Journal of Agricultural and Resource Economics 37(3):415–434

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

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A framework is developed to examine organic crop insurance established by the Risk Management Agency (RMA). Given that the 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, the RMA's fixed-price factor implies an effective coverage ranging from 43% to 105% depending on the ratio of planting-time organic to conventional market prices. Results suggest the RMA's program is likely to induce adverse selection because the nominal coverage level is likely to deviate substantially from the effective coverage.

Key words: adverse selection, crop insurance, organic agriculture

Introduction

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. 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 nonorganic production. Based on examinations of loss history, the Risk Management Agency (RMA) is tasked with revising the 5% premium surcharge for organic crop coverage that applies to all crops and regions across the United States. While federal crop insurance for organic crops accounts 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 questionable (see Singerman, Hart, and Lence, 2010), and 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 prices for conventionally produced crops without accounting for the price premiums that organic producers would have been able obtain for their crops (USDA Risk Management Agency, 2011c).

As a consequence of the 2008 Farm Bill provisions, at the beginning of 2009 the RMA contracted for the development of a pricing methodology to improve crop insurance policies for organic crops. Based on that research, the RMA introduced a pilot program during the 2011 crop year that created a separate price election for certain certified organic crops.[1] Under the 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. These ratios are based on minimum ratios of organic to conventional

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We wish to thank the editor and the reviewers for their guidance in shaping the paper.
Review coordinated by Gary W. Brester.

[1] The certified organic crops are cotton, corn, soybeans, and processing tomatoes.

prices observed from January 2007 through September 2009.[2] 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, but the impact will be greater for revenue insurance products.[3]

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, the RMA's pilot program assumes that the two markets are affected by the same shocks and that 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 United States 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 over conventional products.

Organic price premiums are also expected because organic production involves additional risks (Klonsky and Greene, 2005), which helps explain the lower yields achieved by organic production (Porter et al., 2003; Delate and Cambardella, 2004; Singerman, Hart, and Lence, 2010). McBride and Greene (2008) also found that organic production involves higher per unit costs. Therefore, price premiums, which make organic crop systems competitive with conventional systems, are a major incentive encouraging conventional producers and processors to switch to organic agriculture. However, while organic prices have been steady, organic price premiums for corn and soybeans have been shrinking since October 2010 because of rising commodity prices, increased crop demand for biofuels, and reductions in supply due to weather-related problems in the Southern hemisphere. In late February 2011, when crop insurance prices are determined, prices for organic (conventional) corn and soybeans were $8.60/bu ($6.86) and $18.61/bu ($13.38).[4] Price ratios were 1.25 and 1.39 for corn and soybeans, well below the 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, creating larger or smaller price ratios depending on idiosyncratic shocks, and adds 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 dependent on the relationship between insurance and market prices. If the price ratio at the time of price discovery (February for corn and soybeans) is low (high) and the 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

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[2] The RMA contractor originally recommended that 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, Inc., 2010). The RMA has now moved to setting the price ratios based on data from the most recent three years (USDA Risk Management Agency, 2011b).

[3] Yield protection compensates producers 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 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 revenue protection (RP), the revenue guarantee is based on the maximum of either the market price prior to planting or the market price at harvest. All other aspects of RP insurance match the setup for RPHPE insurance.

[4] Organic crop prices were retrieved from USDA Market News Report NW_GR113 for February 23, 2011, and prices for conventional crops were obtained from the *Wall Street Journal* of the same date.

inflated (deflated).[5] Moreover, pegging organic crop prices to conventional crop prices might also result in systematic over (under) payments to producers under revenue protection coverage because the product insures against losses from yield and/or price decreases. 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. We analyze how the RMA's price misratings in terms of payouts are affected by the relationship between organic and conventional crop prices between planting and harvest time.

The present study extends the framework developed by Lence and Hayes (2005) to incorporate uncertainty and rational expectations. We also show how to apply this framework to the analysis of crop insurance for organic corn in the United States. The results illustrate the magnitude of the inefficiencies promoted by the current program.

Graphical Illustration of the Problem

To illustrate the potential consequences of the RMA's pilot program misalignments under revenue protection 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. We generated 5,000 yield draws using farm-survey yield data for Iowa organic corn producers. We then generated an equal number of price draws from three log-normal distributions with different means and the same volatility as specified by the USDA Risk Management Agency (2011e) to represent the following compensation structures to organic farmers:

1. RMA's conventional prices (following the pattern for insurance policies for all organic crops until 2010 and for most such crops for 2011),
2. Market prices received by organic producers,[6] and
3. RMA conventional prices × 1.788 (i.e., the new pilot program for 2011).

Given the lack of studies or data for the case of organic corn, we imposed the -0.51 correlation estimate 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 a methodology suggested by Iman and Conover (1982). 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 and the corresponding 75% guarantee for each of the three scenarios.[7]

We performed the experiment reflecting market and insurance prices for the years 2009 and 2011 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. The results, shown in figures 1 and 2, make it clear that under the RMA's previous price schedule, organic farmers who 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, but it is also evident that organic producers are likely to be offered a guarantee that is too low or too high in any particular year.

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[5] In crop insurance, price discovery denotes the period of time over which prices are observed and used to determine insurable values for crops. This 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] 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. Organic prices were computed based on this proxy.

[7] We computed the mean of the distribution and then used 75% of that value as a proxy for the corresponding level of coverage.

