Management Factors: What is Important, Costs, Yields, Prices, or Production Practices?

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This paper analyzes the value and feasibility of farming differently than the local average in Kansas crop production. It is an update of previous research with the addition of several new variables--workers per acre, machine costs, and crop input costs--to answer additional questions (Dhuyvetter, Morris, & Kastens, 2011; Kastens, Dhuyvetter, 2007, 2006, 2005, 2004; Nivens, Kastens, & Dhuyvetter, 2002). Farms are broken down by their characteristics, practices, and management performances in order to identify sources of superior performance. Do the number of workers per acre explain differences in farm performance? Do machine costs or crop input costs, relative to averages, have a larger impact on farms' relative performances? The degree and consistency of which farms are different than average is also analyzed. To what degree do farms distinguish their planting intensity from the local average? By how much do the prices received by some farms deviate from the average price received in a county? Lastly, how consistently farms achieve different than average costs, yields, prices, and net incomes is analyzed.

This analysis and previous studies have examined farm characteristics and performances over ten-year periods going back to the 1992-2001 period (Nivens, Kastens, & Dhuyvetter, 2002). Since the first study the estimated impact of farm size and price management increased steadily. The measured impact in this study deviates from the increasing trend, but farm size and price management continue to be significantly related to farm performance.

Introduction

A farm's net income measures its ability to cover the cost of crop inputs, fuel, and wages along with costs of land and equipment assets. Over time farms must maintain a positive net income to remain in business and cover family living expenses. Additionally, a farm's viability is affected by how its net income compares to other operations. Crop production is a competitive industry. Farms compete indirectly with one another through crop markets and directly over land. More profitable farms are more capable of lasting through periods of unprofitability and producing crops at long run equilibrium prices while also remaining more competitive in land markets. Farms that achieve a higher than average net income over time are better positioned to reinvest in and grow their businesses and pass them on to future generations.

In his paper "What is Strategy?" Michael Porter (1996) specifies two ways businesses can outperform their rivals: operation efficiency and strategy. Superior performance by operation efficiency means executing the same activities more efficiently and therefore at a higher profit than rivals. In crop production this could equate to planting the same crops, using the same tillage practices, and applying similar inputs as other rival farms, but doing it more efficiently (i.e., getting a higher yield with similar inputs) and therefore earning a higher profit. Superior performance through strategy means performing different activities or performing similar activities in a different way than rivals. In crop production this could equate to planting different crops, using different tillage technology, or using different rates of inputs (e.g., applying a more optimal rate of fertilizer) than rivals and as a result producing crops at a higher profit. The primary focus of this research is identifying how farms can outperform other farm operations by farming differently (i.e. superior performance through strategy).

Farms can outperform other operations as a direct result or through rippling effects of strategic decisions. Taking pest and weed control as example, farms that use no tillage practices will typically have higher chemical costs and farms that use traditional tillage practices will have higher fuel costs. If one method controls weeds at a lower aggregate cost (also including labor, repair, and depreciation expenses), farms that utilize this method will achieve a higher level of profitability. As another example, farms that own their land instead of renting it may make more valuable long run investments (e.g., apply lime, do conservation work) in their land, while farms that rent land may choose not to make improvements due to the risk of losing the land in the future. Farms that own their land might achieve a higher level of performance as a result of being in a position to make more profitable decisions.

Variables

Farms are broken down by their characteristics, production practices, and management focus. Table 1 list these three categories along with specific variables considered in each category. A farm's characteristics include their size, how they access land and equipment, and how many acres farmed per worker. Whether farms own or rent land is quantified by their share of rented acres. The purpose of the value of equipment per acre variable is to quantify a farms decision to own equipment or hire custom operators. It also implicitly measures a farms use of older or new equipment. The number of workers on the farm is measured by the total number of operators, family laborers, and hired employees per acre.

Farm production practices include the diversity of crops grown, how intensely land is used, and farm tillage practices. The diversification of crops grown is measured by a Herfindahl index of crop acres planted. How intensely a farm uses their land is measured by planted dryland acres divided by total dryland acres, where values less than 1.0 indicate some land being fallowed and a value greater than 1.0 indicates double cropping. A farm's use of traditional tillage or no tillage practices is estimated by the ratio of a farm's chemical costs to their total chemical and equipment costs. A higher ratio is assumed to be correlated with reduced or no-tillage production.

It is in the best interest of farms to minimize their costs, maximize their yields, and market crops at the highest prices. However, it is difficult to do all thing optimally and farms can decide to deviate up or down from the average. Farms can choose to invest less (more) than average in inputs and limit (increase) their yield potential. They can also decide how much time they put into trying to market crops at the highest price. Cost, yield, and price management variables measure the degree farms focus on particular areas of management and the trade-off decisions they make in those areas.

