A Comparison of Conventional and Organic Milk Production Systems in the U.S.

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Abstract: Organic milk production is one of the fastest growing segments of organic agriculture in the U.S., but little is known about the relative costs and returns of organic and conventional dairies. This study utilizes a nationwide survey of dairy operations for 2005 that includes a targeted sample of organic dairies. Treatment-effect sample-selection models were specified to isolate the impact of choosing the organic approach on various levels of milk production costs. Size and location of dairy operation were among the primary factors affecting choice of the organic approach and milk production costs. Organic dairies had production costs about $5 to $7 per cwt higher than conventional dairies and received an average milk price premium of $6.69 per cwt. Results suggest that there may be incentives for small conventional dairies to covert to the organic approach, but probably not for startup organic dairies unless they can enter at a much larger scale than the current industry norm.

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Organic milk production is one the fastest growing segments of organic agriculture in the U.S. Between 2000 and 2005 the number of certified organic milk cows on U.S. farms increased by an average of about 25 percent each year, from 38,000 to more than 86,000 (USDA, Economic Research Service, a). Many of these cows are on small dairy operations that have switched to the organic approach with the hope of improving farm profitability. Despite the growing number of organic dairy operations there is little information about the relative costs and returns of organic and conventional milk production and the farm characteristics of those that have chosen the organic approach. Studies by Dalton et al., Butler, and Barham et al. are among the few examples of information on this subject, but nothing is available on a national basis.

Organic milk production systems rely on ecologically based practices that virtually prohibit the use of antibiotics and hormones in the cow herd and the use of synthetic chemicals in the production of cattle feed. Organic milk production systems also attempt to accommodate the animals' natural nutritional and behavioral requirements, for example ensuring that dairy cows have access to pasture (Greene and Kremen). These requirements add to production costs and create obstacles to widespread adoption, such as higher managerial costs and risks of shifting to a new way of farming, and significant time and costs associated with the transition to organic production.

This study utilizes data collected from U.S. dairy operations for 2005 in a comparison of conventional and organic milk production systems. One objective is to describe characteristics

of farms adopting the organic production approach and how these are related to the likelihood that a farm would choose the organic system. The second objective is to describe and contrast the costs of production for each system and to use these costs to determine the level of milk price premiums that make organic systems competitive with conventional systems. This is among the first studies to describe the organic milk production industry in the U.S. and should be of interest to producers considering the organic production approach and to processors trying to supply the expanding organic milk market.

Background

Organic milk producers usually begin as operators of conventional dairies that go through what can be a challenging and costly transition process. Many changes in such areas as animal husbandry, land and crop management, sourcing new and different inputs, and initiation of the certification process, among others, are required during transition. For example, the pasture and cropland providing feed for organic dairies must be managed organically for a minimum of 36 months before it can be certified. Standards require 12 months of organic health care before the dairy herd can be certified. Grazing is required for all animals over six months of age. Products and feeds that meet organic standards must be found and organic feeds can be priced at more than double that of conventional feeds. Also, the approach to management will likely need to be adjusted as many "quick fixes" provided by conventional inputs are no longer available (Arnold).

Few studies have attempted to quantify these additional costs and to evaluate the returns to organic milk production. Butler measured the differences between organic and conventional costs of production for dairies in California. The analysis was based on 1999 data from 6

organic dairies willing to participate in the project compared to a set of conventional dairies of similar herd sizes chosen from a survey of California milk producers. Results showed that organic producers paid much higher prices for feed items, including alfalfa hay and concentrates, but that differences in total feed costs between organic and conventional producers were not statistically significant. Organic producers more often substituted pasture for these higher priced feed items.

Butler attributed the primary cost differences between organic and conventional operations to reduced milk production, slightly higher feed and labor costs, and significantly higher herd replacement and transition costs. Herd replacement costs were significantly higher for organic producers because replacement heifers must be raised organically, or must be purchased from organic heifer breeders. Transition costs were not obtained directly from farmers, but instead were imputed as the net income foregone during the transition period from selling milk at the conventional price while incurring the higher costs of complying with the organic requirements.

Butler reported that the net returns from organic production in 1999 were more than twice those from conventional production on dairies of a similar size. However, compared to the state average, returns to organic production were less than for conventional production. The author noted that these returns are specific to conditions in 1999. Organic producers are paid a fixed price per hundredweight (cwt) for organic milk determined by organic creameries that does not vary monthly. In contrast, conventional milk producers are paid a blend price linked to the national dairy product market and can vary significantly each month.

