The Structure and Profitability of Organic Field Corn Production

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Abstract: Results from long-term experimental trials suggest that similar yields and lower costs are possible from organic compared with conventional field crop production, but there is little information about the relative costs and returns on commercial farms. This study examines the structure and profitability of field corn production using a nationwide survey of corn producers for 2010 that includes a targeted sample of organic growers. Propensity score matching was used to develop a sample of similar conventional and organic farms based on farm and operator characteristics. Treatment-effect models were estimated using the matched sample to isolate the effect of choosing the organic approach on various levels of corn production costs. The procedure accounts for the impact of both observable and unobservable variables on corn production costs.

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Organic cropping systems rely on ecologically based practices, such as biological pest management and composting, and exclude most synthetic chemicals. Under organic cropping systems, the fundamental components and natural processes of ecosystems—such as soil organism activities, nutrient cycling, and species distribution and competition—are used as farm management tools (Greene and Kremen). For example, crops are rotated, food and shelter are provided for the predators and parasites of crop pests, animal manure and crop residues are recycled, and planting/harvesting dates are carefully managed.

U.S. crop acres under certified organic systems have grown rapidly during the past decade. Organic crop acres were more than 4 times higher in 2008 than in 1995, as acreage increased from 638,500 to over 2.6 million acres (USDA, Economic Research Service, a.). A large part of this growth was in major field crops, corn, soybeans, and wheat. Certified organic production of corn, soybeans, and wheat increased from about 200,000 acres in 1995 to about 736,000 acres in 2008. Sustained higher prices for conventional corn, soybean, and wheat since 2008 (USDA, National Agricultural Statistics Service) may have limited organic acreage in more recent years.

Despite the interest in organic field crop production there is little information about the relative costs and returns of organic and conventional production systems, and the characteristics of farms that are choosing the organic approach. Several researchers (e.g., Delate et al.; Mahoney et al.; Hanson et al.; Pimentel et al.; Smith et al) have examined organic crop production in a long-term experimental setting, but little has been reported about the commercial production of organic field crops (McBride and Greene). This study utilizes farm survey data from U.S. field corn producers from the 2010 crop year in a comparison of conventional and organic systems.

One objective is to describe characteristics of farms adopting the organic production approach and to contrast these with other farms. Another objective is to estimate the difference in costs-of-production for each system on similar farms, using these costs to indicate price premiums that make organic systems competitive with conventional systems.

Data from a targeted sample of organic field corn producers, as part of USDA's annual Agricultural Resource Management Survey (ARMS), support the research in this study. Organic samples of corn producers, along with conventional samples, were collected in the 2010 ARMS. This report contrasts organic and conventional corn production. A matched sample of organic and conventional corn producers, based on farm and operator characteristics, was generated in order to measure costs differences between farm operators and operations of a similar type and size. Treatment-effect models were estimated using the matched sample to isolate the effect of choosing the organic approach on various levels of corn production costs. The procedure accounts for the impact of both observable and unobservable variables on corn production costs.

Experimental Trials

Much of what is known about organic cropping systems stems from multidisciplinary research conducted with long-term experimental trials that compare the agronomic, economic, and sometimes environmental performance of organic and conventional systems. The identical weather and soil conditions under which field experiments are conducted provide opportunities not possible with on-farm studies, such as replication, precise field measurements, and long-term comparisons. In these types of studies, descriptive and analytical data are collected on crop yields and management practices, and the productivity, economic viability, and in some cases the potential environmental impacts of different farming systems are statistically assessed.

Results of an economic analysis of organic cropping systems using data from 1999-2001 were reported from the Neely-Kinyon Long-Term Agroecological Research site in Iowa (Delate et al.). This study compares a conventional corn-soybean rotation with organic rotations that include corn, soybeans, oats, and alfalfa. Both corn and soybean production costs are significantly higher in the conventional system compared with the organic systems mainly due to higher costs of chemical versus mechanical weed control, while crop yields are much the same. Results indicate that returns to corn and soybean production are significantly higher under the organic systems. Returns to land, labor, and management are higher with the organic rotations regardless of whether an organic price premium is received. Sensitivity analysis of labor charges reveal that organic systems have higher returns even when labor is valued at $50 per hour.

