

Payoffs to Farm Management: How Important is Crop Marketing?

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ABSTRACT

In production agriculture, good management is demonstrated by profits that are persistently greater than those of similar neighboring farms. This research examined the effects of management practices on risk-adjusted profit per acre for Kansas farms over 1990–1999. The management practices were price, cost, yield, planting intensity, and technology adoption (less-tillage). Cost management, planting intensity, and technology adoption had the greatest effect on profit per acre, and cash price management was found to have the smallest impact. If producers wish to have continuously high profits, their efforts are best spent in management practices over which they have the most control.

Key Words: *farm management, marketing, risk, technology adoption.*

The removal of target price payments wrought by the 1996 Freedom to Farm bill has increased farmers' and policy makers' interest in marketing issues. As evidence of this, a new Risk Management Agency within the U.S. Department of Agriculture was created to allocate resources in the area of marketing and financial risk management for agricultural producers. However, if the recently increased interest in marketing issues results in farmers "trying to pick high prices in the futures market," it could mean disappointment for those farmers. Empirical evidence supporting efficient grain futures suggests that it is difficult to garner abnormal profits trading futures (e.g., Garcia, Hudson, and Waller; Kastens and Schroeder; Kolb, 1992, 1996; Tomek; Zulauf and Irwin). Further, that difficulty may be increasing (Kastens and Schroeder). This is not to say that

opportunities do not exist in the futures markets. Indeed, Wisner, Blue, and Baldwin point to a number of trading strategies that have distinct profit-increasing potential as long as they can be recognized *ex ante*.

Even if grain futures markets are generally efficient, strategies involving cash markets or cash and futures markets may still be profitable. A comprehensive study assessing this possibility is the ongoing study of AgMAS (Agricultural Marketing Advisory Services), which began in 1994 at the University of Illinois and focuses on evaluating the cash and futures strategies of over 20 marketing advisory services which sell their advice to agricultural producers. Generally, an examination of the various papers and reports at the AgMAS website reveals that it is extremely difficult to consistently "beat the market" over time, even for those who are professionally involved.

When it comes to acquiring favorable crop prices, might it be that those in the know simply are not talking? After all, it probably

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would be in their best interest to keep quiet. Certainly that idea is consistent with Zulauf and Irwin, who note that "... evidence exists that individuals can beat the market, although the number who can consistently do so is small. The primary attributes of these individuals are that they have superior access to information and/or possess superior analytical ability." (p. 327)

The impetus of this research was the desire to find and learn about farm managers who are superior crop marketers. The scope of the research is a group of over 1000 Kansas farms that are principally engaged in crop production. Because "good" marketing is only one aspect of successful farm management, this research examines a number of management traits or factors that together comprise "good" management. After first discussing the idea of good management, the objective is to a) determine which management traits most clearly distinguish producers, and b) quantify the impact on profitability expected by managers who choose to change their management strategies.

Good Management

What is good management? As used in this research, good management, or economic success, is "persistently achieving greater profits than one's neighbors across years."¹ For agricultural producers, what defines economic success? Does it have to do with obtaining higher yields, lower costs, or higher prices? Is it perhaps related to better use of fixed assets such as land, that is, planting intensity? Or is it related more closely to knowing when to adopt new technologies? On the other hand, might more intrinsic farm factors, less under the control of the current farm manager but perhaps not fully capitalized into asset values, be a more important determinant of profit dif-

ferences among farms? One example is government program payments, which are largely determined by base acreages and program crop yields established in the early 1980s.

The issue facing farm managers is where to focus their management efforts. Mishra, El-Osta, and Johnson examined which management aspects would lead to above-average returns. They found that costs, technology, farm diversification, marketing, and farm ownership all had a significant impact on the success of a farm. However, as a producer, is it easier to lower cost, increase crop yields, or increase planting intensity? Does adopting new technologies more quickly or "picking" good prices have a larger impact on profitability? While increasing costs likely reduces profitability, it should not be a foregone conclusion. After all, increased use of fertilizer or herbicide might increase crop yield, thus revenue or crop price (e.g., by increasing the crop's protein content). Clearly, the farm manager must consider many tradeoffs between costs and income in an effort to maximize profit.

In short, some management goals might be hard to achieve yet have large payoffs—producers must determine the tradeoffs. Zulauf and Irwin asserted that the producers who survive will be the ones with the lowest cost of production. Of course, yields and technology also impact the per-unit cost of production, potentially clouding the issue. One of the objectives of this research is to break apart these different aspects affecting per-unit costs. Therefore, costs, yields, and technology are considered as separate variables impacting profitability. In that regard this work is related to non-parametric studies of management efficiency. Comparing a set of farms to a representative or average farm will yield similar conclusions as comparing the same set of farms to an efficiency locus. Hence, the yield variable is similar to technical efficiency and the cost variable is similar to allocative efficiency.²

¹ Though our focus here is profits, because expected-utility-based success is judged on the basis of risk as well as profit we explicitly consider risk in our analysis. We use the colloquial term *neighbors* to indicate farmers in the same geographical area with comparable farming operations—those who are most likely to be competing for production inputs such as farm land.