Dalton et al. reported the average production costs and returns for 2004 from a sample of 30 organic dairy farms in Vermont and Maine. They reported a total cost for organic milk production of $22.58 per cwt, before a deduction for unpaid operator labor and management, which was not significantly different from milk revenues. Thus organic milk production did not generate any return to unpaid labor and management nor did it produce a positive return to farm assets or equity. Even when income from non-dairy farming activities was added, the implicit return to unpaid labor and management was only $4.34 per hour. A sensitivity analysis also indicated that an organic milk price of at least $25.00 would have been needed in 2004 to breakeven on returns to assets, and $28.05 was needed to earn a 5 percent return. These prices were about 9 and 24 percent, respectively, above the average organic milk price in 2004.

This past research identifies factors affecting the costs of and returns to organic milk production and how they differ from the costs and returns of conventional production. However, the prior research is limited in terms of the scope and the depth of data supporting the analyses. This study addresses these limitations, taking advantage of a unique nationwide data set of organic and conventional dairies.

Data

Data used in this study come from the 2005 Agricultural Resource Management Survey (ARMS) of U.S. milk producers. The ARMS data include detailed farm financial information, such as farm income and expenses, and farm assets and debt, as well as farm and operator characteristics. The 2005 ARMS included a version that also elicited detailed information about the production practices and costs of milk production. This version targeted dairy operations in 24 states that

accounted for more than 90 percent of national milk production and covered all major production areas.

The 2005 ARMS dairy version also included a sub-sample targeting organic operations. Of the total dairy sample of 2,987 farms, 737 samples were targeted at organic operations in 19 states nationwide as identified from lists provided by the major organic milk processors and certifiers. After accounting for non-response and missing data, information on 1,814 farms, including 352 operations producing certified organic milk in 16 states, was available for the analysis. Among the organic dairies, 325 sold more than 90 percent of milk production as certified organic, while the other operations were either in transition to organic production or included both organic and conventional systems[1]. Farm survey weights on the ARMS data, proportional to the probability of selection, ensure that the sample expands to represent dairy operations in the 24 states and that organic operations represent their appropriate proportion of the population despite their disproportionate representation in the sample.

Measuring Milk Production Costs

Costs of conventional and organic milk production are computed according to standards recommended by the American Agricultural Economics Association and used by USDA in their annual report of commodity costs and returns (USDA, Economic Research Service, b). Costs are computed per cwt of milk sold and divided into 3 categories: operating costs, operating and capital ownerships costs, and total economic costs. Operating costs include costs for feed;

[1] Of the total sample of 2,987 dairy farms, 1,933 were coded as completed interviews. Of these, 119 were deleted due to missing data for one or more of the cost of production items, leaving 1,814 usable samples. Among the organic milk producers, 367 reported organic milk sales during 2005, of which 12 were deleted due to missing data,

veterinary and medical services; bedding and litter; marketing; custom services; fuel, lubrication, and electricity; repairs; hired labor; other costs; and operating interest. Capital ownership costs include the annualized cost of maintaining the capital investment (economic depreciation and interest) in the dairy operation, and costs for non-real estate property taxes and insurance. Total economic costs are the sum of operating and capital ownership costs, plus opportunity costs for unpaid labor and land, and allocated costs for general farm overhead items. Total operating costs is an indicator of the relative success of dairy operations in terms of their ability to meet short-term financial obligations. The sum of operating and capital ownership costs provides an indicator of whether dairy operations can replace capital assets as needed and thus 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[2].

Operating cost items, except those for farm raised inputs, were taken directly from survey responses to questions about the dairy expenditures for each item. Homegrown harvested and grazed feed costs were computed using market prices for each feed item to estimate the opportunity cost of feed fed to dairy cattle. State average market prices were used to value the harvested feed items fed to dairy cows on conventional dairies (USDA, National Agricultural Statistics Service). Because organic feed prices are significantly higher than those for conventional feeds, premiums paid by organic producers for feed items were estimated from the ARMS data and added to the state average market prices in order to estimate the opportunity cost of these homegrown organic feeds. Pasture rental rates estimated from the ARMS data were

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18 were classified as in transition to organic production, and 9 were mixed operations, leaving 325 samples usable for comparison with conventional dairies.

used to approximate the opportunity costs of grazed feed items on conventional and organic operations. The average prices paid by conventional and organic dairy operations for purchased feed grain, forage, and grazed feed items that were used to set the homegrown feed costs are shown in table 1. Prices reported by conventional and organic dairy farmers for other purchased feed items are also shown in table 1.

Capital ownership costs for milk production (economic depreciation and interest) are computed using the capital recovery approach. Capital recovery is an estimate of the cost of replacing the capital investment for cattle housing, milking facilities, feed storage structures, manure handling and storage structures, feed handling equipment, tractors, trucks, and purchased dairy herd replacements used up in the annual production process, plus interest that the remaining capital could have earned in an alternative use. These costs were computed based on 2005 replacement cost estimates for the dairy assets reported by farmers in the ARMS. Farm expenditures on non-real estate property taxes and insurance were allocated to the dairy enterprise based an estimate of the dairy enterprise gross margin relative to the whole-farm. Ownership costs on organic operations were not computed differently than those for conventional operations[3].

