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

(updated July 2006 – data from 1996-2005)

Terry L. Kastens and Kevin C. Dhuyvetter
Agricultural Economists, Kansas State University

What's New in this Paper?

Near the end of this paper is a new-in-2006 section showing the impact on profit of "being in the best third" for a particular management trait. Also, we introduce the reader to a new analysis, one that allows profit impacts of management to be associated with diminishing returns. In the previous analyses, which continue to be reported and discussed here for consistency reasons, the profit associated with being 20 percent better than one's neighbors at some trait is assumed to be exactly twice the benefit of being 10 percent better (results of a linear modeling exercise). But, in the current analysis, the impact of being 20 percent better is somewhat less than double the impact of being 10 percent better. Hence, in the new model, we assume diminishing returns to improved management.

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 1996-2005. This study marks the tenth such 10-year study of management factors, with the first one occurring in 1997 and examining the 1987-1996 time period. Previous study reports can be found on the www.agmanager website or otherwise obtained directly from the authors.

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 1996-2005 comprise the principal data used in this study (758 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 manager's 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 primarily are 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 so that such less-manageable features do not mask what we wish to find out – how much management matters.

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. Also, it makes our measure of profit a “risk-adjusted” one so that readers do not simply respond with statements like “Sure, doing X makes money, but no one would want to take such risks.”

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]

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

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

[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 field 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 essentially is 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).

likely never even reach 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.

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 1996-2005 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 probably $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 also is $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*, whereas the profits of farm A are much more random.

Based on over 750 farms tested, figure 1 shows persistence of management traits by reporting the percent of farms whose 1996-2005 average management measure was statistically different from 0 (from the average farm in that area). With nearly 84 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 more 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 relative to their neighbors, not jumping about from year to year. Less-tillage technology adoption (Tech) and cost were the next most persistent management traits, where around 59 (Tech) and 58 (Cost) percent of the farms were persistently better or worse than their neighbors on average. A smaller number (44%) 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 24 percent of the farms were significantly higher or lower than the average.

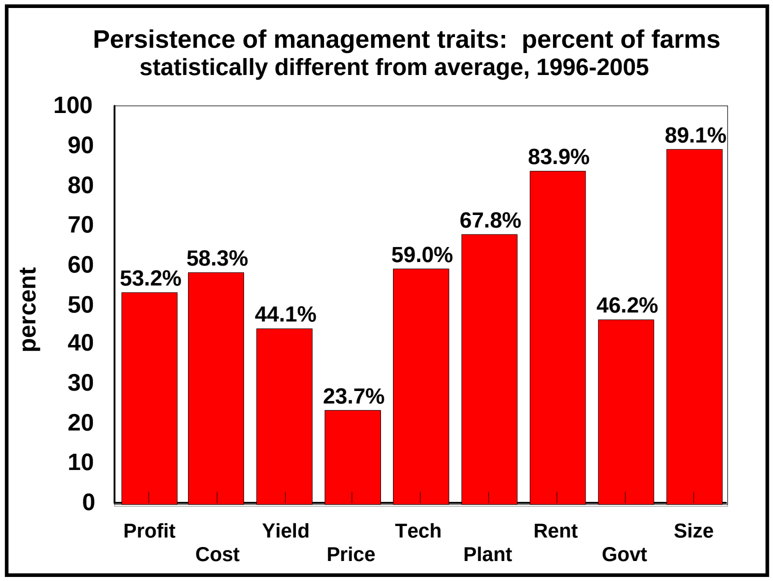

Figure 1

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 also on the expected payoff, which is discussed later.

How variable are the management measures? Table 1 reports the average value and the standard deviation for each measure revealing a seemingly wide range of profitability. Farms that have costs that are one standard deviation lower than the mean are 26.3 percent below their neighbors' costs. The top managers for crop yields have 14.6 percent higher yields than average. Figure 1 showed that it likely would be difficult to become a superior price manager. Table 1 shows that even those who are good at pricing (one standard deviation change from mean) get prices only 8.7 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 26.3% lower costs as it is to get 8.7% 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 26.3% reduction in cost is more profitable than an 8.7% increase in price).

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

Measure	Average	Standard Deviation
Profit	0.00	73.3
Cost	0.00	26.3
Yield	0.00	14.6
Price	0.00	8.7
Less-till technology adoption (herbicide use)	0.00	50.2
Planting Intensity	0.00	21.4
Percent of crop acres rented	0.00	44.9
Government payments	0.00	46.3
Size	0.00	76.8
Risk (Profit variability across years)	0.00	67.9

Historically, this report would show a figure depicting changes in less-till index values over time by Kansas Farm Management region. In such figures it was easy to point to the idea that farmers, on average, have been replacing tillage with herbicides over the years. However, in more recent years, temporally declining glyphosate (an important herbicide; Roundup) prices, especially relative to tillage-related costs such as diesel, have caused the regional graphical lines to appear essentially flat. Consequently, beginning with this year, we no longer show this figure. But, though our index is now less of an indicator of temporal trends in less-tillage, it still remains as an important numerical indicator of less-tillage relative to one's neighbors in farming.