Data from 22 years of experiments from the Rodale Institute Farming Systems Trial in Pennsylvania were used to compare conventional, organic animal, and organic legume systems (Pimentel et al.). Crop yields are similar with each system during normal years, but are higher for two organic systems under drought conditions. Energy input use, including fuels for farm machinery, fertilizers, seeds, and herbicides, is about 30 percent less under the organic systems. Net returns to the organic rotations, without price premiums, are similar to those for conventional rotations during typical years, but are less when the costs of transition years are included. However, the organic price premium required to equalize returns is only 10 percent above the conventional price, much lower than normal price premiums for organic grains.

Long-term cropping system data during 1990-99 were used to examine the relative profitability of organic cropping systems in southwestern Minnesota (Mahoney et al.). The research examines various corn, soybean, oats, and alfalfa rotations and finds that even though crop yields are lower under the organic input strategy, so too are production costs in comparison with conventional strategies. As a result, the organic input strategy provides net returns that are not statistically different from those of conventional strategies without any organic price premium, and are significantly higher when historical organic price premiums are paid.

A similar analysis of organic and conventional crop rotations in the northern Great Plains of Canada was conducted with data from 1997-2000 (Smith et al). Wheat, barley, peas, and forage crops are part of the rotations. Some organic cropping systems are found to be more profitable than conventional systems, but this is conditional on the price premium and cropping system. Also, there is as much variation in net returns within organic and conventional systems as between the two. When costs of transition are taken into account, organic rotations have higher returns relative to many conventional rotations with price premiums at their most likely level, but require higher premiums to compete with the most profitable conventional rotations.

Data from long-term field trials covering 1982-1995 in southeastern Pennsylvania were used to evaluate the net returns to organic and conventional rotations using corn, wheat, soybeans, and forages (Hansen et al.). Annual returns to organic rotations compare favorably with those of conventional rotations after the transition period, but high transition costs may not justify the use of organic systems in some cases. The organic rotations require much more family labor than conventional rotations. This could hinder organic adoption among farmers who primarily work off-farm because of the high opportunity cost of switching to organic farming that would result from foregone wages and benefits.

Long-term agricultural experiments are leading to an improved understanding of the main biophysical and economic processes associated with different farming systems, addressing basic research questions about yields, profitability, and environmental impacts. In most of the situations studied, organic cropping systems generate economic returns equal to or greater than those of conventional systems, and sometimes much greater returns. Despite this progress, comparisons between conventional and organic cropping systems are problematic mainly because the latter employ unique approaches to nutrient availability, pest control, and soil management that are profoundly different and may not be easily employed outside of the experimental setting. These experiments also leave out the "human factor" – that valuable system of local knowledge and expertise that every farmer acquires through on-farm experience that plays a crucial role in organic farming. Our research enhances the long-term experimental trial literature by reporting on actual farmer experience with organic systems.

Data

Data used in this study come from farm operator reports made to USDA's 2010 Agricultural Resource Management Survey (ARMS) administered by the National Agricultural Statistics Service and Economic Research Service. The ARMS data include detailed farm financial information, such as farm income, expenses, assets, and debt, as well as farm and operator characteristics. This study uses a version of the 2010 ARMS that includes detailed information about the production practices and costs of U.S. field corn production. The corn version targeted producers in States that included over 90 percent of U.S. planted corn acreage in 2010.

USDA targeted organic producers of field crops in commodity versions of the ARMS in 2006 (soybeans), 2009 (wheat), and 2010 (corn). Each ARMS commodity version included a subsample targeting organic acreage of each crop. Of the total 2010 corn sample of 3,893 farms, 627 samples targeted organic operations. After accounting for out of business operations, survey refusals, and questionnaires with incomplete data, 1,087 conventional corn farms and 243 organic corn farms from IL, IN, IA, KS, MI, MN, MO, NE, NY, ND, OH, PA, SD, and WI were used in this study. Farm survey weights on the ARMS data ensure that samples expand to represent the appropriate crop acreage in the surveyed states, and that organic operations represent their correct proportion of the target population despite their disproportionate share of the sample[1].

Costs of organic and conventional corn production are computed according to procedures used by USDA (USDA, Economic Research Service, b) and endorsed by the American Agricultural Economics Association. Costs are computed per bushel and divided into three categories: operating costs, operating plus capital costs, and total economic costs. Operating costs include costs for seed; fertilizer; chemicals; custom operations; fuel, lubrication, and electricity; repairs; purchased irrigation water; hired labor; and operating interest. Capital costs include the annualized cost of maintaining the capital (economic depreciation and interest) used in corn production, and costs for non-real estate property taxes and insurance. Total economic costs are the sum of operating and capital costs, plus opportunity costs for land and unpaid labor, and allocated costs for general farm overhead items.

