixed proportion would not only be incorrect, but would also make the level of participation in crop insurance by organic producers dependant on the relationship between the insurance and market prices. If the price ratio at the time of price discovery<sup>5</sup> (in February for corn and soybeans) is low (high) and RMA offers to insure the crops at a higher (lower) level, it creates a clear incentive for organic producers to insure (not insure) their crops during that year under that policy, as the guarantee is being unduly inflated (deflated). Moreover, pegging organic crop prices to conventional crop prices might also result in systematic over (under) payments to producers under the Revenue Protection types of coverage because the product insures against losses from yield and/or price decreases. Hence, for example, a decrease in organic prices at harvest time will never be compensated for (unless conventional prices are also affected), whereas a decrease in conventional prices will incorrectly be part of an organic producer's indemnities. Therefore, we analyze how RMA's price mis-ratings in terms of payouts are affected by the relationship between organic and conventional crop prices between planting and harvest time.

### *Graphical Illustration of the Problem*

To illustrate the potential consequences of RMA's pilot program misalignments under Revenue Protection types of coverage with respect to organic crop markets, we conducted a simple Monte Carlo experiment. Our results hold for both Revenue Protection (RP) and Revenue Protection with Harvest Price Exclusion (RPHPE), but for simplicity we only examine the latter.<sup>6</sup> Using

farm survey yield data for organic corn producers from Iowa we generated 5,000 yield draws. Then, we generated an equal number of price draws from three log-normal distributions with different means (and the same volatility as specified by RMA (2011c)) to represent the following compensation structures to organic farmers:

- (a) RMA's conventional prices (following the pattern for insurance policies for all organic crops until 2010 and for most such crops for 2011),
- (b) Market prices received by organic producers,<sup>7</sup> and
- (c)  $1.788 \times$  RMA's conventional prices (i.e., the new pilot program for 2011).

Given the lack of studies or data for the case of organic corn, we imposed the correlation estimate of  $-0.51$  used by Hart, Hayes, and Babcock (2006) as the target historical correlation between yields and prices for each of the three scenarios. The target correlation was imposed by applying Iman and Conover (1982) methodology. As explained in Hart, Hayes, and Babcock (2006), "The [Iman and Conover] method is fully transparent since the only manipulation to the original marginal probability draws is a resorting of the draws. Thus, the marginal distribution for each data series remains unchanged, but the correlations among the series are adjusted." We then obtained the revenue distribution, as well as the corresponding 75% guarantee,<sup>8</sup> for each of the three scenarios.

To represent the cases of an inflated and deflated guarantee according to whether the true ratio of organic to conventional prices in February is lower or higher compared to the 1.788 ratio, we performed the experiment reflecting market and insurance prices for the years 2009 and 2011. The results are shown in figures 1 and 2, respectively. From those figures it is clear that under RMA's previous price schedule, organic farmers that purchased revenue coverage were always offered a lower guarantee compared to the actual organic market. The figures suggest that the new pilot program is an improvement compared to the previous policy because it is closer to the organic distribution. However, it is also evident that on any particular year organic producers are likely to be offered a guarantee that is too low or too high.



To better illustrate the potential consequences for payouts due to misalignment between RMA's pilot program prices and the prices of the organic corn market, in figures 3 and 4 we used the empirical distributions obtained in the above Monte Carlo experiment to illustrate the cases in which an indemnity would correctly compensate a producer facing a crop loss and in which cases it would incorrectly do so. From figure 3, it can be seen that when the conventional price is relatively low compared to the organic price (i.e., the organic price premium is high), the percentage of organic producers not compensated for their true losses (quadrant I, 1.7%) is relatively high compared to the percentage of producers that will receive an indemnity for their false losses (quadrant II, 1.1%). In contrast, in figure 4 it can be seen that when the conventional price is relatively high compared to the organic price (i.e., the organic price premium is low), the percentage of organic producers compensated for false losses (quadrant II, 1.4%) is larger than the percentage of producers who receive no indemnity for their true losses (quadrant I, 1.2%).

Importantly, over- and under-payments due to RMA's price misalignments will not only affect organic producers represented by quadrants I and II, but they will also impact producers in the lower-left quadrant. This is true because indemnities for the latter would be based on a compensation price that is either too low or too high, thereby increasing the extent of mis-payments. Hence, in the following sections we analyze how different market scenarios will determine the amount of payouts to organic producers.

### **Theoretical Model**

For the purpose of examining the relationship between organic and conventional crop prices from February (just before planting time, which is when producers must decide whether to buy crop insurance or not), until yield is realized (harvest time), we propose a structural model. Our model is an extension of that introduced by Lence and Hayes (2005) but, unlike theirs, our framework is stochastic and incorporates producers' rational expectations in the planting-to-harvest time span that we analyze. As explained by Williams and Wright (p.32, 1991) "[I]n modeling supply, the issue of a time lag between input commitment and output response is

crucial” because, as they indicate, “[a]ll commodity production involves commitment of inputs before the output price is known, so that the formation of price expectations is of major concern to producers.” Producers’ beliefs regarding variables that are random at planting time determine their optimal production decisions and influence the distribution of market outcomes. Therefore, assumptions regarding agents’ beliefs about the distributions of the variables that are random at planting time are needed to solve the model. Here, we assume that producers hold rational expectations. That is, the agents’ subjective beliefs regarding the probability distributions of all of the variables that are random from the standpoint of planting time are the same as the true distributions of such variables.

### *Supply of Organic and Conventional Crops*

To become a certified organic producer, the producer must embark on a 3-year transition period during which he/she cannot obtain certified organic market price premiums. Hence, farmers who choose to switch to organic production will only supply a certified organic crop in the long-run.<sup>9</sup> In contrast, switching from organic to conventional production is straightforward. Given the transition-period investment, however, organic farmers are not likely to switch to conventional production based on a single year’s low organic market premium (Kuminoff and Wossink, 2010). Thus, for our short-run model we take producers’ preferences regarding whether to grow organic or conventional crops as given by planting time.

Crop production involves a time lag from input commitment at planting (time =  $t$ ) until output is realized at harvest (time =  $t + 1$ ). Hence, the supply of grain  $i \in \{\text{organic, conventional}\}$  at harvest time  $t + 1$  ( $S_{t+1}^i$ ) is postulated to consist of

$$(1) \quad S_{t+1}^i = A_t^i y_{t+1}^i,$$

where  $A_t^i$  equals the number of acres planted at time  $t$  and  $y_{t+1}^i$  is the realization of a random yield due to weather, pests, *etc.* Importantly, producers at time  $t$  are assumed to make their

planting decisions so as to maximize expected profits at  $t + 1$  ( $\pi_{t+1}^i$ ), conditional on their information at time  $t$  and subject to any existing constraints.<sup>10</sup> Mathematically:

$$\begin{aligned}
 (2) \quad A_t^{i*} &= \operatorname{argmax}_{A_t^i} E_t(\pi_{t+1}^i) \\
 &= \operatorname{argmax}_{A_t^i} E_t[P_{t+1}^i S_{t+1}^i - v^i(A_t^i)] \\
 &= \operatorname{argmax}_{A_t^i} [E_t(P_{t+1}^i y_{t+1}^i) A_t^i - v^i(A_t^i)] \\
 &= \operatorname{argmax}_{A_t^i} [R_t^i A_t^i - v^i(A_t^i)] \\
 (2') \quad &= a^i(R_t^i),
 \end{aligned}$$

where  $\operatorname{argmax}_{A_t^i}$  is the set of values for  $A_t^i$  that maximizes the specified function,  $E_t(\cdot)$  is the expectation operator conditional on information at time  $t$ ,  $v^i(\cdot)$  denotes crop  $i$ 's cost function, and  $R_t^i \equiv E_t(P_{t+1}^i y_{t+1}^i)$  is the producers' incentive revenue.<sup>11</sup> The producers' incentive revenue is generally different from the product of expected price times expected yield (i.e.,  $R_t^i \neq E_t(P_{t+1}^i)E_t(y_{t+1}^i)$ ) because producers recognize that yield disturbances are correlated with the market price (Lence and Hayes 2000; Wright 1979). Under standard regularity conditions for the cost function, optimal acreage increases at an increasing rate with the producers' incentive revenue ( $\partial a^i(\cdot)/\partial R_t^i > 0$ ,  $\partial a^i(\cdot)^2/\partial^2 R_t^i > 0$ ).