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 that adopt new technologies), our statistical model also included a variable of farm size (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 $0.45/acre. Also, a one percent increase in relative herbicide usage resulted in increased profits of $0.11/acre. A one percent increase in the percent of crop acres rented resulted in increased profits of

$0.20/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 investment study; land ownership is considered a separate profit center, outside of this analysis. That is, owner-operators are "charged" a rent on owned land as if they rented it. A one percent increase in farm size is associated with a $0.19/acre increase in profit, indicating economies of size in crop production. Increasing farm income variability by one percent results in a $0.41/acre increase in profit, which shows that producers who are willing to take on more risk receive a higher profit.

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	$0.97*	A **26.3%** decrease in costs	$25.51
A 1% increase in yields	$0.45*	A **14.6%** increase in yields	$6.53
A 1% increase in prices	$0.70*	An **8.7%** increase in prices	$6.14
A 1% increase in the % herbicide is of herbicide plus machinery costs	$0.11*	A **50.2**% increase in the % herbicide is of herbicide plus machinery costs	$5.52
A 1% increase in planting intensity	$0.60*	A **21.4%** increase in planting intensity	$12.83
A 1% increase in percent of acres rented	$0.20*	A **44.9%** increase in percent of acres rented	$9.13
A 1% increase in government payments	$0.11*	A **46.3%** increase in government payments	$4.93
A 1% increase in farm size above average	$0.19*	A **76.8%** increase in size	$14.82
A 1% increase in farm income variability	$0.41*	A **67.9%** increase in farm income variability	$27.63

* denotes significantly different than 0 at the 95% confidence level

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

[3] With data that follow 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.

average yields to one standard deviation above the average implies 14.6 percent higher yields, which implies $6.53/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 planting intensity significantly impacted profits, followed by percent of crop acres rented, and then by being one standard deviation above the mean for yields, prices, and technology adoption.

Over the ten years that this study has been undertaken, the least changing and likely most important result is that farms desiring to increase profitability should focus mostly on lowering costs (see the large value associated with the cost row in the rightmost column of table 2). Also, from those prior studies, we have regularly noted that managers should focus more on technology adoption, planting intensity, land tenure, and farm size than on crop yields and prices. Although these statements still are true in this present study, some additional points are worth making. In particular, this study is the first time that price management was significantly different from zero in terms of impacting profits. Similarly, this is the first of the studies where price management was associated with a greater profit impact than any of the other traits. In particular, this study shows that two traits, technology adoption and government payments, have smaller profit impacts than price management. This is not so much an indication of weakening impacts of technology adoption as it is strengthening impacts of price management over the years. Nonetheless, we should not lose sight of the fact that price impacts pale relative to cost impacts in terms of management.

It is worth noting that, despite our efforts to statistically identify a separate variable for each management trait of interest, it is likely that many reported impacts are still somewhat confounded. For example, less tillage typically goes along with increased planting intensity (i.e., less summerfallow in western Kansas and more double-crop soybeans in eastern Kansas). So, it might be that a reader would want to add together the technology impact and the planting intensity impact to represent the best expected impact of adopting less tillage (hence, $18.35/acre). Similarly, large farms tend to rent a greater portion of the crop land they operate. Hence, it might be that the impact of increased farm size actually is best measured by adding together the impact of renting and farm size (hence, $23.95/acre).