² A producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input and if a reduction in any input requires an increase in at least

The efficiency literature shows that reduced efficiency decreases economic profit, and allocative efficiency and scale efficiencies impact economic profit more significantly than technical efficiency (e.g., Chavas and Aliber). Therefore, an important way for less profitable farms to increase economic profits is by decreasing costs (increasing allocative efficiency). Featherstone, Langemeier, and Ismet found that profitability was positively correlated to technical, allocative, and scale efficiency. Rowland et al. reported similar findings.

While efficiency studies are comparable to this research, they typically compare individual farms to the "best" farm in terms of each efficiency measure. The "best" farm may or may not be representative of what all farms are capable of achieving. In addition, efficiency studies offer little to assess the relative ease or cost of changing management strategies. That is, is it easier for a farm to improve allocative or technical efficiency? And which improvement will enhance profits the most? By considering the percentage of farms that are statistically different from average, by each factor, this research should help a farm manager decide where to focus management efforts. That is, knowing whether many or only a few farms have been able to achieve the goal provides useful information to the manager.

This research departs from that typically described in non-parametric studies of management efficiency in that it considers crop marketing, technology adoption, government payments, and the planting intensity of crops as other measures by which producers are distinguished from their neighbors in terms of profitability. In addition, risk is considered an important profit determinant. That is, farmers often have to take on additional risk to obtain more profit.

The history of agricultural production has been one of constant adjustment to new technologies. Over time, producers vary in the degree to which they have adopted a particular

technology. That fact alone surely causes producers to wonder if they are adopting a technology at the optimal rate. Consequently, it could be that farmers differentiate themselves from their neighbors by focusing on (or ignoring) new technologies. Empirical evidence suggests that farmers often adopt parts of the technological package instead of the whole (Leathers and Smale). This suggests that although producers might test a new technology they may not heavily invest in it until it has been "proven." Therefore, economic profit could be a function of technology adoption rate.

Regardless of how farmers adopt a new technology it is an important variable that should be considered in a description of what causes differences in profits among producers. It is likely that some technologies are only feasible for larger farms; therefore, there is some likelihood that size economies exist in production agriculture. Thus farm size could be a reasonable indicator of a broad class of technologies or, more appropriately, their adoption rates. However, farm size may be similar to government payments in that its determination is often exogenous to the current farm manager. Thus care should be taken in interpreting variables such as government payments or farm size as "management" variables.

Conceptual Model and Data

A conceptual model to describe the degree of management superiority is

$$\text{profit} = f(\text{prices, yields, costs, technology adoption, planting intensity, government payments, farm size, and risk}),$$

where all variables are treated as relative to one's neighbors or, more precisely, relative to an appropriate representative (average) farm. For example, the *yields* variable represents the degree to which a producer tends to have higher or lower crop yields than a representative or average farm in the same area with the same crop mix.

It is often difficult to distinguish management ability from mere luck, especially for

one other input or a reduction in at least one output (Koopmans p. 60). *Allocative efficiency* is the extent to which input choices satisfy the marginal equivalencies for cost minimization (Greene p. 90).

farming, where profitability is heavily influenced by weather. Thus it is important to conduct a study of management success from a multi-year standpoint. To that end, this study relies on the 10-year Kansas Management, Analysis, and Research (KMAR) data set, obtained by a yearly survey of farmers in Kansas. The 10-year data set involves financial and production information from approximately 1000 producers who have participated continuously in the farm management program for 10 years (1990–1999). The producers are located in six geographical KMAR regions of Kansas. In this research, the farms within any particular region are considered to be neighbors and are used to construct an appropriate representative farm for each year. The KMAR database information was augmented with data from Kansas Department of Agriculture's *Kansas Farm Facts* and the Kansas Farm Management Association's *The Enterprise Analysis Report 1999*.

Empirical Specification

The model conceptualized above can be empirically specified as

$$(1) \quad \begin{aligned} PROFIT_i = & \beta_0 + \beta_1 COST_i + \beta_2 YIELD_i \\ & + \beta_3 PRICE_i + \beta_4 TECH_i \\ & + \beta_5 PLANT_i + \beta_6 GOVT_i \\ & + \beta_7 SIZE_i + \beta_8 RISK_i + \varepsilon_i, \end{aligned}$$

where $PROFIT_i$ is a measure of long-run profit superiority for farm i ; $COST_i$, $YIELD_i$, $PRICE_i$, $PLANT_i$, and $GOVT_i$ represent the ability of farm i to demonstrate management superiority, relative to its "neighbors," in the stated category; $TECH_i$ represents how much ahead, or behind, a producer is at adopting technology; $SIZE_i$ indicates relative farm size; $RISK_i$ represents relative income variability; and ε_i denotes an error term.³

³ The specific technology considered here is less-tillage. More detail is provided later. For continuity, $GOVT$ is described as a management variable similar to the other variables. As noted, however, differences in government payments among farmers may be due more to prior than to current management. Nonetheless, omitting $GOVT$ would result in biased estimates since it is a relevant variable in determining profit differences among farms.