Table 1: Explanatory Variables

Characteristics	Practices	Management Focus
Farm Size	Crop Specialization	Machine Costs
Proportion of Acres Rented	Tillage Practices	Input Costs
Workers per Acre	Planting Intensity	Yields
Equipment Investment per Acre		Prices
Government Payments per Acre		Risk

Methodology

The conceptual framework for this analysis can be shown as:

$$Relative\ Net\ Farm\ Income = Function\begin{pmatrix} Relative\ Characteristcs, \\ Relative\ Practices, \\ Relative\ Management\ Performance \end{pmatrix}.$$

In words, how do relative characteristics, practices, and management performance explain relative farm performance?

A farm's $Relative\ Net\ Farm\ Income_i$ is equal to the average difference between a farm's net income per acre and the local average over a ten-year period. The local average is the average net income in the farm's KFMA region. The calculation can be shown as:

$$Relative\ NI = \frac{(Relative\ NI_1 + Relative\ NI_2 + \cdots + Relative\ NI_{10})}{10}$$

$$Relative\ NI_1 = Net\ Income_{2005} - KFMA\ Region's\ Average\ Net\ Income_{2005}$$

$$Relative\ NI_2 = Net\ Income_{2006} - KFMA\ Region's\ Average\ Net\ Income_{2006}$$

…

$$Relative\ NI_{10} = Net\ Income_{2014} - KFMA\ Region's\ Average\ Net\ Income_{2014}$$

Net farm income includes income for crops fed to livestock, a salary for each owner operator, market rent for owned crop acres, and an opportunity cost for equipment. Interest expenses are not included so that a farm's relative performance is not affected by its cost of borrowing. All income and expenses are measured on an accrual basis and net income is measured per acre so the performance of different size operations can be compared to one another.

Farms' relative characteristics, practices, and management performance are equal to the average difference between their particular variable and the local average over the 2005 to 2014 period. Taking a farm's relative size as an example:

$$Relative\ Size = \frac{(Relative\ Size_1 + Relative\ Size_2 + \cdots + Raltive\ Size_{10})}{10}$$

$$Relative\ Size_1 = \frac{(Farm\ Size_{2005} - KFMA\ Region's\ Average\ Farm\ Size_{2005})}{KFMA\ Region's\ Average\ Farm\ Size_{2005}}$$

$$Relative\ Size_2 = \frac{(Farm\ Size_{2006} - KFMA\ Region's\ Average\ Farm\ Size_{2006})}{KFMA\ Region's\ Average\ Farm\ Size_{2006}}$$

…

$$Relative\ Size_{10} = \frac{(Farm\ Size_{2014} - KFMA\ Region's\ Average\ Farm\ Size_{2014})}{KFMA\ Region's\ Average\ Farm\ Size_{2014}}$$

Each farm's relative size is equal to the average difference between its size and the average farm size in their respective KFMA region average over the 2005 to 2014 period. Similar calculations are done for the other variables.

A regression analysis quantifies the relationships between relative characteristic, practice, and management performance and relative farm performance. As an example, during the 2005-2014 period did farms that used their acres more intensely than average, after accounting for other differences, achieve a higher than average net income per acre? The variability of characteristics, practices, and management performance is measured to assess the degree farms are different from the local average. How different are farms' crop diversification in each KFMA region? How different are farms' equipment costs in each KFMA region? Lastly, the consistency of farms' relative cost, yield, and price management performances are analyzed. How many farms in the sample consistently achieve higher than average yields or sell their crops for higher than average prices?

Data

The 451 farms analyzed are members of the Kansas Farm Management Association (KFMA). All farms in the sample had to be members of the KFMA every year of the 2005 to 2014 period, at least 50 percent of their labor had to be allocated to crop production, and at least 50 percent of crop acres had to be planted to wheat, milo, corn, soybeans, or alfalfa. The KFMA splits Kansas into six geographical regions and there are farms from each region in the sample. The Southeast region has the most farms in the sample while the Western regions have the fewest (Figure 1). Other information used in the analysis is provided by the Kansas branch of NASS (National Agricultural Statistics Service), the Farm Service Agency, and Kansas State University Farm Management Guides.

Table 2 shows the average farm size, workers per thousand acres and equipment investment per acre in the sample. The coefficient of variation is a normalized variability measure equal to a variable's standard deviation divided by its average. The higher the coefficient of variation, the more variability there is across farms. The size of farms varies from 148 acres to 8,605 acres, while operators make up the majority of labor in the sample. The average number of owner operators per 1,000 acres is 0.77 and the average number of workers (including owner operators) is 0.95. The average farm allocated 88.5% of labor to crop production and on average 92% of crop acres were planted to wheat, milo, soybeans, corn, and alfalfa. Figure 2 shows the average net income per acre by year for all farms in the sample over the period.

