The Conventional-Organic Crop Yield Gap: Evidence from Farm-Level Data

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Several long-term experimental trials in the midwestern United States have shown that organic crop production methods can achieve yields nearly as high as those achieved by conventional methods (Coulter et al., 2011; Pimenetl et al., 2005; Delate et al., 2003). This yield competitiveness, along with significant price premiums available for organic crops, has led authors of economic studies to conclude that organic cropping systems may be more profitable than conventional systems (e.g. Delbridge et al., 2011). However, available crop yield and financial data from farms in the Midwest show that organic crop farms tend to perform worse, on average, than conventional crop farms. In Minnesota, average organic crop yields for some crops have been well below average conventional yields achieved in the state, and overall organic farm profitability, measured by return on assets, has been lower than conventional farm profitability in nearly every year for which data are available (Center for Farm Financial Management, 2014).

It is possible that experimental trials tend to overstate the yield potential of organic farms because relatively small plot sizes facilitate the management of the more complex organic system. However, there are individual organic farms that consistently have yields close to, or even above, county averages. An alternative explanation for the observed yield gap is that there is a significant selection effect among those that choose to manage their farms organically, and that these farms have a lower yield potential, on average, than the full population of midwestern crop farms. Although several studies have found that organic farmers are often attracted to organic management due to perceived environmental or health benefits (e.g. Darnhofer et al., 2005), these studies do not shed much light on the differences in yield potential between organic and conventional farms. This paper investigates the relationship between conventional and organic crop yields at the farm level using a unique set of yield data from "split-operation" crop farms that have grown either corn or soybean using both organic and conventional management in the same year. This is the first paper that uses such a data set to show the existence of a selection effect in organic transition and to explore its impact on observed organic yield averages.

There is a fairly large branch of literature that has focused on farmer motivation for adopting (and not adopting) organic cropping systems (e.g. Peterson et al., 2012; Stofferahn, 2009; Darnhofer et al., 2005; Duram, 2000). These studies have consistently concluded that farmers choose organic production for a variety of reasons that often include perceived environmental or health benefits, in addition to access to higher organic prices. This is consistent with the expanded utility framework proposed by Chouinard et al. (2008), in which farmers derive utility from conservation and land stewardship as well as profits. Given the survey and interview results in the previously cited literature on motivations for organic transition, one would expect those that have chosen to farm organically to value stewardship and environmental conservation relatively more, and profits relatively less, than those that have chosen not to farm organically. If organic farmers do not always seek to maximize yield and profits conditional on maintaining organic certification, the observed production and financial outcomes of existing organic farms may be lower than the yield and profit potential of conventional farms considering organic management for profit-based motives. This could have the effect of discouraging further transition.

A farm's physical and geographic characteristics may be just as important to the organic transition decision as a farmer's beliefs. Because cropland must have no synthetic pesticides or fertilizers applied to it for three years prior to organic certification, land enrolled in the Conservation Reserve Program (CRP) can often be taken out of the program and immediately certified as organic. This is a common organic transition strategy for farms with land in the CRP program. Since CRP land is likely less fertile and less productive than land that has not been enrolled in CRP, organic cropland may tend to be so as well.

Even among farms that do not have access to CRP land, there may be a greater incentive for lower yielding farms to be transitioned to organic management. Farms that have high conventional corn and soybean yields have a relatively high opportunity cost of abandoning conventional production and diversifying to include the less profitable crops that are necessary in an organic crop rotation (e.g. alfalfa hay, small grains). This opportunity cost is lower for low yielding conventional farms, potentially making these farms more likely to transition. Both the preferences of established organic farmers and the potential advantages of transitioning low-yielding crop land to organic management may lead to a selection effect that significantly biases the organic farm-level data that is currently available.

Whereas previous research has investigated personal characteristics of organic adopters, this study explores the productive characteristics of these farms. By focusing on the comparison between the conventional crop yields achieved by farms that decide to transition to organic management, and those achieved by their conventional neighbors, this study contributes to the understanding of the population of certified organic farms and helps to appropriately interpret the data that they generate. Specifically, this paper provides some of the first empirical evidence that farms that choose organic production have lower yield potential than average conventional farms in their counties. Another contribution of this paper is the estimation of the relationship between a farm's conventional crop yields and their organic crop yields, suggesting that farms with high conventional yields can expect higher organic yields.

This paper proceeds with a short background on past experimental and farm-level comparisons of organic and conventional crop yields, followed by a description of the unique yield data used in this study. The next section presents comparisons of the sample farms' conventional yields and county yield averages to test for the existence of a selection effect in organic transition. This is followed by the presentation of a simple econometric model to estimate the relationship between conventional and organic crop yields on partially transitioned farms. Finally, we discuss the implications of the results to business planning and crop insurance applications. A short discussion concludes the paper.