### *Demand for Organic and Conventional Crops*

Following Lence and Hayes (2005), aggregate demands for organic and conventional crops is an aggregation of individual demands from type- $\delta$  ( $0 \leq \delta \leq 1$ ) consumers, who will substitute conventional crops for organic crops if the price paid for the former is less than or equal to a fraction  $\delta$  of the price of the latter. In this way, parameter  $\delta$  describes preferences that consumers have for the two kinds of crops. At the two extremes, consumers who are indifferent between consuming conventional or organic crops have  $\delta = 1$ ; whereas consumers who cannot be induced into consuming conventional crops regardless of the discount have  $\delta = 0$ .

At time  $t + 1$ , demand schedules for organic and conventional crops by consumers of type  $\delta$  are represented by expressions (3) and (4), respectively,

$$(3) \quad D_{\delta,t+1}^O = \begin{cases} d_{\delta}(P_{t+1}^O) \xi_{t+1}^O & \text{if } P_{t+1}^C > \delta P_{t+1}^O, \\ d_{\delta}(P_{t+1}^O) \xi_{t+1}^O - D_{\delta,t+1}^C & \text{if } P_{t+1}^C = \delta P_{t+1}^O, \\ 0 & \text{if } P_{t+1}^C < \delta P_{t+1}^O, \end{cases}$$

$$(4) \quad D_{\delta,t+1}^C = \begin{cases} d_{\delta}(\delta^{-1}P_{t+1}^C) \xi_{t+1}^C & \text{if } P_{t+1}^C < \delta P_{t+1}^O, \\ d_{\delta}(\delta^{-1}P_{t+1}^C) \xi_{t+1}^C - D_{\delta,t+1}^O & \text{if } P_{t+1}^C = \delta P_{t+1}^O, \\ 0 & \text{if } P_{t+1}^C > \delta P_{t+1}^O, \end{cases}$$

where  $d_{\delta}(\cdot)$  is a well-behaved demand function (i.e.,  $\partial d_{\delta}(P)/\partial P < 0$ ), and  $\xi_{t+1}^i > 0$  is a multiplicative demand shock for crop  $i \in \{\text{organic, conventional}\}$ . Shocks greater than one increase demand, whereas shocks less than one reduce demand. Since demand shocks are modeled as a multiplicative factor, they are restricted to be positive.<sup>12</sup> Aggregate demand for organic (conventional) crops  $D_{t+1}^O = \sum_{\delta} D_{\delta,t+1}^O$  ( $D_{t+1}^C = \sum_{\delta} D_{\delta,t+1}^C$ ) is obtained by adding the demands for organic (conventional) crops across all consumer types  $\delta \in [0, 1]$ . This specification implies that demand schedules for each type of crop are interrelated, with the price of the conventional crop affecting the demand for the organic crop and *vice versa* (although to a different degree). Succinctly, economic fundamentals suggest a relationship between organic and conventional prices that cannot be characterized by a fixed price ratio, as RMA's pilot program does.

#### *Market Equilibrium Under Rational Expectations*

Equations (1), (3), and (4) imply that market-clearing prices for conventional and organic crops at harvest time ( $\underline{P}_{t+1}^i$  for  $i \in \{\text{organic, conventional}\}$ , where the underline indicates market-clearing) must satisfy conditions (5) and (6):

$$(5) \quad S_{t+1}^O = [D_{\underline{\delta}_{t+1}}^O + \sum_{\delta < \underline{\delta}_{t+1}} d_{\delta}(P_{t+1}^O)] \xi_{t+1}^O,$$

$$(6) \quad S_{t+1}^C = [D_{\underline{\delta}_{t+1}}^C + \sum_{\delta < \underline{\delta}_{t+1}} d_{\delta}(\delta^{-1} P_{t+1}^C)] \xi_{t+1}^C,$$

where  $\underline{\delta}_{t+1} \equiv P_{t+1}^C / P_{t+1}^O$  is the market-clearing consumer discount for the conventional crop at harvest time. Thus, organic and conventional markets will clear at harvest time if consumers with a preference factor strictly smaller (greater) than  $\underline{\delta}_{t+1}$  will only consume the organic (conventional) crop; consumers of type  $\underline{\delta}_{t+1}$  will be indifferent between consuming either, so they will consume the amounts that balance the corresponding supplies.

Given (1), conditions (5) and (6) imply that market-clearing prices depend on the acreage and yields of both types of crops. That is,

$$(7) \quad \underline{P}_{t+1}^i = \underline{p}^i(A_t^O y_{t+1}^O, A_t^C y_{t+1}^C, \xi_{t+1}^O, \xi_{t+1}^C)$$

for  $i \in \{\text{organic, conventional}\}$ , where  $\underline{p}^i(\cdot)$  is a function. For the market-clearing equilibrium to be consistent with rational expectations, however, crop acreages cannot be arbitrary; instead, they must satisfy the condition

$$(8) \quad \hat{A}_t^{i*} = a^i \{E_t[\underline{p}^i(\hat{A}_t^{O*} y_{t+1}^O, \hat{A}_t^{C*} y_{t+1}^C, \xi_{t+1}^O, \xi_{t+1}^C) y_{t+1}^i]\}$$

for  $i \in \{\text{organic, conventional}\}$ . In words, optimal acreage (2') under a rational-expectation equilibrium ( $\hat{A}_t^{i*}$ ) but must be determined by the objective probability distribution of market-clearing prices conditional on the information available at planting time.

## Application to the U.S. Corn Market

In this section the theoretical model is illustrated with a simulation of the U.S corn market between planting and harvest time. We employed a procedure that resembles the structure for crop insurance in the U.S.; that is, yields are estimated at the producer level and pricing is unique (at the national level).

### Yield Calibration

As in many previous applied studies (see Babcock and Blackmer 1992; Borges and Thurman 1994; Babcock and Hennessy 1996; and Coble *et al.* 1996), yields are assumed to follow a Beta density function:

$$(9) \quad f(y) = \frac{\Gamma(\alpha + \beta)}{\Gamma(\alpha)\Gamma(\beta)} \frac{(y - y_{\min})^{\alpha-1} (y_{\max} - y)^{\beta-1}}{(y_{\max} - y_{\min})^{\alpha+\beta-1}},$$

for  $y_{\min} \leq y \leq y_{\max}$ , where  $\alpha$  and  $\beta$  are shape parameters, and  $y_{\min}$  and  $y_{\max}$  are the minimum and maximum possible yields, respectively. Define  $\mu$  as the mean yield and  $\sigma$  as the standard deviation of yields. Following Johnson and Kotz (1970), the shape parameters can be obtained from the following equations:

$$(10) \quad \alpha = \left( \frac{\mu - y_{\min}}{y_{\max} - y_{\min}} \right)^2 \left( 1 - \frac{\mu - y_{\min}}{y_{\max} - y_{\min}} \right) \left( \frac{\sigma^2}{(y_{\max} - y_{\min})^2} \right)^{-1} - \frac{\mu - y_{\min}}{y_{\max} - y_{\min}},$$

$$(11) \quad \beta = \frac{\mu - y_{\min}}{y_{\max} - y_{\min}} \left( 1 - \frac{\mu - y_{\min}}{y_{\max} - y_{\min}} \right) \left( \frac{\sigma^2}{(y_{\max} - y_{\min})^2} \right)^{-1} - 1 - \alpha,$$

where  $y_{\min} = \max(\mu - 4\sigma, 0)$  and  $y_{\max} = \mu + 1.5\sigma$ , respectively.

To estimate the above Beta distribution for conventional corn, we first calculated detrended conventional corn yields from 1980 to 2010 in Adair County, Iowa.<sup>13</sup> Thus, the data reflect current

technology but historical weather variability (i.e., weather draws). The 2011 trend yield was computed and used as the mean of the Beta yield distribution. As in Hart, Hayes, and Babcock (2006), we searched for the standard deviation value that generated RMA's Actual Production History (APH) premium rate<sup>14</sup> at the 65% coverage level for that county. In this manner, we calibrated our yield distribution to match RMA's rating for yield insurance. This procedure assumes RMA's yield rating is correct, allowing us to focus on the price setting for the insurance.

The Beta yield distribution for organic corn was obtained in a similar fashion; we used the same standard deviation as for conventional corn, but imposed a penalty yield of 30% on the mean. This is consistent with the findings of Singerman, Hart, and Lence (2010), Porter (2003), and Delate and Cambardella (2004).<sup>15</sup>

The final step in the calibration of the joint yield distribution consisted of using the Iman and Conover procedure to impose the observed correlation of 0.70 between organic and conventional corn yields (Delate 2009). The resulting joint distribution of conventional and organic yields can be interpreted as that of representative producers in Adair County.