The largest component of other costs for milk production is that for unpaid labor. Unpaid labor is charged using the quantity of labor used for dairy production, as reported in the survey, times an imputed wage rate. The wage rate reflects the opportunity cost of farm operator labor

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[2] Opportunity costs of owned resources may vary significantly among producers and many producers are willing to accept returns to these resources different from assumed charges. Lifestyle preferences and costs of switching occupations, among others, affect producers' perceptions of their opportunity costs.

[3] Butler reported that purchased organic herd replacements would be more costly than conventional herd replacements, but analysis of the ARMS data did not show a difference in the prices paid for organic and conventional replacement heifers. The cost differential for homegrown replacement heifers would be reflected in differences in the operating costs for organic and conventional operations.

employed off-farm, estimated from an econometric model of off-farm labor supply and wages (El-Osta and Ahearn). Any differences between organic and conventional dairies would be due to the amounts of labor reported as used in the dairy enterprise, and to a lesser extent the characteristics of farm operators that influence their opportunity wage (i.e., age, education, farm location). General farm overhead costs are non-enterprise specific costs allocated to the enterprise based on dairy gross margins, while the land cost is an opportunity cost of the land used for building sites and animal holding areas.

Milk is the primary product produced and sold from dairy enterprises, but secondary revenue sources including cattle sales, cooperative dividends, and the value of manure are also available. In the ARMS data, the costs associated with these secondary items cannot be separated from those for milk. In order to estimate milk production costs to compare with prices for conventional and organic milk an equivalent milk production is computed (Frank). Following this approach, a milk production equivalent from both the primary and secondary products that would have been necessary to provide the same level of total enterprise income is computed. The equivalent units of production (i.e., cwt of milk) are then used to estimate per unit costs of producing milk.

Empirical Model

In order to isolate the impact that selecting the organic approach has on milk production costs, other factors that affect costs should be addressed. In other words, a simple comparison of the mean difference between conventional and organic production costs can be misleading because other differences between these farms, such as their size, location, other technologies, and

management, may also influence cost levels. To isolate the effect that choice of the organic approach has on milk production costs, a treatment-effects sample-selection model is employed (Greene).

The model accounts for observable differences between organic and conventional dairies using the detailed data from the ARMS. 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 to correct for sample-selection bias allows for an unbiased estimate of the impact that choice of the organic approach has on milk production costs. For example, differences in the level or philosophy of management are not observable but may influence both the choice between organic and conventional production and the level of production costs.

Applying this two-stage model (Heckman), 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:

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

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 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, such as management factors, that may also affect production costs. If this is the case, the error terms in equations (1) and (2) will be correlated, leading to 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 costs 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).

The second stage model is specified using the 3 levels of production costs as the dependent variables: operating costs, operating and capital ownership costs, and total economic costs. The comprehensive nature of the ARMS provides data on a variety of operator, farm structural and financial, and diary enterprise characteristics that were used as independent variables. Once estimated, the difference in costs between organic and conventional dairies is determined by (Greene, pg. 788):

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

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

Characteristics and Practices of Conventional and Organic Dairies

Organic dairies surveyed in the ARMS averaged 82 cows per farm compared to 156 cows on conventional operations (table 2), but this difference was not statistically significant due to the wide variation in herd size on conventional operations[4]. The difference in milk production per cow was statistically significant and nearly 30 percent less on organic operations. Organic operations averaged about 13,600 pounds of milk per cow compared to nearly 19,000 pounds on conventional operations.

More than 80 percent of organic diary operations were located in either the Northeast or Upper Midwest, compared to 65 percent of conventional operations. These regions also included 60 percent of all organic milk cows compared to 42 percent of conventional milk cows. In contrast, only 7 percent of organic dairies were in the West region, but these operations held about a third of total U.S. organic milk cows, the same as among conventional operations. Organic dairies in the West were much larger than in other regions (381 cows), and their mean size was not statistically different from the mean size of conventional operations (431 cows). The mean size of organic dairies in the Northeast was only half the size of conventional dairies (52 versus 104 cows), and those in the Upper Midwest were about two-thirds the mean size of conventional

[4] The standard error on the estimate of average herd size for conventional operations was more than 3 times that for organic operations.

dairies (64 versus 98 cows). However, these differences were also not statistically significant. No organic dairy operations in the ARMS data were from the Southeast or Southwest regions.

Most farm operator characteristics were not significantly different for conventional and organic dairies. Nearly all of farm operators in both groups reported farming as their primary occupation, common on dairy operations due to their substantial on-farm labor requirements. The distribution of operator education levels showed that those in the organic group were neither more nor less educated than operators of conventional dairies. The average age of farm operators on conventional and organic dairies was also not significantly different. Most organic operations had converted to organic production after many years as conventional operations. Of the 21 years that organic operations had been dairying, they had been producing organic milk for only 5 years and took an average of 2.5 years for the transition. Organic dairy operators were more optimistic about their future in the business as significantly fewer had plans to exit in the next 10 years, and significantly more planned to be in business 20 or more years.

