The Structure and Profitability of Organic Field Crop Production: The Case of Wheat

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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 commercial wheat production using a nationwide survey of wheat producers for 2009 that includes a targeted sample of organic growers. Treatment-effect models were specified to isolate the impact of choosing the organic approach on various levels of wheat production costs. Average organic wheat yields were much lower than for conventional wheat, but per acre operating plus capital costs were also lower. Estimated operating costs per bushel for organic wheat were lower than for conventional wheat, but operating plus capital costs and total economic costs were about $2 to $4 per bushel higher. The average organic price premium in 2009 was $3.79 per bushel, enough to cover the difference in operating plus capital costs of organic versus conventional wheat production, but was short of the difference in total economic 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.

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 U.S. 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 (NASS, Agricultural Prices) 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 area of research utilizes farm survey data from U.S. corn, soybean, and wheat production in a comparison of conventional and organic systems. One objective is to describe characteristics of farms adopting the organic production approach. Another objective is to describe and contrast the costs of production for each system, using these costs to indicate price premiums that make organic systems competitive with conventional systems.

Data from targeted samples of organic field crop producers, as part of USDA's annual Agricultural Resource Management Survey (ARMS), support this area of research. Organic samples of soybeans (2006), wheat (2009), and corn (2010), along with corresponding conventional samples, have been collected in the ARMS. This report describes the case of organic versus conventional wheat production. Treatment-effect models were specified to isolate the impact of choosing the organic approach on various levels of wheat production costs. This technique corrects for sample-selection bias and allows for an unbiased estimate of the impact that choice of the organic approach has on wheat 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 area of 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 2009 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 2009 ARMS that includes detailed information about the production practices and costs of U.S. wheat production. The wheat version targeted wheat producers in states that included over 90 percent of U.S. planted wheat acreage in 2009.

USDA has 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 sub-sample targeting organic acreage of each crop. Of the total 2009 wheat sample of 3,699 farms, 483 samples targeted organic operations. After accounting for out of business operations, survey refusals, and questionnaires with incomplete data, 1,339 conventional wheat farms and 182 organic wheat farms from CO, ID, IL, KS, MI, MN, MO, NE, ND, OH, OK, OR, SD, TX, AND WA 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.

Costs of organic and conventional wheat 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 wheat 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 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.

Survey Results

A summary of the 2009 ARMS data of wheat producers indicates that organic wheat production was conducted on farms similar in size to conventional producers, but with less wheat acreage. Conventional wheat producers harvested an average of 405 wheat acres as part of 1,641 total farm acres, compared to 258 wheat acres on 1,469 total farm acres by organic wheat producers (table 1). Operator characteristics, including operator age and education were statistically different between organic and conventional wheat producers. Organic wheat producers were younger, with a higher percentage less than 50 years old (33 versus 22 percent). Also, a higher proportion of organic producers, 73 percent, had attended college, compared with 60 percent of conventional wheat producers. Among wheat regions, conventional farms made up a significantly larger percent of wheat farms in the Southern Plains (KS, OK, and TX) region than did organic farms. Organic wheat farms were largely in the Northern Plains (CO, MT, NE, ND, and SD) region (42 percent), but the percent of organic farms in the Northern Plains, Corn Belt (IL, MI, MN, MO, and OH), and Northwest (ID, OR, and WA) was not statistically different than the percent of conventional farms in each region..

Organic production practices varied from those used for conventional wheat. Most conventional producers planted wheat in rotation with row crops, particularly corn and soybeans (54 percent). Organic producers often used an idle year and other crops in rotation with wheat. Organic producers more often controlled weeds by using intensive tillage practices with 30 percent using a moldboard plow, compared with only 5 percent of conventional wheat producers. A third of conventional producers used a no-till planter to sow wheat and relied on chemical weed control. Only 14 percent of organic wheat growers used a no-till planter. Commercial fertilizers were applied by more than 80 percent of conventional wheat producers, while about a third of organic producers applied manure or compost.

Average costs per acre of producing wheat were not significantly different between conventional and organic producers, but the composition of operating costs was very different (table 2). Conventional wheat growers had significantly higher fertilizer and chemical costs than organic growers, but lower costs for seed, fuel, and repairs as organic producers substituted these inputs for fertilizers and chemicals. Total operating costs and operating plus capital costs per acre for organic wheat were about $20 per acre lower than for conventional wheat, but were not significantly different because of substantial variation in organic wheat production costs[1].