Profit

Although economic profits are zero in the long run for average producers, superior managers may reap positive profits in the long run. In the short run differences in economic profits among managers are likely even larger. Because farms vary widely in scale of operation, per-acre rather than per-farm profits are used. The measure of profitability is

$$(2) \quad PROFIT_{ij} = \frac{\sum_t \Pi_{ijt}}{T}, \quad \text{where}$$

$$(3) \quad \Pi_{ijt} = NETREV_{ijt} - \overline{NETREV}_{jt}, \quad \text{and}$$

where $NETREV_{ijt}$ is the difference between the total crop income (as given by the KMAR data) and the total crop expense for farm i in region j year t . Total crop expense is the sum of all crop expenses (labor, machinery, seed, fertilizer, marketing, herbicide, and irrigation costs) plus an interest (actual and opportunity) cost and owned and rented land charges. Land values are ascribed to the land every five years by the producer and the KMAR economist. To obtain yearly estimates of the land values underlying annual land costs, a state-wide yearly proportional adjustment from Kansas Agricultural Statistics is used. \overline{NETREV}_{jt} depicts the average net crop income per acre (across all farms in region j in year t —the benchmark for that region that year), and $PROFIT_{ij}$ is the average (over T years, here 10) of profit differenced from the annual benchmarks for farm i in region j .⁴

Independent Variables

Generally, the independent variables are defined as follows; however, technology is defined in the following section. The general form is

$$(4) \quad \%DIFVAR_{ijt} = \left(\frac{V_{ijt}}{EV_{jt}} - 1 \right) \times 100,$$

⁴ Although not needed in the final estimable specification in (1), the location indicator (here, j) is retained throughout the empirical development to aid in exposition.

where V_{ijt} is the observed value of the variables *COST*, *PRICE*, *YIELD*, *PLANT*, *GOVT*, and *SIZE*. EV_{jt} is the expected V_{jt} (that of the representative farm) for region j in year t . $\%DIFVAR_{ijt}$ is the variable that has been “percent-differenced” from the neighbors. V_{ijt} and EV_{jt} for all variables are defined in Appendix A, as is the risk variable.

The across-years persistent variable applicable to the independent variables in equation (1) is

$$(5) \quad VAR_{ij} = \frac{\sum_t \%DIFVAR_{ijt}}{T}$$

where, once again, VAR_{ij} refers to *COST*, *PRICE*, *YIELD*, *PLANT*, *GOVT*, and *SIZE*, and is now the average percent different from the neighbors. The risk variable requires no averaging across time because it is computed as a constant across time.

Technology

As representative of technology in general, a technology that has been especially important for Kansas farmers over the last 10–20 years was considered—substituting chemicals for tillage. A less-tillage index (LT) was established as

$$(6) \quad LT_{ijt} = \frac{herb\$_{ijt}}{herb\$_{ijt} + mach\$_{ijt}}$$

where $herb\$_{ijt}$ is the herbicide expenditures and $mach\$_{ijt}$ is the total crop machinery ownership and operation costs for farm i in region j year t .⁵ Defined this way, if a producer did not use any machinery then LT would equal 1 and if the producer used only machinery and no herbicides the index would equal 0. To get at an average, or expected, *rate of adoption* of this technology, LT was considered to be a linear function of time in a series of j regressions:

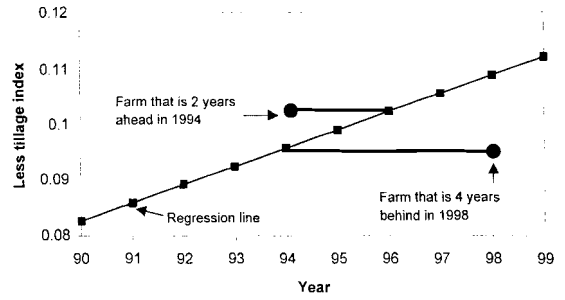


Figure 1. Rate of Less-tillage Adoption, North Central Kansas Example

$$(7) \quad LT_{ijt} = \alpha_j + \beta_j t_t + \epsilon_{ijt}$$

The parameter estimates from these regressions were then used to determine the difference from the expected adoption rate (in years) for each farm (see Figure 1 for an example):