The primary difference in the production practices used by organic and conventional dairies was in the feeding system used. More then 60 percent of organic operations reported using pasture based feeding that provides more than 50 percent of seasonal forage (during the grazing months) from pasture, compared to just 18 percent of other operations (table 3). rbST, not available to organic producers, was used by 17 percent of conventional operations who also were much more likely to utilize regular veterinary services (69 versus 38 percent of farms) and a nutritionist (72 versus 45 percent of farms). Differences in the use of these practices may have contributed to the significantly higher production per cow on conventional versus organic operations.

Labor use also distinguished conventional from organic dairies. Organic operations used nearly twice the hours of total labor per cwt, on average, than did conventional operations (0.50 versus 0.26 hours). Most of this difference was from significantly more unpaid labor hours worked on organic dairies. This result is influenced by the smaller average size and lower productivity of organic dairies as fixed labor inputs are spread over fewer units of production on the smaller organic dairies.

Production Costs of Conventional and Organic Dairies

Mean production costs of and returns to conventional and organic dairy operations in 2005 are shown in table 4. Organic producers received $21.88 per cwt for milk sold in 2005, a premium of $6.69 over the $15.19 received by conventional producers. Organic producers incurred higher mean costs for many operating inputs, including feed, bedding and litter, fuel, repairs, and hired labor, but only those for feed and fuel were statistically different from these costs on conventional operations. Feed costs were $4.66 per cwt higher for organic operations, accounting for most of the difference in operating costs. Mean capital recovery costs were almost $2.00 per cwt higher, while the opportunity cost of unpaid labor averaged $3.57 per cwt more for organic than conventional dairies, both statistically significant.

After accounting for the milk equivalent production of secondary products (i.e., cattle and other income), the cost summary can be directly compared with milk prices. Operating costs on organic dairies averaged $5.48 per cwt higher than on conventional dairies. This is the average price premium that organic dairies would have needed to break-even with conventional

producers. In 2005, the price premium for organic milk was $6.69 per cwt, meaning that organic producers earned about $1.21 more per cwt over operating costs, on average, than did conventional producers. However, much higher capital costs raised the average break-even premium for organic producers to $7.29 for operating and capital ownership costs, and the addition of unpaid labor charges raised the break-even premium to $10.93. These are much higher than the price premium paid to organic producers in 2005.

Mean costs by region and by size of operation, along with the average premium that organic producers required to break-even with conventional producers, are shown in table 5. Milk prices and price premiums received in 2005 are also shown. The average price premiums needed to cover operating costs in 2005 were $4.31 per cwt in the Northeast, $4.98 in the Upper Midwest, and $6.49 in the West. Milk price premiums received in 2005 were sufficient in all regions to cover the added operating costs of organic production. Average premiums needed to cover operating and capital ownership costs ranged from $6.67 in the Northeast to $7.81 in the West. The higher price premiums paid to Northeast producers in 2005 covered these added costs, but not in the other regions. In contrast, premiums needed to cover total economic costs were highest in the Northeast ($13.84 per cwt) and lowest in the West ($8.50), but were much higher than those paid in 2005. Likewise, the average price premiums paid in 2005 were sufficient to cover operating and capital costs in each of the size groups, but not enough to cover total economic costs due to the charge for significantly more unpaid labor used on organic operations.

These average cost and price relationships between conventional and organic operations are influenced by several factors. The next step is to control for these factors, including region, size,

other differences in production practices, operator characteristics, and potential sample selection bias, to more precisely estimate the price premiums that make organic production competitive with conventional production.

Model Results

Estimates for a probit model of choice of the organic approach to milk production are shown in table 6. Among the operator characteristics, only the planning horizon variable was statistically significant. This result shows that dairy operations planning to exit the industry in the next 10 years were less likely be organic, and thus indicates that operations with a longer planning horizon are more likely to choose the organic approach. Also, it was thought that dairy operations in areas where milk prices are higher would be less likely to choose the organic approach. However, the milk price variable, specified in the model as the state average price during 2001-05, was not statistically significant.

The most important factors determining the likelihood of choosing the organic approach to milk production were size of operation and location. Size of operation was specified as discrete categories based on the number of cows milked on the operation with the smallest size designated as the reference group. Results indicated that the likelihood of choosing the organic approach declined with each successively larger size category. Also, regional variables indicating location in the Northeast or Upper Midwest were associated with a higher probability of choosing the organic approach.

