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# Price Analysis, Risk Assessment and Insurance for Organic Crops

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**Price analysis, risk assessment and insurance for organic crops**

by

**Ariel Singerman**

A dissertation submitted to the graduate faculty  
in partial fulfillment of the requirements for the degree of  
**DOCTOR OF PHILOSOPHY**

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## DEDICATION

This dissertation is the culmination of many years of challenging study and strenuous work, in what has been a long and winding road towards achieving my Ph.D. in Economics. I have accomplished this endeavor only with my greatest efforts and perseverance. However, I could have never been able to endure such process alone; therefore, I am grateful to all the people that have helped me along the way. But she went beyond helping; she enlightened me. Without her support I would probably had not only failed in this ambition, but also gone mad. She is my muse, my sage, and my most precious finding: *l'amore della mia vita; sei l'amor, il sole, e l'altre stelle insieme*. Anything and everything I could write in this or any other language would not suffice to describe what she means to me, my gratitude to her, and most importantly how happy I am with her. It is then not with grand eloquent words, but with simplicity and joy that I dedicate this work to her. Therefore, as in a toast:

To Eleonora!

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## Abstract

This dissertation consists of three essays in which I apply econometric and numerical methods to analyze different aspects of organic agriculture in the U.S. In the first essay cointegration is tested between organic and conventional corn and soybean markets in several locations throughout the U.S. using a unique data set. Organic prices are found to behave like jump processes rather than diffusions, and Monte Carlo methods are developed to compute appropriate critical values for such tests. Findings indicate that no long-run relationship exists between organic and conventional prices, implying that price determination for organic corn and soybean is independent from that for the conventional crops. This suggests that organic corn and soybean prices are driven by demand and supply forces idiosyncratic to the organic market. For each crop, cointegrating spatial relationships are found between prices at the main organic markets. However, such relationships are generally weaker than the ones for the corresponding conventional prices, implying that organic markets are more affected by idiosyncratic shocks than conventional markets.

For the second essay, a survey of organic grain and oilseed producers in Iowa, Minnesota and Wisconsin was conducted to collect information about their demographic characteristics, production and price risk management strategies, yields and losses, and crop insurance decisions. The data are analyzed using a discrete choice model to establish which variables influence organic producers' decision of whether to purchase crop insurance and also which ones affect the insurance product choice when applicable. In addition, this study describes the risk profiles of organic producers, and analyzes whether significant variations in yield exist between organic and conventional methods of production. This research may contribute to the design of an organic crop insurance policy in which organic producers would be charged according to their idiosyncratic production risks, rather than the arbitrary 5% blanket premium surcharge currently in use.

In the third essay, a framework is developed to examine the 2011 pilot program established by the Risk Management Agency (RMA) to insure organic crops. Given that for insurance purposes RMA links organic crop prices to their conventional counterparts by a fixed percentage, we calibrate our model to reflect the organic and conventional corn markets to illustrate the impacts that such pricing potentially has on Revenue Protection payouts under different scenarios. Findings indicate that at the 75% nominal coverage level, RMA's fixed price factor implies an effective coverage ranging from 45 to 106% depending on what the organic to conventional market price ratio is; resulting, therefore, in lower and higher indemnities compared to those organic producers should get when considering their idiosyncratic revenue distribution.

## Chapter 1: General Introduction

In recent years there has been a steady and significant growth of the organic sector. However, little economic research has been performed on the subject, likely due to the lack of data availability. Also likely because of it, the creation of the current crop insurance policy for organic farmers has been ad hoc and not based on the idiosyncratic characteristics of the organic sector. The present study aimed at starting filling this gap.

The Agricultural Risk Protection Act of 2000 recognized organic farming as a “good farming practice”, making Federal crop insurance coverage available for organic crops taking into account the idiosyncrasies of their production system. However, the incorporation of organic production 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. In addition, in the case of crop failure, organic farmers receive a compensation based on conventionally produced crop prices, so organic price premiums are not accounted for under the current insurance policy (Risk Management Agency (RMA) 2008).

During 2001 and 2002, Hanson *et al.* (2004), with RMA sponsorship, organized nationwide focus groups with organic farmers to identify and describe their risks and needs for assistance. In their study, they point out that organic farming may involve different risks than conventional farming because it does not rely on the use of pesticides and insecticides as risk management tools. Organic farmers rely instead, for example, on the use of mechanical cultivation, crop rotation and use of beneficial insect populations to manage their crops. The authors also indicate that besides weeds, pests and diseases, contamination with genetically modified organisms (GMOs), input shortage, and non-stable price premiums were mentioned by organic producers as the most relevant risks that affect their production.

In addition, at the focus group meetings organized by Hanson *et al.* (2004), organic farmers identified Federal crop insurance as a useful risk management tool. However, they also expressed their discontent with the current crop insurance policies. Farmers argued that the coverage being offered does not reflect the organic price premiums that they would receive in the market compared to their fellow non-organic producers (Hanson *et al.*, 2004). Further evidence in this regard is provided by Chen *et al.* (2007), who showed that, even though crop insurance is an important tool for apple growers to manage risk, “the low price selection and low price premium setting do not provide enough indemnity [to organic growers] when losses occur”. Furthermore, Greene and Kremen (2003) also argue that limited access to crop insurance may discourage conventional farmers from switching to organic farming.



The Food, Conservation and Energy Act of 2008, which amends part of the Federal Crop Insurance Act, was written to investigate some of these claims, requiring the U.S. Department of Agriculture to examine the 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). Such provisions establish the need to review, among others, the underwriting risk and loss experience of organic crops, determine whether significant, consistent, or variations in loss history exist between organic and non-organic production, and in accordance with the results, reduce, eliminate or increase the 5% premium surcharge for coverage of organic crops that applies to all crops and regions across the U.S.

This dissertation presents three analyses on key elements for the insurance of organic crops, namely, prices, yields and revenue; in an effort to contribute to the design of an organic crop insurance policy in which organic producers would receive coverage according to their idiosyncratic risks.

### **Dissertation Organization**

The rest of this dissertation is organized as follows. Chapter 2 investigates the dynamic relationship between organic and conventional prices for corn and soybean at the main U.S. organic markets. In addition, the dynamic relationships between organic prices across different geographic locations are analyzed and compared with their conventional counterparts. For such analysis, Monte Carlo experiments are conducted to compute appropriate critical values for such cointegration tests given the behavior shown by the organic price series.

In chapter 3, the objective is to analyze the current demand for crop insurance from organic grain and oilseed producers in three Midwestern states using farm-level data. More specifically, the chapter aims at delineating the profile characteristics of organic corn and soybean producers in Iowa, Minnesota and Wisconsin; as well as describing their production and price risk management strategies usage and comparing it to that of crop insurance. In addition, the demand for crop insurance from organic corn and soybean producers in the aforementioned states is analyzed using a discrete choice model so as to determine which variables, if any, influence their decision of whether to purchase crop insurance, as well as their product choices. Finally, chapter 3 investigates whether significant variations in yield exist between organic and conventional methods of production.

In chapter 4, a framework is developed to examine the 2011 pilot program established by the RMA to insure organic crops. For that purpose, a stochastic structural model that incorporates producers' rational expectations is calibrated to reflect the organic and conventional corn markets,

and illustrates the impacts that such pricing potentially has on Revenue Protection indemnities under different scenarios.

Chapter 5 summarizes the findings of this dissertation and presents the general conclusions.

## Chapter 2: Organic Crop Prices, or 2x Conventional Ones?

### Introduction

Born (2005, p. 1) noted that “prices for organic grains and oilseeds were about double the conventional prices from 1995 to 2003”. Such “doubling” in organic crop prices is a commonly held belief in the organic agriculture sector. But, does that “doubling” depict the true existing relationship between the conventional and organic grain and oilseed markets? Is there any other relationship that links those conventional and organic markets? Or, is it that they are not really related to each other? The present study provides information to answer these questions.

A priori, one would expect organic crop prices to closely follow conventional ones in the U.S., not only due to the thinness of organic markets, but also because organic crops account for a very small share of cropland. In 2008, only 0.57% of U.S. cropland was planted with organic crops; and although organic corn and soybeans are among the main organic crops in the U.S. in terms of acreage, they respectively account for only 0.21% and 0.20% of the total cropland devoted to such crops (USDA-ERS 2008a). In addition, one might expect organic crops to sell at a premium because, as argued by Clarkson (2007) and exemplified by Loureiro, McCluskey and Mittelhammer (2001), some consumers strongly prefer them 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). McBride and Greene (2008) also found that organic production involves higher 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 as profitable as, or outperform, conventional ones.<sup>1</sup>

Price dynamics in organic crop markets need not be the same as in conventional ones because they are less liquid. In many instances, it is difficult for organic producers to find spot markets for their crops to turn them into cash. This feature stimulates more complex relationships between producers and buyers in organic markets, and it makes contracting ahead of planting a key feature of crop marketing (Born 2005). Dimitri and Oberholtzer (2008) found evidence that contracting is the primary method for selling in the organic sector, with organic handlers procuring 46% of their supply under written contracts, 24% under informal contracts, and only 27% through spot markets in 2004. In contrast, spot market transactions account for almost a 60% share for the agricultural sector as a whole (MacDonald *et al.* 2004).

The Agricultural Risk Protection Act of 2000 recognized organic farming as a “good farming practice”, making Federal crop insurance coverage available for organic crops taking into account the idiosyncrasies of their production system. However, the incorporation of organic production 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). In addition, in the case of crop failure, organic farmers receive a compensation based on conventionally produced crop prices, so organic price premiums are not accounted for under the current insurance policy (Risk Management Agency (RMA) 2008).<sup>2</sup> In this regard, Chen, Wang, and Makus (2007) showed that crop insurance is an important risk management tool for apple growers; however, “the low price selection and low price premium setting do not provide enough indemnity [to organic growers] when losses occur”. Greene and Kremen (2003) further argue that limited access to crop insurance may discourage conventional farmers from switching to organic farming.

Having established the importance of price premiums for the organic agricultural sector, from producers to processors, as well as for governmental agencies and insurance companies, it should be evident that a better understanding of the relationship between organic and conventional crop markets is quite relevant. Interestingly, however, an extensive literature review resulted in a noticeable lack of rigorous studies focusing on the analysis of organic crop prices and their premiums over conventional ones. One possible exception is Streff and Dobbs (2004), but their work was limited to the northern plains and upper Midwest region, and provided no quantitative analysis of the organic price premiums depicted in their plots.

Given the relevance of the relationship between organic prices and conventional ones, and the absence of related quantitative studies, the present work aims at starting to fill this gap in the literature by analyzing organic price premiums. More specifically, this study investigates the dynamic relationship between organic and conventional prices for corn and soybean at the main U.S. organic markets. In addition, the dynamic relationships between organic prices across different geographic locations are analyzed and compared with their conventional counterparts. Results may prove useful to identify the price risks that organic methods of production are subject to. The analysis is also likely to yield useful information to improve the pricing provisions of RMA organic insurance rates, correct the insurance price determination by which organic producers get compensated for when losses occur, and offer additional price elections for organic crops. Further, the present results may help determine the potential usefulness of existing futures and option markets to cross hedge organic producers’ price risks.

## Data

Organic market data are scarce and difficult to obtain, so we are grateful to the Rodale Institute (Rodale) for providing us its unique historic time series of organic corn and soybean spot prices, and the procedures it follows to acquire them. Rodale's database comprises a number of market locations that roughly cover the entire U.S. and constitutes, to the best of our knowledge, the most complete, updated and extensive set of historic organic prices. Rodale has been collecting and comparing the prices of organic and conventional crops, in some cases as far back as 2003, and making them publicly available on the internet via their Organic Price Report.

The main data set used here consisted of organic corn and soybean feed price series. Such prices are provided to Rodale on a weekly basis by large elevators or handlers that specialize in organic grains and oilseeds, and reflect spot prices paid to organic producers. We focused on corn and soybean because they are among the organic crops with the largest area planted in the U.S. (USDA-ERS 2008a). In addition, corn and soybean had the fewest number of missing observations relative to the other available series. The main corn (soybean) series corresponded to the Dallas, Fargo, Minneapolis, and Omaha (Fargo, Minneapolis, and Omaha) markets, each involving 246 weekly price observations starting in late October 2004 and ending in early July 2009. Two additional price series for both corn (Detroit and San Francisco) and soybean (Detroit and Dallas) were also analyzed, but they covered a period about one year shorter. Table 1 shows additional information regarding period covered and number of observations for each series.

Missing observations were replaced by the average of the two contiguous ones, provided the previous and following observations were the same. However, in a few instances the missing observations were between a price change. To assess the robustness of the results to the method used to fill in such missing observations, we performed all of the analysis under three different scenarios. Missing observations were replaced by the values of the immediately preceding and the immediately following observations in the first and second scenarios, respectively, and by the average of the contiguous observations in the third one.<sup>3</sup> Since results were essentially the same under all of them, only results for the first scenario are reported throughout this article.

For comparative purposes, Rodale uses conventional crop prices gathered by the United States Department of Agriculture's (USDA) Agricultural Marketing Service (AMS), selecting AMS regions that handle product within the geographic location of the elevators or handlers (see <http://www.rodaleinstitute.org/Organic-Price-Report>). Here we used comparable conventional price series, obtained by applying the procedure described by Rodale to the data in the corresponding AMS reports (i.e., US GR 110, SF GR 110, MS GR 110, and WH GR 111 for Dallas, Fargo, Minneapolis,

and Omaha, respectively).<sup>4</sup> The analysis was also conducted employing the conventional Rodale series instead. In the interest of space, the latter results are omitted because the main conclusions remained unchanged.

## Methods

The dynamic relationships between organic and conventional prices were investigated using time series econometrics. To this end, following standard practice in the literature, all of the original price series were converted to natural logarithms. In a first stage, the stationarity properties of the series were explored by visual inspection of the sample autocorrelation (ACF) and partial autocorrelation (PACF) functions (Box and Jenkins 1970), to determine the parameter of integration that would make them stationary. The visual analysis was supplemented with the Elliot, Rothenberg, and Stock (ERS) unit-root tests, which are formal statistical tests to determine the parameter of integration. The ERS test is a modified Augmented Dickey Fuller (ADF) test that can accommodate more general formulations of the error (Greene 2002). Maddala and Kim (2004, p.99) point out that the ERS test dominates the ADF test and, therefore, should be used instead.

ERS's Dickey-Fuller GLS (DF-GLS) method is described in Maddala and Kim (2004). Succinctly, ERS tests the null hypothesis that  $a_0 = 0$  in the following equation:

$$(1) \quad \Delta y_t^d = a_0 y_{t-1}^d + a_1 \Delta y_{t-1}^d + \dots + a_q \Delta y_{t-q}^d + \varepsilon_t,$$

where  $\Delta \equiv (1 - L)$  denotes first differences,  $L$  is the lag operator,  $y_t^d$  is the locally detrended series  $y_t$ ,  $a_s$  are regression parameters, and  $\varepsilon_t$  is an error term. A detrended series model with a linear trend is generally used, which takes the form  $y_t^d \equiv y_t - \hat{\kappa}_0 - \hat{\kappa}_1 t$ , where  $\hat{\kappa}_0$  and  $\hat{\kappa}_1$  are obtained by regressing  $\bar{y} \equiv [y_1, (1 - L \bar{\alpha}) y_2, \dots, (1 - L \bar{\alpha}) y_T]$  on  $\bar{z} \equiv [z_1, (1 - L \bar{\alpha}) z_2, \dots, (1 - L \bar{\alpha}) z_T]$ ,  $z_t \equiv [1, t]'$ ,  $\bar{\alpha} \equiv 1 + \bar{c} / T$ ,  $T$  is the number of observations in the time series, and  $\bar{c}$  is a parameter fixed by ERS at  $-13.5$ .

A potentially important pitfall of the procedure just described for the present data is that, as shown later, there is strong evidence that organic prices do not follow the same distribution as conventional prices. In particular, organic prices are more realistically modeled as jump processes rather than diffusions. The ERS test (as well as the ADF test) is only asymptotically valid for non-normal errors (Elliot, Rothenberg, and Stock 1996); hence, their applicability to a small sample like the one under study is questionable. For this reason, Monte Carlo experiments were conducted to

compute appropriate critical values for this application. The advocated Monte Carlo experiments are explained next.

*Monte Carlo Experiment to Test for Unit Roots in Organic Prices*

Organic log-prices were simulated as the jump process (2):

$$(2) \quad \ln(P_t^o) = \begin{cases} \ln(P_{t-1}^o) + J_t^o & \text{with probability } \pi_t^o, \\ \ln(P_{t-1}^o) & \text{with probability } (1 - \pi_t^o). \end{cases}$$

If the organic log-prices were stationary, they would have an unconditional mean equal to  $\mu^o$ .

Defining the difference between the log-price at date  $t$  and the unconditional mean as  $e_t^o \equiv \ln(P_t^o) - \mu^o$ , for organic prices to tend to return back to their long-term mean both the jump probability ( $\pi_t^o$ ) and the jump size ( $J_t^o$ ) were assumed to be functions of the lagged residuals ( $e_{t-1}^o$ ) as in (3) and (4):

$$(3) \quad \pi_t^o = 1 / \{1 + \exp[-\gamma(\lambda_0^o + \lambda_1^o |e_{t-1}^o|) - (1 - \gamma) A_0^o]\},$$

$$(4) \quad J_t^o \sim N(\gamma\theta^o e_{t-1}^o, \gamma^2(\theta^o \sigma^o)^2 + (1 - \gamma)^2(\Sigma^o)^2).$$

In (3) and (4),  $\lambda_0^o$ ,  $\lambda_1^o$ ,  $A_0^o$ ,  $\theta^o$ ,  $\sigma^o$ , and  $\Sigma^o$  are parameters whose values were set equal to the respective point estimates computed using organic Minneapolis log-price data. Minneapolis was used as the baseline market because it is located in Minnesota across the border from Wisconsin, and the former was the state with the largest area devoted to organic soybean from 2000 to 2008 and to organic corn from 2003 to 2006, and the second largest area planted with organic corn in 2007 and 2008 after Wisconsin (USDA-ERS 2008b-c). Parameter  $\gamma \in [0, 1]$  can be fixed so as to yield price autocorrelations of varying strength. The extreme scenarios of  $\gamma = 1$  and  $\gamma = 0$  result in the strongest possible autocorrelation and unit root, respectively.

Parameters  $\lambda_0^o$  and  $\lambda_1^o$  in (3) were set equal to the coefficient estimates from a logit regression in which the dependent variable took values of zero or one depending on whether an organic price change occurred, and the independent variables were a vector of ones and the absolute value of the lagged error  $e_{t-1}^o$ . However, since  $\lambda_0^o$  and  $\lambda_1^o$  are meant to represent the strongest autocorrelation possible consistent with the number of jumps and the lagged errors in the data, the values of the variables were reordered before fitting the logit so as to have the jumps aligned with the largest absolute lagged errors. Parameter  $A_0^o$ , on the other hand, is associated with the opposite case of no autocorrelation (i.e., the lagged error does not affect the occurrence of price changes).

Therefore,  $A_0^O$  was set equal to the point estimate of the coefficient of another logit regression in which the dependent variable was a binary variable taking values of zero or one depending on the occurrence of price changes, but where the independent variable was a vector of ones.

The log-jumps simulated according to (4) have a normal distribution with mean and variance consisting of a  $\gamma$ -weighted combination of jumps inducing autocorrelation and jumps not inducing autocorrelation. The former jumps are governed by parameters  $\theta^O$  and  $\sigma^O$ , and their magnitudes are inversely related to the lagged errors  $e_{t-1}^O$  to the maximum extent possible consistent with the data. Jumps not inducing autocorrelation are driven by parameter  $\Sigma^O$ , and their size is independent of the lagged errors  $e_{t-1}^O$ . The value of  $\theta^O$  was set equal to the ordinary least squares (OLS) estimates from a regression of the organic corn and soybean log-price jumps against the corresponding lagged errors  $e_{t-1}^O$ , previous rearrangement of the variable values so as to associate the largest (smallest) jumps with the smallest (largest) lagged errors. Parameter  $\sigma^O$  was set equal to the standard deviation of the residuals from such regression. The value of  $\Sigma^O$  was fixed at the standard deviation of the log-jump magnitudes in the data.

Importantly, because of the chosen parameterization, the Monte Carlo design allowed us to simulate series that depicted key features of the actual series (e.g., jump probabilities and jump sizes), while varying the strength of the simulated autocorrelation relationship by fixing the value of parameter  $\gamma$  in (3) and (4) anywhere between 0 and 1. Reported results correspond to simulations performed for the polar case of unit root ( $\gamma = 0$ ) and a scenario of medium-strength autocorrelation ( $\gamma = 0.5$ ). The unit-root case was used to compute the critical values for the unit root test in the presence of jumps, whereas the autocorrelation case enabled us to examine the power of the test. Both experiments consisted of 10,000 simulations of the organic log-price series following the aforementioned parameterizations.

Observations for each of the 10,000 simulated series were obtained by performing the following iterative procedure:

- Step 1. Set  $\ln(P_{(0)}^O)$  equal to the first observation from the actual organic log-price series for Minneapolis.
- Step 2. Compute the  $j$ th lagged error  $e_{(j)}^O = \ln(P_{(j)}^O) - \mu^O$ .



Step 3. Compute the  $(j+1)$ th probability of jump:

$$\pi_{(j+1)}^o = 1/\{1 + \exp[-\gamma(\lambda_0^o + \lambda_1^o |e_{(j)}^o|) - (1 - \gamma) A_0^o]\}.$$

Step 4. Generate an observation  $U_{(j+1)}$  from a standard uniform distribution.

Step 5. If  $U_{(j+1)} > \pi_{(j+1)}^o$ , set  $\ln(P_{(j+1)}^o) = \ln(P_{(j)}^o)$  and go to Step 7. Otherwise, go to Step 6.

Step 6. Draw  $J_{(j+1)}^o \sim N(\gamma\theta^o e_{(j)}^o, \gamma^2(\theta^o\sigma^o)^2 + (1 - \gamma)^2(\Sigma^o)^2)$ , and set  $\ln(P_{(j+1)}^o) = \ln(P_{(j)}^o) + J_{(j+1)}^o$ .

Step 7. If  $j < 10,000 + T$ , go back to Step 2. Otherwise, stop.

The first 10,000 observations of each simulation were used as a “burning period” and discarded to ensure randomness and independence from starting values. The last  $T$  observations of each simulation were kept to compute critical values for the unit root test, by fitting regression (1) and then estimating the  $t$  statistic corresponding to the associated coefficient  $a_0$  for each of the simulated series under  $\gamma=0$ . For example, the critical residual test value at the  $z\%$  significance level was set equal to the  $(1 - z)^{\text{th}}$  percentile of the 10,000  $t$  values obtained in this manner. To compute the power of the test, an additional 10,000  $t$  statistics were estimated in the same way but for the series simulated under  $\gamma=0.5$ . Then, the power corresponding to the  $z\%$  significance test was calculated as the percentage of such  $t$  values that exceeded the  $z\%$  critical value.

### *Cointegration Analysis*

As shown in the “Results and Discussion” section, both the visual ACF and PACF inspection and ERS tests strongly supported the hypothesis that all log-price series are nonstationary and integrated of order one ( $I(1)$ ), i.e., they were rendered stationary after taking first differences. Therefore, the relationship between organic and conventional log-prices was examined by means of cointegration analysis. Introduced by Granger (1981), cointegration is a concept involving long run relationships between integrated variables. In a bivariate case, for example, if  $x_t$  and  $y_t$  are both  $I(1)$  variables, they are cointegrated if there exists a  $\beta$  such that the linear combination  $u_t = y_t - \beta x_t$  is stationary (i.e.,  $u_t$  is  $I(0)$ ), where  $\beta$  indicates the long-run equilibrium relationship between the two variables. However, if  $u_t$  is  $I(1)$ , then it means that  $y_t$  and  $x_t$  are not cointegrated (Maddala and Kim 2004). Intuitively, if  $y_t$  and  $x_t$  are cointegrated, on average the difference between  $y_t$  and  $\beta x_t$  is the unconditional expectation of  $u_t$  ( $E(u_t)$ ). At any point in time  $y_t - \beta x_t$  may be different from  $E(u_t)$ , but  $y$  and  $x$  will evolve in such a way so as to bring the difference  $y - \beta x$  back to  $E(u_t)$ . In contrast, if  $y$  and  $x$  are not cointegrated, the

unconditional mean of  $u_t$  does not exist, and as  $y$  and  $x$  evolve over time they do not have a tendency to restore a long-run relationship between them.

With the cointegration concept in mind, the second step of the data analysis was to determine whether organic and conventional prices were linked by any long-run equilibrium relationship by testing for cointegration. For this purpose, OLS regressions of organic log-prices ( $\ln(P_t^O)$ ) on conventional log-prices ( $\ln(P_t^C)$ ) were fit for each market location:

$$(5) \quad \ln(P_t^O) = b_0^{OC} + b_0^{OC} \ln(P_t^C) + v_t^{OC},$$

where  $b^{OC}$ s are parameters and  $v_t^{OC}$  is a residual. Then, the estimated residuals ( $\hat{v}_t^{OC}$ ) were examined to determine whether they were stationary or not.