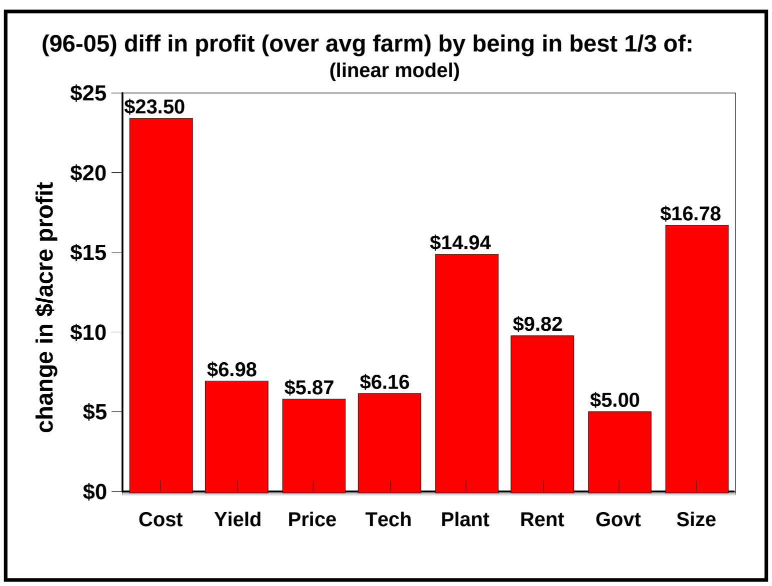

Figure 2

Another View of the Impact of Management Traits

Evaluating a statistical model at the one "standard deviation different from average" variable value, as is shown in table 2, is similar to evaluating the model at the typical value in the “best third” of a category of interest – at least if variables are normally distributed about their means. Yet, thinking of farms as being in the “top third” often is more understandable than farms being one standard deviation above their neighbors. In particular, for a particular trait, we ask the following questions. First, what is the average value of that variable for only those farms in the best third of that variable? Second, what does the model predict for an expected change in profit associated with that best-third average value? Figure 2 shows the profit impacts associated with being in the best third for each category (the risk impact is not shown). Notice that, though not identical to the numbers in table 2’s right column, corresponding values in figure 2 are similar.

Consideration of Non-linear Impacts of Management Traits

Impacts on profit depicted in table 2 and figure 2 arise from what is referred to as a linear model. The linear model has only 9 variables, one for each of the management traits already discussed. No intercept is included in the model since the mean of each variable is equal to zero. For the diminishing returns model we considered a quadratic plateau (QP). Besides the 9 variables in the linear model, their squared counterparts also are added to the QP model, so there are now a total of 18 variables rather than only 9. In a quadratic model, the impact of a variable on profit is assumed to diminish (profits rise as a variable improves, but at a diminishing rate). Normally, a quadratic model allows for predicted profit to “turn down” as a variable’s values become ever higher. However, we do not believe that the benefits of management improvement eventually become a dis-benefit at ever higher values. Consequently, we force a variable’s impact on profit to rise at higher variable values, but to plateau when the quadratic function reaches its apex (rather than turn back down thereafter). Hence the model is referred to as a quadratic *plateau*.

Figure 3 shows the QP model’s predictions when that model is evaluated at the average value for the top third of farms by each measure of interest. Clearly, figure 3’s results are not identical to figure 2’s despite showing considerable similarities. Finally, we should note that, in an out-of-sample prediction framework, the QP model performed more accurately than the linear model. Thus, we may at some point choose to display only the QP model’s results. However, for now, we intend to continue to show mostly the linear model’s results, since they are more consistent with the previous years’ studies.

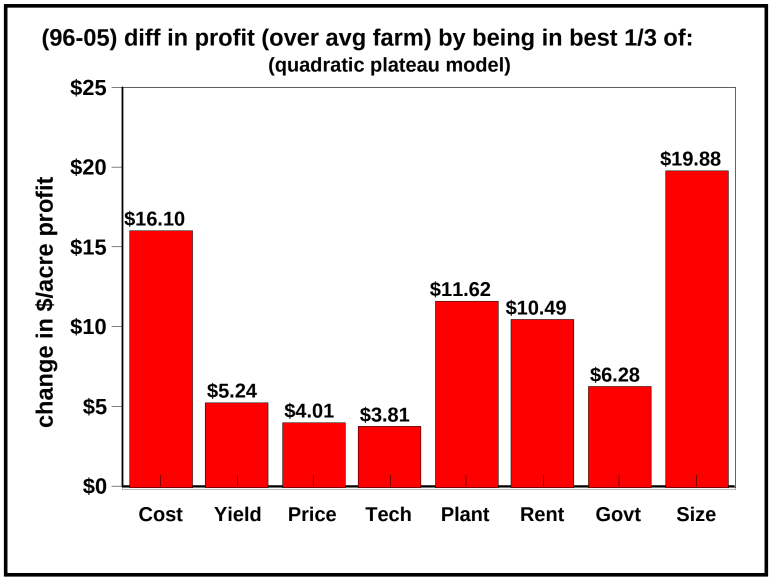

Figure 3

Summary

A study of over 750 farms in Kansas over the 1996-2005 time period revealed that farmers are most able to differentiate themselves from their neighbors in terms of cost, planting intensity, and land tenure, followed next by yields, prices, and less-tillage adoption. 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 generally outside the control of the manager – at least in the short-run. Consequently, being in the low cost group of a region's farms was substantially more important than being in the high price group or getting high yields.

References

Agricultural Land Values. Kansas Agricultural Statistics. Kansas Department of Agriculture, U.S. Department of Agriculture. Various annual issues.

The Enterprise Analysis Report. Kansas Farm Management Associations. Department of Agricultural Economics, Kansas State University, Manhattan, Kansas. Various annual issues.

Kansas Farm Facts. Kansas Agricultural Statistics. Kansas Department of Agriculture, U.S. Department of Agriculture. Various annual issues.

Kansas Farm Management Guides. Department of Agricultural Economics. Kansas State University. Various annual issues.

Nivens, H.D., T.L. Kastens, and K.C. Dhuyvetter. *Payoffs to Farm Management: How Important is Grain Marketing?* A departmental paper in the Dept. of Agricultural Economics, Kansas State University. 1999.