Operator and farm characteristics were more important for explaining variation in the costs of milk production than for selection of the organic approach (table 7). Operator age and a primary occupation off-farm were positively associated with production costs in each of the 3 models. Some older operators may have higher costs because they are semi-retired and may devote less time to the dairy operation, are more often using older equipment that they do not plan to replace before retirement, or perhaps are easing toward retiring by using facilities and equipment at less than full capacity. Higher costs for operators working primarily off-farm may be because they have less time and fewer incentives to devote time and effort to the dairy operation. An unexpected finding was that in 2 models the operators with the lowest education levels had lower costs than those with the most education (the reference group).

Variables for size of operation were not statistically significant in the model of operating costs, but were negatively and highly significant in the models specified with operating and capital costs and total economic costs. The models were specified with the smallest size group as the reference group so that the coefficients indicate the difference in costs for each size group relative to the smallest dairies. In the models specified with operating and capital costs and with total economic costs the value of the coefficients decreased with successive size categories indicating economies of size associated with these costs. Costs declined as size increased as fixed amounts capital and labor were spread over more units of output.

Location differences among farms also influenced the costs described by each of the models. The estimated coefficients indicate differences between the region and the reference group, the Northeast region, which were consistent across all 3 of the estimated models. Statistically

significant and negative coefficients on the variables for the Upper Midwest, Corn Belt, Southwest, and West regions indicates that all cost levels were lower in these regions than in the Northeast. Only the Southeast region had costs that were not significantly different from those in the Northeast.

Among dairy production practices the use of regularly scheduled veterinary services and of a nutritionist were associated with the greatest reduction in production costs. In all 3 models operations reporting the use of regular veterinary services had lower costs and those farms had total economic costs that were $2.44 per cwt lower relative to other farms. Likewise, the reported use of a nutritionist was associated with total economic costs that were $1.38 per cwt lower while participation in the DHIA program was associated with $1.22 per cwt lower costs. In contrast farms reporting the use of pasture based feeding had total economic costs that were $1.06 per cwt higher.

With regard to the objectives of this study, the most important coefficients are those in table 7 on the variable for organic dairies. These coefficients were used in equation (4) to estimate the difference in costs between organic and conventional dairies, and thus the price premium required for organic milk production to be competitive with conventional milk production. The results indicate that operating costs for organic dairies are $4.92 per hundredweight higher, operating and capital ownership costs are $5.55 per hundredweight higher, and total economic costs are $7.02 higher, after accounting for the influence of other factors on production costs and

potential sample selection bias[5]. These estimates are much lower than those suggested by a simple comparison of group means.

Conclusions

This study takes advantage of unique and detailed data from a recently conducted survey of U.S. dairy operations for 2005. 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 of dairy farms. This allows for a statistical analysis of differences between conventional and organic milk production systems.

One objective of the study was to describe characteristics of farms adopting the organic production approach and how these are related to the likelihood that a farm would choose the organic system. Size of operation was found to be one of the primary factors determining the likelihood of a dairy operation using the organic approach. Because of significant economies of size in milk production, small farms likely view the organic approach as among the few alternatives to reorganize current resources in a way to improve farm returns and the odds of economic survival. Small scale production may also be more conducive to sourcing organic inputs which may be of limited supplies in some areas. In contrast, because larger farms have more invested in their current production technology (which typically confines milk cows in large barns and limits access to pasture) and because of economies of size, larger farms likely have less incentive to consider alternatives. Also, larger farms may have more difficultly

[5] Insignificant coefficient estimates on the sample-selection correction variable, lambda, suggests that selection bias was not a severe problem with the sample. Estimates of the organic treatment effect without the correction for selection bias at 4.84, 5.67, and 7.27, respectively for each cost level, are similar to those estimated with the correction.

sourcing sufficient quantities of organic inputs, and adopting the organic approach may require significantly more adjustments on larger farms due to the pasture requirements for certification.

Location in the Northeast and Upper Midwest were also among the primary factors determining the likelihood of a dairy using the organic approach. These areas have a resource base that may be more conducive to farms adopting the organic approach because of access to high quality pastures and the ability to manage pasture as a dairy feed source. These areas also have a long history of small dairy operations and thus have the infrastructure available to provide inputs and manage the output from several small operations. In addition, the largest U.S. organic milk cooperative pioneered organic milk production in these regions during the mid-1990's. Proximity to markets with highly affluent and "socially aware" consumers also makes these attractive locations for organic milk operations.

The second objective of the study was to describe and contrast the costs of production for each production system and to use these to determine milk price premiums that make organic systems competitive with conventional systems. The results indicated that the average operating costs for organic dairies are $4.92 per cwt higher, operating and capital ownership costs are $5.55 per cwt higher, and total economic costs are $7.02 per cwt higher, after accounting for the influence of other factors on production costs and sample selection bias. These estimates are significantly lower than the difference in means for organic and conventional operations that show cost differences of $5.46, $7.23, and $10.78 per cwt, respectively, for the 3 cost levels. Thus, a simple comparison of means significantly overstates the cost differences between conventional and organic dairies that can be attributed to the organic production approach.