[1] The coefficient of variation (CV) on the estimates of organic wheat operating, and operating plus capital costs was 29 and 13 percent, respectively, compared to CVs less than 2 percent for conventional wheat cost estimates.

Organic wheat producers had an average yield of 30 bushels per acre in 2009, compared with 44 bushels for conventional producers (table 2). With lower yields, average operating costs per bushel of organic wheat production were 45 cents higher, operating plus capital costs were $1.43 per bushel higher, and total economic costs were $3.04 per bushel higher than for conventional wheat. The average price reportedly received for organic wheat in 2009 was $9.30 per bushel[2], compared with a harvest-period price of $5.51 per bushel for conventional wheat. With an average organic price premium of $3.79 per bushel in 2009, average returns above all costs were higher for organic wheat than for conventional wheat production in 2009.

Organic wheat producers report that they had been producing organic wheat for an average of 10 years as of 2009, and reported an average of 81 total hours used for organic wheat certification, or about 2.5 hours per acre. About half of organic wheat producers reported all of the above in response to a list of reasons for producing organic wheat[3]. Increasing income was the most commonly reported single reason for producing organic wheat, reported by 30 percent of producers. Forty percent of organic wheat producers reported that controlling weeds was the most difficult aspect of organic wheat production, followed by achieving yields (17 percent) and certification paperwork (16 percent).

Empirical Procedure

[2] Organic food grade wheat comprised 89 percent of organic wheat sales and received higher prices than feed grade wheat. The average price received for organic food grade wheat was $9.77 per bushel compared with $7.33 per bushel for organic feed grade wheat. Production cost differences between organic food and feed grade wheat were not statistically significant.

[3] The list included the options of protecting health, more environmentally friendly, increasing income, some other reason, and all of the above.

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 isolate the effect that choice of the organic approach has on production costs, a treatment-effect model is employed (Greene).

The model accounts for observable differences between organic and conventional production using the detailed ARMS data. Unobservable differences are addressed 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 sample-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 not observable but may be correlated with both the choice between organic and conventional production and the level of production costs.

Applying the treatment-effect model, the decision to chose 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) $O_i^* = Z_i\gamma + u_i$; where $O_i = 1$ if $O_i^* > 0$, 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 operator, farm, and regional characteristics.

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:

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

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 operator, farm structural and financial, and enterprise characteristics that are used as independent variables. Once estimated, the difference in costs between organic and conventional systems is determined by (Greene):

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

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

Model Results

Estimates for a binomial probit model of choice of the organic approach by wheat 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 in their stead for brevity. A coefficient estimated for a farm operator education variable is statistically significant. Operator education is specified using discrete categories with graduated from high school as the omitted group. The results indicate that farm operators who had attended college were more likely to choose the organic approach than high school graduates that had not attended college. Also, farm operations with a livestock enterprise were more likely to choose organic wheat production than others. Livestock provide a source of organic fertilizer, manure, for organic wheat.

Size of operation and location also play a role in choice of the organic approach. As operated farm acreage increases, the likelihood of choosing the organic approach for wheat declines (at a decreasing rate). This may be due to the additional labor requirement of organic production, but also to the potentially higher returns per acre available to smaller farmers from producing a higher-valued crop. Location in the Northern Plains States (CO, MT, NE, ND, and SD) and Northwest States (ID, OR, and WA), relative to the Southern Plains (KS, OK, and TX) is also associated with the adoption of organic wheat, possibly due to less weed pressure which facilitates organic production in the areas further north.

Coefficients on farm operator characteristic variables are not statistically significant in any of the treatment-effect models of wheat production costs, but those for farm location are significant (table 4). Specifying the Southern Plains as the reference group, coefficients on variables for location in the Northern Plains and Northwest indicate that wheat operating, operating plus capital, and total economic costs per bushel are all lower in these regions. Operating plus capital, and total economic costs per bushel are lower in the Corn Belt (IL, MI, MN, and OH) than in the Southern Plains. Higher wheat yields in the Corn Belt and Northwest, compared with the Southern Plains, contribute to lower unit costs in these regions[4]. Economies of size were indicated only for total economic costs. Total economic costs per bushel for wheat decline as size, measured as the number of wheat acres, increases.