Total operating costs is an indicator of the relative success of operations in terms of their ability to meet short-term financial obligations. The sum of operating and capital costs provides an indicator of whether operations can replace capital assets as needed and stay in business over

[1] Certified organic corn acreage represented less than 1 percent of total corn acreage in 2008 (USDA, Economic Research Service, a.), but 18 percent of the ARMS survey respondents.

time. Other costs are primarily opportunity costs of owned resources (land and labor) that may or may not influence production decisions. Opportunity costs of owned resources may vary significantly among producers and producers may be willing to accept returns to these resources different from assumed charges. Lifestyle preferences and costs of switching occupations, among other factors, affect producers' perceptions of their opportunity costs.

Empirical Procedure

Identical weather and soil conditions and field management practices under which cropping system experiments provide precise field measurements are not possible using producer survey data. When using producer survey data to measure cost differences between cropping systems, other factors that affect costs should be addressed. A simple comparison of the mean difference between conventional and organic production costs can be misleading because other differences, such as in farm size, location, technologies, input quality, and management, may also influence cost levels.

To measure the cost difference between conventional and organic corn production, a two-step approach is followed. In the first step a propensity score matching (PSM) model is used to match each organic corn farm with a similar conventional corn farm based on the observable farm and operator characteristics of each. To implement the PSM model a probability model for adoption of the organic approach is estimated and used to calculate the probability, or propensity score, of being organic for each observation. Each organic farm is then matched to a conventional farm with a similar propensity score. In this analysis, the single nearest neighbor matching technique (Dehijia and Wahba) is used, where each organic farm is paired with the conventional farm that has the closest propensity score. All other conventional farms are discarded from the analysis. The difference in costs between the matched organic and conventional farms is then evaluated.

While the matching technique accounts for observable differences between organic and conventional corn farms, unobservable variables that may affect both the choice of production technique and production costs are not accounted for directly. This correlation of unobservable variables will introduce self-selection bias into estimates of the difference in production costs. To account for the potential bias caused by unobservable variables, a treatment-effect model (Greene) is employed in the second step. The model is estimated on the matched conventional/organic sample[2].

Unobservable differences are addressed in the treatment-effect model by assuming a joint normal distribution between the errors of a selection equation (choice of the organic approach or not) and treatment equations (measures of production costs). This technique corrects for self-selection bias and allows for an unbiased estimate of the impact that choice of the organic approach has on production costs. For example, differences in input quality and management are unobservable but may be correlated with both the choice between organic and conventional production and the level of production costs. These differences cannot be accounted for in the PSM model.

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[2] It has been argued that matching models are special cases of selection models which assumes that conditioning on observable variables eliminates self-selection bias (Heckman and Navarro-Lozano; Mayen et al.). That is, matching models create the conditions of an experiment in which the treatment variable is randomly assigned. However, the matching model cannot directly account for correlation among unobservable variables that could bias the treatment-effect. Imbens argues that the assumption that the distribution of unobserved variables is similar for treated and untreated agents is ultimately an empirical question.

Applying the treatment-effect model, the decision to choose the organic approach or not can be expressed with the latent variable O_i^* indicating the net benefit from using this approach compared to not using, so that:

$$(1) \qquad O_i^* = Z_i\gamma + u_i \text{ ; where } O_i = 1 \text{ if } O_i^* > 0, \text{ 0 otherwise,}$$

where Z_i is a vector of operator, farm, and regional characteristics. If the latent variable is positive, then the variable indicating organic production O_i equals one, and equals zero otherwise. A measure of the impact of the organic approach on production costs y_i can be expressed by:

$$(2) \qquad y_i = X_i\beta + O_i\delta + \varepsilon_i$$

where X_i is a vector of farm and operator characteristics, and farm production practices.

Equation (2) cannot be estimated directly because the decision to choose the organic approach may be determined by unobservable variables that may also affect production costs. If this is the case, the error terms in equations (1) and (2) will be correlated, resulting in a biased estimate of δ. This selection bias can be accounted for by assuming a joint normal error distribution with the following form:

$$\begin{bmatrix} u \\ \varepsilon \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho \\ \rho & \sigma_\varepsilon^2 \end{bmatrix}\right)$$

and by recognizing that the expected cost of choosing the organic approach is given by:

$$(3) \qquad E[y_i | O_i = 1] = X_i\beta + \delta + \rho\sigma_\varepsilon\lambda_i$$