The 2005 to 2014 period included extreme weather events, historically high crop prices, and increased crop costs. There was a late frost in 2007 and drought in 2012 and 2013. Average Kansas crop prices peaked in 2008 and 2013 and Kansas farmers shifted some wheat and milo acres to corn and soybeans in this period to take advantage of higher profit potential. While crop inputs and cash rents followed crop prices higher, the sample's average net income peaked at $112.28/acre in 2013. Farms invested their net income in fixed assets. Average owned acres increased from 398 in 2005 to 514 in 2014 and equipment investment increased from $149/acre to $320/acre. At the end of the period as crop prices fell, and costs remained high, average farm net income ended close to where it started at $8.30/acre.

Figure 1: Sample Distribution

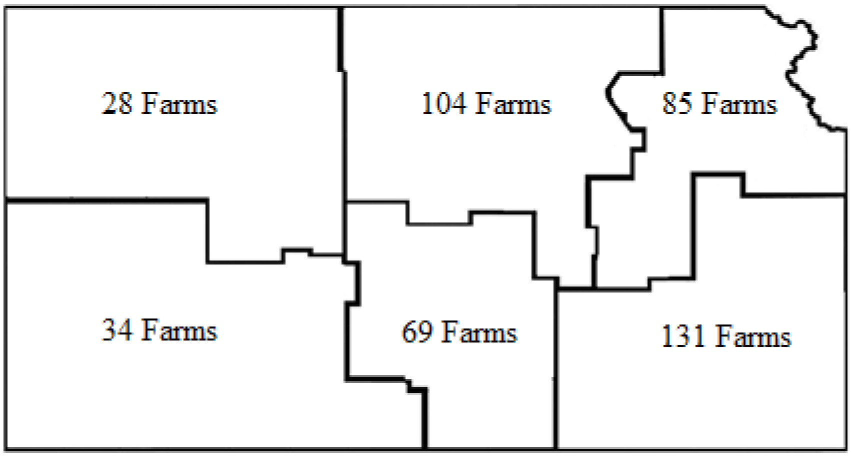
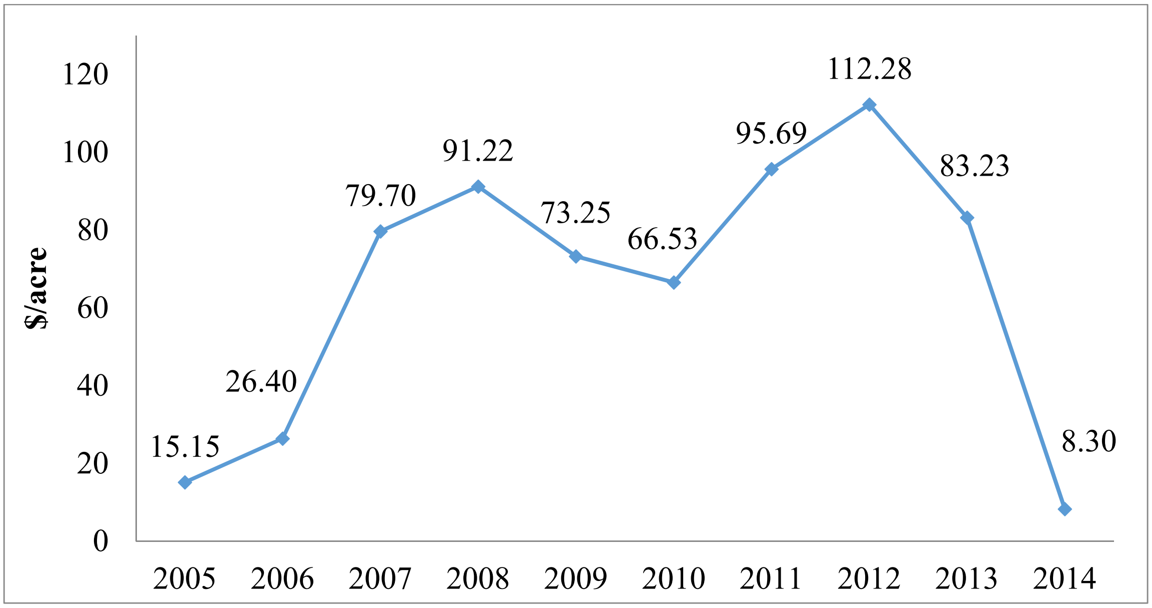


Table 2: Summary Statistics

	Average	Coefficient of Variation	Minimum	Maximum
Farm Size (acres)	1,569	0.74	148	8,604
Share of Rented Acres (%)	67.6	0.39	0.0	100.0
Crop Labor Percentage (%)	88.5	0.14	52.5	100.0
Total Workers per 1,000 Acres	0.95	0.47	0.28	4.23
Owner operators per 1,000 Acres	0.77	0.53	0.11	2.86
Equipment Investment ($/acre)	218.5	0.47	0.0	697.2
Share of Main Crop Acres (%)	92.1	0.09	62.9	100.0

