THE VALUE, DEGREE, AND CONSISTENCY OF KANSAS CROP FARMS' RELATIVE
CHARACTERISTICS, PRATICES, AND MANAGEMENT PERFORMANCES

By

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Abstract

This research analyzes how crop farms can achieve a higher net income per acre than other operations by farming fundamentally differently than others. There are many factors that are important to the long-term viability of today's crop operations, one of which is how farms profitability compares with other operations. This determines farms' ability to compete for land, outlast other operations through periods of unprofitability, and produce crops at long run equilibrium prices. These factors are relevant in today's crop production industry where farms sit on a segment of the agribusiness supply chain. Therefore, in the interest of providing farms relevant information to manage their operations, this research analyzes how farms can distinguish their performance from other operations by accessing land and equipment resources, production practices for growing crops, and focusing their management efforts differently than other operations.

There are three parts to this analysis. First, farms are broken down by characteristics, practices, and management performances. Then an econometric analysis quantifies the integrated correlation between farms' distinguished characteristics, practices, and management performances and their distinguished net incomes per acre. Next a standard deviation analysis measures the degree to which farms are capable of distinguishing particular characteristics, practices, and management performances from other operations. Lastly, the performance of farms over the 2001 to 2010 time period is used to quantify how feasible it is for farms to maintain particular differences from other operations. Data used in this analysis were provided by the Kansas Farm Management Association, Kansas State University's Department of Agricultural Economics, and Kansas's National Agricultural Statistics Service office.

The results suggest the way farms distinguish their characteristics, practices, and management performances from other operations impacts how their net income compares to other operations. The econometric analysis found that relative farm size, share of rented acres, the value of overhead and equipment investment per acre, government payments, planting intensity, risk, and cost, yield, and price management performances were all significantly related to farms' relative net income. In regards to farms' comparative profitability, this suggests farms should be aware of how their characteristics, practices, and management performances compare to other operations.

The results also suggest the degree to which and the consistency with which farms can distinguish particular characteristics, practices, and management performances are different from one another. Over the 2001 to 2010 period, Kansas farms distinguished their characteristics from other operations to a larger degree than they distinguished their practices and management performances. Farms also maintained differences in their characteristics more consistently than they maintained differences in their practices and management performances. This suggests farms that are actively seeking to distinguish their net income per acre from other operations should be aware of the degree and consistency with which they can maintain particular differences from other operations.

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Chapter 1 - Introduction

Self-Sufficiency to Commercialization

Not so long ago, Kansas agriculture was a self-contained industry where farms executed every stage of their food production process. The typical American family farm worked their fields with draft animals that they raised; they manufactured their own equipment; and processed, stored, and consumed their own food. They sold their surplus to the non-agricultural community to purchase the small number of consumer goods they did not produce themselves. At this time the farm's short and long term viability was solely dependent on itself as it was nominally connected to the larger economy. This is a far cry from today's specialized family farm operation that represents just one segment of the agribusiness supply chain.

The industrial revolution catalyzed the changes that led to the gradual commercialization of the American family farm. As the railroads connected the rural areas to industrial centers, the farm took advantage of the urban market's growing demand for food and the modern goods and services it offered in return. Through the course of the 20th century farms began selling a larger share of their crops to purchase electricity, consumer products, and processed food. With a heightened focus on increasing crop revenues to pay for a modern lifestyle, farms also began adopting new equipment and input technologies manufactured off the farm. This equipment and these inputs were also products of the industrial revolution.

The gas powered tractor, hybrid seeds, fertilizers, and pesticides improved working conditions and helped farms increase revenues per acre. The tractor was easier to repair and operate than draft animals were to raise and command, while a post-World War II study found that for each 1 dollar farms spent on fertilizer and pesticides revenues increased 3 to 5 dollars (Gardner, 2002). As equipment, input supply, and grain processing businesses formed around

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farming operations, the family farm transitioned from executing a wide range of activities to executing a more specialized set of activities.

Today crops farms play a specific role in the production of food, clothing, and industrial products for the larger economy. Below farms, equipment and input companies develop and manufacture trucks, tractors, field implements, crop inputs and other farm supplies. Crop farms use this equipment and these inputs to plant, spray, and harvest crops that are sold to the next level of the supply chain. Livestock, food processing, and industrial companies transform crops into goods demanded by the market place: including protein, calories, clothing, and industrial products. Transportation companies bring the food and other products to the restaurants, grocery stores, department stores and gas stations where they are purchased by the end consumer. While farms serve a critical role in agriculture, they represent just one part of a much larger agribusiness supply chain.

American farmers made several decisions in the 20th Century that resulted in a change in their way of life. Two key decisions were one, the decision to incorporate goods and services produced off the farm into their lifestyle and two, the decision to use equipment and inputs manufactured off the farm into their crop production process. It is not clear which came first, but the order is less relevant than the results. By the end of the 20th century, the 94 million crop acres previously used to feed draft animals in 1910 were used to produce crops demanded by the market place. The time the household previously spent processing their food was now spent helping in farm business tasks. As result, farms work environment improved and farms were able to enjoy the modern goods and services offered by other businesses in the modern economy. Also as a result farms' viability became dependent on their net farm income.

Net Farm Income

When farms began using equipment and inputs manufactured off the farm and consuming goods and services provided by other businesses, their viability became dependent on their net farm income. Just like any other family in today's economy, farms pay their utility bills, grocery bills, and their children's college tuition out of their checking account. The goods and services part of the farms lifestyle is paid for in cash. Net farm income measures what farms have to pay for their lifestyle after covering the cost necessary to keep the farm business operating in the future.

To keep the farm running each year farms must cover the cost of accessing land, owning equipment, and crop inputs. In a simplified form, a farm's net income can be expressed as:

$$Net\ Farm\ Income$$
$$= Crop\ Sales - Crop\ Inputs - Operating\ Expenses - Depreciation$$
$$- Interest - Rent.$$

The cost of crop inputs and operating expenses (i.e., seed, fertilizer, labor, fuel, repairs) are short term expenses that farms incur each year in the process of producing crops. Deprecation accounts for a portion of the cost farms will pay when they replace their equipment in the future, while rent and interest payments reflect the cost of retaining access to long term land assets. These are long term expenses. Paying both short and long term expenses are necessary to keep the farm operating in future.

Net farm income is equal to what farms have left to provide for their lifestyle and grow their farm business after selling their crop and covering the expenses necessary to keep the farm business operating. For these reasons, it is key performance measure in crop production. From another perspective net farm income can be thought of as what farms are paid to execute their segment of the agribusiness supply chain. It is the difference between what farms pay equipment

and input manufactures below them on the supply chain and what farms are paid by the grain off takers above them on the supply chain.

Competition in Today's Crop Production Industry

While farms do compete over customers like many businesses in other industries, competition has always existed in crop production. When the American frontier was being settled, at the time of the Homestead Act, farms competed against one another to claim the best land. Farms needed to claim enough land to sustain their livelihood, i.e., to raise enough crops and livestock to provide for their essential needs. Today farms still compete with one another over land, but they also compete with one another during periods of unprofitability and for the ability to produce crops at long run equilibrium prices.

Land is a key area of competition in crop production agriculture. A farm's total net income is a function of the number of acres they farm and because land is a scarce resource farms compete with other operations to access enough of it to achieve a high enough quality of life. There are about 26 million acres of arable land in Kansas or 550 acres of land for each of the 55,000 Kansas crop farmers. Table 1:1 below shows the number of acres of wheat, soybeans, or corn a farm would have to plant to achieve a $50,000 net income. The acre estimates are based on average dry land yields, state KFMA crop budgets, and 2013 market prices. If corn and soybeans could be planted on every acre of crop ground in Kansas, or if every acre could be irrigated for that matter, then the land base in Kansas would support more than 55,000 farms earning $50,000 in net farm income. However, this is not the case and thus it typically will take considerably more acres than 550 acres to support a full-time farm (i.e., one without off-farm income). Therefore, Kansas farms compete against one another at land auctions and over land available to rent in order to acquire enough ground.

Table 1:1 Dryland Crop Acres Required to Achieve a $50,000 Net Income

Crop*	Acres	Net Income
Wheat	1,739	$50,000
Soybeans	499	$50,000
Corn	262	$50,000

*Assumes farms only plant one crop.

Farms also indirectly compete to outlast other operations through periods of unprofitability. When crop prices rise, farms respond by increasing supply (changing crop mix, farming more intensively, etc.) to meet the increase in demand. The crop supply curve shifts out to meet the demand curve. However when the demand for crops decreases significantly, causing the demand curve to shift downward, crop prices fall due to oversupply. When prices fall below breakeven levels, supply needs to decrease and that often happens by less efficient operations exiting the industry, which then allows for prices to return to profitable levels.

During these periods of unprofitable, farms must stay in business long enough for less efficient operations to exit the industry. Therefore, in a sense farms are indirectly competing with other farms. Farms are trying to stay in business long enough for less efficient firms to exit the industry. At this time, prices will rise and their profitability will continue. While less direct than the competing over land, farms are indirectly competing with one another during periods of unprofitability.

Because crop farmers are price takers, farms are also indirectly competing to produce crops at the same prices as other farms in the industry. The long run equilibrium price of crops is representative of the average cost of producing crops. Over time, periods of unprofitability wean out less profitable operations and the long run price of crops is reflective of the average costs of those farms that remain. Farms must attain a high level efficiency to achieve a positive net income at these prices. If farms cannot produce crops at the same, or lower, prices as other

farms, they will be forced to exit the industry. Therefore farms are indirectly competing to produce crops as profitable as other operations.

In summary there may be people that would like to farm and produce crops for a living, but there is a limited supply of land and limited demand for crops. Therefore, in order to grow crops to make a living, farms must compete with other operations. Farms must out bid other operations for land: to purchase or to rent. Farms must also outlast other operations through periods of unprofitable crop prices. And farms that do survive periods of unprofitability must be able to produce crops as profitable as other operations in order to remain viable. Farms compete with one another directly and indirectly to remain viable operations in the long run.

The Viability of Today's Crop Operations

At one point the viability of American farms was measured by whether they could produce enough food to provide for their own needs. Farms were self-sufficient and therefore their viability was dependent on their own production and affected by weather and other events on the farm. As farms have become specialized commercial businesses, their yield performances are still very important, but within the context of how it relates to their net incomes. A farm's net income is also affected by not only affected by weather, but also by the cost of inputs and the value of crop production.

The cost of equipment, fuel, and fertilizer that farms are dependent on are impacted by the supply and demand for steel, rubber, and petroleum. These core inputs are demanded by many industries and therefore their cost will fluctuate from year to year and over time. Similarly, the prices of crop products are dependent upon domestic inventories, international supply and demand, and currently the Federal government's renewable fuels initiative (i.e., policy).

Regardless of how well farms choose their crop rotation, hit their planting windows, and market their crops, a large portion of the net income is somewhat outside of their control.

While running efficient operations, farms must navigate changes in the cost of inputs and the value of crops. In other words, they must be profitable given the environment of the industry. And while farms might not be able to achieve a positive net income in every year, they must make up for years of poor performance with years of above average performance. Also related to farms' profitability, because farms compete with one another, their net incomes compared to other operations is an important aspect of their viability. As discussed, competition plays a large role in crop production. When farms compete over land, during periods of unprofitability, and the ability to produce crops at the same prices as other operations, their comparative profitability is important.

A farms comparative profitability determines its ability to attain and retain access to land. The cost of purchasing and renting land will oscillate with the profitability of the crop production industry. During periods of high profits, land will be very expensive and during periods of low profits, land will be less expensive. At any point in time farms ability to access land will be dependent on its ability to outbid other operations for it. Farms that are more profitable can afford to make higher debt or lease payments on land, therefore being able to outbid other operations. Therefore, farms' comparative profitability determines their ability to continually access enough land to provide a healthy lifestyle to the farm family.

A farm's comparative profitability also determines its ability to last through periods of unprofitability caused by a decline in crop prices. During periods of unprofitability farms have to rely on the equity they have built up during profitable periods to cash flow their operations and living expenses. During these periods some farms also have to exit the industry in order for the

supply of crops to decline and prices to return to profitable levels. Thus, these periods are essentially a battle of attrition where farms try to outlast other operations with their retained earnings. Farms that have built up higher retained earnings with higher net incomes during periods of profitability will have more equity to draw on and cash flow their operations. More profitable farms put themselves in a better position to outlast other operations through periods of unprofitability and therefore stay viable in the long run.

A farm's comparative profitability also determines its ability to produce crops at long run equilibrium prices. As the crop production industry has gone through periods of unprofitability, less profitable operations have been forced to exit the industry. Today, as will be the case in the future, the long run prices of crops are reflective of prices at which farms in the industry are capable of producing crops. In order to be viable in the long run, a farm must be able to match the level of profitability of other crop operations. If farms cannot match the same level of profitability as other operations they will eventually be forced to exit the industry. Therefore, in order to remain viable in the long run farms must match the profitability of other operations in the industry.

While farms profitability will oscillate with cost of inputs and the value of crops, a key to their long run viability is how their net incomes compare to other operations. A farm's comparative profitability determines how well it can profitable maintain access to land given the general level of profitability in the industry. It also determines how well operations can last through periods of unprofitability and produce crops at long run equilibrium prices. In this regard a farm's net income compared to other operations is an important determinant of the viability of farm operations. And compared to the time when farms were self-sufficient, the comparative profitability of farms operations is new dimension to farms' viability.

Chapter 2 - Thesis

Distinguishing Farms' Financial Performance

As part of running a farm operation, farm managers must service equipment, hit their planting windows, and manage markets risks. Farms must stay current with Uncle Sam, (i.e. they must be aware of income tax and other government program provisions and requirements). In addition to completing tasks, how profitable farms complete these tasks compared to other operations is also relevant to their viability. This measures farms' ability to retain access to land, work through periods of unprofitability, and produce crops at long run equilibrium prices. Therefore, on top of running a commercial business, to remain viable, it is important that farms distinguish their operation's net income from other farms.

There are many ways farms can distinguish their performance from other operations. Farms can repair their own equipment, make superior crop input decisions, or market their crops at higher prices. With superior knowledge and skills farms can keep their cost lower and revenue higher than other operations. Farms can also run their operation more efficiently than others; farming more acres with less equipment, inputs, and workers than other operations. Farms can negotiate better deals on land rentals, equipment purchases, and input purchases; outperforming other operations through superior allocative efficiency. To put it simple, farms can achieve higher net income per acre through superior management. Outside of management quality, farms can also distinguish performance by farming fundamentally differently than other operations.

Farms have opportunities to access core resources and perform core activities differently than other operations. The core resources in crop production include land and equipment. Farms can finance land purchase with banks or rent land from land owners. Farms can own or lease equipment and perform their own field work or farms can hire custom operators to plant, spray,

and harvest their crops. Operations can also distinguish how they farm. The core activities in crop production include managing weed and pest problems, purchasing inputs, executing field work, and marketing their crops. Farms can choose whether to use tradition or no-tillage practices to plant crops and control weeds. Farms can choose how many crops to grow, how much they invest in inputs, and how much focus they put marketing their crops. Land lords and banks, input suppliers, equipment dealers and custom operators, and marketing services give farms opportunities to access resources and to execute activities differently than other operations.

By doing things fundamentally differently than other operations farms can achieve higher net incomes. Taking tillage practices as an example, farms can plant crops and control weeds using traditional tillage practices or no-tillage practices. Comparing the two practices, traditional tillage has higher fuel and labor costs and no-tillage practices have higher chemical costs. Given the cost of fuel, chemicals, and labor, one type of planting practice may control weeds at lower cost than other. Therefore, by choosing the practice that reaches the same end at lower cost, farms can distinguish their performance from operations that choose the less profitable option.

Taking accessing land as another example, whether farms own or rent a majority of their land can indirectly affect their profitability. Farms might make more valuable long run investments in land that they own. For example, they may make improvements that impact productivity (e.g., apply lime, do conservation work) on land that is owned, but choose not to make those same investments on rented land due to the risk of losing the land in the future. Therefore, farms that own more of their land might end up making higher profits over time because their superior management decisions. In other words, owning land puts farms in position to make better decisions. The rippling effects that result from farms doing things fundamentally

differently than other operations might also enable farms to distinguish their performance from other operations.

This thesis will evaluate how farms can distinguish their performance from other operations by distinguishing fundamental aspects of their operations: including how they access land and equipment, their production practices, and their management focus. By distinguishing the fundamentals of their operations, farms can directly and indirectly achieve higher net incomes compared to other operations. On top of these differences, farms can also achieve higher net incomes for superior expertise, technical efficiency, and allocative efficiency. Much like farms comparative profitability is underlying measurement of farms viability, the underlying reasons behind farm comparative profitability will be analyzed in this thesis.

Characteristics, Practices, and Management Focuses

In order to evaluate how farms can fundamentally distinguish their operations from others, a framework must be created to break the farm into fundamental parts. For this analysis, Kansas farms are broken down by their resources, production practices, and management focuses. Farm resources are identified as farm characteristics. Farm production practices are identified as farm practices. Farm focus on cost, yield, and price performance are identified as farm management focuses. Table 2:1 lists the three different categories of attributes and lists the specific variables/factors in each category. The variables paint a complete picture of Kansas crop operations; representing areas that farms can distinguish from other operations.

Table 2:1 Farm Resources, Practices, and Management

Characteristics	Practices	Management Focus
Farm Size	Crop Specialization	Costs
Share of Rented Acres	Tillage Practices	Yields
Workers per Acre	Planting Intensity	Prices
Equipment Investmens per Acre	Seed Costs	
Custom Hire Costs	Risk	
Government Payments		

Farm Characteristics

Generally speaking, the farm resources include land, equipment, and labor. The ways farms access these resources is quantified by their characteristics. Farms can own or rent land and equipment assets. The share of rented land quantifies whether farms tend to own or rent land. Equipment investments per acre and the share of equipment costs attributed to custom hiring expenses quantifies whether farms own, lease, or custom hire their equipment. The number of workers farmer employ is measured by workers per acre and farms' total size is measure by the number of acres they plant. Farm characteristics quantify the overall size of the operation, while also how it accesses land, equipment, and labor resources.

Farm Production Practices

Farm's production practices represent farms' style of crop production. A Herfindahl index is used to measure how diversified farms' crop rotations are; whether they tend to plant a small or wide range of crops. Farms' planted acres divided by their total owned and rented acres measures how intensively they use their crop ground. Farms use of traditional tillage practices versus no-till production is measured by a ratio of herbicide costs to total machine costs. Farms seeds costs per acre are used as a proxy variable that quantifies farms use of Genetically Modified or Non Genetically Modified seeds. How many crops farms grow, how intensively

they use their crop acres, and how they control weeds and pests are quantified under production practices.

Farm Management Focus

Farm management performance represents how much farms focus on each area of management: including production costs, crop yields, and crop prices. It is a well held fact that cost and yield management are paramount to the success of farm operations. However, farms can deviate from the cost minimization and yield maximization industry benchmark depending on their crop input decisions. Farms can choose to invest less than average in inputs and limit their yield upside potential or invest more than average in inputs and increase their yield upside potential. The degree farms choose to deviate in either direction is measured by the degree farms costs and yields are higher or lower than the local average. Similarly, farm focus on marketing is measured by the degree farms sell their crops at higher than average price. This is dependent on the assumption that farms that invest more time and resources in marketing will sell their crops at higher prices. The management variables represent a combination of farms management decisions and their management focus.

Summary - Farm Attributes

Kansas farms operations are broken down by three categories of variables: farm characteristics, production practices, and management performance. Farm characteristics represent how farms access the resources that are needed to grow crops: including land, equipment, and labor. Farm practices represent the particular style in which farms produce crops: including how many crops farms grow, how intensively they use land assets, and their tillage practices. Farm management focuses represent the degree farms focus on particular management

outcomes: including costs, yields, and marketing. From this point forward these variables will be referred to as farm attributes, as they are used to describe each Kansas farm operation.

Introduction into the Analysis

The conceptual framework that centers this analysis is:

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

$Relative\ Net\ Income$ is the difference between an operation's net income per acre and other operations net income per acre.

$Relative\ Characteristics, Practices, and\ Managment\ Performances$ are the differences between an individual farm's attributes and of farms' attributes. Therefore, the thesis will analyze how farms can distinguish their net income per acre from other operations by distinguishing their characteristics, practices, and management focuses from other operations.

There are three parts to this analysis: including the value, degree, and consistency of relative attributes. First the integrated relationships between farms' distinguished attributes and distinguished net incomes are measured with an econometric analysis. This will identify how farms can distinguish their net incomes from other operations by distinguishing their attributes from other operations. Next the degree farms can distinguish each attributes from others will be analyzed with a standard deviation analysis. This will identify how much farms can expect to distinguish different parts of their farms from other operations. Lastly, for each attribute the feasibility of maintaining differences from other operations will be quantified. This will measure how likely farms are to maintain particular differences from other operations over time. In

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summary this analysis will identify how farms can achieve higher net incomes by distinguishing their characteristics, practices, and management operations, and the degree and consistency with which farms can maintain these sources of relative net income.

