Management Factors: What is Important, Prices, Yields, Costs, or Technology Adoption?

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Terry L. Kastens and Kevin C. Dhuyvetter

Agricultural Economists, Kansas State University

Defining Good Farm Management

Economically, a well-managed farm is one that *consistently* makes greater profits than similarly structured *neighboring* farms. Because external macroeconomic factors, such as prices, often affect an entire industry, it is important to compare profits relative to other industry participants as opposed to profits in absolute levels. Thus, even during especially good or especially bad times for the industry as a whole, individual management differences can still be identified. However, because random, localized events, such as weather, often mask differences or similarities in management, it is important to observe profit differences among farms that persist over time.

In the context of crop production management, an operator could be more profitable than his neighbors for a number of reasons. Perhaps he tends to get higher crop yields. Or perhaps he is a better marketer and consistently gets higher crop prices. Maybe he does a better job of controlling costs than his neighbors. Or maybe he does a better job of using fixed assets such as land in planting intensity. Or, does the more profitable manager do a better job of determining when and how to adopt new agricultural technologies)) such as less tillage? Other questions also arise. Are profitable operators especially good at one thing? Or, are they better than average at a number of tasks? How easy is it to be better than average at cutting costs or increasing crop prices? How are profits impacted by having input costs that are 10% lower than average? This paper addresses questions such as these in an empirical study of Kansas farms from 1994-2003.

Description of the Study

The Department of Agricultural Economics at Kansas State University maintains an historical economic database of financial records from Kansas farms that are members of one of six regional farm management associations. The database is often referred to as KMAR, for Kansas Management, Analysis, and Research. Records from farms continuously enrolled from 1994-2003 comprise the principle data used in this study (over 800 farms). The KMAR data were augmented with data from other sources as needed (see Nivens, Kastens and Dhuyvetter for additional detail).

Goals of this study involved quantifying the following basic management measures:

a) In dollars per cropped acre, how much greater (less) was each farm's cropping enterprise ***profit*** than that of the average farm in that KMAR region that year? This measure of economic profits equaled zero for the average farm in a region for a given year. Thus, negative values imply lower, and positive values higher, than average profits.

b) For each major crop (wheat, corn, grain sorghum, soybeans, alfalfa) raised each year, what was a farm's ***yield*** as a percent of the county average for that year? What was the average of that measure across all crops raised by that farm for each year, where the average was a weighted average (by number of acres of each crop), so that crops with larger acreages on a farm are given more weight in the yield performance measure? This index provided a measure of yield superiority, with negative values implying lower than expected yields and positive values higher than expected yields.

c) As a percentage, how much higher/lower were crop input ***costs*** for a farm in some year relative to what was expected in the region for similar cropping programs in that year? This index provided a measure as to whether or not a producer was low cost relative to other producers.

d) For the important crops raised each year, as a percentage, how much higher/lower was the overall ***crop value*** compared to what was expected based on other farms in the county raising the same crop mix and having the same crop yields? This provided a general measure of pricing superiority/inferiority (Is the producer a relatively good marketer?).

e) Compared to the average farm within a region in a given year, how much more or less, as a percentage, of total "chemical (herbicide & insecticide) cost + crop machinery cost + crop labor cost" was chemical cost? This provides a measure of the impact relative use of chemicals (rather than machinery) has on crop relative profitability. It is intended to serve as a proxy for less tillage, i.e., **technology**.

f) As a percentage, how much higher/lower was the ***planting intensity*** for a farm in some year relative to what was expected in the region in that year? This provides a measure of a managers ability to use fixed assets.

g) Compared to the average farm within a region in a given year, how much more or less, as a percentage, of total crop acres does a farm ***rent*** rather than own. This provides a measure of the impact land tenure (own versus rent) has on crop relative profitability.

h) As a percentage, how much higher/lower were the overall ***government payments*** compared to what was expected based on other farms in the region? Because government payments are primarily based on historical yields and acres, they cannot necessarily be "managed." However, differences in payments between farmers will impact profitability differences so this variable is included in the analysis.

i) Relative to the average farm within a region in a given year, how much larger or smaller, as a percentage, is the ***size*** of the farm in terms of total crop acres. This variable is included to determine if farms that are larger (smaller) than the average sized farm are more or less profitable — after accounting for the other management variables.

j) As a percentage, how much higher/lower was the overall ***risk*** (farm income variability across years) compared to what was expected based on other farms in the region? This provides a general measure of how farm profitability is associated with risk.