Figure 2: Average Net Income per Acre

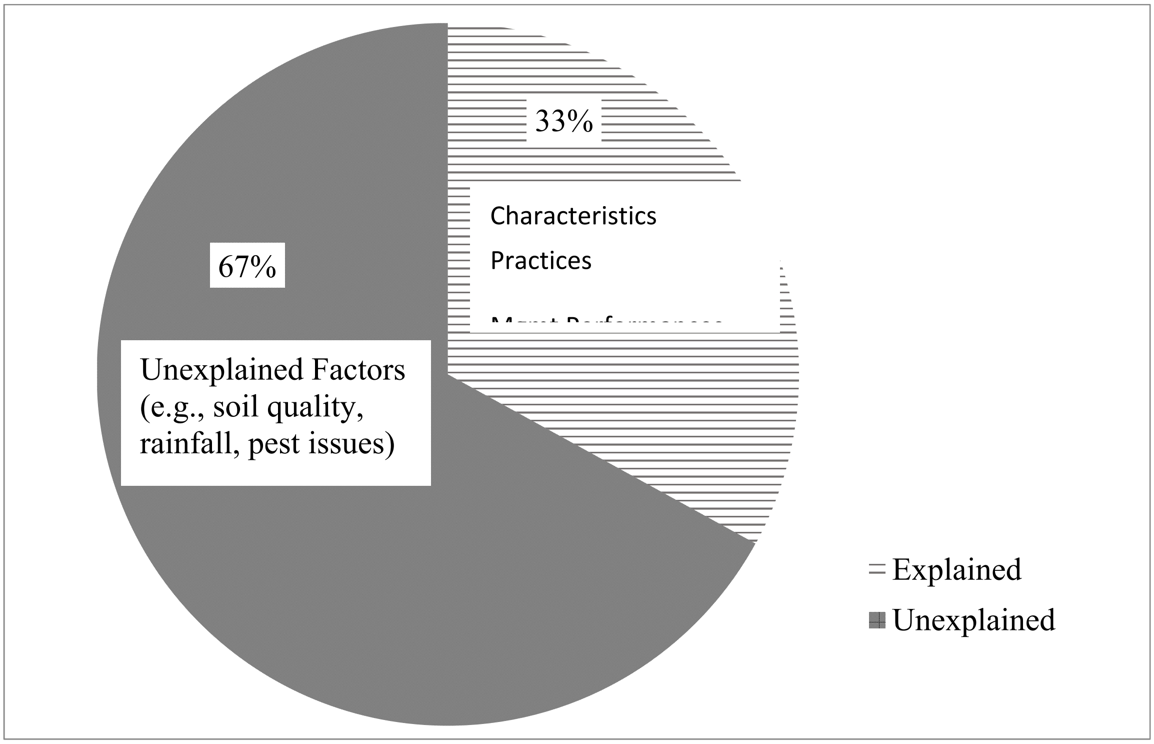


Results

The Value of Farming Differently than the Average

Relative characteristics, practices, and management explain 33 percent of the variation in relative net income per acre (Figure 3). Soil quality, local weather, and pest problems are variables not included and are likely part of the unexplained variability of farm performance. Farm size, share of rented acres, workers per acre, crop specialization, planting intensity, machine cost management, yield management, and price management are significantly related to farm performance (Table 3).

Figure 3: Variation of Relative Net Income



The interpretation of each coefficient is the $/acre higher (lower) than average net income for being 1% different than the local average, holding all other variables equal to their averages. A farm that was one percent larger than the local average achieved a $0.142/acre higher than average net income per acre. The size required to be 1% larger than average is dependent on the KFMA region. Table 4 shows the average size, workers per acre, planting intensity, and machinery costs per acre for each KFMA region during the period.

The significant effect of workers per acre is primarily explained by the number of operators per acre on a farm. Operators account for 81% of farm workers in the sample and were charged an average salary of $49,875. Farms with one percent lower machine costs achieved a $0.318/acre higher than average net income.

Part of the value of farm size is accounted for in the impact of workers per acre and machine costs per acre. Larger farms are able to spread these fixed costs over more acres. Farm size is also significant by itself, which may account for the value of input discounts and bargaining power with grain buyers that larger farms often realize.

Kansas’ late spring frost in 2007 and drought in 2012 and 2013 may explain the effect of government payments. Farms that qualified for disaster payments may have achieved higher than average net incomes as a result. Consistent with previous findings farms that used their acres more intensively than average achieved higher than average net incomes. Contrary to previous findings and common industry understanding, the use of no tillage practices was negatively related to farms’ performance. The varying uses of branded and generic chemicals may be affecting the quantification of tillage practices and therefore its estimated relationship with profitability.