Residual-based cointegration tests have “no cointegration” as the null hypothesis and, thus, test  $\hat{v}_t^{OC}$  for a unit root.<sup>5</sup> For this purpose it is common practice to apply Phillips’ (1987)  $Z_\alpha$  test (Maddala and Kim 2004), which Phillips and Ouliaris (1990) advocate over the ADF or  $Z_t$  tests for having superior power properties. Phillips’  $Z_\alpha$  test statistics is calculated as

$$(6) \quad \hat{Z}_\alpha = T(\hat{\alpha} - 1) - (1/2)(s_{Tl}^2 - s_k^2)(T^{-2} \sum_{t=2}^T (\hat{v}_{t-1}^{OC})^2)^{-1},$$

where  $s_{Tl}^2 \equiv T^{-1} \sum_{t=1}^T \hat{k}_t^2 + 2T^{-1} \sum_{\tau=1}^l w_{\tau l} \sum_{t=\tau+1}^T \hat{k}_t \hat{k}_{t-\tau}$ ,  $s_k^2 \equiv T^{-1} \sum_{t=1}^T \hat{k}_t^2$ ,  $w_d = 1 - d(l+1)$ ,  $l$  is a window parameter, and  $\hat{\alpha}$  and  $\hat{k}_t$  are obtained by performing the regression  $\hat{v}_t^{OC} = \hat{\alpha} \hat{v}_{t-1}^{OC} + \hat{k}_t$ .

In addition to the relationship between organic and conventional prices, the extent to which organic prices at different locations are related in the long run was examined by fitting OLS regressions like (5) but using organic log-prices for two different markets at a time, and performing cointegration tests on their residuals. For comparative purposes, a similar procedure was also employed on conventional log-prices for different market locations.

Similar to the unit root tests discussed earlier, a potentially important shortcoming of applying cointegration to our data is that organic log-prices are better represented as jump processes, whereas existing critical test values have been generated from two series with independent and identically distributed (i.i.d.) normal errors with zero mean and constant variance (e.g., Phillip and Ouliaris 1990, p. 168 eq. (3) and Engle and Yoo 1987, p.153). Hence, appropriate critical values were obtained from the Monte Carlo experiments described next.

*Monte Carlo Experiment to Test for Cointegration Between Organic and Conventional Prices*

Given the widespread belief that organic prices are twice as large as conventional prices, for simulation purposes the postulated cointegrating relationship between the two price series was

$$(7) \quad \ln(P_t^O) = \ln(2) + \ln(P_t^C) + v_t^{OC}.$$

Further, since the conventional market dwarfs the organic one, it was assumed that cointegration was due to the organic prices changing in response to changes in conventional prices, rather than the other way around. That is, the simulated cointegrated series involved log-prices changing independently of organic log-prices, and the latter reacting so as to re-establish the long-term relationship between the two price series.

$I(1)$  log-price series for conventional corn and soybean were computed by letting  $\ln(P_t^C) = \ln(P_{t-1}^C) + \varepsilon_t^C$ , where  $\varepsilon_t^C \sim N(0, s^2)$  and the values used for parameter  $s^2$  matched the estimates from the original Minneapolis conventional log-price data, as explained in Tsay (2005). That is, conventional prices were assumed to follow a discrete-time limiting case of a geometric Brownian motion (Dixit and Pindyck 1994).

Organic log-prices were simulated as a jump process like (2). However, consistent with the assumption of organic-conventional cointegration being driven by organic prices reacting so as to restore the long-run relationship with conventional prices, both the jump probability and the jump size were made functions of the lagged cointegration residuals ( $v_{t-1}^{OC}$ ) as follows:

$$(8) \quad \pi_t^O = 1/\{1 + \exp[-\gamma(\lambda_0^{OC} + \lambda_1^{OC} |v_{t-1}^{OC}|) - (1 - \gamma) A_0^{OC}]\},$$

$$(9) \quad J_t^O \sim N(\gamma\theta^{OC} v_{t-1}^{OC}, \gamma^2(\theta^{OC} \sigma^{OC})^2 + (1 - \gamma)^2(\Sigma^{OC})^2).$$

That is, (8) and (9) are functions analogous to (3) and (4), but involving  $v_{t-1}^{OC}$  instead of  $e_{t-1}^O$ .

Parameters  $\lambda_0^{OC}$ ,  $\lambda_1^{OC}$ ,  $A_0^{OC}$ ,  $\theta^{OC}$ ,  $\sigma^{OC}$ , and  $\Sigma^{OC}$  were estimated using sample data in a manner analogous to the estimation of  $\lambda_0^O$ ,  $\lambda_1^O$ ,  $A_0^O$ ,  $\theta^O$ ,  $\sigma^O$ , and  $\Sigma^O$  described earlier.<sup>6</sup>

It should become clear that the design of the Monte Carlo experiment followed the reasoning behind an error correction model; hence, under the hypothesis of cointegration, the organic log-prices tended to change so as to bring the system back to the long-run equilibrium (7). In other words, in the cointegration case, the short-run dynamics of the organic prices were influenced by the departures from the long-run equilibrium, so that

$$(10) \quad \Delta \ln(P_{t+1}^O) = \phi [\ln(P_t^O) - \ln(2) - \ln(P_t^C)] + e_{t+1}^O, \phi > 0,$$

whereas changes in conventional log-prices were exogenously driven.

Reported results correspond to simulations performed for scenarios with  $\gamma=0$  (used to compute the critical values for the residual test in the presence of jumps) and  $\gamma=0.5$  (used to examine the power of the test).

Both experiments consisted of 10,000 simulated series, each of them computed by performing the following iterations:

Step 1. Set  $\ln(P_{(0)}^O)$  and  $\ln(P_{(0)}^C)$  equal to the first observation from the actual organic and conventional log-price series for Minneapolis, respectively.

Step 2. Compute the  $j$ th cointegration error  $v_{(j)}^{OC} = \ln(P_{(j)}^O) - \ln(2) - \ln(P_{(j)}^C)$ .

Step 3. Compute the  $(j+1)$ th probability of jump:

$$\pi_{(j+1)}^O = 1/\{1 + \exp[-\gamma(\lambda_0^{OC} + \lambda_1^{OC} |v_{(j)}^{OC}|) - (1 - \gamma) A_0^{OC}]\}.$$

Step 4. Generate an observation  $U_{(j+1)}$  from a standard uniform distribution.

Step 5. If  $U_{(j+1)} > \pi_{(j+1)}^O$ , set  $\ln(P_{(j+1)}^O) = \ln(P_{(j)}^O)$  and go to Step 7. Otherwise, go to Step 6.

Step 6. Draw  $J_{(j+1)}^O \sim N(\gamma\theta^{OC} v_{(j)}^{OC}, \gamma^2 (\theta^{OC} \sigma^{OC})^2 + (1 - \gamma)^2 (\Sigma^{OC})^2)$ , and set  $\ln(P_{(j+1)}^O) = \ln(P_{(j)}^O) + J_{(j+1)}^O$ .

Step 7. Draw  $\varepsilon_{(j+1)}^C \sim N(0, s^2)$ , and set  $\ln(P_{(j+1)}^C) = \ln(P_{(j)}^C) + \varepsilon_{(j+1)}^C$ .

Step 8. If  $j < 10,000 + T$ , go back to Step 2. Otherwise, stop.

The critical values and the power of the residual cointegration test were calculated from the final  $T$  simulated observations.

#### *Monte Carlo Experiment to Test for Cointegration Between Organic Prices at Different Markets*

Another Monte Carlo experiment was performed to determine the critical values and the power of the cointegration tests for the organic log-prices at different markets. This experiment differed from the previous one in that it involved the relationship between two series characterized by jump processes, so as to emulate the behavior of organic log-prices at different market locations.

The organic markets used to calibrate the cointegration errors were Minneapolis and Dallas for corn, and Minneapolis and Fargo for soybean. The Dallas market was chosen because among the other markets we had the longest series available for, its state ranked highest in terms of acreage devoted to organic corn. In the case of soybean we used Fargo because its series was about one year

longer than the Dallas series (see Table 1). The postulated long-run equilibrium relationship (i.e., the analog of (7)) between the organic log-prices at the two markets (i.e., Minneapolis and Dallas for corn, and Minneapolis and Fargo for soybean) was (11):

$$(11) \quad \ln(P_t^{O_1}) = \ln(P_t^{O_2}) + v_t^{O_1 O_2} .$$

The prices of both of the simulated organic series were assumed to change as defined by the analogs of expressions (8)-(9), so as to bring the system back to the long-run equilibrium (11). The parameterization of the (8)-(9) analogs and the simulations were performed by applying procedures similar to the ones used to analyze the organic-conventional relationship. Therefore, their description is omitted to save space.

### Results and Discussion

The organic and conventional corn and soybean spot prices series for the Minneapolis market, as well as their ratio, are depicted in panels A and B of Figure 1; the plots for the rest of the corn and soybean markets look similar and are omitted here in the interest of space. The first noticeable feature in Figure 1 is the piecewise linear shape of the organic prices, denoting a constant price for several weeks before a price change or jump occurs. It is evident that organic prices do not follow the same distribution as conventional prices, and are better characterized by a jump process. Their step-shape pricing pattern is likely to be associated with the relative thinness of the organic markets and the impact of contracting on them. According to the lower plots of both panels, the relationship between the organic and conventional prices throughout the period analyzed has been oscillating around two; as mentioned earlier, this doubling of conventional crop prices to price organic crops is considered the rule of thumb pricing in the organic sector.

Table 2 reports summary statistics for organic and conventional prices, price premiums, and price ratios for all of the market locations under study. Average ratios for all corn markets are above the “2x” threshold, denoting the persistence of substantial price premiums for organic corn. For soybean, average ratios are more closely aligned with the “doubling” rule. In all instances, however, the ratios vary substantially, as evidenced by the coefficients of variation of the ratios, and the minimum and maximum ratios in the series.

Additional information about the jump-like behavior of organic prices is furnished in Table 3. Minneapolis exhibited the largest number of jumps for both crops. Even for this market, organic corn (soybean) prices only changed 12.2% (19.9%) of the weeks. Alternatively, the average period between price jumps in Minneapolis was 8.2 (= 1/0.122) weeks for corn and 5.0 (= 1/0.199) weeks

for soybean. When a price change did occur in Minneapolis, its average size (standard deviation) was \$0.22/bu (\$1.11/bu) for corn and \$0.31/bu (\$3.10/bu) for soybean.

Figure 2 shows the ACFs and PACFs of the conventional and organic log-price series for corn in Minneapolis. Both pairs of plots are very similar; the ACFs decay very slowly and the PACFs have a significant first lag that then becomes insignificant. These ACF and PACF patterns are characteristic of nonstationary time series. Furthermore, according to Table 3.1 from Shumway and Stoffer (2006, p.109) the properties of the ACFs and PACFs depicted in Figure 2 suggest that both series follow an autoregressive process of order one or AR(1).

A series is integrated of order one, or  $I(1)$ , whenever stationarity can be achieved by taking first differences. For the Minneapolis corn data this seems to be the case, as seen from the ACFs and PACFs of the differenced organic and conventional corn log-price series shown in Figure 3. The organic series shows a spike at lag 1 in both the ACF and PACF graphs that is just above the confidence interval; however, the excess magnitude is negligible and so it could be said that after differencing once the series became stationary.

The results of the ERS tests for the complete set of organic and conventional series are presented in Table 4. For log-price levels, all test statistics are substantially below the critical values corresponding to standard levels of significance, whereas the opposite is true for log-price first differences. Therefore, the empirical evidence is consistent with the assumption that both log-price series are  $I(1)$ .

Table 5 shows results for the cointegration regression (5) and the residual-based tests corresponding to (6). The  $p$ -values for the  $\hat{Z}_\alpha$  test statistics are all larger than conventional levels of significance, with the smallest  $p$ -value equal to 0.116 (for soybean in Omaha). This indicates that the data fail to reject the null hypothesis of no cointegration for both crops in all markets. Importantly, the power of the tests is high, suggesting that the alternative of cointegration is not likely. In other words, there is not enough evidence to reject the null hypothesis that the residuals from the organic-conventional cointegrating regression contain a unit root, which means no cointegrating relationship between organic and conventional prices. These results would imply that the regressions of organic prices on conventional ones would be spurious in the sense of Granger and Newbold (1974). The organic-conventional relationship was further examined using logit and OLS regressions analogous to (8) and (9), respectively. To save space, results are omitted because no significant relationships emerged, which is consistent with the findings from the residual-based unit root tests.

In summary, the data and the tests performed on it lead us to conclude that there is no evidence of a long-run relationship, i.e., cointegration, between organic and conventional prices. This means that the relationships obtained from regressing organic prices on conventional ones for the different locations we had data for are spurious. Furthermore, the “doubling” hypothesis that endorses that organic crop prices double the conventional ones is not supported by our data, as the organic/conventional crop ratio has varied within very large bounds (see Table 1).

It is arguable whether the present results are surprising. On one hand, one might think that organic crop prices would reflect the additional cost of such method of production, making organic crops a “premium” commodity compared to their conventional counterparts, and allowing therefore for some degree of substitutability between them. In this regard, a close association between organic and conventional prices is more likely to be observed if the two types of crops are highly substitutable in production or consumption.

On the other hand, for some purposes organic and conventional crops cannot really be considered close substitutes, if substitutes at all. For example, for livestock to be considered organic it is required that it be fed with organic products as established by the National Organic Program regulations in section §205.237: “The producer of an organic livestock operation must provide livestock with a total feed ration composed of agricultural products, including pasture and forage, that are organically produced ...”

Nonetheless, it could be argued that some degree of substitutability could exist even in this latter context if the producer switches his livestock to conventional feed, making it non-organic livestock because in section §205.236 (a) the National Organic Program regulations establishes that “Livestock products that are to be sold, labeled or represented as organic must be from livestock under continuous organic management from the last third of gestation or hatching”. But such substitution is limited to a one-time event, since section §205.236 (b) states that “Livestock or edible livestock products that are removed from an organic operation and subsequently managed on a nonorganic operation may be not sold, labeled or represented as organically produced”. Therefore, producers could switch their livestock to conventional but after that they could no longer switch it back to organic. Dairy producers eventually could, however, do the switch more than once because in section §205.236 (a) it is stipulated that “Milk or milk products must be from animals that have been under continuous organic management beginning no later than one year prior to the production of the milk or milk products that are to be sold, labeled or represented as organic”, with some specific exceptions being also admitted.

Our findings of no cointegration between organic and conventional prices not only support the limited substitutability argument in production, but also exemplify the significant impact that the organic livestock feed requirements have in the organic crop market. Taking a closer look at Figure 1.A, it can be seen that in mid 2007 there was a sizable jump in organic corn prices in Minneapolis. Such a change is the largest in the series, with prices rising from \$6.75/bu to \$10/bu, that is, a 48% increase from the second to third week of July 2007. Importantly, Figure 1.A also reveals that conventional corn prices in Minneapolis did not experience a similar price change over the same period; in fact, they decreased by 13%. The behavior of corn prices in Minneapolis during mid 2007 is representative of the price dynamics in all other locations around that period.

Looking for an explanation of the contrasting behavior of the organic prices compared to the conventional ones, Born's (2005, p. 1) characterization seems to fit in: "Organic markets can be volatile, with periods of high demand and short supply for certain crops and periods of high supply and sluggish demand for others". Evidence on the matter can be found that not only supports Born's statement, but also provides further explanation with respect to the 2007 organic price jumps and their link to organic livestock requirements. For example, Clarkson (2007, p. 163) pointed out before the U.S. House of Representatives' Agriculture Committee that "demand is troubled by an increasing shortfall in the supply of organic raw materials" and then added that "U.S. demand for organic soy foods and feeds is growing so rapidly that processors probably consume twice as many organic soybeans as are produced in the U.S. Despite excellent prices and an abundance of land and great farmers, these U.S. processors find themselves importing organic soybeans from countries such as China, Brazil, Paraguay, Bolivia and Argentina".

Along the same lines, Lavigne (2007) argued that shortages of organic feed were due to the different growth pace of livestock feed demand and supply, and further added that imports of organic soybean had held its price steady while organic corn had not faced foreign competition and had, therefore, increased significantly.<sup>7</sup> Furthermore, Dimitri and Oberholtzer (2009, p. 8-9) stated that "Organic 'handlers' move nearly all organic products from the farm to the retailer" and they added that "sourcing organic ingredients has become even more challenging as demand for organic products has increased". In that study, the authors indicated that almost 60% of organic handlers faced limited supply of raw materials during 2007.

Examining the organic livestock growth trend in recent years (see Figure 4) and comparing it with the trend for acreage destined for organic corn and soybean production over the same period (Figure 5), the explanation for having short supply of organic feed crops and consequent increase in their prices (as the one we noted particularly for corn) is evident. From 2001 through 2007 the U.S.



organic beef, dairy, and poultry production increased by 325%, 241%, and 143%, respectively, whereas over that same period the acreage destined in the U.S to organic corn production increased by only 84% and the one for organic soybean actually decreased by 42%. Such disparity in growth rates between livestock and acreage for feedstuff within the organic agriculture sector, along with the imports' explanation discussed above, helps better understand the significant 2007 organic corn jump in our data.

It is worth pointing out that it is evident from Table 2 that the data are consistent with the hypothesis that organic crops sell at a premium over conventional ones. This is true because all of the minimum organic/conventional price ratios in the table are greater than unity. This means that the relationship between organic and conventional prices may be characterized by threshold cointegration. Threshold cointegration refers to the case in which the adjustment towards the long-run equilibrium, like the one defined by equation (7), is discrete (Balke and Fomby 1997; Maddala and Kim 2004) rather than continuous as assumed in the present study. In our case, threshold cointegration would imply that the adjusting process would be triggered when the organic log-price minus the conventional log-price fell below a sufficiently small positive threshold, whereas no adjustment would occur above such threshold allowing organic and conventional prices to freely diverge. Threshold cointegration could be even more relevant in the context of spatial markets, due to the presence of transaction costs (Goodwin and Piggott 2001). Unfortunately, if such thresholds do exist, the price series available are not nearly long enough to allow us to estimate them with any reasonable degree of accuracy.

The present results are useful for several reasons. Firstly, they provide important information for designing organic insurance pricing provisions. In this regard, RMA should not only take into account that prices for organic corn and soybean are higher than the corresponding conventional prices (see Table 2), but also that the former do not follow the latter. It seems sensible that crop insurance policies be offered with additional price elections, compensating organic farmers so as to better reflect the idiosyncrasies of organic agriculture. Given that RMA currently calculates organic crops' insurance rates using conventional crop prices, this recommendation is particularly relevant for the determination of rates for the Actual Production History and Crop Revenue Coverage insurance products. Secondly, conventional producers evaluating whether to switch to organic production should be aware that organic corn and soybean prices have been about as volatile as their conventional counterparts. Further, they should also be aware that organic corn and soybean have sold at a premium, but that such premium has experienced substantial volatility in both absolute as well as relative terms. Finally, the historical data indicate that existing futures and option markets

would be of little use to cross hedge the price risks of organic corn and soybean in any meaningful way.

#### *Cointegration Between Organic Prices at Different Markets*

Another dimension to the study consisted of analyzing whether organic prices in different locations are related to each other in the long run. In this way, we wanted to assess how idiosyncratic organic markets are. To this end, we fitted OLS cointegration regressions similar to (5) but for pairs of organic log-prices at different markets, so that the organic series for one location was regressed against its counterpart for a different location.

Results for the OLS regressions and the corresponding residual-based tests for location pairs for which we had at least  $T = 246$  observations are reported in Table 6. It can be noticed that all of the pairs but one for corn (Omaha-Dallas) show evidence of cointegration. It can also be seen that the evidence in favor of cointegration is strongest for pairs involving Minneapolis, suggesting that the organic hub is the Minneapolis market and that there could be some sort of price disagreement between the markets in the second tier. This is consistent with Minnesota being a top state in organic corn and soybean acreage.

To shed further light on the relationships between organic log-prices at different markets, we fitted the analogs of regressions (8) and (9). Results for the jump probability logit model and the jump size regression model are reported in Tables 7 and 8, respectively. The main insight from Table 7 is that departures from the cointegrating relationship between pairs of organic log-prices do not seem to induce changes in the probabilities of price changes. That is, jump probabilities do not appear to respond to deviations from the respective long-run relationships. However, Table 8 shows strong evidence that when organic price changes do occur, their magnitudes are significantly negatively related to the lagged cointegrating errors, so as to restore the corresponding long-run relationship between organic prices. This is true because all of the

slope estimates  $\theta_1^{O_i O_j}$  are negative and, with the exception of Omaha-Dallas corn, at least one of such estimates is statistically significantly negative for each location pair. The evidence also suggests that when the prices in the Minneapolis organic market do change, the magnitude of those price changes is influenced by shortages or excess supply in the other markets. This is interesting because, as pointed out earlier, the cointegration results in Table 6 suggest that Minneapolis is a hub, and it may be a consequence of the thinness of organic markets. Together,

Tables 7 and 8 provide further support for the hypothesis that there are long-run relationships between log-prices at different U.S. organic markets.

For completeness, and as a way of comparing the relationship between organic log-prices at different locations with those between conventional log-prices, results for the cointegration regressions and residual-based cointegration tests for the conventional log-price series are shown in Table 9. According to this table, cointegration is present in all conventional market locations at any reasonable level of significance. By comparing the results in Tables 6 and 9, it seems safe to conclude that the long-run relationship between log-prices at different locations is stronger for conventional than for organic markets.

### Conclusions

In recent years there has been a steady and significant growth of the organic sector (OTA 2009). However, little economic research has been done on the subject likely due to the lack of data availability. The present study aimed at starting filling this gap; in particular at determining whether the organic corn and soybean prices in the U.S. follow their conventional counterparts. Our findings suggest that there is no basis for advocating the existence of a long-run relationship between organic and conventional prices.

Evidence of spatial price cointegration among organic markets was found, particularly between pairs of markets we had data for and the presumed organic hub, Minneapolis, indicating that such market is the leading one. Overall, spatial cointegration in organic markets seems weaker than the one present in conventional markets, suggesting that local market forces may exert a stronger effect on the determination of local prices for organic crops than for conventional ones. Departures from the long-term relationships across organic markets do not seem to increase the probability of price changes, however, whenever price changes do occur, they tend to restore such long-term relationships.

If our conclusions for the organic corn and soybean markets extend to other organic crop markets, it would imply that organic crop markets have unique characteristics when compared with their conventional counterparts. Such idiosyncrasies need to be taken into consideration, for example, by RMA when setting the Federal crop insurance policy for organic farmers. Our results also suggest that organic prices are as volatile as conventional ones, that the premiums paid for organic crops exhibit substantial variability, and that existing futures and derivatives markets do not provide effective tools to manage price risks for the organic sector.

## Notes

1. It must be noted, however, that Welsh (1999) reported some Midwestern organic grain and soybean production systems to be more profitable than conventional ones, even without price premiums.
2. RMA is preparing a pilot program that will offer additional price elections in 2011 for four organic crops, including corn and soybean. For these two organic crops, contrarily to what our analysis will indicate as being a non-existent long run relationship, the additional price elections RMA will offer are going to be based on the prices of conventional crops. More specifically, they will be based on the minimum ratio that was observed between the corresponding organic crop price and its conventional counterpart, over the 3-year period they considered (RMA 2010).
3. It will be evident later, however, that the third scenario is inconsistent with the observed patterns for organic corn and soybean prices.
4. The SF GR 110 AMS report actually corresponds to East River South Dakota Grain Markets, but Rodale identifies it with Fargo, which is relatively close. For the San Francisco and Detroit corn series, and the Dallas and Detroit soybean series, both the organic as well as the conventional series were provided by Rodale because they were not available from AMS. There were 9 and 7 missing observations in the conventional corn series for San Francisco and Detroit, respectively, and 7 missing observations in each of the conventional soybean series for Dallas and Detroit; all of which were replaced by the average of the two contiguous observations.
5. Although a test with the null of cointegration instead might seem more appealing, Phillips and Ouliaris (1990) point out some major pitfalls associated with such an approach.
6. For example, appropriate values for  $\lambda_0^{oc}$  and  $\lambda_1^{oc}$  were obtained from a logit regression involving the re-ordered (so as to build the “ideal” logit) organic-conventional cointegrating errors for the Minneapolis market.
7. Our data confirm this line of thought because for all locations the jump in organic soybean prices over the period being discussed was much smaller; the biggest one being 18% for one location.