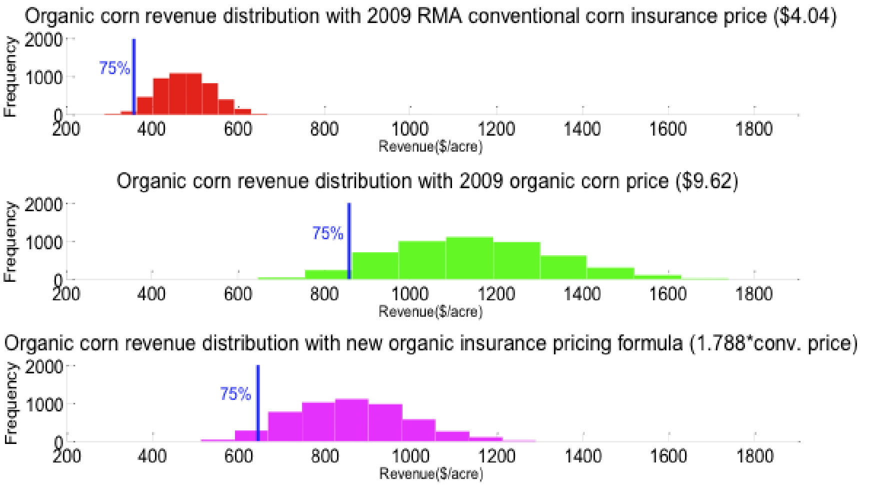

Figure 1. Revenue Distributions for Organic Corn Producers Denoting 75% Coverage Level under Various Prices, 2009

Notes: The year 2009 can be characterized as a year with a "high" organic-to-conventional price ratio.

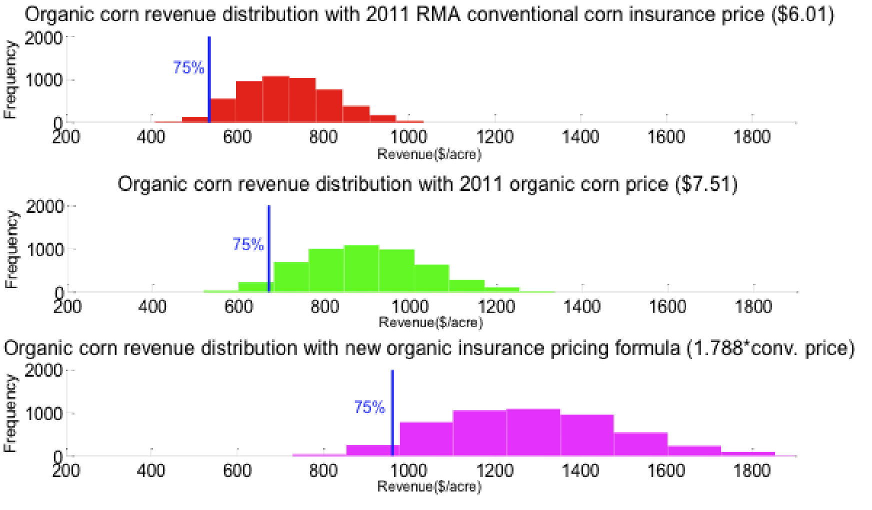

Figure 2. Revenue Distributions for Organic Corn Producers Denoting 75% Coverage Level under Various Prices, 2011

Notes: The year 2011 can be characterized as a year with a "low" organic-to-conventional price ratio.

To better illustrate the potential consequences for payouts due to misalignment between the RMA's pilot program prices and market prices for organic corn, we used the empirical distributions obtained in the 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 (figures 3 and 4). 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 who will receive an indemnity for their false losses (quadrant II, 1.1%). In contrast, figure 4 illustrates that when the conventional price is relatively high compared to the organic price (i.e.,

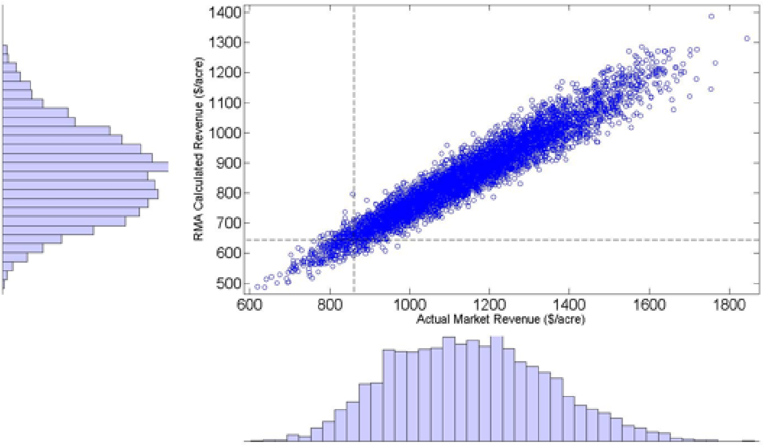

Figure 3. Scatter Plot of Revenue Distributions for Organic Corn Producers, 2009
Notes: The year 2009 can be characterized as a year with a "high" organic-to-conventional price ratio.