The tillage technology index used in this research is referred to as "less-tillage" to avoid being confused with the terms "reduced-tillage" or "no-till." The measure, computed for each farm each year, measured the tradeoffs between herbicides and tillage (and crop labor).[1]

$$\text{less-till index} = \frac{\text{herbicide expense}}{\text{herbicide expense + (crop labor and crop machinery operation expense)}}$$

The less-till index increases in value as herbicide expenditures increase relative to crop labor and machinery expenditures.[2] With 0 herbicide expense the index equals 0 and if labor and machinery costs were 0 the index would equal +1. The index value would tend to be small and likely never even 0.5 because crop labor and machinery operating costs typically exceed herbicide costs.

It should be noted that the "less-tillage" index also captures changing crop mixes to the extent that different crops rely more (less) on herbicides than others. Thus, while this variable quantifies the changing relationship between herbicide and tillage (machinery and labor) expenses over time, changes cannot be attributed exclusively to tillage practices. However, this likely is not a large problem because often the tillage and crop rotation decisions go hand in hand. But, changes in herbicide prices and especially fuel prices over time can make this index less than desirable as an indicator of less tillage. Regardless, it should provide a good place to start discussion about the impact of tillage practices on profitability.

After quantifying each of the management measures described above such that they were "relative to their neighbors" (i.e., compared to the average farm in the region), the effect yield, cost, price, technology adoption, planting intensity, rent, government payments, farm size, and risk had on profitability was established in a statistical model.

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[1] A farmer's involvement in less-tillage practices is not typically all-or-none. Often only a part of the farm is no-tilled, or only in some years, or only with some crops, or only for some tillage operations. Thus, it is most difficult to label one farmer as a no-tiller and another as a conventional farmer. What is needed is some measure of the extent tillage is used that covers the continuum from moldboard plowing to 100% herbicide-based weed control and seedbed preparation. Then, the impact of that less-tillage measure on profitability could provide the answers needed. But, farm profitability is affected by more than the decision to adopt less tillage; other management characteristics might be equally important, as might be luck or land quality or weather. To properly understand the relationship between no-till and profitability, it is important to identify the impact of less tillage on profitability)) *after* other important profitability-determining factors are accounted for. After all, no-till adoption is essentially a management issue similar to marketing or cost control.

[2] Machinery operation expense is defined as the crop share (as opposed to livestock share) of: machinery repairs, gas-fuel-oil, farm auto expense, motor vehicle depreciation, and machinery-equipment depreciation; plus crop machine hire expense; plus an opportunity interest charge on crop machinery investment; minus machine work income. To that value is added the crop share of labor (operator, hired, and unpaid family labor).

Results of the Farm Management Study

The first question to answer is, How persistent were the management measures: profits, yields, costs, prices, less-till adoption, planting intensity, rent, government payments, and farm size? This was determined by averaging each of the management measure's annual values for a farm over the 1994-2003 period and testing whether this average measure was statistically different from 0 (from the average or typical farm).

Statistical significance is important for establishing confidence in the results. Using the profit per acre variable as an example, consider hypothetical farm A, which is assumed to have this annual profit stream over 5 years: {!$80, $200, !$50, !$270, $300}. The average annual profit for farm A is $20/acre. What would you expect farm A's profit to be in year 6? Although your best guess is $20/acre you would not have much confidence in that prediction. With the large variability displayed in farm A's profits it can easily be shown that its $20/acre profit is not statistically different from 0. Now consider farm B whose profit stream is {!$5, $30, $20, $25, $30}. Like farm A, farm B's average profit is also $20/acre. Now, however, it is much easier to have confidence in a $20 prediction for year 6. In this case, the $20 average is statistically different from 0. Thus, farm B's profits are said to be substantially more persistent than farm A's. It is much easier to believe that farm B's manager has the management skills necessary to make positive profits of $20/acre. On the other hand, it appears farm A's $20/acre profits might chiefly be due to chance. In other words, the profits of farm B are persistent while the profits of farm A are much more random.