Expenditures on crop inputs were positively but insignificantly related to farm performance. The marginal effect on relative profitability is also notably less than what was estimated for lower machine costs. Not surprisingly, higher yields and higher crop prices were significantly related to superior performance. The positive coefficient on marketing performance suggests spending more time or investing more resources marketing crops may not detract from the performance of other areas of the farm business. The risk variable measures the variability of farms’ relative performance over the period and the results show that producers who are willing to take on more risk achieve a higher profit.

Table 3: Regression Results

Variable	Estimate		Std. Dev.	T-statistic	P-Value
Intercept	0		1.952	0.00	1.000
Farm Characteristics					
Plant Crop Acres	0.142	**	0.032	4.39	<0.001
Rent	0.116	*	0.061	1.91	0.057
Workers per Acre	-0.398	**	0.057	-6.99	<0.001
Equipment Investment Per Acre	0.114		0.073	1.56	0.118
Government Payments	0.311	**	0.058	5.34	<0.001
Farm Practices					
Specialization Index	-0.200	**	0.083	-2.39	0.017
Planting Intensity	0.300	*	0.157	1.91	0.0575
Tillage Index	-0.044		0.071	-0.62	0.536
Management Performance					
Machine Costs	-0.318	**	0.130	-2.44	0.015
Input Costs	0.001		0.143	0.01	0.991
Yields	0.709	**	0.187	3.79	<0.001
Prices	1.045	**	0.269	3.88	<0.001
Risk	0.167	**	0.062	2.71	0.007
Adjusted R-Squared	0.33				

*significant at the 0.10 level

**significant at the 0.05 level

Table 4: KFMA Region Averages

	NW	SW	NC	SC	NE	SE
Farm Size (planted acres	2,484	1,131	1,393	1,708	1,308	1,723
Workers per 1,000 acres	0.73	1.35	0.83	0.95	1.16	0.84
Planting Intensity	0.67	0.54	0.93	0.94	0.90	1.02
Machine Cost per Acre ($/acre)	89	103	74	82	86	78

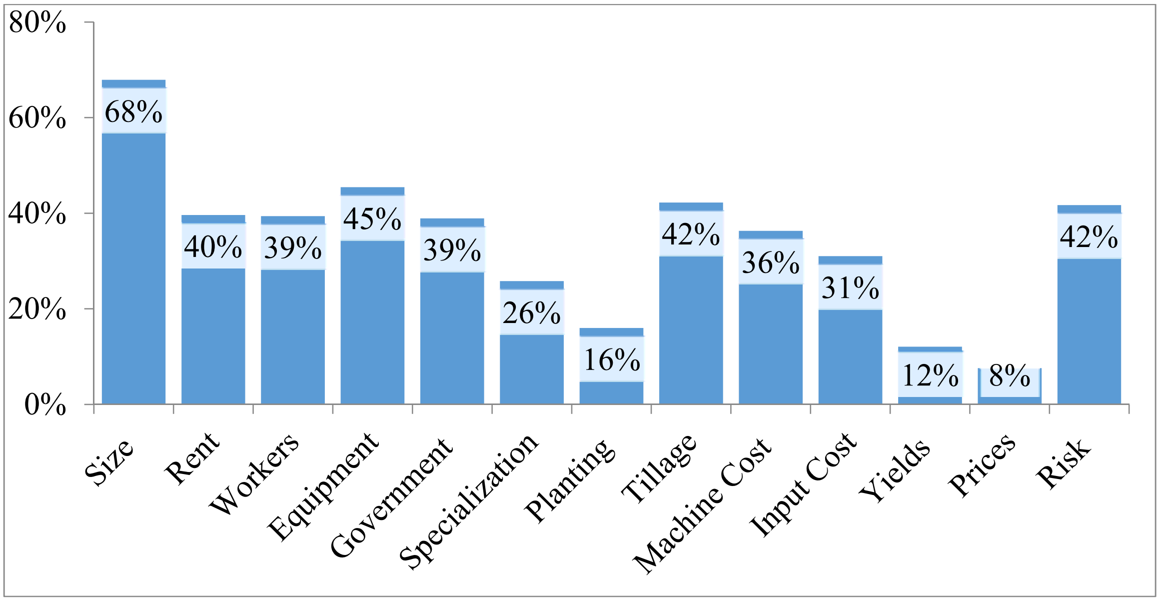
The Feasibility of Being Different than Average

The standard deviation of each variable measures how similar or different farms are compared to the local average. A larger (smaller) standard deviation means the variability across farms is larger (smaller). Figure 4 shows the standard deviation of each variable. Farm characteristics are generally more variable than production practices, while yield and price management performances are very similar across farms.

The variability of characteristics may be explained by farms' different preferences and circumstances. The variability of size may reflect the different growth goals of managers, but also the capital constraints that smaller operations face. The similarities of crop specialization and planting intensity across farms shows farms utilize similar crop rotations within each KFMA region. This is not surprising given planting season constraints and limited market opportunities for alternative crops. The variability of tillage practices may be explained by the different tillage practices of farms and possibly the varying use of branded and generic chemicals as well.