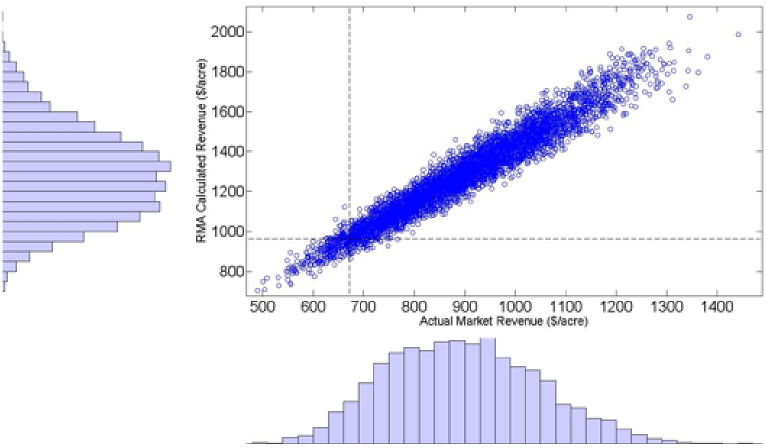

Figure 4. Scatter Plot of Revenue Distributions for Organic Corn Producers, 2011
Notes: The year 2011 can be characterized as a year with a "low" organic-to-conventional price ratio.

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, mispayments resulting from the RMA's price misalignments would affect organic producers in the lower left quadrant as well as in quadrants I and II because indemnities for the former would be based on a compensation price that is either too low or too high, increasing the extent of mispayments.

Theoretical Model

We propose a structural model to examine the relationship between organic and conventional crop prices from February (just before planting time, when producers must decide whether to buy crop insurance) until yield is realized (harvest time). Our model is an extension of one introduced by Lence and Hayes (2005), but, unlike theirs, our framework is stochastic and incorporates producers' rational expectations. As explained by Williams and Wright (1991, p. 32), "in modeling supply, the issue of a time lag between input commitment and output response is crucial" because "all 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. We assume that producers have rational expectations. That is, the agents' subjective beliefs regarding the probability distributions of all of the variables that are random at planting time are the same as the true distributions of such variables.

Supply of Organic and Conventional Crops

To become a certified organic producer, producers must embark on a three-year transition period during which they 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.[8] 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^i_{t+1}) is postulated to consist of:

$$(1) \qquad S^i_{t+1} = A^i_t y^i_{t+1},$$

where A^i_t equals the number of acres planted at time t and y^i_{t+1} is the realization of a random yield due to weather, pests, and other factors. We assume that producers at time t make their planting decisions so as to maximize expected profits at $t+1$ (π^i_{t+1}), conditional on their information at time t and subject to any existing constraints.[9] Mathematically:

$$(2) \qquad \begin{aligned} A^{i*}_t &= argmax_{A^i_t} E_t(\pi^i_{t+1}) \\ &= argmax_{A^i_t} E_t[P^i_{t+1}S^i_{t+1} - v^i(A^i_t)] \\ &= argmax_{A^i_t} [E_t(P^i_{t+1}y^i_{t+1})A^i_t - v^i(A^i_t)] \\ &= argmax_{A^i_t} [R^i_t A^i_t - v^i(A^i_t)] \end{aligned}$$

$$(2') \qquad = a^i(R^i_t),$$

where $argmax_{A^i_t}$ is the set of values for A^i_t 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 $R^i_t \equiv E_t(P^i_{t+1}y^i_{t+1})$ is the producers' incentive revenue.[10] The producers' incentive revenue is generally different from the product of expected price times expected yield (i.e., $R^i_t \neq E_i(P^i_{t+1})E_i(y^i_{t+1})$) because producers recognize that yield disturbances are correlated with the

[8] Our model is consistent with the RMA's insurance policies because conventional prices are applied to transitioning acreage (USDA Risk Management Agency, 2011b).

[9] This implies that decision makers are risk neutral. It is straightforward to generalize the model to allow for risk aversion, but in the present application the gains from doing so 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 κ^i_A, leaving acreage supply essentially unchanged.

[10] In this case, incentive revenue is equal to expected revenue for the crop on a per acre basis.

market price (Lence and Hayes, 2000; Wright, 1979). Under standard regularity conditions for the cost function, optimal acreage increases at an increasing rate with 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 demand for organic and conventional crops is an aggregation of individual demands from type-δ ($0 \le \delta \le 1$) consumers, who will substitute conventional crops for organic crops if the price paid for the former is less than or equal to a fraction δ of the price of the latter. In this way, parameter δ 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 to consume conventional crops regardless of the discount have $\delta = 0$.

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

$$(3) \qquad D^O_{\delta,t+1} = \begin{cases} d_\delta(P^O_{t+1})\xi^O_{t+1} & \text{if } P^C_{t+1} > \delta P^O_{t+1} \\ d_\delta(P^O_{t+1})\xi^O_{t+1} - D^C_{\delta,t+1} & \text{if } P^C_{t+1} = \delta P^O_{t+1} \\ 0 & \text{if } P^C_{t+1} < \delta P^O_{t+1} \end{cases}$$

$$(4) \qquad D^C_{\delta,t+1} = \begin{cases} d_\delta(P^C_{t+1})\xi^C_{t+1} & \text{if } P^C_{t+1} < \delta P^O_{t+1} \\ d_\delta(P^C_{t+1})\xi^C_{t+1} - D^O_{\delta,t+1} & \text{if } P^C_{t+1} = \delta P^O_{t+1} \\ 0 & \text{if } P^C_{t+1} > \delta P^O_{t+1} \end{cases}$$

where $d_\delta(\cdot)$ is a well-behaved demand function (i.e., $\partial d_\delta(P)/\partial P < 0$) and $\xi^i_{t+1} > 0$ is a multiplicative demand shock for crop $i \in$ {organic, conventional}. Shocks greater than one increase demand and shocks less than one reduce demand. Since demand shocks are modeled as a multiplicative factor, they are restricted to be positive.[11] Aggregate demand for organic (conventional) crops $D^O_{t+1} = \sum_\delta D^O_{\delta,t+1}$ ($D^C_{t+1} = \sum_\delta D^C_{\delta,t+1}$) 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 the 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 ($\underline{P}^i_{t+1}$ for $i \in$ {organic, conventional}, where the underline indicates market clearing) must satisfy conditions (5) and (6):

$$(5) \qquad S^O_{t+1} = [D^O_{\underline{\delta}_{t+1}} + \sum_{\delta < \underline{\delta}_{t+1}} d_\delta(\underline{P}^O_{t+1})],$$

$$(6) \qquad S^C_{t+1} = [D^C_{\underline{\delta}_{t+1}} + \sum_{\delta < \underline{\delta}_{t+1}} d_\delta(\delta^{-1}\underline{P}^C_{t+1})],$$