Even though producer yields covary with national yields, the price-yield relationship is more realistically established at the national level. Hence, in our model national yields are given by:

$$(12) \quad y_{US} = \gamma y_f + (1 - \gamma) \bar{y},$$

where  $y_{US}$ ,  $y_f$ , and  $\bar{y}$  denote the national, producers', and unconditional yield levels, respectively; and  $\gamma \in [0, 1]$  defines the weight of the two components. Equation (12) can be re-written as  $y_f = \bar{y} + 1/\gamma(y_{US} - \bar{y})$ , which is identical to Miranda's (1991) equation relating disaggregated (farm-level) yields with the aggregated (county-level) yields, except in that the residual term is assumed away. We estimated the value of  $\gamma$  by resorting to the variance of expression (12), as follows. First, we computed the variance of national yields based on detrended yields from 1980 to 2010. Second, we estimated the coefficient of variation in Adair County, Iowa (equal to 0.25) using the procedure in Harwood *et al.* (1999). Finally, we derived the variance for Adair County,

and obtained  $\gamma = 0.37$ . To obtain a national yield distribution for organic corn, we used an analogous procedure as just described for its conventional counterpart.

### *Acreage Calibration*

The function defining optimal acreage in (2') is assumed to be isoelastic, taking the form  $a^i(R_t^i) = \kappa_A^i (R_t^i)^{\varepsilon_S^i}$ , where  $\varepsilon_S^i$  is the constant supply elasticity for crop  $i$  and  $\kappa_A^i$  represents an acreage scaling parameter consistent with observed acreage shares.

### *Demand Calibration*

To calibrate the demand model, the parameters used are either measures based on previous studies or estimates calculated from the data we had available. As in Lence and Hayes (2005), the demand function  $d_\delta(\cdot)$  in equations (3) and (4) is modeled with the following isoelastic form

$$(13) \quad d_\delta(P) = \kappa_\delta P^{-\varepsilon_\delta},$$

where  $\kappa_\delta$  is a scaling parameter and  $\varepsilon_\delta$  is the constant demand elasticity of type- $\delta$  consumers. Demand calibration consists of specifying values for these two parameters so as to make them consistent with available market information for some baseline period. These calibrations define high, medium, and low price ratio scenarios used in the analysis. These scenarios are based on the range of organic-to-conventional price ratios over the period 2004-2009 as documented by Singerman, Lence, and Kimble-Evans (2010).

For given elasticity values, it is possible to recover  $\kappa_\delta$  from the market shares ( $m_\delta$ ) of different types of consumers. Let  $m_\delta \equiv D_\delta/D$ , where  $D_\delta$  denotes the grain consumed by type- $\delta$  consumers, and  $D \equiv \sum_\delta D_\delta$  is aggregate consumption of organic and conventional crops during the period used for calibration. Combining the definition of market shares with (13) and solving for  $\kappa_\delta$ , we obtain:



$$(14) \quad \kappa_{\delta} = m_{\delta} \times D \times P_{\delta}^{\varepsilon_{\delta}},$$

where  $P_{\delta}$  is the crop price paid by type- $\delta$  consumers in the calibration period, defined as  $P_{\delta} = P^O$  if  $P^C \geq \delta P^O$ , and  $P_{\delta} = \delta^{-1} P^C$  otherwise.

Given the lack of data on the own-price elasticity of demand for organic corn,  $\varepsilon_{\delta}$  was assumed to be the same across all consumer types and was computed from the 2010 FAPRI estimates (McPhail 2010). We obtained values for prices and consumption of corn based on the April 2011 World Agricultural Supply and Demand Estimates (WASDE) for the 2010/11 marketing year; we also used their disaggregated demand estimates to infer consumer preferences so as to obtain values for  $m_{\delta}$ . Adding the corresponding market share for organic consumption, we categorize corn consumers in the following broad groups:  $m_{\delta=0.1} = 0.0025$ ,  $m_{\delta=0.9} = 0.6475$ , and  $m_{\delta=1} = 0.35$ . The group of consumers with  $\delta = 0.1$  is strongly opposed to consuming conventional food, perhaps for philosophical or food safety reasons. The group with  $\delta = 0.9$  represents local and foreign firms that use corn for feeding conventional livestock or to process non-organic food; hence, they might have a slight preference for organic corn. The group with  $\delta = 1$  denotes ethanol firms that have no strict preference for organic corn.

If we used only the available data on market shares and deltas, we would miss the slight differences in preferences that are likely to exist within the broad groups of consumers. To get around this shortcoming we follow Lence and Hayes (2005) by adopting a continuous distribution instead; specifically, a Beta distribution for  $\delta$  ( $\delta \mid \alpha = 1.63, \beta = 0.028, \delta_{\min} = 0, \delta_{\max} = 1$ ) that was fitted by maximum likelihood to the calibrated discrete cumulative distribution function. This continuous distribution avoids the coarseness of the aggregate industry data by providing an approximation to the preference differences within groups. Then, using computer routines developed by Miranda and Fackler (2011), we computed Gaussian quadrature nodes and weights to approximate the distribution of  $\kappa_{\delta}$ .

Exogenous shocks to consumer demands are assumed to be identically and independently log-normally distributed,  $\xi_{t+1}^i \stackrel{iid}{\sim} LN(\mu_\xi, \sigma_\xi^2)$  for  $i \in \{\text{organic, conventional}\}$ . The mean of the demand shocks was fixed at  $E_t(\xi_{t+1}^i) = 1$ , and their variance was calibrated so as to obtain the desired level of correlation between prices and yields. As stated earlier, we employed a price-yield correlation of -0.51. Later in the study, we examine implications of varying the price-yield correlation.

### *Numerical Methods*

The proposed rational expectations model was solved by a combination of the Newton's method to determine the optimal number of acres that made the model internally consistent, the bisection method to determine consumers' substitution between organic and conventional corn, and an optimization routine to ensure that markets cleared. The iteration steps involved can be summarized as follows:

- Step 1. Set up the parameters of the model, obtain the time  $t + 1$  exogenous random producer yields  $\{y_{f,\omega}^O, y_{f,\omega}^C\}$  and national yields  $\{y_{US,\omega}^O, y_{US,\omega}^C\}$  from the specified Beta distributions for yields, and for each state of the world at time  $t + 1$  ( $\omega$ ) compute the corresponding Gaussian quadrature nodes and probability weights for the demand shocks  $\{\xi_\omega^O, \xi_\omega^C\}$ .
- Step 2. Define  $j$  as the iteration number, set  $j = 0$ , and specify initial guesses for the optimal acreages under rational expectations equilibrium  $\{\hat{A}^{O*(0)}, \hat{A}^{C*(0)}\}$  and the market-clearing consumer discount for the conventional crop at each state of the world  $\omega$   $\{\underline{\delta}_\omega^{(0)}\}$ .
- Step 3. Given  $\{\hat{A}^{O*(j)}, \hat{A}^{C*(j)}\}$ , compute aggregate supplies of organic and conventional crops at each state of the world  $\omega$   $\{S_\omega^{O(j+1)}, S_\omega^{C(j+1)}\} = \{\hat{A}^{O*(j)} y_{US,\omega}^O, \hat{A}^{C*(j)} y_{US,\omega}^C\}$ .
- Step 4. Given  $\{S_\omega^{O(j+1)}, S_\omega^{C(j+1)}\}$ ,  $\{\underline{\delta}_\omega^{(j)}\}$ , and the demand shocks  $\{\xi_\omega^O, \xi_\omega^C\}$ , compute the market-clearing prices at each state of the world  $\omega$   $\{\underline{P}_\omega^{O(j+1)}, \underline{P}_\omega^{C(j+1)}\}$ .

- Step 5. Given  $\{ \underline{P}_\omega^{O(j+1)}, \underline{P}_\omega^{C(j+1)} \}$ , calculate the market-clearing consumer discount for the conventional crop at each state of the world  $\omega$   $\{ \underline{\delta}_\omega^{(j+1)} = \underline{P}_\omega^{C(j+1)} / \underline{P}_\omega^{O(j+1)} \}$ .
- Step 6. If  $|\underline{\delta}_\omega^{(j+1)} - \underline{\delta}_\omega^{(j)}|$  is smaller than the desired tolerance, go to step 7. Otherwise, compute the *bisection* innovation for  $\underline{\delta}_\omega^{(j+1)}$ , set it as  $\underline{\delta}_\omega^{(j)}$ , and go back to step 4.
- Step 7. Given  $\{ \underline{P}_\omega^{O(j+1)}, \underline{P}_\omega^{C(j+1)} \}$  and the random yields, compute the producers' incentive revenues  $\{ R^{O(j+1)}, R^{C(j+1)} \}$ .
- Step 8. Given  $\{ R^{O(j+1)}, R^{C(j+1)} \}$ , calculate the optimal acreage values under rational expectations equilibrium  $\{ \hat{A}^{O*(j+1)}, \hat{A}^{C*(j+1)} \}$ .
- Step 9. If  $|\hat{A}^{O*(j+1)} - \hat{A}^{O*(j)}|$  and  $|\hat{A}^{C*(j+1)} - \hat{A}^{C*(j)}|$  are larger than the desired tolerance, compute the *Newton* innovations for  $\{ \hat{A}^{O*(j+1)}, \hat{A}^{C*(j+1)} \}$ , set those as  $\{ \hat{A}^{O*(j)}, \hat{A}^{C*(j)} \}$ , and go back to Step 3. Otherwise, stop and set the solution for acreage and prices equal to the values obtained in the  $(j + 1)^{\text{th}}$  iteration.