Objectives

1) Measure the interrelated correlation between relative net farm income per acre and relative farm characteristics, practices, and management performances. An Ordinary Least Squares (OLS) regression measures the integrated correlation between 433 farms' relative net income per acre and their relative characteristics, practices, and management performances. The econometric analysis identifies how farms have distinguished their net income from other operations by distinguishing their underlying characteristics, practices, and management focuses.

2) Quantify the degree to which farms can distinguished their characteristics, practices, and management performances from other local operations. The standard deviation of relative attribute will quantify the degree that farms have been able distinguish their characteristics, practices, and management performances from other operations in each KFMA region. The degree farms have been able to distinguish variables from other operations in the past will suggest the degree farms will be able to distinguish them from other operations in the future.

3) Quantify how feasible it is for farms to consistently distinguish characteristics, practices, and management performance from other local operations. Statistical hypothesis testing will be used to identify whether farms did or did not maintain relative attributes over the 2001 to 2010 period. The number of farms that did and did not maintained relative

attributes in the past will be used to assess how likely farms will be able to maintain them in the future.

Chapter 3 - Literature Review

Evaluating how farm characteristics, farm practices, and management abilities determine a farm's financial success.

In the 1970s, 1980s, 1990s, and 2000s, the value of farm characteristic, farm practices and management abilities has been analyzed in agricultural production businesses. Researchers have used farm management association and agricultural resource management survey data to evaluate the performance of crop, dairy, and beef farms in Tennessee, New York, Illinois, North, Dakota, and Kansas. Farm size, number or age of operators, crop yields or animal production, variable costs, and marketing performance are widely used variables. Using summary statistics, ranking methods, and econometrics, agricultural economists have provided farmers, extension educators, agribusiness managers, and policy makers information about what core factors determine a farm's financial success.

Motivation for the Research

There has always been interest in understanding the farm manager abilities, production practices, and farm characteristics that create successful farm operations. Farm managers take on a broad range of decisions and management responsibilities: including capital and land investment decisions, production practice and technology adoption decisions, input purchasing and product marketing decisions, and hiring and employee managing responsibilities. The range and complexity of the farm management creates questions as to what exactly determines the success of farms and where they should focus their management efforts and their resources. Particular as the technology farms use and the industry environment that farms operate within

changes, research on farms financial performances sought to identify the key drivers of farms' financial performance.

A number of studies have been performed in the interest of maintaining healthy of rural communities. A study of North Dakota farming links the health of entire rural communities and economies to the health and viability of the declining number of midsized farms (Ali & Roger, 1987). For purpose of maintaining North Dakota's rural economy, they researched the characteristics of successful beef, dairy, and crop farms in North Dakota. A study by Gloy, Hyde, and LaDue (2002) identify a similar motivation for their research. In New York, 58% of agricultural income was from the sale of dairy products (USDA statistics) and between 1980 and 2000 the number of farms declined from 19,000 to 7,900 while the average herd size increased from 48 to 87 cows (Gloy, Hyde, & LaDue, 2002). The decreasing number of farms has been a key motivator for research determinants of financial success in production agriculture.

More recent publications by Boehlje also consider how the demands of larger farms are affecting the way equipment dealers, input suppliers, and grain purchases structure their value offerings to farmers (Boehlje & Erickson, Farm Consolidation and Market Intergration: Will Crop Production Follow Livestock's Lead, 2007); (O'Donaghue, MacDonald, Vasavada, & Sullivan, 2011). The literature is directed at farmers, agricultural extension educators, and agricultural policy makers, but there is recognition the research relates to the structure and health of rural communities and the structure of the agricultural industry.

Individual Studies

Three studies on the value of farm characteristics, production practices, and manager abilities in dairy and crop farming are described detail. The literature uses farm management association data, similar farm financial success measures, and equivalent explanatory variables to

quantify farm characteristics, production practices, and management abilities. Each uses a combination of statistical and econometric methods to identify the particular drivers of farm success: including farm size, milk production and yield performance, technology adoption, and marketing performance. Two studies on the production dairy industry are first evaluated and then three papers on crop production are summarized.

Haden and Johnson: Factors which contribute to the Financial Performance of Selected Tennessee Dairies.

Published in the Southern Journal of Agricultural Economics in 1989, this paper analyzes a set of 81 Tennessee dairy farms over a two year period in order to identify the determinants of financial success in the dairy industry. Between 1978 and 1985 there was a 44% decline in the number of dairy farms in Tennessee. This created the question, what makes some dairy farms more successful than others? In this study, cash farm income, net farm income and returns to management were used to measure the success of farms. These financial measures are regressed over farm characteristics, organization types, marketing efficiencies, resource use efficiencies, and financial exposures to identify the determinants of financial success. Haden and Johnson found that cow productivity, milk marketing, and forage cost management are key determinants to dairy farm incomes.

Sample

Two years of data from a select group of 81 Tennessee dairy farms is used in the analysis. The University of Tennessee's Resource Development Program (RDP) collected farm level data from Tennessee dairy farms through a *Farm Business Survey.* Data were collected between 1980 and 1986 in an effort to identify and demonstrate that farms could increase their incomes by making resource use adjustments. Farms were selected if they 'offered opportunities for

demonstrating solutions to major resource problems,' (p107). A somewhat selective process

makes the sample less random, but summary statistics showed that selected dairy operations

shared similar characteristics to other Tennessee dairies. From the sample of farms surveyed in

1985 and 1986, 81 full time dairy farms were selected for the analysis. Farm information was

averaged over the two year time period to mitigate the effects of individual years of unusual

performance. All farms are located within a 56 county region and managers are expected to make

decisions within similar weather conditions and production environments.

Measuring Financial Performance

Farm performance is a subjective term that depends partly on the time period in question. To

circumvent this issue, Haden and Johnson analyze how farm characteristics, production

practices, and management abilities are related to short term and long-term financial

performance. Cash farm income (CFI) and net farm income (NFI) measure an operation's ability

to meet short term financial obligations--including borrowing costs. Returns to operator labor

and management (ROLM) measure the long-term performance of farms. The long term financial

success of the farm is tied to the manager's ability to choose the correct set of farm enterprises

and make efficient management decisions within them. ROLM accounts for the cost of debt,

opportunity cost of family labor, and the opportunity cost of farm capital. The ROLM for farm

(i) is,

$$ROLM = NFI + Cost\ of\ Interest - Opporunity\ Cost\ of\ Family\ Labor$$
$$- Opportunity\ Cost\ of\ Capital$$

This measure is a step closer to a real economic profit, as it accounts for the opportunity costs of

family labor and capital. The opportunity cost of family labor and capital are subjective terms

which could have a significant effect on the sample. The combination of the short and long term measures create a comprehensive analysis of the driving forces of farm success.

Method

The three dependent variables, (CFI, NFI, and ROLM), were regressed on ten explanatory variables. Ordinary Least Squares (OLS) is used because no heteroscedasticity problem was identified. Haden and Johnson separate the explanatory variables into six categories: farmer characteristics, farm organization, marketing efficiency, resource use efficiency, and indicator of financial exposure. Farm explanatory variables for each farm represent an average between the 1985 and 1986 years.

Explanatory Variables

The average age of the operator(s) is the only farmer characteristics variable. The average age of operators is an instrument variable for the experience and knowledge resource of the farmer. No relationship to the dependent variable was hypothesized because Haden and Johnson believed increased experience and knowledge would be mitigated by an aversion to technology adoption. There are two farm organization variables: milks sales as a portion of total farms sales and number of milking cows. Increased cash flow from crop production, such as tobacco for Tennessee dairy farmers, could reduce interest costs, but labor pulled away from forage operations could reduce the dairy operation productivity. Marketing efficiency is represented by the average price received per hundred weight of milk and is expected to be positively related to all three dependent variables. The quality of milk, milk fat, and average blend prices could influence the marketing efficiency--activities and results not caused by a farmer's marketing ability. The resource use efficiency category includes five normalized variables: milk sold per cow, forage production costs per cow, feed purchased per cow, labor cost per cow, and value of

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buildings and equipment per cow. Cow productivity is expected to be positively correlated with

CFI, NFI, and ROLM, while the remaining cost variables are believed to be negatively correlated

with a farm's financial performance. The debt-to-asset ratio is the financial exposure variable

and is expected negatively related to CFI and NFI. Because the cost of interest is not included in

the ROLM variable, no hypothesis is given for the correlation between farm's debt position and

returns to management.

Results

The ten explanatory variables explained 60.41% of the variation in CFI, 55.17% of the

variation in NFI, and 53.37% of the variation in ROLM. Marketing efficiency, cow productivity,

forage costs and financial exposure were significantly related to CFI, NFI, and ROLM. Milk

prices and cow productivity had positive relationships and forage costs a negative relationship to

the three dependent variables. There is a negative relationship between the debt-to-asset ratio and

CFI and NFI and a positive relationship between the debt-to-asset ratio and ROLM.

Conclusions

The significance of cow productivity could identify the value of good herd management

practices. Forage cost's robust significance compared to other cost variables may be explained

by the Tennessee dairy industry's reliance on forage produced on the farm. Feed costs per cow

were negative, but the coefficient was not significant in any of the regression. The negative

relationship between farm leverage of CFI and NFI demonstrates importance of debt in the short

term financial performance of farms. A positive relationship between debt-to-assets and ROLM

suggests that debt costs are a larger determinant of returns than the opportunity cost of capital.

Operator age was significant and negatively related to NFI and ROLM. The results suggest that

older farms may have better cash incomes because of low debt costs, but may not be the most

efficient users of resources. Farm diversification was positively and significantly related to CFI and insignificantly related to NFI and ROLM.

Productivity for cows, milk prices received, and controlling forage costs are primary contributors to dairy farm's incomes and return to operator labor and management. Good herd management practices and milk quality may be drivers of the significance of productivity and marketing ability. Farm diversification may create added cash flow that lowers debt costs, but does not affect the efficiency of resource use. The debt-to-asset ratio insignificance for ROLM and age's significantly negative relationship with ROLM suggest younger farmers with larger debts are retaining lower incomes, but their returns to management are strong.

Sonka, Hornbaker, and Hudson: Income Variability for a Sample of Illinois Cash Grain Producers.

In an early effort to analyze farm performance over an extended period of time, Sonka, Hornbaker, and Hudson examined the managerial performance and income variability of 179 Illinois grain farmers between 1976 and 1983. Changing commodity prices and the risk tied to biological uncertainty in agriculture makes it important to judge the long term performance of farms. The lack of literature evaluating long term farm performance and the farm financial crisis of the 1980s provided added purpose to the research. The characteristics of superior and inferior performing farms are summarized and farm performance variability is analyzed.

Sample

The study uses a sample of farm level data from the Illinois Farm Business Farm Management (FBFM) records. A set of 179 farms with eight years of continuous data, between 1976 and 1983, was selected. All financial data were converted to 1972 dollars. Only farms with data certified usable by the FBFM field staff in all eight years were selected. Farms in the sample

had at least 95% of their land available for crop production, and less than 5% of their cash receipts were from cattle. The average farm in the sample was 598 acres, while farm size ranged from 153 acre to 2,121 acres.

Measuring Farm Performance

Management returns per acre were used to judge farm performance. Management earnings are equal to net farm income after an opportunity cost charge for farm capital and unpaid family and operator labor. This economic profit measurement was chosen over net income per acre, whole farm income, and rate earned on assets.

Method

The characteristics of superior and inferior farms were identified using summary statistics and hypothesis testing. Summary statistics were calculated for three sets of farms: all 179 farms in the sample, the top 44 performing farms, and the bottom 44 performing farms. The average management returns, farm sizes, soil productivity, operating expenses, interest expenses, price received, and yields were computed for each farm for the 8 year time period. The average farm performance, characteristics, and manager abilities were then taken for each sample. Using t-test at the .05 level of significance, statistical hypothesis tests were used to test the significance of differences between samples. This statistical difference between the whole and the samples of superior and inferior farms were tested.

The variability of farm performance was assessed by running logit regressions. The logit model was used to estimate prediction equations for the top and bottom quartile performances of farms. Performance was analyzed for the entire 8 year time period (1976-1983), and for two four year time periods (1976-1979) and (1980-1983). Estimating prediction equations for the two time periods analyzes the variability of farm performance in different commodity market

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environments. For both sets of regressions, dependent variables were equal to (1) and (0) depending on farms average performance. For the top quartile regression, the 44 farms with best average management returns have dependent variables equal to (1). The remaining 132 farms have dependent variables equal to (0). For the bottom quartile regressions, farms with the lowest average returns to farm management have dependent variables equal to one. The remaining farms have dependent variables equal to (0).

Results

Summary statistics and hypothesis testing produced significant results. The returns to management of superior and inferior performing farms were statistically significantly greater and less than the sample mean, respectively. The 44 superior performing farms had significantly lower cash operating expenses and higher corn and soybean yields. The bottom performing farms had significantly smaller crop acres, soil productivity indexes, and corn yields, while operating expenses and interest paid were significantly greater the sample mean. The price difference received by top and bottom performing farms was surprisingly insignificant. The percent of acres planted to corn is also insignificant.

The logit regression results paralleled the results of the summary statistics, but demonstrated their limited effectiveness. Total cash operating costs were negatively related to farm performance, while prices and yields were positively related to farm performance. Corn and soybean prices received were significantly tied to farm success, more so than the summary statistics illustrated. Farm size and interest paid were not significantly related to farm performance. Crop mixes--the proportion of crop acres planted to corn or soybeans--did have a significant effect on management returns for either regression. The soil productivity index is negatively related to superior farm performance. Owned land is charged an opportunity cost. The

negative relationship between soil productivity and farm performance suggests that better quality land is overvalued.

The predication equation for the two shorter time periods showed some interesting results. For the 1976-1979 time period, the significance and signs of variables were consistent with those estimated for the 8 year time period. Prices and yields are positively related to farm performance and operating expenses are negatively related to farm performance. For the 1979-1983 period, prices received were not as significant. Only one of the four price coefficients was significant. This suggested the depressed prices of the 1779-1983 period provided fewer opportunities to receive comparatively higher prices. Similar to the first period, and 8 year time period, operating expenses were negatively related to farm performance while yield performance was positively related to farm performance.

Conclusions

There was significant variability in farm performance across the sample. When farms were ranked by return to management annually over the eight year period, 70% of farms were in the top quartile of performers at least once. And, 70% of farms were also in the bottom quartile of performers at least once. Only 5 farms were in the top fourth of performers in 5 out of the 8 years. Even for superior performing farms, there was significant variability in farm performance. The year to year variability suggested that farm performance needs to be analyzed over a long time window.

The results did not support commonly held theories about the determinants of farm success. Farm size and cropping patterns were not significantly related to farm performance. Despite the problems debt caused to farms in the 1980s, interest rate expenses were not significantly related to farm performance. The changing significance of price performance in

different commodity market environments also suggested that the value of different management abilities may vary significantly with changing business environments.

Nivens, Kastens, and Dhuyvetter: Payoffs to Farm Management: How Important is Crop Marketing?

Nivens, Kastens, and Dhuyvetter analyzed the average performance of over 1,000 Kansas crop farms over a ten year time period in order to quantify the value of different types of management. Farmers and policy makers became more interested in marketing after the Freedom to Farm bill eliminated target price payments. In order to either support or refute farmers' new found interest in marketing, this study analyzed the value of being a good marketer while accounting for the value of cost management, yield management, farm size, share of rent land, planting intensity, technology adoption, and risk preferences. The study worked to identify which management factors distinguished producers' net incomes per acre from the average farm's performance.

Sample

Over a thousand Kansas crop farms from the Kansas Management, Analysis, and Research (KMAR) data set were analyzed over a ten year period. Each farm in the sample had ten years of continuously reported information (1990-1999) that was graded usable by extension economists. These farms also allocated at least 50 percent of labor to crop production and at minimum they planted wheat, milo, soybeans, corn, or alfalfa on 50 percent of their crop acres. Historical KFMA crop production costs and land prices for Kansas regions and historical yield and price information reported by the National Agricultural Statistics Service (NASS) were also used. Historical information was used to calculate expected prices, yields, and costs in order to compare the management performances of farms that planted different types of crops.

Measuring Farm Performance

Net farm incomes equaled crop incomes minus land rents, crop expenses, unpaid family labor costs, and unpaid operator labor and management costs. Crop income was the total accrual income from grain, hay and silage, and cash crops. Accrual crop expenses included cash rent, hired labor, machinery, seed, herbicide, pesticide, fertilizer, marketing, and irrigation costs. Owned land is also charged an opportunity cost in order to evaluate the performance of farms' that rented land and owned land equivalently.

Comparative Performance and Characteristics

Each farm's per acre profits were compared to other farms in their Kansas Farm Management Association (KFFMA) region. Kansas is split six KFMA regions: Northwest, Southwest, North Central, South Central, North East, and South East. The Net Crop Income (NCI) of each farm in the Southwest region was compared to the average crop income of all farms in the Southwest region. The Northeast farms' crop incomes were compared to the average farm per ace incomes in the Northeast region. The same method was used for the four other farm regions. In each year (t), the difference between farm (i)'s per acre net income their region (r)'s average income was calculated. These differences were averaged over the ten year time period to calculate a farm's comparative profit performance in their local region. The calculation is shown below:

$$PROFIT_{irt} = \frac{\sum_{k=1}^{10} \pi_{irt}}{10},$$

where

$$\pi_{irt} = NCI_{irt} - \overline{NCI_{rt}},$$

and

$\overline{NCI_{rt}}$ is region (r)'s average net income in year (t).

Explanatory Variables

   Explanatory variables were calculated similarly to the net income dependent variables.

The explanatory variables are a farm's comparative yield, costs, and price performance. Farm

size, planting intensity, and government payments were also used to explain the variance in farm

performance. For each explanatory variable, the difference between the farm characteristic, cost,

or yield compared to the (k) region average for each year (i) in the ten year time window. The

rudimentary form is:

$$VAR_i = \sum_{t=1}^{10} \frac{\%DIFVAR_{irt}}{10},$$

where

$$\%DIFVAR_{irt} = \left(\frac{(V_{irt} - EV_{irt})}{EV_{irt}}\right) * 100,$$

and

V_{irt} is farm (i)'s explanatory variable in year (t).

A farm (i)'s comparative farm size is equal to the average of each comparative farm size over the

ten year period. The same method was used to calculate each farm's comparative planting

intensities, technology adoption, yields, costs, prices, and government payments.

Method

   A t-test procedure was used to judge the persistency of farm performance over the ten

year time window. Using cost management as an example, a farm's average comparative cost

management abilities were tested to see if they were significantly different than the region

average. The average and variability of each farm's comparative costs over the ten year time

period was used to compute a t-statistic. A two tailed t-test at the 95% confidence level is used.

The percentage of farms that had statistically different comparative costs management abilities

was then calculated. For a given management variable, if a large percentage of farms are

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statistically different than region average, than it suggests that managers have control over this particular type of performance. If a small percentage of farms are statistically different than average, then it suggests that managers do not have control over this particular management performance.

An OLS regression was used to value different types of farm differentiation. Comparative net farm incomes are regressed over eight comparative explanatory variables. The explanatory variables represent farm characteristics (farm size), production practices (planting intensity, technology adoption), technical performance (yields), financial costs (crop production costs) and marketing performance (price, risk, government payments).

Results

The t-test procedure suggested it is easier to persistently control cost and planting intensities than to persistently achieve higher yields and market crop at higher prices. In the sample of 1,020 Kansas crop farms: 47.4% of farms have net farm incomes statistically different than their region averages. For explanatory variables, 54% farms had persistently different than average cost performance and 67% had persistently different planting intensities than average. Only 35% of the sample differentiated themselves in yield performance, while only 24% of the sample differentiated themselves in marketing performance. This aligned with the expectation that it is harder to achieve differentiate yield and marketing performance compared to cost management.

The OLS method identified the value of controlling costs, achieving high yields, and farming more acres. The explanatory variables explained 32% of the variance in comparative net farm incomes. Costs, yields, technology adoption, planting intensity, government payments, and size are all significantly related to net farm incomes. Costs are negatively related to net farm

incomes, while yields, technology, planting, intensity, government payments, and farm size are positively related to superior farm performance. Holding other things constant, a one percent decrease in cost compared to the region mean will increase net farm income by $.61. Increasing the size of a farm by one percent of the region average will increase net farm income per acre by $.25 per acre.