[11] Otherwise, the quantity demanded would be less than zero whenever a negative shock occurred.

where $\underline{\delta}_{t+1} \equiv \underline{P}^C_{t+1}/\underline{P}^O_{t+1}$ 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 equation (1), conditions (5) and (6) imply that market-clearing prices depend on the acreage and yields of both types of crops. That is:

$$\underline{P}^i_{t+1} = \underline{p}^i(A^O_t y^O_{t+1}, A^C_t y^C_{t+1}, \xi^O_{t+1}, \xi^C_{t+1}) \tag{7}$$

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:

$$\hat{A}^{i*}_t = a^i\{E_t[\underline{p}^i(\hat{A}^{O*}_t y^O_{t+1}, \hat{A}^{C*}_t y^C_{t+1}, \xi^{O*}_{t+1}, \xi^C_{t+1}) y^i_{t+1}]\} \tag{8}$$

for $i \in$ {organic, conventional}. In words, optimal acreage (2′) under a rational-expectation equilibrium ($\hat{A}^{i*}_t$) 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 2008, only 0.7% of U.S. cropland was planted with organic crops and the percentage of organic to conventional corn acreage was 0.2% (USDA Economic Research Service, 2010). Direct human corn consumption is of organic sweet corn and food-grade corn for processing, but most organic corn is used as livestock feed. Between 2001 and 2007, U.S. organic beef, dairy, and poultry production increased by 325%, 241%, and 143% (figure 6), but acreage dedicated to organic corn production increased by only 84% (figure 6). We illustrate the theoretical model with a simulation of the U.S corn market between planting and harvest time using a procedure resembling the structure for crop insurance in the United States. Yields are estimated at the producer level and pricing is unique at the national level.

Yield Calibration

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

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

for $y_{\min} \le y \le y_{\max}$, where α and β are shape parameters, $y_{\min}$ and $y_{\max}$ are the minimum and maximum possible yields, μ is the mean yield, and σ is the standard deviation of yields. Following Johnson and Kotz (1970), the shape parameters can be obtained from:

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

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

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

To estimate the Beta distribution for conventional corn, we first calculated detrended conventional corn yields from 1980 to 2010 in Adair County, Iowa.[12] 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 the RMA's Actual Production History (APH) premium rate at the 65% coverage level for that county.[13] In this manner, we calibrated our yield distribution to match the RMA's rating for yield insurance. This procedure assumes the RMA's yield rating is correct, allowing us to focus on the price setting for the insurance. The estimated marginal distribution for conventional corn has parameters $y_{\min} = 0$, $y_{\max} = 235$, $\alpha = 2.98$, and $\beta = 1.28$.

The Beta yield distribution for organic corn was obtained using the same standard deviation as for conventional corn, but imposing a penalty yield of 30% on the mean consistent with findings from Singerman, Hart, and Lence (2010), Porter et al. (2003), and Delate and Cambardella (2004).[14] The resulting marginal distribution for organic corn has parameters $y_{\min} = 0$, $y_{\max} = 186$, $\alpha = 1.66$, and $\beta = 1.02$.

The final step in the calibration of the joint yield distribution used the Iman and Conover procedure to impose the observed correlation of 0.70 between organic and conventional corn yields (Delate et al., 2009). The resulting joint distribution of conventional and organic yields can be interpreted as representative of 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:

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

where y_{US}, y_f, and $\bar{y}$ denote the national, producers', and unconditional yield levels; and $\gamma \in [0,1]$ defines the weight of the two components. Equation (12) can be rewritten 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 aggregated (county-level) yields, except that the residual term is assumed away. We estimated the value of γ by resorting to the variance of equation (12). First, we computed the variance of national yields based on detrended yields from 1980 to 2010. Second, using the variance computed above for Adair County, Iowa, we obtained $\gamma = 0.32$. Due to lack of data, for organic corn we used the same γ value as for conventional corn.

Acreage Calibration

The function defining optimal acreage in equation (2′) is assumed to be isoelastic, taking the form $a^i(R_t^i) = \kappa_A^i (R_t^i)^{\varepsilon_S^i}$, where ε_S^i is the constant supply elasticity for crop i and κ_A^i represents an acreage-scaling parameter consistent with observed acreage shares.[15] For the simulations, the supply elasticities were fixed at 0.436 and 0.378 for organic and conventional crops. These values were obtained by calibrating the elasticities to match the historical data for 2009 and 2011 and are consistent with the corn supply elasticities reported by Westcott (1998).

[12] 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.

[13] Given the name changes in crop insurance for the 2011 crop year, this is now known as the yield protection (YP) premium rate.

[14] A recent study by Delate, Flater, and Butler (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 are more easily managed than entire farms.