Background

Most of the information that is available on organic crop yields comes from experimental trials. In the Midwest, there have been several long-term cropping system trials that have aimed to compare the crop yields of organic and conventional systems under identical soil and weather conditions. Based on 16 years of trial data from Minnesota, Coulter et al. (2011) found that corn, oat, and alfalfa yields were not significantly lower in an organic system than in a conventional system, though organic soybean had lower yields than conventional soybean. Delate et al. (2003) analyzed data from a cropping systems trial in Iowa and found that organic corn and soybeans achieved roughly equal yields as in conventional systems, with both corn and soybean yielding more in the organic system in some years. Pimentel et al. (2005) used 22 years of data from the Rodale cropping systems trial to conclude that average organic yields were roughly equal to average conventional yields, except during a drought year, when organic yields were quite dramatically higher than conventional yields. An earlier study in South Dakota found that over the 7 years of a side-by-side trial, average corn and soybean yields were significantly lower in an organic system than in a conventional system (Smolik et al., 1995).

At the farm-level, data on organic crop yield outcomes is more scarce. Since 2006, the University of Minnesota's Center for Farm Financial Management has made available enterprise data for certain organic crops grown in Minnesota and a few other midwestern states (Center for Farm Financial Management, 2014). These data show that farms that grow certified organic corn and soybean usually do not achieve the same high organic yield levels that have been reported by studies drawing on experimental trial data. For example, the average organic corn yield from 2006-2013 in Minnesota was 105 bu/acre, which compares to an average yield of 166 bu/acre for conventional corn[1]. Another source of data on organic yields is the USDA ARMS survey, which sampled 1,425 conventional soybean producers and 237 organic soybean producers across the Corn Belt and Midwest in 2006. McBride and Greene (2009) analyzed this data and found that, on average, the organic farms achieved soybean yields of 31 bu/acre while the conventional farms achieved 47 bu/acre.

Data

This study uses farm-level data on the production of corn and soybean gathered by the Minnesota Farm Business Management (FBM) program. Data include information on crop yields, acreage and some expense and management records for all crops grown on an included farm in a given year. The unique feature of this data set is that the farms represented are those that grew a crop (either corn or soybean[2]) both conventionally and organically *in the same year*. This allows the analysis to avoid the complicating issues of varying location[3], weather, and farm management that typically plague comparisons of organic and conventional yield data at the farm-level.

The data used in this study include observations (i.e. farm-year combinations) from Minnesota farms from 1996 to 2012. There are 93 soybean observations from 54 farms and 70 corn observations from 33 farms. Farms are represented more than once if they grew the same crop conventionally and organically in more than one year. Although these yield data allow us to investigate the gap between organic and conventional yields on "split operations", they tell us little about the relationship between these farms and the larger population of conventional crop producers. To study this relationship we combine the farm-level data with the USDA-NASS crop yield averages from each farms' county in the relevant year (USDA-NASS, 2014). Table 1 shows summary statistics for the data included in the analysis. Particularly noteworthy is that organic yields are, on average, roughly 75% of the conventional yields on the same farm for both corn and soybean. However, the organic yields of corn and soybean on these farms are only 70% and 63% of the county average conventional yields respectively.

It should be noted that since these data were collected through an FBM program, whose participation is voluntary, there is another selection effect to consider. Both organic and conventional farmers pay a "tuition" fee to participate in the Minnesota FBM program, for which they receive instruction in preparation of their financial and production records. Previous research, though now somewhat dated, has found that farms that elect to participate in FBM programs tend to be larger and achieve higher rates of return to manager labor than the population average (Anderson and Olson, 1996). While Anderson and Olson did not investigate differences in yield between FBM participating farms and those that choose not to participate, given the profitability results, we would expect the yields of participating farms to be no lower than those of the full population. Thus, we can consider the organic production data used in this study, and included in the FINBIN database, to be near the upper bound of organic farms in terms of yields and profitability outcomes.

Mean-Differences

If there is a selection effect present among farms that adopt organic crop production methods, there should be detectable differences in production outcomes between these farms and the larger population of conventional crop farms. Of particular interest is any difference between the distribution of conventional yields achieved by farms that choose to adopt organic production methods and the distribution of conventional yields achieved by neighboring conventional farms. We proceed by testing the null hypothesis that the difference between the conventional crop yields on split operations and the average crop yields achieved in their respective counties is greater than or equal to zero. Formally, this can be written as:

(1) $$H_o : \frac{1}{n}\left(\sum_{i=1}^{n} Y_i^c - Y_i^{cty}\right) \geq 0$$

where i indexes the farm-year yield combination, superscript c denotes conventional production and $Y^c ty$ denotes the county-level yield average. This hypothesis can be tested using a standard one-sample t-test if we assume that the population of sample means is normally distributed. By the Central Limit Theorem, the sample means will be approximately normally distributed if the sample is randomly drawn and the sample size is large, with the degree of approximation dependent on how far the true distribution lies from normal, and the size of the sample. The null hypothesis in (1) can also be tested using a non-parametric Wilcoxan sign rank test, which only requires the assumption of random sampling and a symmetric, though not necessarily normal, distribution. Results for the parametric and non-parametric one-sided t-test for both crops are presented in table 2. The data for both corn and soybean are presented graphically if figure 1.