where λ_i is the inverse Mills ratio. To derive an unbiased estimate of δ, the two-stage approach begins with a probit estimation of equation (1). In the second stage, estimates of γ are used to compute the inverse Mills ratio, which is included as an additional term in a least-squares estimation of equation (2). This two-stage Heckman procedure is consistent, albeit not efficient. Efficient maximum likelihood parameter estimates can be obtained by maximizing:

$$L(\gamma,\beta,\sigma,\rho)=\prod_{A_i=0}\int_{-\infty}^{0}\int_{-\infty}^{\infty} f(A_i^*, y_i;\gamma,\beta,\sigma,\rho)\,dy\,dA^* \cdot \prod_{A_i=1}\int_{0}^{\infty}\int_{-\infty}^{\infty} f(A_i^*, y_i;\gamma,\beta,\sigma,\rho)\,dy\,dA^*$$

where $f(A_i^*, y_i;\gamma,\beta,\sigma,\rho)$ is the joint normal density function, which is a function of the parameters. In practice, the negative of the log of the likelihood function is minimized using the estimates from the Heckman procedure as starting values.

The model is specified using the three levels of production costs as the dependent variables: operating costs, operating plus capital costs, and total economic costs. The ARMS provides data on a variety of farm and operator characteristics, and farm production practices that are used as independent variables. Once estimated, the difference in costs between organic and conventional systems is determined by (Greene):

$$(4) \qquad E[y_i \mid O_i = 1] - E[y_i \mid O_i = 0] = \delta + \rho\sigma_\varepsilon\left[\frac{\phi_i}{\Phi_i(1-\Phi_i)}\right]$$

where φ is the standard normal density function and Φ is the standard normal cumulative distribution function evaluated using the selection equation estimates.

Survey Results

A summary of the 2010 ARMS data of corn producers indicates that organic corn production was conducted on smaller farms with less corn acreage than conventional production. Conventional corn producers harvested an average of 289 corn acres as part of 794 total farm acres, compared to 103 corn acres on 451 total farm acres by organic corn producers (table 1). Operator characteristics, including age and off-farm employment were not statistically different between organic and conventional corn produces, but fewer organic producers had completed high school than had conventional producers. Among corn regions, organic producers were more likely to be located in the Lakes States (MI, MN, and WI) and Northeast (NY and PA), and less likely to be located in the Plains States (KS, NE, ND, and SD) than were conventional producers. The percent of organic farms in the Corn Belt (IL, IN, IA, MO, OH) was not statistically different than the percent of conventional farms.

Organic production practices varied from those used for conventional corn. Most conventional producers planted corn in rotation with row crops, mainly soybeans. Organic producers more often used an idle year and a meadow crop in rotation with corn. Organic producers more often controlled weeds by using intensive tillage practices with 65 percent using a moldboard plow, compared with only 9 percent of conventional corn producers. More than a third of conventional producers used a no-till corn planter, planting various types of genetically modified seed (92 percent), and relied on chemical weed control. Only 5 percent of organic corn growers used a no-till planter and 68 percent used a row cultivator for weed control. Commercial fertilizers were applied by more than 90 percent of conventional corn producers, while 75 percent of organic producers applied manure or compost. More than half of organic corn growers adjusted planting dates and used buffer strips, possibly in an attempt to prevent the cross pollination of organic corn with the genetically modified varieties used on conventional farms.

Propensity score matching was used to match the organic sample with similar conventional farms based on farm and operator characteristics. Consequently, the differences in farm and operator characteristics of the matched conventional/organic sample were in most cases not statistically significant (table 1). A higher percent of farm acres were owned on matched organic farms, but differences in operator age, education, and the distribution of farms by region were not significantly different. However, the matched conventional farms had more corn acreage on average, and their production practices were very different than among the matched organic farms and more like those of the entire conventional sample. This difference in production practices reflects inherent differences between the organic and conventional production systems.

Mean operating and operating plus capital costs per acre of producing corn were significantly less for organic than for conventional corn farms, while the difference in total economic costs was not statistically significant (table 2). Conventional corn growers had significantly higher seed, fertilizer, and chemical costs than organic growers, but lower costs for fuel, repairs, capital, and labor as organic producers substituted these inputs for fertilizers and chemicals. Total operating costs and operating plus capital costs per acre for organic corn were about $80 and $50 per acre lower, respectively, than for conventional corn.