Conclusions

Given the results of the variability and OLS analysis, farms have the best probability of increasing profits by focusing on costs, planting intensity, technology adoption, and yields. The variability analysis suggested that while yields are difficult to manage, superior yield performance has a substantial effect on increasing a farm's net income. Few farms persistently achieved significantly different marketing performances and marketing performance was not found to be expressly related to net crop incomes. This suggests farms do not differentiate themselves from their neighbors by superior marketing ability. Concentrating on cost management and farm growth may be more valuable goals than achieving superior marketing performance.

Measuring Farm Performance

Success is subjective and can change with the financial position, organization, and position of the farm. The short term performance of farms is measured by cash farm income (Haden & Johnson, 1989). The long term performance of the farms is measured by net farm income, operator labor and management income, and operator management income (Gloy, Hyde, & LaDue, 2002). The accrual net farm income measure is preferred over cash income because it eliminates problems posed by the timing of inventory and capital purchases and sales. Unpaid family and operator labor and unpaid operator management prevalent in production agriculture

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make a modified net farm income measure relevant to clearly judging farm performance. For economists, it is also important to include opportunity cost charges so farm success or failure is measured by comparing it to the next best investment or business opportunity.

A strong point of some studies is that they look at multiple types of measures. Many are very much related to one another—net farm income versus returns to operator management—but others incorporate both net farm income and returns to assets. This serves as a check against measurement error and outlier data, while also looking at how different management characteristics, technical and allocative efficiencies, and marketing abilities are related to different types of farm performance. Haden and Johnson look at cash income and return to management and in effect are only judging the end result and not efficiency or the real value of the investment.

Persistency of Performance

The persistency of farm performance has been measured by ranking the performance of farms or comparing the performance farms to bench marks over periods of time (Langemeier, 2010) (Gloy, Hyde, & LaDue, 2002) (Nivens, Kastens, & Dhuyvetter, 2002) (Nivens, Kastens, & Dhuyvetter, 2002).

The ranking procedure is the most widely used method. Each year farms are ranked in different performance groups (i.e. top or bottom 25 percent or top and bottom 10 percent), and the number times farm are ranked in a specific group is recorded. A study of 128 Illinois crop farms found that 18 percent of producers were in the top fourth category in 5 or more years out of 8 years, while 96 percent of producers were ranked in the lowest category at least once (Sonka, Hornbaker, & Hudson, 1989). Small set of farms were able to achieve superior

performance, while the majority of farms did experience at least one year of poor performance. Farm performance was measure by returns to operator management.

In each year of seven year period, a study on 294 New York Dairy farms ranked the return-on-assets of farms into ten categories: from the top performing to the bottom performing. A level a consistent performance was observed as 59.81% of farms were never in the top 10 percent group and 65.42 percent of farms were never in the bottom performing group (Gloy, Hyde, & LaDue, 2002). Compared to the less detailed ranking of the analysis of Illinois, the study of New York dairy farms shows that farms show less variability of performance from year to year.

A study of 1,062 Kansas farms found similar results as the New York dairy study. They were ranked into four categories based on operating profit margins. Over a five year period, 18 percent of farms were in the top performing category in at least three years, while 20 percent of farms were in the bottom performing category for three or more years. A study on sustainable competitive advantage in Kansas crop and cattle production concluded it important to analysis farm performance overall several years because it is difficult for a form to consistently outperform their peers every year (Yeager & Langemeier).

The common finding of all research has been that despite year to year variability, farms do tend to consistently achieve different levels of performance across time (Gloy, Hyde, & LaDue, 2002) (Langemeier, 2010) (Sonka, Hornbaker, & Hudson, 1989) (Yeager & Langemeier).

Time Windows

Long Term Time Windows

Long term time windows provide a more robust analysis of farm performance. Multiple years of farm performance mitigates the effect of a single year of unusual high or low performance (Haden & Johnson, 1989); (Nivens, Kastens, & Dhuyvetter, 2002). The biological uncertainty in the agricultural production environment and changing commodity prices can cause short term farm performances that do not represent the long term viability of a farm (Sonka, Hornbaker, & Hudson, 1989); (Nivens, Kastens, & Dhuyvetter, 2002).

Also, technology, market demands, and other factors cause the agricultural industry that farms are a part of to change over time. As such, it is important identify the consistent determinants of farms success amongst industry changes. Sonka, Hornbaker and Hudson pointed to the 1980s farm financial crisis to demonstrate the importance of the analyzing long term farm performance. They analyzed farm's average performance of over an 8 year time period, 1976 to 1983, that included high and low commodity market prices. There were farms struggling in the 1980s that were believed to be financially successful in the 1970s. Looking at farms in different economic environments produces a more robust analysis long term farm performance.

One study of New York dairy farms (Gloy, Hyde, & LaDue, 2002) looked at farm results over 7 year time periods and another study of Illinois crop farmers analyzed the performance of farms over an 8 year time period (Sonka, Hornbaker, & Hudson, 1989). Nivens, Kastens, and Dhuyvetter draw conclusions by looking at the 10 year average performance and characteristics of about 1,000 Kansas cash crop farms. The analyses of the persistence of farm performance underscores the need to observe farm performance over an extended period of time in order to

measure superior farm performance that results from superior management ability instead of random events.

Explanatory Variables

The studies on dairy and crop farming use variety of explanatory variables to explain the variability of farms' financial performance. These explanatory variables can be split up into six core sets within which more particular measures exist: manager characteristics; farm characteristics; technical efficiency of inputs, labor, and equipment; allocative efficiency of inputs, labor, and equipment; purchase of inputs and marketing of outputs; and financial position. Studies typically use a combination of continuous variables and binary variables that fit into these six categories.

Manager Characteristics

Age of operator, level of education, and other demographic variables that try to approximate the manager(s) experience, knowledge, and skill base provide ambiguous results across studies. Dairy and crop farm studies use dummy variables for education (Mishra & Morehart, Factors Affecting Returns to Labor and Management on U.S. Dairy Farms, 2001) (Mishra, El-Osta, & Johnson, Factors Contributing to Earning Succes of Cash Grain Farmers, 1999) to predict manager's abilities and find mixed results of positive, negative, and insignificant relationships. The use of extension services, as a dummy variable, is also used and shown to be significantly and positively related to farm's financial performance (Mishra & Morehart, Factors Affecting Returns to Labor and Management on U.S. Dairy Farms, 2001) (Mishra, El-Osta, & Johnson, Factors Contributing to Earning Succes of Cash Grain Farmers, 1999).

Farm Characteristics

A few farm characteristics, particularly farm size, are included to test their effect on net crop incomes. Farm size is a key variable that is significant in all but one study. The size of dairy farm is measured by the number of milking cows (Haden & Johnson, 1989) (Gloy, Hyde, & LaDue, 2002), while total crop acres (Sonka, Hornbaker, & Hudson, 1989), main crop acres (Nivens, Kastens, & Dhuyvetter, 2002), and total assets (Ali & Roger, 1987) are used to represent the size of crop farming operations.

The specialization of an operation has been found to be positively or negatively related to farms' financial performance. The proportion of milk sales to total farm sales (Haden & Johnson, 1989), a diversification index (Mishra & Morehart, Factors Affecting Returns to Labor and Management on U.S. Dairy Farms, 2001), and the percent of acres devoted to corn or diverted from production (Sonka, Hornbaker, & Hudson, 1989) (Mishra, El-Osta, & Johnson, Factors Contributing to Earning Succes of Cash Grain Farmers, 1999) represent the effect that diversification has on the operation from which negative, positive, and insignificant relationships have been recorded.

Long term investments and utilization of assets have been found to have a significant effect on financial performance. Buildings and equipment per cow (Haden & Johnson, 1989), value of machinery per acre, (Mishra, El-Osta, & Johnson, Factors Contributing to Earning Succes of Cash Grain Farmers, 1999), and machinery costs per acre (Ali & Roger, 1987) were all found to be negatively related to net farm or operator incomes.

The relationship between the share of crop acres rented and farm financial performance has also been analyzed. The share of crop acres rented is found insignificant in the dairy industry (Mishra & Morehart, Factors Affecting Returns to Labor and Management on U.S. Dairy Farms,

2001) and significant in the crop industry (Nivens, Kastens, & Dhuyvetter, 2002) (Mishra, El-Osta, & Johnson, Factors Contributing to Earning Succes of Cash Grain Farmers, 1999).

Financial Position

The financial leverage of farms was found to be both negatively and positively related to net farm incomes. The debt-to-asset ratio (Haden & Johnson, 1989) (Gloy, Hyde, & LaDue, 2002) and proportion of long-term assets to short-term assets (Gloy, Hyde, & LaDue, 2002) are found to be negatively and positively related to farm success.

Technical Efficiency

Superior farm performance is related to doing more work with fewer workers. The relationship between farm financial success and the number of operators (Gloy, Hyde, & LaDue, 2002) and tillable acres per worker (Ali & Roger, 1987) has been analyzed. The number of operators in the dairy industry study was insignificant, but the Ali and Johnson study found that tillable acres per worker were positively, and statistically significantly, related to net farm income.

Allocative Efficiencies

Cost efficiencies are an important part of the financial performance of dairy and crop farms. In their study of New York dairy farms, Gloy, Hyde, and LaDue found the average wage rate was significantly correlated with the farm's financial performance while Hade and Johnson found that labor cost per cow was insignificantly related to net farm income. Forage costs and feed purchased per cow were found to be negatively related to dairy farm performance (Haden & Johnson, 1989). In crop farming the total cash operating expenses (Sonka, Hornbaker, & Hudson, 1989), ratio of cash expenses to value of production (Mishra, El-Osta, & Johnson, Factors Contributing to Earning Succes of Cash Grain Farmers, 1999), and farm crop costs

compared to neighboring farms' crop costs (Nivens, Kastens, & Dhuyvetter, 2002) were negatively related to farm profits.

Marketing

The majority of studies found that superior marketing is positively related to net farm income. The price received for milk (Haden & Johnson, 1989), price for corn and soybeans (Sonka, Hornbaker, & Hudson, 1989) (Ali & Roger, 1987) were significantly and positively correlated with the farm's financial success. The value of marketing was found to be insignificantly related to net farm incomes in the analysis of Kansas crop farms (Nivens, Kastens, & Dhuyvetter, 2002). In their study of Illinois crop farms, Sonka, Hornbaker, and Hudson also found marketing was more signficant during periods of volatile commodity markets.

Technology

Mishra, El-Osta, and Johnson and Nivens, Kastens, and Dhuyvetter found that technology adoption, after it has been proven, is positively related to the farm's financial performance. Gloy, Hyde, and LaDue found that milking parlors and different types of paper and computer accounting methods were positively related to net farm incomes.

Creative Variables

A set of more creative variables have also been used to quantify farm characteristics and farm practices in some studies. Nivens, Kastens, and Dhuyvetter calculate the percentage of field costs that are tied to herbicides in order to measure farmer's utilization of no-till technology. In the evaluation of the success of dairy farms, Gloy, Hyde, and LaDue include the number of operators on the farm—assuming that more operators will improve farm performance. They also calculate the average age difference between oldest and youngest farm manager. Different aged

people will likely have different culminations of experiences, opinions on technology adoption, and goals for the business, and therefore a large age gap may cause management conflicts and a decrease in ROA.

Explaining Variance in Farm Performance

The integration of many farm characteristics, farm practices, and management abilities make it necessary to account for a large set of factors when evaluating the determinants of farm performance. Econometric analysis has been a key tool in identifying core attributes that are correlated with superior farm performance.

Researchers have been generally ineffective at explaining the variance in farm performance. Analyzing the performance of 81 dairy farms in ten county region of Tennessee, Haden and Johnson record a 0.60 r-squared. Mishra and Morehart's results from a national cross sectional data set of 596 dairy farms only explained 30% of the variance in farm performance. Gloy, Hyde, and LaDue had similarly low r-squared score of .5442, and an analysis of cash crop production in Kansas by Nivens, Kastens and Dhuyvetter yielded an r-squared of 0.32. The inability of these models to explain the majority of the variance suggests that larger picture, structural analysis of farm performance is partially effective. This may be the result of not effectively measuring the management abilities and the uncontrollable volatility in production environments and commodity markets affect farms' financial success.

Chapter 4 - Relative Net Income, Characteristics, Practices, and Management Performances

The purpose of this thesis is to identify and analyze how Kansas farms can distinguish their net income from other operations by distinguishing their characteristics, practices, and management performances from other operations. Farms have different options to access land and equipment, their production practice alternatives, and where to focus their management efforts. And, by fundamentally distinguishing their operations from others, farms may be able to realize higher net income than other operations. To this end, farms' characteristics, practices, and management focuses will be analyzed in the context of how they are different from other operations. In other words, the focus is not on a farm's particular size, diversification, and focus on cost management, but rather on the difference between their particular attributes and the attributes of other local operations.

There are three main parts to this analysis: including the Value, Degree, and Consistency of relative attributes. However, before the Value, Degree, and Consistency of local differences are analyzed it is important to have an underlying understanding of the variables used in each section. The variables are relative characteristics, relative practices, and relative management performances and relative net income and they are the foundation of all the analyses.

Relative Net Income, Characteristics, Practices, and Management Performances

Relative attributes and net incomes are calculated locally. Kansas is split into six Kansas Farm Management (KFMA) regions: Northeast, Southeast, North Central, South Central, Northwest, and Southwest. In each of these regions climates, soil systems, agricultural economies, and nonagricultural economies are similar. Relative attributes are equal to the

differences between individual farms and the average operation in their KFMA region. Therefore, a farm's relative characteristics, practices, and management performances, and net incomes measure how they distinguish their attributes and performances from operations that grow crops in similar production environments and agricultural economies.

Relative Net Farm Income

Relative net crop income is equal to the dollar per acre difference between a farm's net crop income and the average net crop income in their KFMA region. The calculation is specified as follows:

$$(4) \quad NFI_{it} = nfi_{irt} - \overline{nfi_{rt}} \,,$$

where nfi_{irt} is farm i's observed net crop income per acre and $\overline{nfi_{rt}}$ is the across-farm average observed net crop income per acre in their KFMA region. The units of relative net income per acre are \$/acre so that the net farm income of difference size operations can be compared on equivalent terms.

A farm's relative net income per acre is representative of how profitable they produced crops compared to other farm producing crops in similar climate, soil types, and agricultural economies. Farms in each KFMA region grow crops in similar soil types, they have access to input through the same input suppliers, and have access to similar grain markets. The average, $\overline{nfi_{rt}}$, represents how profitable farms were in year t given the general weather events and the particular local crop basis they faced in the market. Put another way, farms' relative net income is equal to how farm distinguished their net farm income from the average net income of farms that grew crops in similar production and economic circumstances.

The net farm income is adjusted so that the performances of all farms are measured on equivalent economic terms. On the income side, for livestock operations an income is estimated for grain fed to livestock. Therefore, livestock operations are credited for crops they fed in their livestock enterprises. On the cost side, a local market rent is charged to all owned acres and all operators are charged labor and management cost of $50,000. Farms that own and rent land are charged the market cost to access land. All farms are charged a market cost for the operator management and labor. The detailed calculation of net farm income can be found in **Appendix A**.

Characteristics and Practices

Farms' relative characteristics and practices are equal to the normalized difference between their characteristic or practice and the average characteristic or practice in their KFMA region. The calculation is specified as follows:

(1) $\quad Relative\ Attribute_{it} = \frac{attribute_{irt} - \overline{attribute_{rt}}}{\overline{attribute_{rt}}}$,

where $attribute_{irt}$ is the observed value of farm *i*'s *SIZE*, *SHARE OF RENTED LAND*, *WORKERS PER ACRE*, *EQUIPMENT INVESTMENT PER ACRE*, *CUSTOM OPERATORS SHARE OF EUIPMENT COSTS*, *GOVERNEMENT PAYMENTS PER ACRE*, *CROP SPECIALIZATION*, and *PLATING INTENSITY* and $\overline{attribute_{rt}}$ is the average characteristics or practice observed in the farm's KFMA region in year *t*. The difference between each farm's characteristic or practice is normalized by the average in their KFMA region and is calculated for each year of a ten-year time period. The detailed calculation of each relative characteristic and practice can be found in the appendix.

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Relative characteristics and practices quantify how farms access resource and produce crops differently than the average operation in the particular climates, resource systems, and agricultural economy. The average characteristics and practices, $\overline{attribute_{rt}}$, in each KFMA region r is representative of the farms in the region. Each KFMA region receives similar amounts of rainfall annually, grows crops in similar soil systems, purchase equipment and inputs in similar markets, and sell crops to similar buyers. The average farm size, share rent acres, crop specialization, and planting intensity represents a summary of how large farms are, what share of acres they rent, how many crops they plant, and how intensively they use their acres within a particular production environment and agricultural economy. Therefore, relative characteristics and practices measure how individual farm's characteristics and practices differ from the average farm that grows crops in similar circumstances.

Relative Management Performances

Relative management abilities are equal to the difference between farm's management performance and average normalized performance of farms in their KFMA region. The calculation is specified as follows:

(2) $Management\ Performance_{irt} = \frac{Performance_{irt} - Expected\ Performance_{irt}}{Expected\ Performance_{irt}}$

and

(3) $Relative\ Management\ Perf_{irt} = Management\ Perf_{irt} - \overline{Management\ Perf_{rt}}$

where $Management\ Performance_{irt}$ is farm i's observed *COSTS*, *YIELDS*, or *PRICES* and $Expected\ Performance_{irt}$ is a farm's expected *COSTS*, *YIELDS*, or *PRICES*, respectively. The difference between each farm's $Performance_{irt}$ is normalized by their

$Expected\ Performance_{irt}$. The $Relative\ Performance_{irt}$ of each farm i is equal to the difference between their normalized performance and the average normalized performance of farms in their KFMA region r. The detailed calculation of each management variable can be found in the appendix.

The calculation of relative management performances compensates for the different crops that each farm grows. Values of farms' costs, yields, and prices, $Performance_{irt}$, are compared to their expected costs, yields, and prices, $Expected\ Performance_{irt}$. Each farm's expected costs are predicted using *Kansas Management Guides* for irrigated and non-irrigated crops in the NE, SE, NC, SC, and West KFMA regions. Expected yields and prices are equal to historical Kansas National Agricultural Statistics Services (NASS) county average prices and yields. Farms' expected costs, yields, and prices are based on local averages. Therefore, similar to relative characteristics and practices, a farm's relative management performances, $Relative\ Managment\ Performance_{irt}$, measure the degree farms cost, yields, and prices deviate from average costs, yields, and prices of farms that grow and sell crop in similar circumstances.

The Use of Relative Attributes

Relative attributes are used for the Value, Degree, and Consistency methodologies of this thesis. In each analysis they serve a different purpose or are used in a different mathematical process. However, in each section they are used to quantify how farms are different from the average farm in their KFMA region. This calculation for each farm's relative net income and attributes, the difference from a farm and the local average, forms the foundation of the analysis of how farms can distinguish their operations net incomes per acre from other operations.

Value of Relative Attributes

The integrated correlation between local relative attributes and relative net incomes from all KFMA regions are used to assess how farms can achieve higher than average net income by distinguishing their attributes from the average farm in the KFMA region. The variability of relative net incomes and relative attributes will be used to quantify the value of farms distinguishing their attributes from the average operation in their KFMA region.

In this analysis relative net incomes and relative attributes are averaged over the ten-year time period. Then the average net incomes of 433 crop operations in the KFMA regions are regressed over their average relative attributes. An OLS regression model is employed to quantify the impact having different attributes than the local average has on relative net income.

Degree of Relative Attributes

The variability of each relative attribute, as measured by its standard deviation, is used to assess the degree that farms can and cannot expect to distinguish their attributes from the local average. The larger (smaller) a relative attribute's standard deviation, the more (less) farms have distinguished their particular attribute from the local average. In other words the spread of operation's attributes within KFMA regions provides evidence of the degree farms can expect to distinguish their attributes from the local average.

Like in the Value analysis, the relative attributes of farms are average over the ten-year time period. The standard deviation of all farms average relative characteristics, practices, and management performance are calculated. The standard deviation of relative attributes quantifies the degree that farms can distinguish their attributes from the local average.

Consistency of Relative Attributes

The consistency of each farm's relative attributes over the 2001 to 2010 period is used to determine if individual farms maintained their relative attributes. In each year of the 2001 to 2010 time period, each relative attribute is calculated for each farm. The consistency of the numerical value of each farm's relative attribute can be used to determine if farms maintained their relative attribute over the 2001 to 2010 period. From this, the share of all farms that do and do not maintain their relative attributes is used to quantify how feasible it is for farms to maintain differences from the local average in the same direction of over time.

For this section, statistical hypothesis testing is performed on relative attributes. Farms average relative attribute and their standard deviation are used to determine if farms did or did not maintain the difference from the local average in the same direction over time. In this section both farms ten-year average relative attribute and their standard deviation over the ten-year period are used.