## Results and Discussion

The results of the structural model for twelve different scenarios are summarized in tables 1 and 2. The scenarios are divided into sets of three to reflect market conditions with low, medium, and high organic-to-conventional price ratios (represented by price ratios of 1.30, 2.27, and 3.17, respectively). The structural model hinges on some of the parameters, particularly the correlation imposed between organic and conventional corn yields, and the correlation imposed between yields and prices for each crop. Hence, four sets of scenarios explore how the results are influenced by changes in those key parameters.

For the first three scenarios in tables 1 and 2, the correlation between organic and conventional corn yields is set at 0.70 as discussed in the “Yield Calibration” subsection, whereas the yield-price correlation is set at  $-0.51$ , based on Hart, Hayes, and Babcock (2006). The results for scenario 1 show that when the price ratio is low, the average indemnity that organic producers would receive under RPHPE coverage with the pilot program (denoted by the “RMA” column) is \$342/acre, which is substantially higher than the \$195/acre they should

receive if they were insured considering instead their idiosyncratic distribution (denoted by the “Org.” column). When the indemnities are multiplied by their probabilities, the expected loss per acre for RMA is \$78 under the pilot program, versus \$44 under the organic distribution.

To better understand these results, revenue distributions corresponding to each of the first three scenarios are depicted in figures 5 through 7, respectively. In those figures, the black line in the top graph indicates the revenue level based on 75% coverage from the distribution of organic revenues. The blue line indicates the revenue level based on 75% coverage from RMA’s revenue formulation, and the blue line in the top graph is the imposition of the revenue guarantee from RMA’s formulation on the actual organic revenue distribution. The results in table 1 compare insurance performance between the black line in the top graphs of the figures (i.e., 75% coverage based on the actual organic revenue distribution), and the blue line in the bottom graphs of the figures (i.e., 75% coverage based on RMA’s formulation for organic revenues). The average indemnity is the average payout needed to bring all of the revenues below the insurance guarantee (in the figures, these are the revenues to the left of the line) up to the level of the guarantee. The expected loss is the average indemnity weighted by the probability of a loss (the probability of being to the left of the line).

Scenario 2 shows that when the price ratio is at a medium level (i.e., somewhat higher than the RMA factor), organic producers still get over-compensated under RMA’s pilot program. Scenario 3 shows that when the price ratio is at a high level, under RMA’s pilot program organic producers get an average indemnity of \$227/acre, which is lower than the \$260/acre that they should receive, and the expected loss by RMA is \$61/acre in both instances.

An alternative measure of RMA’s mis-pricing across scenarios is the loss-cost ratio, defined as the ratio of indemnities to coverage (or liability). Table 1 shows that for scenarios 1 through 3, not only do the loss-cost ratios under the pilot program increase with the price ratio, but also they are all greater than the loss-cost ratios obtained under the organic distribution. The loss-cost ratios reported in table 1 are represented graphically in the figures as the ratio of the expected loss, defined above, and the revenue guarantee.

In summary, from figures 5 through 7 it becomes clear that the above results are driven by the dissimilar shapes of the organic and RMA revenue distributions. The explanation behind the contrasting shapes is given by the different behavior of the yield-price relationship for organic and conventional crops.

The set of scenarios 4-6 and 7-9 show how the results change when the correlation between organic and conventional corn yields is assumed to equal 0.4 and 0.9, respectively. There are two main findings from this sensitivity analysis. First, the lower (higher) the correlation, the higher (lower) the value for the average indemnity, expected loss and cost-loss ratio with respect to scenarios 1-3. This result intuitively makes sense. Given a lower correlation between organic and conventional yields, the likelihood increases for a low organic yield-low price combination, which would raise the average indemnity, expected loss and cost-loss ratio. Second, the difference between the loss-cost ratios under the organic distribution versus that of RMA increases with the yield correlation. Scenarios 10-12 show how imposing a yield-price correlation of  $-0.63$  affects the results. In this instance, the value for the expected loss and the cost-loss ratio both decrease with respect to scenarios 1 through 3, and the difference between the loss-cost ratios under the organic distribution versus that of RMA also decreases with respect to scenarios 1-3.

Overall, the results from table 1 suggest RMA's pilot program is likely to induce adverse selection, as expected payouts from crop insurance exceed (fall below) expected revenue losses from organic production when the ratio of organic to conventional market prices at planting time is low (high).

From the top panels in figures 5 through 7 it can also be seen that the 75% nominal coverage implies a different coverage level in terms of the organic distribution. To estimate the effective coverage (denoted by the blue lines in figures 5-7) we combined the organic revenue distribution with RMA's insurance guarantee. The results in table 2 compare insurance performance between the blue lines in the top and bottom panel figures 5 through 7. Thus, table 2 shows the expected loss, loss-cost ratio, and effective coverage using RMA's guarantee. The

reported values provide evidence of the extent to which nominal and effective coverage differ. From the effective coverage column it can be seen that when the price ratio is low (high), a 75% nominal coverage level translates into an effective coverage of 106% (45%) under the organic revenue distribution. In the low price ratio scenario, the effective coverage level exceeds 100% as the revenue guarantee in the insurance coverage is greater than the mean for organic revenues. Based on the sensitivity analyses with the organic and conventional corn yield correlation and the price-yield correlation, the level of effective coverage appears to be insensitive to changes in either variable. These results also make intuitive sense, as the effective coverage level is related to the mean revenue values. The change in correlation has little impact on those mean values.

Overall, the results from table 2 suggest RMA's pilot program is likely to induce adverse selection, because the nominal coverage level is likely to substantially understate (overstate) the effective coverage when the ratio of organic to conventional market prices at planting time is low (high).

## **Conclusions**

The incorporation of organic production into the Federal crop insurance rating structure has been limited. In the case of crop failure, price premiums that organic producers are able to obtain in the market are not compensated for under current policy. In an attempt to overcome this deficiency, in 2011 RMA introduced a pilot program for certified organic corn and soybeans by which price determination for insurance purposes for these crops is still pegged to that of their conventional counterparts, but by a fixed factor of 1.788 for corn and 1.794 for soybeans, respectively.

Given evidence of a changing multiplicative relationship between organic and conventional crop prices, RMA's pilot program is likely to cause the insurance guarantee for organic crops to be either inflated or deflated depending on whether the level of the market price ratio is below or above the fixed price factor offered by RMA for insurance purposes. Therefore, we analyze what the consequences of price misalignment derived from the pilot program are

under RPHPE coverage. To this end, we develop a stochastic structural model between planting and harvesting applied to the U.S. corn market to evaluate the organic insurance program for a producer in a representative Iowa county. Using the proposed model, we find that for the 75% nominal coverage level, when the price ratio is low (high) the mis-pricing induces an effective coverage of 106% (45%). This results in higher (lower) indemnities compared to the indemnities organic producers should get when considering their idiosyncratic revenue distribution. It should be evident that organic producers will then benefit from this policy if the ratio of organic to conventional crop prices determined in the market is low compared to that established by RMA. However, the impact that this policy will have on organic producers over time will depend on how often the price ratio will be above or below RMA's factor.

Thus, even though the new pilot program represents an improvement over the policy by which (in case of a crop failure) organic producers obtain an indemnity based on  $1 \times$  conventional prices, linking organic crop prices to their conventional counterparts creates mis-pricing in their insurance coverage. Given the relevance contracting has in the organic agricultural sector, using organic contract prices not only would be a simpler, more appropriate, and less controversial alternative to setting insurance prices for organic products, but it would also yield RMA prices better aligned with the organic market.