[15] This implies that the underlying cost function is $v^i(A_t^i) = (\kappa_t^i)^{-1/\varepsilon_S^i} (A_t^i)^{1/\varepsilon_S^i + 1}$. This is true because the first-order condition for the maximization of $[R_t^i A_t^i - v^i(A_t^i)]$ in equation (2) is $R_t^i - (\kappa_t^i)^{-1/\varepsilon_S^i} (A_t^{i*})^{1/\varepsilon_S^i} = 0$, which can be solved for A_t^{i*} to obtain the postulated optimal acreage function.

Demand Calibration

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

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

where κ_δ is a scaling parameter and ε_δ is the constant demand elasticity of type-δ 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 the high-, medium-, and low-price ratio scenarios used in the analysis. These scenarios are based on the range of organic-to-conventional price ratios between 2004 and 2009 as documented by Singerman, Lence, and Kimble-Evans (2010).

For given elasticity values, it is possible to recover κ_δ from the market shares (m_δ) of different types of consumers. Let $m_\delta \equiv D_\delta / D$, where D_δ denotes the grain consumed by type-δ 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 equation (13) and solving for κ_δ, we obtain:

$$\kappa_\delta = m_\delta \times D \times P_\delta^{\varepsilon_\delta}, \tag{14}$$

where P_δ is the crop price paid by type-δ 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.

For the simulations, the demand elasticities were fixed at -1.28 and -0.308 for organic and conventional crops. These values were obtained by calibrating the elasticities to match the historical data for 2009 and 2011. 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 to obtain values for m_δ. Adding the corresponding market share for organic consumption, we categorize corn consumers in three broad groups: $m_{\delta=0.1} = 0.0025$, $m_{\delta=0.9} = 0.6475$, and $m_{\delta=1} = 0.35$. Consumers with $\delta = 0.1$ are 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 nonorganic 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 preference that are likely to exist within the broad groups of consumers. We follow Lence and Hayes (2005) to get around this shortcoming by adopting a continuous Beta distribution for δ ($\delta | \alpha = 1.63, \beta = 0.028, \delta_{\min} = 0, \delta_{\max} = 1$) 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 of the preference differences within groups. Using computer routines developed by Miranda and Fackler (2011), we computed Gaussian quadrature nodes and weights to approximate the distribution of κ_δ. For that purpose, ε_δ was assumed to be the same across all consumer types at -0.36 and was computed from the 2010 FAPRI estimates (McPhail, 2010).[16]

Exogenous shocks to consumer demand are assumed to be identically and independently log-normally distributed, $\xi_{t+1}^i \overset{i.i.d.}{\sim} LN(\mu_\xi, \sigma_\xi^2)$ 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 to obtain the desired price-yield correlation of -0.51.

[16] For the 2010 FAPRI projections, the elasticities of corn demand by sector were -0.19 for feed, -0.07 for food, -0.40 for ethanol, and -0.95 for exports. The composite elasticity was constructed by weighting each elasticity by the market share corresponding to each sector (38.15%, 10.37%, 37.04%, and 14.44%, respectively).

Numerical Methods

The proposed rational expectations model was solved by a combination of 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:

1. Set up the parameters of the model, obtain the time $t+1$ exogenous random producer yields $\{y^O_{f,\omega}, y^C_{f,\omega}\}$ and national yields $\{y^O_{fUS\omega}, y^C_{US,\omega}\}$ from the specified Beta distributions for yields. For each state of the world at time $t+1$ (ω) compute the corresponding Gaussian quadrature nodes and probability weights for the demand shocks $\{\xi^O_\omega, \xi^C_\omega\}$.[17]

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 $\omega\{\underline{\delta}^{(0)}_\omega\}$.

3. Given $\{\hat{A}^{O*(j)}, \hat{A}^{C*(j)}\}$, compute aggregate supplies of organic and conventional crops at each state of the world $\omega\{S^{O(j+1)}_\omega, S^{C(j+1)}_\omega\} = \{\hat{A}^{O*(j)} y^O_{US,\omega}, \hat{A}^{C*(j)} y^C_{US,\omega}\}$.

4. Given $\{S^{O(j+1)}_\omega, S^{C(j+1)}_\omega\}$, $\{\underline{\delta}^{(j)}_\omega\}$, and the demand shocks $\{\xi^O_\omega, \xi^C_\omega\}$, compute the market-clearing prices at each state of the world $\omega\{\underline{P}^{O(j+1)}_\omega, \underline{P}^{C(j+1)}_\omega\}$.

5. Given $\{\underline{P}^{O(j+1)}_\omega, \underline{P}^{C(j+1)}_\omega\}$, calculate the market-clearing consumer discount for the conventional crop at each state of the world $\omega\{\underline{\delta}^{(j+1)}_\omega = \underline{P}^{C(j+1)}_\omega / \underline{P}^{O(j+1)}_\omega\}$.

6. If $|\underline{\delta}^{(j+1)}_\omega - \underline{\delta}^{(j)}_\omega|$ is smaller than the desired tolerance, go to step 7. Otherwise, compute the bisection innovation for $\underline{\delta}^{(j+1)}_\omega$, set it as $\underline{\delta}^{(j)}_\omega$, and go back to step 4.

7. Given $\{\underline{P}^{O(j+1)}_\omega, \underline{P}^{C(j+1)}_\omega\}$ and random yields, compute the producers' incentive revenues $\{R^{O(j+1)}, R^{C(j+1)}\}$.

8. Given $\{R^{O(j+1)}, R^{C(j+1)}\}$, calculate the optimal acreage values under rational expectations equilibrium $\{\hat{A}^{O*(j+1)}, \hat{A}^{C*(j+1)}\}$

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 them 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.