The average yield for organic corn was 118 bushels per acre in 2010, compared with 161 bushels for conventional producers. With lower yields, average operating costs per bushel of organic corn production were about the same as those for conventional producers, while average operating plus capital and total economic costs were significantly higher among organic corn producers. Average total economic costs were $1.25 per bushel higher for organic than for conventional corn producers. Despite higher costs, the average price reportedly received for organic corn in 2010 was $7.15 per bushel[3], compared with a harvest-period price of $4.32 per bushel for conventional corn. With an average organic price premium of $2.83 per bushel in

[3] Organic feed grade corn comprised 90 percent of organic corn sales and received lower prices than food grade corn. The average price received for organic feed grade corn was $6.96 per bushel compared with $7.92 per bushel for organic food grade corn. Production cost differences between organic food and feed grade corn were not statistically significant.

2010, average returns above all costs were higher for organic corn than for conventional corn production.

Organic corn producers reported that they had been producing organic corn for an average of 8 years as of 2010, and reported an average of 39 total hours used for organic corn certification, or about 2.6 hours per acre. About 40 percent of organic corn producers reported controlling weeds as the most difficult aspect of producing organic corn. Thirty-four percent reported certification paperwork as the most difficult aspect and 12 percent reported achieving yields. Less than 5 percent reported each of sourcing inputs, controlling insects, certification compliance costs, and other as the most difficult aspect of organic corn production.

Model Results

Estimates for a binomial probit model of choice of the organic approach by corn producers are shown in table 3. These estimates are nearly identical to those in the selection equations estimated in the treatment-effect models and are shown instead for brevity. The binomial probit model is estimated for both the full sample, and the matched conventional/organic sample to show impacts of the matching technique.

In the model estimated with the full sample several of the farm and operator characteristics had a statistically significant impact on choice of organic corn production. The larger the farm, the less likely it was to produce organic corn as the likelihood of organic corn production declined with size at a decreasing rate. Younger and less educated producers were more likely to be organic corn producers, as were producers whose primary occupation was farming. This profile of organic growers may be indicative of those with fewer off-farm job opportunities, as well as reflect the greater labor requirements associated with organic production.

Farms with a higher percentage of farm acreage owned were also more likely to produce organic corn. Location in the Lake States relative to the Corn Belt was associated with the adoption of organic corn, possibly due to less weed pressure which facilitates organic production in the areas further north. Producers located in the Plains States were less likely to be organic than those in the Corn Belt.

None of the farm and operator characteristics specified in the model estimated with the matched conventional/organic sample had a statistically significant impact on choice of organic corn production (table 3). This is another indication that the matching technique resulted in farms similar with respect to the observed farm and operator variables.

Estimates for the treatment-effect cost equations using the matched conventional/organic sample are shown in table 4. Coefficients on farm operator characteristic variables are not statistically significant in any of the treatment-effect models of corn production costs, but those for farm location are significant (table 4). Specifying the Corn Belt as the reference group, coefficients on variables for location in the Northeast region indicate higher corn operating, and operating plus capital costs per bushel. Higher corn yields among Corn Belt farms compared with the Northeast contributed to higher unit costs in the Northeast[4]. Economies of size were indicated for all cost levels, but the coefficient on size was statistically significant only for total economic

[4] Average corn yields in 2010 among farms in the matched conventional/organic sample were 172 and 133 bushels per acre in the Corn Belt and Northeast, respectively, and 179 and 140 bushels per acre in the Lake States and Plains States, respectively.

costs. Total economic costs per bushel for corn declined as size, measured as the number of corn acres, increased.

Despite significant differences between the production practices used in organic and conventional corn production, none of the specified production practices had a statistically significant effect on corn production costs using data from the matched conventional/organic sample. The estimated coefficients in table 4 on the variables for organic corn production are statistically significant in the operating plus capital costs and the total economic costs equations. These results and the estimated coefficients for sigma and rho were used in equation (4) to estimate the difference in costs between organic and conventional corn production. The results indicate that operating costs for organic corn production were $0.16 per bushel higher than for conventional corn production, although this result was not statistically significant. Operating plus capital costs were $0.68 per bushel higher, and total economic costs were $1.53 per bushel higher in 2010, after accounting for the influence of both observable and unobservable factors on corn production costs (table 5).

The estimated correlation of errors for the selection and cost equations, rho, was not statistically significant in any of the corn production cost models. This indicates that self-selection bias was not an issue in the matched conventional/organic data. Self-selection bias was indicated in estimates made from the full sample, as the value of rho was statistically significant in the operating and capital cost and total economic cost equations. This suggests that the matching procedure mitigated the impact of selection bias on the estimates of conventional and organic cost differences for field corn production.