$$(8) \quad TECHI_{ijt} = \frac{LT_{ijt} - \hat{\alpha}_j}{\hat{\beta}_j} - t,$$

where $TECHI_{ijt}$ is the number of years farm i in region j and year t was ahead of (or behind) its neighbors in terms of less-tillage adoption. Finally, the technology variable consistent with that displayed in (2) is

$$(9) \quad TECH_{ij} = \frac{\sum_t TECHI_{ijt}}{T}$$

Results

To examine persistence of management, the mean (across the 10 annual values, 1990–1999) for each management measure for each farm was tested to see if it was statistically different from zero using a two-tailed t -test at the 95-percent confidence level. The means, standard deviations, and percent of farms whose mean management measures were significantly different from zero are noted in Table 1. Acres of main crops (described in more detail in the appendix) is also included to help the reader better understand the farm size and its variability within the data.

Persistence is an important aspect of man-

⁵ A reviewer correctly pointed out that LT_{ijt} likely captures other features in addition to less-tillage, for example crop rotation. We have attempted to improve the accuracy of the less-tillage adoption rate variable by adding planting intensity as a separate variable.

Table 1. Summary Statistics and Percent of Farms with Management Measures that are Significantly Different from Zero, 1020 Kansas Farms, 1990–1999

Variable	Mean	Standard Deviation	% Different ^a
PROFIT (\$/acre)	0.00	72.7	47.4
COST (% different from the expected cost)	0.00	30.0	54.6
YIELD (% different from expected yield)	0.00	14.9	35.0
PRICE (% different from the expected price)	0.00	8.5	24.0
TECH (no. of years ahead of neighbors)	0.00	14.1	56.1
PLANT (% different from the average planting intensity)	0.00	23.4	67.0
GOVT (% different from the average govt)	0.00	88.7	58.3
SIZE (% different from average size)	0.00	78.6	84.8
RISK (% different from average risk)	0.00	67.3	N/A
MCA (main crop acres)	832.30	617.6	N/A

^a Percent of farms whose mean (across 10 years) management measure significantly differs from zero based on a two-tailed *t*-test at the 95-percent confidence level.

agement. To maintain or enhance positive economic profits, a farm must first differentiate itself from its neighbors in the right direction and across time. Among those categories considered most under the control of the current manager, Table 1 shows that over 50 percent of the farms had costs, planting intensity, and technology adoption rates significantly different from zero, and 47 percent had profits significantly different from zero. This suggests that producers can and do “manage” these traits, whereas yields and prices must be less “manageable” or at least less managed.⁶

The Pearson’s correlation matrix associated with equation (1) variables is shown in Table 2. Each of the 1020 observations underlying

Table 2 is an individual farm’s 10-year average of the respective management factor. This table shows that price relationships are among the weakest. The fact that profit and price are not highly correlated is somewhat surprising. However, considering that it might be difficult for farm managers to control the prices they receive it makes sense that profit would be correlated stronger with variables that are more controllable—at least in this “long run” (10-year) setting.

The OLS regression estimates for equation (1) are reported in Table 3. Holding other management measures constant, for each 1 percent higher costs that a farm has than its representative farm, per-acre profits are expected to be \$0.61 lower. All coefficient estimates are highly significant except for price. It is worth noting that this regression indicates

⁶ RISK is not included in the persistence analysis since it is intrinsically an across-time variable.

Table 2. Pearson’s Correlation Coefficients for Selected Variables, 1020 Kansas Farms 1990–1999

Variable	COST	YIELD	PRICE	TECH	PLANT	GOVT	SIZE	RISK
PROFIT	-0.24*	0.23*	0.03	0.31*	0.28*	-0.03	0.41*	0.16*
COST		-0.02	0.01	-0.28*	-0.21*	0.39*	-0.28*	0.38*
YIELD			0.03	0.25*	0.23*	-0.11*	0.28*	-0.02
PRICE				0.07*	0.10*	-0.03	0.12*	-0.01
TECH					0.21*	-0.09*	0.39*	-0.01
PLANT						-0.42*	0.42*	-0.24*
GOVT							-0.14*	0.35*
SIZE								-0.19*

* Significantly different from zero at the 95-percent confidence level.

Table 3. Regression Results, 1020 Kansas Farms, 1990–1999

Variable	Parameter Estimate	Standard Error	P Value	Impact on Profitability from 1 Standard Deviation Change in Management Category (\$/acre)
COST	-0.61*	0.08	0.00	-18.30
YIELD	0.48*	0.14	0.00	7.15
PRICE	-0.12	0.22	0.59	-1.02
TECH	0.41*	0.15	0.01	5.78
PLANT	0.58*	0.10	0.00	13.57
GOVT	0.08*	0.03	0.00	7.10
SIZE	0.25*	0.03	0.00	19.95
RISK	0.35	0.03	0.00	23.56

* Significantly different from zero at the 95-percent confidence level. The model R^2 is 0.32.

