Relative Technical and Cost Efficiency of No-Till Farms

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Abstract

The objective of this paper was to examine the relative technical and cost efficiency of no-till farms in central Kansas. Data from the Kansas Farm Management Association (KFMA) for farms that have adopted a no-till production system and for farms with a conventional or reduced tillage system were utilized in this study. Technical efficiency was not significantly different between the two groups of farms. However, cost efficiency was significantly higher for the no-till farms. The no-till farms were also larger, produced more feed grains and oilseeds, produced less wheat, had higher operating profit margin and asset turnover ratios, and utilized their labor and capital inputs more efficiently.

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Introduction

For the counties in the United States participating in the 2006 Crop Residue Management Survey, the adoption of no-till production has increased from 7.4% of planted acres in 1990 to 31.5% of planted acres in 2006 (Conservation Technology Information Center, 2006). Another way of looking at this increase is to note that two-thirds of the farms surveyed have still not adopted a no-till production system. Given this fact, examining the relative efficiency of a no-till production system would be of interest to both farms that have adopted a no-till production system and to those who have not adopted this system.

The objective of this paper was to examine the relative technical and cost efficiency of no-till farms in central Kansas. Technical and cost efficiency indices were computed using linear programming. Comparisons were made between farm size, financial ratios, technical and cost efficiency, income shares, and cost shares for no-till farms, and farms with a conventional or a reduced tillage production system.

Data and Methods

Table I presents the average and standard deviation of the variables used to compute technical and cost efficiency as well as variables pertaining to farm size, farm type, and tillage system. The data were obtained from the Kansas Farm Management Association (KFMA) databank. Information pertaining to the variables in the KFMA databank can be found in Langemeier (2003) and on the KFMA web site (KFMA, 2010). To be included in this study, a farm had to have continuous data from 2004 to 2008 and be located in central Kansas. Economists working with KFMA farms in central Kansas have been designating farms as no-till or mixed tillage for the last several years. Mixed tillage farms include those with conventional or reduced tillage systems. Because farms in central Kansas have been categorized by tillage system, this study focused on this region of Kansas. To be designated as a no-till farm, a farm had to utilize a no-till production system for all of their crops.

Table I. Summary Statistics for 311 Central Kansas Farms.

Variable	Average	Std. Dev.
Farm Characteristics		
Gross Farm Income ($)	384,651	338,690
Value of Farm Production ($)	360,434	279,910
Net Farm Income ($)	80,660	71,154
Total Economic Cost ($)	410,105	320,622
Total Hectares	760	481
Labor Devoted to Crops (%)	0.8337	0.1775
Less Tillage Index	0.1298	0.0883
No-Till Farms (%)	0.2476	0.4323
Outputs		
Crop (Index)	482,702	443,965
Livestock (Index)	77,851	135,601
Inputs		
Labor (Number of Workers)	1.47	0.90
Livestock (Index)	46,076	191,695
Seed (Index)	29,566	30,248
Fertilizer (Index)	91,648	73,367
Chemicals (Index)	24,790	22,374
Capital (Index)	250,367	171,695
Input Prices		
Labor (Index)	44,687	8,145
Livestock (Index)	0.727	0.000
Seed (Index)	0.750	0.000
Fertilizer (Index)	0.555	0.000
Chemicals (Index)	0.921	0.000
Capital (Index)	0.874	0.008

On average, the sample farms had a gross farm income of $384,651, a value of farm production of $360,434, and a net farm income of $80,660. Total hectares, which included crop, pasture, and farmstead hectares, averaged 760 and ranged from 71 to 3,646 hectares. Approximately 83 percent of the farm operators' time allocated to the farm operation was devoted to producing crops. The less tillage index was computed by dividing herbicide and insecticide cost by total crop machinery cost which included repairs; fuel; auto expense; machinery and equipment depreciation; crop machine hire; and an opportunity interest charge on crop machinery and equipment investment. The less tillage index was used by Nivens, Kastens, and Dhuyvetter (2002) to examine the adoption of reduced tillage practices. A farm that has reduced tillage would have relatively higher chemical costs, relatively lower machinery costs, and a higher less tillage index. The average less tillage index was 0.1298. Approximately 25 percent of the farms were designated as no-till farms.