[4] Average wheat yields in 2009 were 58 and 69 bushels per acre in the Corn Belt and Northwest, respectively, and 45 and 42 bushels per acre in the Northern Plains and Southern Plains, respectively.

Few of the specified production practices have a statistically significant effect on wheat production costs. Crop rotations are specified with idle land as the deleted group. The only statistically significant rotation variable was that for monoculture wheat, which has higher operating plus capital, and total economic costs than for the rotation including an idle year. Also, using purchased seed instead of homegrown seed was associated with higher costs, while the use of commercial fertilizer was associated with higher operating costs.

The estimated coefficients in table 4 on the variable for organic wheat production, and for sigma and rho are used in equation (4) to estimate the difference in costs between organic and conventional wheat production. The results indicate that operating costs for organic wheat production are $0.33 per bushel lower than for conventional wheat production. Operating plus capital ownership costs are $1.36 per bushel higher, and total economic costs are $3.35 per bushel higher in 2009, after accounting for the influence of other factors on production costs and sample selection bias (table 5).

The estimated correlation of errors for the selection and cost equations, rho, is statistically significant in all wheat production cost models. This is an indicator that self-selection bias was present in the data. The negative coefficients on rho in each model indicate a negative selection bias, meaning that the cost difference between organic and conventional wheat production would have been overstated without the correction. Least squares estimates of the models show higher costs of organic compared with and conventional wheat production of $1.00, $2.50, and $4.55

per bushel, respectively for operating, operating plus capital, and total economic costs. This implies that the estimated selection bias is $1.33, $1.14, and $1.30 per bushel, respectively.

Transition Costs

The estimated cost differences indicate the additional costs incurred by operations producing organic wheat relative to conventional wheat, but do not include the costs associated with the transition to organic production. Before an operation is certified to sell organic wheat 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 wheat as certified organic.

Higher costs for 3 years can be considered an investment necessary to return higher wheat prices over the expected life of the operation. The investment is 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 is computed using the capital recovery approach like the other capital costs. The investment is 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 are $0.25 per bushel for operating plus capital costs and $0.61 per bushel for total economic costs. Thus, the total estimated additional costs for producing organic relative to conventional wheat are -$0.33 per bushel for operating costs, $1.61 per bushel for operating plus capital costs, and $3.96 per bushel for total economic costs.

Conclusions

This study takes advantage of unique and detailed data collected in an economic survey of U.S. wheat producers for the 2009 crop year. The data is unique in that it includes a targeted survey of organic producers sampled at a much higher rate than their occurrence in the population. 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 wheat are $0.33 per bushel lower, operating plus capital costs are $1.61 per bushel higher, and total economic costs are $3.96 per bushel higher, after accounting for the influence of other factors on production costs, sample selection bias, and organic transition costs. These higher costs compare to an average price premium of $3.79 per bushel for organic wheat in 2009. This suggests that organic wheat producers, on average when compared to conventional producers, earned higher returns above operating costs of $4.12 per bushel, and higher returns above operating plus capital costs of $2.18 per bushel in 2009. Total economic costs of organic production were $0.17 per bushel higher than the organic wheat price premium in 2009.

Previous research, based on long-term cropping system data, suggests that significant returns are possible from organic wheat 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 wheat yields to be much lower and organic production costs to be about the same or somewhat higher than for conventional wheat. 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. The main reason that organic wheat returns above operating plus capital costs are higher in the analysis of the 2009 ARMS data is not from higher yields, but rather from the price premiums paid for organic wheat.

The negative self-selection bias found by the analysis in this study indicates that the cost difference between organic and conventional wheat would have been overstated without the bias correction. This means that unmeasured factors correlated with the selection and cost of organic wheat production, result in higher wheat production costs. Two factors important to the costs and yields of crop producers are land quality and producer management, both difficult to measure. If organic wheat is more often planted on lower quality land than conventional wheat, land quality differences would contribute to their cost difference. Also, producer management of organic wheat may not be as refined as that for conventional wheat, adding to the difference in production costs.