that increasing a farm's crop price by 1 percent compared to the representative farm would decrease profit by a statistically insignificant \$0.12 per acre—a surprise given that changes in price essentially go directly to the bottom line.⁷ Likely this is a conditionality issue. Given that price is expected to impact profitability but is not found to, and given that it is not generally correlated with other individual explanatory variables, it must be the case that it is systematically related to some combination of other explanatory variables. Farms that consistently get different prices than their neighbors must have offsetting impacts on profitability from other management traits. This is consistent with the idea that farms getting higher prices than their neighbors must sacrifice something. Farms might trade off price and some combination of other management factors. Such an explanation would be consistent with the zero impact of price on profitability as well as the generally zero correlation

between price and other explanatory variables.⁸

A 1-percent increase in risk (standard deviation in net farm income) will increase profit by \$0.35 per acre. This implies that for increased profits a farmer must increase risk, and some farmers forgo increased profits for decreased risk.

Results in Table 3 are consistent with economies of size for Kansas farms. That is, after

⁸ Examination of multicollinearity was inconclusive at best. The condition index test of Belsley et al. (1980) suggests values greater than 20 indicate a problem. Here the largest condition index was 2.49. The variance decomposition test (Belsley et al.) examines the proportion of variance for an independent variable associated with each characteristic root, with values above 0.5 indicating a possible problem. Here 3 of 64 (8 independent variables, 8 roots) values were greater than 0.5, with one (for the *PRICE* variable) at 0.82, indicating a potential problem. A third "test," suggested by Greene (1993), is that multicollinearity may be a problem if the overall R^2 in the regression is less than the R^2 values associated with regressing each independent variable on all other independent variables. Here the overall R^2 was 0.32, whereas the 8 auxiliary R^2 values ranged from 0.02 to 0.33, which does not seem particularly convincing of a problem. More importantly, the *PRICE* R^2 was only 0.02. A fourth "test" suggests that in the presence of multicollinearity coefficient estimates change substantially for small changes in the data. We re-estimated the model 500 times, each time throwing out a random 10 percent of the data. For each coefficient but *PRICE*, the 500-observation mean was within 0.02 of the estimate reported in Table 3 (*PRICE* was within 0.04). Certainly, it does not appear that disentangling the *PRICE* relationships is particularly straightforward.

⁷ Earlier it was asserted that differences in government program payments are intrinsic rather than managed. In 1998 and 1999, substantial loan deficiency payments within the *GOVT* measure imply that this variable has marketing management implications along with *PRICE*. Nonetheless, results reported here do not substantially differ from the 1997 analysis by Nivens, Kastens, and Dhuyvetter. However, in the 1997 analysis, government payments were not included, but an intercept was. When the 1997 analysis was revisited in a framework compatible with the current one, the results remained robust over time.

accounting for other management measures, the *SIZE* parameter estimate suggests that for each percent a farm is larger than neighboring farms (i.e., the average farm size in the region) that farm is expected to receive an additional \$0.25/acre profit.

The rightmost column of Table 3 shows the impact on profitability associated with a one-standard-deviation change from the mean in each management category. For example, a one-standard-deviation change from the mean for yield management was associated with a \$7.15/acre change in profits. Clearly, being one standard deviation away from the mean for costs and planting intensity was more valuable than being good at attaining high yields or being a forerunner in technology adoption and especially more profitable than being one standard deviation away from the mean, price-wise. Interestingly, being one standard deviation away from the mean of risk has the highest impact on profits, indicating that farmers who want to increase profits should not overlook the possibility that they may need to be willing to take on more risk. Since being one standard deviation away from the mean is assumed to happen with equal likelihood, then it can be asserted that it should be easier to generate higher profits by focusing management on costs, planting intensity, less-tillage adoption, and yields, rather than by focusing on crop price.

Conclusion

This research sought to determine which management traits are most important in determining profitability and in segregating producers by profitability. Because average producers garner zero economic profits in the long-run, producers must differentiate themselves from their neighbors, and in the right direction, in order to be profitable. In this research, 1020 Kansas farms were examined from 1990–1999 using measures that distinguish producers from their neighbors (a representative farm) in terms of production costs, yields, prices received, planting intensity, government payments, rate of technology (less-tillage) adoption, farm size, and risk (income variability).

Over the entire 10-year period, more than 50 percent of the farms were significantly different, either better or worse, than their neighbors in terms of cost management, planting intensity, government payments, rates of less-tillage adoption, and farm size. On the other hand, 47 percent of the farms were able to distinguish themselves from their neighbors in terms of crop profits, and only 35 percent and 24 percent in terms of yields and price, respectively. These results are consistent with yields being more random, or harder to manage, than costs, planting intensity, and technology adoption and price being more random still. In that sense, price appears to be the least manageable factor in this data set. However, in this analysis, prices are not exactly synonymous with crop marketing. Indeed, if government payments were considered a marketing variable, then the conclusion would be that it is possible to distinguish oneself with crop marketing.