## Notes

1. The certified organic crops are cotton, corn, soybeans, and processing tomatoes.
2. The RMA contractor originally recommended that the price determination for organic corn (soybeans) for insurance purposes be the price of its conventional counterpart multiplied by 1.52 (1.68), the minimum ratio observed from January 2007 through February 2010 (Watts and Associates 2010). RMA has now moved to setting the price ratios based on data from the most recent three years (RMA 2011b).
3. Under Yield Protection, producers are compensated when crop yields fall below a chosen yield guarantee, based on an expected yield computed as an average of historical yields (known in crop insurance as the producer's Actual Production History [APH] yield). Under Revenue Protection, producers have two insurance options that provide payments when crop revenues fall below a chosen revenue guarantee. Under what is labeled Revenue Protection with Harvest Price Exclusion (RPHPE), the revenue guarantee is based on the producer's APH yield and the market price prior to planting (for corn and soybeans, this price is set in February). Under what is labeled Revenue Protection (RP), the revenue guarantee is based on the maximum of the market price prior to planting or the market price at harvest. All other aspects of RP insurance match the set-up for RPHPE insurance.
4. Organic crop prices were retrieved from USDA Market News report NW\_GR113 for February 23, 2011, whereas prices for conventional crops were obtained from the *Wall Street Journal* of the same date.
5. In crop insurance, price discovery denotes the period of time over which prices are observed and used for determining insurable values for crops. Such a meaning is clearly different in the price analysis literature, where price discovery represents "the process of buyers and sellers arriving at prices for a commodity when market conditions do not permit either group to set prices" (Rhodes, Dauve, and Parcell 2007, p. 357).



6. See footnote 3 for a description of RPHPE and RP.
7. Due to the lack of futures markets for organic crops, we used the ratio of organic to conventional prices in February as a proxy for the ratio of prices at harvest time, based on which we computed the organic price.
8. We computed the mean of the distribution and then used 75% of that value as a proxy for the corresponding level of coverage.
9. RMA applies conventional prices to transitioning acreage (RMA 2011). Therefore, our model is consistent with RMA's insurance policies.
10. This implies that decision makers are risk neutral. It is straightforward to generalize the model to allow for risk aversion, but the gains from doing so in the present application are minimal because we are not modeling a portfolio choice (recall that we take producers' preferences regarding whether to grow organic or conventional crops as given by planting time). Assuming risk aversion simply leads to a smaller calibrated value of the acreage scaling parameter  $\kappa_A^j$  discussed later in the "Supply Calibration" subsection, leaving acreage supply essentially unchanged.
11. In this case, the incentive revenue is equal to the expected revenue for the crop on a per-acre basis.
12. Otherwise, the quantity demanded would be less than zero whenever a negative shock occurred.
13. We selected Adair County because we have data available for organic and conventional crops grown side-by-side from Iowa State University experimental station plots, which allowed us to estimate the correlation between yields for the two types of crops.
14. Given the name changes in crop insurance for the 2011 crop year, this is now known as the Yield Protection (YP) premium rate.

15. A recent study by Delate (2010) found the yield difference between organic and conventional corn to be insignificant. However, Singerman, Hart and Lence (2010) concluded that the reason why some studies have reported equivalent organic and conventional yields could be the fact that their data were obtained from small experimental plots, which can be more easily managed than entire farms.
16. This implies that the underlying cost function is  $v^i(A_t^i) = (\kappa_t^i)^{-1/\epsilon_s^i} (A_t^i)^{1/\epsilon_s^i + 1}$ . This is true because the first-order condition for the maximization of  $[R_t^i A_t^i - v^i(A_t^i)]$  in (2) is  $R_t^i - (\kappa_t^i)^{-1/\epsilon_s^i} (A_t^{i*})^{1/\epsilon_s^i} = 0$ , which can be solved for  $A_t^{i*}$  to obtain the postulated optimal acreage function.

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**Table 1. Effect of organic-to-conventional price ratios on insurance performance for organic corn producers under RPHPE at the 75% coverage level**

Scenario	Correlation		Expected Price (\$/bu)		Org.-Conv. Price Ratio	Average Indemnity (\$/acre)		Expected Loss (\$/acre)		Loss-Cost (%)	
	Org.-Conv.	Yield-Price	Org.	Conv.		Org.	RMA	Org.	RMA	Org.	RMA
1	0.70	-0.51	7.59	5.85	1.30	195	342	44	78	6.60	8.23
2	0.70	-0.51	9.94	4.38	2.27	258	304	59	78	6.66	10.46
3	0.70	-0.51	10.23	3.23	3.17	260	227	61	61	6.67	11.00
4	0.40	-0.51	7.59	5.85	1.30	218	379	54	101	7.74	10.29
5	0.40	-0.51	9.94	4.38	2.27	285	332	71	102	7.83	13.08
6	0.40	-0.51	10.23	3.23	3.17	296	250	73	80	7.82	13.74
7	0.90	-0.51	7.59	5.85	1.30	177	322	32	53	4.81	5.66
8	0.90	-0.51	9.94	4.38	2.27	231	279	43	54	4.85	7.36
9	0.90	-0.51	10.23	3.23	3.17	234	213	44	42	4.82	7.80
10	0.70	-0.63	7.59	5.85	1.30	196	269	39	62	5.97	6.79
11	0.70	-0.63	9.94	4.38	2.27	249	222	52	54	6.02	7.80
12	0.70	-0.63	10.23	3.23	3.17	255	167	53	41	6.00	8.06

Notes: "Average Indemnity" is the average insurance payment given a loss, "Expected Loss" (= "Average Indemnity" × "Probability of a Loss") is the average insurance payment over all cases, and "Loss-Cost" is the ratio of indemnities to coverage (or liability).

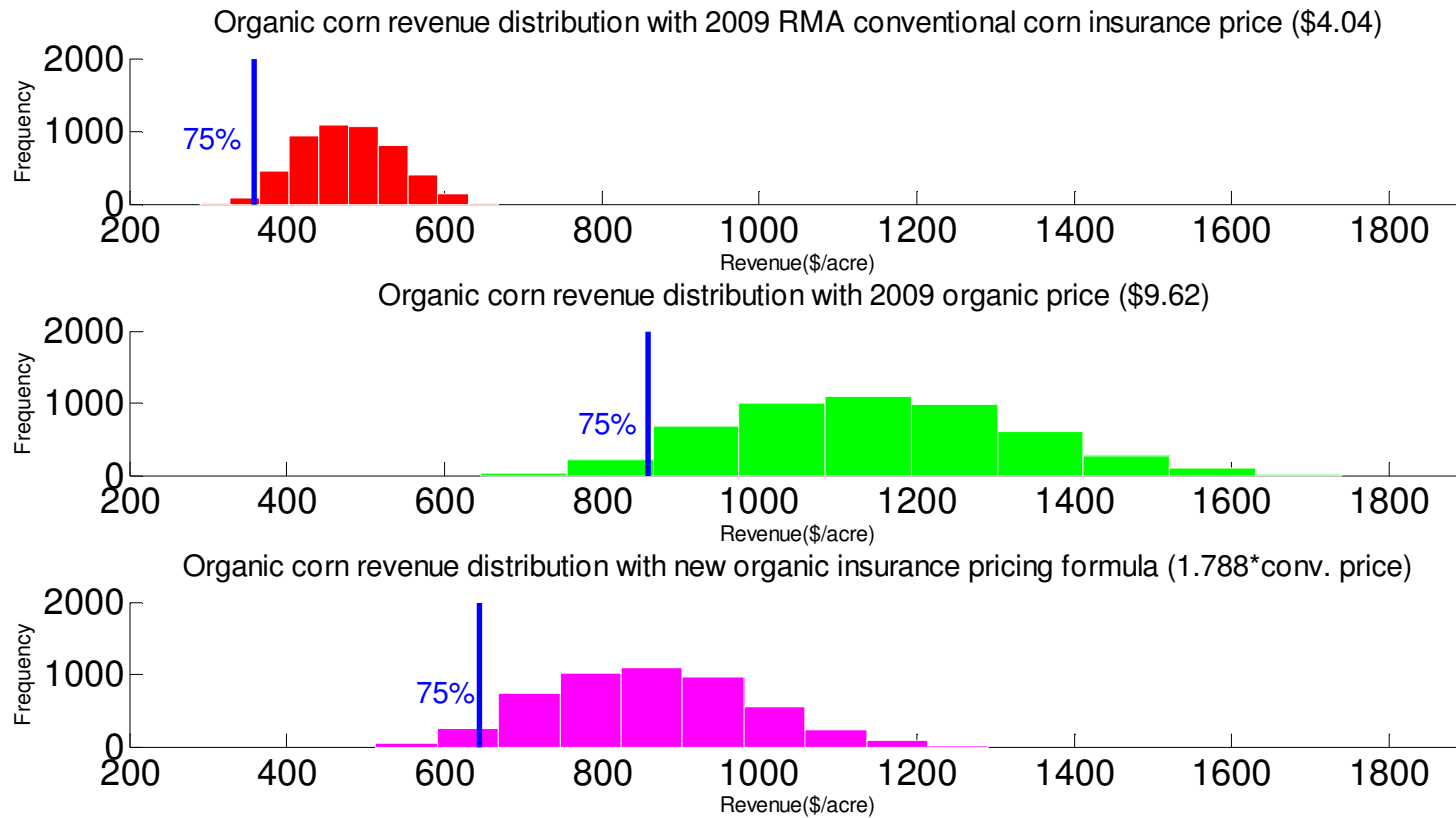
**Table 2. Effect of organic-to-conventional price ratios on insurance performance for organic corn producers under RPHPE at the effective coverage level**