Higher costs ranging from about $5 to $7 per hundredweight for organic milk compares with an average price premium of $6.69 per hundredweight for organic milk in 2005. This suggests that organic milk producers, on average, were sufficiently compensated in 2005 for the additional operating and capital costs of organic production. This is not to say that many organic producers were in a much better financial position than similar conventional operations. Most organic dairies are small operations. Returns to these small organic operations compare favorably with those of small conventional operations, but at their scale of operation the prospects of generating much of a return to operator labor and management are limited. These results suggest that there may be economic incentives for small existing dairies that have already committed much of the fixed investment in milk production to consider switching to the organic approach. However, there does not appear to be much of an economic incentive for startup organic dairies unless they can enter at a much larger scale of production than the current norm for the organic industry.

An important caveat to the results of this study is the failure to account for transition costs on organic operations. Ideally, these would have been estimated and prorated over the life of the dairy operation. However, difficulties in quantifying these costs that may have occurred several years prior to the survey and then were incurred over multiple years made it impractical to acquire the data through the farm survey. In addition, the actual costs and returns during the transition period may be changing as organic milk processors offer additional incentives for producers to switch to organic production. These additional costs of organic production would have affected the comparison of organic and conventional operations but it is difficult to speculate by how much.

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Table 1. Prices paid by U.S. conventional and organic dairy operations for purchased feed grain, forage, and grazed feed items, and other purchased feed items, 2005

Item	Unit	Type of dairy operation	
		Conventional	Organic
		dollars per unit	
Feed grains:			
Corn	bushel	2.42	5.42
High moisture corn	bushel	2.37	5.15
Barley	bushel	2.87	5.24
Oats	bushel	2.23	3.11
Forage:			
Alfalfa hay	ton	104.54	146.68
Other hay	ton	86.17	89.33
Silage	ton	35.88	40.74
Grazed feed:			
Improved pasture-irrigated	acre	115.81	152.14
Improved pasture-dry	acre	47.17	60.81
Other purchased feed:			
Complete feed mixes	ton	285.92	345.90
Protein supplements	cwt	15.62	23.52
Vitamin/mineral premix	cwt	35.69	59.35
Milk replacer/calf starter	pound	0.82	1.06

Source: 2005 Agricultural Resource Management Survey.

Table 2. Test of equality of means on characteristics of U.S. conventional and organic dairy operations, 2005

Item	Type of dairy operation		
	Conventional	Organic	t-stat
Milk cows (per farm)	156	82	1.20
Milk production (lbs per cow)	18,983	13,601	2.63
Region (percent of farms/cows)			
Northeast (ME, NY, PA, VT)	26/17	41/26	1.25/2.55
Upper Midwest (MI, MN, WI)	39/25	43/34	0.13/2.36
Corn Belt (IL, IN, IA, MO, OH)	15/10	8/8	1.18/0.71
Southeast (FL, GA, KY, TN, VA)	6/6	0/0	na
Southwest (AZ, NM, TX)	2/10	0/0	na
West (CA, ID, OR, WA)	11/32	7/32	0.90/0.03
Region (milk cows per farm)			
Northeast (ME, NY, PA, VT)	104	52	0.74
Upper Midwest (MI, MN, WI)	98	64	0.34
Corn Belt (IL, IN, IA, MO, OH)	108	75	0.46
Southeast (FL, GA, KY, TN, VA)	152	0	na
Southwest (AZ, NM, TX)	781	0	na
West (CA, ID, OR, WA)	431	381	0.16
Farm operator			
Off-farm occupation (percent of farms)	2	4	0.24
Education (percent of farms)			
Less than high school	18	26	0.75
Completed high school/some college	66	54	1.38
Graduated from college	16	20	0.59
Age (years)	51	49	0.66
In dairy business (years)	23	21	1.03
Selling certified organic milk (years)	na	5	na
Transition to certified organic (years)	na	2.5	na
Exit dairy business (percent of farms)			
5 years or less	25	16	1.27
10 years or less	51	33	1.99
20 or more years	30	47	2.05
Number of observations	1,462	325	

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: 2005 Agricultural Resource Management Survey.

Table 3. Test of equality of means on production practices and labor use of U.S. conventional and organic dairy operations, 2005

Item	Type of dairy operation		t-stat
	Conventional	Organic	
Production practices (percent of farms)			
DHIA program participation	45	46	0.05
Pasture based feeding	18	63	6.42
Milking 3X or more daily	7	1	1.47
rbST	17	0	na
Artificial insemination	82	73	1.14
Embryo transplants or sexed semen	10	3	1.44
Controlled breeding/calving season	25	35	1.31
Regular veterinary services	69	38	3.69
Nutritionist	72	45	3.38
Computerized milking system	5	2	0.72
Computerized feeding system	7	3	0.87
Kept individual cow records	61	62	0.17
Johne's disease program participation	20	26	0.78
On-farm computer records	26	21	0.64
Dairy information from internet	38	41	0.30
Forward purchased inputs	20	8	1.69
Negotiate input price discounts	35	21	1.63
Labor use (hours per cwt)			
Paid labor	0.12	0.16	1.34
Unpaid labor	0.13	0.34	2.81
Total labor	0.26	0.50	3.32

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: 2005 Agricultural Resource Management Survey.