Conclusion

Everything in this research is about a farm's relative net income and their relative characteristics, practices, and management abilities. First the integrated correlation between farm relative net income per acre and relative attributes is assessed. This identifies how farms can distinguish their net incomes from the average by distinguishing their attributes from the average. Second, the degree farms have achieved relative attributes is measured. This identifies the degree farms can distinguish each attribute and therefore the degree farms benefit from the $/acre value of being different from the local average for each attribute. Third, the consistency shows how feasible it is for farms to continuously distinguish their attributes from the average and therefore how feasible it is to maintain each source of relative net income. Each part of the

analysis is based on and connected to the relative net income and relative attribute variables.

These variables are the foundation of the analysis.

Chapter 5 - Econometric Analysis of Relative Farm Characteristics, Farm Practices, and Management Focus

Econometrics is commonly used to estimate and quantify economic relationships, confront economic theory with facts, and forecast the behavior of economic variables. Mathematic, statistic, and probability theory are used to measure the affect that several independent variables have on a dependent variable. For this analysis, econometrics is used to measure how the local differences in farms' characteristics, farming practices, and management focus affect the local difference in their net incomes per acre.

The 10 year average relative net incomes of 433 Kansas crop farms will be regressed over their 10 year average relative attributes over the same period using the Ordinary Least Squares (OLS) regression model. Unique compared to previous studies of farms' performance, difference in farms attributes and net incomes are calculated locally before being put into one regression. This tries to account for different soil quality, climates, and agricultural economies that exist in different areas of Kansas.

Therefore the model will measure how the local differences in net incomes per acre that is explained by the variability of their local difference in characteristics, practices, and management focuses. The significance and value of individual coefficient estimates will identify the affect that individual attributes have on relative net income per acre, after accounting for other significance factors. To properly execute the evaluation of relative attributes and relative farm performance, the variables are measured over a 10 year period, while problems of autocorrelation and heteroscedasticity must be identified and worked around.

Conceptual Framework

The relative attributes affect farms relative net income directly and indirectly through differences in farm income statements. The conceptual framework for the econometric analysis is:

$$Net\ Income\ per\ Acre_i =\ Function\ (Relative\ Characteristics_i,$$

$$Relative\ Practices_i,$$

$$Relative\ Management\ Performances_i)\ ,$$

where relative net income is the differences between farms' net income and the local average and relative attributes represent the difference in farms' attributes and the local average.

Relative attributes can affect farms relative net income per acre directly. As an example farms' relative no-tillage variable represents whether farms control weeds with tradition tillage practices or whether farms used chemicals to control weeds. Concerning farms income statement, it determines whether farms pay higher fuel bills or higher chemical bills to control weeds. Depending on whether is less costly to pay for more fuel or more chemical, farms will have higher or lower expenses to control weeds and therefore a higher lower net income per acre. Therefore, whatever method controls weeds a lower cost, farm's will have a higher or lower net income per acre than average. Similar circumstances exist for other relative characteristics, practices, and management performances.

Farms' relative attributes can also affect farms relative net income per acre indirectly. The different ways farms access land, equipment, practice farming, and focus their management can have rippling affects through the business. As an example, farms that own their land instead of renting it may make more valuable long run investments (e.g., apply lime, do conservation work) on their land, while farms that rent land choose not to make them due to the risk of losing the land in the future. Because farms with long term control of their land make more valuable

investment decisions, farms that rent more land might make higher net incomes per acre than operations that rent more land. Relative attributes represent the differences in rippling effects that may explain the difference in farms' relative net income per acre.

Relative attributes can affect farm's relative net income per acre over time directly and indirectly. Relative attributes represent the underlying differences between crop operations costs and revenues. They also represent the different positions farms choose to operate from. Both the different expenses farms have to access land, equipment, and executive field work and the different positions they make decisions from may explain the differences in their net incomes per acre. The regression analysis will measure whether differences in relative attributes (i.e. how farms access land and equipment, farm their crops, and focus their management) affect the differences in farms net incomes per acre.

Local Differences

The relative net income and relative attributes of Kansas farms from six KFMA regions are put into the same regression. Therefore, the model assumes the effect of the percent difference between attributes and the average attribute in the region has the same effect on relative net income per acre across KFMA regions.

Relative attributes and relative net incomes per acre are measured locally:

$$Relative\ Attribute = \frac{Attribute - \overline{Attribute_{local}}}{Attribute_{local}},$$

$$Relative\ Net\ Income = Net\ Income - \overline{Net\ Income_{local}},$$

where $\overline{Attribute_{local}}$ and $\overline{Net\ Income_{local}}$ are the average attribute and average net income per acre in each KFMA region, respectively.

Regression analysis measures how the differences between an individual farm's attributes and the local averages determine the difference between their net income per acre and the local average. The focus is not the $/acre value of being a particular size, planting intensity, or input cost per acre for all farms. Instead, the focus is how farms have distinguished their net income per acre from the local average net income as a result of having different characteristics, practices, and management focuses than the local average. Everything is analyzed in the context of how farms distinguish their performance from the local average.

Ten-Year Period

The OLS regression uses the variability of the dependent variable and the variability of the independent variables to estimate the isolated affects each independent variable have on the dependent variable. In order for the analysis to work, both the relative net incomes of farms and the relative attributes of farms must be measured accurately. To work around the random weather, pest, and market events that affect farms performance, a snap shot of farms' relative net income per acre and relative attributes is taken over a ten year period.

Farms' relative net income per acre and relative characteristics, practices, and management performances are calculated in each year of the 2001 to 2010 period. The average is taken of the dependent variable and the explanatory variable for each farm *i* as such:

$$\overline{Relative\ Net\ Income_i} = \frac{\sum_{t=1}^{10} Relative\ Net\ Income_{it}}{10},$$

$$\overline{Relative\ Characteristic_i} = \frac{\sum_{t=1}^{10} Relative\ Characteristic_{it}}{10},$$

$$\overline{Relative\ Practice_i} = \frac{\sum_{t=1}^{10} Relative\ Practice_{it}}{10},$$

$$\overline{Management\ Performance_i} = \frac{\sum_{t=1}^{10} Relative\ Management\ Performance_{it}}{10},$$

where $\overline{Relative\ Net\ Income_i}$ is the average difference between farm i's net income per acre and the local average over the ten year period. The same average is calculated for every relative characteristic, practices, and management performance for each farm i.

The 10 year period is an effective way to measure farms' relative net income performance. In a particular year, uncontrollable weather events and changes in commodity market prices can cause farm performance to deviate from its normal relative performance. In a study of 128 Illinois crop farms over 8 years, 18 percent of farms were in the top 25 percent group of performing farms in 5 out of 8 years, while 96 percent of farms were in the bottom 25 percent of performing farms at least once (Sonka, Hornbaker, & Hudson, 1989). In other words in more profitable farms will be less profitable than other farms in any given years for reasons outside of their control. Measuring farms performance over an extended period mitigates the effect of a single year of unusual high or low performance (Haden & Johnson, 1989); (Nivens, Kastens, & Dhuyvetter, 2002). Farms' 10 year average net income should reflect the true performance of the farming operation, and its difference from the local average whether it tends to achieve a higher or lower than average net income per acre.

The 10 year period is also an effective way to measure farms' relative cost, yield, and price management focuses. Relative management focuses are quantified by the farm's relative management performances. If farms have higher yields than average they are assumed to invest in more inputs and strive for higher yield goals. If farms sell their crops at higher prices they are assumed to invest more time and resource into marketing crops. However, in any given year farms, relative management performances may be affected by uncontrollable weather, pest, or market events. In these years the relative performance of farms will not reflect their relative

management focus. Taking a farm's relative management performance over the 10 year period

mitigates these outliers years. Farms' 10 year average performance is expected to accurately

measure farms' relative management performances and therefore their relative management

focuses.

Farms' 10 year average relative net incomes per acre and 10 year average relative

attributes are inputted into the OLS regression. The 10 year block mitigates the problems posed

by uncontrollable weather, pests, and market events in measuring farms relative net income and

relative management performances. It is not necessary to measure relative characteristics over

ten year period, but out of necessity to measure farms' relative net income and relative

management performances, this ends up being the case.

Econometrics

The integrated correlation between local relative attributes and relative net incomes from

all KFMA regions are used to assess how differences from local average attributes results in

differences from local average net incomes. The relative net incomes of 433 Kansas crop farms

from six KFMA regions are regressed over their corresponding relative characteristics, practices,

and management performances. The empirical model is:

$Net\ Income\ per\ Acre_i$

$$= \beta_0 + \beta_1 SIZE_i + \beta_2 WORKER_i + \beta_3 INVESTMENT_i + \beta_4 GOVERNMENT_i$$

$$+ \beta_5 RENT_i + \beta_6 SPECIALIZATION_i + \beta_7 PLANT_i + \beta_8 TILLAGE_i$$

$$+ \beta_9 CUSTOM_i + \beta_{10} RISK_i + \beta_{11} SEED\ COST_i + \beta_{12} TOTAL\ COST_i$$

$$+ \beta_{13} YIELD_i + \beta_{14} PRICE_i + e_i.$$

The OLSR regression estimates a $\widehat{\beta_k}$ for each relative attribute k, which is equal to correlation

between the relative attribute and relative net income per acre holding all other relative attributes

constant. The units of relative net income per acre are in \$/acre and the units of the relative

attributes are in percentages. Therefore, the $\widehat{\beta_k}$ coefficient is equal to the \$/acre effect of a one

percent change in farms relative attribute k.

The Ordinary Least Squares (OLS) Regression

The OLS regression estimates the model's coefficients by solving a mathematical

problem. The regression solves for the coefficients that minimize the sum of square errors,

defined as the following:

$$Sum\ of\ Square\ Errors = \left(\sum_{i=1}^{n} \hat{u}_i^2\right),$$

$$\sum_{i=1}^{n} \hat{u}_i^2 = \sum_{i=1}^{n} (Y_i - \widehat{Y}_i)^2,$$

$$Y_i = Relative\ Net\ Income_i,$$

$$\widehat{Y}_i = \widehat{\beta_0} + \widehat{\beta_1}SIZE_i + \widehat{\beta_2}WORKER_i + \widehat{\beta_3}INVESTMENT_i + \widehat{\beta_4}GOVERNMENT_i + \widehat{\beta_5}RENT_i$$

$$+ \widehat{\beta_6}SPECIALIZATION_i + \widehat{\beta_7}PLANT_i + \widehat{\beta_8}TILLAGE_i + \widehat{\beta_9}CUSTOM_i$$

$$+ \widehat{\beta_{10}}RISK_i + \widehat{\beta_{11}}SEED\ COST_i + \widehat{\beta_{12}}TOTAL\ COST_i + \widehat{\beta_{13}}YIELD_i$$

$$+ \widehat{\beta_{14}}PRICE_i.$$

The sum of square errors measures the variance in farm's relative net incomes that the

explanatory variables do not explain. The Y_i is farm i's observed relative net income per acre and

$\widehat{Y}_i$ is farm i's estimated relative net income per acre given the model's estimated coefficients $\widehat{\beta_1}$

through $\widehat{\beta_k}$.

The OLS regression solves for the set of coefficients that minimize the models error in predicting farm's relative net income per acre. By finding the coefficients that best fit the sample, the coefficients measure how relative attributes determine farms relative net income per acre. This is a way to determine the affect relative attributes have on relative net income per acre using available production level information about farms' relative attributes and their financial performance. However, in order for the error minimizing process to work a few statistical assumptions must hold.

The assumptions relate to the relationship between explanatory variables and between explanatory variables and error terms. The assumptions include:

1) $\rho_{x_1 x_2} \neq 1$ for any two $X'_k s,$

2) $E(e_i{}^2 | X) = \sigma^2,$ and

3) $E(e_i e_j | X) = 0$ for $i \neq j.$

The first assumption is that no two explanatory variables can be exactly linearly correlated. The second is that variance of error terms is equal for all subsets of data in sample. In other words, estimating a model with a subset of the farms cannot explain the affect relative attributes have on relative net income per acre more accurately for than a model estimated with all farms in the sample. The third assumption is that error terms cannot be correlated with one another, or in other words there is not a pattern that explains why the model does not accurately explain the variability of farms' relative net income per acre. Each assumption can be broken by a particular problem: multicollinearity, heteroscedasticity, and autocorrelation, respectively. Because this is cross sectional data set, serial correlation will not be an issue and therefore the third assumption

will hold. Multicollinearity and heteroscedasticity could exist and therefore are tested for and worked around as they relate to the first two conditions.

The existence of multicollinearity disrupts the estimation and interpretation of individual coefficients. Multicollinearity is defined as the correlation between explanatory variables.

1) $\rho_{x_1 x_2} = 1 \; for \; any \; two \; X_k' s.$

When two variables are linearly correlated, it is difficult for the OLS regression to estimate each variables isolated effect on the dependent variable, as the variables move in tandem. As long as explanatory variables are not exactly linearly correlated, the OLS regression produces statistically valid results. However, the correlation of explanatory variables can increase the standard deviation of individual coefficient estimates, therefore making coefficients less significant. If multicollinearity exists, the effect relative attributes have on relative net income per acre could be more significant than as measured by the regression. There are a few explanatory variables that might be linearly correlated with one another.

Multicollinearity could exist between variables calculated with the same farm level data and between variables hypothesized to be related to one another. The number of acres planted is an explanatory variable (farm size) and it is in the denominator of two other explanatory variables: workers per acre and equipment investment per acre. These variables could be very closely linearly correlated. Less directly, farms that achieve higher than average yields are also expected to have higher than average costs. The natural correlation between farms' input allocation decisions and their yields may also result in multicollinearity as farms that strive for and achieve higher than average yields will also likely have higher than average costs. None of these variables are expected to be directly linearly correlated, but the correlation could prevent the OLS regression from measuring their complete effect on farm's relative net incomes per acre.

A Pearson correlation matrix for the explanatory variables is estimated to assess the affect multicollinearity has on the model's results. The estimated correlation between two explanatory variables X and Y is:

$$\rho_{X,Y} = \frac{\sum_{i=1}^{n}(\bar{x} - x_i)(\bar{y} - y_i)}{\sqrt{\sum_{i=1}^{n}(\bar{x} - x_i)^2(\bar{y} - y_i)^2}}.$$

If variables X and Y are perfectly linearly correlated, then $\rho_{X,Y}$ will be equal to one. If there is no correlation between variables X and Y, then $\rho_{X,Y}$ will be equal to zero. The coefficient matrix will assess whether variables can be included in the model and if the significance of particular variables may be affected by multicollinearity. The significance of multicollinearity is subjective, but a $\rho_{X,Y}$ value of 0.50 will be used to determine if multicollinearity exists between any two variables. If any two variables have a $\rho_{X,Y}$ equal to or greater than 0.50, results will be interpreted such the relative attribute will have at least that much of an effect on relative net incomes and be at least as significant as the model estimates.

Heteroscedasticity affects the estimation of coefficients and the analysis of the results. When a model does not explain the variability of the dependent variable equally across the sample, the model's error term is not distributed with equal variance. This is called heteroscedasticity.

$$E(e_i{}^2|X) \neq \sigma^2,$$

When this is the case, the OLS estimates are still consistent and unbiased, but they are not the most efficient. In other words they are still good estimates, but a different type of regression model could produce better coefficient estimates. The existence of heteroscedasticity also negates the ability to analyze the significance of coefficients. Hypothesis testing with t-test

statistics requires that all error terms have the same variance. The statistical significance of each coefficient, and therefore each relative attribute's effect on relative net income per acre, cannot be assessed if heteroscedasticity exists. This issue could be a significant problem, but it can be worked around by calculating White errors, a statistical procedure to correct standard error estimates for heteroscedasticity.

Heteroscedasticity could exist in the cross-sectional data set. The exact $/acre affect each relative attribute farms have could be different in different KFMA regions. The significance and direction of relative attributes relationships' with relative net incomes are hypothesized to be the same across regions. Farms that are larger than average in Northeast Kansas are expected to achieve higher than average net incomes per acre due to bulk discounts, lower fixed costs per acre, and bargaining power, just as farms in South Central and Western Kansas are. And while farm's absolute attributes will be different things in each KFMA region (i.e. the size, planting intensity, or yield they need to achieve the same relative attribute), normalizing variables by the local average is expected to negate these difference. In other words, the effect farms size has on net incomes per acre might be different, but the affect relative attributes have and relative net incomes is expected to be the same across each region. Nonetheless, as the result of the difference across KFMA regions, including soil types, rainfall, production practices, and crop off-takers, even after the normalization process, $/acre effect of relative attributes on net income per may be different across KFMA regions.

Taking yield management as an example, farms in Northeast Kansas plant dryland corn and soybeans that likely result in different net income per acre compared to dryland wheat and milo in South Central Kansas. The cost and potential revenue of dryland corn and soybeans is higher than dryland wheat and milo. As a result, farms that apply more fertilizer than average or

hit their planting windows more optimally than average in Northeast Kanas may have the potential to make a higher net income per acre as a result from the same superior yield management performance than for farms in South Central Kansas.

If this was the case, relative yield management performances, as measured by a model including both regions, would explain more of the variability if farms' net income per acre in South Central Kansas than Northeast Kansas. After the model explains the affect relative yield management has on relative net incomes per acre for farms in South Central Kanas, there would still be a $/acre amount of relative incomes per acre difference in Northeast Kansas that the model would not explain. This is the definition of heteroscedasticity, as explanatory variable's effect on the dependent variable may not be consistent across the whole sample of farms. The same problem may hold for other variables, as the differences in production environments, climates, and agricultural and nonagricultural economies across the KFMA regions to the extent the particular $/acre relative net income effects of variables are unique to each region. The $/acre effect of having a higher planting intensity in Southeast Kansas, where the average planting intensity is 1.02, may be different than the affect in Western Kansas whether average planting intensity is less than 1. Because of the possibility it might exist, heteroscedasticity must be tested for and worked around.

Heteroscedasticity will be tested visually. The models squared error terms will be graphed against the six KFMA regions. If the variances of error terms appear to be smaller or larger for particular KFMA regions, then heteroscedasticity will be a problem. In this case, the coefficient estimates will be consistent and efficient, but they will not be the best estimates of the relationships between relative attributes and relative net income per acre.

White Errors will be calculated in order to test the significance of individual coefficients. In order for the significance of individual estimated coefficients, all errors terms must be distributed normally. This is required to perform hypothesis testing that will be discussed later. In 1980 White published a method to eliminate the problem of heteroscedasticity in hypothesis testing (White, 1980). After the model is estimated, the error terms are transformed so they are distributed with equal variance. Therefore, White Errors create a way to navigate around the problem of heteroscedasticity in testing the significance of estimated coefficients. White Errors will be used regardless of the results of visual test to prevent the possibility it exists but it is not seen visually.

The ordinary least squares model measures the affect farms' relative attributes have on farms' relative net income per acre. It does this by solving for the set of coefficients that minimize the sum of squares error equation. In order for the OLS regression process to work a few assumptions must hold which can be broken by multicollinearity, heteroscedasticity, and serial correlation. Pearson's correlation coefficients will test for multicollinearity and White Errors will be estimated to work around the potential problem of heteroscedasticity. Serial correlation is a prominent problem with time series data. Because this is a cross-sectional data set, serial correlation was not considered a significant problem and therefore was not addressed. The general problems run into when using the OLS regression are addressed and worked around.

Regression Results

There are two ways the significance of relative characteristics, practices, and management performances will be assessed: cumulatively and individually. Their cumulative effect of relative attributes will indicate their general importance in explaining the differences in the performance of Kansas crop farms. If relative attributes explain a large share of the

variability in farms relative performance, they may represent a relevant area of focus for farmers, extensions workers, and policy makers in order to improve the profitability of Kansas crop farms. Secondly, the significance of individual attributes pin point the particular sources of farms higher or lower relative net income per acre. The significance identifies areas of operations farms can adjust to improve their relative performance. An adjusted R-squared (R^2) statistic is used to measure the cumulative effect of relative attributes, while statistical hypothesis testing is used to determine the significance each relative attribute.

An adjusted R^2 statistic measures the share of variability in farm's relative net income per acre that is explained by the farms' relative attributes. The goodness of fit of regression can be measured by a R^2 statistic and is calculated as:

$$R^2 = 1 - \frac{\sum(\widehat{Y}_i - Y_i)^2}{\sum(Y_i - \bar{Y})^2},$$

where $\sum(\widehat{Y}_i - Y_i)^2$ measures the variability not explained by the OLS estimates and $\sum(Y_i - \bar{Y})^2$ measures the total variability of farm's relative net incomes per acre. However, it can be proven that the R^2 statistic of a model can be improved by simple adding explanatory variables to the model regardless of whether they are correlated with the dependent variable or not. The *Adjusted R^2* statistic compensates for this by docking R^2 each time an explanatory variable k is added to the model. It is calculated as:

$$Adjusted\ R^2 = R^2 - \frac{k}{(n-1)}\left(\frac{(n-1)}{(n-k-1)}\right).$$

Given the number of explanatory variables, it is a more robust way to measure the share of variance the OLS regression explains.