Scenario	Correlation		Expected Price (\$/bu)		Org.-Conv. Price Ratio	Comparative Expected Loss (\$/acre)	Comparative Loss-Cost (%)	Comparative Effective Coverage (%)
	Org.-Conv.	Yield-Price	Org.	Conv.				
1	0.70	-0.51	7.59	5.85	1.30	151	15.93	106
2	0.70	-0.51	9.94	4.38	2.27	33	4.55	63
3	0.70	-0.51	10.23	3.23	3.17	15	2.69	45
4	0.40	-0.51	7.59	5.85	1.30	177	18.09	106
5	0.40	-0.51	9.94	4.38	2.27	45	5.89	64
6	0.40	-0.51	10.23	3.23	3.17	22	3.71	46
7	0.90	-0.51	7.59	5.85	1.30	129	13.81	105
8	0.90	-0.51	9.94	4.38	2.27	26	3.61	62
9	0.90	-0.51	10.23	3.23	3.17	14	2.62	44
10	0.70	-0.63	7.59	5.85	1.30	120	13.26	104
11	0.70	-0.63	9.94	4.38	2.27	26	3.72	60
12	0.70	-0.63	10.23	3.23	3.17	13	2.48	43

Notes: "Comparative Expected Loss" is the Expected Loss under the RMA guarantee, given the organic corn revenue distribution.

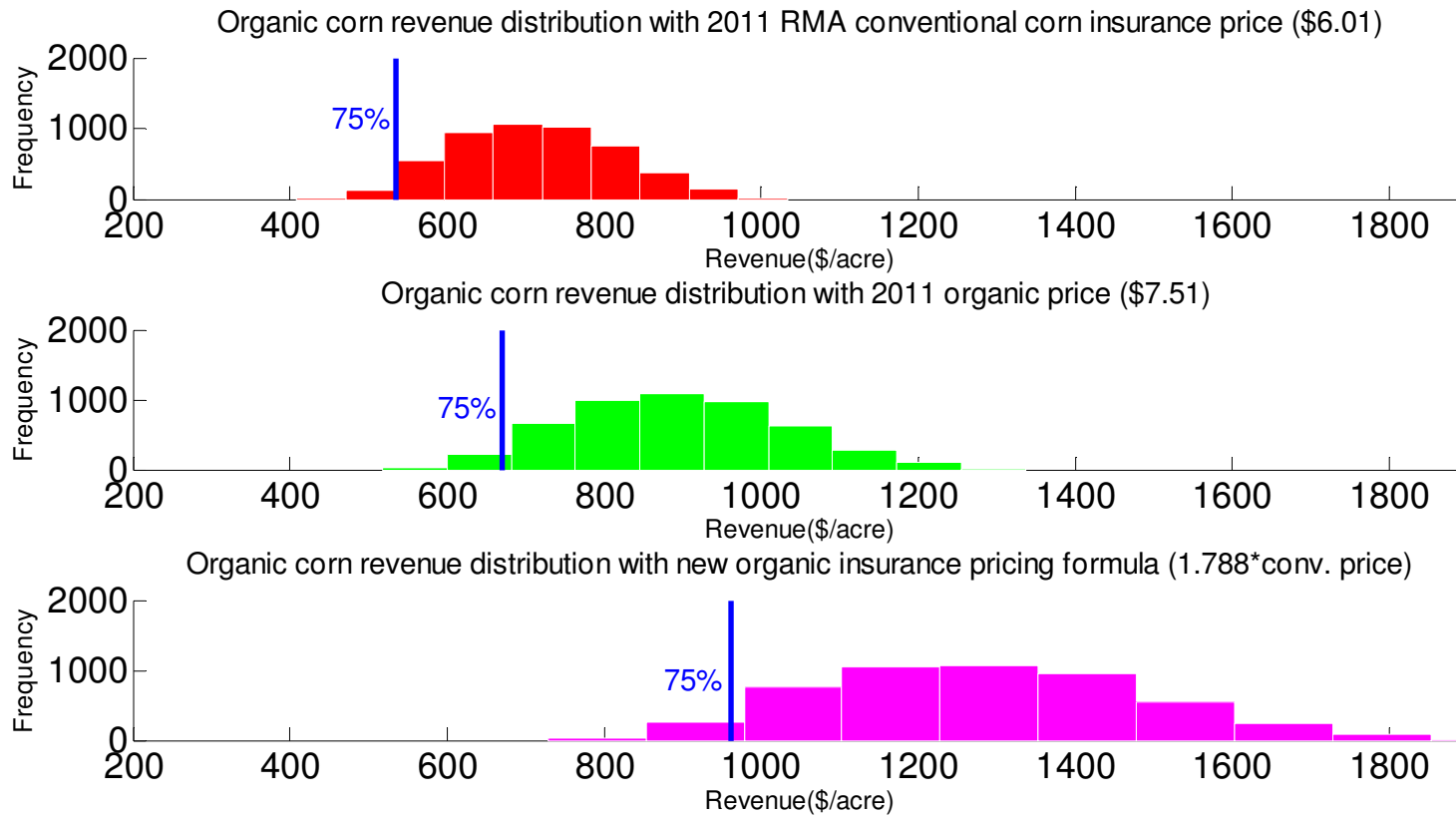
"Comparative Loss-Cost" is the Loss-Cost under the RMA guarantee, given the organic corn revenue distribution. "Comparative Effective Coverage" is the coverage level under the RMA guarantee, given the organic corn revenue distribution.





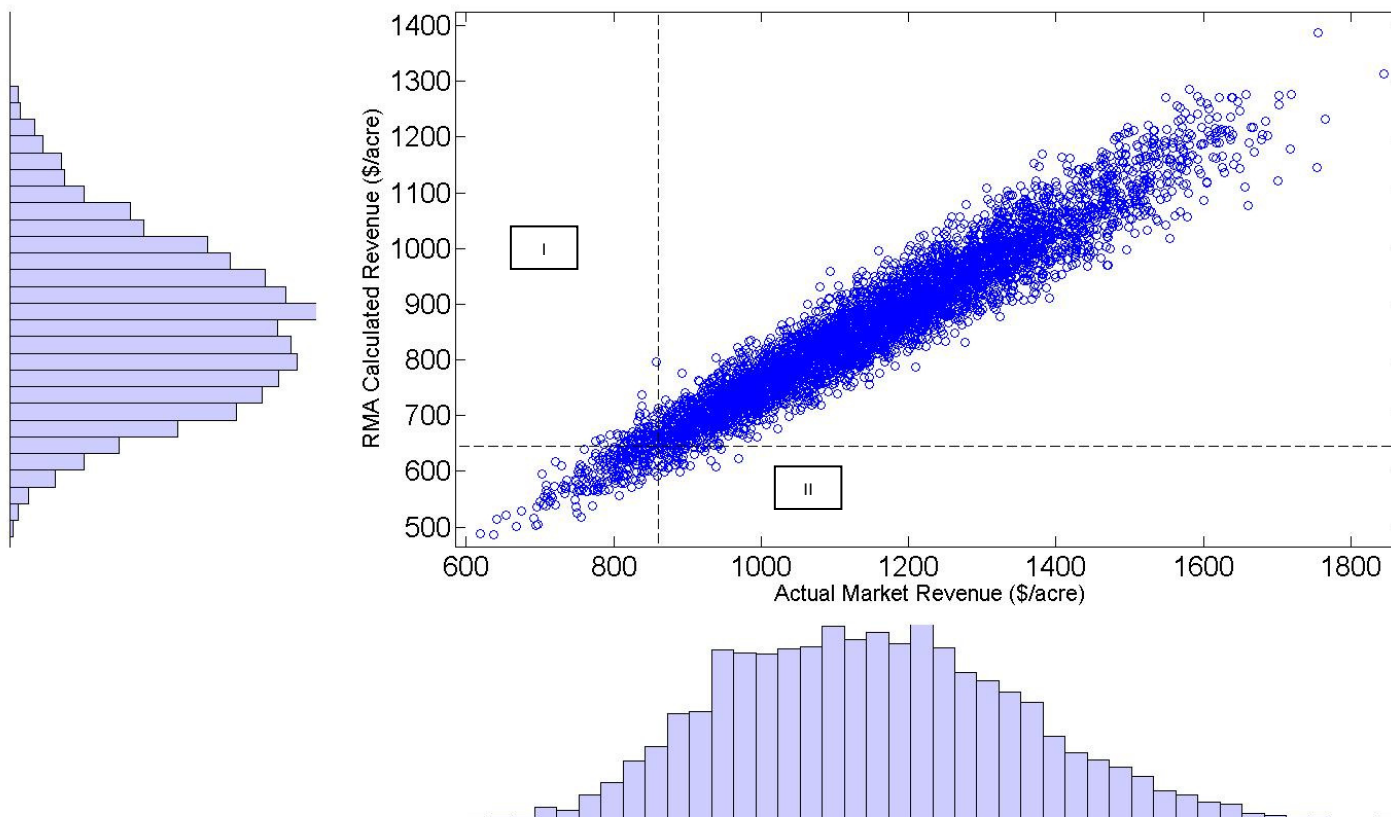
Note: The year 2009 can be characterized as a year with a “high” organic-conventional price ratio.