With the lack of selection bias indicated in the conventional/organic sample data, it is interesting to compare the full model estimates to those of a simple comparison of means and those where the model is estimated using only ordinary least squares. These results show estimates of the difference of operating and capital and total economic costs that were consistently lower, from 10 to 20 percent, than those estimated with the full model. Thus despite the absence of self-selection bias in the matched conventional/organic data, the model accounting for both observed and unobserved variables found a greater difference between conventional and organic corn production costs than was indicated with other methods.

Transition Costs

The estimated cost differences indicate the additional costs incurred by operations producing organic corn relative to conventional corn, but do not include the costs associated with the transition to organic production. Before an operation is certified to sell organic corn the cropland must be managed organically for a minimum of 36 months. This means that operations must undergo 3 years of higher costs before selling corn as certified organic.

Higher costs for 3 years can be considered an investment necessary to return higher corn prices over the expected life of the operation. The investment was determined by the estimated additional costs incurred by organic operations from the treatment-effect models for each year of the 3-year transition period. The annualized cost of this investment was computed using the capital recovery approach like the other capital costs. The investment was spread over an expected life of 20 years.

The estimated transition costs and total additional costs on organic operations are shown in table 5. Transition costs were $0.12 per bushel for operating plus capital costs and $0.28 per bushel for total economic costs. Thus, the total estimated additional costs for producing organic relative to conventional corn were $0.16 per bushel for operating costs, $0.80 per bushel for operating plus capital costs, and $1.81 per bushel for total economic costs.

Conclusions

This study takes advantage of unique and detailed data collected in an economic survey of U.S. corn producers for the 2010 crop year. The data are unique because data from a targeted survey of organic producers sampled at a much higher rate than their occurrence in the population is included along with data from conventional corn producers. This allows for a statistical analysis of differences between conventional and organic crop production systems.

Size of operation is found to be one of the primary factors determining the likelihood of an operation using the organic approach. Because of economies of size, small farms likely view the organic approach as among the few alternatives to reorganize current resources to improve farm returns. Larger farms likely have less incentive to consider alternatives because of economies of size. Also, significant labor requirements associated with organic crop production may make organic production less practical on larger farms due to the need to hire additional labor, while the labor requirements on smaller farms are often meet by operator and other unpaid sources.

Results of the analysis in this study indicate that the average operating costs for producing organic compared with conventional corn were $0.16 per bushel higher, operating plus capital costs were $0.80 per bushel higher, and total economic costs were $1.81 per bushel higher, after accounting for the influence of both observable and unobservable factors on production costs, and organic transition costs. These higher costs compare to an average price premium of $2.83 per bushel for organic corn in 2010. This implies that organic corn producers, on average, when compared with conventional producers, earned higher returns above operating costs of $2.67 per bushel, and higher returns above operating plus capital costs of $2.03 per bushel, and higher returns above total economic costs of $1.02 per bushel in 2010.

Previous research, based on long-term cropping system data, suggest that significant returns are possible from organic corn production. However, these returns are often the result of obtaining similar conventional and organic yields and lower organic production costs. Findings of this study show organic corn yields to be much lower than those of conventional growers, averaging about 40 bushel per acre less, and total organic production costs to be similar to those for conventional corn. These results are same regardless of whether organic corn producers are compared to all conventional growers or a sample of conventional producers matched on farm and operator characteristics. A reason for the yield differences observed in the ARMS data may be the unique problems presented from implementing organic systems outside of the experimental setting, such as achieving effective weed control. Also, it is likely that the genetically modified conventional varieties that are commonly used are simply higher-performing than standard organic varieties. The main reason that organic corn returns are higher in the analysis of the 2010 ARMS data is not higher organic corn yields, but rather the price premiums paid for organic corn.

While results of this study provide insight about the returns to organic corn production, the findings are based only on a single year of data. The production of organic corn, in contrast to conventional corn, is more often part of a multi-year rotation of crop enterprises and idled land. Organic corn producers may rotate with less profitable enterprises, lowering overall cropping system returns, or the synergism associated with the management of multiple crop enterprises may result in greater returns than indicated by this single-enterprise analysis. A more thorough study of the economic returns to organic systems would account for the inherent multi-year nature of organic cropping systems.