While results of this study provide insight about the returns to organic wheat production, the findings are based only on a single year of data. The production of organic wheat, in contrast to conventional wheat, is most often part of a multi-year rotation of crop enterprises and idled land. Organic wheat 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 conventional and organic U.S. wheat farms, 2009

Item	Type of farm Conventional	Organic	t-stat
Farm Characteristics:			
Harvested wheat acres (per farm)	405	258	3.19
Farm acres operated (per farm)	1,641	1,458	0.92
Farm operator			
Off-farm occupation (percent of farms)	16	22	1.62
Age (years)	58	55	1.52
Less than 50 years (percent of farms)	22	33	1.95
Education (percent of farms)			
Less than high school	4	3	0.29
Completed high school	37	24	1.94
Attended college	60	73	1.91
Region (percent of farms)			
Corn Belt	34	27	1.32
Northern Plains	34	42	0.97
Southern Plains	28	12	5.53
Northwest	3	19	1.40
Wheat Production Practices:			
Seed (percent of farms)			
Homegrown	45	50	0.59
Purchased	55	50	0.59
Crop rotation (percent of farms)			
Monoculture	3	1	3.28
Row crops and small grains	54	40	1.93
Idle year	36	37	0.10
Other crop	8	22	0.99
Field Operations (percent of farms)			
Moldboard plow	5	30	2.99
No-till planter	36	14	6.22
Other practices (percent of farms)			
Irrigation	3	21	1.54
Applied commercial fertilizer	84	17	4.39
Applied manure or compost	6	37	2.50
Number of observations	1,339	182	

Notes: Statistical significance in test of equality of means is indicated by t-statistics greater than 1.96 and 1.65 at the 5 and 10 percent levels, respectively. na=not applicable. States in each region are: Corn Belt, IL, MI, MN, and OH; Northern Plains, CO, MT, NE, ND, and SD; Southern Plains, KS, OK, and TX; Northwest, ID, OR, and WA.
Source: 2006 Agricultural Resource Management Survey, USDA National Agricultural Statistics Service and Economic Research Service.

Table 2. Test of equality of means on production costs and returns of conventional and organic U.S. wheat farms, 2009

Item	Type of farm: Conventional	Organic	t-stat
	dollars per planted acre		
Gross value of production	244.12	289.56	0.82
Operating costs:			
Seed	14.19	20.28	7.60
Fertilizer	45.54	8.12	7.54
Chemicals	15.53	0.06	21.05
Custom operations	8.63	7.88	0.13
Fuel, lubrication, and electricity	11.40	15.75	3.00
Repairs	19.44	22.43	2.96
Purchased irrigation water	0.32	3.62	0.34
Hired labor	1.88	11.49	0.77
Other costs	0.49	4.14	1.14
Operating capital	0.17	0.14	0.88
Capital ownership costs:			
Capital recovery	75.39	79.45	1.17
Taxes and Insurance	5.98	5.73	0.31
Other costs:			
Opportunity cost of unpaid labor	16.50	20.93	1.04
Opportunity cost of land	43.34	56.77	0.63
General farm overhead	10.17	18.90	0.92
Cost summary:			
Operating costs	117.59	93.90	0.88
Operating plus capital costs	198.95	179.08	0.80
Total economic costs	268.96	275.67	0.13
Value of production less:			
Operating costs	130.53	195.66	2.58
Operating plus capital costs	49.16	110.48	2.27
Total economic costs	-20.84	13.89	2.53
Cost summary:	dollars per bushel		
Operating costs	2.65	3.10	1.54
Operating plus capital costs	4.49	5.92	2.22
Total economic costs	6.07	9.11	4.52
Yield (bushels per planted acre)	44.31	30.26	2.02
Price (dollars per bushel)	5.51	9.30	5.52

Notes: Statistical significance in test of equality of means is indicated by t-statistics greater than 1.96 and 1.65 at the 5 and 10 percent levels, respectively. na=not applicable.
Source: 2009 Agricultural Resource Management Survey, USDA National Agricultural Statistics Service and Economic Research Service.