Data on total economic cost, outputs, inputs, and input prices were needed to estimate efficiency indices. Total economic cost was computed by summing cash costs, depreciation, an opportunity charge for unpaid operator and family labor, and an opportunity interest charge on net worth. The number of operators on a farm and average family living expenditures were used to compute the opportunity charge for unpaid operator and family labor.

Outputs were computed by dividing crop income by a weighted average crop price, and livestock income by a weighted average livestock price. Relative crop and livestock income shares served as weights in the output price computations. Crop and livestock prices were indexed using an index value of 1.00 for 2008.

With the exception of labour, inputs were computed by dividing input expense by input price indices. The input level for labor represents the number of workers on the farm. Part-time workers were designated as a fraction of a full time worker for the computation of the labor input. Input prices, except the price of labor, were indexed using an index value of 1.00 for 2008. Labor price was computed by dividing labor cost, which includes hired and unpaid operator and family labor, by the number of workers on the farm. The chemical, livestock, and capital inputs represent an aggregate of several inputs. The chemical input included herbicides and insecticides. The livestock input covers dairy expense, feed purchased, veterinarian expenses, and livestock marketing and breeding expenses. The capital input is the sum of repairs, fuel, organizational fees and dues, property taxes, insurance, machine hire, conservation expenses, interest expense, cash farm rent, depreciation, and an opportunity interest charge on net worth.

An overall efficiency index was computed for each farm using linear programming (Fare, Grosskopf, and Lovell, 1985; Coelli et al., 2005). The overall efficiency indices ranged from zero to one. Farms with an overall efficiency index of one were producing on the cost frontier and at the most efficient scale of operation. More specifically, these farms were producing at the lowest cost per unit of aggregate output. Farms with a lower overall efficiency index could lower per unit cost by reducing inefficiency. Overall inefficiency could be due to many factors including farm size, technical problems, and a non-optimal input or output mix. To examine possible sources of overall inefficiency, the overall efficiency index for each farm was decomposed into technical and allocative efficiency indices. Farms and ranches that are technically efficient produce on the production frontier. Farms that are technically inefficient could expand output with the same level of inputs by improving their technical efficiency. Allocative efficiency, a component of overall efficiency, examines whether a farm is using the optimal output and input mix. An allocatively inefficient farm is not using the optimal mix of outputs, inputs, or both.

The focus of this study is on comparing the relative efficiency and performance of no-till and mixed tillage farms. With this in mind, efficiency indices as well as farm size, farm type, financial performance, income shares, and cost shares for the no-till farms and the mixed tillage farms were compared. Financial performance was measured using the operating profit margin ratio (net farm income plus interest expense minus unpaid operator and family labor divided by value of farm production) and the asset turnover ratio (value of farm production divided by total farm assets). Income shares were computed by dividing gross income for a particular group of enterprises (e.g., feed grains) by gross farm income. Similarly, cost shares were computed by dividing input cost for each input (e.g., labor) by gross farm income. To determine whether a specific efficiency index or farm characteristic was statistically different between the two groups of farms, t-tests and a 5 percent significance level were used.

Results

The average overall efficiency index was 0.619. Using this level of efficiency, cost per unit of aggregate output could be reduced by 38.1 percent, on average, if all of the farms were overall efficient. The average technical and allocative efficiency indices were 0.861 and 0.720, respectively. Based on these results, allocative inefficiency seemed to be a larger source of overall inefficiency than technical inefficiency.

Table II contains a summary of farm characteristics, income shares, and cost shares by tillage group. This table also indicates whether each variable was significantly different between the two groups of farms. Gross farm income, value of farm production, net farm income, and total hectares were significantly different between the two groups of farms. Thus, on average, the no-till farms were larger than the mixed tillage farms. More importantly, the operating profit margin ratio, the asset turnover ratio, and the overall efficiency index were significantly higher for the no-till farms. At least a portion of this improvement in performance exhibited by the no-till farms could be due to the fact that these farms were larger.

Table II. Characteristics of No-Till and Mixed Tillage Farms in Central Kansas.