For both corn and soybean we can easily reject the null hypothesis in equation (1) that the conventional yields achieved by organic split operations are no less than the average yields in the county in which the farm is located. There is also little qualitative difference between the results of the t-test and the Wilcoxan sign-rank test. This suggests that there is indeed a significant selection effect in the organic transition of Minnesota organic crop producers and that those who transition to organic production are more likely to operate lower yielding farms. There may be several reasons for this selection effect. For one, organic production could be more attractive to a farm that achieves lower conventional corn and soybean yields, as the returns to conventional management are likely lower for such a farm. That is, as noted earlier, the opportunity cost of abandoning conventional production and diversifying away from high value corn and soybean crops is lower for low yielding farms. Another reason might be that those that choose to transition are less likely to use a high level of chemical inputs when managing their farms conventionally. As many organic farms cite an aversion to heavy use of crop chemicals as a motivation to transition (Padel, 2001), it could be that some of these split operations are practicing a lower-input, lower-yield conventional management strategy than the other conventional farms in their county. Whatever the nature of the selection effect, its identification highlights the need for a more careful analysis of the relationship between a farm's conventional yield history and the organic yields that they could expect to achieve if they adopted organic production methods.

Relationship between high conventional yields and high organic yields.

The identification of a selection effect in organic transition does not, by itself, prove that organic farm-level crop yield averages misrepresent the true organic yield potential of the average conventional crop farm. What is also needed is a link between the conventional and organic yields that farms are able to achieve. If there is no significant relationship between a farm's conventional crop yields and their organic crop yields after adjusting for farm location, then farmers and insurance rate makers have very little ability to predict organic performance before an organic transition is actually undertaken. However, if there is a significant relationship, we can calculate a predicted organic yield for the "average" conventional farm. The difference between this prediction and the existing organic farm-level yield average is an estimate of the impact of the organic selection effect on crop yield data.

To investigate the relationship, both organic and conventional yield observations are first normalized by the county average conventional yields. The resulting ratios, which represent the percentage of the county average yield that is achieved by a farm in a given year, are then averaged for each farm and crop. This eliminates the farm effect and reduces the size of the sample to 35 and 55 yield observations for corn and soybean respectively. Because the number of yearly observations available for each farm varies, each farm-level average is weighted by the square root of the number of observations for that farm/crop combination. The weighted averages of the organic to county yield ratio are regressed on the weighted averages of the conventional to county yield ratio to identify the relationship between a farm's conventional yield performance and their organic yield performance. Both corn and soybean are included in the model and a crop dummy variable interacted with the conventional to county yield ratio allows for the estimation of a seperate relationship for each crop. The model is:

$$\frac{Y^o_{kj}}{Y^{cty}_{kj}}\sqrt{n_{kj}} = \beta_0\sqrt{n_{kj}} + \beta_1 I(soybean) \times \frac{Y^c_{kj}}{Y^{cty}_{kj}}\sqrt{n_{kj}} + \beta_2 I(corn) \times \frac{Y^c_{kj}}{Y^{cty}_{kj}}\sqrt{n_{kj}} + \varepsilon_{kj}\sqrt{n_{kj}} \tag{2}$$

where k and j are the indices for crop and farm respectively, and n is the number of observations. Regression results, including heteroscedasticity-robust standard errors, are presented in table 3 and a graphical representation of the model is presented in figure 2.

The coefficient estimate for corn ($\hat{\beta}_2$) is 0.249 and significant at the 0.05 level. This indicates that a farm that achieves a conventional corn yield equal to the county average yield is predicted to achieve an organic yield that is $0.0249 \times Y^{cty}$ higher than a farm that achieves only 90% of the county average. For example, a corn producer that achieves the county average of 160 bu/acre is predicted to yield 4.0 bu/acre more organic corn than another farmer in the same county that yields only 144 bu/acre conventionally. This effect might seem fairly small, though at current organic corn prices ($\approx$ \$13/bu) it represents an approximate \$50/acre difference in gross returns (USDA-AMS, 2014).

Note that the model fit is quite poor ($R^2 = 0.060$). This points to the complexity of organic cropping systems and the large number of factors that contribute to a particular yield outcome. This model is likely picking up the impact that a farm's land and soil quality has on both conventional and organic yields, rather than a farmer's management skill. The next section will more thoroughly explore the implications of this result.