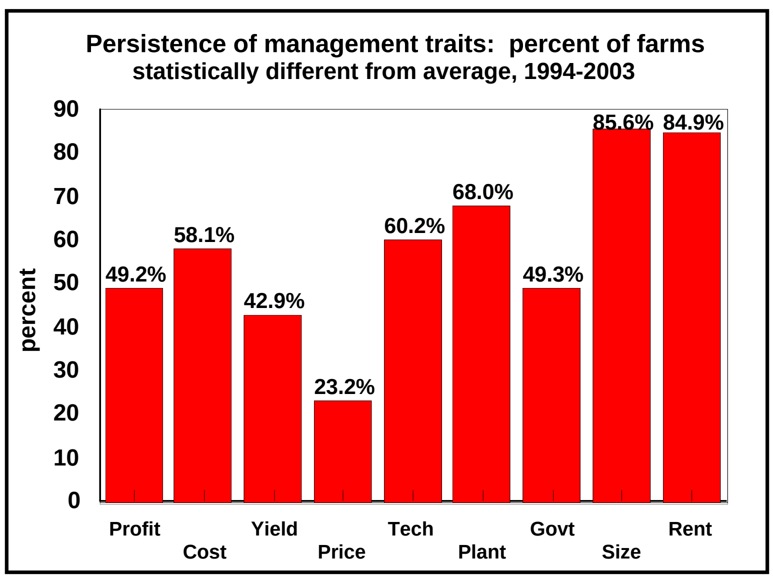

Figure 1

Based on over 800 farms tested, figure 1 shows persistence of management traits by reporting the percent of farms whose 1994-2003 average management measure was statistically different from 0 (from the average farm in that area). With 85 percent of the farms statistically different from 0, the percent of acres rented (Rent) is shown to be highly persistent among farmers. This is not unexpected as it simply means that producers tend to rent a consistently high or low percent of their crop acres from year to year. The most persistent management measure is size, however this and government payments (Govt) are not highly manageable, at least not in the short run. Therefore, of the manageable traits the next most persistent measure with 68 percent of the farms statistically different from 0, is planting intensity (Plant). That is, producers tend to have consistently low or high planting intensity, not jumping about from year to year. Less-till technology adoption (Tech) and cost were the next most persistent management traits, where around 60 percent of the farms were persistently better or worse than their neighbors on average.

A smaller number (43%) of farms were significantly better or worse at yields than their neighbors. This should not be too surprising given that crop yields are so weather dependent. The least persistent management measure is prices, where only 23 percent of the farms were significantly higher or lower than the average.

For farms wishing to differentiate themselves from their neighbors, figure 1 suggests which management aspects should be the easiest ones to focus on – those with the greatest persistence. For example, it should be relatively easy for a farm to set itself off from its neighbors, presumably to make more profit, by either increasing or decreasing the percent of acres rented or planting intensity. We know that because so many farms have demonstrated they can do it. On the other hand, the low persistence on price management suggests it will be especially difficult for a farm to become better at achieving higher prices than its cohorts. But, the appropriate effort expended to achieve higher prices depends on the potential payoff, which is discussed later.

How variable are the management measures? Table 1 reports the average value and the standard deviation for each measure. Table 1 shows a seemingly wide range of profitability. Farms that have costs that are one standard deviation lower than the mean are 26.7 percent below zero, relative to their neighbors. The top managers for crop yields have 15.0 percent higher yields than average. Figure 1 showed that it would likely be difficult to become a superior price

Table 1. Variability of Management Measures: Average Value and Standard deviation.

Measure	Average	Standard Deviation
Profit	0.00	77.3
Cost	0.00	26.7
Yield	0.00	15.0
Price	0.00	8.3
Less-till technology adoption	0.00	50.6
Planting Intensity	0.00	22.5
Percent of crop acres rented	0.00	44.8
Government payments	0.00	65.1
Size	0.00	77.5
Risk (Profit variability across years)	0.00	65.9

manager. Table 1 shows that even those who are good at pricing (one standard deviation change from mean) get prices only 8.3 percent higher than average. In general, each value in table 1 is expected to have the same likelihood of occurrence. That is, it should be as easy to get 26.7% lower costs as it is to get 8.3% higher prices. If we assume that the typical price just breaks even, then it is certainly more profitable to be a superior cost manager. Like figure 1, table 1 suggests that producers should focus on planting intensity, cost, and yield ahead of price (i.e., a

26.7% reduction in cost is more profitable than an 8.3% increase in price).

Figure 2 depicts changes in less-till index values over time by Kansas Farm Management region. To some extent, index levels indicate crop mixes in regions. For example, the less-till index value generally has been the highest in NE Kansas, where soybeans, sorghum, and corn (crops that typically require herbicides) largely dominate over wheat. In SC Kansas, where wheat largely dominates, the index value is lowest throughout the time period.