Variable	No-Till	Mixed Tillage	Difference Significant
Number of Farms	77	234	
Farm Characteristics			
Gross Farm Income ($)	510,557	343,221	yes
Value of Farm Production ($)	468,629	324,832	yes
Net Farm Income ($)	108,467	71,510	yes
Operating Profit Margin Ratio	0.1676	0.1247	yes
Asset Turnover Ratio	0.4070	0.3199	yes
Technical Efficiency	0.858	0.862	no
Allocative Efficiency	0.773	0.703	yes
Overall Efficiency	0.662	0.605	yes
Total Hectares	879	721	yes
Labor Devoted to Crops (%)	0.8475	0.8292	no
Less Tillage Index	0.1734	0.1154	yes
Income Shares			
Feed Grains	0.2303	0.1805	yes
Hay and Forage	0.0328	0.0440	no
Oilseeds	0.1687	0.1059	yes
Small Grains	0.2271	0.3071	yes
Beef	0.1380	0.1623	no
Dairy	0.0124	0.0274	no
Cost Shares			
Labor	0.1702	0.2299	yes
Livestock	0.0619	0.0642	no
Seed	0.0663	0.0534	yes
Fertilizer	0.1318	0.1353	no
Chemicals	0.0797	0.0552	yes
Capital	0.5626	0.6695	yes

Note: The income shares do not sum to one. Shares for miscellaneous livestock enterprises (e.g., swine; poultry), government payments, crop insurance proceeds, and patronage dividends are not shown.

Technical efficiency was not significantly different between the two groups of farms. In contrast, allocative efficiency was significantly higher for the no-till farms. The average percent of labor devoted to crops was not significantly different between the two groups of farms. However, the less tillage index for the no-till farms was significantly higher.

The results with respect to technical efficiency, allocative efficiency, and overall efficiency suggest that the efficiency problems faced by the mixed tillage farms may be related to either not using the optimal mix of outputs, the optimal mix of inputs, or both. Income and cost shares were compared between the two groups of farms to examine differences in input and output mixes. The income share comparisons show differences in output mix between the two groups. The no-till farms generated more income from feed grains (e.g., corn and grain sorghum) and oilseeds (e.g., soybeans and sunflowers), and less income from small grains (e.g., wheat) than the mixed tillage farms. Beef and dairy income were not significantly different between the groups.

The cost share comparisons can be used to examine differences in input mix between the two groups of farms. As on average the farms in both groups are not covering all economic costs, the cost shares in Table II sum to a value greater than one. The no-till farms used relatively less labor and capital, and relatively more seed and chemicals. Given the difference in the mix of crops grown and the substitution of chemicals for fuel associated with a no-till production system, the results with respect to seed and chemicals were not surprising. Anecdotal evidence supports the difference in labor use between the two groups of farms. Many farmers indicated that they adopted a no-till production system to more efficiently utilize labor. The result with respect to capital was at least partially due to the difference in farm size between the two groups. Previous research found that larger farms use capital more efficiently than smaller farms (Bradford and Langemeier, 2006).

Though not shown in Table II, off-farm wages were not significantly different between the two groups. The smaller farms were either young operators or older operators phasing out of agriculture. Anecdotal evidence garnered from discussions with the KFMA economists who work with these farmers suggests that many small farms are leaving agriculture.

Summary and Implications

The objective of this study was to examine the relative technical and cost efficiency of no-till farms in central Kansas. Data for KFMA farms that have adopted a no-till production system were compared with KFMA farms with a conventional or a reduced tillage production system. In addition to having higher cost efficiency indices, the no-till farms were larger, had a higher level of financial performance, produced relatively more feed grains and oilseeds, relatively less wheat, and more efficiently utilized their labor and capital inputs. There was not a significant difference in technical efficiency between the two groups of farms.

Results of this study have implications for the future adoption of no-till production systems. The no-till farms had significantly higher overall efficiency indices reflected in lower per unit costs. Another possible advantage of a no-till production system that was evident from the results was related to crop mix flexibility. The no-till farms in central Kansas have used the no-till production system to add feed grains and/or oilseeds to their rotations. The combination of lower per unit costs and added crop mix flexibility will certainly attract the attention of farms that currently have conventional or reduced tillage production systems.

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