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**Table 1. Summary Information for Organic Prices Series**

	Corn				Soybean			
	Date		Observations		Date		Observations	
	Start	End	Total	Missing	Start	End	Total	Missing
Minneapolis	10/26/04	7/9/09	246	13	10/26/04	7/2/09	246	13
Omaha	10/26/04	7/9/09	246	13	10/26/04	7/2/09	246	13
Fargo	10/26/04	7/9/09	246	15	10/26/04	7/2/09	246	13
Dallas	10/26/04	7/9/09	246	13	10/26/04	8/5/08	198	7
Detroit	10/26/04	8/5/08	198	7	10/26/04	8/5/08	198	7
San Francisco	11/9/04	7/8/08	193	6	n/a	n/a	n/a	n/a



**Table 2. Summary Statistics for Organic and Conventional Prices, Price Premiums and their Ratio by Market**

		Corn				Soybean			
		Organic	Conv.	Premium	Ratio	Organic	Conv.	Premium	Ratio
Minneapolis	Mean	7.21	3.05	4.17	2.52	16.29	7.84	8.45	2.09
	Std.dev.	2.32	1.23	1.63	0.63	6.42	2.61	4.75	0.49
	Coeff.var.	0.32	0.40	0.39	0.25	0.39	0.33	0.56	0.24
	Min.	4.00	1.30	1.47	1.45	9.50	4.74	3.66	1.37
	Max.	11.00	6.66	8.31	4.23	31.00	14.74	22.69	3.82
Omaha	Mean	7.24	3.18	4.05	2.38	15.09	8.02	7.07	1.96
	Std. dev.	2.70	1.33	1.83	0.56	3.92	2.79	2.26	0.35
	Coeff.var.	0.37	0.42	0.45	0.23	0.26	0.35	0.32	0.18
	Min.	4.00	1.47	1.09	1.28	11.00	4.89	3.36	1.29
	Max.	11.00	7.09	8.00	3.67	25.00	15.74	16.47	2.93
Fargo	Mean	7.16	3.11	4.05	2.47	15.53	7.79	7.74	2.02
	Std.dev.	2.29	1.34	1.42	0.60	5.97	2.74	3.95	0.41
	Coeff.var.	0.32	0.43	0.35	0.24	0.38	0.35	0.51	0.20
	Min.	4.50	1.46	1.23	1.33	10.00	4.78	3.39	1.35
	Max.	11.00	7.08	7.63	3.94	31.00	15.48	19.57	3.11
Dallas	Mean	7.72	3.59	4.13	2.17	14.39	7.11	7.28	2.13
	Std.dev.	3.02	1.25	2.11	0.45	3.15	2.61	1.32	0.36
	Coeff.var.	0.39	0.35	0.51	0.21	0.22	0.37	0.18	0.17
	Min.	4.35	2.07	0.58	1.13	11.25	4.30	4.50	1.42
	Max.	13.00	7.49	8.14	3.18	21.00	14.55	10.58	2.94
Detroit	Mean	6.99	3.07	3.92	2.40	14.10	7.60	6.51	1.95
	Std.dev.	2.61	1.34	1.77	0.58	3.14	2.83	1.23	0.33
	Coeff.var.	0.37	0.44	0.45	0.24	0.22	0.37	0.19	0.17
	Min.	4.15	1.58	1.11	1.29	11.25	4.95	3.65	1.31
	Max.	11.00	7.05	7.85	3.49	21.00	16.04	9.69	2.67
San Francisco	Mean	9.00	4.30	4.70	2.10	n/a	n/a	n/a	n/a
	Std.dev.	3.28	1.43	2.28	0.41	n/a	n/a	n/a	n/a
	Coeff.var.	0.36	0.33	0.48	0.20	n/a	n/a	n/a	n/a
	Min.	5.45	2.38	2.13	1.49	n/a	n/a	n/a	n/a
	Max.	14.00	8.79	9.74	3.29	n/a	n/a	n/a	n/a

**Table 3. Summary Statistics for Jumps in Organic Prices, by Market**

		Corn	Soybean
Minneapolis	Number of observations	246	246
	Number of jumps	30	49
	Frequency of jumps	0.122	0.199
	Average jump size	0.22	0.31
	Std. Dev. jump size	1.11	3.10
Omaha	Number of observations	246	246
	Number of jumps	19	24
	Frequency of jumps	0.077	0.098
	Average jump size	0.34	0.35
	Std. Dev. jump size	1.34	1.98
Fargo	Number of observations	246	246
	Number of jumps	14	14
	Frequency of jumps	0.057	0.057
	Average jump size	0.32	0.36
	Std. Dev. jump size	0.98	3.39
Dallas	Number of observations	246	198
	Number of jumps	20	17
	Frequency of jumps	0.081	0.086
	Average jump size	0.31	0.56
	Std. Dev. jump size	1.43	1.11
Detroit	Number of observations	198	198
	Number of jumps	16	18
	Frequency of jumps	0.081	0.091
	Average jump size	0.43	0.49
	Std. Dev. jump size	0.95	1.20
San Francisco	Number of observations	193	n/a
	Number of jumps	16	n/a
	Frequency of jumps	0.083	n/a
	Average jump size	0.53	n/a
	Std. Dev. jump size	1.12	n/a

**Table 4. ERS DF-GLS Unit Root Test Statistics for Organic and Conventional Log-Prices****A. Log-Price Levels [ $\ln(P_t)$ ]**

	Conventional		Organic					
	Corn	Soybean	Corn			Soybean		
	Test stat. <sup>a</sup>	Test stat. <sup>a</sup>	Test stat.	<i>p</i> -value	Power	Test stat.	<i>p</i> -value	Power
Minneapolis	-1.81	-2.16	-1.75	0.460	0.830	-1.30	0.737	0.990
Omaha	-1.37	-1.91	-1.64	0.525	0.877	-1.49	0.628	0.976
Fargo	-1.53	-1.87	-1.33	0.715	0.964	-0.93	0.893	0.998
Dallas	-1.63	-1.81	-1.47	0.630	0.934	-0.74	0.940	1.000
Detroit	-2.31	-1.49	-1.45	0.641	0.939	-0.65	0.957	1.000
San Francisco	-1.44	n/a	-1.72	0.477	0.843	n/a	n/a	n/a

<sup>a</sup>For the conventional series, critical values for the test statistics are -3.48 (-2.89, -2.57) at the 1% (5%, 10%) significance levels, respectively (Elliot, Rothenberg and Stock, 1996, p.825).

**B. Log-Price First Differences [ $\Delta \ln(P_t) \equiv \ln(P_t) - \ln(P_{t-1})$ ]**

	Conventional		Organic <sup>b</sup>			
	Corn	Soybean	Corn		Soybean	
	Test stat. <sup>a</sup>	Test stat. <sup>a</sup>	Test stat.	<i>p</i> -value	Test stat.	<i>p</i> -value
Minneapolis	-7.77***	-5.89***	-18.50***	0.000	-13.77***	0.000
Omaha	-4.39***	-12.17***	-16.07***	0.000	-16.30***	0.000
Fargo	-5.80***	-11.80***	-15.68***	0.000	-15.65***	0.000
Dallas	-7.12***	-6.73***	-15.71***	0.000	-14.30***	0.000
Detroit	-4.50***	-8.14***	-16.17***	0.000	-15.76***	0.000
San Francisco	-3.40**	n/a	-14.94***	0.000	n/a	n/a

<sup>a</sup>For the conventional series, critical values for the test statistics are -3.48 (-2.89, -2.57) at the 1% (5%, 10%) significance levels, respectively (Elliot, Rothenberg and Stock, 1996, p.825).

<sup>b</sup>Power is omitted because the null is being rejected at standard levels of significance.

**Table 5. Regression Results for Cointegration between Organic and Conventional Log-Prices, and Residual-Based Cointegration Tests**

Model:		$\ln(P_t^O) = b_0^{OC} + b_1^{OC} \ln(P_t^C) + v_t^{OC}$						
		Residual-based test						
		$b_0^{OC}$	$b_1^{OC}$	$R^2$	# Obs.	$\hat{Z}_\alpha$	$p$ -value	Power
Corn	Minneapolis	1.28 (35.89)	0.62 (19.15)	0.60	246	-14.62	0.186	0.99
	Omaha	1.14 (30.78)	0.71 (22.12)	0.67	246	-12.32	0.277	1.00
	Fargo	1.29 (41.77)	0.60 (21.74)	0.66	246	-7.60	0.555	1.00
	Dallas	0.88 (16.68)	0.89 (21.52)	0.65	246	-11.88	0.296	1.00
	Detroit	1.18 (27.68)	0.67 (17.37)	0.61	198	-8.00	0.526	1.00
	San Francisco	0.81 (12.85)	0.94 (21.66)	0.71	194	-10.56	0.363	1.00
Soybean	Minneapolis	0.86 (9.57)	0.93 (21.01)	0.64	246	-12.17	0.282	0.761
	Omaha	1.41 (27.20)	0.63 (25.02)	0.72	246	-17.19	0.116	0.466
	Fargo	0.92 (12.21)	0.88 (23.79)	0.70	246	-9.59	0.418	0.891
	Dallas	1.58 (39.43)	0.56 (26.75)	0.79	198	-10.22	0.381	0.863
	Detroit	1.53 (37.17)	0.56 (27.01)	0.79	198	-10.39	0.373	0.854

Note:  $t$  statistics are shown in parenthesis below the corresponding coefficients.

**Table 6. Regression Results for Cointegration between Organic Log-Prices at Different Markets, and Residual-Based Cointegration Tests**

Model:		$\ln(P_t^{O_i}) = b_0^{O_i O_j} + b_1^{O_i O_j} \ln(P_t^{O_j}) + v_t^{O_i O_j}$				Residual-based test	
		$b_0^{O_i O_j}$	$b_1^{O_i O_j}$	$R^2$	# Observ.	$\hat{Z}_\alpha$	$p$ -value
Corn	Minn.-Omaha	-0.21 (-5.58)	1.10 (55.68)	0.93	246	-44.82	0.001
	Minn.-Fargo	0.11 (2.87)	0.94 (49.94)	0.91	246	-44.93	0.001
	Minn.-Dallas	-0.16 (-3.47)	1.11 (45.69)	0.90	246	-30.07	0.010
	Omaha-Fargo	0.37 (10.26)	0.81 (43.36)	0.89	246	-21.52	0.049
	Omaha-Dallas	0.04 (2.15)	1.01 (97.85)	0.98	246	-13.77	0.212
	Fargo-Dallas	-0.15 (-2.86)	1.11 (40.14)	0.87	246	-20.54	0.058
Soybean	Minn.-Omaha	1.09 (20.30)	0.58 (29.84)	0.78	246	-26.22	0.020
	Minn.-Fargo	0.34 (5.04)	0.86 (34.05)	0.82	246	-27.48	0.016
	Omaha-Fargo	-0.80 (-7.71)	1.30 (33.71)	0.82	246	-22.26	0.042

Note:  $t$  statistics are shown in parenthesis below the corresponding coefficients.

**Table 7. Logit Regression Results for Jump Probabilities between Organic Log-Prices at Different Markets**

Model:	$\pi_t^{O_i} = 1/\{1 + \exp[-(\lambda_0^{O_i O_j} + \lambda_1^{O_i O_j}  v_{t-1}^{O_i O_j} )]\}$							
	Corn				Soybean			
	$\lambda_0^{O_i O_j}$	$\lambda_1^{O_i O_j}$	<i>Mc-Fadden</i> <i>Pseudo-R</i> <sup>2</sup>	# Obs.	$\lambda_0^{O_i O_j}$	$\lambda_1^{O_i O_j}$	<i>Mc-Fadden</i> <i>Pseudo-R</i> <sup>2</sup>	# Obs.
MO: Minn.	-1.73*** (-5.65)	-4.14 (-0.97)	0.006	246	-1.46*** (-6.66)	0.57 (0.46)	0.001	246
MO: Omaha	-2.83*** (-8.20)	4.27 (1.58)	0.016	246	-2.39*** (-7.85)	2.03 (0.83)	0.004	246
MF: Minn.	-2.37*** (-7.91)	4.99 * (1.92)	0.018	246	-1.42*** (-6.15)	0.24 (0.16)	0.0001	246
MF: Fargo	-2.92*** (-6.60)	1.44 (0.32)	0.001	246	-3.12*** (-7.15)	2.62 (1.02)	0.009	246
MD: Minn.	-1.82*** (-5.97)	-2.04 (-0.64)	0.002	246	n/a	n/a	n/a	n/a
MD: Dallas	-2.80*** (-7.38)	3.64 (1.38)	0.013	246	n/a	n/a	n/a	n/a
OF: Omaha	-2.99*** (-7.66)	4.70 * (1.87)	0.024	246	-2.18*** (-5.97)	-0.56 (-0.15)	0.00001	246
OF: Fargo	-2.18*** (-4.41)	-8.80 (-1.34)	0.022	246	-2.78*** (-6.07)	-0.20 (-0.06)	0.0001	246
OD: Omaha	-1.83*** (-3.65)	-13.27 (-1.37)	0.014	246	n/a	n/a	n/a	n/a
OD: Dallas	-1.93*** (-4.32)	-10.41 (-1.22)	0.011	246	n/a	n/a	n/a	n/a
FD: Fargo	-2.47*** (-6.39)	-4.74 (-1.07)	0.012	246	n/a	n/a	n/a	n/a
FD: Dallas	-2.70*** (-7.26)	2.48 (1.04)	0.007	246	n/a	n/a	n/a	n/a

Note: MO, MF, MD, OF, OD, and FD mean Minneapolis-Omaha, Minneapolis-Fargo, Minneapolis-Dallas, Omaha-Fargo, Omaha-Dallas, and Fargo-Dallas, respectively. *t* statistics are shown in parenthesis below the corresponding coefficients.

\*\*\* (\*\*, \*) Denotes significantly different from zero at the 1% (5%, 10%) level, based on the two-sided *t* statistic.

**Table 8. OLS Regression Results for Jump Sizes between Organic Log-Prices at Different Markets**

Model:	$J_t^{O_i} = \theta_0^{O_i O_j} + \theta_1^{O_i O_j} v_{t-1}^{O_i O_j} + error_t^{O_i O_j}$							
	Corn				Soybean			
	$\theta_0^{O_i O_j}$	$\theta_1^{O_i O_j}$	$R^2$	# Observ.	$\theta_0^{O_i O_j}$	$\theta_1^{O_i O_j}$	$R^2$	# Observ.
MO: Minn.	0.01 (0.57)	-0.81*** (-4.36)	0.41	30	0.03 (1.57)	-0.33*** (-3.63)	0.22	49
MO: Omaha	0.05 (1.08)	-0.13 (-0.29)	0.005	19	0.02 (0.79)	-0.24 (-1.14)	0.05	24
MF: Minn.	0.02 (1.00)	-0.63*** (-3.16)	0.26	30	0.03 (1.45)	-0.40*** (-4.08)	0.26	49
MF: Fargo	0.02 (0.90)	-0.70*** (-3.39)	0.48	14	0.04 (1.06)	-0.56** (-2.16)	0.28	14
MD: Minn.	0.01 (0.66)	-0.66*** (-3.63)	0.32	30	n/a	n/a	n/a	n/a
MD: Dallas	0.04 (1.01)	-0.13 (-0.41)	0.009	20	n/a	n/a	n/a	n/a
OF: Omaha	0.03 (0.82)	-0.36 (-1.15)	0.07	19	0.01 (0.56)	-0.55*** (-3.02)	0.29	24
OF: Fargo	0.02 (0.77)	-0.91*** (-4.44)	0.62	14	0.005 (0.14)	-0.56** (-2.37)	0.32	14
OD: Omaha	0.05 (1.30)	-0.28 (-0.33)	0.006	19	n/a	n/a	n/a	n/a
OD: Dallas	0.04 (1.07)	-0.70 (-0.92)	0.04	20	n/a	n/a	n/a	n/a
FD: Fargo	-0.03 (-0.14)	-1.05*** (-4.41)	0.68	14	n/a	n/a	n/a	n/a
FD: Dallas	0.028 (0.72)	-0.36 (-1.34)	0.09	20	n/a	n/a	n/a	n/a

Note: MO, MF, MD, OF, OD, and FD mean Minneapolis-Omaha, Minneapolis-Fargo, Minneapolis-Dallas, Omaha-Fargo, Omaha-Dallas, and Fargo-Dallas, respectively.  $t$  statistics are shown in parenthesis below the corresponding coefficients.

\*\*\* (\*\*, \*) Denotes significantly different from zero at the 1% (5%, 10%) level, based on the two-sided  $t$  statistic.

**Table 9. Regression Results for Cointegration between Conventional Log-Prices at Different Markets, and Residual-Based Cointegration Tests**

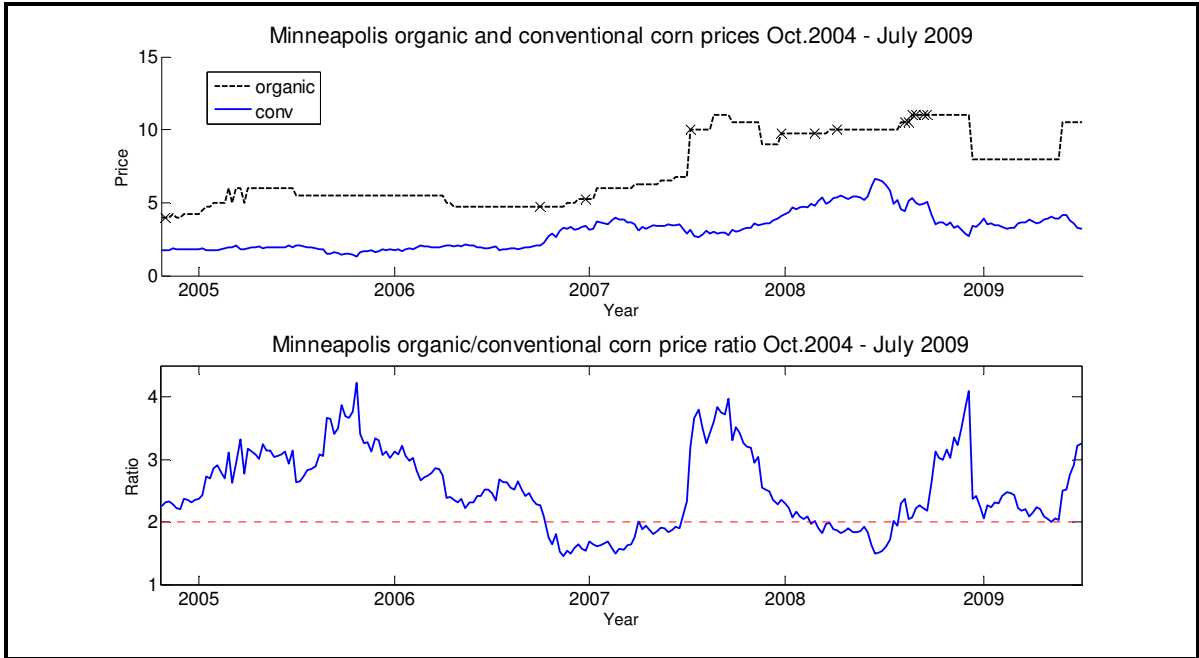
Model:		$\ln(P_t^{C_i}) = b_0^{C_i C_j} + b_1^{C_i C_j} \ln(P_t^{C_j}) + v_t^{C_i C_j}$				Residual-based test	
		$b_0^{C_i C_j}$	$b_1^{C_i C_j}$	$R^2$	# Observ.	$\hat{Z}_\alpha$	$p$ -value <sup>a</sup>
Corn	Minn.-Omaha	-0.002 (-0.24)	1.04 (125.77)	0.98	246	-65.12	0.0000
	Minn.-Fargo	-0.05 (-5.08)	1.06 (112.56)	0.98	246	-59.78	0.0000
	Minn.-Dallas	0.36 (38.86)	0.84 (101.30)	0.98	246	-83.65	0.0000
	Omaha-Fargo	-0.04 (-6.82)	1.02 (166.38)	0.99	246	-23.91	0.0005
	Omaha-Dallas	0.36 (43.79)	0.80 (111.35)	0.98	246	-49.80	0.0000
	Fargo-Dallas	0.40 (59.34)	0.79 (130.83)	0.99	246	-74.23	0.0000
Soybean	Minn.-Omaha	-0.02 (-1.31)	1.02 (132.05)	0.99	246	-34.43	0.0000
	Minn.-Fargo	-0.06 (-3.66)	1.02 (128.43)	0.98	246	-31.80	0.0000
	Omaha-Fargo	-0.04 (-5.19)	1.00 (292.28)	0.99	246	-82.71	0.0000

<sup>a</sup>Calculated based on McKinnon (1994).

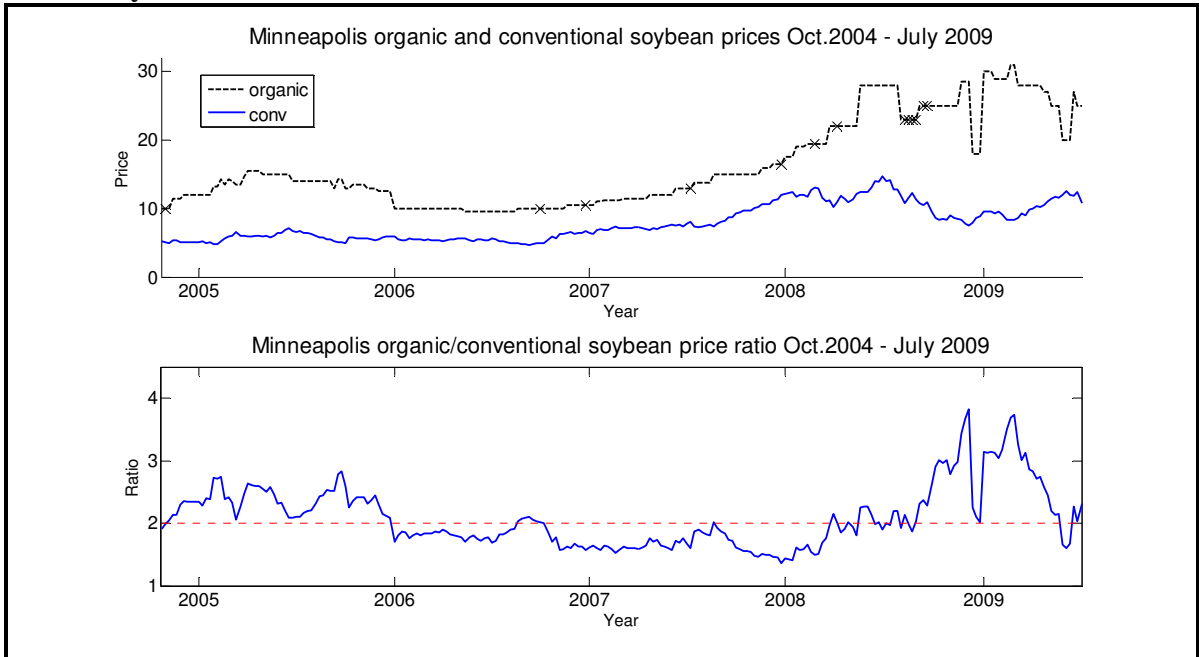
Note:  $t$  statistics are shown in parenthesis below the corresponding coefficients.