**Figure 1. Revenue distributions for organic corn producers denoting 75% coverage level under various prices, 2009**



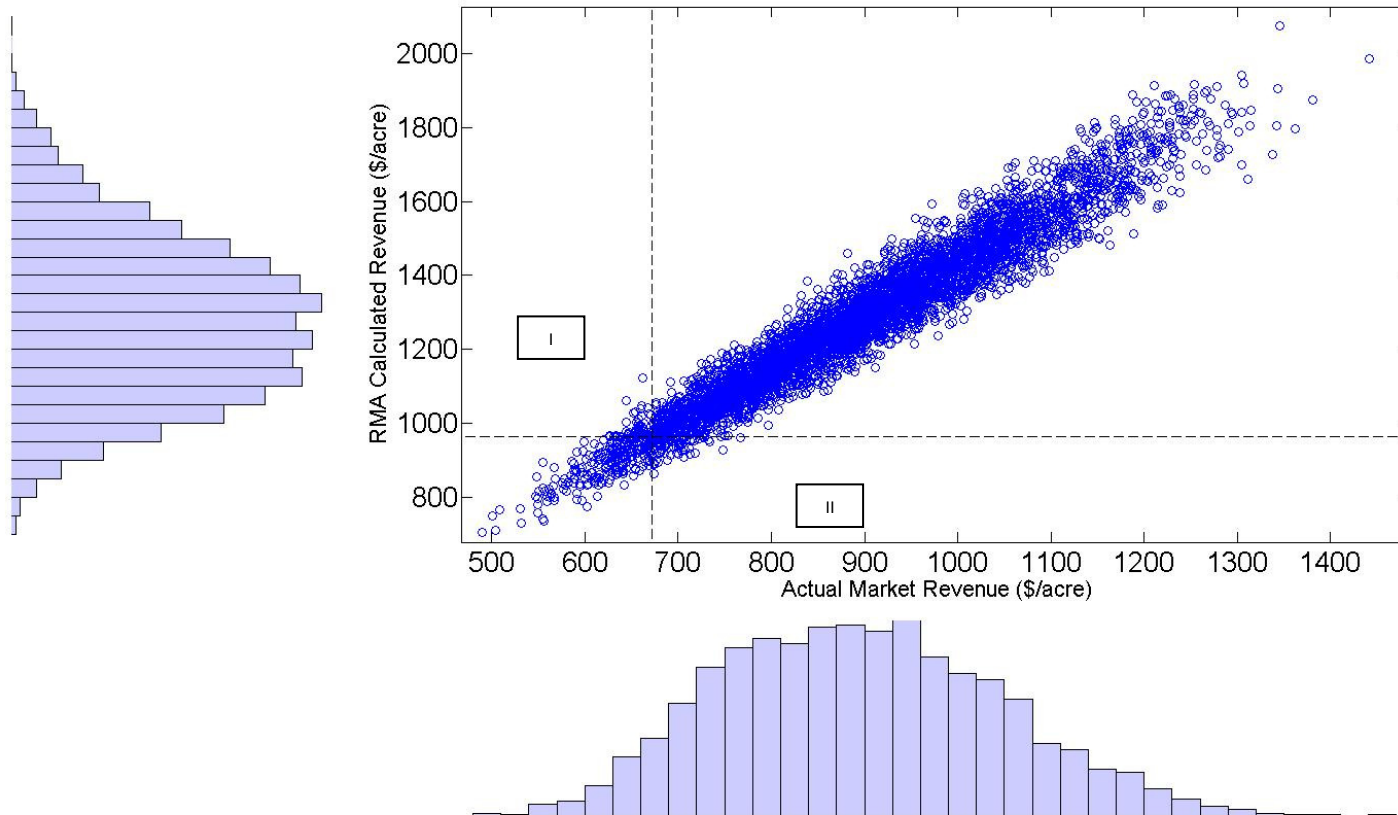
Note: The year 2011 can be characterized as a year with a “low” organic-conventional price ratio.

**Figure 2. Revenue distributions for organic corn producers denoting 75% coverage level under various prices, 2011**



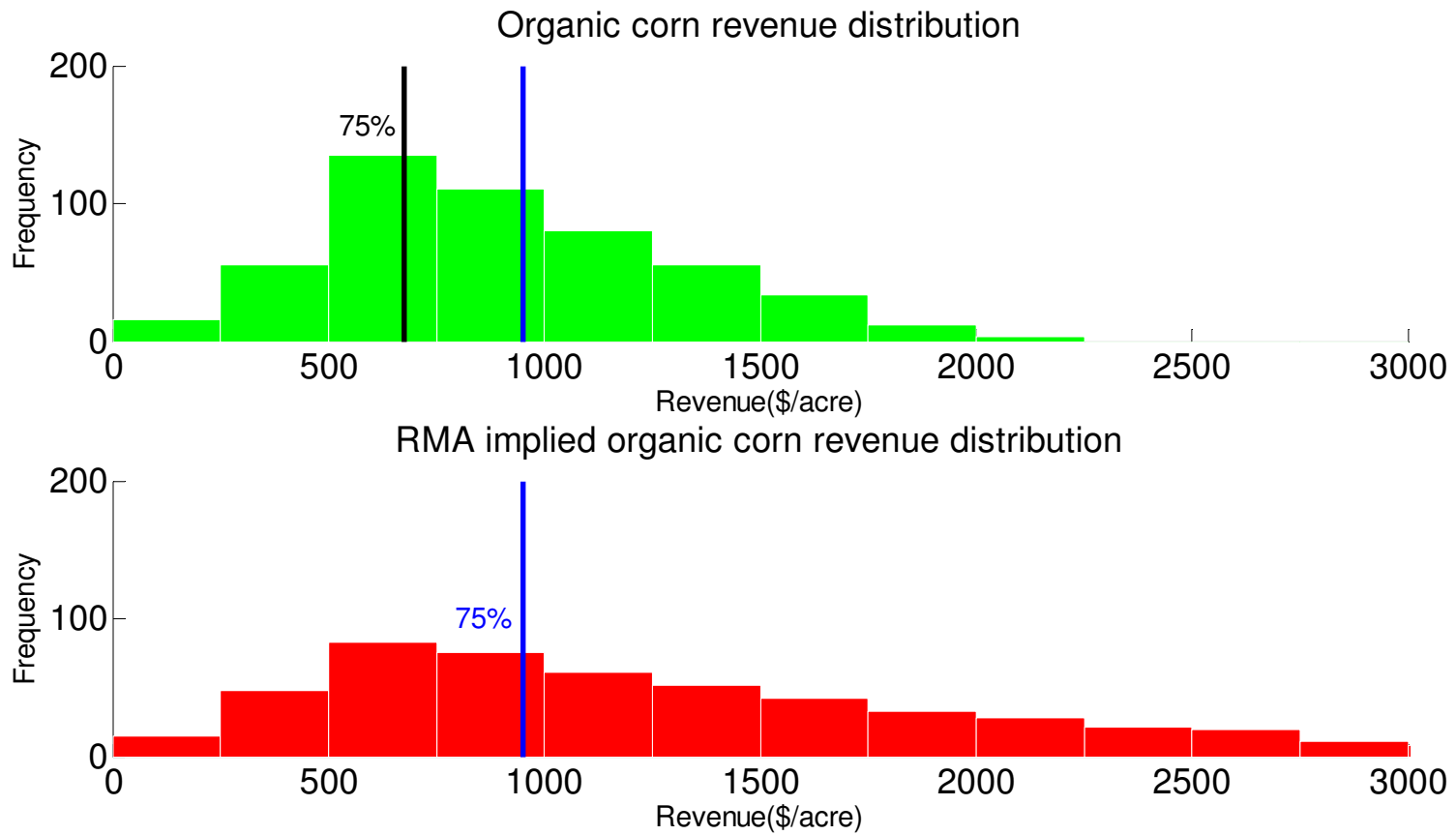
Note: The year 2009 can be characterized as a year with a “high” organic-conventional price ratio.