In a regression framework, persistently having increased risk, low costs relative to neighboring farms, high yields, greater planting intensity, higher government payments, larger farm size, and persistently being ahead of one's neighbors in less-tillage adoption were each important drivers of relative profitability. However, having persistently higher cash prices than one's neighbors did not significantly impact profitability. Thus, insofar as government payments and farm size may be outside the control of the current farm manager, it appears that it should be easier for producers to enhance profits by focusing on costs, planting intensity, less-tillage adoption, and yields than on price. This is not to say that price received is absolutely unimportant, only that we have not found much evidence indicating that farm managers are generally able to profitably differentiate themselves from other farms when it comes to price.

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Appendix A

Cost

The cost variable in (1) is designed to capture the tendency for a farm to have higher or lower crop input costs than the representative farm. Crop input costs include machinery costs, seed, fertilizer, marketing, herbicide, fuel, rent (actual or opportunity depending on whether land is rented or owned), and labor (paid and unpaid) cost. Crop input costs are intrinsically different for different crops. For example, farms that grow irrigated corn would not be expected to have the same costs as those growing non-irrigated wheat. Thus what is needed is a measure of a representative cost for a given farm's crop mix with an average manager. For that, enterprise budget values from *The Enterprise Analysis Report 1999* were used, along with each farm's crop mix of main crop acres (main crops are irrigated and non-irrigated wheat, corn, grain sorghum, soybeans, and alfalfa). Ultimately, to get at management superiority actual costs must be compared to the representative costs. Relevant actual costs are given by

$$(A1) \text{ CROPCOST}_{ijt} = \text{EXPENSE}_{ijt} \times \left(\frac{\text{MCA}_{ijt}}{\text{TCA}_{ijt}} \right),$$

where CROPCOST_{ijt} is the actual crop cost as-

signed to the main crops for farm i in region j and year t .⁹ It is the ratio of main crop acres (MCA_{ijt}) to total crop acres (TCA_{ijt}) multiplied by the total recorded crop expense for all crops on farm i in region j and year t ($EXPENSE_{ijt}$).

The first step in deriving a representative cost-per-main-crop acre is developing an annual cost ratio to adjust 1999 enterprise costs to provide estimates for the previous years:¹⁰

$$(A2) \quad AVG_{COST}_t = \frac{\sum_i \sum_j CROPCOST_{ijt}}{\sum_i \sum_j MCA_{ijt}},$$

where AVG_{COST}_t is the state average (across all farms and regions in year t) cost-per-main-crop acre, and other variables are as already defined. The next step in deriving a representative cost-per-main-crop acre for each farm-year depends on

$$(A3) \quad MCE_{ijt} = \frac{\sum_k ENTERPRISE_{jk} \times AC_{ikt}}{MCA_{ijt}},$$

where MCE_{ijt} is the representative per-acre main crop expense for farm i in region j in year t in 1999 dollars. $ENTERPRISE_{jk}$ is *The Enterprise Analysis Report 1999* cost data for region j and main crop k .¹¹ AC_{ikt} is the acres planted for farm i in region j to main crop k in year t . The representative cost in 1999 dollars is adjusted to provide estimates for other years using

$$(A4) \quad PREDICTCOST_{ijt} = MCE_{ijt} \times \frac{AVG_{COST}_t}{AVG_{COST}_{99}},$$

where $PREDICTCOST_{ijt}$ is the predicted crop costs for farm i in region j and year t . It is representative of a farm's crop cost (per main crop acre) for an average manager for each year, given the crops actually planted that year.

A cost-per-acre management variable, $COSTPA_{ijt}$, in "percent different from the representative

cost" is defined as (equivalent to equation (5) in the body of the paper)¹²

$$(A5) \quad COSTPA_{ijt} = \left(\frac{CROPCOST_{ijt}}{PREDICTCOST_{ijt}} - 1 \right) \times 100.$$

Finally, to arrive at the cost variable in (1) that defines *persistent* management, the cost variable in (A5) is averaged across years for each farm (equivalent to (6)):

$$(A6) \quad COST_{ij} = \frac{\sum_t COSTPA_{ijt}}{T},$$

where T equals 10 in this research.

For an example, take farm i , in region 1, which has 150 total acres with a total cost of production of \$15,802.50 in 1995. It has 50 acres of non irrigated wheat, 30 acres of irrigated corn, and 20 acres of non-irrigated grain sorghum; the other 50 acres are some "other" crop (i.e., not a main crop). Multiplying the total cost of production by the ratio of total acres to main crop acres (in this case main crops are corn, grain sorghum, and wheat since this producer does not produce soybeans or alfalfa) results in a cost of production for the main crop acres of \$10,535, or \$105.35/acre for the cropcost value in (A1).