Implications

This section applies the results from the previous sections to show how currently available organic yield data leads to the underestimation of the returns to organic crop production. The first application will be to a business planning scenario in which the identified selection effect discourages organic transition. The second application will show how the selection effect may result in less attractive crop insurance policies for organic crop producers.

Business Planning

When preparing a business plan for a potential organic transition, yield projections are of vital importance. An obvious strategy for forecasting a farm's organic yields is to consult yield averages from other organic crop farms. The University of Minnesota's Center for Farm Financial Management offers one of the few sources for this type of data in the form of the publicly available FINBIN database. Suppose the prospective organic farmer queried the database for yield averages of all organic corn and soybean producers in Minnesota for the most recent five years, and made the reasonable assumption that his/her farm could expect to see organic yields that were equal to the average of the organic yields achieved by other farms in the state. From 2009-2013, the average organic corn and soybean yields achieved by contributors to the FINBIN database were 111.6 bu/acre and 25.8 bu/acre respectively (Table 4). However, given the results in the previous section, it is likely that the farms contributing to these averages achieved below average conventional yields prior to organic certification. Furthermore, given the significant and positive relationship between conventional and organic crop yields, these organic yield averages are likely understating the organic yield potential of average yielding and above average yielding conventional farms.

The organic split operations in our data set have average organic to county yield ratios of 0.68 and 0.63 for corn and soybean respectively (Table 1). Dividing the average organic yields drawn from the FINBIN database by these ratios gives the average county yields that we would expect to be associated with the FINBIN organic yield averages. These are $0.68/111.6 = 164.1$ bu/acre for corn and $0.63/25.8 = 41.0$ bu/acre for soybean. Now, if we assume that the prospective organic farmer who is conducting a business planning exercise tends to achieve conventional yields that are on par with county averages, the regression results from equation (2) suggest that he/she should expect organic yields that are higher than those achieved by the split operations in our data set. The predicted organic corn yield for this average-yielding conventional farm would be 114.9 bu/acre and the predicted organic soybean yield would be 26.5 bu/acre[4]. These yields are higher than the published state averages for the organic crops, and when priced using current organic grain prices, result in a difference of roughly $40 per acre for corn, and $20 per acre for soybean. If this difference in returns is averaged over a three-year crop rotation it is roughly $20 per acre. Given that Minnesota organic crop farms had an average net return of $160 per acre from 2009-2013, $20 per acre represents a 13% increase in expected net returns[5].

Insurance

Prior to the 2014 crop year, the USDA-Risk Management Agency (RMA) offered yield and revenue insurance products to organic producers of some crops but used the conventional t-yield for farms that did not have an established organic production history. Because the conventional t-yield is usually higher than the expected organic yield, organic producers were charged an additional 5% premium surcharge. Starting in the 2014 crop year, RMA began issuing an organic specific t-yield for several crops, including corn and soybean. The new organic t-yield is simply the conventional t-yield scaled down by a factor as low as 0.65, with the factor assigned separately for each crop and county. RMA intends to update organic t-yields to more accurately reflect the experience of organic farms in each county as more farms purchase organic crop insurance products and more yield data become available (USDA-RMA, 2013).

Given the finding that there is a significant selection effect present in farm-level organic yield averages, the yield data that RMA uses to establish organic specific t-yields may underestimate the organic yields that would be achieved if organic farms were more representative of the full population of crop producers. Therefore, while the t-yields that are currently offered may be appropriate for existing organic farms, they may be inappropriately low for an average-yielding conventional crop farm that considers a transition to organic management.

This sub-section will present a simple example of the degree to which low organic t-yields can impact the expected return to the purchase of a yield protection product for a newly certified organic farm. To investigate the expected return (i.e. expected indemnity minus premium) under existing organic t-yields we first simulate a distribution of organic crop yields for a particular county using the organic yield data from the split operations in our dataset. This is done by estimating the linear relationship between county average conventional yields and farm-level organic yields for each crop in our data set. The model is simply:

$$(3) \quad Y_{jt}^{o} = \beta_0 + \beta_1 Y_{jt}^{cty} + \varepsilon_{jt}$$

where Y_{jt}^{o} is the farm-level organic yield for farm j and year t, and Y_{jt}^{cty} is the corresponding county average yield. This model is estimated separately for corn and soybean and the regression residuals are saved. The coefficient estimates for equation (3) are presented in table 3. A 40-year series of county average crop yields is detrended to 2014 terms for Redwood County[6] in southwestern Minnesota. Using this detrended series of county-level yields along with the coefficient estimates and residuals from the estimation of equation 3, a simulated distribution of farm-level organic yields for each crop is constructed using the formula

$$(4) \quad \dot{Y}_{it}^{o} = \hat{\beta}_0 + \hat{\beta}_1 Y_{t}^{cty} + \hat{\varepsilon}_i$$

where i is the index of regression residuals and t is the year index of Redwood county yields. For corn, this procedure results in a distribution of $(40 \times 76 =)$ 3,040 simulated organic yields.