Machine costs are considerably more variable across farms than yields and prices. Uncontrollable pest and weather events might prevent farms from distinguishing their average yield performances. The difficulty of beating the market might prevent farms from marketing their crops at considerably higher than average prices over time. Each farm's risk variable measures how much their net income varied through the ten-year period and the results show this was very different across farms.

Figure 4: Variability Results

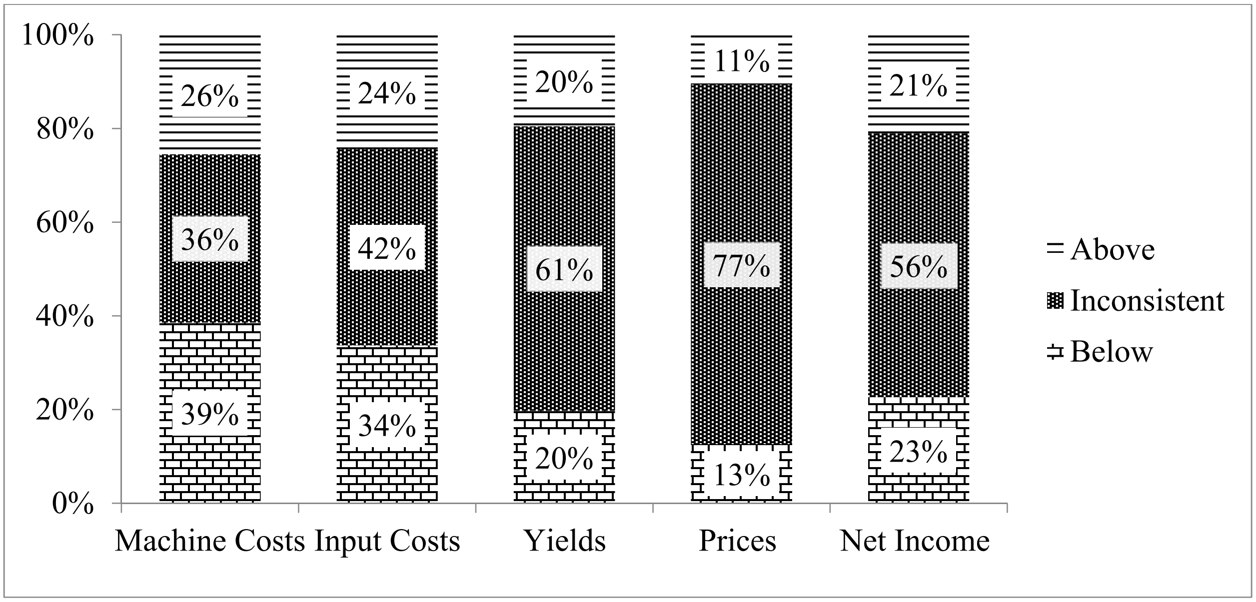


A statistical analysis is used to determine how many farms had consistently different than average costs and yields between 2005 and 2014 and how many farms consistently sold their crops at different than average prices. For each variable the share of farms that were consistently above and below average and the share of farms that were not consistently different than average are shown in Figure 5.

The majority of farms had inconsistent relative yield performances and relative marketing performances over the period. Unique pest problems and weather events may prevent farms from consistently achieving higher yields. The inconsistency of price management performances supports the theory that it is difficult to consistently beat the market. The majority of farms had consistently different than average machinery and input costs. Farms have more control over their costs than their yields and prices. Figure 5 also shows the variability of net farm incomes over the period. The variability of farms' relative management performances explains the variability of farms' relative net incomes per acre.

Despite the variability in farms' performances, the regression analysis showed that farms with superior average management performances did achieve higher than average net incomes per acre. The two results suggest that while farms might not outperform the average each year, farms can still benefit from a superior average performance over time. In other words farms might not achieve higher than average yields each year, but farms that achieve a higher yield performance over the 10-year period would be expected to achieve a higher than average net income.