The *Adjusted R^2* statistic will be between 0.0 and 1.0. If it is close to 0, then the cumulative effect of relative attributes on determining farms' relative net incomes is small. In

this case, the different ways farms access land, produce crops, and manage different aspects of the business do not significantly determine farms' relative performance. If the $Adjusted\ R^2$ is closer to 1.0, this indicates that the relative attributes (independent variables) explain much of the differences in farms' net incomes per acre. In this case, farms decision over owning or renting land, planting intensity, and focusing their management on particular areas will play a role in determining farms' relative performance. The share of the relative net income variability the model explains can help gage the importance of the results for farmers, extension agents and specialists, and policy makers interest in improving Kansas crop production industry.

The significance of the affect each relative attribute has on farms' relative net income per acre is determined by testing the statistical significance of model's estimated coefficients. The OLS regression estimates a coefficient, $\widehat{\beta_k}$, for each relative attribute k. Each coefficient is an estimate of the impact that relative attribute has on relative net income per acre while simultaneously accounting for the impact all other relative attributes have on relative net income per acre. For each coefficient $\widehat{\beta_k}$ the null hypothesis is that $\widehat{\beta_k}$ is equal to zero and the alternative hypothesis is that $\widehat{\beta_k}$ is not equal to zero. This can be written as:

$$H_o: \widehat{\beta_k} = 0$$

$$H_1: \widehat{\beta_k} \neq 0.$$

In order to conclude the relative attribute has a significant effect on farms' relative net income per acre, the null hypothesis must be rejected. The significance of coefficients will be tested at the 0.10 level, which relates to the probability the null hypothesis will be rejected when it is actually true. In other words, the null hypothesis will not be rejected unless there is 10 percent or less chance it is true but appears false for this particular sample of Kansas farms.

By definition, assuming the null hypothesis true, H_o, is true, $\widehat{\beta_k}$ is distributed normally. Because the distribution is known, a t-test can be used to accept or reject the null hypothesis. The test statistic is:

$$t_{test} = \frac{(\widehat{\beta_k} - 0)}{s_{\widehat{\beta}}},$$

where $\widehat{\beta_k}$ is the estimated coefficient, 0 is the hypothesis value of the coefficient, and $s_{\widehat{\beta}}$ is the coefficients estimated standard error. The test statistic accounts for variability of the relative attribute and therefore accounts for possibility the variable is correlated with relative net farm income by chance. The t-test statistic is compared to a t-critical value which is the benchmark used to assess whether the variable is significantly different than zero given is estimated coefficient and variability. For this sample, at the 0.10 level of significance, t-critical is 1.66.

If the absolute value of the estimated t-statistic, $|t_{test}|$, is greater than 1.66, the null hypothesis is rejected. In other words, the data suggest the relationship between the relative attribute and relative farm net income per acre is not equal to zero and therefore the relative attribute has a significant effect on relative net income. If the absolute value of the test statistic, $|t_{test}|$, is less than 1.66, then the relationship between relative attribute and relative net income is not statistically significant and therefore the relative attribute does not have a significance effect on relative net income per acre. If a relative attribute is significant, this is an area of the farm operations farmers can change to improve their profitability. In order to improve the profitability of the Kansas crop production industry, extension agents and consultants can target their programs at relative attributes that are significant.

The adjusted R-squared statistic measures the overall affect farms' relative attributes have in determining their relative net income per acre, while hypothesis testing identifies the

significance of each individual relative attribute. Kansas farmers, extension agents and specialists, and policy makers have interest in keeping individual crop farms and Kansas crop production industry running as profitable as possible. Depending on the explanatory power of the model and the significance of individual relative attributes, stakeholders in Kansas crop production may or may take an interest in the result of the analysis. The significance of relative attributes relates to the affect different ways of accessing land, executing field work, producing crops, and focusing management have on farms performance compared to other local farms. It may be beneficial for farmers and others to note what has worked well for farmers in the past in order to emulate it or find new ways to take advantage of changes in the future.

Hypothesis about Relative Characteristics, Practices, and Management Performances

The affect each relative attributes will have on relative net income per acre is hypothesized give previous analysis and industry expectations.

Farm Size

The increasing farm size and increasing proportion of crops produced by larger farms suggests that larger farms are likely more profitable than smaller operations. Larger farms are expected to achieve economies of size through lower average fixed costs, lower input costs and more full utilizing equipment and human capital. Reduced input costs are realized because the transaction, transportation, and default costs of bulk orders are significantly less than small orders for inputs (Duffy 2009).

There also can be significant disadvantages to farm size. Transportation costs increases as fields become further apart, which by definition is necessary as farm size increases. Field sizes generally have not changed with the size of equipment. Small and awkwardly shaped field increases overlap and reduced the efficiency of larger pieces of equipment that are necessary to

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farm more acres. When time becomes more scarce, details like keeping up with servicing

equipment, managing soil systems, and applying of seed, fertilizer, and chemicals at the ideal

time are less likely to be executed properly (Duffy, 2009). Thus, there can be both advantages as

well as disadvantages to larger farm operations.

Previous research on the farm income variability has found farm size to be significantly

and positively related to farm performance (Nivens, Kastens, & Dhuyvetter, 2002), (Ford &

Shonkwiler, 1994), (Haden & Johnson, 1989). Given these findings and the observed growth in

farm sizes over time, it is hypothesized that the effect of farm size will be positively related to

income per acre (i.e., the advantages are larger than the disadvantages).

Renting versus Owning Land

For this analysis, owned land is charged an opportunity cost and the value of land

appreciation is not included in crop income. Each acre of owned crop land is charged the region

cash rent recorded by Kansas Extension Economists. Charging owned land market value cash

rents in consistent with previous studies of farm performance (Ali & Roger, 1987) (Nivens,

Kastens, & Dhuyvetter, 2002). Therefore, farm relative net income accounts for the complete

cost of owning land, the opportunity cost, but does not account for its value in land appreciation.

Renting land can free up cash for more productive investments (Garcia, Sonka, & Yoo,

1982) (Mishra, El-Osta, & Johnson, 1999) (Gloy, Hyde, & LaDue, 2002). High land prices have

increased the risk of purchasing land, and high mortgage payments may prevent farms from

purchasing the optimal amounts of valuable yield enhancing inputs (e.g., genetically modified

seed and fertilizer). If cash rents or rent shares are below average market rates charged as

opportunity costs for owned land, farmers that rent more land may realize more economic

profits. However, without complete, long term control of land assets, farms may not make

economically beneficial investments in crop land. Renting land also requires farms to manage

and maintain relationship with landlords which take away time and resources from other more

profitable activities on the farm.

Kansas farms with a larger share of rented land have been found to have higher net crop

incomes (Nivens, Kastens, & Dhuyvetter, 2002), while more profitable Illinois farmers were

found to rent a smaller share of their land (Garcia, Sonka, & Yoo, 1982) (Paulson & Lv, 2012).

High cash rents were believed to have an effect on the profitability of Illinois crop farms that

rented more land. Given the lack of consistency of historical studies, no relationship between

rent share and net farm income is postulated.

Custom Hiring Practices

There is no predicted relationship between custom expense and net farm income. Does

custom contracting free up time, optimize planting, spraying, and harvesting windows, or have

other effects that lead to increased net income? Kansas farmers have been increasingly asking

this question recently (i.e., should they own machinery or hire custom operators to do the

operations?). This variable should shed light on the net profit outcomes of contracting more or

less machine work to custom operators.

Specialization

Diversification can affect net farm incomes through different channels. Farm

diversification can spread out cash flows and reduce a farm's operating interest expenses. As

crop prices fluctuated over time, farms that produce a wider range of crops will see their income

fluctuated less. The stability of income for farms that produce a wider range of crops might help

them make better financial decision. However, specialization can reduce equipment investments

per acre and therefore deprecation costs per acre--both directly related to farm's bottom line. In

addition, specialization in fewer crops might enable farms to develop a greater expertise in these areas which results in an improvement in the operation's profitability.

Over the last 40 years farm have become increasingly more specialized. Previous research does not provide conclusive evidence on the value of crop diversification. The effects crop patterns have on net farm incomes was found to be insignificant in a study of Illinois crop farmers (Sonka, Hornbaker, & Hudson, 1989). Given the rising cost of equipment, and the across the board increase in commodity prices, specialization is hypothesized to be positively related to net crop incomes.

No-Till Technology Index

The no-till technology index represents different costs, yields, and technology preferences of farms. Farms that use tillage practices take on higher chemical and depreciation cost, while farms use traditional tillage practices take on higher fuel and labor costs. At the same time no-tillage practice results in higher yields: decreasing soil erosion, increasing water retention, and reducing chemical run-off. No-tillage is also a relatively new technology, therefore it represents the degree farms adopt new technologies. The variable might represent the degree farms adopt other new technologies: such a GPS guidance systems, marketing plants, and computer accounting practices.

The no-till index is expected to be positively related to net farm incomes. For the last 20 to 30 years no-till production practices have provided farmers an opportunity to substitute chemical cost for fuel and machinery costs. This has reduced farms operating costs, while also improve yield outcomes. These positive effects are expected to be represented in the estimated coefficient. A willingness to adopt new technology is expected to be positively related to net farm income.

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Planting Intensity

Higher planting intensity strategies are expected to be positively correlated with a net crop income. Farms with higher planting intensities, than average, are expected to make better use of their fixed assets. Planting intensity is expected to be negatively related to investments per acre and workers per acre. Nivens, Kastens, and Dhuyvetter found a positive and significant relationship between planting intensity and net crop incomes and results are expected to be consistent with these findings.

Seed Expenditures

Seed expenditures are expect to be positively correlated with net crop income. There are many different types of seed, at both ends of the spectrum, for farmers to choose from. Farms that spend more money on new genetically modified seed varieties are expected to achieve higher net crop incomes. ERS research has found that farmers have economically benefited from the adoption of new seed technologies through lower pesticide costs, higher yields, and higher net returns (Fernandez-Cornejo & McBride, 2000).

Risk

It is typically understood that it may be necessary to take on a greater degree of risk to earn higher profits. Risk (the standard deviation of net crop incomes over the ten-year time period) is expected to be positively related farm profits. In a study on Kanas crop farms, greater income variability was significantly and positively related to higher net crop incomes (Nivens, Kastens, & Dhuyvetter, 2002). If this relationship is positive, that is not necessarily suggesting that farmers should go out and take on risky ventures, but it would suggest that farmers may have to take on additional risk if they wish to achieve higher profits than other farms.

Cost, Yield, and Price Management

Should farms focus more on managing their costs, yields, or marketing their crops? On the farm there is a wide range of decisions and activities to execute: from purchasing inputs, to making planting decisions, to executing field work, to marketing crops. This forces farm managers to decide where they should focus their management efforts. Do farms that are better than average at managing costs, managing yields, or marketing crops make superior profits relative to the average farm?

Farms with lower production cost per acre, higher yields per acre, and higher prices per bushel are expected to have higher net farm incomes. Measuring the relationship between profits and different types of management abilities provides quantitative evidence to help farmers decide where they should focus their management efforts. Accounting for the effect of production costs, yields, and marketing performance is also important to effectively measure the value of different farm characteristics and production practices.

Chapter 6 - Degree of Relative Characteristics, Practices, and Management Performances

The degree farms have higher than average net incomes per acre is relevant. When farms bid against one another in land markets, they bid against operations with other than average net incomes. The higher farms net income per acre, the better positioned they are to compete in land markets. Similarly, the higher a farm's net incomes are than the average in its area, the more capable the farm is of outlasting other operations through periods of unprofitability. Furthermore, farms with higher than average net incomes are more capable of producing crops at long run equilibrium prices.

The value of relative attributes are affected by the degree farms can distinguish the attribute from the local average. The econometrics analysis measures the relative net income per acre farms can expect to achieve for being incrementally different than the local average for each attribute. Equally important is the degree to which farms can expect to distinguish their particular attributes from local averages. While a relative attribute might have small incremental $/acre effect on relative net income, if a farm can distinguish itself from the average to a large enough degree, the attribute is good source of relative net income. On the other hand, a relative attribute might have large $/acre affect, but if a farm cannot distinguish the particular attribute to a large enough degree, it is not as good a source of relative net income as initially perceived. Therefore the significance and value of relative attributes should be weighted by the degree farms can achieve them.

In this section the degrees to which farms are capable of distinguishing each attribute from the local average is analyzed. First, theories are proposed to explain why farms are or are not capable of distinguishing each attribute to a large degree. After the theories are outlined, the

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methodology used to test the theories is explained. Hypothesis's are given for expectation concerning to what degree farms can distinguish their characteristics, practices, and management performances. Lastly, the standard deviations results are combined with econometric results to measure $/acre relative net income per acre farms will achieve for being in the top 1/3rd of farms for each attribute. The degree section analyzes a farm's ability to distinguish its attributes from the local average and relates it to its relative net income per acre.

Theory

Two sets of theories are proposed to explain why farms may or may not be able to distinguish each attribute from the local average: one set for *Characteristics and Practices* and one set for *Management Performances*. The Characteristics and Practices category represents how farms access resources, as well as their particular style of crop production. Management Performances represent the bottom line performances of farms: costs per acre, number of bushels per acre, and prices per bushel. These sets of variables measure different aspects crop farming, but within each set of variables, common theories can be used to explain the degree to which farms can expect to distinguish each attribute from the local average.

Relative Characteristics and Practices

Can Distinguish

Kansas farms have many opportunities to distinguish their characteristics from the local average. The two main resources in crop production are land and equipment. Farms can access land through ownership or rent. Farms can purchase land through financing with a local bank, or could establish relationships with landlords to rent land with either crop share or cash rent leases. Farms can also own, lease, or custom hire their equipment. Dealerships and custom operators offer farms options for how they access equipment resources. Farms can distinguish their

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characteristics from other operations by using banks, landlords, dealerships, and custom operators to do this differently.

Today's crop rotation strategies and equipment technologies give farms opportunities to distinguish their production practices. Farms' primary operating activities are planting, controlling weeds, and harvesting crops. Within each KFMA region farms can choose their particular crop rotation: such as corn to corn, corn to soybeans, wheat to double crop soybeans, wheat to wheat, or wheat to milo. Using any of the rotation strategies, farms can choose how many crops to plant and how intensely to use each of their acres. And, within any given crop rotation farms can control weeds with traditional tillage practices or no-tillage practices. Sophisticated genetically modified seeds have given farms yet another avenue to control pest problems. In summary, there are enough crop rotation strategies and equipment technologies for farms to choose from such that farms are able to distinguish their production practices from the local average.

Cannot Distinguish

The existence of profitable characteristics and best practices may prevent farms from distinguishing their characteristics and practices from the local average. Over time, the profitability and other advantages of particular characteristics and practices might naturally present themselves. Given a region's particular production environment, agricultural economy, and nonagricultural economy, it might be more profitable to either rent or own land, own or custom hire equipment, and use tradition or no-tillage practices. In order to stay comparatively profitable and competitive in land markets, farm would have to adopt the most profitable characteristic and practices. Therefore, despite farms options, the existence of best practices might limit farms ability to distinguish their characteristics and practices from the local average.

Management Performances

Can Distinguish Attributes

The choices farms can make in their particular management strategies enable them to distinguish their management performances. Generally speaking all farms have goals of keeping their costs low while striving for the highest yield and of selling their crops for the highest possible price. However farms can deviate from these industry baselines. Concerning cost and yield management, farms can adjust the amount of yield enhancing inputs they apply in order to have a better chance at a higher yield. Farms can choose their cost and yield management strategies through their input investment decisions.

Farms can also choose their price management strategies by the amount money and time they invest in creating marketing strategies. Farms can decide whether to pay for marketing services in order to have access to market information, or they may decide not to spend significant resources toward that end. The more or less farms focus on marketing crops, the higher or lower the prices farms may sell their crops at. Within each area of management farms have opportunities to deviate from the local average: focusing on costs, yields, or prices to particular degrees. Farms' strategies in dealing with these variables enable them to distinguish their management performances from the local average.

Cannot Not Distinguish Attributes

Unforeseen pest problems and uncontrollable weather events may prevent farms from positively distinguishing their cost and yield management performances from the local average. Every year, farms in each KFMA region will face unforeseen pest problems and difficult weather, requiring input investments which could prevent farms from distinguishing their cost management performances. Similarly, the particular climate of the growing season or local

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weather events can contribute to either above average or diminished crop yields. In these ways, uncontrollable events often raise costs and diminish yields so that the even the best managers will struggle to positively distinguish their management performances from the local average.

Research has shown that it is difficult to beat the market. Regardless of whether farms do their own market research or pay for marketing services, it is unlikely a farm will beat the market in any given year. And while a farm may sell their crops at higher than average prices in one year, it is unlikely they will be able to do it consistently enough to market their crops at higher prices on average over time. Good marketing years will likely be canceled out by bad marketing years. The difficulty of consistently selling crops at higher than average prices is another factor that will prevent farms from distinguishing their price management performances.

Summary

As previously discussed, in order to distinguish their characteristics and practices, farms have a number of options from which to choose. However these opportunities may be restricted by the superior profitability of particular characteristics and practices. Farms can also make input decisions and choose how much to focus on marketing crops in order to distinguish cost, yield, and market management performances. The randomness of farms' uncontrollable production environment and the difficulty of beating the market will counter farms' management strategies. These theories will be tested by the degree to which farms have and have not distinguished their attributes from local average.

Methodology

The variability of relative attributes are used suggest the degree to which farms can expect to distinguish their attributes from other local operations. Within each KFMA region, farms have different preferences. Some will prefer to own land while others prefer to rent. Some

will prefer traditional tillage technology while others no-tillage practices. Some will prefer to focus on yield management while others prefer to focus on marketing crops. Assuming farms are all striving for the particular preferences, the degree operations have different attributes from one another is representative of the natural bounds of distinguished attributes. The more (less) farms have been able to distinguish themselves differently from the local averages compared other operations the more (less) farms have proven they can distinguish their attributes as they please. The degree farms have been able to distinguish each attribute from other operations will be measure by standard deviation of the relative attribute. Therefore, the standard deviation of each relative attributes is used to quantify the degree to which farms can expect to distinguish each attribute from the local average.

A standard deviation is equal to the square route of a sample's variance. The estimated standard deviation of a sample is:

$$Standard\ Deviation\ (X) = \sqrt{\frac{1}{T-1}\sum_{T=1}^{T}(x_i - \bar{x})^2},$$

where X is sample of data $\{x_1, x_2, \ldots x_T\}$ and $\bar{x}$ is the sample's average. The differences between individual data and the sample mean quantifies the degree the variables in the sample $\{x_1, x_2, \ldots x_T\}$ are similar or different from one another. In this case standard deviations will measure the degree farms' attributes are similar or different within KFMA regions.

The standard deviation (SD) of each relative attribute is estimated as:

$$SD\ (Relative\ Attribute) = \sqrt{\frac{1}{433-1}\sum_{i=1}^{433}\left(Relative\ Attribute_i - \overline{Relative\ Attribute}\right)^2},$$

where

$$Relative\ Attribute_i = \sum_{t=1}^{10}\frac{Relative\ Attribute_{it}}{10}.$$

Each farm's average *Relative Attributes* over the 2001 to 2010 time period is calculated. The

10 year average mitigates the affects that random outlier years of performance have on

measuring farms cost, yield, and price management performance. The units of standard

deviations are in the same units as the relative variables (the percent difference from the local

average).

The standard deviations of relative attributes provide a general assessment of the degree

farms can expect to distinguish each attribute from the local average. The larger an attributes

standard deviation (the larger the spread farms' relative attributes) the more farms have proven

they can be successfully different from the local average. Therefore, if a relative attributes has

standard deviation, farms can expect to distinguish it to a large degree. The smaller an attributes

standard deviation (the smaller the spread farms' relative attributes) the less farms have shown

they are capable of being than one another. If a relative attribute has a small standard deviations

farms can only expect to distinguish these attributes to a small degree from the local average.

In summary, the variability of each relative attribute, as measured by its standard

deviation, is used to assess the degree that farms can and cannot expect to distinguish their

attributes from the local average. The larger (smaller) a relative attribute's standard deviation, the more (less) farms can expect to distinguish the particular attribute from the local average. And because the relative attributes are normalized by the local average, the standard deviation of different attributes can be compared to one another. The standard deviation of relative farm size can be compared to the standard deviation of relative cost management, as both variables are normalized by the local average.