Table 3. Binomial probit maximum likelihood estimates: Choice of the organic production approach by U.S. wheat producers, 2009

Variable Description	Coefficient	Standard Error
Constant	-2.7977**	0.2156
Size (100 acres operated)	-0.0094**	0.0035
Size squared	2.72e-5**	8.47e-6
Age class (less than 50 years)	0.0312	0.1234
Age class (more than 65 years)	-0.1873	0.1343
Education class (less than high school)	0.0642	0.2054
Education class (attended college)	0.2113**	0.1014
Primary occupation is off-farm	0.0321	0.2004
Livestock operation on farm	0.2885**	0.1261
Location in Corn Belt	0.2063	0.1641
Location in Northern Plains	0.4016**	0.1655
Location in Northwest	1.0616**	0.3202
Log likelihood	-3,776.5552	
Pseudo R^2	0.0692	

Notes: Dependent variable in the probit equation is whether the farm produced organic wheat (0,1). * and ** denote statistical significance at the 10 percent and 5 percent levels, respectively. Deleted location is the Southern Plains.

Table 4. Treatment-effect model maximum likelihood estimates: Costs of U.S. wheat production, 2009

Variable Description	Operating costs	Operating plus capital costs	Total economic costs
	Coefficient (std. error)	Coefficient (std. error)	Coefficient (std. error)
Constant	3.2929**	7.007**	10.385**
	(0.009)	(2.215)	(3.676)
Age (years)	0.121	0.016	0.023
	(0.009)	(0.011)	(0.017)
Education (years)	-0.084	-0.178	-0.203
	(0.087)	(0.117)	(0.175)
Primary occupation is off-farm	0.320	-0.0247	-0.133
	(0.309)	(0.408)	(0.575)
Location in Corn Belt	-1.061	-1.864**	-2.093**
	(0.659)	(0.838)	(1.215)
Location in Northern Plains	-1.247**	-1.616**	-2.248**
	(0.556)	(0.723)	(1.064)
Location in Northwest	-1.355**	-1.886**	-2.073*
	(0.618)	(0.808)	(1.112)
Size (100s of harvested wheat acres)	0.004	0.035	-0.023**
	(0.016)	(0.024)	(0.038)
Size squared	1.36e-5	-2.21e-4	2.57e-4
	(1.66e-4)	(2.49e-4)	(4.14e-4)
Rotation-monoculture wheat	0.396	1.247**	1.705**
	(0.262)	(0.417)	(0.673)
Rotation-wheat and idle	-0.404	0.298	0.642
	(0.355)	(0.469)	(0.718)
Rotation-wheat and other crops	1.498	2.016	2.855
	(0.053)	(1.366)	(1.771)
Purchased seed	0.663**	0.632*	0.918*
	(0.268)	(0.361)	(0.546)
No-till planter	-0.131	-0.322	-0.582
	(0.198)	(0.275)	(0.390)
Moldboard plow	-0.575	-0.554	-0.861
	(0.596)	(0.918)	(1.222)
Irrigation	0.402	0.253	0.116
	(0.344)	(0.497)	(0.794)
Commercial fertilizer	0.782**	0.200	-0.752
	(0.210)	0.445	(0.907)
Manure	0.424	0.020	-0.688
	(0.328)	(0.541)	(0.822)

--*continued*--

Table 4 (continued). Treatment-effect model maximum likelihood estimates: Costs of U.S. wheat production, 2009

Variable Description	Operating costs	Operating plus capital costs	Total economic costs
	Coefficient (std. error)	Coefficient (std. error)	Coefficient (std. error)
Organic	5.667**	8.442**	12.204**
	(1.332)	(1.791)	(2.902)
Sigma	2.677**	3.718**	4.452**
	(0.642)	(0.690)	(0.550)
Rho	-0.801**	-0.680**	-0.580**
	(0.083)	(0.141)	(0.213)
Log likelihood	-183,393	-238,048	-325,886

Notes: Dependent variables in each equation are the operating, operating plus capital, and total economic costs per bushel of wheat 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. Deleted location is the Southern Plains.

Table 5. Additional costs incurred for organic wheat production in relation to conventional wheat production, 2009

	Operating costs	Operating plus capital costs	Total economic costs
		dollars per bushel	
Additional costs from:			
Producing organic	-0.33	1.36	3.35
Transitioning to organic	na	0.25	0.61
Total additional costs	-0.33	1.61	3.96

na=not applicable.

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