Figure 5: Consistency Results

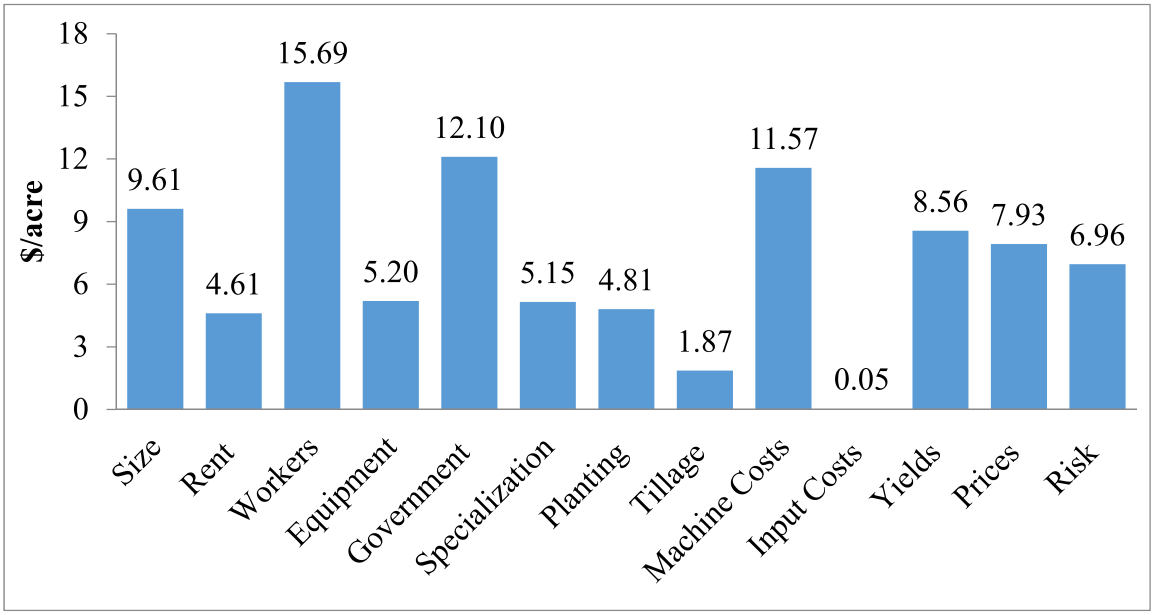


Top Third Analysis

Figure 6 shows the value of being in the top third (1/3rd) of all farms for each variable. This takes into account the degree farms in the top 1/3rd are different from average and the estimated value of being different than average. The value of lower machine costs and higher crop prices is a good example. The marginal value of selling crops at 1% higher prices is greater than the marginal value of having 1% lower machine costs, but the value of being in the top 1/3rd for lowest machine cost is greater than being in the top 1/3rd for highest crop prices. Why the difference? The farms with lowest machine costs per acre distinguished themselves from the average to a larger degree than the top crop marketers.

The salary charged owner operators explains the large impact of having the fewest workers per acre. Farms that spread this fixed cost over more acres achieve considerable higher than average net incomes. Farms in the top 1/3rd for planting intensity made $4.81/acre higher than average net income. Producers that use their acres more intensively essentially spread out their fixed cost over more acres. The value of having low machine costs and achieving the highest yields confirms the importance of lower costs and higher yields in crop production.

Figure 6: Top Third Analysis

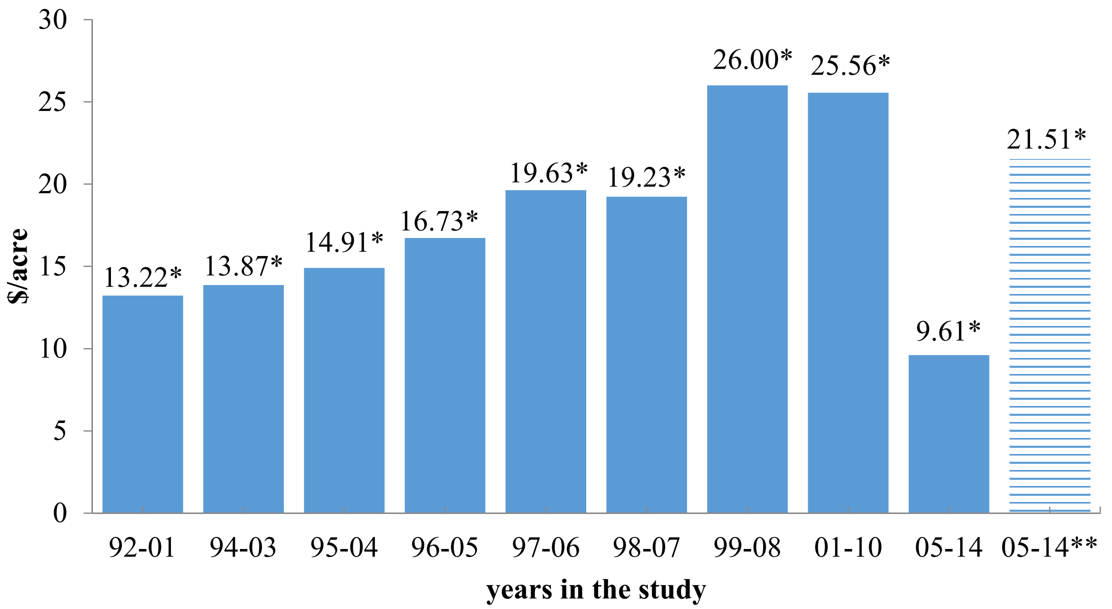


Trends over Time

Versions of this analysis have been conducted nine times over the past 20 years. Each time the same core variables and same basic model have been used. This presents an opportunity to look at how the impacts of specific variables have changed over time. Figure 7 and Figure 8 show the estimated impact of being in the top 1/3rd for farm size and marketing going back to the first analysis. The impact of farm size and price management declined in the most recent study which is a departure from a previously increasing trend.