The algorithm does not address insurance participation directly but establishes the acreage, demands, and prices for given yield draws. As such it provides appropriately correlated organic and conventional yield and price draws under market-clearing conditions. Once the algorithm is run, we use the results to explore insurance performance, assuming the distributions of prices and yields represent a typical producer.

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[17] We used ten Gaussian quadrature nodes for each type of demand shock (i.e., organic and conventional) and fifty yield draws for each type of crop. Demand shocks are assumed to be independent, but yield shocks are correlated (so that the fifty draws for each crop are grouped into fifty organic-conventional yield pairs by means of the Iman-Conover method). This resulted in 500 $(= 10 \times 50)$ states of the world.

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. The price ratio is not fixed in the simulations; the ratio is the result of the market clearing prices in each market for each state of the world. The ratios shown in the tables are the ratios of expected prices from the distributions of optimal market clearing resulting from the rational expectations model.

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.[18] For the first three scenarios in tables 1 and 2, the correlation between organic and conventional corn yields is set at 0.70, whereas the yield-price correlation is set at -0.51 (Hart, Hayes, and Babcock, 2006). Results for scenario 1 show that when the price ratio is low, the average indemnity received by organic producers under RPHPE coverage with the pilot program (denoted by the "RMA" column) is \$350/acre, which is substantially higher than the \$195/acre they would 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 the RMA is \$79 under the pilot program versus \$46 under the organic distribution.

To better understand these results, revenue distributions corresponding to each of the first three scenarios are depicted in figures 7–9. In those figures, the continuous line in the top graph indicates revenue levels based on 75% coverage from the distribution of actual organic revenues. The dashed line in the bottom graph indicates revenue levels based on 75% coverage from the RMA's revenue formulation and the dashed line in the top graph is the imposition of revenue guarantees from the RMA's formulation on actual organic revenue distribution. Results in table 1 compare insurance performance between the continuous line in the top panel and the dashed line in the bottom panel. 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 are still overcompensated on average under the RMA's pilot program. Scenario 3 shows that when the price ratio is at a high level, organic producers get an average indemnity of \$226/acre under the RMA's pilot program, which is lower than the \$263/acre that they should receive. In this case, the expected loss per acre for the RMA is \$59 under the pilot program versus \$63 under the idiosyncratic organic distribution.

An alternative measure of the RMA's mispricing across scenarios is the loss-cost ratio, defined as the ratio of indemnities to coverage (or liability). Table 1 shows that for scenarios 1–3, not only do loss-cost ratios under the pilot program increase with the price ratio, but they are also greater than 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 expected loss and the revenue guarantee. From figures 7–9 it becomes clear that these results are driven by the dissimilar shapes of the organic and RMA revenue distributions. The explanation for 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 shows how the results change when the correlation between organic and conventional corn yields is assumed to equal 0.4 and 0.9. This sensitivity analysis shows that lower (higher) correlations are linked to higher (lower) values for average indemnity, expected loss, and cost-loss ratio with respect to scenarios 1–3. This result makes sense intuitively. Given a lower correlation between organic and conventional yields, the likelihood of a low-organic-yield,

[18] Results for different parameterizations of the Beta yield distributions are available from the authors by request; the results did not change significantly.

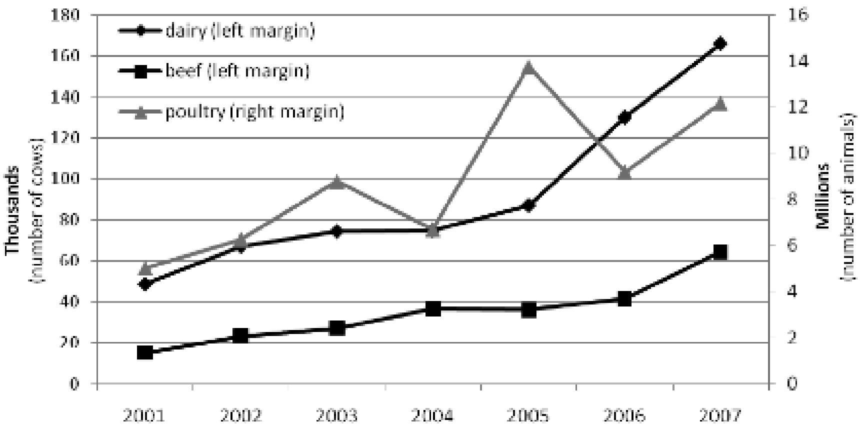

Figure 5. Organic Dairy and Beef Cow Production and Poultry Production in the United States, 2001–2007 (USDA-ERS)

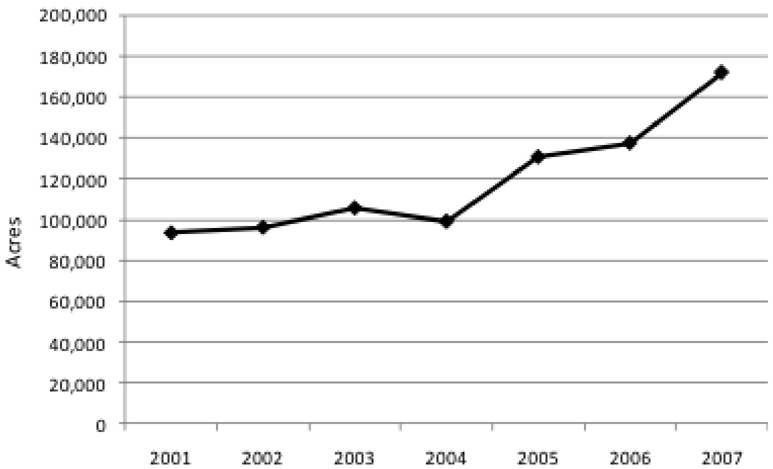

Figure 6. Organic Corn Acreage in the United States, 2001–2007 (USDA-ERS)