Note that these simulated yield distributions are constructed using data from existing organic farms and thus exhibit the selection effect bias identified in the previous sections. We would expect the full population of conventional crop farms in Minnesota to face organic yield distributions with higher means than the ones simulated using yield data from established organic farms. Although admittedly ad hoc, one way to investigate the expected insurance implication of the selection effect for average-yielding conventional crop farms that may transition to organic management is to simply shift the simulated organic yield distributions to the right by the difference in yields used in the business planning exercise in the previous section. For corn, this is a shift of 3.27 bu/acre and for soybean it is a shift of 0.73 bu/acre. Kernel densities for the simulated organic yield distributions (both baseline and shifted) are presented in figures 3 and 4 for corn and soybean, respectively.

The RMA crop insurance premium calculator (USDA-RMA, 2014) is used to estimate premiums for a yield protection product with 75% coverage using the published organic t-yields and price election (Table 5). We assume that the farm in our example has never grown organic corn or soybean, and therefore uses the full t-yield for their Actual Production History (APH). The total premium estimate is $19 for both corn and soybean, of which the producer pays $9 for corn and $8 for soybean[7]. Since the APH is equal to the t-yield, the loss trigger yield for a 75% coverage yield protection product is simply .75 $\times$ t-yield. With the loss trigger held fixed, a farm with the alternative yield distributions shown in figures 3 and 4 is less likely to receive an indemnity than a farm with the baseline yield distribution, and the indemnities that it does receive will be smaller. However, the effect is fairly small, and the expected indemnity for the yield protection product falls by only $3.64 per acre for corn and $2.51 per acre for soybean as the yield distribution is shifted to the right.

Conclusion and discussion

The objective of this study is to explore the possibility of a selection effect among organic crop producers, and the implication that self-selection in the transition decision has on farm-level yield data. Using data from partially organic farms in Minnesota that have grown the same crop organically and conventionally in the same year, we find that the conventional corn and soybean yields achieved by these farms are significantly lower than the average yields achieved in their counties. We then estimate a linear relationship between the conventional yields and the organic yields produced by the same farms. The relationship is statistically significant, suggesting that farms that achieve high conventional yields tend to also achieve high organic yields. Together, these results indicate that data derived from farms that have chosen to adopt organic management likely understate the organic yield potential of the full population of conventional crop producers.

Accurate predictions of organic yield outcomes are particularly important for business planning purposes and the design and implementation of organic crop insurance products. This study shows that the magnitude of the selection effect on existing yield data is such that the expected net returns to organic crop production are understated by roughly $20 per acre, which is more than 10% of the average net return for organic farms in Minnesota. Conventional farms that transition to organic production, and thus have no organic yield history with which to purchase crop insurance products, could also be effected by low organic yield averages. Although average-yielding conventional crop growers that transition to organic production may have higher yields and thus find organic t-yields less attractive than established organic farms, the effect on expected indemnities is likely to be quite small.

This analysis raises the question: how can data on organic production outcomes be improved? Although RMA is well positioned to gather further data on organic yields from those farms that chose to purchase crop insurance, relatively low participation rates among organic crop farms and possible adverse selection problems may make RMA yield data unreliable for many applications. Another option would the expansion of existing farm survey programs, such as ARMS, so that individual farms are followed over multiple years. This would allow a panel data structure that could provide information on within-farm temporal variation of organic crop yields that is currently unavailable. An alternative approach that could help provide data on farm-level organic production and financial outcomes would be to further encourage (i.e. subsidize) participation in farm business management programs, similar to the program available in Minnesota which gathered the data used in this study.

Notes

[1]This comparison was drawn from state-wide crop enterprise reports that included both rented and owned acres.

[2]Although several other crops are represented in the primary data, only corn and soybean have an adequate number of observations for statistical analysis.

[3]Since land quality can also vary within a farm we cannot be certain that the organic and conventional yield observations come from land of equal quality. However, there is no reason to suspect that organic cropland on a particular farm is any better or worse than the farm's conventional cropland.

[4]The calculation for corn is: $164.1 \times (0.45 + 0.249 \times 1) = 114.9$, and for soybean is: $41.0 \times (0.45 + 0.196 \times 1) = 26.5$

[5]This assumes that production costs do not change from the baseline to higher yield scenario.

[6]Any county could be used for this application, though we use Redwood County as it is the site of a University of Minnesota agricultural research and outreach center.