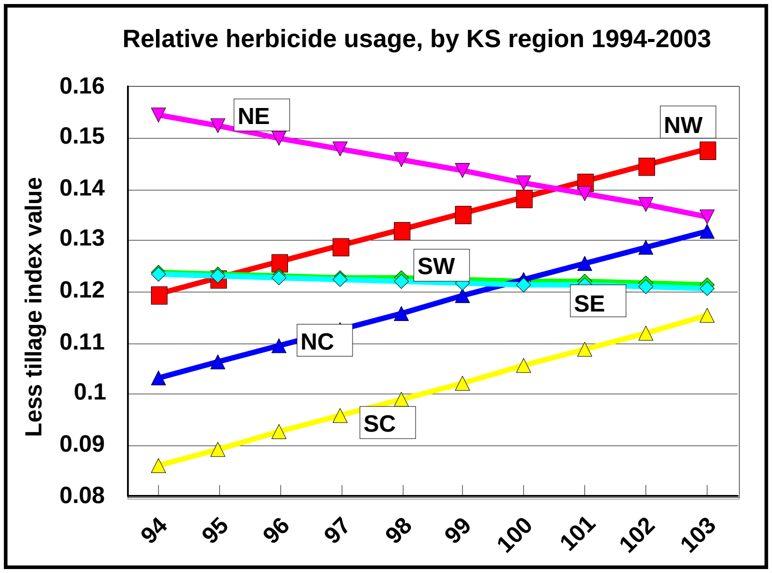

Figure 2

The slopes, or steepness, of the lines in figure 2 are of more interest than the levels as they provide a potential indication of the speed of less-till adoption. NW, NC, and SC Kansas appear to have the fastest adoption rates. In the last version of this study (1992-2001), SW Kansas also displayed fast adoption. We indicated then, that the fast adoption rates in western Kansas correspond to the ongoing transition from wheat-fallow cropping systems to wheat-row crop-fallow systems in that area. We noted further, that profits associated with less-tillage adoption have generally been larger in western Kansas than in other regions (see the economics chapters of K-State's *No-Till Handbook*). Now, the relative flat line for SW Kansas may be an indication of some retrenchment in that area due to recent and ongoing droughts in the area. Alternatively, it could be due to a "leveling-off" of adoption, where those who clearly have an incentive to adopt the technology may already have done so. The down-trending line for NE Kansas is somewhat surprising. But, it might be due to increased substitution of seed for herbicide in the form of Roundup-Ready soybeans in that area. Also, sharply higher fuel prices in several of the recent years may be differentially impacting machinery costs relative to herbicide costs, causing all lines in the figure to be flatter than they otherwise would be. Each of these observations suggests that our less-tillage index may be less than perfect as an indicator of less tillage. Additional research will eventually help increase understanding in this area.

Can the effects of management traits be quantified? For example, can we establish how much more profitable a farm manager was who was one standard deviation greater than the average of a management trait compared to if he were only at the average? To accomplish this, a statistical model was constructed that measures the effect each management trait has on profitability, holding all other traits constant. Although the only technology adoption variable explicitly considered was our less-tillage proxy, other technologies might also be important in explaining profitability. Consequently, because technology adoption often can be measured by farm size (larger farms tend to be those which adopt new technologies), our statistical model also included a variable of excess crop acres (the percent of acres greater or less than the regional average).

Table 2 reports the impact of the various management values on profit per acre. The left side of the table reports how marginal changes in management impacted profitability for the farms in this study. A one percent increase in yields resulted in farm profits rising by $0.23/acre. Also, a one percent increase in relative herbicide usage resulted in increased profits of $0.16/acre. A one percent increase in the percent of crop acres rented resulted in increased profits of $0.44/acre. This suggests that producers who rent crop land have been more profitable that those who own their land. However, it should be noted that capital gains associated with owning land have not been included in this analysis, which makes it a farming profitability study rather than a land ownership study. A one percent increase in farm size is associated with a $0.14/acre increase in profit, indicating economies of size in crop production. Increasing farm income variability by one percent results in a $0.56/acre increase in profit, which shows that producers who are willing to take on more risk receive a higher profit. In the statistical model underlying table 2, price was the only factor whose impact on profitability was not significantly different from 0.