low-price combination increases, which would raise the average indemnity, expected loss, and cost-loss ratio. Additionally, the difference between the loss-cost ratios under the organic distribution versus that of the RMA increases with 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 loss-cost ratio both decrease with respect to scenarios 1–3, and the difference between the loss-cost ratios under the organic distribution versus that of the RMA also decreases with respect to scenarios 1–3. Overall, the results from table 1 suggest that the RMA's pilot program is likely to induce adverse selection because 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 7–9 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 lighter lines in figures 5–7) we combined the organic revenue distribution with the RMA's insurance guarantee. The results in table 2 compare insurance performance between

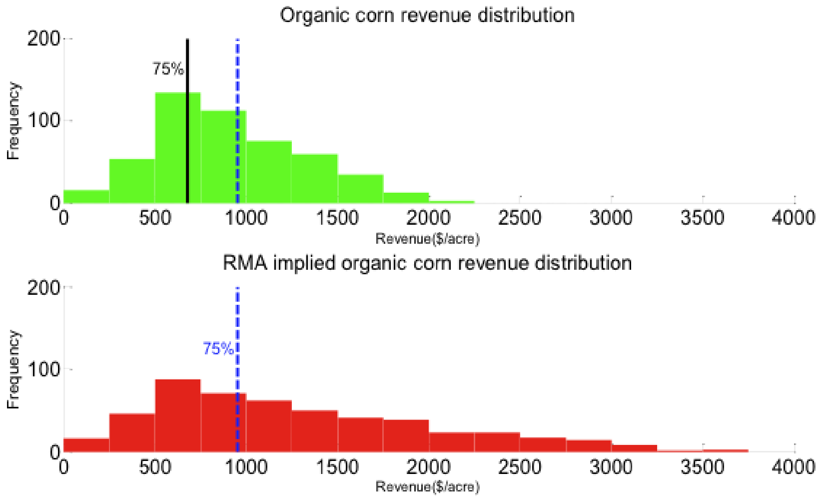

Figure 7. Revenue Distributions from the Structural Model for Organic Corn Producers, Low Organic to Conventional Price Ratio (scenario 1, tables 1 and 2)

the continuous and dashed lines in the top panel of figures 5–7. Thus, table 2 shows the expected loss, loss-cost ratio, and effective coverage using the 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 105% (43%) 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 the 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, current policy does not compensate organic producers for price premiums that they are able to obtain in the market. In an attempt to overcome this deficiency, the RMA introduced a pilot program in 2011 for certified organic corn and soybeans where price determination for insurance purposes is tied to conventional crops by a fixed factor of 1.788 for corn and 1.794 for soybeans.

Given evidence of a changing multiplicative relationship between organic and conventional crop prices, the 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 RMA's fixed-price factor. We analyze the consequences of price misalignment derived from the pilot program under RPHPE coverage by developing a stochastic structural model between planting and harvesting applied to the U.S. corn market. Using the proposed model to evaluate the organic insurance program for a producer in a representative Iowa county, we find that the

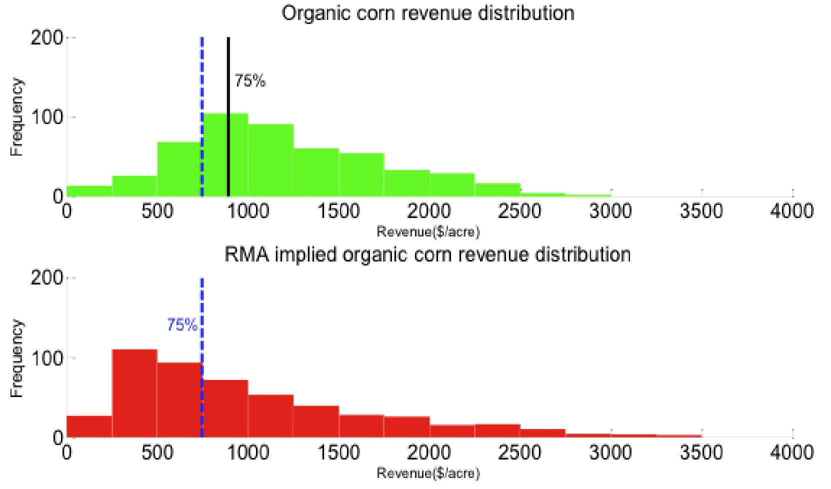

Figure 8. Revenue Distributions from the Structural Model for Organic Corn Producers, Medium Organic to Conventional Price Ratio (scenario 2, tables 1 and 2)