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Table 1. Test of equality of means on characteristics and practices of U.S. conventional and organic corn farms, 2010

Item	Type of farm		
	Organic *(N=243)*	Conventional *(N=1,087)*	Matched Conventional *(N=243)*
Farm Characteristics:			
Farm acres operated (per farm)	451	794**	508
Percent of acres owned	69	55**	59**
Farm operator			
Off-farm occupation (percent)	11	18	12
Age (years)	51	56	54
Less than 50 years (percent)	44	30	39
Education (percent)			
Less than high school	24	8	17
Completed high school	29	45**	33
Attended college	47	47	50
Location (percent)			
Corn Belt (IL, IN, IA, MO, OH)	40	49	40
Lake States (MI, MN, WI)	40	24**	35
Northeast States (NY, PA)	14	6*	16
Plains States (KS, NE, ND, SD)	6	21**	9
Livestock operation (percent)	64	50*	59
Corn Production Practices:			
Harvested corn acres (per farm)	103	289**	197**
GM Seed (percent)	0	92**	89**
Crop rotation (percent)			
Monoculture	0	0	0
Continuous row crop	17	77**	67**
Idle year	35	10**	18**
Rotation with meadow	48	13**	15**
Field Operations (percent)			
Moldboard plow	65	9**	18**
No-till planter	5	35**	31**
Row cultivator	68	5**	6**
Other practices (percent)			
Irrigation	d	7**	2
Applied commercial fertilizer	51	97**	95**
Applied manure or compost	75	22**	34**
Pest control practices (percent)			
Choice of crop variety	20	52**	48**
Adjustment of dates	52	14**	11**
Buffer strips	53	4**	3**

Notes: Asterisks denote a statistically significant difference with the organic mean at the 10 percent (*) and 5 percent (**) levels. d=insufficient data for legal disclosure.
Source: 2009 Agricultural Resource Management Survey, USDA National Agricultural Statistics Service and Economic Research Service.

Table 2. Test of equality of means on production costs of conventional and organic U.S. corn farms, 2010

Item	Type of farm		
	Organic *(N=243)*	Conventional *(N=1,087)*	Matched Conventional *(N=243)*
	dollars per planted acre		
Gross value of production	848.03	696.08**	707.38**
Operating costs:			
Seed	60.56	82.43**	81.04**
Fertilizer	58.25	112.77**	104.52**
Chemicals	0.02	25.40**	23.63**
Custom operations	12.40	16.33	13.21
Fuel, lubrication, and electricity	36.62	25.01**	22.18**
Repairs	33.43	23.59**	24.02**
Purchased irrigation water	0.00	0.08	0.17
Hired labor	5.49	3.10	3.36
Operating capital	0.30	0.42**	0.39**
Capital ownership costs:			
Capital recovery	102.68	84.39**	87.78
Taxes and Insurance	23.00	8.21**	8.03**
Other costs:			
Opportunity cost of unpaid labor	65.99	22.50**	26.30**
Opportunity cost of land	107.69	130.64**	129.01*
General farm overhead	47.80	17.56**	20.07**
Cost summary:			
Operating costs	207.07	289.11**	272.50**
Operating plus capital costs	332.75	381.71**	368.32**
Total economic costs	554.23	552.42	543.70
Value of production less:			
Operating costs	640.96	406.96**	434.88**
Operating plus capital costs	515.28	314.36**	339.06**
Total economic costs	293.80	143.66**	163.68**
	dollars per bushel		
Cost summary:			
Operating costs	1.75	1.80	1.65
Operating plus capital costs	2.81	2.37**	2.23**
Total economic costs	4.68	3.43**	3.29**
Yield (bushels per planted acre)	118.46	161.04**	165.39**
Price (dollars per bushel)	7.15	4.32**	4.27**

Notes: Asterisks denote a statistically significant difference with the organic mean at the 10 percent (*) and 5 percent (**) levels. d=insufficient data for legal disclosure.
Source: 2009 Agricultural Resource Management Survey, USDA National Agricultural Statistics Service and Economic Research Service.

Table 3. Binomial probit maximum likelihood estimates: Choice of organic production by U.S. corn producers, 2010

Variable Description	Sample Full coefficient (std. error)	 Matched coefficient (std. error)
Constant	-2.692** (0.140)	-1.900** (0.218)
Size (100 acres operated)	-0.012* (0.009)	-0.004 (0.012)
Size squared	1.19e-4** (5.89e-5)	3.25e-6 (7.82e-5)
Age class (less than 50 years)[1]	0.225* (0.114)	0.126 (0.140)
Age class (more than 65 years)[1]	-0.378** (0.127)	0.035 (0.193)
Education class (less than high school)[2]	0.436** (0.184)	0.199 (0.225)
Education class (attended college)[2]	0.188 (0.105)	-0.076 (0.156)
Primary occupation is off-farm	-0.327** (0.120)	-0.117 (0.158)
Owned acres (percent of farm acres)	0.385** (0.150)	0.092 (0.192)
Livestock operation on farm	0.061 (0.103)	0.064 (0.144)
Location in Lake States[3]	0.252** (0.117)	0.008 (0.149)
Location in Northeast States[3]	0.276 (0.196)	-0..623 (0.221)
Location in Plains States[3]	-0.338** (0.140)	-0.047 (0.205)
Log likelihood	-11,838	-9,714
Pseudo R^2	0.09	0.01