[7]producer premium $=$ total premium $-$ premium subsidy

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Figures

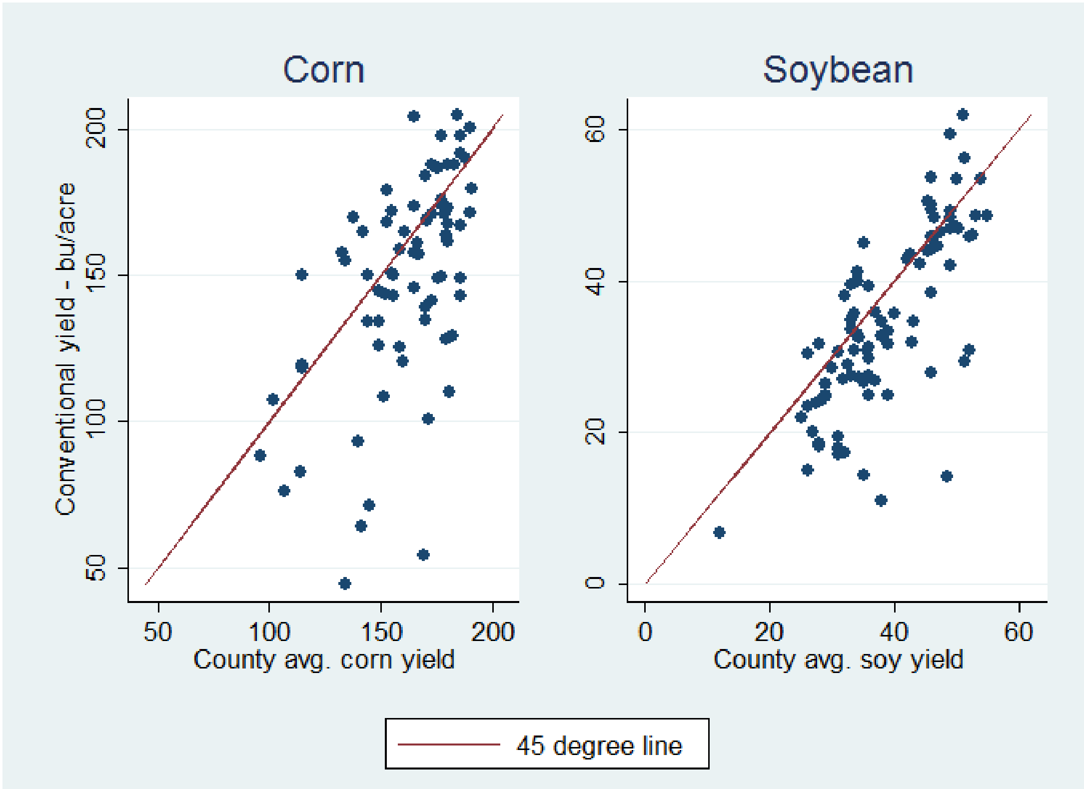

Figure 1. Conventional yields and county yield averages for corn and soybean