Hypothesis

The degree the farm have distinguished their attributes from the average is expected to be similar within characteristics, practices, and management performances. Farms are expected to be able to distinguish their characteristics from the local average to large degree. On the other hand, farms are expected to be able to distinguish their practices and management performances to a small degree.

Crop farms are expected to have flexibility in how they access land and equipment. In crop production, there is not a set of best characteristics for farms in particular geographical regions. In the dairy industry, it widely known that given current technology 3,000 to 3,500 units are the most efficient and profitable operating units. Milking this number of cows constitutes an optimal combination of capital, labor, and cows. Such a standard does not exist in the crop production industry. It is not widely held that farms that own or rent land or own or hire equipment are more profitable than other farms. Every characteristic has it pros and cons. As such, crop operations are expected to and to be able to distinguish the characteristics; fitting them to their particular preferences.

Farms are not expected to be able to distinguish their practices to a large degree from the local average. Given current equipment, input technology, agronomy research, best production

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practices are well known and practiced by farms within particular geographical regions. For example, today no-tillage is the industry standard in some regions (e.g., Western Kansas), whereas, tillage is still a common practice in other regions (Southeast Kansas). While there is always some debate and disagreement, as a general rule the best practices to use in a region typically become fairly well known and accepted. Because there are clear best and most profitable practices, farms are not expected to distinguish their practices from other local operations to a large degree.

Farms' access to equal information is another reason farms are not expected to be able to distinguish their practices to a large degree. Land grant universities, input suppliers, and equipment dealers regularly publish and disseminate information about new production technologies and best practices. Even if a new production practices is developed, if it is best practice, it will quickly become well known to all operations through one avenue or another. In other words farms do not have the ability to distinguish their production practices with new technologies.

Farms are not expected to be able to distinguish their cost, yield or price management performances to a large degree. The uncontrollable pest and weather events that affect farms' input investment decisions and yields are expected prevent farms from distinguishing their cost and yield management performances. Farms can have an input and yield strategy, but this is expected to mitigate by natural events; making all farms cost and yield management performances close to average. Concerning price management, Research has shown that is difficult to beat the market. The difficulty of predicting market movements and consistently selling crops at higher than average prices is expected to prevent farms from distinguishing their price management performance.

Top 1/3rd Relative Net Income Affect

The standard deviation analysis is crossed with the econometrics analysis. The purpose of distinguishing farm's characteristics, practices, and management performances is to achieve a higher net income per acre than other farms. To achieve this desired result, farms can distinguish many attributes to small degree or farms can distinguish on attribute to a large degree. In the latter case, farms can decide to be in the top 1/3rd of farms for a particular attribute. As such, farms would achieve higher net income per acre due to this attribute more so than 2/3^{rds} of other operations. Along these lines, the standard deviation analysis is combined with the econometric analysis to show the $/acre relative net income farms can expect to achieve for being in the top 1/3rd of farms for a particular attribute.

The standard deviation of relative attributes map out the degree farms have distinguished their attributes from their local averages. Assuming a sample is normally distributed, 68.2 percent of all observations are within plus and minus one standard deviation of the mean. Figure 1 shows a normal distribution and how the percentages of observations would be distributed around the mean (μ) given the standard deviation (σ). In this analysis, by definition the average relative attribute is equal to zero. Therefore assuming each attribute is distributed normally, if a farm achieves a relative attribute equal to the relative attribute's standard deviation, the farm has distinguished the attribute to larger degree than 68.2 percent of the farms in the sample. As an example, farms with a relative size equal to a positive (negative) standard deviation would have relative farm size that is larger (smaller) than 68.2 percent of the other farms in the sample.

Figure 1: Normal Distribution
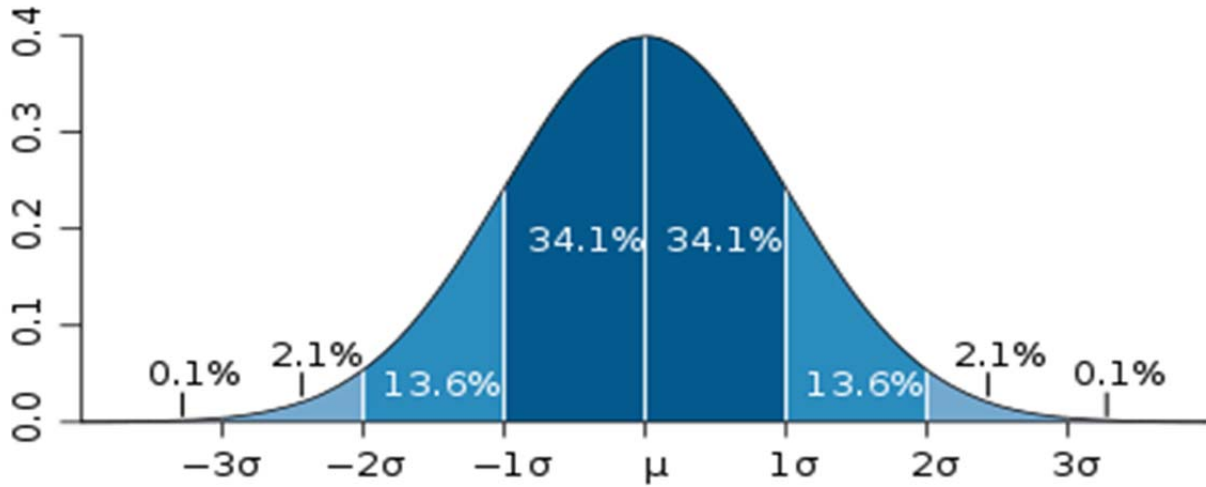
The standard deviation map can be used to pin point degree farms have to distinguish an attribute to be in middle of the top 1/3rd of farms for particular relative attribute. A farm that has relative attribute equal to 1 standard deviation in the right direction it is in the middle of the top 1/3rd of all farms for the attribute. If the sample of farms was split into the bottom, middle, and top third of farms for each attribute, 33.33% of farms would in the bottom top, middle, and top. The middle of the top third would in include 83.33% of farms. Similarly, if a farm has relative attribute equal to its standard deviation (positive or negative), it has a relative attribute that is better positioned to achieve higher relative net income than 84.2 percent of farms. A relative attribute equal to the sample's standard deviation equates to a farm that is in the middle of the top 1/3rd of farms for a particular attribute.

The $/acre relative net income per acre result of being in the top 1/3rd of all farms for each attribute is calculated by multiplying the standard deviation by the respective relative attribute's estimated coefficient. The coefficient of each variable is equal to the $/acre relative net income a farm will achieve for being 1 percent different than local average, holding all other

variables equal to the average. Standard deviations are in the same units as the variables; the percent difference from the local average. Therefore, the standard deviation multiplied by the coefficient is equal to the relative net income per acre a farm in the top $1/3^{rd}$ of farms for the attribute, holding all other relative attributes equal to zero.

These $/acre figures represent the outcomes farms can expected from outperforming a particular share of other operations in distinguishing a particular attribute. The larger (smaller) the relative net income outcome the more (less) beneficial it will be for farms to achieve larger relative attribute than a particular share of Kansas farms. Looking at the result of this across attribute shows the relative net income farm can expect to achieve for reaching this equivalent milestone for each relative attribute.

In order to outperform other operations, farms may choose to differentiate themselves from other operations more so for some attributes than for others. Such a goal could be to be in the $1/3^{rd}$ of farms for a particular attribute: such as size, planting intensity, or yield management. The $/acre benefit of being in the top $1/3^{rd}$ of farms for relative size, planting intensity, yield management, and other relative attributes are reported in this standard deviation analysis. Farm can look across it and see what they can achieve for the particular amount of resources and focus it will take for them to be in the top $1/3^{rd}$ of farms for a particular relative attribute.

Chapter 7 - Consistency

Farms' relative net incomes per acre are relevant over multiple ten-year time periods. When farms bid against one another in the land market they draw on their retained earnings and their expected net income for many years in the future. When crop prices fall below breakeven levels, the battle of attrition between farms ties back to the differences between their profitability (i.e., net income per acre) over time. Farms that maintain higher than average net income per acre over long periods of time will have a competitive advantage in land markets, outlasting other operations through period of unprofitability, and producing crops at long-run equilibrium prices. Therefore, to remain viable and sustainable, farms must not only be as profitable as other crop operations today, but they must also be as profitable as other crop operations in the future.

The econometric analysis measured the value of relative attributes for the 2001 to 2010 time period. However, equally important if not more so than this particular 10-year period, will be farms' relative net income per acre over multiple time periods to come. If farms can expect to maintain a relative advantage for a particular attribute across time, and therefore benefit from it over long periods of time, then the value of the estimated coefficient becomes more significant. On the other hand if a farm cannot expect to maintain a relative advantage to an attribute across time, and therefore not benefit from it over long periods of time, then the value of the estimated coefficient becomes less significant. Therefore, the significance and $/acre value of each relative attribute should be weighted by how likely farms are to maintain them in the future.

In this section, first theories are proposed that explain why it is feasible or infeasible for farms to maintain their relative characteristics, practices, and management abilities from the local average. After the theory is established, the methodology used to measure how feasible it is for farms to maintain each relative attribute is explained. Hypotheses are also given the feasibility of

maintain relative attributes across time. The degree section measured the relative net income per acre farms could achieve by distinguishing a relative attribute to a particular degree from the average. This consistency section evaluates the likelihood that farms can maintain relative attribute across time and therefore the likelihood of maintaining sources of relative net income per acre.

Theory

A few theories are proposed to suggest exactly why it may or may not be feasible for farms to maintain relative characteristics, practices, and management performances over time. Two sets of theories are proposed: one for the feasibility of maintaining relative characteristics and a set for the feasibility of maintaining relative management performances. Relative characteristics and practices measure the resources and practices of farm deviate from the average. Relative management performance measures how farms $/acre costs, bushel/acre yields, and $/bushel prices deviate from the average. These two set of variables measure different aspects of the farm operation. As such, different theories are proposed for each category. Under the two categories, theories are proposed as to why it may be infeasible or why it may be feasible for an individual farm to maintain their relative attributes across time.

Relative Characteristics and Practices

Infeasible

The difficulty of staying ahead of other local operations on industry trends can prevent farms from maintaining relative characteristics and practices across time. To hold relative attributes across time farms must consistently evolve their operations. As shown in Table 7.2, the average farm size and the average degree of specialization increased over the 2001 to 2010 time period. To stay ahead of the local average, or other local farming operations, farms had to change

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more quickly than other operations. The difficulty of changing resources and practices faster than other operations is expected to make it difficult to maintain relative attributes across time. The theory of leaping frogging may also be applicable. Farms ahead of other operations, such as in size and planting practices, may become complacent and therefore be passed up by other operations that take more risks and learn from the mistakes the leading operations.

Feasible

On the other hand, the difficulty of catching up with industry trends may make it easy for farms to maintain their relative characteristics and practices across time. Changing characteristics requires access to resources and changing production practices requires research and changing the way the farm operates. Smaller operations may lack the resources to catchup with the size of other larger local operations. Farms using older production practices may also struggle to change their operations to effectively employ the newest production practices. In other words, there may be barriers to change that prevent farms from catching up with industry leaders.

Also relevant, the different preferences of farms might make it easy for farms to maintain their relative characteristics and practices. Some farms may have no interest of following industry trends. There is not a particular right or wrong size or way to execute field work. Some farms may prefer to be smaller than average or be less specialized than average. As each operation has different preferences than others, maintaining relative characteristics and practices may not be difficult at all. If enough farms are set in there ways, operations do not need to change their operation across time to maintain their relative attributes. Similar to barriers to change, the different preferences of farms concerning how they access land, execute field work, and the produce crops, may make it feasible for farms to maintain relative characteristics and practices across time.

Table 7:1 Average Farm Characteristics and Farm Practices, 2001-2010

Variable	2001	2005	2010
Farm Characteristics			
Farm Size (acres)	1,219.58	1,321.75	1,422.78
Overhead and Equipment Investments ($/acre)	124.42	149.13	227.05
Share of Rented Land	0.71	0.69	0.66
Farm Practices			
Specialization	0.42	0.44	0.46
Planting Intensity	0.90	0.92	0.91
Seed Costs ($/acre)	14.24	19.55	35.85

433 Kansas farms

Relative Management Performances

Infeasible

The different climates, production environments, and market conditions that Kansas farms face over time may prevent farms from maintaining their relative management performances. Farms' relative management performances are partly a function of how well farms' resources and expertise match the environment in which they plant, harvest, and sell their crops. Every farm has a unique set of resources and expertise that will be more or less advantageous in particular input costs, weather, and market environments compared to resources and expertise of other operations. Therefore, in any given year farms' relative management performances might be dependent on well their resources and skills match particular environment. Because production and market environment change uncontrollable over time, regardless of their efforts, it might be infeasible for farms to maintain their relative management performances.

Taking yield management as an example, the average dryland wheat yield oscillated between 40 bushel/acre and 60 bushel/acre in the 2001 to 2010 time period (Figure 2). The different yields represent the different climates Kansas farms planted crops in each year. Given

their production practices and expertise some farms would achieve higher than average yields when all yields were high and others would achieve higher than average yields when all yields are low. In other words farm's relative yield management performance are partly dictated by how well the farms practices and skill set matches the weather and pest problems all Kansas farms face. Therefore, farms relative yield management performances are partly outside of farms control and therefore difficult to maintain across time. The same logic can be applied to cost management and price management. All relative management performances are a function of whether farms practices and expertise match the particular environment that changes from year-to-year and this will make it difficult for farms to maintain them across time.

Figure 2: Dryland and Irrigated Wheat Yields, 2001-2010
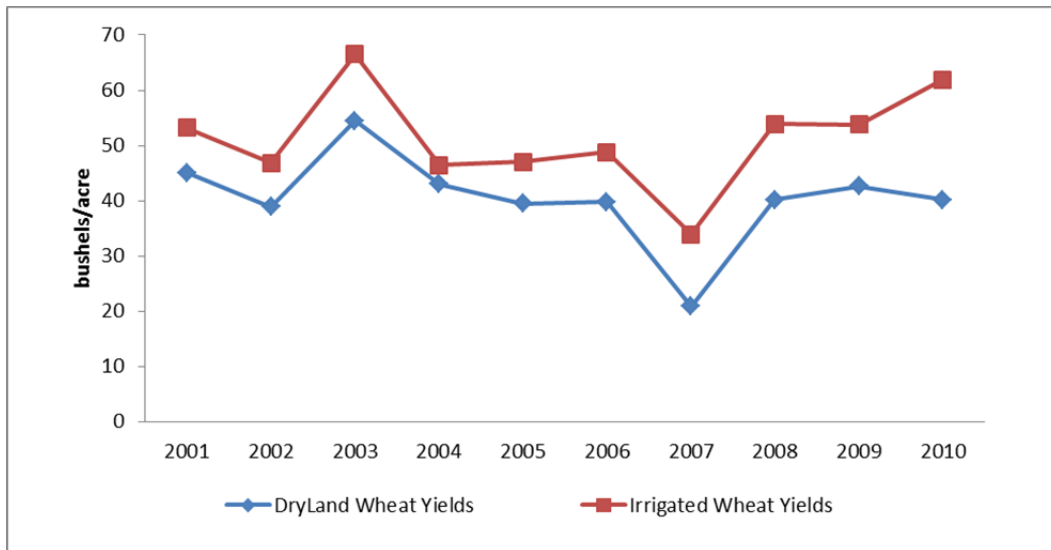
As yet another reason, due to local events that affect individual farms differently, it may infeasible for farms to maintain their relative cost and yield management performances across time. In any given year, individual farms can face different weather events and pest problems than other operations in their KFMA region. These events outside their control will have a significant effect on farms' relative cost and yield management performances. If individual farms face unique circumstances often enough and cannot manage around them, they will not be able to

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consistently maintain their relative cost and yield management performances. If such is the case, a farm's relative cost and yield management focus will be a function of the particular circumstances of farms--not the conscious decisions and management abilities of the farm operations. In other words, the relative management performances of farms will be random, and therefore it will be considered in feasible for farms to maintain them across time. This theory fits within the context of year-to-year changes in the industry, weather, and market environment. The affect the business and production environment has on farms management performances in any given year are expected to be compound or mitigate farm's particular local circumstances--again creating randomness in farm's relative performance.

Feasible

Kansas farms may have the experience and expertise such that is feasible for them to maintain their relative management performances across different production and market environments. Farming is very competitive industry and to stay viable farms have had to operate through many different conditions and market circumstances. Today's crop operation may have the knowhow to keep cost low when the price of seed, chemical, and fertilizer are high or low; the expertise to maintain relative yield performance when growing conditions are good and poor; and the ability to hit higher than average prices when market are flat or volatile. Given farm's required level of expertise to remain viable, Kansas farms may be able to maintain their relative performance across time. Even when farms face different weather and pest problems than other local farm operations, they may be able to maintain their relative management performance. The performance of farms over the 2001 to 2010 period will suggest how dynamic Kansas farmer managers can be across different environments.

Theory Summary

In the case of each relative characteristic, practice, and management performance it might be feasible or infeasible for farms to maintain it across time. The competition between farms to pass one another on industry trends, barriers to change, and the different preferences of farms might make it less or more feasible for farms to maintain their relative characteristics and practices across time. Similarly, the year-over-year changes in production and market environments, the particular circumstances that farms face, and the flexibility of farm managers might make it less or more feasible for farms to maintain their relative management performances across time. To quantify the difficulty of maintaining relative attributes, the ability of the 433 farms in the sample to maintain each attribute across the 2001 to 2010 time period will be analyzed.

Methodology

The performances the 433 Kansas farms is used to measure how feasible it was for farms to maintain each attribute over the 2001 to 2010 time period. Any particular operation may have been able to maintain a relative characteristic, practice, or management performance over the ten year period. However, their ability to do so might have been due to luck or randomness (i.e. fortunate opportunity to rent additional acres or randomly getting better rains than other local farms). On the other hand, a large sample of farms includes operation with different resources and expertise that faced may different circumstances over the 10 year time period. The performance of the large sample shows how well a variety of farms in a variety of circumstances maintained their attributes over the 2001 to 2010 period. This provides a general measurement of feasibility--independent on the circumstance of a particular operation and its abilities. Therefore,

for each attribute, the share of farms that does and does not maintain the attribute over the 2001 to 2010 time period quantifies how feasible it was for farms to maintain them.

For each attribute, statistics hypothesis testing is used to determine if a farm did or did not maintained its relative attributes through the 2001 to 2010 time period. Hypothesis testing uses the each farm's 10-year average relative attribute, the variability of its relative attribute over the 10-year period, and probability theory to determine whether farms did not did not maintain the relative attribute. This process is discussed in detail in the **Appendix B**. But simply put, if a farms relative attribute was consistently positive or negative (i.e. size was consistently larger than the local average), then hypothesis testing will find the farm maintained their relative attribute. If a farms relative attributes start on one side of the average and end on another, or their relative attribute oscillate between being above and below the average, hypothesis testing will find the farm did not maintained their relative attribute. The same hypothesis testing procedure is used for each attribute.

For each attribute, the number of farms that do and do not maintain an attribute on one side of the local average are tabulated and totaled. Each total number of farms is expressed as a share of all farms:

$$Percentage = \frac{G}{433}$$

$$Percentage = \frac{N}{433}$$

$$Percentage = \frac{L}{433}.$$

where G is the number of farms with an attribute that is consistently greater than average, N the farms with an attributes that is neither consistently greater nor less than the average, and L is the number of farms with an attribute that is consistently less than the average. In Figure 3 below,

for Example 1, 40 percent of farms are consistently greater than average, 20 percent are neither consistently greater nor less than average, and 40 percent are consistently less than average. The distribution of farms across the three categories is used to assess the feasibility of maintaining each relative attributes across time.