**Figure 3. Scatter plot of revenue distributions for organic corn producers, 2009**

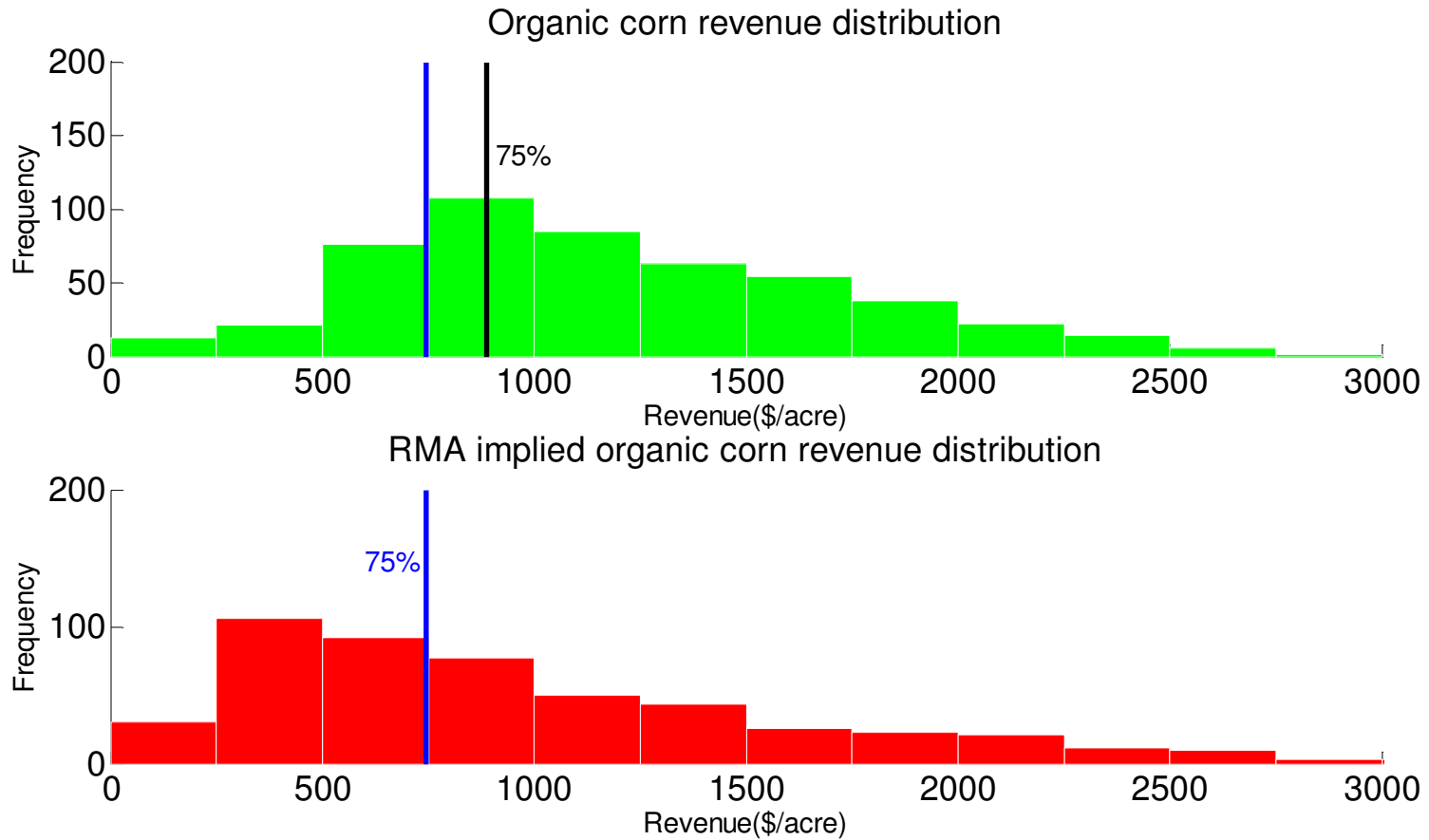


Note: The year 2011 can be characterized as a year with a “low” organic-conventional price ratio.

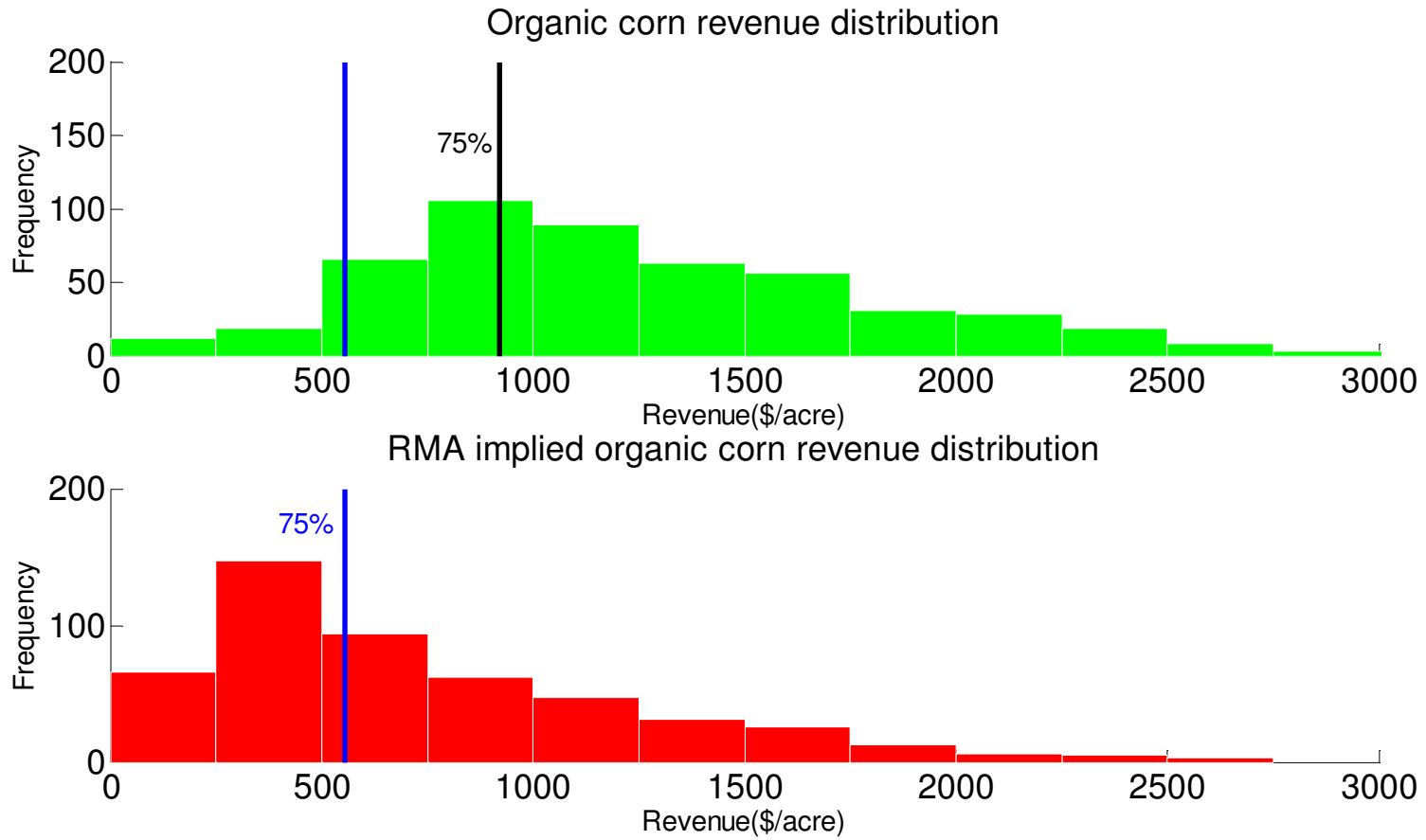
**Figure 4. Scatter plot of revenue distributions for organic corn producers, 2011**



**Figure 5. Revenue distributions from the structural model for organic corn producers, low organic to conventional price ratio (scenario 1, tables 1 and 2)**



**Figure 6. Revenue distributions from the structural model for organic corn producers, medium organic to conventional price ratio (scenario 2, tables 1 and 2)**



**Figure 7. Revenue distributions from the structural model for organic corn producers, high organic to conventional price ratio (scenario 3, tables 1 and 2)**