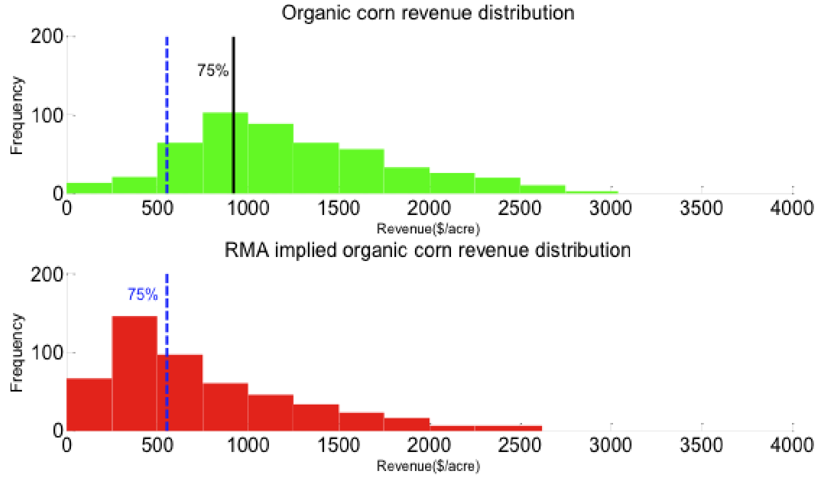

Figure 9. Revenue Distributions from the Structural Model for Organic Corn Producers, High Organic to Conventional Price Ratio (scenario 3, tables 1 and 2)

mispricing induces an effective coverage of 105% (43%) when the price ratio is low (high) for the 75% nominal coverage level. 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 benefit from this policy if the ratio of organic to conventional crop prices determined in the market is low compared to that established by the RMA. However, the impact of this policy on organic producers over time will depend on how often the price ratio is above or below the RMA's factor.

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 × conventional prices, linking organic crop prices to their conventional counterparts creates mispricing in their insurance coverage. Dimitri and Oberholtzer (2008) and Singerman, Hart, and Lence (2010) found evidence that contracting accounts for approximately 70% of transactions in the organic sector. Given this prevalence, using organic contract prices would not only be a simpler, more appropriate, and less controversial alternative to setting insurance prices for organic crops, but it would also yield RMA prices better aligned with the organic market.

The use of contract pricing for crop-insurance purposes is not novel; the RMA has been using it for select conventional crops such as malting barley, peanuts, and processing pumpkins (USDA Risk Management Agency, 2011a,d,f). Capped in some cases, contract pricing has also been used for insuring certain organic crops. In fact, having contracted production is a requirement for obtaining coverage for such organic crops (USDA Risk Management Agency, 2010). The benefit of using this approach is that indemnities reflect market prices, via contracts. However, two potential problems arise from extending it across organic production. First, February, when crop insurance prices were determined, might be too early to require producers to have contracts in place. Second, setting guarantees for organics based on production contracts might create an incentive for farmers and processors to establish high contract prices for insurance purposes and renegotiate those prices downward when actually marketing. The first problem could be managed by stipulating a pricing rule if contract prices are not available (for example, establishing insurable prices from publicly available contracts or USDA-Agricultural Marketing Service current organic price listings if contract prices are not available). The second issue could be handled by imposing spot audits of organic crop insurance claims to verify contract prices, with penalties imposed if fraudulently high contract prices were reported.

[Received February 2012; final revision received September 2012.]

Table 1. Effect of Organic-to-Conventional Price Ratios on Insurance Performance for Organic Corn Producers under RPHPE at the 75% Coverage Level

	Correlation		Expected Price ($/bu)		Org.-Conv.	Average Indemnity ($/acre)		Expected Loss ($/acre)		Loss-Cost (%)	
Scenario	Org.-Conv.	Yield-Price	Org.	Conv.	Price Ratio	Org.	RMA	Org.	RMA	Org.	RMA
1	0.70	-0.51	7.52	5.78	1.30	195	350	46	79	6.79	8.27
2	0.70	-0.51	9.86	4.32	2.28	253	299	62	76	6.90	10.21
3	0.70	-0.51	10.17	3.17	3.21	263	226	63	59	6.88	10.70
4	0.40	-0.51	7.50	5.77	1.30	220	379	54	96	7.81	9.90
5	0.40	-0.51	9.82	4.31	2.28	289	325	72	96	7.89	12.40
6	0.40	-0.51	10.14	3.17	3.20	298	244	74	75	7.83	12.98
7	0.90	-0.51	7.54	5.79	1.30	183	328	35	55	5.21	5.90
8	0.90	-0.51	9.86	4.32	2.28	240	282	47	55	5.28	7.48
9	0.90	-0.51	10.20	3.18	3.21	247	214	48	43	5.31	7.87
10	0.70	-0.63	7.52	5.77	1.30	198	273	41	63	6.22	6.92
11	0.70	-0.63	9.86	4.30	2.29	261	223	55	53	6.31	7.72
12	0.70	-0.63	10.15	3.16	3.21	269	167	56	41	6.27	7.92

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

	Correlation		Expected Price($/bu)		Org.-Conv.	Comparative Expected	Comparative Loss	Comparative Effective
Scenario	Org.-Conv.	Yield-Price	Org.	Conv.	Price Ratio	Loss ($/acre)	Cost (%)	Coverage (%)
1	0.70	−0.51	7.52	5.78	1.30	152	15.88	105
2	0.70	−0.51	9.86	4.32	2.28	35	4.72	63
3	0.70	−0.51	10.17	3.17	3.21	16	2.88	45
4	0.40	−0.51	7.50	5.77	1.30	176	17.96	106
5	0.40	−0.51	9.82	4.31	2.28	46	5.90	64
6	0.40	−0.51	10.14	3.17	3.20	22	3.75	46
7	0.90	−0.51	7.54	5.79	1.30	133	14.19	105
8	0.90	−0.51	9.86	4.32	2.28	28	3.84	62
9	0.90	−0.51	10.20	3.18	3.21	15	2.80	44
10	0.70	−0.63	7.52	5.77	1.30	122	13.38	104
11	0.70	−0.63	9.86	4.30	2.29	28	3.99	60
12	0.70	−0.63	10.15	3.16	3.21	13	2.60	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.

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