The left side of table 2 does not address whether it is easier to get a one percent increase in yields or a one percent reduction in costs. One way to examine this is to look back at table 1 at the values associated with being one standard deviation above (or below) the mean in a management category rather than at its mean.[3] Roughly, it should be as easy to be one standard deviation above or below the mean in one category as another. Thus, the right side of table 2 reports the effects of those larger changes on profits. For example, going from a farm with average yields to one standard deviation above the average implies 15.0 percent higher yields, which implies $3.44/acre higher profits. Being one standard deviation below the mean for costs impacts profits more than any other management trait except for the risk measure, which is not necessarily a desired management factor. Of the other factors that are within the managers control, being one standard deviation above the mean in terms of percent of crop acres rented significantly impacted profits, followed by an increase in planting intensity, and then by being one standard deviation above the mean for technology adoption and then for yields. The impact of being in the top price-wise, at $0.77/acre, was not statistically different from 0. Size and government payments are not considered manageable traits, so while changing both will have significant impacts on profit, it is generally not within the realm of the manager to do so.

[3] With data that follows a normal distribution (i.e., the bell-shaped curve), the mean plus one standard deviation is roughly equivalent to the average of the top-third of the data and the mean minus one standard deviation is comparable to the average of the bottom-third. Thus, evaluating the impact of a specific management trait at plus (minus) one standard deviation is similar to talking about a producer being in the top (bottom) third of producers with regard to that management trait.

Table 2. Impact on Profit per Acre of Management Traits.

Marginal		One Standard Deviation Change	
This change „	Results in this change in profit/acre	This change „	Results in this change in profit/acre
A 1% decrease in costs	$0.96*	A **26.7%** decrease in costs	$25.78
A 1% increase in yields	$0.23*	A **15.0%** increase in yields	$3.44
A 1% increase in prices	$0.09	An **8.3%** increase in prices	$0.77
A 1% increase in the % herbicide is of herbicide plus machinery costs	$0.16*	A **50.6**% increase in the % herbicide is of herbicide plus machinery costs	$7.97
A 1% increase in planting intensity	$0.72*	A **22.5%** increase in planting intensity	$16.06
A 1% increase in percent of acres rented	$0.44*	A **44.8%** increase in percent of acres rented	$19.92
A 1% increase in government payments	$0.07*	A **65.1%** increase in government payments	$4.79
A 1% increase in farm size above average	$0.14*	A **77.5%** increase in size	$10.72
A 1% increase in farm income variability	$0.56*	A **65.9%** increase in farm income variability	$36.70

* denotes significantly different than 0 at the 90% confidence level

The results of tables 1-2 confirm that farm operators who wish to improve profitability by improving management might do well to focus less on price and more on costs, land tenure, planting intensity, technology, and yields. It was especially surprising to see that the percent of crop acres rented, as opposed to owned, had that much impact on profits. However, it is important to remember that capital gains on land have not been accounted for.

This study now marks the eighth year of such research. Earlier versions treated the technology variable as one that showed "years ahead of your neighbors" in adoption. That framework allowed us to assert that the benefits to speed of less-tillage adoption have been dissipating over time. This was due to the fact that, as agricultural technologies are adopted, farms are less able to differentiate themselves from their neighbors and associated profits disappear because they are bid into land prices. Being one year ahead of one's neighbors in terms of speed of technology adoption is especially important when a technology is quite new (assuming it is not a passing fad). After the newness has worn off, the benefit of being one year ahead of one's neighbors is smaller. Now, since the speed of adoption appears to have decreased (some lines are flatter in figure 2 than they were in previous versions), we have chosen to analyze this technology trait in a manner similar to the other traits, that is, as "intensity of use" rather than as "speed of adoption." Finally, there likely are diminishing returns to specific areas of management. For example, farms that already are superior in all areas except price may need to focus on improving price.

Summary

A study of over 800 farms in Kansas over 1994-2003 revealed that farmers are most able to differentiate themselves from their neighbors in terms of land tenure, planting intensity, technology adoption, and costs, followed next by yields, and last by prices. Increasing the variability in farm income would increase overall profit as well, however this is generally not a goal of producers. Increasing size and government payments would make a significant impact on profitability as well, however these are outside the control of the manager – at least in the short-run. Consequently, being in the low cost of a region's farms was substantially more important than being in the high price. In three regions of Kansas farms have been expanding herbicide expenditures relative to machinery operation expenditures, possibly indicating the adoption of less-till practices. But, relative to earlier studies, SW and SE Kansas appear to be flat in terms of this measure. Interestingly, NE Kansas has a declining relative herbicide usage index. But, this may be due to increased use of Roundup-Ready soybeans and recent high fuel prices. As a profit-maximizing management goal, increasing the percent of crop acres that are rented ranked second behind being a low-cost operator and increasing planting intensity ranked third. Both of these management factors were more important than substituting herbicide for machinery and managing for high yields, both of which ranked more important than seeking high prices.

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