The decline in farm size is primarily explained by the addition of workers per acre and machinery investments per acre. In Figure 7 the column furthest to the right shows the measured impact of farm size if these two variables are not included in the model. In previous models the impact of these variables was included in the value of farm size. In the most recent study a new method is also used to estimate the value of crops fed to livestock and analysis suggests the new method also reduced the impact of farm size.

Figure 7: Top 1/3rd in Farm Size over Time



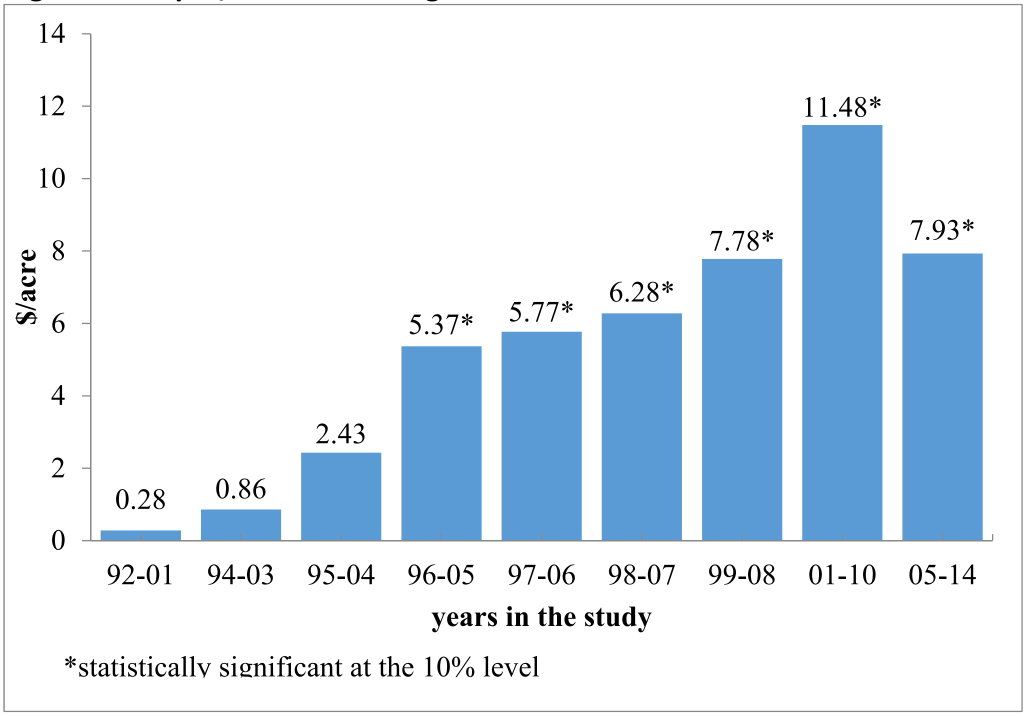
*statistically significant at the 10% level

**farm size effect when workers per acre and investment per acre is not included in model

The decline in the impact of marketing is surprising given what crop markets have done in recent years. Since the last study crop prices were volatile and reached historically high levels. Farms had more opportunities to sell crops at higher than average prices compared to previous periods. While there are farms that have remained in the sample since the first study in 2001, each study has analyzed a different sample as individual farms have joined and left the KFMA. A change in the most recent sample may explain the change in the estimated impact of marketing.

The farm size and marketing results depart from their historical trends. It is possible the value of size and crop marketing has been over-estimated in the past, but it is also possible they are being underestimated currently. What has not changed is that both variables continue to be significantly related to farm performance. Farms that are larger than average and farms that market their crops at higher than average prices achieve considerably higher than average net incomes.

Figure 8: Top 1/3rd Marketing over Time



Conclusion

This research analyzed the value and feasibility of farming differently than average. A sample of 451 Kansas farms from the Kanas Farm Management Association was analyzed over the 2005 to 2014 period. The economic performance of farms was measured by an adjusted net income per acre. Characteristics, practices, and management performance explain a significant share of the differences in farm performance. The way farms access resources, produce crops, and manage their operations may impact how their farm performs compared to other operations. Farm size, share of rented acres, workers per acre, government payments, crop specialization, planting intensity, machine costs, yield management, and price management were all significantly related to farm performance.

Farm size, share of rented acres, and equipment investment per acre varied significantly across farms in each KFMA region. On the other hand, a farm's crop specialization, planting intensity, and yield and price management performance were similar. The results also suggest farms cannot expect to outperform the average in yield and price management every year, but superior management performances on average over time can result in higher than average net income.

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