Using *The Enterprise Analysis Report 1999* budgets, if farm i planted the same acres in 1999 as in 1995, its total costs would be expected to be \$10,995.70, or \$109.96/acre. Following equation (A4), to derive representative costs for this farm in 1995, the 1999 value is multiplied by the ratio of statewide cost per acre in 1995 to statewide cost per acre in 1999; in this case the ratio is 0.8823. Thus the representative cost per acre for 1995 is \$97.02 ($PREDICTCOST$ in A4). The actual cost per acre observed for farm i in 1995 was \$105.35 (the $CROPCOST$ in A5). Finally, the 1995 costs for

⁹ To focus on farms with a majority of acres in main crops, if MCA_{ijt}/TCA_{ijt} was less than 0.5 for any year the farm was deleted (this criteria removed approximately 6 percent of the total farms).

¹⁰ The annual enterprise report depicts average costs and returns for the KMAR subset reporting enterprise accounts. Insufficient historical enterprise reports caused us to use an adjusted 1999 report for years before 1999.

¹¹ When region enterprise budget data were not available, state enterprise budgets were used.

¹² Management measures defined in this research were designed to conceptually center on zero. Empirically derived proxies are rarely identically zero, although they are close. To make statistical tests around zero appropriate some normalization was inevitably required. In each case, linear as opposed to proportional normalizations were used. For example, before use in (A5), each observation on $PREDICTCOST_{ijt}$ from (A4) was adjusted by adding the appropriate across-farms (by region by year) mean, $(CROPCOST_{jt} - PREDICTCOST_{jt})$. This caused actual cost measures to center on expected cost measures by each region each year. Subsequently, after deriving $COSTPA_{ijt}$ in (A5), that series was differenced with its mean (by region each year).

farm i in region 1 are 8.6 percent greater than the representative costs (the $COSTPA$ in A5).

Yield

Since different crops have intrinsically different yields per acre, comparing aggregated yield data without first normalizing for each crop would be inappropriate. So crop yields were first determined by farm, region, crop, and year:

$$(A7) \quad YLDK_{ijkt} = \frac{PROD_{ijkt}}{AC_{ijkt}},$$

where $YLDK_{ijkt}$ is the yield for crop k for farm i in region j and year t , defined in terms of production ($PROD$) per acre (AC).

Expected farm-level crop yields in Kansas vary widely geographically due to weather. It would be inappropriate to expect all farms in the same KMAR region to have the same yield for a given crop. Thus the expected yield for crop k of farm i in county c of region j in year t , $EYLDK_{icjkt}$, is taken to be the regional average (across farm) annual yield, as adjusted by county where the farm is located:

$$(A8) \quad EYLDK_{icjkt} = \overline{YLDK}_{jkt} \times \frac{CYLD_{cjk}}{\overline{CYLD}_{jkt}},$$

where \overline{YLDK}_{jkt} is the across-farms average yield for crop k in region j year t , $CYLD_{cjk}$ is crop k yield for county c in region j in year t , and \overline{CYLD}_{jkt} is the average county yield across all counties in region j .¹³ An appropriate “different from expected” yield variable is then

$$(A9) \quad \%DIFYLD_{ijkt} = \left(\frac{YLDK_{ijkt}}{EYLDK_{ijkt}} - 1 \right) \times 100.$$

¹³ County yield data ($CYLD$) are from *Kansas Farm Facts*. Farm-level yield data ($YLDK$) are from the KMAR data set. Thus \overline{YLDK}_{jkt} is an average across individual farms and \overline{CYLD}_{jkt} is an average across counties. Both averages are for crop k in farm management region j in year t . County yields were not used directly for expected farm yields because the ratio of average KMAR yields to average county yield varied by crop. That is, KMAR farms were relatively better at attaining high yields than farms sampled by Kansas Agricultural Statistics—for some crops. Using county yields as direct expectations would bias the general yield management variables in equation (A8) in favor of farms that raised more of the crops where KMAR farms were generally better at attaining high yields.

where the county subscript is dropped because it is no longer needed. To get at an overall (across main crops) measure of yield superiority, the yield index in (A9) is weighted by crop acres to become a new yield variable YLD_{ijt} :¹⁴

$$(A10) \quad YLD_{ijt} = \frac{\sum_k \%DIFYLD_{ijk} \times AC_{ijk}}{MCA_{ijt}}.$$