**A. Corn**

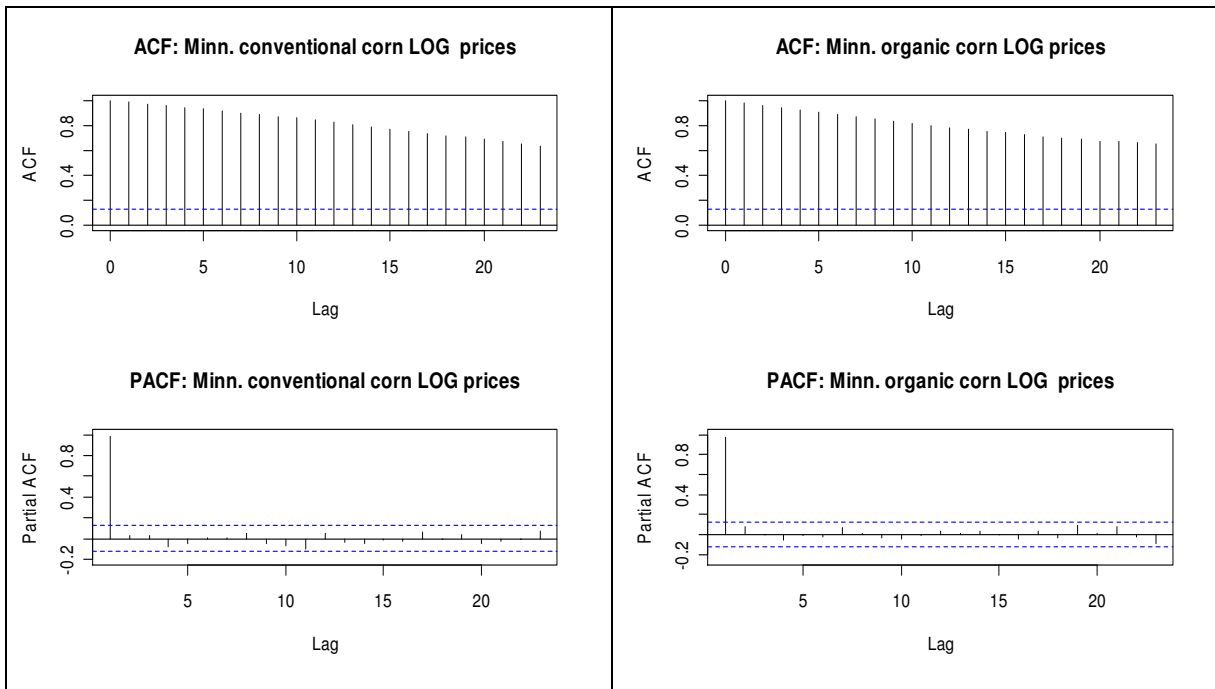


**B. Soybean**

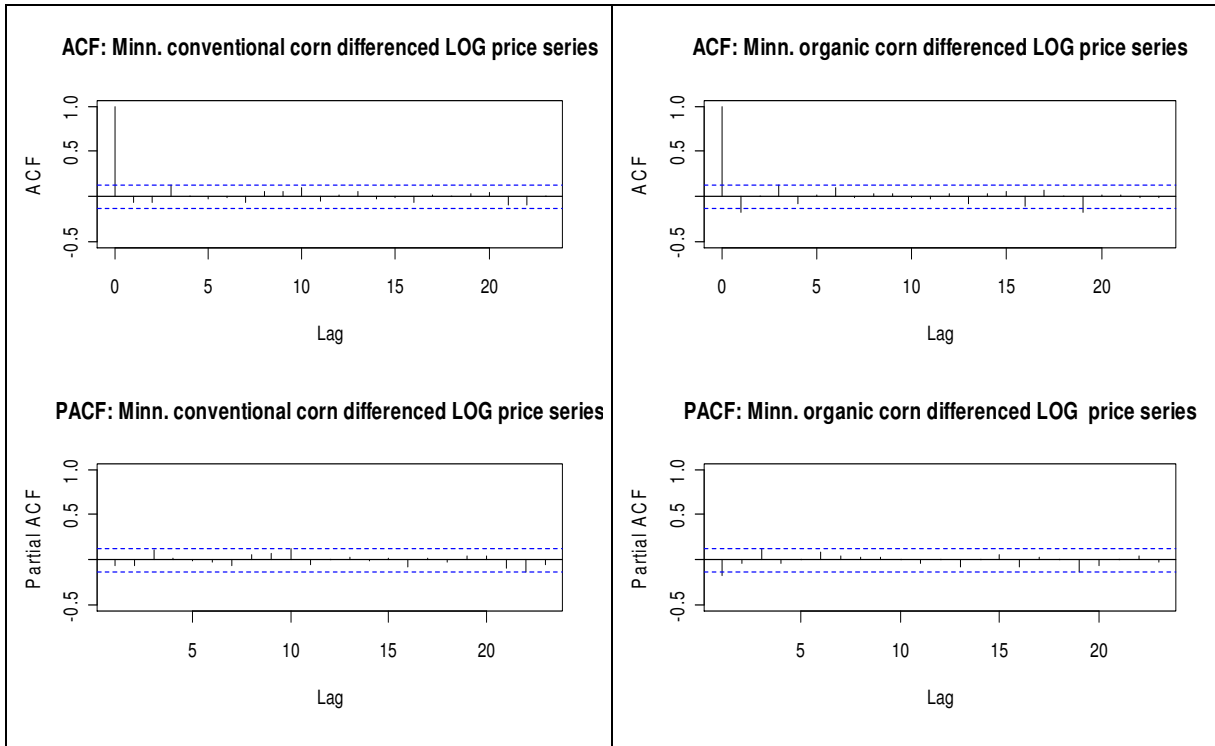


**Figure 1. Organic and Conventional Prices and their Ratios for Minneapolis**

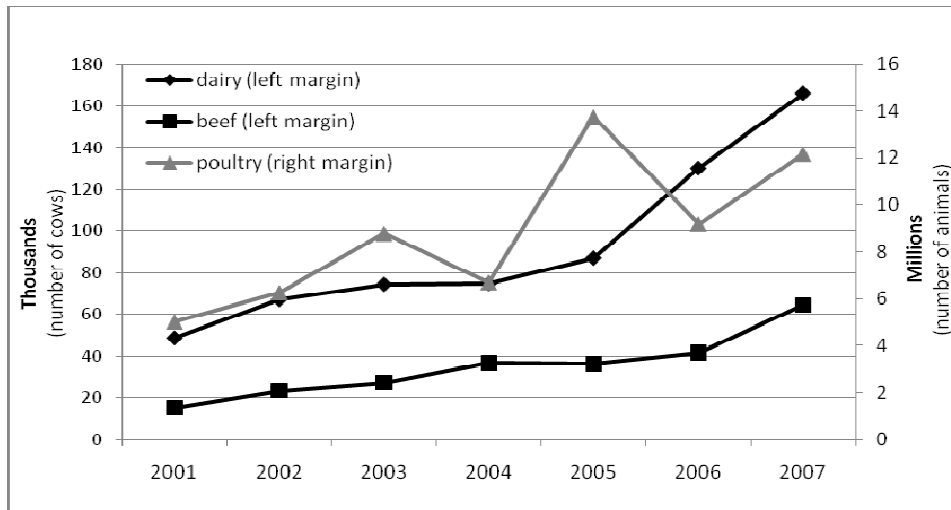
Note: The crosses denote missing observations in the original series



**Figure 2. ACFs and PACFs of Corn Log-Prices in Minneapolis**

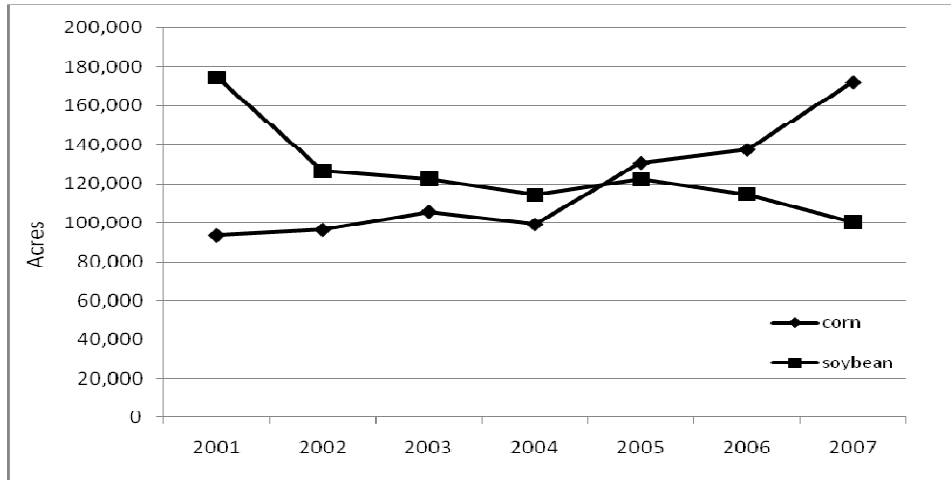


**Figure 3. ACFs and PACFs of First-Differenced Corn Log-Prices in Minneapolis**



Source: USDA-ERS (2008d).

**Figure 4. Organic Dairy and Beef Cow Production, and Poultry Production in the U.S., 2001-2007**



Source: USDA-ERS (2008b-c).

**Figure 5. Organic Corn and Soybean Acreage in the U.S. 2001-2007**

### Chapter 3: Demand for Crop Insurance for Organic Corn and Soybean Farmers in Three Major Producing States

#### Introduction

The Agricultural Risk Protection Act of 2000 recognized organic farming as a good farming practice. Thus, organic crops are covered by Federal crop insurance taking into account some of the idiosyncrasies of the organic production system. In addition to the production risks covered for conventional producers, organic farmers that sign up for coverage are compensated for production losses from damage due to insects, disease, and/or weeds (Dimitri and Greene, 2002). In total, the Risk Management Agency (RMA) provided roughly \$90 billion in crop insurance protection in 2008, covering over 350 commodities across 272 million acres.

However, the incorporation of organic production into the crop insurance rating structure has been limited. Currently, the base premium rates are determined across all production practices, both conventional and organic. In choosing the organic production practice, producers are charged an arbitrary 5% premium surcharge over conventional crop insurance. No other adjustments are made to the premium rate to reflect organic production practices. In the case of crop failure, organic farmers receive compensation based on conventionally produced crop prices. Thus, price premiums that organic producers are able to obtain in the market are not compensated for under the current insurance policy structure (RMA, 2008).

During 2001 and 2002, Hanson *et al.* (2004), with RMA sponsorship, organized nationwide focus groups with organic farmers to identify and describe their risks and needs for assistance. In their study, they point out that organic farming may involve different risks than conventional farming because it does not rely on the use of pesticides and insecticides as risk management tools. Organic farmers rely instead, for example, on the use of mechanical cultivation, crop rotation and use of beneficial insect populations to manage their crops. The authors also indicate that besides weeds, pests and diseases, contamination with genetically modified organisms (GMOs), input shortage, and non-stable price premiums were mentioned by organic producers as the most relevant risks that affect their production.

In addition, at the focus group meetings organized by Hanson *et al.* (2004), organic farmers identified Federal crop insurance as a useful risk management tool. However, they also expressed their discontent with the current crop insurance policies. Farmers argued that the coverage being offered does not reflect the organic price premiums that they would receive in the market compared to their fellow non-organic producers (Hanson *et al.*, 2004). Further evidence in this regard is provided

by Chen *et al.* (2007), who showed that, even though crop insurance is an important tool for apple growers to manage risk, “the low price selection and low price premium setting do not provide enough indemnity [to organic growers] when losses occur”. Furthermore, Greene and Kremen (2003) also argue that limited access to crop insurance may discourage conventional farmers from switching to organic farming.

The Food, Conservation and Energy Act of 2008, which amends part of the Federal Crop Insurance Act, was written to investigate some of these claims, requiring the U.S. Department of Agriculture to examine the 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). Such provisions establish the need to review, among others, the underwriting risk and loss experience of organic crops, determine whether significant, consistent, or systematic variations in loss history exist between organic and non-organic production, and in accordance with the results, reduce, eliminate or increase the 5% premium surcharge for coverage of organic crops that applies to all crops and regions across the U.S.

In reviewing the scientific literature related to organic versus conventional yield comparisons, several examples can be cited. The results are mixed. Badgley *et al.* (2007) conducted the most comprehensive review of organic vs. conventional yields worldwide and found few differences between the two production systems. Delate *et al.* (2003) found that organic corn and soybean yields were equivalent to conventional yields. Pimentel *et al.* (2005) reported that, over 22 years of a long-term comparison trial, organic yields were comparable to conventional corn and soybean yields. Mäder *et al.* (2002) obtained organic yields that were between 80% and 100% of conventional yields for all crops over 21 years in an organic rotation of wheat, potatoes, and grass-clover hay. Other studies reported corn yield in an organic system reaching 91.8% of conventional corn yield (Delate and Cambardella, 2004). In the same study, organic soybean yield was 99.6% of conventional soybean yield. Porter (2003) reported organic corn yields 7% to 9% lower and organic soybean yields 16% to 19% lower than conventional crop yields. In a survey conducted by the Organic Farming Research Foundation (2001), organic corn yields across the U.S. were found to average 95% of conventional yields. In general, organic horticultural crops often yield less than conventional horticultural crops (Delate, 2002), but some exceptions exist.

Importantly, after an extensive literature review we found a noticeable lack of rigorous studies focusing on the difference in production risks of organic versus conventional crops on actual farms. The majority of the data comes from yields obtained at experimental plots. This implies that, to the best of our knowledge, currently there is no basis to quantitatively determine the differential

production risk associated with organics, and therefore, whether the insurance premiums currently charged to organic producers are actuarially fair. This lack of data implies that research is needed to start filling that gap and to better understand organic farmers' demand for crop insurance (or lack of it). Thus, given the review of the organic crop insurance coverage policies mandated by the Farm Bill, the purpose of this study is to investigate the current demand for crop insurance from organic grain and oilseed producers in three Midwestern states.

Specifically, the objectives of this study are three-fold. First, the study aims at delineating the profile characteristics of organic corn and soybean producers in Iowa, Minnesota and Wisconsin; as well as describing their production and price risk management strategies usage and comparing it to that of crop insurance. Second, the study analyzes the demand for crop insurance from organic corn and soybean producers in the aforementioned states using a discrete choice model, and attempts to determine which variables, if any, influence their decision of whether to purchase crop insurance, as well as their product choices. Finally, the third objective of this study is to analyze whether significant variations in yield exist between organic and conventional methods of production.

## **Data**

The lack of available data on organic crops in general, and on the demand for crop insurance by organic farmers in particular, stimulated us to collect it ourselves by using a mail survey instrument. We conducted a survey targeting organic corn and soybean producers in three Midwestern states: Iowa, Minnesota and Wisconsin. These three states were selected because they account for over 40% of the U.S. organic cropland destined for organic corn and soybeans, which in turn are among the main organic crops in the U.S. in terms of acreage. Furthermore, Iowa, Minnesota and Wisconsin are the top three states in terms of organic corn acreage, and Iowa and Minnesota are the top two states regarding organic soybean acreage (USDA-ERS, 2008a-b-c).

The clientele targeted by our survey were 665 producers of organic corn and soybean in Iowa, 366 in Minnesota and 550 in Wisconsin, adding up to a total of 1,581. The survey was sent out in late March 2009 to organic producers across Iowa, and in early May 2009 to farmers in Minnesota and Wisconsin. In both rounds, after three weeks a reminder letter was sent to increase the number of returns. A total of 212 surveys were returned giving a response rate of 13%; however, the number of surveys that effectively corresponded to organic producers who gave sufficiently comprehensive responses was 129. Panels A and B of figure 1 show the number of responses by state and by type of operation, respectively. Type of operation refers to whether the producer is certified organic,



transitioning to organic or mixed (i.e.: conventional and organic simultaneously). We also received one survey in which the farmer stated that his production was chemical free.

The survey's questions (Appendix I) could be divided into three categories according to the nature of the information that they intended to gather. The first part of the survey was intended to collect information on demographic variables of organic producers so as to delineate the profile of organic grain and oilseed producers. The distributions for those variables are shown in the different panels of figures 2 and 3.

The second part of the survey was designed to collect information on producers' production and marketing risk strategies. The purpose of this section was to be able to understand what alternatives to crop insurance organic producers use to diversify their risks because organic markets are characterized by being thin; therefore, marketing is different from that of conventional crops. Born (2005) exemplifies this situation with the case of organically produced grains: "While the conventional grower can deposit a whole harvest at the elevator, organic production is usually contracted with a specific buyer ahead of planting". Born argues that this is due to the fact that in many cases organic crops do not have spot markets, and so contracts are a tool producers use to manage risk.

Dimitri and Oberholtzer (2008a) found evidence that contracting is the primary method for selling in the organic sector. In 2004, organic handlers procured 46% of their supply under written contracts, 24% under informal contracts and 27% through spot markets. In contrast, MacDonald *et al.* (2004) found that in conventional agriculture spot market transactions account for 60% of all purchases. Dimitri and Oberholtzer (2008b) also found that contracts in the organic sector are based on the handlers' perspective to reduce transaction costs of finding enough product, not for risk sharing. In addition to contracting, the authors found that handlers in many cases maintain close relationships with suppliers by assisting them, sometimes even recruiting them, in order to gain access to organic products. To evaluate the validity of these findings, we asked organic producers to indicate and rank in percentages the way they market their crops. The results that we obtained are displayed in figure 4.

The third part of the survey was aimed at collecting information regarding organic producers' demand for crop insurance and their risk and loss experience during the last few years. As in previous studies (Sherrick *et al.*, 2004; Vandever and Loehman, 1994), variables that measured producers' characteristics included age, education, operation, farm size, farm and off-farm income, number of years farming and number of years of organic farming. Age, farm size, number of years farming and number of years of organic farming were continuous variables, whereas education, operation, and

farm and off-farm income were all ordered categorical variables. Education took values from 1 to 5 according to the number of years that the main operator attended school, where a higher number denoted more years. Operation took values from 1 to 4, where 1 indicated chemical free, 2 certified organic, 3 transitioning, and 4 mixed production. Farm and off-farm income had 5 and 6 categories respectively, and a higher income bracket translated into a higher number.

One final note on the nature of our survey is that, in contrast to the insurance data that RMA will use to develop the new crop insurance policy, the data we collected is unlikely to be biased by adverse selection. The RMA database has been gathered by having insured organic producers each year. However, adverse selection and moral hazard are likely to be found in agricultural insurance markets due to asymmetric information (Smith and Baquet, 1996). Hence, the RMA data may be biased by adverse selection because in most likelihood the proportion of organic producers finding the 5% organic policy premium attractive is much greater in the RMA sample than in the population of organic farmers as a whole; in other words, the database of organic farmers that have been purchasing insurance under the current insurance policy is likely to comprise the producers with the greatest risk.<sup>1</sup> Also, given the relatively new incorporation of organic agriculture to the Federal crop insurance coverage and the lack of experience of new organic producers, adverse selection could be even greater for the pool of insured organic producers; this is due to the fact that RMA's calculation of insurance guarantees and premium rates require as few as four years of yield data available inducing large sample errors.<sup>2</sup> Therefore, to the extent that the survey data differ from the RMA data, we might be better positioned to determine the organic risk differential and the factors that influence the demand for organic corn and soybean crop insurance in the geographic area under study.

### **A Discrete Choice Model of Insurance Demand by Organic Farmers**

There is a vast empirical economic literature on the demand for crop insurance, but much of it is based on aggregate data (e.g., Barnett; Gardner and Kramer; Barnett, Skees and Hourigan; Goodwin; Richards). Empirical studies relying upon farm-level data can be divided into two groups, namely, one group focusing on the producer's decision of whether to purchase insurance (Calvin 1992; Coble *et al.*, 1996; Just and Calvin, 1994; Vandever and Loehman, 1994), and another group analyzing simultaneous decisions regarding crop insurance. These simultaneous decisions are either insurance purchase and coverage-level election (Smith and Baquet, 1996) or insurance purchase and product choice (Makki and Somwaru, 2001; Mishra and Goodwin, 2003; Shaik *et al.*, 2008; Sherrick *et al.*, 2004). The present analysis follows the latter line of work.

The theoretical framework under which farmers' crop insurance purchase decision is typically examined is that of expected utility maximization subject to a set of constraints (Sherrick *et al.*, Smith and Baquet, Goodwin, Coble *et al.*, Calvin, Just and Calvin). In the theoretical model presented by Shaik *et al.* (2008), which is built upon the participation model of Coble *et al.* (1996), the authors assume that farmers have a Von Neuman-Morgenstern utility function and that they maximize their expected utility by choosing among the insurance alternatives that they have available. Mathematically, their expected utility model is given by  $EU_j = \beta'_j X + \varepsilon_j$ , where  $j$  denotes each alternative, the  $\beta$ s are vectors of coefficients on exogenous variables  $X$  and the  $\varepsilon$ s are random disturbances. Shaik *et al.* empirically analyze the participation choice of producers using a multinomial logit model. Contrastingly, Sherrick *et al.* (2004) evaluate the producers' participation decision in a first stage by means of a binomial logit; and then in a second stage the authors evaluate the product choice of those farmers that purchased insurance using an unordered multinomial logit. Therefore, the main difference between the empirical models by Shaik *et al.* and Sherrick *et al.* is whether the product choice is modeled in the same stage as the participation decision.

Due to the disparity in the number of responses regarding purchase and product choice that we obtained in our survey, a model with a single step decision process would have discarded valuable information from producers that reported whether they purchased insurance but did not specify which product they bought. Thus, a two-stage empirical model similar to that of Sherrick *et al.* (2004) was more appropriate for our analysis. Given that we evaluated the purchase of only two alternative insurance products (because of the responses that we received), we ran two binomial logit regressions sequentially; the first one to evaluate the organic producers' participation decision, and the second one for those who purchased insurance and decided between yield and revenue products. In the first (second) stage, it is assumed that the probability of farmer  $n$  choosing alternative  $j$  is given by:

$$P_{jn} = \frac{\exp(\beta'_j X_n)}{\sum_{j=1}^2 \exp(\beta'_j X_n)} \quad j=1, 2 \quad (1)$$

where 1 and 2 denote no insurance and insurance purchase (yield insurance and revenue insurance), respectively. Given that the probabilities add up to one, the parameter vectors of one alternative can be normalized to zero. Thus, based on equation (1), the probabilities of each alternative are given by:

$$P_{1n} = \frac{1}{1 + \exp(\beta'_2 X_n)} \quad \text{and} \quad P_{2n} = \frac{\exp(\beta'_2 X_n)}{1 + \exp(\beta'_2 X_n)}$$

The explanatory variables included in  $X_n$  are age, farm size, number of years farming, number of years of organic farming, type of operation, education, farm and off-farm income, as well as dummy variables for the state in which the farm was located. Appendix II includes the variance-covariance matrix and the variance inflation factor (VIF) for each coefficient as diagnostics on multicollinearity; the values evidence that multicollinearity does not pose a problem for estimation.

For the first stage, a priori one would expect age, number of years farming and education to have a positive sign, implying that those producers are more experienced and knowledgeable about crop insurance as a risk diversifying tool. One would also expect farm size to have a positive sign, indicating that producers with more acreage would have, to some extent, a greater need for managing their risk. With respect to type of operation and years of organic farming, one would expect them to have a negative sign, denoting organic producers' reluctance to purchase crop insurance under the current policy. Finally, one would expect farm income to have a positive sign, conveying the reliance of the household income on farm operations; contrastingly, one would expect off-farm to have a negative sign, because working off-farm is a risk-diversifying strategy competing with crop insurance.

## Results

The results for the two sequential logit regressions for corn and soybean are shown in Tables 1 and 2 respectively.<sup>3</sup> The panels denoted as first stages correspond to the logit analysis of the question of whether producers had bought crop insurance in the year 2008, whereas the second stage panels denote the logit analysis of which insurance product they purchased for that year. In the first stages the base case was no insurance purchase and in the second ones it was the purchase of a yield product.

The results of the first stage for corn shown in Table 1 suggest that insurance purchasers are characterized by being older, having more (fewer) years of farming (organic farming), and higher (lower) farm income (off-farm income). The signs of the corresponding estimated coefficients are consistent with the a-priori expected relationships, but none of them turned out to be statistically significant. Instead, farm size and education were significant at the 10 and 5% level respectively; thus, organic farmers with larger farms and more formal education were more likely to purchase crop insurance. Also the type of operation influenced corn producers' insurance purchasing decision. Not surprisingly, mixed farmers were found to be more likely to purchase crop insurance, most likely due to the fact that they purchase it for their conventional crops and just extend the coverage to the organic ones. In addition, the dummy variable for organic farmers in Wisconsin shows that producers

in that state are significantly less likely to purchase insurance than farmers in Iowa, which is the base case. Contrastingly, the results of the first binomial logit stage for soybean producers shown in Table 2 indicate that type of operation is the only variable statistically significant at the 5% level. Although the variable years of organic farming is not significant, it has a negative coefficient in this case as well.

In the second stage for corn (soybean) the number of observations dropped to 47 (49) because the sample only included those organic farmers that stated which crop insurance product they purchased for the year 2008. The results for corn suggest that producers who are younger, have larger farms, fewer (more) years of (organic) farming, more education and lower farm and off-farm income are more likely to purchase Crop Revenue Coverage (CRC) products than yield products like Actual Production History (APH). Nevertheless, only age and education were significant at the 5% level. In the second stage for soybean, age and off farm income have a negative coefficient and they are significant at the 5% level, whereas years of organic farming and education have positive coefficients and are significant at the 10% level; implying that organic producers who are younger, have less off-farm income, more organic farming experience, and more years of formal education are more likely to buy CRC.

The survey data contain additional information that complement the above discrete choice model results and may help to better understand organic farmers' demand for crop insurance. To this end, figure 5 displays the farmers' participation decision in percentages by state. Interestingly, the percentage of organic farmers surveyed in Wisconsin who purchased crop insurance (34.7%) was about the same as the one for those in Iowa who did not purchase it (36.4%). Meanwhile, in Minnesota the percentage of buyers (45.7%) and non-buyers (51.4%) was divided more evenly. The reasons for this difference in participation among states are not clear, but they might be related to a similar behavior in the commodity cases. In terms of product choice, for corn (soybean) 24 (22) out of the 47 (49) producers chose CRC over APH coverage.

Figure 6 shows the distribution of the surveyed farmers' responses regarding their usage of alternative strategies to diversify production risk, including crop insurance. It can be seen that planting multiple crops and employing rotations is a standard practice (and a mandatory one if a producer wants to become certified organic). The results also show that having livestock in an organic farm is a widespread practice, whereas irrigating is not. From figure 6 it can also be seen that the waters are divided among organic farmers when it comes to crop insurance, since about half of them purchase it and the other half does not.

If organic producers responded that they had never bought crop insurance, they were asked to indicate in a Likert scale their motivation for not buying it among a list of preponderant reasons found in the literature as the result of focus groups. The usefulness of the information provided by the responses to this question should be evident, since it would give policymakers valuable knowledge regarding organic corn and soybean producers' demand (or lack of it) for crop insurance. The distribution of such responses is summarized in figure 7. An important result is that the top reason organic farmers indicated for not buying crop insurance is that they use their own strategies to diversify risk (43% of the respondents agreed with that statement). An even more important result from figure 7 is that 34% of the farmers responded that they have never purchased crop insurance because they prefer not to participate in federal programs, implying that they would not buy it regardless of any improvement to the insurance policy to make it more actuarially fair.