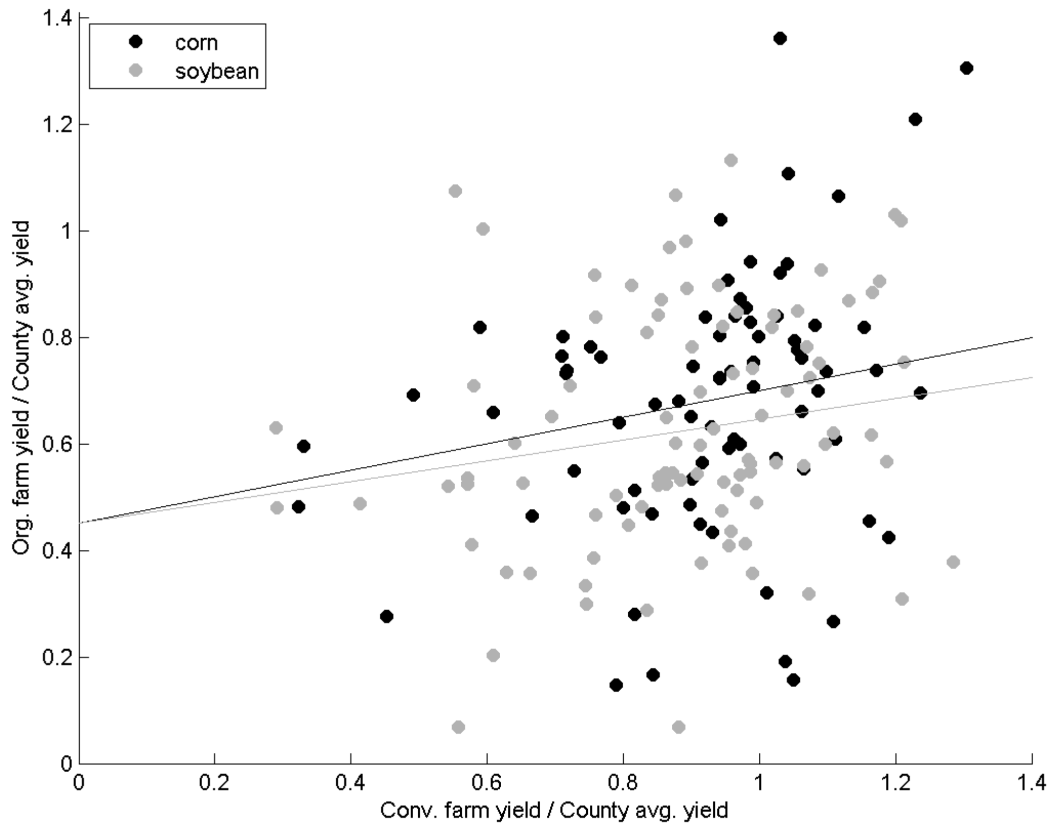

Figure 2. Scatter plot and predicted values for equation 2.

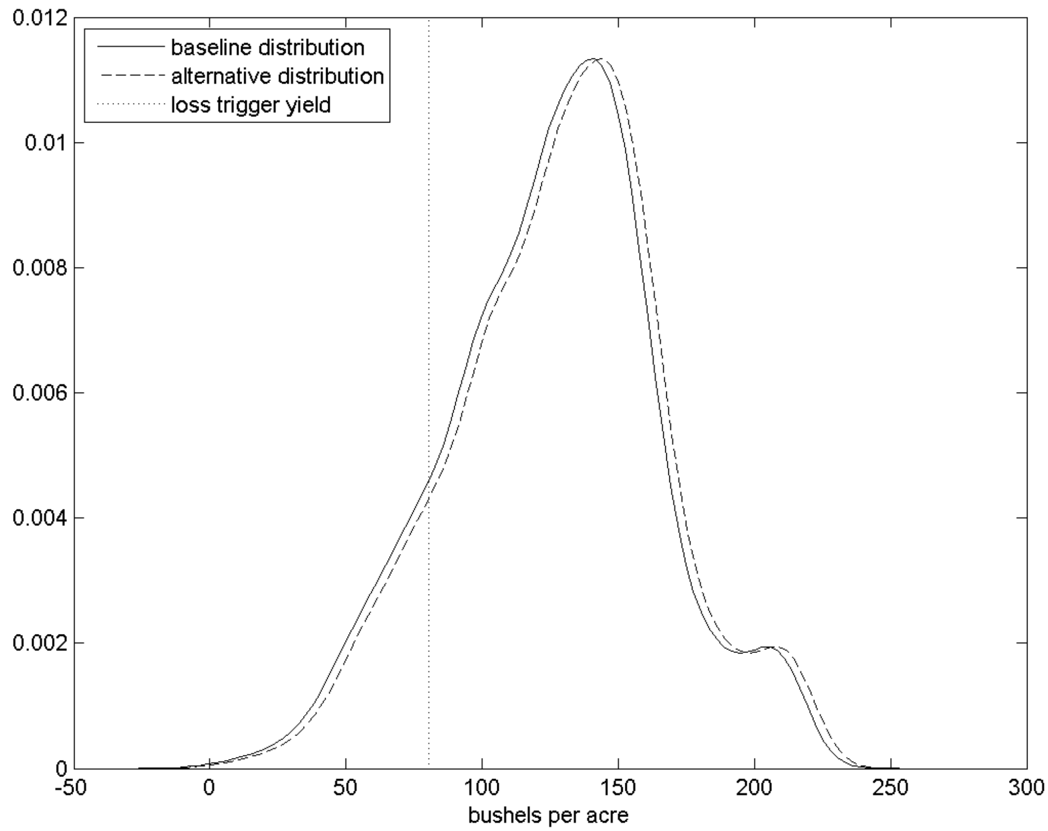

Figure 3. Kernel densities of simulated organic corn distributions with loss trigger yield overlayed (75% coverage).