Figure 3: Consistency
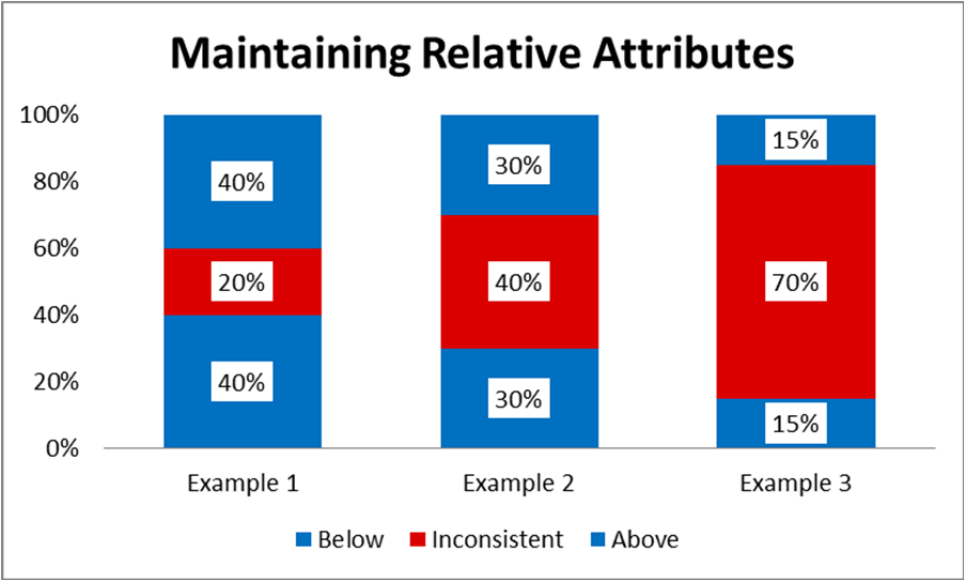
The performance of each farm over the 10 year period is like an experiment. Each farm has a particular set of resources, expertise, and goals, while they face a particular set of circumstances through the 10 year period. And, over the period, each farm either maintains their relative attribute or does not maintain their relative attribute. With each farm that maintains their relative attributes over the period, there is evidence that is feasible for farms maintain their attribute. One farm did it; other farms can also accomplish it. On the other hand, with each farm that does not maintain their relative attribute, there is evidence that it is not feasible for farms to maintain their relative attribute. One farm did not maintain their relative attribute; others may not be able to maintain it either. The accumulation of the total number of farms that do and do not

maintain a relative attribute over the 10 year period measures the feasibility of maintaining the relative attribute.

The more farms that maintained relative attribute on either side of the local average, the more feasible it was for farms to maintain their relative attribute over the 2001 to 2010 period. This scenario is shown by Example 1. The majority of farms, 40 percent below the average and 40 percent above for a total of 80 percent of farms, maintained the attribute, therefore it is expected to be feasible for any farm to maintain it. On the other hand, the more farms that did not maintain their relative attributes on either side of the average, the less feasible it is for farms to maintain their relative attribute. This scenario is shown in Example 3. In this case the majority of farms, or 70 percent of farms, did not maintain the relative attribute, therefore it not expected to be generally feasible for farms to maintain across time.

For each attribute, the culmination of all farms performances is a general assessment of the feasibility of maintaining the relative attribute across time. The sample of 433 farms includes farms with different resources and expertise and that worked through different circumstances during the 2001 to 2010 period. The larger (smaller) the share of farms that maintained an attribute on either side of the local average the more (less) feasible it expected to be for farm to maintain. The share farms that maintain the relative attribute show degree farms with different resources and that work through different circumstances can maintain the attribute; painting a general picture of feasibility. The results of the analysis support or disprove the theories proposed for maintaining relative characteristics, practices, and management performances. These include staying ahead of industry trends, farms' different preferences, changing environments, and the flexibility of farm managers.

Hypothesis

The feasibility of maintaining each relative attribute can be compared to one another. A consistent scientific process is used to determine the share of farms that maintained each relative attribute. Statistical hypothesis testing at the same level of significance was used to determine the share of farms that maintained their relative characteristics, practices, and management performances. Therefore, the shares of farms that maintained each relative attribute can be used to compare feasibility of maintaining the different attributes. If more farms maintained one relative attribute compared to another, it can be inferred that farms are more likely to maintain that relative attribute. That said, the feasibility of maintaining relative attributes is expected to be similar within each attribute category: characteristics, practices, and management performances.

Farms are expected to be able to maintain their relative characteristics more easily than production practices and management performances. Large shares of farms are expected to have maintained their relative characteristics over the 2001 to 2010 time period. Industry trends related to characteristics are slow moving and the resources necessary to change characteristics is expected to prevent farms from catching up with leading operations. The size of farms, share of rented acres, and other characteristics are expected to vary significantly from operation to operation. The large resource changes that farms would have to make to affect the relative attributes of other operations will also make it more difficult to surpass other operations on industry trends. As a result, farms with established relative attributes are expected to maintain them.

Farms are expected to maintain relative production practices less easily than farm characteristics, but more easily than relative management performances. Kansas farms have access to similar production technologies. Local areas have established best practices concerning tillage, crop rotation, and planting intensity. As such, farms are not expected to distinguish their

production practices to a large degree from the local average. Therefore, weather events that only affect particular operations are expected to affect farms relative attributes and put them on either side of the average in any given year. In other words, the similarities of farms production practices within KFMA regions and local weather events are expected to prevent farms from maintaining relative practices over time.

It is expected to be more difficult for farms to maintain their relative management performances as compared to their relative characteristics and practices. Changes in the production and market environment are expected to prevent farms from maintaining their relative performance across time. Farms are expected to be able achieve particular relative management performances in some environments, but not others, leaving a farms relative performance up to chance.

Local weather and pest problems are expected to prevent farms from maintaining their relative cost and yield management performances across time. The expertise and flexibility of farms is expected to be outmatched by the uncontrollable environment that farms operate in. Concerning price management, the difficulty of beating the market is expected to prevent farms from consistently marketing their crops at higher prices than other local operations. With relative management performances, in the order from the most to least maintainable, farms are expected to be able to maintain their cost, yield, and price management performances.

Relating the Consistency Analysis to the Econometric Analysis

The consistency analysis is overlapped with the econometric analysis. More so than in single year, farms competitiveness in land markets, periods of unprofitability, and production in the long run is dependent on farms maintaining higher than average net income per acre across

time. It is helpful for farms to know the relative attributes that will result in higher than average net income per acre, but it also important for farms to understand how likely they can maintain sources of relative net income in the future. A source of a smaller relative net income that can be maintained may be more valuable in the future than a source of larger relative net income that cannot be maintained. Therefore, the significance and $/acre value of relative attribute for a 1% change are therefore weighted by feasibility farms will be able to maintain them in the future.

The feasibility Kansas farms will be able to maintain relative attributes in the future is assumed to be equal to the feasibility farms maintained them in the 2001 to 2010 time period. The challenges farms faced to maintain their relative attributes in the future will be similar to challenges faced in the past. Therefore, Kansas farms' ability to maintain relative characteristics, practices, and management performances in the 2001 to 2010 period can be used to suggest how feasible it will be for farms to maintain them in the future.

The more feasible a relative attribute is to maintain the more farms should weight the relative net income per acre affect. A relative attribute may have a low coefficient, but if it is a safe bet, farms should give the relative attribute more weight. The feasibility analysis suggests farms will be able to maintain the attribute over time and therefore maintain the relative net income per acre. Therefore this presents a valuable and feasible opportunity for farms to distinguish their net income per acre from other operations across time.

The less farms can expect to maintain a relative attribute the more farms should discount the relative net income per acre affect. A relative attribute may have a high coefficient, but it is unlikely farm will benefit from it in the future because it is unlikely they will maintain it. The feasibility analysis shows that whether farms maintain the relative attribute is significantly out of the farms hands (i.e., it is quite random). Because farms cannot expect to maintain it across time

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(i.e., it is more random), focusing on distinguishing it from the average provides less of a value opportunity. Because farms relative net income is more relevant across time, farms should discount the coefficient on attributes that are less feasible to maintain.

Farms could use their own individual performance in the 2001 to 2010 period to assess the feasibility of maintaining their relative attributes in the future. If a farm was able to maintain their relative size or higher than average yields, the might expect to maintain these relative attribute again. However, the performance of an individual farms does not account for all the circumstances that farms could face in the future. Farms might have maintained a relative attribute in one period, but give different circumstances in the next period they might not be able to. Farms might have luckily come across opportunities to rent land and experience favorable weather events in the 2001 to 2010 period, but will likely not see such favorable circumstances again. The performance of the 433 farms in the 2010 period includes the performance of farms that worked through many different circumstances--favorable and unfavorable. Therefore, how well the entire sample performed for each attribute gives a broader, unbiased analyze of the feasibility of achieving the particular outcome across time. Farms can use the performance of the sample of farms to more realistically asses how likely it is they maintain a relative attribute and source of relative net income in the future.

Chapter 8 - Data

Data Sources

The main source of data for this research is the Kansas Farm Management Association (KFMA) database. The KFMA staff, which includes approximately 20 extension economists, collects, analyzes, and disseminates farm level information for producers across the State of Kansas. They provide relevant information and consultation to Kansas farmers. Information from Farm Characteristic, Accrual and Cash Expense and Receipts, Crop Production Items, and Miscellaneous Farm Income are used to calculate specific categories of management performance on the farms—from costs per acre to yields to prices received.

Historical K-State Farm Management Guides are used to generate expected crop costs. Since 1974, the Department of Economics and Extension at Kansas State University has annually published crop enterprise budgets in the *Kansas Farm Management Guides*. Historical farm crop costs for non-irrigated and irrigated crops are used to predict expected crop cost in each KFMA region for the following year. The crop budgets for 2010 were published in October of 2009. The guides are a reliable and consistent source of historical cost of production information.

The Kansas branch of NASS (National Agricultural Statistics Service) collects data alongside and with the help of the Kansas Department of Agriculture. Kansas NASS provides average crop price and yield information for every county in Kansas. These prices and yields are used to calculate price and yield expectations that are used to evaluate the marketing and yield management abilities of farmers.

Data Checks

This research had access to 740 farms with 10 years of recorded information in the Kansas Farm Management Association (KFMA) database. As shown in Table 8:1, farms are

from six KFMA regions. Over a third of the farms are from Southeast Kansas (289), while there

are only 83 farms from Western Kansas. These farms have continuously reported crop and/or

livestock enterprise information to the KFMA and their information is graded 'usable' by

extension economists. Farms are required to have ten years of complete and accurate

characteristics, production, and financial information. The data requirements increase the

accuracy of the analysis.

Table 8:1 Distribution of Farms by KFMA Region before Data Filters

Region	Number of Farms*	Share of Sample
North Central (NC)	146	18%
South Central (SC)	137	17%
Southwest (SW)	40	5%
Northeast (NE)	139	18%
Northwest (NW)	43	5%
Southeast (SE)	289	36%
Total	794	100%

*Each farm has ten years of observations.

Each farm's information is used in the calculation of other farm's explanatory variables.

This research is a comparison-based analysis where farm characteristics and management

performances are compared to those of 'neighboring' farms. Farms in the same KFMA region

are considered 'neighbors.' Each farm's information (i.e., size, share rented acres, production

costs, and yield performances) are used to calculate average characteristics and management

abilities in a particular region. These region averages are used to measure how farms

differentiate themselves from the average farm in their region and the value of specific types of

differentiation--from farm size to cost management to marketing ability. Through these region

averages, one farm's inaccurate data will affect the differentiation calculations of all farms in

their region.

Two Stage Data Filtering Process

Two stages of data checks are performed: 1) preliminary data check, 2) explanatory variable data check. Preliminary and explanatory variable data checks are executed to reduce the sample to set of crop producing farms that have accurate of farm characteristic, production information, and financial data.

There are approximately 140 pieces of information used to quantify farm characteristic, production practice, and management performance variables. In the preliminary data check, the accuracy of these individual pieces of information is checked. The effectiveness of the analysis is partly a function of the accuracy of farms' recorded planted acres, grain crop incomes, crop seed expenses, bushels of wheat, the value of crop production, and other information. Starting with the farmer and extension officer entering data and ending with information being input into the SAS model, there are multiple places where information can be miss-calculated or entered incorrectly. Missing planted acres, negative crop incomes, unbelievable high yields, and negative expenses are identified and checked to mitigate the probability of including farms with data errors. Most farms with inaccurate data were eliminated from the sample, while some information is modified using data estimations processes.

In the second stage of data checks, potential outlier explanatory variables are identified and analyzed. The preliminary data requirements assure that farm information is within logical bounds--accounted for planted acres, positive total crop income and crop expense, etc.--but this along does not guarantee it accuracy. Explanatory variables are also checked to affirm that accuracy of information. Multiple pieces of farm level data are combined to calculate explanatory variables. Taking total crop production costs per planted acres as an example, whole-farm seed costs, labor costs, and machines cost may appear to be reasonable, but when

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combined and normalized by dividing by planted acres, it may become apparent costs are inaccurate. The preliminary data checks assure that farms with reasonable data and the explanatory variable check further reduces the probability inaccurate data exists in the sample.

Data Filter Results

The two stage filter process reduces the sample size by 41 percent to 433 farms. The majority of the sample was eliminated by farm type filters. Each farm in the sample is required to allocate at least of 50 percent of their labor to crop production and plant at least 50 percent of their crop land to wheat, milo, soybeans, corn, and/or alfalfa. Out of 740 farms, only 580 farms fit these description criteria. A larger set of farms are also eliminated for negative or missing accrual crop income, crop production expenses, and machine depreciation information. Only 445 farms remained after the preliminary data checks. A significantly smaller set of farms was eliminated by the explanatory variable data checks. One farm is eliminated for inaccurate planted acres information and eleven farms are eliminated for questionable information about the value of crop production.

Table 8:2 Distribution of Farms by KFMA Region after Data Filters

Region	Number of Farms*	Share of Sample
North Central (NC)	91	21%
South Central (SC)	94	22%
Southwest (SW)	17	4%
Northeast (NE)	76	18%
Northwest (NW)	20	5%
Southeast (SE)	135	31%
Total	433	100%

*each farm has ten years of observations

The remaining farms are believed to have ten years of accurate crop production, crop income, and crop expenses information. As Table 3.2 shows, the distribution of farms across regions does not change significantly. The largest shares of farms are still in the SE, while the

smallest shares of farms are in the Western KFMA regions. A detailed, step by step description

of the preliminary and explanatory variable data checks can be found in Appendix B.

Chapter 9 - Results

There are three sets of results: Econometric, Standard Deviation, and Consistency. Each constitutes a different perspective of farm's relative attributes. The econometric results identify the significance of relative attributes in determining farming relative net incomes: both cumulatively and individually. The standard deviation results measure the degree farms can expect to distinguish their attributes from the local average and the value of being in the top $1/3^{rd}$ of farms for each attribute. The consistency results quantify how feasible it for farms to maintain each relative attribute across time and therefore can be used to weight the likelihood farms will be able to maintain these sources of relative net incomes per acre across time. The results of each section will be discussed individually and then the three sections will be combined to give a brief overview of the farms ability to achieve higher relative net incomes per acre.

Value of Relative Characteristics, Practices, and Management Performances

The relative net income of 433 Kansas farms is regressed over their relative characteristics, practices, and management performances. The OLS model uses the variability of relative net income per acre and relative attributes in the sample to estimate the affect each relative attribute on relative net income per acre. The difference between farm income and attributes are measured locally in order to account for the differences between the production environment and agricultural economies farms grow crops within. Relative net incomes and relative attributes are analyzed over a 10-year period to mitigate the affect random events have on distorting farms relative performance. An analysis of Pearson-Correlation coefficients and graphs of residuals indicate that auto-correlation and heteroscedasticity were not significant. Graphs of residuals against region, farms size, and crops share can be found in the **Appendix C**.

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Econometric Results

The results of the regression are shown in Table 9:1. The adjusted R-Squared statistic is equal to 0.40. Given variability of the sample's relative attributes, the model explains 40 percent of the variability of farm's relative net incomes per acre. The other 60 percent of the variability that is not explained could be the result of differences in soil resource quality, rainfall levels, tactical management abilities, other factors not included in the model. A number of the estimated coefficients are statistically significant, indicating that relative attributes, which represent the different ways farms access resources, style of crop production, and management focuses, do play a significant role in determining farm net income per acre relative to the local average (i.e., other farm operations).

Farm size, share of rented acres, the value of overhead and equipment investment per acre, government payments, planting intensity, risk, and cost, yield, and price management focuses were significant at the 0.05 level. In regards to farm size, the results suggest the value of discounted input costs and lower fixed cost per acre outweigh potential diseconomies of scale, including additional transportation costs and time scarcity. The significance of farms size with workers per acre and equipment costs in the model, suggests superior management abilities and bargaining power may also equate to improved net income for large operations.

Surprisingly the tillage index is not significantly related to high net income, suggesting that the substitution of chemical costs for fuel and labor expenses did not result in higher net income. Given how the tillage index is calculated, farms use generic herbicides could impacts the measuring of the tillage index. Thus, operations that use no-till practices may achieve higher net income, but the model may fail to accurately capture farms use or non-use of these practices and therefore accurately measure their effect on relative net income per acre.

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Farms that had lower than expected costs, higher than average yields, and higher than average prices achieve higher than average net income per acre. All three management variables are significantly related to relative net income per acre. To the degree farms have to spend more money on inputs, and therefore have higher costs, to achieve higher yields, there might be a trade-off between cost management and yield management. And, despite the difficulty of beating the market, farms that do sell crops at higher prices achieve higher net incomes per acre. In other words spending time marketing crops did not detract enough from other areas of the business to mitigate the effect of achieving higher than average prices.

Table 9:1 Regression Results

Coefficient	Estimate	Std.	T-Statistic	P-Value
Intercept	0.000	1.481	0.00	1
Farm Characteristics				
Main Crop Acres	0.077 **	0.034	2.29	0.022
Rent	0.146 **	0.054	2.71	0.007
Workers per Acre	-0.230 **	0.056	-4.10	<.0001
Over Head and Equipment Investment	-0.042	0.045	-0.92	0.357
Custom Costs	-0.015	0.015	-0.94	0.347
Government Payments	0.341 **	0.072	4.71	<.0001
Farm Practices				
Specialization Index	-0.080	0.072	-1.10	0.270
Planting Intensity	0.411 **	0.133	3.08	0.002
Tillage Index	0.052	0.046	1.13	0.260
Seed Costs	-0.037	0.072	-0.51	0.608
Risk	0.128 **	0.057	2.26	0.024
Management Abilities				
Costs	-0.462 **	0.150	-3.08	0.002
Yields	0.915 **	0.123	7.39	<.0001
Prices	0.689 *	0.251	2.75	0.006
Observations	433			
R-Square	0.42			
Adjusted R-Squared	0.40			
F-Statistic	21.20 (p-value <.0001)			

*significant at the 0.10 level
**significant at the 0.05 level

Interpreting Coefficients

In Table 9.1 each estimated coefficient is equal to $/acre relative net income per acre farms will achieve for distinguishing an attribute one percent from the local average. As an example, farms that are one percent larger than the local average (Main Crop Acres), all else equal, will have a net income per acre that is $0.08/acre higher than the local average. As another example, if farms increase their relative planting intensity by one percent, holding all variables unchanged, relative net income per acre would increase by $0.41/acre.

When interpreting the results it is important to keep in mind that the characteristics, practices, and management performances that farms need to have to achieve a one percent change are different in each KFMA region. Relative attributes are equal to the percent difference between a farms attribute and the local average. Table 9:2 shows average value and the resulting amounts required to achieve the one percent change for several attributes in the different KFMA regions. The variability of farms suggests a farm will have to be 11.7 acres larger than average in NE Kansas versus 17.0 acres larger than average in SC Kansas to achieve the $0.08/acre relative net income per acre. Therefore, while the $/acre effect for each relative attribute is the same, the specific attribute or change required to achieve that will be unique to each region.

Each of the relative attributes is equal to percent difference from average to account for differences across KFMA regions. This normalizing process allowed the farms across different KFMA regions to be used to measure the value of the various attributes. The relationships between relative attributes and relative net income per acre are assumed to be equivalent across regions after normalizing relative characteristics, practices, and management performances by region averages. Therefore, the significance of coefficients and each variable can be used to suggest their importance to farms relative performance.

Table 9:2 Region Averages

Region	Farm Size		Planting Intensity		Costs ($/acre)	
	Avg.	1%	Avg.	1%	Avg.	1%
Northeast	1,169	13.6	0.15	0.001	164.9	1.65
Southeast	1,363	13.6	1.02	0.010	139.5	1.39
North Central	1,088	10.9	0.90	0.009	131.9	1.32
South Central	1,697	17.0	0.94	0.009	137.0	1.37
West	1,356	13.6	0.62	0.006	166.7	1.67

Degree of Relative Characteristics, practices, and Management Performances

For each attribute, the standard deviation is calculated where each sample of relative attributes include those of 433 farms located across Kansas' six KFMA regions. Relative attributes are measured locally and therefore the standard deviation measures the variability of farms attribute within each of the production regions and agricultural economies in Kansas. The larger (smaller) the standard deviation the larger (smaller) the differences in farms attributes within each particular region. The difference in farm attributes within KFMA regions is used for two purposes. First to assess the degree farms can expect to distinguish themselves from the local average. Second to show the relative net incomes farms will achieve for being in the top $1/3^{rd}$ category of each relative attribute.

Standard Deviation Results

The standard deviation of each relative attribute is shown in Table 9.3. The standard deviation of farm size is 55.97 percent, specialization 23.73 percent, and yield management 13.06 percent. The larger the standard deviation, the more farms can distinguish themselves from the local average. The large standard deviation of rent share shows that farms are capable of owning or renting more of their acres. The smaller the standard deviation suggests farms do not distinguish themselves from the local average. The small standard deviation of planting intensity suggests that farms choose not to distinguish the production practice from the local average. The small standard deviation of yield suggests that farms are not capable of distinguishing this management performance from other local operations to a large degree.