### **Yields and Prices Associated with Organic Grains and Oilseeds**

The results from the discrete choice model presented in the previous section offer only a partial analysis of the crop insurance demand by the surveyed organic producers. As mentioned earlier, the incorporation of organic production into the crop insurance rating structure has been limited, thereby negatively influencing producers' crop insurance purchase decisions. First, because RMA assumes that organic production has the same yield level as conventional production with 5% more yield risk. The evidence shown next suggests that although organic oats attain equivalent yields to that of its conventional counterpart, that is not the case for organic corn and soybean. Second, because RMA in the current crop insurance policy also assumes that the prices that organic and conventional producers obtain in the market are the same. But Singerman, Lence and Kimble-Evans (2010) have shown that organic corn and soybean prices are consistently and significantly higher than the prices of conventional corn and soybean, with about the same risk. As explained below, in our survey we also found evidence regarding this issue. In addition, and perhaps more importantly, Singerman, Lence and Kimble-Evans (2010) found that organic crop prices do not follow conventional crop prices.

Table 3 shows the average yield, price and revenue obtained by the organic producers we surveyed (denoted as organic) for corn, soybean and oats. As a way of comparing such results to those of conventional producers, we used National Agriculture Statistics Service (NASS) data; the results are also included in table 3, and are denoted as conventional. In that table there is also a column called 4-year APH (Actual Production History), which denotes the 4-year yield average calculation. In the three Midwestern states surveyed, organic corn and soybean yields are about 70% of conventional yields. However, organic oat yields are about the same as conventional ones.

The finding of a lower yield level for organic corn and soybean on its own does not allow one to infer that organic crops are riskier. Instead, it indicates that when insuring their crops under the current policy, organic corn and soybean farmers are being mis-rated because under the Multiple Peril Crop Insurance calculations the Base Premium Rate is computed taking into account a reference yield that is determined at the county level, and it is irrespective of the farmers' production practices. Thus, based on our results when having a lower yield level and being compared to conventional yields, organic producers are subject to premium rates that are not tied to their idiosyncratic yield distributions

Table 3 also shows that as a consequence of receiving higher prices for their crops, organic corn and oats producers obtained an average revenue per acre about 80% higher than that of their conventional counterparts; while for soybean it was about 60% more. The differential yield and price level for organic soybean that we found is very similar to the ones that McBride and Greene (2008) reported using a nationwide on-farm survey. Yet such price difference is not reflected in the crop insurance coverage that organic producers can obtain.

Table 4 shows a comparison between the insured and non-insured organic producers that we surveyed regarding average yield, and yield variability across farmers each year, as well as average price. Yields were sometimes lower for non-insurers for corn and oats, but were higher in all cases (but one) for soybean. A relevant finding is that for all three crops and states, in most instances the coefficient of variation of yields across farmers was higher for insurers than for non-insurers, suggesting that insurers' distribution is less uniform (has more variability) than that of non-insurers. In terms of price differential between insurers and non insurers, there seems to be none.

We were able to obtain farm-level data for conventional producers for Iowa only (from the Iowa Farm Business Association (IFBA)) for corn and soybean. Therefore, we used the survey panel data of the organic producers that provided us with four successive years of their yield history to construct their four-year APHs<sup>4</sup>, and then averaged their individual APHs to obtain a state APH. One caveat of constructing such 4-year APH is that we had a limited number of observations available for organic farmers that reported at least a 4 years of their historic yields; they were 17 and 14 for corn and soybean, respectively. However, using the IFBA data similarly we can compare a state APH for organic and conventional corn and soybean producers, as well as their respective variability (see Table 5).

It can be seen in Table 5 that the yield for organic corn (soybean) is 68% (58%) that of its conventional counterpart. In addition, the coefficients of variation indicate that organic corn and soybean production are also riskier. Nevertheless, it is important to be careful when interpreting the

variability of the two systems of production implied in Table 5 due to the limited data available for organic producers, and also because for crop insurance purposes, unlike for the estimation of the coefficient of variation, the relevant variability is the one that corresponds to the lower tail of the yield distribution.

### **Yield Density Function Comparison between Organic and Conventional Corn and Soybean Producers in Iowa**

Given the significant difference in yield levels between organic and conventional corn and soybean producers described in the previous section, it seems useful to compare the extent to which their density functions differ. To perform such comparison, we estimated the nonparametric density function of their yields using the same raw data that we used for constructing Table 5. Given the limited number of observations available for organic farmers the analysis described below is valid as a case study; once more data become available, future research could confirm our results.

To estimate the yield density functions, we used the kernel density estimator with kernel  $K$  defined as:

$$\hat{f}(x) = \frac{1}{Nh} \sum_{i=1}^N K\left(\frac{x - X_i}{h}\right) \quad (2)$$

where  $N$  is the number of observations and  $h$  is the bandwidth or smoothing parameter. Regarding the choice of function  $K(\cdot)$ , Dinardo and Tobias (2001, p. 9) explain that "...the particular kernel employed imposes nothing on the shape of the probability density function we estimate", and then they continue arguing that the choice of bandwidth is more important; but they add that "despite a huge literature [...] bandwidth choice remains largely an art". As Silverman (1986) suggests, the choice of the bandwidth hinges on the purpose for which the density estimate will be used, and he further adds that in some cases a subjective choice could be sufficient and even desirable. Hence, in our estimates we chose the smallest  $h$  that would make the yield densities smooth.

We estimated the yield density functions for organic and conventional corn and soybean using the 4-year APH farm-level data, and drawing 5,000 estimates from them to construct their respective *pdfs*. The estimated densities for corn and soybean are shown in panels A and B of figure 8, respectively. The underlying assumption behind the 5% surcharge to organic farmers is that, when comparing the distributions of organic and conventional crop yields, the only difference between them is that organic crops should exhibit 5% more risk than conventional ones. Such clear-cut result cannot be inferred from figure 8; nevertheless, both panels of that figure clearly show that the yield



distributions for organic and conventional corn and soybean are different because the mean of the organic *pdfs* are to the left of the conventional ones, denoting their lower mean yields.

Thus, the empirical evidence indicates that organic yields of both crops do not come from the same distribution as that of their conventional counterparts, as implied by the current crop insurance policy. Consequently, if our results extended to larger (organic) data analyses and other crops, this evidence should be used by RMA to provide crop insurance for organic producers based on their idiosyncratic yield curves, rather than extrapolating the ones used for conventional farmers.

### Conclusions

In recent years there has been a steady and significant growth of the organic sector (OTA, 2009). However, little economic research has been performed on the subject, likely due to the lack of data availability. Also likely because of it, the creation of the current crop insurance policy for organic farmers has been *ad hoc* and not based on the idiosyncratic characteristics of the organic sector. The present study aimed at starting filling this gap; in particular we analyzed the demand for crop insurance and examined yield variations between organic and conventional farmers in three states where acreage for organic production is among the greatest in the U.S. for the crops that we studied.

In this manuscript we analyzed organic producers' demand for crop insurance using a discrete choice model that showed the impact of demographic variables on their purchasing and product choice decisions. But perhaps more importantly, we complemented those results with additional crop insurance usage information, as well as yield, price and revenue comparisons between organic and conventional producers. Although some authors have reported that organic and conventional yields are equivalent, in this study we found that corn and soybean under organic management attain about 70% of the yield of that of conventional crops. The dissimilarity of the results could be due to the fact that many of those authors performed the experiments on (smaller) experimental plots that are more easily controlled for weeds than entire farms are. However, those experiments reveal the potential for organic farming of achieving yields equivalent to those of conventional crops, something exemplified by the yield level for organic oats attained by producers in our sample. The present study provides further evidence that organic producers obtain higher prices than their conventional fellows. In fact, in our sample the higher prices received for the organic crops more than offset their lower yields, resulting in higher revenues per acre compared to their conventional counterparts.

Our findings regarding the different yield levels (and their probability distribution functions) between organic and conventional corn and soybean producers, along with the substantial price premiums that organic farmers obtain, call for RMA to perform additional analyses to evaluate the

validity of our findings on a nationwide basis and, if so, modify the current organic farming insurance policy accordingly to provide a more actuarially fair coverage to organic producers.

**Notes**

1. Just, Calvin, and Quiggin (1999) analyze the effects of asymmetric information on adverse selection in crop insurance.
2. See Carriquiry, Babcock and Hart (2008) for an analysis of such sampling errors in the estimation of farmer's mean yields and their effects on adverse selection, as well as their proposed estimator to reduce it.
3. We also ran the models including an additional variable; namely, the actual production history (APH) premium rate that we calculated for each farmer based on their yields and county information. Thus, such variable represented the premium rate that each farmer would have had to pay had he chosen APH coverage at the 65% coverage in 2008. However, the variable was not statistically significant and the rest of the results did not change considerably.
4. We did not use the RMA's transition or T-Yield procedure, by which the missing data are replaced by a percentage of the county average yield according to the number of years missing. For a complete description of APH rules and T-Yields definitions, see [http://www.rma.usda.gov/FTP/Publications/directives/18000/pdf/05\\_18010.pdf](http://www.rma.usda.gov/FTP/Publications/directives/18000/pdf/05_18010.pdf) .

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**Table 1. Econometric results for insurance participation and product choice of organic corn producers**

	Stage 1:				Stage 2:			
	No purchase / Purchase				APH / CRC			
	Coefficient	t-stat	p-value		Coefficient	t-stat	p-value	
Constant	-4.441	-2.37	0.018	**	-0.646	-0.28	0.782	
Age	0.023	0.98	0.329		-0.235	-2.46	0.014	**
Farm size	0.002	1.80	0.071	*	0.000	0.32	0.750	
Yrs. Farming	0.021	0.82	0.411		-0.001	-0.01	0.992	
Yrs.Org. farm	-0.001	-0.02	0.981		0.124	1.63	0.103	
Operation	0.818	2.20	0.028	**	0.701	1.23	0.218	
Education	0.462	2.20	0.028	**	1.130	2.09	0.037	**
Farm income	0.034	0.19	0.850		-0.101	-0.33	0.743	
Off farm inc.	-0.062	-0.55	0.581		-0.231	-1.04	0.296	
Minnesota	-0.293	-0.49	0.628		-0.677	-0.57	0.569	
Wisconsin	-0.995	-1.85	0.064	*	-0.131	-0.12	0.907	
Nobs	109				47			
Log. Likelihood	-58.07				-18.66			
AIC	138.15				65.13			

\*\*\* (\*\*, \*) Denotes significantly different from zero at the 1% (5%, 10%) level, based on the two-sided *t* statistic.

**Table 2. Econometric results for insurance participation and product choice of organic soybean producers**

	Stage 1:				Stage 2:		
	No purchase / Purchase				APH / CRC		
	Coefficient	t-stat	p-value		Coefficient	t-stat	p-value
Constant	-3.474	-2.21	0.027	**	-0.937	-0.41	0.681
Age	0.037	1.11	0.269		-0.147	-2.39	0.017 **
Farm size	0.001	1.40	0.162		0.000	0.57	0.569
Yrs. Farming	0.032	1.05	0.293		0.018	0.38	0.705
Yrs.Org. farm	-0.002	-0.06	0.949		0.136	1.87	0.062 *
Operation	0.950	2.08	0.038	**	0.243	0.51	0.610
Education	0.323	1.36	0.175		0.705	1.72	0.086 *
Farm income	-0.061	-0.31	0.755		-0.109	-0.45	0.655
Off farm inc.	-0.012	-0.09	0.929		-0.434	-1.99	0.046 **
Minnesota	-0.056	-0.08	0.934		0.070	0.07	0.948
Wisconsin	0.136	0.20	0.842		-0.434	-0.46	0.649
Nobs	78				Nobs 49		
Log. Likelihood	-42.86				Log. Likelihood -22.47		
AIC	107.73				AIC 66.95		

\*\*\* (\*\*, \*) Denotes significantly different from zero at the 1% (5%, 10%) level, based on the two-sided *t* statistic.



**Table 3. Comparison of average yield, price and revenue obtained by organic (survey) and conventional (NASS) producers from 2005 to 2008 in the selected states**

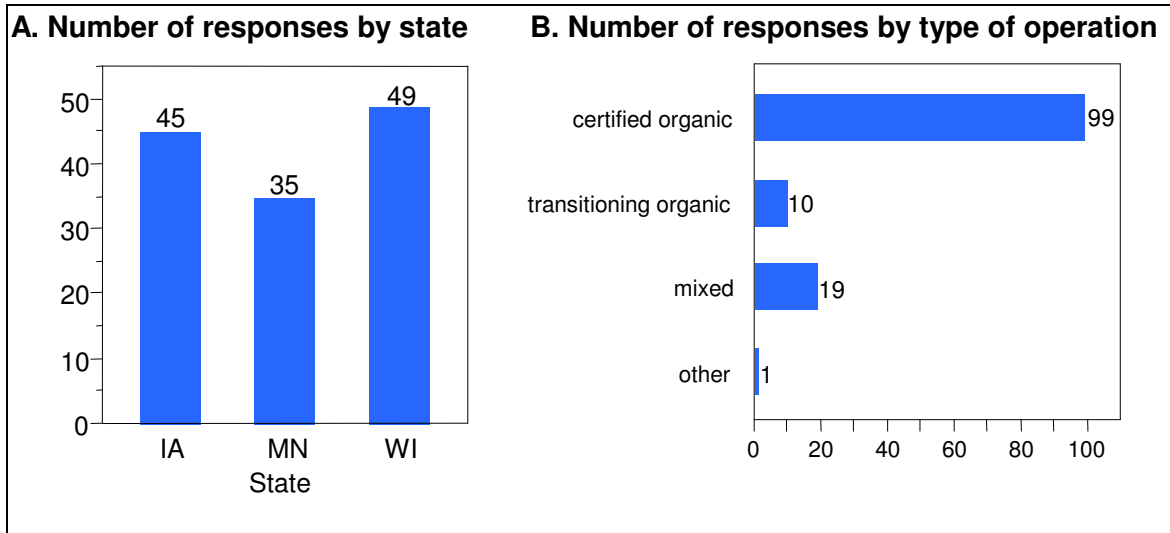
		<b>Corn</b>																
		2008				2007				2006				2005				
4-year APH		avg yield	avg price	avg revenue	# obs	avg yield	avg price	avg revenue	# obs	avg yield	avg price	avg revenue	# obs	avg yield	avg price	avg revenue	# obs	
IA	organic	118	113	9.02	1,017	35	125	8.97	1,120	30	123	6.54	805	26	112	5.22	583	21
	conventional	170	171	3.95	675	n/a	171	4.29	734	n/a	166	3.03	503	n/a	173	1.94	336	n/a
MN	organic	106	107	8.09	864	13	115	9.41	1,081	9	102	7.66	784	9	101	6.47	655	7
	conventional	161	164	3.80	623	n/a	146	4.13	603	n/a	161	2.89	465	n/a	174	1.86	324	n/a
WI	organic	99	102	9.39	953	20	94	8.27	778	15	102	8.58	879	10	99	8.15	803	7
	conventional	141	137	3.50	480	n/a	135	4.11	555	n/a	143	3.04	435	n/a	148	1.94	287	n/a
		<b>Soybean</b>																
		2008				2007				2006				2005				
4-year APH		avg yield	avg price	avg revenue	# obs	avg yield	avg price	avg revenue	# obs	avg yield	avg price	avg revenue	# obs	avg yield	avg price	avg revenue	# obs	
IA	organic	31	26	21.69	574	27	31	20.80	648	23	35	16.69	577	20	33	14.89	494	21
	conventional	50	46	9.65	444	n/a	52	10.50	546	n/a	51	6.58	332	n/a	53	5.54	291	n/a
MN	organic	29	28	25.11	709	9	28	17.51	496	12	29	15.77	453	11	31	16.42	509	10
	conventional	43	38	9.60	365	n/a	43	10.20	434	n/a	45	6.26	279	n/a	46	5.53	252	n/a
WI	organic	29	29	21.67	618	8	27	20.60	564	8	32	13.67	437	5	29	15.31	450	5
	conventional	41	35	9.20	322	n/a	41	9.83	398	n/a	44	6.04	266	n/a	44	5.64	248	n/a
		<b>Oats</b>																
		2008				2007				2006				2005				
4-year APH		avg yield	avg price	avg revenue	# obs	avg yield	avg price	avg revenue	# obs	avg yield	avg price	avg revenue	# obs	avg yield	avg price	avg revenue	# obs	
IA	organic	67	59	5.33	312	11	59	4.29	254	11	73	4.21	306	9	78	3.83	299	9
	conventional	73	65	3.20	208	n/a	71	2.74	195	n/a	76	1.94	147	n/a	79	1.69	134	n/a
MN	organic	69	71	5.27	372	9	65	3.95	257	9	68	3.55	241	8	72	3.27	236	8
	conventional	62	68	2.65	180	n/a	60	2.49	149	n/a	56	1.93	108	n/a	62	1.47	91	n/a
WI	organic	63	59	3.58	210	7	64	4.28	273	9	66	2.11	139	3	63	n/a	n/a	2
	conventional	64	62	2.70	167	n/a	67	2.46	165	n/a	63	1.78	112	n/a	64	1.54	99	n/a

**Table 4. Comparison of average yield, coefficient of variation and average price obtained by insured and non-insured organic producers from 2005 to 2008 in the selected states**

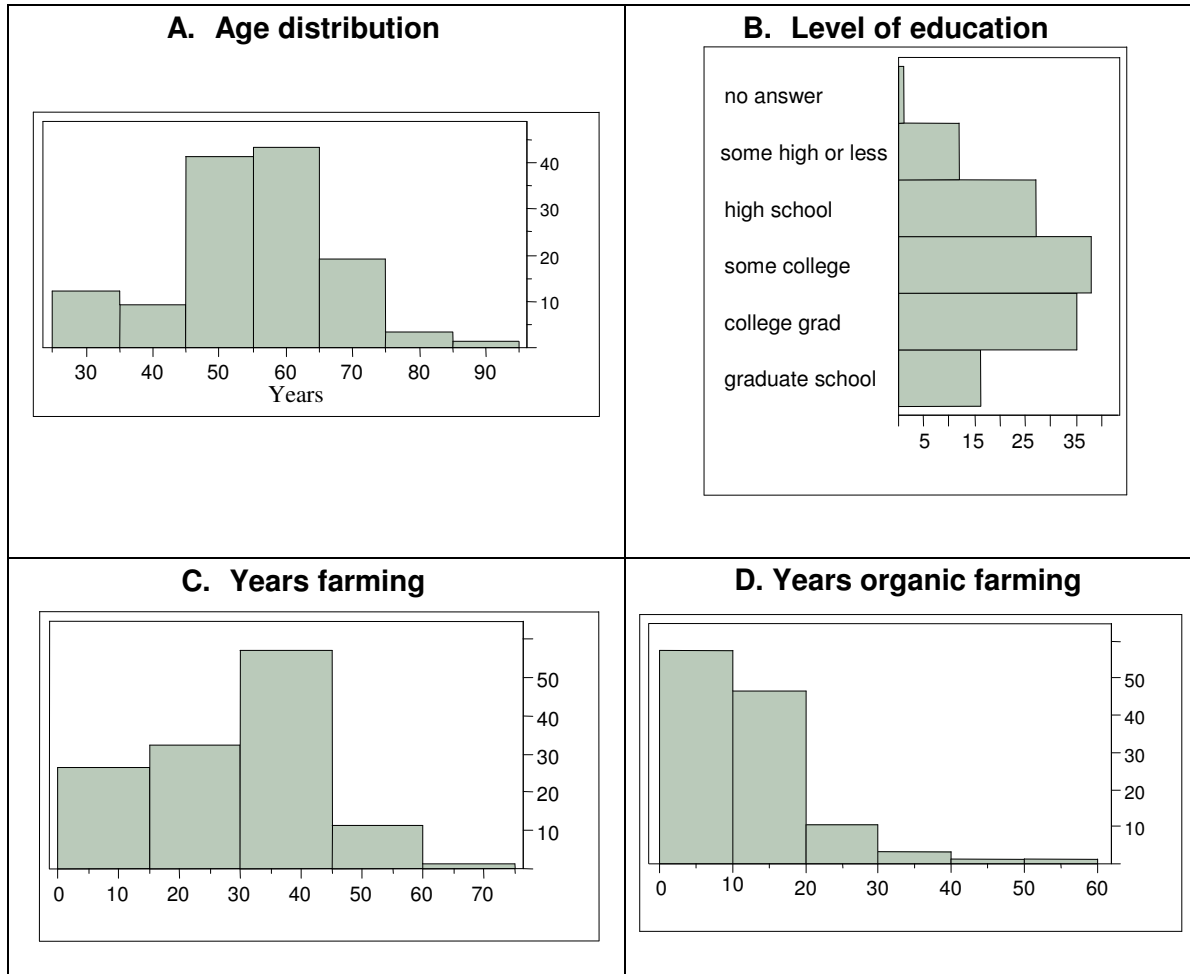
		<b>Corn</b>																
		2008				2007				2006				2005				
4-year APH		avg yield	CV	avg price	# obs	avg yield	CV	avg price	# obs	avg yield	CV	avg price	# obs	avg yield	CV	avg price	# obs	
IA	insurers	121	114	0.35	9	20	126	0.19	9	20	123	0.31	6	18	120	0.25	5	15
	non-insurers	110	105	0.19	9	14	122	0.15	9	10	124	0.21	7	8	90	0.28	5	6
MN	insurers	73	122	0.13	8	3	87	0.42	10	3	43	0.53	11	2	40	n/a	12	1
	non-insurers	121	120	0.17	9	8	129	0.19	9	6	122	0.26	6	7	114	0.09	5	6
WI	insurers	103	100	0.35	9	9	85	0.48	9	6	115	0.31	6	4	110	0.35	5	5
	non-insurers	93	103	0.19	10	11	100	0.31	8	9	94	0.49	10	6	75	0.60	13	2
		<b>Soybean</b>																
		2008				2007				2006				2005				
4-year APH		avg yield	CV	avg price	# obs	avg yield	CV	avg price	# obs	avg yield	CV	avg price	# obs	avg yield	CV	avg price	# obs	
IA	insurers	30	25	0.39	22.20	17	28	0.40	20.10	14	33	0.38	16.63	13	33	0.36	15.20	15
	non-insurers	33	28	0.27	22.32	9	36	0.31	22.11	9	37	0.33	16.85	7	34	0.27	14.18	6
MN	insurers	25	24	0.24	24.88	4	25	0.18	17.40	5	24	0.29	14.10	5	27	0.23	15.00	4
	non-insurers	32	32	0.30	25.30	5	31	0.43	17.59	7	33	0.40	17.16	6	34	0.40	17.55	6
WI	insurers	28	24	0.37	21.25	5	25	0.40	19.80	5	34	0.33	14.75	4	30	0.35	14.42	4
	non-insurers	30	36	0.15	22.50	3	31	0.18	21.67	3	26	n/a	11.50	1	29	n/a	18.00	1
		<b>Oats</b>																
		2008				2007				2006				2005				
4-year APH		avg yield	CV	avg price	# obs	avg yield	CV	avg price	# obs	avg yield	CV	avg price	# obs	avg yield	CV	avg price	# obs	
IA	insurers	74	66	0.30	5.88	7	64	0.42	4.38	8	84	0.29	4.31	6	81	0.29	4.38	6
	non-insurers	54	48	0.24	4.59	4	47	0.05	4.00	3	51	0.22	4.00	3	71	0.30	2.75	3
MN	insurers	60	62	0.34	5.03	4	58	0.55	4.05	3	58	0.66	3.52	3	62	0.48	3.42	3
	non-insurers	75	76	0.20	5.50	5	69	0.38	3.88	6	75	0.26	3.60	5	80	0.14	3.12	5
WI	insurers	67	75	0.20	n/a	2	69	0.03	3.00	3	65	n/a	n/a	1	60	n/a	n/a	1
	non-insurers	61	52	0.41	3.58	5	61	0.30	4.53	6	67	0.05	2.11	2	65	n/a	n/a	1

**Table 5. Comparison of yields and risk associated with organic and conventional practices from 2005 to 2008 in Iowa**

		Corn				Soybean			
		2005-8 APH				2005-8 APH			
		yield	std dev	CV	Nobs	yield	std dev	CV	Nobs
IA	organic	120	19	0.16	17	31	8	0.24	14
	conventional	177	14	0.08	145	54	5	0.10	138