Finally, to arrive at the across-years yield variable depicted in (1) (equivalent to (6)):

$$(A11) \quad YIELD_{it} = \frac{\sum_j YLD_{ijt}}{T}.$$

Price

Like the cost and yield measures in (1), the price measure also depends on actual and representative values. A measure of the representative value of main crop production for farm i in region j in year t for an average manager, $EXPVALUE_{ijt}$, is

$$(A12) \quad EXPVALUE_{ijt} = \frac{\sum_k YLDK_{ijk} \times AC_{ijk} \times PR_{ckt}}{MCA_{ijt}},$$

where PR_{ckt} is a county price for the county where farm i is located, and for crop k in year t .¹⁵ Other variables in (A12) have already been defined. As with costs and yields, a “different from the representative” index is derived as

$$(A13) \quad CROPVAL_{ijt} = \left(\frac{GROSSVALUE_{ijt}}{EXPVALUE_{ijt}} - 1 \right) \times 100,$$

where $CROPVAL_{ijt}$ is the percent that farm i 's (in region j and year t) crop value is above or below the representative value, and $GROSSVALUE_{ijt}$ is derived from KMAR-reported gross value of crop production.¹⁶ Again, to arrive at the across-years price superiority measure in (1) (equivalent to (6)):

¹⁴ The yield management series in (A10), YLD_{ijt} , was subsequently differenced with its mean (by region each year).

¹⁵ Crop prices for crop reporting districts from *Kansas Farm Facts* were adjusted to each county using government farm program loan price differentials reported by the Kansas office of USDA's *Farm Services Agency*.

¹⁶ KMAR-reported total crop value (reported crop sales if crop sold before December 31 each year, else “marked to market” on December 31) is adjusted for

$$(A14) \quad PRICE_{ij} = \frac{\sum_t CROPVAL_{ijt}}{T}$$

Planting Intensity

To obtain the planting intensity variable associated with equation (1) actual and expected planting intensity variables were defined. The actual planting intensity variable is defined by

$$(A15) \quad PL_{ijt} = \frac{\sum_k AC_{ijk}}{TCA_{ijt}}$$

where the numerator is the total acres harvested and the denominator is the total cropland acres. The annual percent difference-in-planting-intensity variable, $PLANTI_{ijt}$ is defined by

$$(A16) \quad PLANTI_{ijt} = \left(\frac{PL_{ijt}}{\overline{PL}_{jt}} - 1 \right) \times 100,$$

where \overline{PL}_{jt} is the average (expected) planting intensity for region j in year t . The across years planting intensity variable associated with equation (1) is (equivalent to (6)):

$$(A17) \quad PLANTI_{ij} = \frac{\sum_t PLANTI_{ijt}}{T}$$

Government Payment

The annual percent difference-in-payments variable, GOV_{ijt} is defined by

$$(A18) \quad GOV_{ijt} = \left(\frac{PAY_{ijt}}{\overline{PAY}_{jt}} - 1 \right) \times 100,$$

where PAY_{ijt} is the government payments received by farm i in region j for year t . \overline{PAY}_{jt} is the average

the proportion a farm's main crops acres are of total crop acres. Following footnote 12, $EXPVALUE$ in (A12) was normalized so that its mean equaled the mean of $GROSSVALUE$ by region by year. $Price_{ij}$ in (A14) was subsequently differenced with its mean (by region by year). The only price variable available ($GROSSVALUE_{ijt}$) is somewhat limiting given it tells nothing about the marketing strategy of the producer and only the total value of crops produced in a given year.

of the government payments in region j for year t (i.e., the benchmark). The across years government payments variable associated with equation (1) is (equivalent to (6)):

$$(A19) \quad GOVT_{ij} = \frac{\sum_t GOV_{ijt}}{T}$$

Size

In this research, what is most relevant is not how absolutely large farm i is, rather how large it is relative to its neighbors. The annual percent difference-in-main-crop-acres variable, $\%DIFMCA_{ijt}$ is defined by

$$(A20) \quad \%DIFMCA_{ijt} = \left(\frac{MCA_{ijt}}{\overline{MCA}_{jt}} - 1 \right) \times 100,$$

where \overline{MCA}_{jt} is the average farm size (in terms of main crop acres) in region j and year t . The across-years farm size variable applicable to equation (1) is (equivalent to (6)):

$$(A21) \quad SIZE_{ij} = \frac{\sum_t \%DIFMCA_{ijt}}{T}$$

Risk

The final variable depicted in (1) is income risk, i.e., the standard deviation in farm income across years. This is defined as

$$(A22) \quad STD_{ij} = \sqrt{\frac{\left(\sum_t \Pi_{ijt} - \overline{\Pi}_{ij} \right)^2}{T - 1}}$$

where Π_{ijt} is defined in equation (4) in the body of the paper and is the profit difference from the annual benchmark farm. $\overline{\Pi}_{ij}$ is the average profit difference for farm i across years. STD_{ij} is the standard deviation of profit for farm i in region j . The across-years risk variable applicable equation (1):

$$(A23) \quad RISK_{ij} = \left(\frac{STD_{ij}}{\overline{STD}_j} - 1 \right) \times 100,$$

where $RISK_{ij}$ is the relative risk of farm i to its neighbors in region j .