Table 4. Test of equality of means on production costs and returns of U.S. conventional and organic dairy operations, 2005

Item	Type of dairy operation		
	Conventional	Organic	t-stat
	dollars per cwt sold		
Gross value of production:			
Milk sold	15.19	21.88	20.40
Cattle	1.30	1.78	0.16
Other income	0.50	0.69	3.71
Total value of production	16.99	24.35	11.85
Operating costs:			
Feed--			
Purchased feed	5.02	6.55	2.63
Homegrown harvested feed	3.01	5.57	3.27
Grazed feed	0.08	0.67	5.60
Total feed cost	8.12	12.78	5.75
Other--			
Veterinary and medicine	0.78	0.62	1.49
Bedding and litter	0.21	0.33	0.95
Marketing	0.26	0.25	0.13
Custom services	0.41	0.42	1.50
Fuel, lubrication, and electricity	0.55	0.75	2.01
Repairs	0.56	0.91	1.08
Hired labor	1.46	2.19	1.60
Other operating costs[a]	0.00	0.10	na
Operating capital	0.21	0.31	5.66
Capital ownership costs:			
Capital recovery	2.82	4.73	2.02
Taxes and Insurance	0.21	0.31	1.54
Other costs:			
Opportunity cost of unpaid labor	2.28	5.85	2.65
Opportunity cost of land	0.03	0.10	3.27
General farm overhead	0.52	0.93	3.86
Cost summary:			
Operating costs	12.57	18.66	5.66
Operating and capital ownership costs	15.60	23.70	5.06
Total economic costs	18.44	30.58	2.80
Cost summary-equivalent production:			
Operating costs	11.22	16.70	6.27
Operating and capital ownership costs	13.93	21.22	5.87
Total economic costs	16.45	27.38	2.80

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: 2005 Agricultural Resource Management Survey.
[a]Other operating costs are for organic certification.

Table 5. Production costs[a] and returns of U.S. conventional and organic dairy operations, by region and size of operation, 2005

Item	Type of dairy operation		
	Conventional	Organic	Premium[b]
	dollars per cwt sold		
Region			
Northeast (ME, NY, PA, VT)			
Operating costs	12.88	17.19	4.31
Operating and capital ownership costs	16.22	22.89	6.67
Total economic costs	20.35	34.19	13.84
Milk price	15.95	24.32	8.37
Upper Midwest (MI, MN, WI)			
Operating costs	11.14	16.12	4.98
Operating and capital ownership costs	14.25	21.00	6.75
Total economic costs	17.73	28.30	10.57
Milk price	15.74	21.19	5.45
West (CA, ID, OR, WA)			
Operating costs	10.73	17.22	6.49
Operating and capital ownership costs	12.66	20.47	7.81
Total economic costs	13.74	22.24	8.50
Milk price	14.26	20.94	6.68
Size of operation			
Less than 50 cows			
Operating costs	10.98	15.74	4.76
Operating and capital ownership costs	15.81	21.12	5.31
Total economic costs	25.77	34.36	8.59
Milk price	15.38	22.79	7.41
50-99 cows			
Operating costs	12.10	16.49	4.39
Operating and capital ownership costs	16.41	22.11	5.70
Total economic costs	22.45	30.18	7.73
Milk price	15.48	22.49	7.01
100-199 cows			
Operating costs	11.44	15.99	4.55
Operating and capital ownership costs	15.10	20.38	5.28
Total economic costs	18.51	25.60	7.09
Milk price	15.30	20.95	5.65

Source: 2005 Agricultural Resource Management Survey.

[a]Production costs are presented per unit of equivalent production for the primary and secondary products so that costs are directly comparable to milk prices.

[b]The premium on each cost item is the average amount of added revenue that organic producers would need to have returns equivalent to those of conventional producers. The milk price premium is the average premium received by organic producers in 2005.