**Figure 1. Number of surveys by state and by type of operation**



**Figure 2. Distribution of the respondents' demographic characteristics**

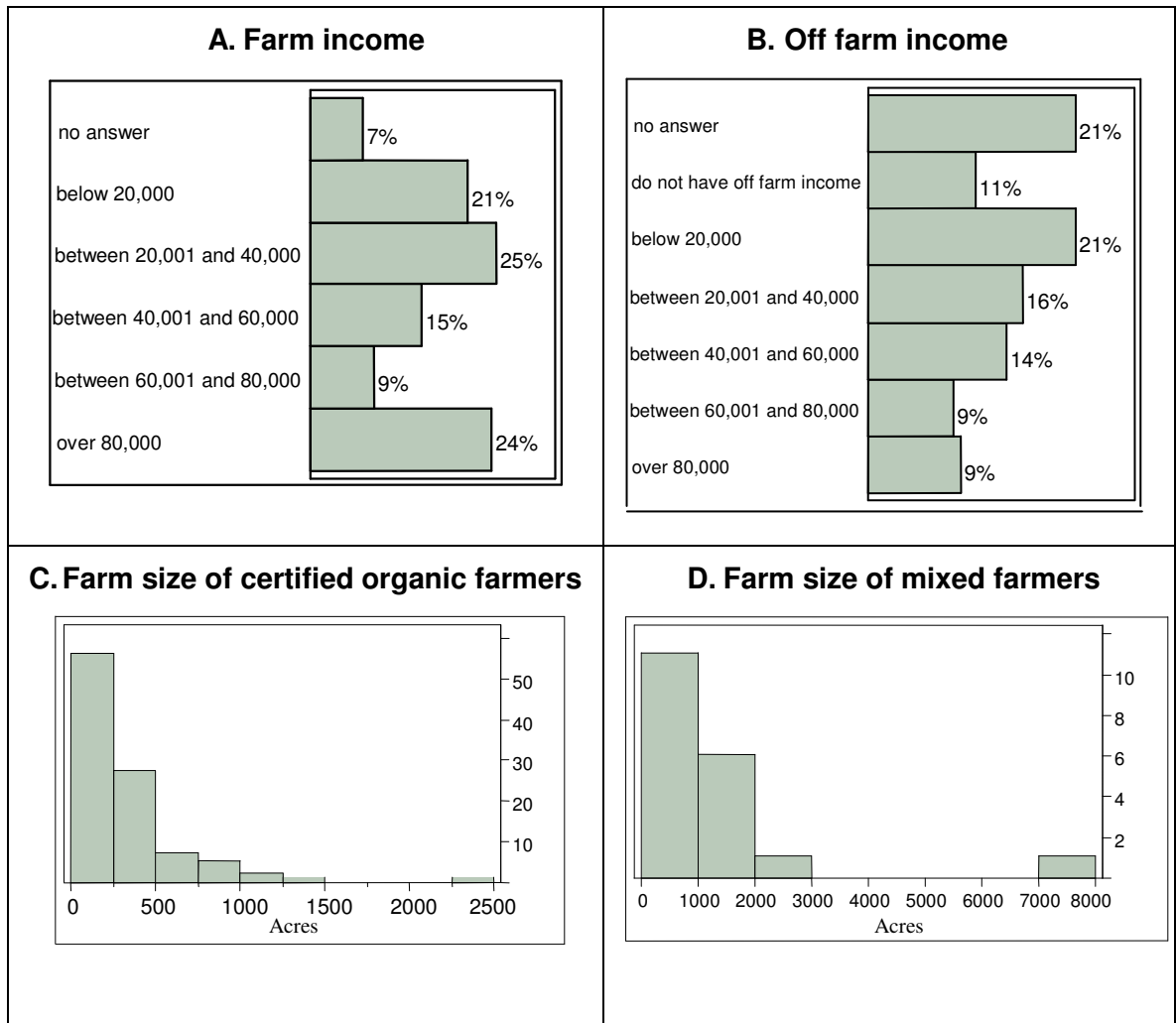
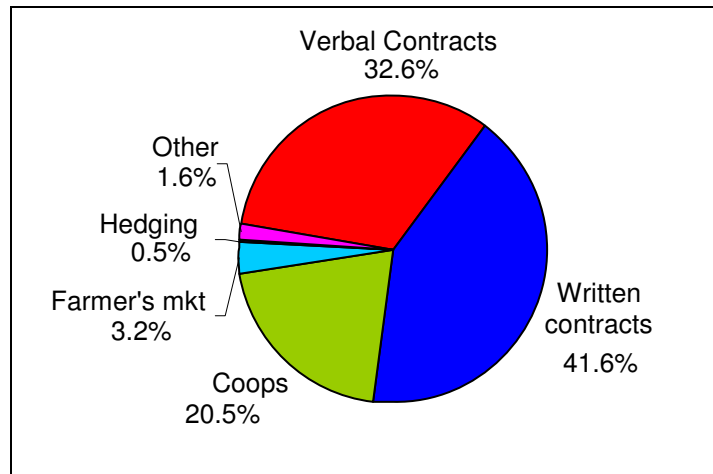
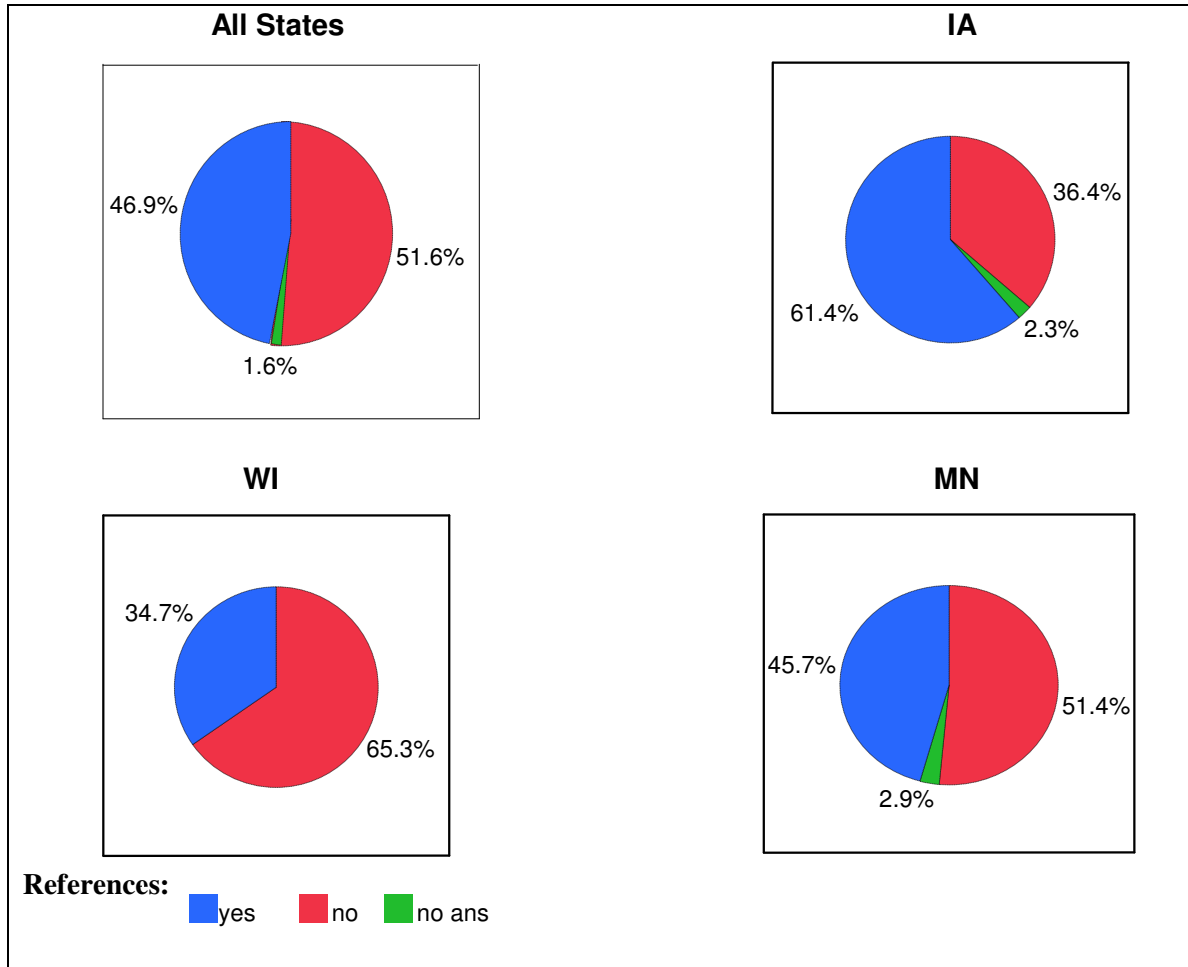


Figure 3. Distribution of the respondents' farm and off-farm income, and farm size

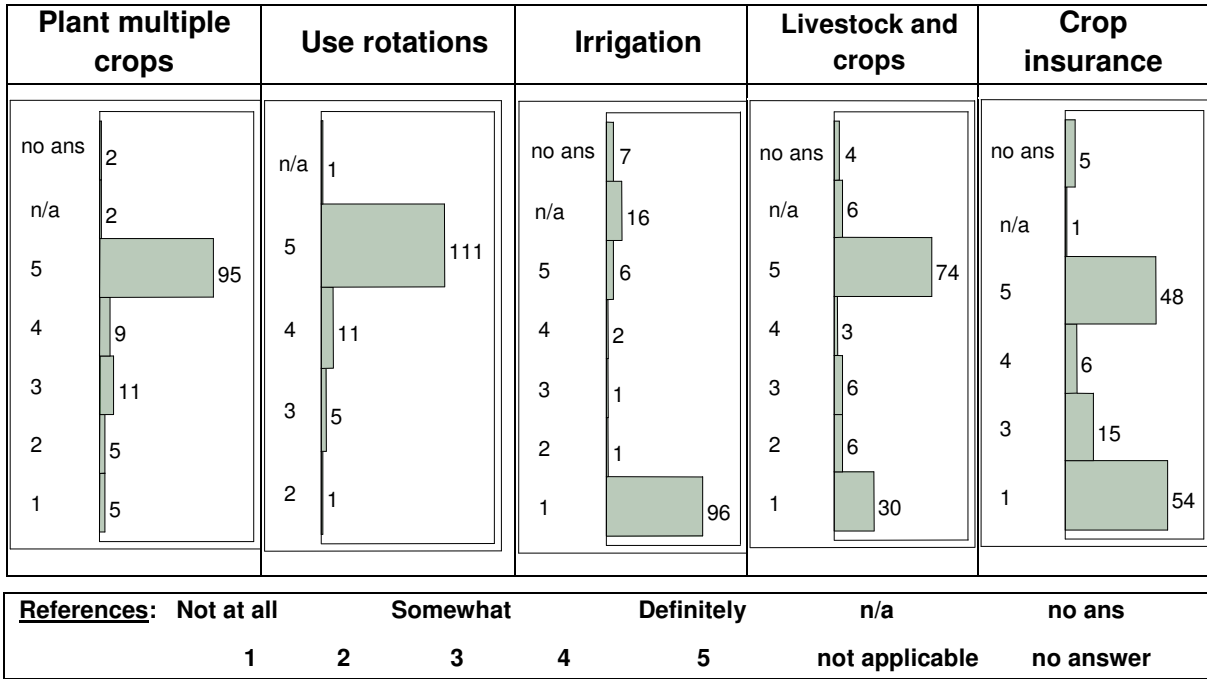


**Figure 4. Marketing / price risk management strategies**

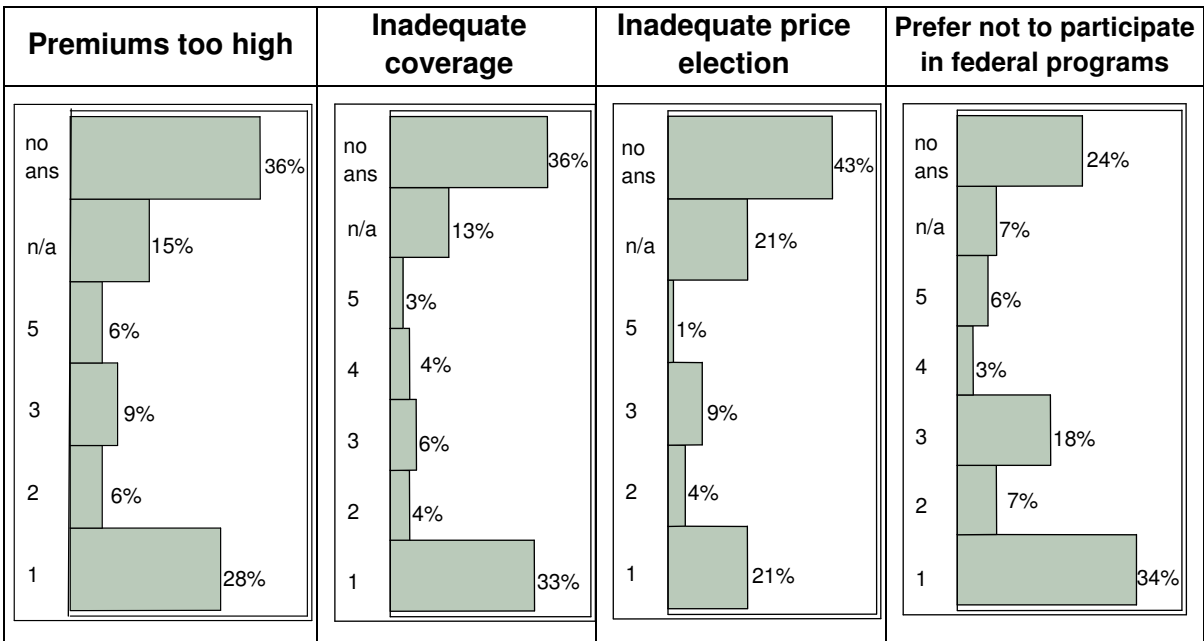
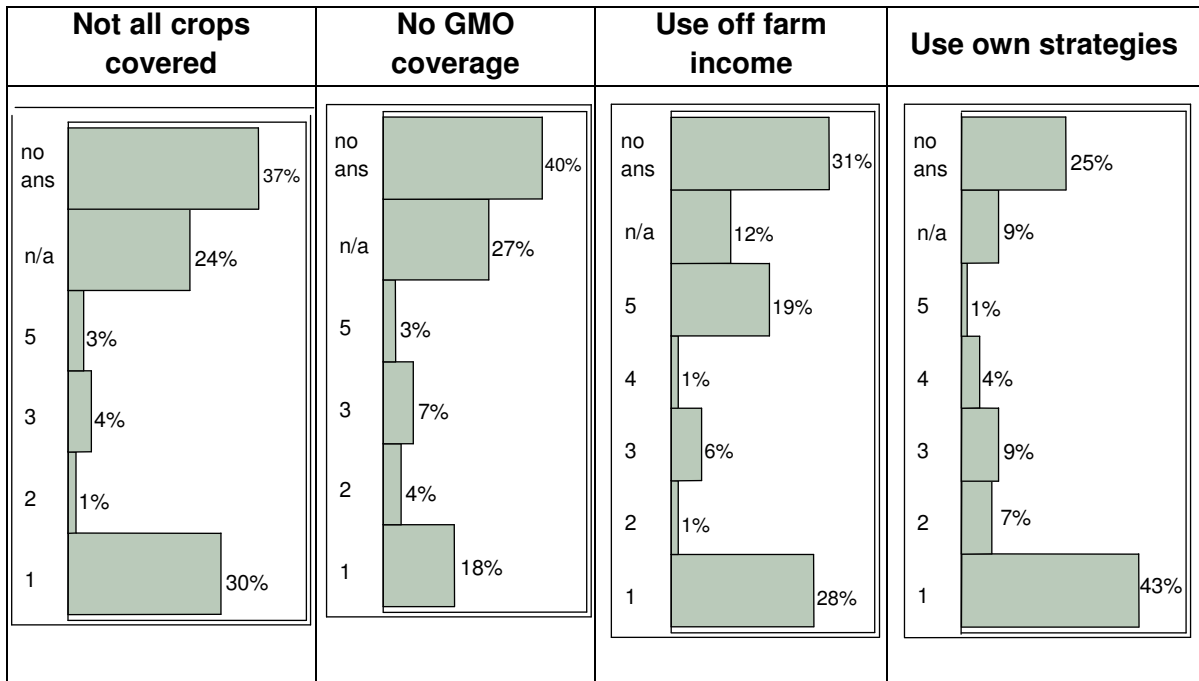


**Figure 5. Insurance purchase by state**



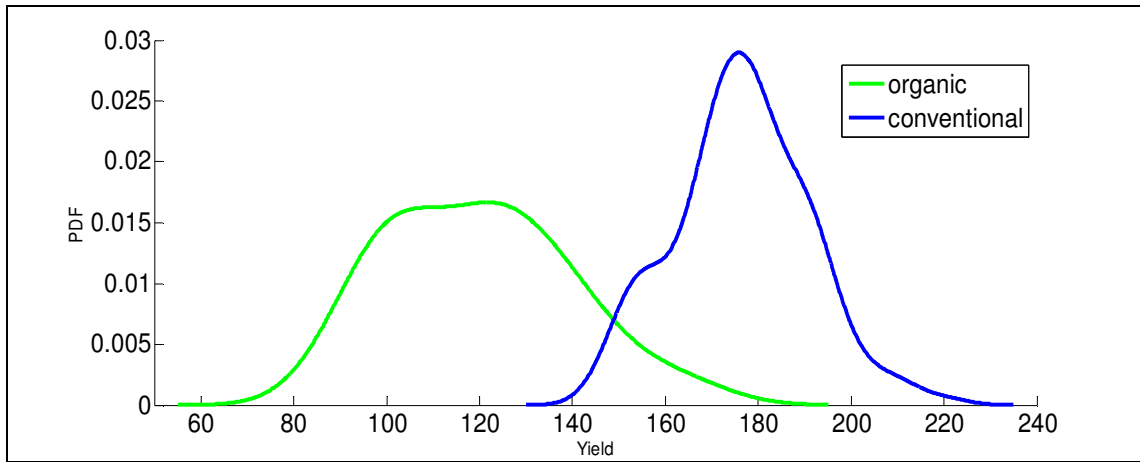
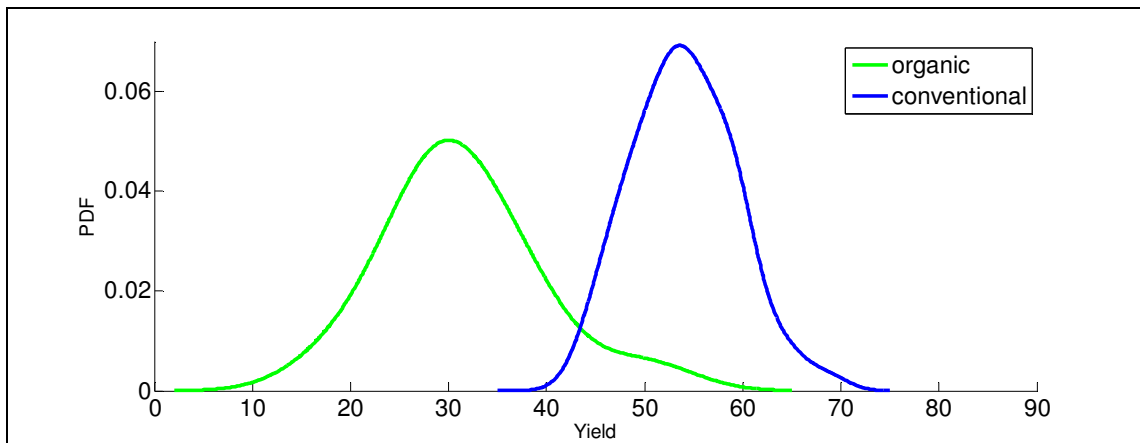


**Figure 6. Production risk diversifying strategies and usage comparison relative to crop insurance**



References:	Agree	Somewhat agree	Disagree	n/a	no ans
	1	2 3 4	5	not applicable	no answer

Figure 7. Non buyers' reasons for not purchasing crop insurance: Likert scale responses' distribution

**A. Corn****B. Soybean**

**Figure 8. Iowa organic and conventional producers' 4-year yield APH kernel**

## Appendix I: Survey Questionnaire

### Survey of Midwest Organic Grain Producers Iowa State University Organic Program

- This survey is anonymous and all data will be coded and remain confidential at Iowa State University.
- If you have any question about how to complete any part of this survey, please call to 515-294-2536.
- When finished, please mail in self-addressed stamped envelope being provided.

Fill in the boxes where requested

1. Please provide the following information regarding your farming operation:

- State  County
- Main operator's age
- Total farm size in acres
- Number of owned acres  Number of rented acres
- Number of years farming  How many of those were of organic farming?

Circle your response

2. Which of the following best describes your operation?

- a - Certified organic farmer
- b - Transitioning organic farmer (planning on moving entire farm to organic)
- c - Mixed organic and conventional farmer (intend to keep some organic and some conventional crops)
- d - Other (please specify)

3. Main operator's level of education:

- a -Some high school or less
- b -High school
- c -Some college
- d -College graduate
- e -Graduate school

4. In which of the following categories do your annual farm and off-farm income fit best?

- |                     |                                |                         |                                |
|---------------------|--------------------------------|-------------------------|--------------------------------|
| <u>Farm income:</u> | a -Below \$20,000              | <u>Off-farm income:</u> | a -Below \$20,000              |
|                     | b -Between \$20,001 – \$40,000 |                         | b -Between \$20,001 – \$40,000 |
|                     | c -Between \$40,001 – \$60,000 |                         | c -Between \$40,001 – \$60,000 |
|                     | d -Between \$60,001 – \$80,000 |                         | d -Between \$60,001 – \$80,000 |
|                     | e -Over \$80,000               |                         | e -Over \$80,000               |
|                     |                                |                         | f -Do not have off-farm income |

5. What production risk management strategies do you use? Circle one answer in each row.

	Not at all		Somewhat		Definitely	N/A
Plant multiple crops	1	2	3	4	5	N/A
Rotations	1	2	3	4	5	N/A
Irrigation	1	2	3	4	5	N/A
Livestock and crops	1	2	3	4	5	N/A
Crop Insurance	1	2	3	4	5	N/A

6. Complete the table below:

- for yields please check your organic inspection records
- for other information approximate if necessary

<b>Corn</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>
Yield per acre											
Sale Price (in dollars per bushel)											
Acres planted											
Acres harvested											
Percentage grown under contract											
Expected or trend yield											
If transitional year mark with a "T"											
<b>Soybeans</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>
Yield per acre											
Sale Price (in dollars per bushel)											
Acres planted											
Acres harvested											
Percentage grown under contract											
Expected or trend yield											
If transitional year mark with a "T"											

	Circle one (this should be the third most important crop in your farm): <b>Wheat</b> <b>Oats</b> <b>Other</b> <input type="text"/>										
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Yield per acre											
Sale Price (in dollars per bushel)											
Acres planted											
Acres harvested											
Percentage grown under contract											
Expected or trend yield											
If transitional year mark with a "T"											

7. a) Over a typical 10 year period, you expect your corn yield to average  bu/acre.  
 In how many of those 10 years do you expect your corn yields to deviate from that average?
- 11 bushels above average       22 bushels above average       33 bushels above average   
 11 bushels below average       22 bushels below average       33 bushels below average
- b) Over a typical 10 year period, you expect your soybean yield to average  bu/acre.  
 In how many of those 10 years do you expect your soybean yields to deviate from that average?
- 3 bushels above average       6 bushels above average       9 bushels above average   
 3 bushels below average       6 bushels below average       9 bushels below average
- c) Over a typical 10 year period, you expect your yield for the crop reported at the top of this page to average  bu/acre.  
 In how many of those 10 years do you expect your yields for such crop to deviate from that average?
- 5 bushels above average       10 bushels above average       15 bushels above average   
 5 bushels below average       10 bushels below average       15 bushels below average

8. In what percentage of your sales do you use the following marketing/price risk management strategies?

- a - Verbal contracts with a buyer.....
- b - Written contracts with a buyer.....
- c - Coops as a bargaining agent.....
- d - Farmer's markets.....
- e - Hedging with futures/options.....
- f - Other, specify: \_\_\_\_\_ .....

9. Did you ever purchase crop insurance for your organic crops?

- a - YES  (GO TO QUESTION 10)
- b - NO  (GO TO QUESTION 11)

10. If you ever purchased insurance for your organic crops, please complete the table below:

<b>Corn</b>	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
What type? (e.g.:APH,CRC,etc.)											
What coverage level?											
<b>Soybeans</b>	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
What type? (e.g.:APH,CRC,etc.)											
What coverage level?											
<b>Crop at top of previous page</b>	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
What type? (e.g.:APH,CRC,etc.)											
What coverage level?											