Notes: Dependent variable in the probit equation is whether the farm produced organic corn (0,1). * and ** denote statistical significance at the 10 percent and 5 percent levels, respectively.
[1]Deleted age class is 50-65 years.
[2]Deleted education class is graduated from high school.
[3]Deleted location is Corn Belt.

Table 4. Treatment-effect model maximum likelihood estimates—effect equation: Costs of U.S. corn production, Matched conventional/organic sample, 2010

Variable Description	Operating costs	Operating plus capital costs	Total economic costs
	Coefficient (std. error)	Coefficient (std. error)	Coefficient (std. error)
Constant	1.879** (0.616)	2.472** (0.890)	4.098** (1.465)
Age (years)	-1.75e-5 (0.006)	0.003 (0.007)	0.005 (0.010)
Education (years)	-0.031 (0.036)	-0.578 (0.051)	-0.056 (0.080)
Primary occupation is off-farm	0.224 (0.205)	0.236 (0.308)	0.270 (0.502)
Location in Lake States[1]	0.171 (0.135)	0.160 (0.175	-0.253 (0.281)
Location in Northeast States[1]	0.745** (0.295)	1.042** (0.488)	0.502 (0.749)
Location in Plains States[1]	-0.168 (0.175)	-0.070 (0.194)	-0.313 (0.292)
Size (100s of harvested corn acres)	-0.019 (0.021)	-0.040 (0.033)	-0.120** (0.051)
Size squared	0.001 (0.001)	0.002** (7.28e-4)	0.003** (0.001)
Rotation-continuous corn[2]	0.368 (0.245)	0.455 (0.341)	0.773 (0.544)
Rotation-corn with idle year[2]	-0.120 (0.200)	-0.036 (0.302)	-0.119 (0.488)
Rotation-corn with other crops[2]	0.237 (0.220)	0.495 (0.313)	0.752 (0.490)
No-till planter	0.174 (0.134)	0.154 (0.194)	0.175 (0.296)
Moldboard plow	-0.092 (0.301)	0.015 (0.416)	0.879 (0.722)
Irrigation	-0.055 (0.208)	0.123 (0.261)	0.278 (0.394)
Commercial fertilizer	0.177 (0.263)	0.394 (0.387)	0.187 (0.629)
Manure	0.267 (0.169)	0.328 (0.243)	0.307 (0.387)

--*continued*--

Table 4 (continued). Treatment-effect model maximum likelihood estimates—effect equation: Costs of U.S. corn production, Matched conventional/organic sample, 2010

Variable Description	Operating costs	Operating plus capital costs	Total economic costs
	Coefficient (std. error)	Coefficient (std. error)	Coefficient (std. error)
Organic	0.193 (0.230)	0.701** (0.319)	1.629** (0.537)
Sigma	1.000** (0.125)	1.401** (0.182)	2.195** (0.295)
Rho	-0.011 (0.235)	-0.006 (0.017)	-0.015 (0.018)
Log likelihood	-99,321	-120,577	-148,928

Notes: Dependent variables in each equation are the operating, operating plus capital, and total economic costs per bushel of corn production, respectively. * and ** denote statistical significance at the 10 percent and 5 percent levels, respectively. Selection equation estimates are nearly identical to the probit estimates shown in Table 3.

[1]Deleted location is Corn Belt.

[2]Deleted rotation class is corn with field crops (soybeans, wheat, etc.)

Table 5. Additional costs incurred for organic corn production in relation to conventional corn production, Matched conventional/organic sample, 2010

	Operating costs	Operating plus capital costs	Total economic costs
Additional costs from:	dollars per bushel		
Producing organic	0.16	0.68	1.53
Transitioning to organic	na	0.12	0.28
Total additional costs	0.16	0.80	1.81

na=not applicable.

Notes: Transition costs are treated as a capital investment necessary to return the higher organic corn price over the expected life of the operation, and thus are not part of annual operating costs.