Table 6. Sample selection model probit estimates: Choice of organic milk production approach by U.S. dairy operations, 2005

Variable Description	Coefficient	Standard Error
Constant	-1.2186	1.016
Age (years)	-0.0003	0.003
Education class (less than high school)	-0.0012	0.147
Education class (high school/some college)	-0.1785	0.123
Primary occupation is off-farm	0.0260	0.239
Planning horizon (exit within 10 years)	-0.3774**	0.091
Size class 2: 50-99 cows	-0.1721*	0.097
Size class 3: 100-199 cows	-0.4876**	0.115
Size class 4: 200-499 cows	-0.4970**	0.150
Size class 5: 500-999 cows	-0.7377**	0.188
Size class 6: 1,000 or more cows	-0.9744**	0.244
Location: Northeast (ME, NY, PA, VT)	0.4308**	0.112
Location: Upper Midwest (MI, MN, WI)	0.2918**	0.092
Milk price (5 yr. state average, 2001-2005)	-0.0511	0.070
Log likelihood	-124.9351	
Pseudo R^2	0.0601	

Notes: Dependent variable in the probit equation is whether the farm was an organic dairy operation (0,1). * and ** denote statistical significance at the 10 percent and 5 percent levels, respectively.

Table 7. Sample selection model least squares estimates: Costs of milk production on U.S. dairy operations, 2005

Variable Description	Operating costs	Operating and capital costs	Total economic costs
	Coefficient (std. error)	Coefficient (std. error)	Coefficient (std. error)
Constant	11.064**	17.588**	30.974**
	(1.059)	(1.383)	(2.124)
Age (years)	0.032**	0.052**	0.087**
	(0.012)	(0.015)	(0.023)
Education class (less than high school)	-0.393	-1.053**	-3.076**
	(0.345)	(0.452)	(0.693)
Education class (high school/some college)	0.180	0.290	0.061
	(0.265)	(0.347)	(0.532)
Primary occupation is off-farm	2.462**	3.639**	4.084**
	(0.657)	(0.861)	(1.318)
Time in dairy business (years)	0.018*	0.024*	0.009
	(0.009)	(0.012)	(0.019)
Size class 2: 50-99 cows	-0.169	-0.616	-6.564**
	(0.351)	(0.459)	(0.704)
Size class 3: 100-199 cows	-0.034	-1.569**	-9.892**
	(0.487)	(0.636)	(0.977)
Size class 4: 200-499 cows	0.242	-2.166**	-11.100**
	(0.540)	(0.706)	(1.084)
Size class 5: 500-999 cows	-0.129	-3.020**	-13.544**
	(0.629)	(0.822)	(1.261)
Size class 6: 1,000 or more cows	-0.878	-4.210**	-15.264**
	(0.668)	(0.873)	(1.339)
Dairy specialization (product value percent)	0.410	0.263	2.360*
	(0.616)	(0.802)	(1.235)
Location: Upper Midwest (MI, MN, WI)	-1.809**	-1.970**	-3.696**
	(0.314)	(0.412)	(0.631)
Location: Corn Belt (IL, IN, IA, MO, OH)	-2.316**	-2.306**	-3.217**
	(0.409)	(0.534)	(0.820)
Location: Southeast (FL, GA, KY, TN, VA)	0.046	0.407	-0.709
	(0.419)	(0.548)	(0.841)
Location: Southwest (AZ, NM, TX)	-2.287**	-2.731**	-3.911**
	(0.504)	(0.659)	(1.011)
Location: West (CA, ID, OR, WA)	-1.320**	-2.126**	-3.495**
	(0.416)	(0.545)	(0.835)
DHIA program participation	0.069	-0.413	-1.218**
	(0.246)	(0.321)	(0.494)
Pasture based feeding program	0.104	0.037	1.062*
	(0.297)	(0.386)	(0.596)

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Table 7 (continued). Sample selection model least squares estimates: Costs of milk production on U.S. dairy operations, 2005

Variable Description	Operating costs	Operating and capital costs	Total economic costs
	Coefficient (std. error)	Coefficient (std. error)	Coefficient (std. error)
Milk 3 or more times daily	-0.299	-0.609	-0.731
	(0.355)	(0.463)	(0.712)
rbST	0.342	0.052	-0.024
	(0.294)	(0.384)	(0.590)
Artificial insemination	0.172	-0.443	-0.890
	(0.279)	(0.363)	(0.559)
Embryo transplants or sexed semen	0.747**	0.809*	0.821
	(0.340)	(0.444)	(0.683)
Regularly scheduled veterinary services	-0.632**	-1.167**	-2.438**
	(0.269)	(0.351)	(0.540)
Nutritionist for feeding program	-0.204	-0.592*	-1.378**
	(0.274)	(0.356)	(0.549)
Individual cow records	0.000	-0.198	-1.083*
	(0.280)	(0.365)	(0.562)
Forward purchased dairy inputs	0.092	0.099	-0.045
	(0.275)	(0.358)	(0.551)
Negotiate input price discounts	0.281	0.416	0.268
	(0.250	(0.326)	(0.502)
Organic dairy	4.335**	3.756**	5.961**
	(1.052)	(1.373)	(2.111)
Lambda	0.342	1.050	0.619
	(0.598)	(0.780)	(1.120)

Notes: Dependent variables in each equation are the operating, operating and capital, and total economic costs per hundredweight of milk sold, respectively. * and ** denote statistical significance at the 10 percent and 5 percent levels, respectively.