11. If you have never purchased insurance for your organic crops, what were the reasons? Circle one answer in each row.

	Agree	Somewhat agree	Disagree	N/A		
Not all the crops in my rotation are covered	1	2	3	4	5	N/A
No GMO contamination coverage is available	1	2	3	4	5	N/A
I use off-farm income to offset losses	1	2	3	4	5	N/A
I use my own strategies to manage risk	1	2	3	4	5	N/A
I consider the current premiums too high	1	2	3	4	5	N/A
Level of coverage offered is inadequate	1	2	3	4	5	N/A
Level of price election offered is inadequate	1	2	3	4	5	N/A
I prefer not participate in federal programs	1	2	3	4	5	N/A

Comments:

## Appendix II: Variance-Covariance Matrix and Variance Inflation Factor (VIF)

CORN										
	Age	Farm size	Years farming	Years organic	Operation	Education	Farm income	Off income	Minnesota	Wisconsin
Age	1	-0.13	0.39	0.04	-0.28	0.01	-0.11	0.12	0.06	-0.04
Farm size	-0.13	1	0.16	0.13	0.36	0.15	0.42	0.05	-0.04	0.06
Years farming	0.39	0.16	1	0.10	-0.02	-0.07	0.03	0.27	0.13	-0.07
Years organic	0.04	0.13	0.10	1	0.15	0.02	0.08	0.18	-0.04	0.04
Operation	-0.28	0.36	-0.02	0.15	1	0.03	0.12	0.09	-0.16	-0.08
Education	0.01	0.15	-0.07	0.02	0.03	1	-0.01	0.07	-0.07	-0.10
Farm income	-0.11	0.42	0.03	0.08	0.12	-0.01	1	-0.05	0.14	-0.16
Off income	0.12	0.05	0.27	0.18	0.09	0.07	-0.05	1	-0.08	0.11
Minnesota	0.06	-0.04	0.13	-0.04	-0.16	-0.07	0.14	-0.08	1	-0.41
Wisconsin	-0.04	0.06	-0.07	0.04	-0.08	-0.10	-0.16	0.11	-0.41	1
VIF	2.37	1.46	2.76	1.36	1.34	1.44	1.57	1.44	1.56	2

SOYBEAN										
	Age	Farm size	Years farming	Years organic	Operation	Education	Farm income	Off income	Minnesota	Wisconsin
Age	1	-0.20	0.22	-0.08	-0.31	0.09	-0.07	0.12	0.08	-0.02
Farm size	-0.20	1	0.18	0.13	0.35	0.10	0.42	0.06	-0.07	0.15
Years farming	0.22	0.18	1	0.11	0.03	-0.17	0.22	0.18	0.26	-0.16
Years organic	-0.08	0.13	0.11	1	0.11	-0.18	0.22	0.21	-0.03	0.04
Operation	-0.31	0.35	0.03	0.11	1	0.04	0.09	0.07	-0.19	-0.08
Education	0.09	0.10	-0.17	-0.18	0.04	1	-0.06	0.16	-0.18	0.13
Farm income	-0.07	0.42	0.22	0.22	0.09	-0.06	1	0.04	0.10	-0.11
Off income	0.12	0.06	0.18	0.21	0.07	0.16	0.04	1	-0.05	0.11
Minnesota	0.08	-0.07	0.26	-0.03	-0.19	-0.18	0.10	-0.05	1	-0.32
Wisconsin	-0.02	0.15	-0.16	0.04	-0.08	0.13	-0.11	0.11	-0.32	1
VIF	2.43	1.53	2.99	1.68	1.29	1.54	1.80	1.75	1.42	1



## **Chapter 4: Revenue Protection for Organic Producers: Too Much or too Little**

### **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 the 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). Such provisions established the need to review, among others, the underwriting risk and loss experience of organic crops, determine whether significant, consistent, or systematic variations in loss history exist between organic and non-organic production, and in accordance with the results, reduce, eliminate or increase the 5% premium surcharge for coverage of organic crops that applies to all crops and regions across the U.S. The reason for requiring such analysis was that, even though organic crops were being covered by Federal crop insurance taking into account some of the idiosyncrasies of the organic production system, the incorporation of organic production 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, price premiums that organic producers are able to obtain in the market are not compensated for under the current insurance policy structure (RMA, 2011).

Consequently, RMA contracted for research at the beginning of 2009 for, among other purposes, the development of a pricing methodology that would improve the crop insurance policy for organic crops. Based on that research, for the crop year 2011 a pilot program is in effect, by which a separate price election is established for a few certified organic crops.<sup>1</sup> Thus, the prices of organic corn and soybean for insurance purposes are the prices of their conventional counterparts multiplied by 1.788 and 1.794, respectively, which are based on the minimum ratios of organic to conventional prices observed from January 2007 through September 2009.<sup>2</sup> In this way, the pilot program links the price determination of organic crop prices to their conventional counterparts by a fixed percentage, which will influence the payouts of both Yield and Revenue Protection products for such crops. But the impact will be greater in the latter case.<sup>3</sup>

When RMA's pilot program pegs organic prices to their conventional counterparts and uses commodity futures prices to forecast what the organic crop prices will be at harvest time, they are

assuming that the two markets are not only affected by the same shocks but also that they react 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 long-run relationship between organic and conventional prices, but also sharply contrasts observed market dynamics.

Organic crops have historically shown price premiums over their conventional counterparts. Singerman, Lence and Kimble-Evans (2010) found that the average premium from October 2004 until July 2009 for corn (soybean) across different markets in the U.S. was \$4.17/bu (\$7.41/bu). In general, one might expect organic crops to sell at a premium because, as argued by Clarkson (2007) and exemplified by Loureiro, McCluskey and Mittelhammer (2001), some consumers strongly prefer them 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). McBride and Greene (2008) also found that organic production involves higher 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 as profitable as, or outperform, conventional ones. However, since October 2010 organic price premiums for corn and soybean have been shrinking, due to the rise of commodity prices boosted by increased demand for ethanol and simultaneous reductions in forecasted supply due to weather-related problems in the Southern hemisphere, while organic prices have been steady. In late February 2011, the time at which price determination for crop insurance purposes is established, the prices for organic (conventional) corn and soybean 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 soybean respectively, well below RMA's established compensation prices for both organic crops.

The disparity in the behavior of organic and conventional crop prices implies, therefore, a changing multiplicative relationship between them, making the price ratio larger or smaller depending on idiosyncratic shocks; 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. This is so because, if the price ratio at the time of the price discovery (in February) 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 inflated (deflated).

Moreover, pegging organic crop prices to conventional ones might also result in systematic over (under) payments to producers under the Revenue Protection (RP) coverage, because such product insures against losses due to decreases in yield, prices, or both.<sup>5</sup> Hence, for example, a decrease in organic prices at harvest time will never be compensated for, whereas a decrease in conventional prices will incorrectly be part of an organic producer's indemnities. Therefore, in this paper we propose to examine the relationship between organic and conventional crop prices between planting and harvest time so as to establish the consequences of RMA's price mis-ratings in terms of payouts.

#### *Graphical illustration of the problem*

To illustrate the potential consequences of RMA's pilot program misalignments under RP (with harvest price exclusion (HPE)) with respect to the organic crop markets, we conducted a simple Monte Carlo experiment. Using farm survey yield data for organic corn producers from Iowa<sup>6</sup> we generated 5,000 draws. Then we generated an equal number of price draws from three lognormal distributions with different means (and the same volatility) to represent the following compensation structures to organic farmers:

- (1) RMA's conventional prices (insurance policy for all organic crops until 2010 and for most such crops for 2011)
- (2) Prices received by organic producers in the market<sup>7</sup>
- (3) 1.788 x RMA's conventional prices (new pilot program for 2011)

Given the lack of studies or data for the case of organic corn, to impose a target historical correlation between yields and prices we used Paulson and Babcock (2008) reported estimate of -0.86 for each of the three cases. 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." Thus, we then obtained the revenue distribution, as well as the corresponding 75% guarantee,<sup>8</sup> for each of the cases.

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 the market and insurance prices for the years 2009 and 2011. The results are shown in figure 1. From that figure it is clear that under case (1) organic farmers that purchased revenue coverage were always offered a lower guarantee compared to case (2). From figure 1 it is also clear that although the new pilot program is an improvement compared to the

previous policy because it is closer to the organic distribution, it is almost certain that organic producers would either be offered a lower or higher guarantee as panels A and B depict for the years 2009 and 2011 respectively (unless the ratio of organic to conventional prices is exactly 1.788).

To better exemplify the potential consequences for payouts due to the misalignment between RMA's pilot program prices and the ones of the organic corn market, in figure 2 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 2 panel A, it can be seen that when the conventional price is relatively low compared to organic (i.e., high organic price premium), there might be a relatively higher percentage of organic producers that RMA will not compensate for their true losses compared to the percentage of producers that will receive an indemnity for their false losses as indicated by quadrants I and II respectively. Contrastingly, in panel B it can be seen that when the conventional price is relatively high compared to organic (i.e.: low organic price premium), there might be a relatively higher percentage of organic producers that RMA will compensate for their false losses compared to those that will not receive an indemnity for their true losses as indicated by quadrants II and I respectively.

In addition, over and underpayments due to RMA's price misalignments will not only affect producers represented in quadrants I and II; producers in the lower left quadrant will be affected as well because indemnities would be based on a too low or too high compensation price, increasing, therefore, the degree of the mis-rating. Hence, in this manuscript 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 crop insurance is offered), until yield is realized (harvest time), we propose a structural model. Our model is an extension of that of Lence and Hayes (2005) because, unlike theirs, our framework is stochastic and it 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 not only their optimal production decisions, but also 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 distributions of all of the variables that are random at planting time are the same as the actual distributions of such variables.

Total grain demand is an aggregation of individual demands from type- $\delta$  ( $0 \leq \delta \leq 1$ ) consumers that will substitute conventional for organic grain 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,  $\delta$  describes the preferences that consumers have for the two kinds of grain. At the two extremes, consumers that are indifferent between consuming conventional or organic grain have  $\delta = 1$ ; whereas consumers that cannot be induced into consuming conventional grain regardless of the discount have  $\delta = 0$ . Demand for either type of grain is given by:

$$(1) \quad D_{\delta}^i = d_{\delta}(P_{\delta}^i)$$

where  $P_{\delta}^i$  is the price faced by type- $\delta$  consumers for crop  $i$  ( $i = \text{organic, conventional}$ ), and the demand function is assumed to be well behaved (i.e.:  $\partial d_{\delta} / \partial P_{\delta} < 0$ ). The sum over the whole range of  $\delta$ -type consumers ( $\sum_{\delta} D_{\delta}$ ) yields the aggregate grain demand. The demand schedules for

conventional and organic grain by type- $\delta$  consumers are:

$$(2) \quad D_{\delta}^C = \begin{cases} d_{\delta}(\delta^{-1} P^C) & \text{if } P^C < \delta P^O \\ d_{\delta}(\delta^{-1} P^C) - D_{\delta}^O & \text{if } P^C = \delta P^O \\ 0 & \text{if } P^C > \delta P^O \end{cases}$$

$$(3) \quad D_{\delta}^O = \begin{cases} d_{\delta}(P^O) & \text{if } P^C > \delta P^O \\ d_{\delta}(P^O) - D_{\delta}^C & \text{if } P^C = \delta P^O \\ 0 & \text{if } P^C < \delta P^O \end{cases}$$

The above specification implies that the demand schedules for each type of grain are interrelated; the price of conventional grain affects the demand for organic grain and *vice versa* (although to a different degree).

### *Supply and Rational Expectations*

Becoming a certified organic producer is subject to a 3-year transition period during which farmers 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> Contrastingly, switching from organic to conventional production is straightforward but given the transition period investment, organic farmers are not likely to switch to conventional production based on a single year's low market price premium. Thus, for our short-run model we take producers' preferences regarding whether to grow organic or conventional crops as given by planting time.

As mentioned above, crop production involves a time lag from input commitment at planting until output is realized at harvest. Therefore, the rational expectation supply of crop  $i$  ( $i = \text{organic, conventional}$ ) at time  $t+1$  ( $S_{t+1}^{Ei}$ ) is the number of acres planted at time  $t$  ( $A_t^i$ ) times the realization of a random yield at time  $t+1$  ( $y_{t+1}^i$ ) due to weather, pests, etc. It is important to note that the quantity of acres planted is in turn a function of the expected price ( $E_t(P_{t+1}^i)$ ), since actual prices at time  $t+1$  ( $P_{t+1}^i$ ) are random from the standpoint of time  $t$  due to stochastic yield as well as stochastic demand.

Thus, supply at time  $t+1$  can be expressed mathematically as:

$$(4) \quad S_{t+1}^{Ei} = A_t^i (E_t(P_{t+1}^i)) y_{t+1}^i$$

In this model, individual producers are implicitly assumed to make their planting decisions at time  $t$  (i.e., choose  $A_t^i$ ) so as to maximize their expected profits at  $t+1$  ( $\pi_{t+1}^i$ ), conditional on their information at time  $t$  and subject to any existing constraints. Mathematically:

$$(5) \quad \begin{aligned} E_t(\pi_{t+1}^i) &= E_t(S_{t+1}^{Ei} P_{t+1}^i) - C(A_t^i) \\ &= A_t^i E_t(y_{t+1}^i P_{t+1}^i) - C(A_t^i) \\ &= A_t^i P_{t+1}^{Pi} - C(A_t^i) \end{aligned}$$

where  $C(\cdot)$  denotes the cost function and  $P_{t+1}^{Pi} \equiv E_t(y_{t+1}^i P_{t+1}^i)$  is equal to (a constant times) the producers' incentive price, which in general<sup>10</sup> is different from the expected price ( $P_{t+1}^{Pi} \neq E_t(P_{t+1}^i)$ ) because producers recognize that their yield disturbance is proportional to the aggregate output, and the latter covaries with the market price (Lence and Hayes 2000; Wright 1979). Under standard regularity conditions for the cost functions, the supply functions can be obtained from the first-order condition (FOC) corresponding to equation (5).

### Market equilibrium

Equations (1) through (5) imply that the market clearing conditions for conventional and organic grain are:

$$(6) \quad S^{EC} = D_{\delta^*}^C + \sum_{\delta > \delta^*} d_{\delta} (\delta^{-1} P^{C*})$$

$$(7) \quad S^{EO} = D_{\delta^*}^O + \sum_{\delta < \delta^*} d_{\delta} (\delta^{-1} P^{O*})$$

where  $\delta^* \equiv P^{C*} / P^{O*}$  is the market-clearing consumer discount for conventional grain. Thus, in equilibrium, consumers with a preference factor strictly smaller (greater) than  $\delta^*$  will only consume organic (conventional) grain, whereas consumers of type  $\delta^*$  will be indifferent between consuming either, so they will consume the amounts that balance the corresponding supplies.

### 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 county 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)), for the analysis yields are assume to follow a beta density function:

$$(8) \quad f(y) = \frac{\Gamma(p+q)}{\Gamma(p)\Gamma(q)} \frac{(y - y_{\min})^{p-1} (y_{\max} - y)^{q-1}}{(y_{\max} - y_{\min})^{p+q-1}} \quad \text{where } y_{\min} \leq y \leq y_{\max}$$

where  $p$  and  $q$  are shape parameters and  $y_{\min}$  and  $y_{\max}$  are minimum and maximum possible yields.

Following Johnson and Kotz (1970), the shape parameters can be obtained from the following equations:

$$(9) \quad p = \left( \frac{\mu - y_{\min}}{y_{\max} - y_{\min}} \right)^2 \left( 1 - \frac{\mu - y_{\min}}{y_{\max} - y_{\min}} \right) \left( \frac{\sigma^2}{(y_{\max} - y_{\min})^2} \right)^{-1} - \frac{\mu - y_{\min}}{y_{\max} - y_{\min}}$$

$$(10) \quad q = \frac{\mu - y_{\min}}{y_{\max} - y_{\min}} \left( 1 - \frac{\mu - y_{\min}}{y_{\max} - y_{\min}} \right) \left/ \left( \frac{\sigma^2}{(y_{\max} - y_{\min})^2} \right) \right. - 1 - p$$

and the minimum and maximum yields are defined as  $y_{\min} = \max(\mu - 4\sigma, 0)$  and  $y_{\max} = \mu + 1.5\sigma$ . To estimate the above beta distribution, we first calculated the detrend yields from 1980 to 2010 for conventional corn in Adair County, Iowa<sup>11</sup>. Thus, the data reflects 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 APH premium rate at the 65% coverage level for that county. In this way, we aligned our yield distribution with that of RMA. By doing so we assume that RMA's yield rating is correct, allowing us to focus on the price mis-rating. Thus, the estimated marginal distribution for conventional corn has parameters  $y_{\min} = 59$ ,  $y_{\max} = 234$ ,  $p = 2.98$  and  $q = 1.28$ .

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). Therefore, the estimated marginal distribution for organic corn has parameters  $y_{\min} = 3$ ,  $y_{\max} = 183$ ,  $p = 1.66$  and  $q = 1.02$ . The following step in the yield calibration consisted of imposing the observed correlation of 0.70<sup>12</sup> (Delate 2009) between the organic and conventional independent distributions of yields using the Iman and Conover procedure.

The above distribution of yields can be interpreted as that of representative producers in Adair County. Even though county yields covary with national ones, the price-yield relationship is more realistically established at the national level. Hence, in our model national yields are given by:

$$(11) \quad y^A = \alpha y_i + (1 - \alpha) \bar{y}$$

where  $y^A$ ,  $y_i$  and  $\bar{y}$  denote the national, the producers' and the unconditional yield level, respectively; and  $\alpha$  defines the weight of the two components. By taking the variance of expression (11) we estimated the value of  $\alpha$  in the following way: we computed the variance of national yields based on detrended yields from 1980 to 2011; using Harwood *et al.* (1999) estimate for the coefficient of variation in Adair (0.25) we then derived the variance for that county, and obtained  $\alpha = 0.37$ . To obtain a national yield distribution for organic corn, we used an analogous procedure to the one just described for its conventional counterpart.



### *Demand Calibration*

For the calibration of the model, the parameters used are either measures based on previous studies or estimates calculated from the data we had available. The following isoelastic demand represents equation (1):

$$(12) \quad d_{\delta}(P_{\delta}) = \kappa_{\delta} P_{\delta}^{-\varepsilon_{\delta}},$$

where  $\kappa_{\delta}$  is a scaling parameter and  $\varepsilon_{\delta}$  is the constant demand elasticity of type- $\delta$  consumers. Thus, demand calibration consists of specifying values for these two parameters so as to make them consistent with available market information. 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 total grain consumption during the calibration period. Combining the definition of market shares with (12) and solving for  $\kappa_{\delta}$ , we obtain:

$$(13) \quad \kappa_{\delta} = m_{\delta} \times D \times P_{\delta}^{\varepsilon_{\delta}}$$

where  $P_{\delta}$  is the price faced by type- $\delta$  consumers in the calibration period.

Given the lack of data on the own-price elasticity of demand for organic corn,  $\varepsilon_{\delta}$  was assumed to be the same for both crops and obtained from 2010 FAPRI estimates (McPhail 2010). We obtained values for  $P$ ,  $D$  based on April's 2011 World Agricultural Supply and Demand Estimates (WASDE) for corn 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 consumers in the following broad homogeneous 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  $\delta$  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 postulate the use of a continuous distribution instead; specifically, a

Beta( $\delta \mid \alpha = 1.63, \beta = 0.028, \delta_{\min} = 0, \delta_{\max} = 1$ ) that was fitted by maximum likelihood to the calibrated discrete cumulative distribution function. Then, using the computer routines developed by Miranda and Fackler (2011), we computed Gaussian quadratures nodes and weights to approximate the distribution of  $\kappa_\delta$ . In addition, the exogenous shocks to consumer demand are assumed to be identically and independently log-normally distributed,  $\xi \sim LN(\mu, \sigma^2)$ .  $E_t(\xi) = 1$  and its variance was calibrated so as to obtain the desired level of correlation between prices and yields.

### Supply

The supply function that follows from the FOC of equation (5) is assumed to be isoelastic, taking the form  $s^i(P^{p^i}) = \kappa^i P^{p^i - \varepsilon^i}$  where  $\varepsilon^i$  is the constant supply elasticity for crop  $i$  and  $\kappa^i$  represents a supply scaling parameter that is consistent with the observed producer market shares.

### 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 consumer's substitution between organic and conventional corn, and an optimization routine to ensure that the markets cleared. The iteration steps involved can be summarized as follows:

- Step 1. Compute the county yield draws for each state of the world  $s \{y_s^{Ocounty}, y_s^{Ccounty}\}$  according to equation (8) using estimated parameters defined in expressions (9) and (10). Then compute the corresponding national yield draws  $\{y_s^O, y_s^C\}$  as in expression (11).
- Step 2. Set up the parameters of the model, and compute the Gaussian quadrature nodes and weights for the exogenous demand random shocks  $\{\xi_s^O, \xi_s^C\}$ .
- Step 3. Compute the probability  $\varphi^s$  of each state of the world  $s$  assuming that demand shocks are independent of supply shocks. Specify starting values of acres  $\{A^{O(0)}, A^{C(0)}\}$  and  $\delta_s^{(0)}$ .
- Step 4. Given  $\{A^{O(j)}, A^{C(j)}\}$ , compute supplies of organic and conventional crops at each state of the world  $s$ , so  $\{S_s^{O(j)} = A^{O(j)} y_s^O, S_s^{C(j)} = A^{C(j)} y_s^C\}$
- Step 5. Compute the scaling factor  $\kappa_\delta$  at each state of the world  $s$  consistent with  $\delta_s^{(j)}$ .

Step 6. Given  $\{S_s^{O(j)}, S_s^{C(j)}\}$  together with  $\kappa_\delta$  and the demand shocks  $\{\xi_s^O, \xi_s^C\}$ , compute the market clearing prices at each state of the world  $s\{P_s^{O(j)}, P_s^{C(j)}\}$  using an optimization routine consisting of maximizing a measure of consumer surplus using the utility function that corresponds to the chosen isoelastic demand function subject to the following inequalities:

$$D_s^{O(j)} \leq S_s^{O(j)}$$

$$D_s^{O(j)} + D_s^{C(j)} \leq S_s^{O(j)} + S_s^{C(j)}$$

Step 7. If  $|P_s^{C(j)} / P_s^{O(j)} - \delta_s^{(j)}|$  is smaller than the desired tolerance, go to step 8. Otherwise, compute the *bisection* innovation for  $\delta_s^{(j)}$ , set it as  $\delta_s^{(j+1)}$  and go back to step 5.

Step 8. Given  $\{P_s^{O(j)}, P_s^{C(j)}\}$  compute the producers' incentive prices  $\{P^{P^{O(j)}}, P^{P^{C(j)}}\}$ , and use the latter to compute in turn the values for  $\{A^{O(j+1)}, A^{C(j+1)}\}$ .

Step 9. If  $|\{A^{O(j+1)}, A^{C(j+1)}\} - \{A^{O(j)}, A^{C(j)}\}|$  is smaller than the desired tolerance, stop and set the solution equal to the values obtained in the  $j$ th iteration. Otherwise, compute the *Newton* innovations for  $\{A^{O(j+1)}, A^{C(j+1)}\}$ , set those as  $\{A^{O(j)}, A^{C(j)}\}$ , and go back to step 4.

## Results

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

For the first three scenarios in table 1, the correlation between organic and conventional corn yields is set at 0.70 as discussed in the Yield calibration section, 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 (I) that organic producers would get under RP-HPE coverage with the pilot program (denoted by the RMA column) is \$342/acre, which is higher than what they should (\$195/acre) 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

(defined as  $\sum_i \varphi_i I_i$ ) by acre for RMA is \$78 under the pilot program versus \$44 under the organic distribution.

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. Instead, 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, and the expected loss by acre is \$61 in both cases.

A more suitable measure of RMA's mis-rating across scenarios is the loss-cost ratio, defined as the ratio of indemnities to coverage. For scenarios 1 through 3, table 1 shows not only that the loss-cost ratio under the pilot program increases with the price ratio, but also that they are all greater than the ones obtained under the organic distribution. To better understand this result, the revenue distributions corresponding to each of these three scenarios are depicted in Figure 3. From that figure it becomes clear that the distributions' dissimilar shapes are driving the above result. The explanation behind the contrasting shapes is given by the different behavior of the yield-price relationship for organic and conventional crops.

From figure 3 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 dotted lines in figure 3) we combined the organic revenue distribution with RMA's rating. Thus, the last three columns of table 1 show the expected loss, loss-cost ratio and effective coverage using RMA's guarantee; their values evidence the extent to which the 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 induces an effective coverage of 106% (45%).

The set of scenarios 4-6 and 7-9 show how the results change when the correlation between organic and conventional corn yields is 0.4 and 0.9, respectively. There are three main findings from this sensitivity analysis; first, when the correlation is lower (higher) the value for the average indemnity, expected loss and cost-loss ratio increases (decreases) with respect to scenarios 1-3; second, the difference between the loss-cost ratios under the organic distribution versus that of RMA also increases (decreases) with respect to scenarios 1-3; and third, the level of effective coverage is basically the same as for scenarios 1-3.

Scenarios 10-12 show how imposing a level of yield-price correlation of -0.63 affects the results. In this case, the value for the expected loss and cost-loss ratio decreases with respect to scenarios 1-3, the difference between the loss-cost ratios under the organic distribution versus that of

RMA also decreases with respect to scenarios 1-3; and third, the level of effective coverage is similar to that of the other sets of scenarios.

### **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 the current policy. In an attempt to overcome such deficiency in the policy, in 2011 RMA has introduced a pilot program for certified organic corn and soybean by which the 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 soybean, respectively.

Given the 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, in this paper we analyze what the consequences of the price misalignment derived from the pilot program are under RP-HPE coverage. Using a stochastic structural model between planting and harvesting applied to the U.S. corn market we found that for the 75% nominal coverage level, when the price ratio is low (high) the mis-rating induces an effective coverage of 106% (45%); resulting, therefore, in higher (lower) indemnities compared to those 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 market price ratio of organic to conventional crop prices 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 1x conventional prices, linking organic crop prices to their conventional counterparts creates mis-ratings in their insurance coverage. Using contract prices instead would not only be more appropriate given the relevance that contracting has in the organic agricultural sector, but it would also eliminate RMA's price misalignments.