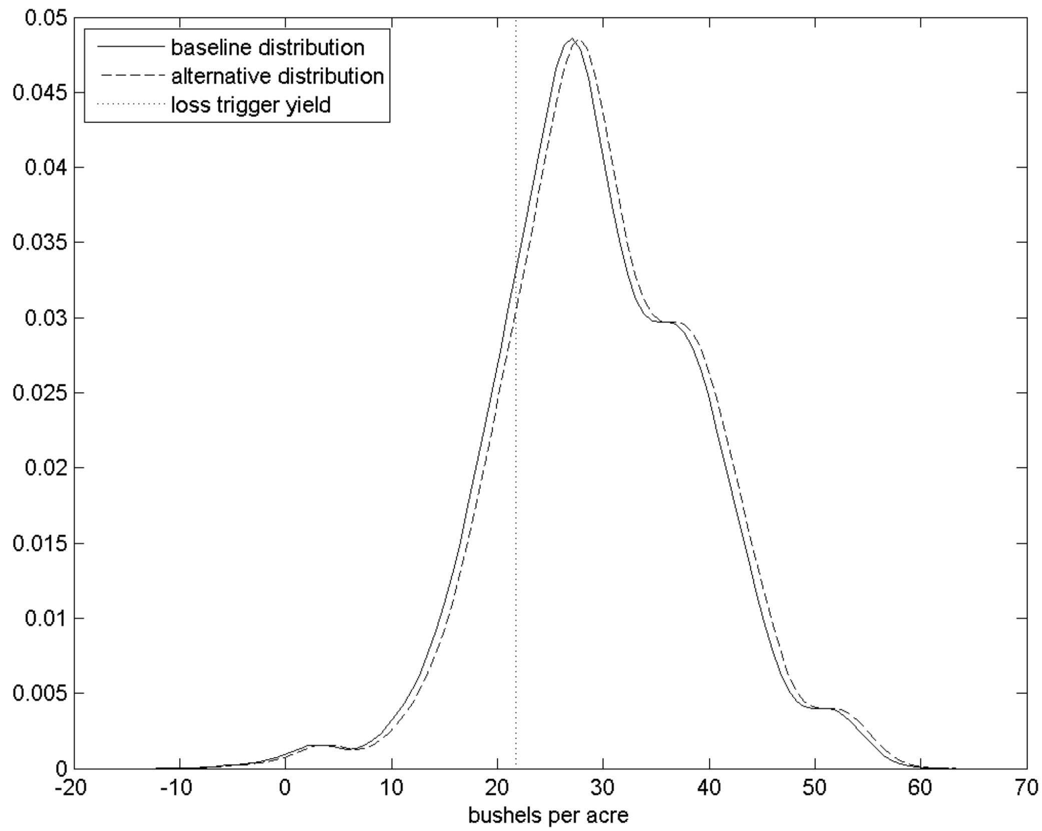

Figure 4. Kernel densities of simulated organic soybean distributions with loss trigger yield overlayed (75% coverage).

Tables

Table 1. Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Corn					
County yield	161.3	22.6	96	191	76
Conv. yield	149.1	36.1	44.4	204.6	76
Org. yield	109.6	39.5	16.0	199.3	76
Conv. yield / County avg. yield	0.92	0.19	0.32	1.3	76
Org. yield / County avg. yield	0.68	0.24	0.15	1.36	76
Org. yield / Conv. yield	0.76	0.3	0.15	1.8	76
Soybean					
County yield	38.9	8.8	12	55	94
convyield	34.74	12.01	6.68	61.82	94
Org. yield	24.3	10.0	0.8	52.2	94
Conv. yield / County avg. yield	0.88	0.2	0.29	1.28	94
Org. yield / County avg. yield	0.63	0.23	0.07	1.13	94
Org. yield / Conv. yield	0.75	0.34	0.08	2.18	94

Table 2. Results from t-test and Wilcoxan signed-rank test of mean difference between conventional and county average yields.

		Standard		T-test		Signed-rank test	
Crop	Mean	deviation	N	T-statistic	P-value	Z-statistic	P-value
Corn	-12.18	29.54	76	-3.596	0.0006	-2.954	0.0031
Soybean	-4.12	7.76	94	-5.150	0.0000	-4.749	0.0000

Table 3. Regression results from equations 2 and 3.

	Eq. 2 Org./County avg.	Eq. 3 Org. Corn	Eq. 3 Org. Soy
$I(soybean)\times$	0.196*		
Conv./County avg.	(0.103)		
$I(corn)\times$	0.249**		
Conv./County avg.	(0.108)		
County avg. yield		0.712***	0.543***
		(0.185)	(0.105)
Constant	0.451***	-5.334	3.211
	(0.0932)	(30.18)	(4.171)
Observations	90	76	94
R^2	0.060	0.167	0.226

Standard errors in parentheses

* p<0.1, ** p<0.05, *** p<0.01

Table 4. Parameters and results of business planning implication exercise.

	Corn	Soybean
MN state average organic yield	111.6 bu	25.8 bu
Split operation conv:county yield avg.	0.925	0.885
Predicted county yield	163.9 bu	41.4 bu
Predicted organic yield	114.9 bu	26.5 bu
Organic crop price ($/bu)	$12.25	$26.45
Net return difference	$40.06	$19.23

Table 5. Parameters and results of insurance implication exercise.

	Corn	Soybean
Organic t-yield/APH	107 bu	29 bu
Price election	$8.97 bu	$19.12 bu
Total premium	$19	$19
Premium subsidy	$10	$11
Loss trigger yield	81.8 bu	21.8 bu
Baseline yield distribution		
Expected indemnity	$23.71	$18.32
Expected economic subsidy	$14.71	$10.32
Expected loss ratio	1.25	$ 0.96
Alternative yield distribution		
Expected indemnity	$20.07	$15.80
Expected economic subsidy	$11.07	$7.80
Expected loss ratio	1.06	$ 0.83