## Notes

1. The certified organic crops are cotton, corn, soybean and (processing) tomatoes.
2. The RMA contractor originally recommended that the price determination for organic corn (soybean) 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.
3. Under Yield Protection, producers will be compensated by RMA's price in case of lower yield. Under Revenue Protection they will also get compensated if the (conventional) price decreases.
4. The organic crop prices were retrieved from USDA Market News report NW\_GR113 for February 23<sup>rd</sup> 2011, whereas the ones for conventional crops were obtained from the Wall Street Journal of the same date.
5. RP includes compensation for a price increase at harvest time by recalculating the guarantee if the harvest price is higher than the projected one, as opposed to RP with exclusion.
6. The data is the same as that used by Singerman, Hart and Lence (2010).
7. Due to the lack of futures 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 the insurance practices.
10. That is, unless the disturbance of yields is additive.
11. We selected Adair because we have data available for organic and conventional crops grown side by side from Iowa State University experimental stations, which allowed us to estimate the correlation between the yields for the two types of crops.
12. Such correlation figure is similar to the one obtained in the 20-year period data corresponding to Rodale Institute trials in Kutztown, PA.

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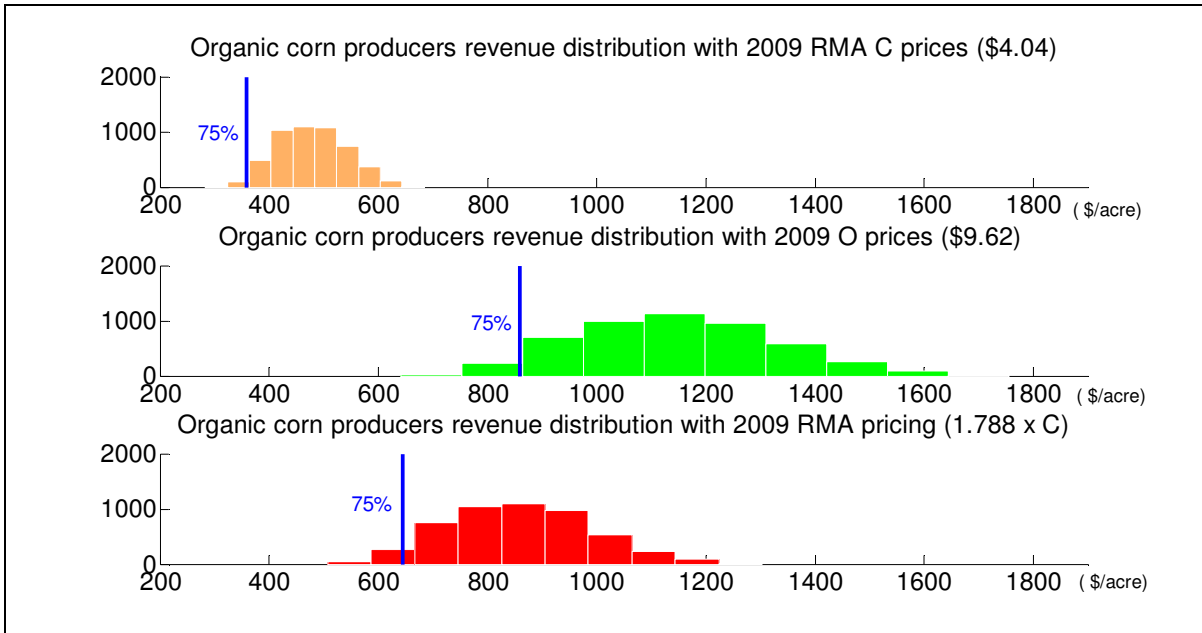
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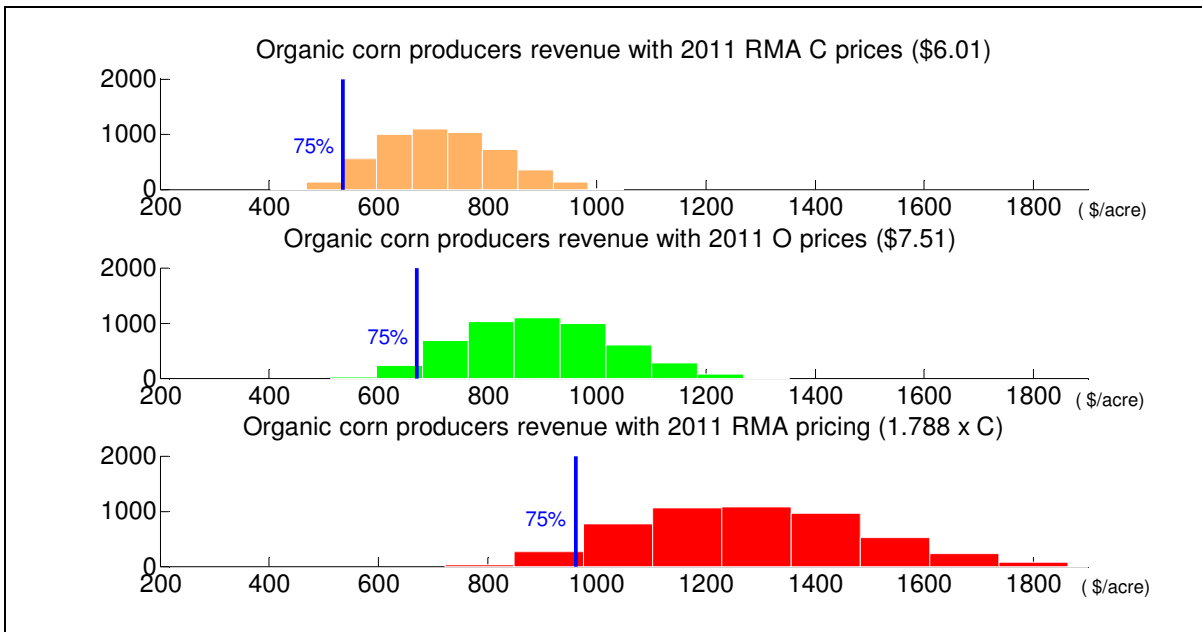
**Table 1. Effect of organic to conventional price ratios on RMA's mis-ratings for organic corn producers under RP-HPE**

Yield correlation (Org., Conv.) = 0.70					Comparative								
Yield-price correlation = -0.51					Average Indemnity (\$/acre)		Expected Loss (\$/acre)		Loss-cost (%)		Expected Loss (\$/acre)	Loss cost (%)	Effective coverage (%)
Expected price(\$/bu)					Org.	RMA	Org.	RMA	Org.	RMA			
Scenario	Organic	Conv.	Ratio		Org.	RMA	Org.	RMA	Org.	RMA	(\$/acre)	(%)	(%)
1	7.59	5.85	1.30	LOW	195	342	44	78	6.60	8.23	151	15.93	106
2	9.94	4.38	2.27	MEDIUM	258	304	59	78	6.66	10.46	33	4.55	63
3	10.23	3.23	3.17	HIGH	260	227	61	61	6.67	11.00	15	2.69	45
Yield correlation (Org., Conv.) = 0.40					Comparative								
Yield-price correlation = -0.51					Average Indemnity (\$/acre)		Expected Loss (\$/acre)		Loss-cost (%)		Expected Loss (\$/acre)	Loss cost (%)	Effective coverage (%)
Expected price(\$/bu)					Org.	RMA	Org.	RMA	Org.	RMA			
Scenario	Organic	Conv.	Ratio		Org.	RMA	Org.	RMA	Org.	RMA	(\$/acre)	(%)	(%)
4	7.59	5.85	1.30	LOW	218	379	54	101	7.74	10.29	177	18.09	106
5	9.94	4.38	2.27	MEDIUM	285	332	71	102	7.83	13.08	45	5.89	64
6	10.23	3.23	3.17	HIGH	296	250	73	80	7.82	13.74	22	3.71	46
Yield correlation (Org., Conv.) = 0.90					Comparative								
Yield-price correlation = -0.51					Average Indemnity (\$/acre)		Expected Loss (\$/acre)		Loss-cost (%)		Expected Loss (\$/acre)	Loss cost (%)	Effective coverage (%)
Expected price(\$/bu)					Org.	RMA	Org.	RMA	Org.	RMA			
Scenario	Organic	Conv.	Ratio		Org.	RMA	Org.	RMA	Org.	RMA	(\$/acre)	(%)	(%)
7	7.59	5.85	1.30	LOW	177	322	32	53	4.81	5.66	129	13.81	105
8	9.94	4.38	2.27	MEDIUM	231	279	43	54	4.85	7.36	26	3.61	62
9	10.23	3.23	3.17	HIGH	234	213	44	42	4.82	7.80	14	2.62	44
Yield correlation (Org., Conv.) = 0.70					Comparative								
Yield-price correlation = -0.63					Average Indemnity (\$/acre)		Expected Loss (\$/acre)		Loss-cost (%)		Expected Loss (\$/acre)	Loss cost (%)	Effective coverage (%)
Expected price(\$/bu)					Org.	RMA	Org.	RMA	Org.	RMA			
Scenario	Organic	Conv.	Ratio		Org.	RMA	Org.	RMA	Org.	RMA	(\$/acre)	(%)	(%)
10	7.59	5.85	1.30	LOW	196	269	39	62	5.97	6.79	120	13.26	104
11	9.94	4.38	2.27	MEDIUM	249	222	52	54	6.02	7.80	26	3.72	60
12	10.23	3.23	3.17	HIGH	255	167	53	41	6.00	8.06	13	2.48	43

**A. For 2009**

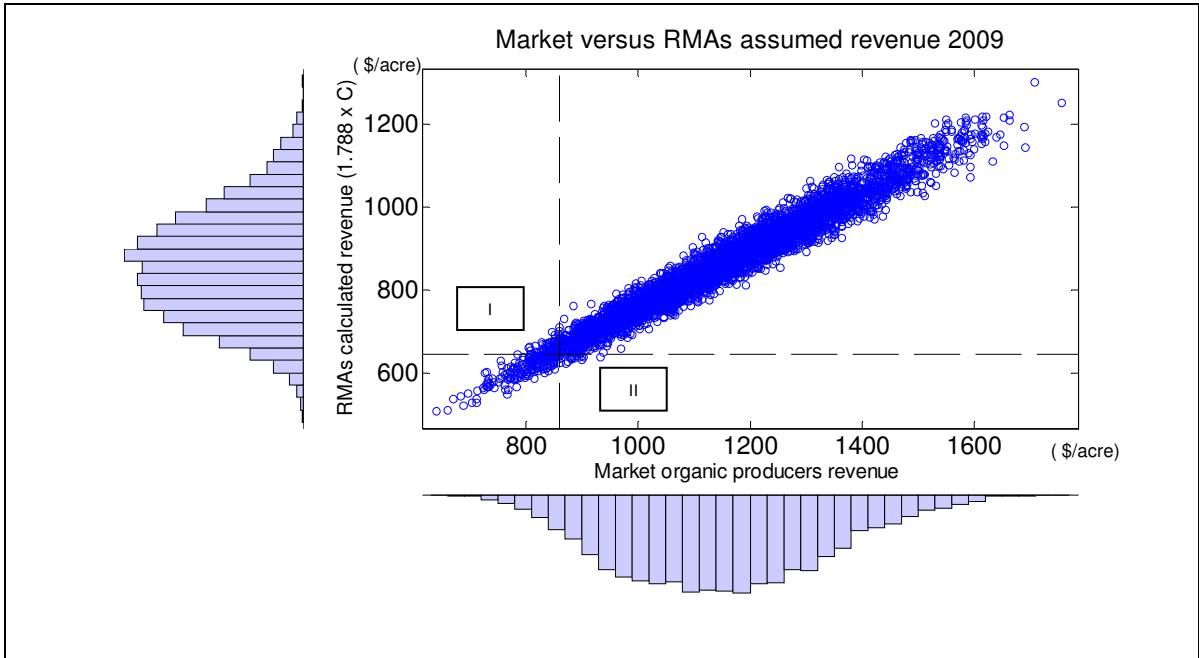


**B. For 2011**

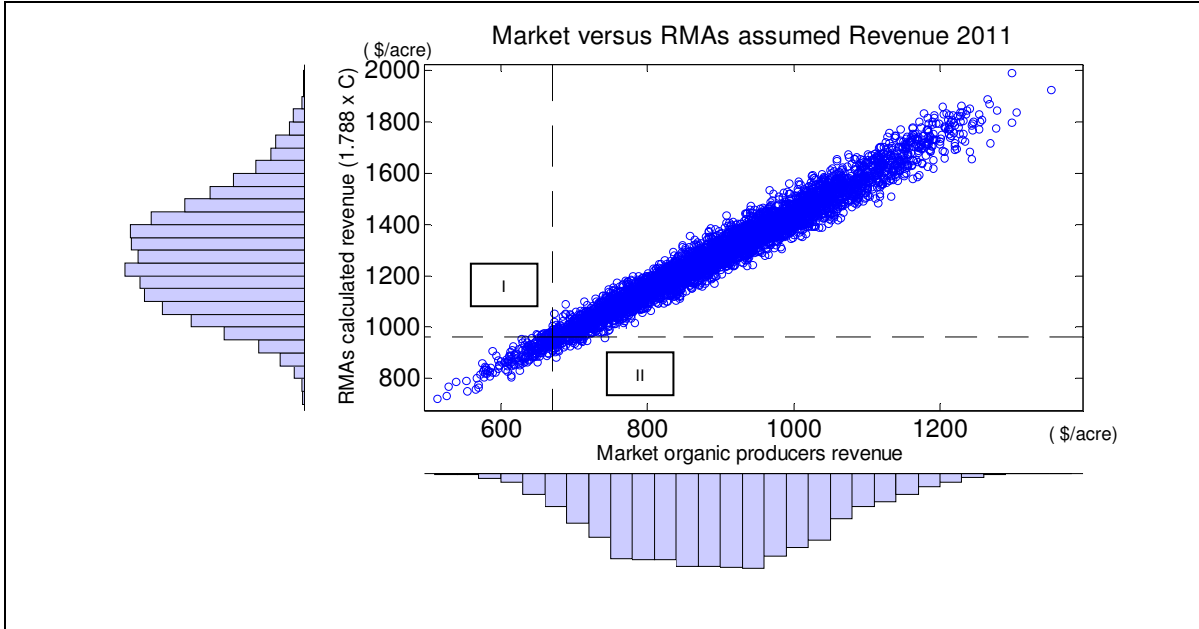


**Figure 1. Revenue distributions for organic corn producers denoting 75% coverage level using different pricing**

**A. For 2009**

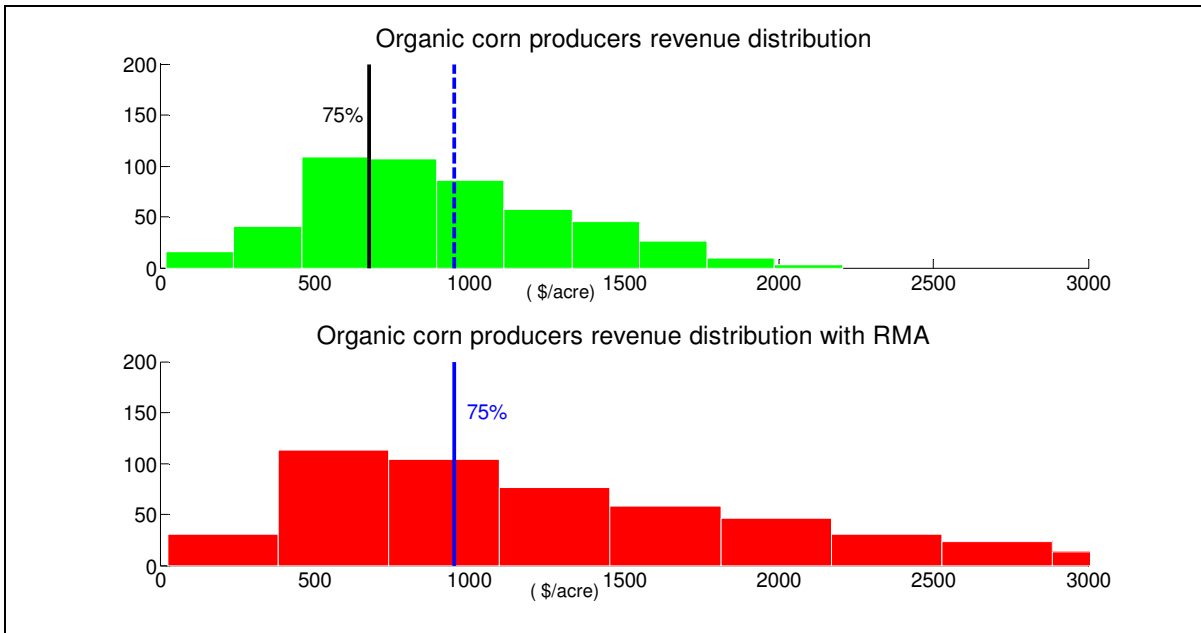


**B. For 2011**

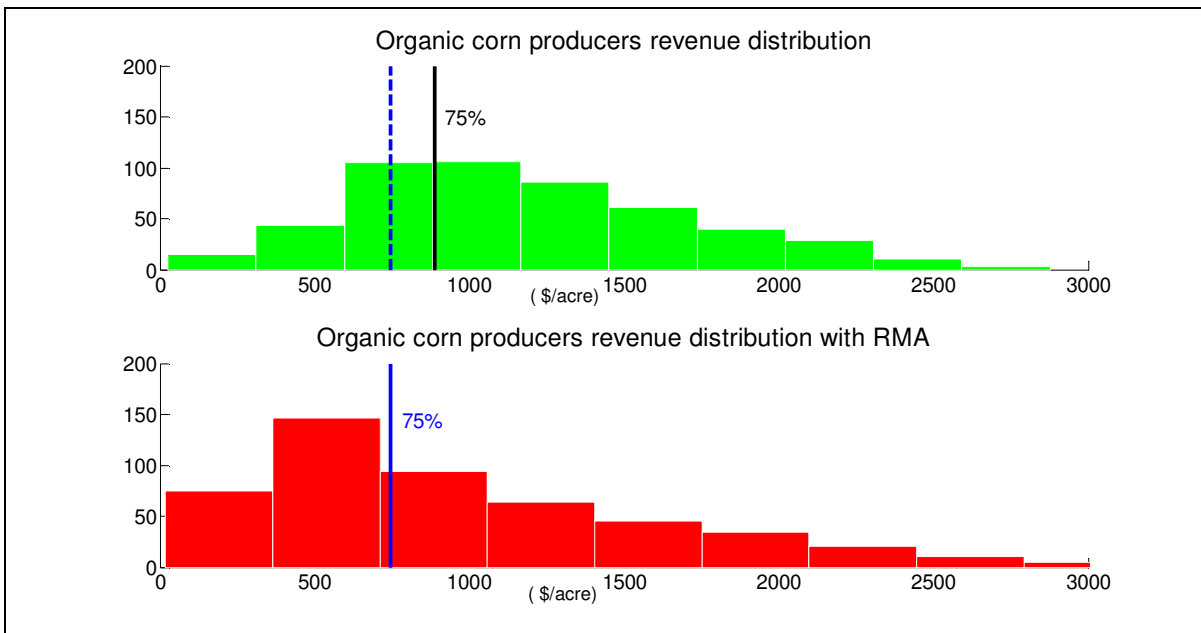


**Figure 2. Scatter plot of revenue distributions for organic corn producers denoting 75% coverage level using different pricing**

**A. Low organic to conventional price ratio (scenario 1 table 1)**

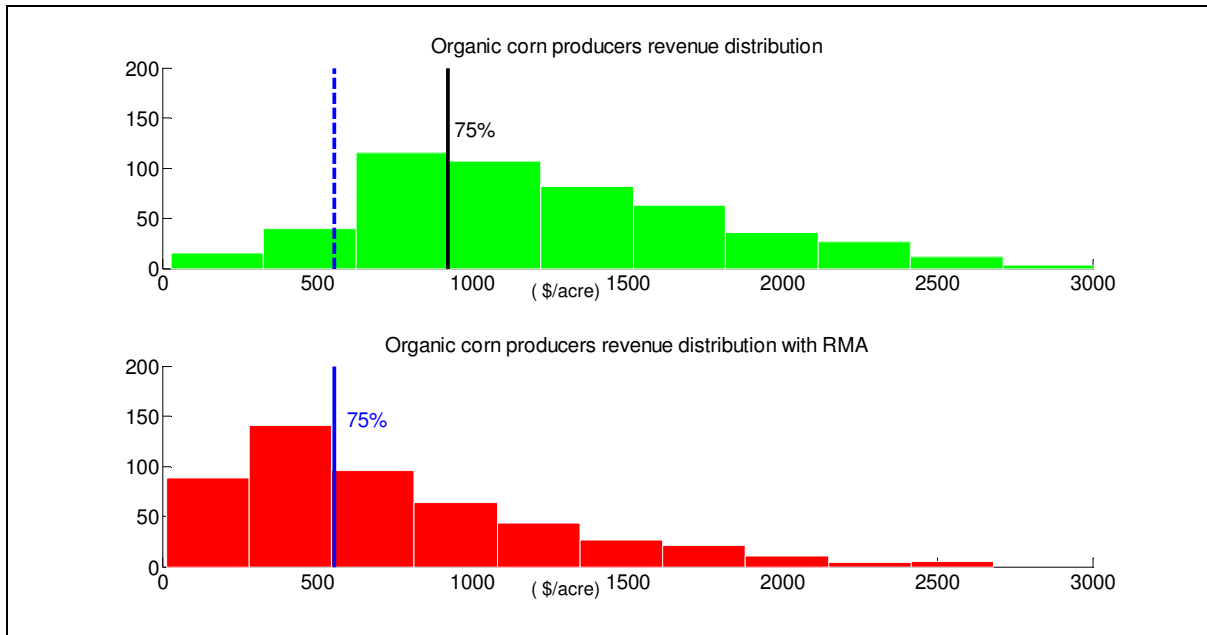


**B. Medium organic to conventional price ratio (scenario 2 table 1)**



**Figure 3. Revenue distributions from the structural model for organic corn producers denoting 75% coverage level under different pricing**

**C. High organic to conventional price ratio (scenario 3 table 1)**



**Figure 3. (continued)**

## Chapter 5: General Conclusions

In this dissertation different aspects related to the insurance policy for organic crops are analyzed using econometric and numerical methods. A summary of the main findings of the three preceding chapters and their policy implications follows.

In the first paper evidence of spatial price cointegration among organic markets was found, particularly between pairs of markets we had data for and the presumed organic hub, Minneapolis, indicating that such market is the leading one. Overall, spatial cointegration in organic markets seems weaker than the one present in conventional markets, suggesting that local market forces may exert a stronger effect on the determination of local prices for organic crops than for conventional ones. Departures from the long-term relationships across organic markets do not seem to increase the probability of price changes, however, whenever price changes do occur, they tend to restore such long-term relationships.

In the second paper, the demand for crop insurance by organic producers' was analyzed using a discrete choice model that showed the impact of demographic variables on their purchasing and product choice decisions. But perhaps more importantly, we complemented those results with additional crop insurance usage information, as well as yield, price and revenue comparisons between organic and conventional producers. Although some authors have reported that organic and conventional yields are equivalent, in this study we found that corn and soybean under organic management attain about 70% of the yield of that of conventional crops. The dissimilarity of the results could be due to the fact that many of those authors performed the experiments on (smaller) experimental plots that are more easily controlled for weeds than entire farms are. However, those experiments reveal the potential for organic farming of achieving yields equivalent to those of conventional crops, something exemplified by the yield level for organic oats achieved by producers in our sample. The present study provides further evidence that organic producers obtain higher prices than their conventional fellows. In fact, in our sample the higher prices received for the organic crops more than offset their lower yields, resulting in higher revenues per acre compared to their conventional counterparts.

In the third paper, RMA's 2011 pilot program for certified organic corn and soybean is examined. Such program pegs the price determination of those crops for insurance purposes to that of their conventional counterparts by a fixed factor of 1.788x and 1.794x for corn and soybean, respectively. Using a stochastic structural model between planting and harvesting that incorporates producers' rational expectations applied to the U.S. corn market, we found that for the 75% nominal

coverage level under the RP-HPE policy, when the price ratio is low (high) the mis-rating induces an effective coverage of 106% (45%); resulting, therefore, in higher (lower) indemnities compared to those organic producers should get when considering their idiosyncratic revenue distribution.

Thus, the results of the first paper suggest that organic prices are as volatile as conventional ones, that the premiums paid for organic crops exhibit substantial variability, and that existing futures and derivatives markets do not provide effective tools to manage price risks for the organic sector. Results from the second paper regarding the different yield levels (and their probability distribution functions) between organic and conventional corn and soybean producers, along with the substantial price premiums that organic farmers obtain, call for RMA to perform additional analyses to evaluate their validity on a nationwide basis and, if so, modify the current organic farming insurance policy accordingly to provide a more actuarially fair coverage to organic producers.

The findings from the third paper imply that given the evidence of a changing multiplicative relationship between organic and conventional crop prices, RMA's pilot program will 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. Consequently, the effective level of coverage is going to be different from the nominal one.

The above findings imply that organic crop markets have unique characteristics when compared with their conventional counterparts. Such idiosyncrasies need to be taken into consideration, for example, by RMA when setting the Federal crop insurance policy for organic farmers.