Table 9.3: Standard Deviations of Relative Attributes

Variable	Mean*	Standard Deviation
Relative Farm Characteristics		
Size	0.00	55.97
Share of Rented Acres	0.00	36.29
Workers per Acre	0.00	39.02
Over Head and Equipment Investment	0.00	42.75
Custom Hire Costs	0.00	96.67
Government Payments	0.00	29.54
Relative Farm Practices		
Specialization Index	0.00	23.73
Planting Intensity	0.00	14.06
Tillage Index	0.00	39.30
Seed Costs	0.00	26.44
Risk	0.00	42.86
Relative Management Performances		
Costs	0.00	18.04
Yields	0.00	13.06
Prices	0.00	6.49
Relative Net Income		
Profit	0.00	40.34

433 observations in the sample

*because each variable represents the difference from the average, the average variable is equal to zero by definition
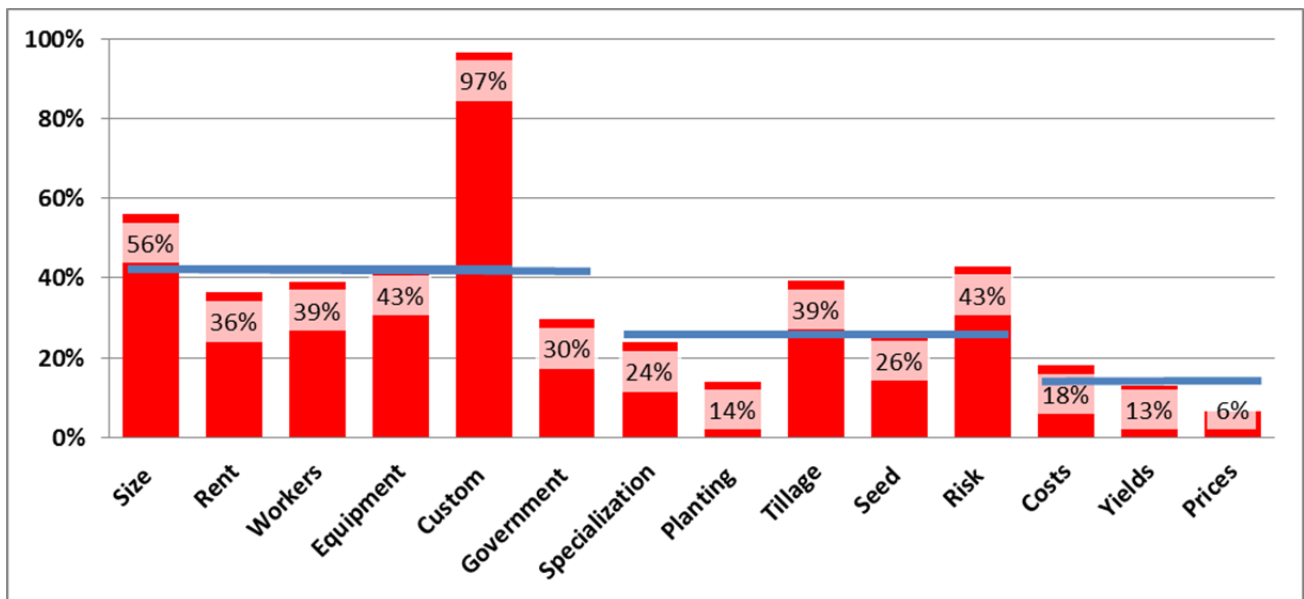
Comparing Standard Deviations

The results show that farms have distinguished their relative characteristics from the local average to the largest degree and management performances to the least degree. Figure 4 gives a visual representation of standard deviation results for all relative attributes. The standard deviations of relative characteristics are around 40 percent, relative practices are around 30 percent, and relative management performances are around 15 percent.

These results support the theory that farms are capable of successfully accessing resources differently than other operations (achieving large relative characteristics), while it might be difficult for farms to distinguish their production practices from the local average given well known best practices. The results also support the theory that given the importance of cost

and yield management and difficulty beating the market, farms are not as capable of distinguishing their management performances from the local average to a large degree.

In summary, the degree farms have distinguished themselves from other farms for each attribute suggests that farms can expect to distinguish their characteristics from the local average more so than they can expect to distinguish their practices and management performances.

Figure 4: Standard Deviation of Relative Attributes

Standard Deviation and Econometrics

The purpose of achieving differences in relative attributes is to identify a net income per acre difference associated with outperforming other operations. In this regard farms can focus on distinguishing an attribute to a larger degree than other operations (i.e. being in the top 1/3rd of operations for a particular attribute). The standard deviation results are combined with the econometric analysis to show the $/acre relative net income farms would achieve for being in the top 1/3rd of all producers. The calculation of the $/acre effect of being in middle of the top 1/3rd of farms for each attribute is shown in Table 9:3. Coefficients are taken from the estimated econometric model and equal the $/acre effect of a one percent change in a relative attribute,

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holding all other relative attributes equal to zero. The estimated coefficients are then multiplied

by the positive or negative standard deviation of their respective variable, as it aligns with the

higher net income per acre. The resulting products in the right column are approximately equal to

the $/acre effect farms would achieve if they were in top 1/3rd of farms for particular attribute.

Table 9:3 Top 1/3rd Farmers

Variable	Coefficient	Standard Deviation	$/acre Result
Characteristics			
Size	0.08	55.97	4.48
Rent	0.15**	36.29	5.44
Workers per Acre	-0.23**	-39.02	8.97
Over Head and Equipment Investment	-0.05	-42.75	2.14
Custom Costs	-0.01	-96.67	0.97
Government Payments	0.34**	29.54	10.04
Practices			
Specialization Index	-0.08	-23.73	1.9
Planting Intensity	0.41**	14.06	5.76
Tillage Index	0.05	39.30	1.96
Seed Costs	-0.04	-26.44	1.06
Risk	0.13**	42.86	5.57
Management Performances			
Total Costs	-0.46**	-18.04	8.30
Yields	0.90**	13.06	11.75
Prices	0.69*	06.49	4.48

*significant at the 0.10 level

**significant at the 0.05 level

Figure 5 reports the $/acre farms can expect to achieve for being in the top 1/3rd of farms

for each of the attributes. The results assume that all other relative attributes are equal to zero. A

farm that was in the top 1/3rd of farms in terms of relative size, or distinguished their size from

the local average more so than 84.2 percent of farms, would achieve a $4.48/acre relative net

income per acre. A farm in the top 1/3rd of farm's in terms of cost, or distinguished their cost

management performance below the local average more than 84.2 percent of farms, would

achieve relative net income per acre advantage of $8.30.

Farms in the top 1/3rd of farms in relative workers per acre, government payments, and cost and yield management performances achieved higher relative net income per acre. While the value of being in the top 1/3rd of producers in term of size is not very large, larger farms have fewer workers per acre. Therefore, as result of being in the top 1/3rd of farms for size, they might also benefit from being in the top 1/3rd of workers per acre--a valuable outcome. The $/acre outcome of receiving higher government payments is surprising, but could be explained by the large disaster payments farm received in 2001 and 2002 due to spring frosts. Farms that qualified for disaster payments could have achieved significantly higher net income per acre. It is also important to note that the value of being in the top 1/3rd of price managers is less than being in the top 1/3rd of cost and yield managers. Farms might be better off focusing on controlling cost and managing yields than trying to beat the market.

Figure 5: Impact of being in the Middle of the Top 1/3rd of Farms
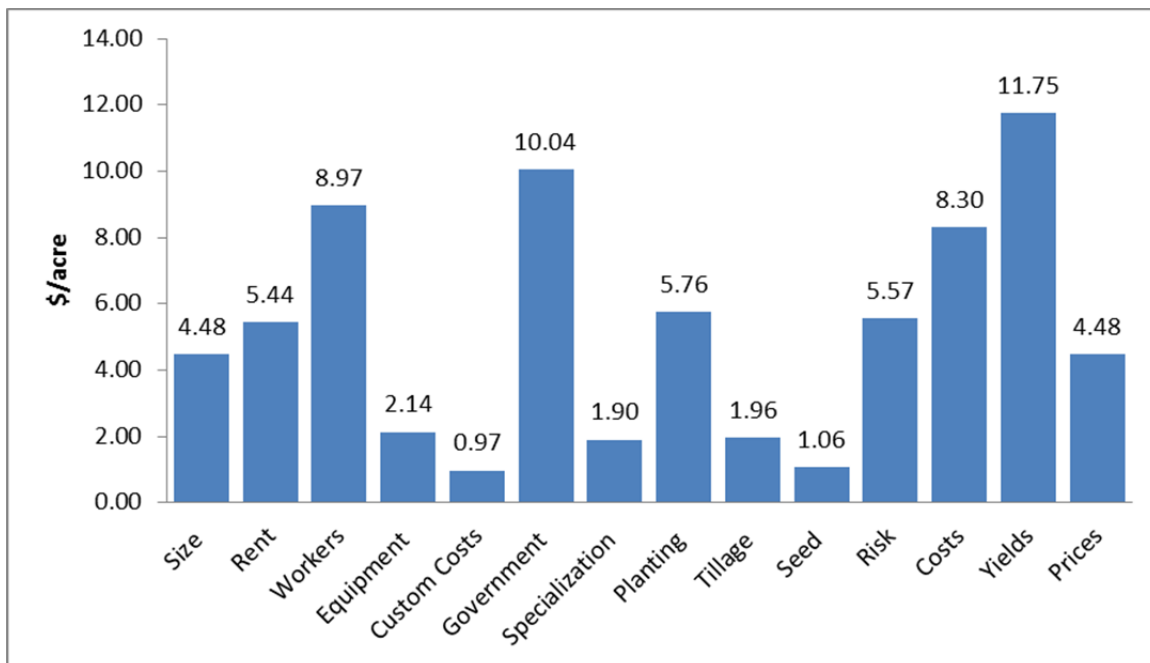
It is important to note the difference between the $/acre effect of being one percent different than the local average and being in the top 1/3rd of producers for an attribute. The top 1/3rd analysis accounts for the degree farms can distinguish themselves from the local average.

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Taking relative renting shares and relative planting intensity as an example, the estimated coefficient for relative rent share is $0.08/acre and relative planting intensity is $0.43/acre which equates to the $/acre effect of a one percent difference from the local average. These results suggest farms should focus on changing their relative planting intensity to achieve the largest possible relative net income per acre affect.

However, looking at the results of being in the top 1/3rd of farms for planting intensity, both variables have similar outcomes: $5.44/acre for renting share and $5.76/acre for planting intensity. While farms will achieve a higher relative net income per acre for changing their relative planting intensity one percent, farms cannot expect to distinguish this relative to a large degree, as shown by its low standard deviation in Table 9.4. On the other hand the small value of an incremental change in relative rental share is made up for by the large degree farms can distinguish it from the local average.

In summary, the top 1/3rd analysis accounts for the value of an incremental difference from the local average and the degree farms can expect to distinguish themselves from the local average. Just because the relative net income per acre for being one percent different from the average is large, does not mean that farms will achieve an equally large net income for being in the top 1/3rd of farms.

Consistency of Relative Characteristics, Practices, and Management Performances

The consistency of 433 Kansas crop farms performances is used to assess how feasible it is for farms to maintain their relative attributes across time. Hypothesis testing is used to determine if each farm did or did not maintain each of their relative attributes over the 2001 to 2010 time period. The more farms that maintain a relative attribute over the period is evidence

that it feasible for farms to maintain it across time. Similarly, the fewer farms that maintain a relative attribute is evidence that an attribute is more random (i.e., less consistent) over time. The sample of 433 Kansas farms includes farms with different resources and management expertise that worked through different circumstances in the 2001 to 2010 time period. Therefore, the total share of farms maintaining an attribute over the 10-year period is used to make a general assessment of the feasibility of maintaining each attribute across time.

Results - Characteristics

The performance of farms over the 2001 to 2010 period suggests that it is feasible for farms to maintain their relative characteristics. As shown in Figure 6 the majority of farms remained larger or smaller than average, consistently rented a larger or smaller share of acres than average, and maintained their relative equipment investments per acre. Even as the average farm size increased from about 1,200 acres to 1,400 acres and investments per acre from $124/acre to $227/acre, only 14 and 27 percent of farms did not maintain their relative size and investments per acre, respectively. Resource constraints may prevent farms from passing other farms on these industry trends.

Also, some farms that are smaller than average may not have a growth objective, therefore it may not be difficult for farms to maintain this relative size over time. This may also explain why a large shares of farms maintain their relative rent shares, workers per acre, and custom work make be explained by the same theory. Because farms preferred to maintain their particular characteristics, or in other words not change the way they have farm historically, it was not difficult for all farms to maintain these relative attributes.

Figure 6: Consistency of Farm Characteristic Attributes over the 2001 to 2010 Period
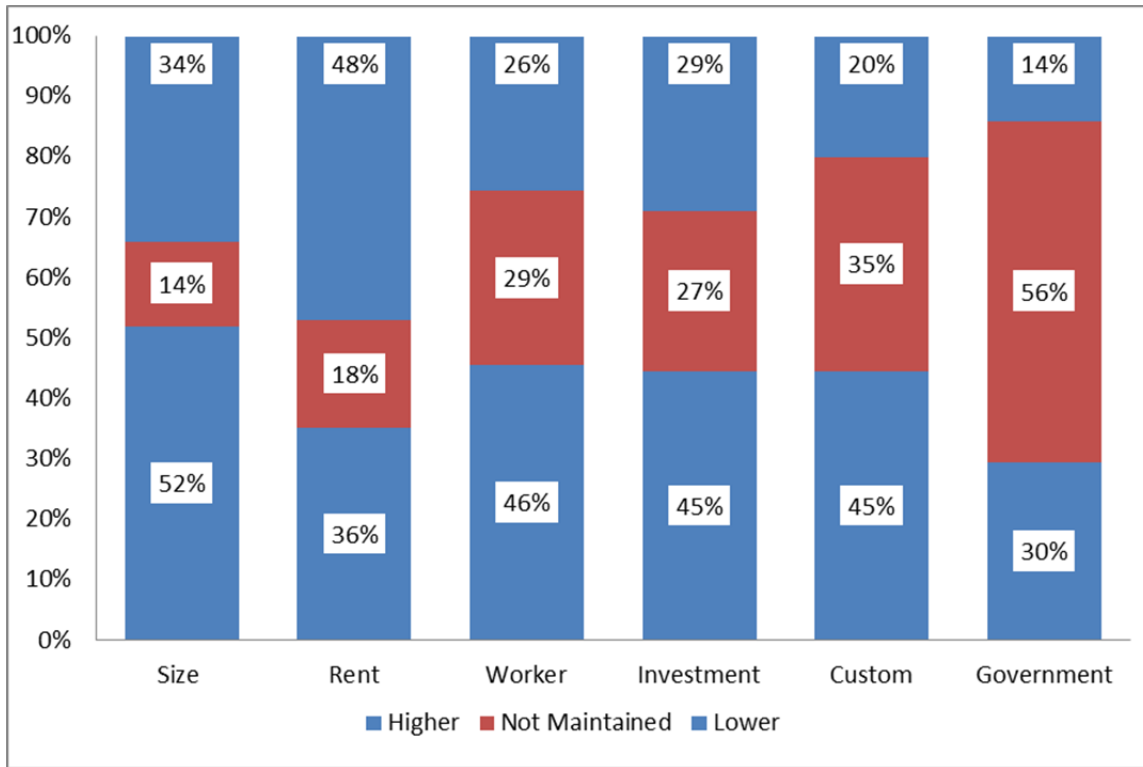
Surprisingly farms did not tend to receive more or less than average government payments over time. To the extent that government payments, such as Direct Payments, are fixed and based on historical production, it would be expected that producers' level of government payments, relative to other farms, would be persistent from year to year. That is, producers that receive higher government payments because of strong historical base acres and yields would be expected to consistently receive higher payments than farms with weaker bases and yields. The 56 percent of farm that neither consistently received higher or lower government payments suggests disaster payments are made often enough where farms do not consistently receive more or less payments form the government. The frosts of 2001 and 2002 might be distorting the analysis, as many farms received disaster payments in those years.

Results - Practices

Perhaps slightly less than relative characteristics, it is feasible for farms to maintain their relative practices. As shown in Figure 7 the majority of farms maintain their relative practices over the period: including 65 percent for specialization, 60 percent for planting intensity, and 54 percent for tillage. The average attributes for these variables did not change significantly across Kansas. Between 2001 and 2010, the average specialization index increased from 0.42 to 0.46 and the average planting intensity increased from 0.90 to 0.91. The small change in average practices and the majority of farms that remained either above the average or below the average suggests many farms have practice preferences that do not change over time.

It is important to note that compared to relative characteristics, more farms did not maintain their relative practices. Related to the theory proposed for the difficulty of maintaining relative management performances, the different and particular circumstances that farms face each year may prevent them from maintaining their relative attributes. Outside industry trends, the variability in farm production environments might prevent them from maintaining relative practices over time--explaining 35, 39, and 46 percent of farms that did not maintain their relative specialization, planting intensity, and tillage practices, respectively, over the 2001 to 2010 period.

Figure 7 : Consistency of Farm Practices Attributes over the 2001 to 2010 Period.
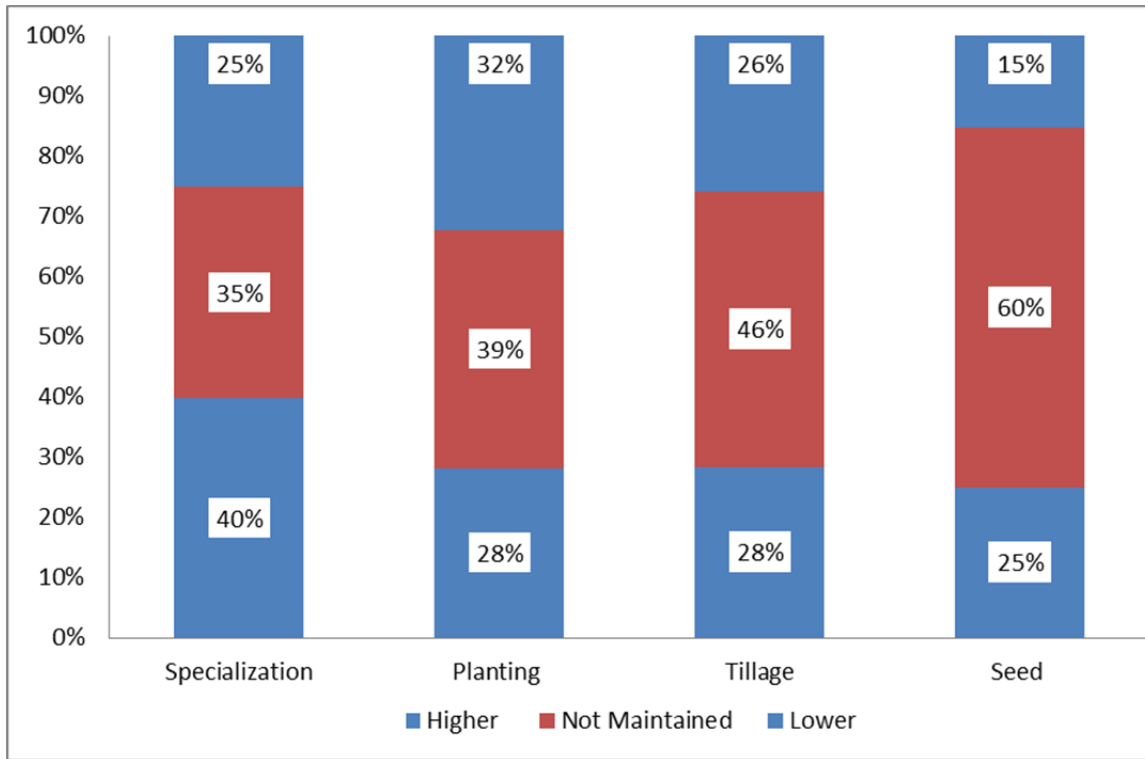
The results suggest farms generally did not maintain their relative seed cost over the period. The majority of farms, 60% percent, did not maintain higher or lower seed costs than the average farm in their KFMA region. Between the beginning and end of the 2001 to 2010 period, the average seed cost per acre increased from $14.24/acre to $35.85/acre. The increase in average seed costs illustrates the industry movement to more expensive seed varieties. The results of the consistency analysis suggest that farms using less expensive seed varieties than other farms at the beginning of the period were using more expensive seed varieties at the end of the period. In other words there was leaping frogging going on: farms behind the industry trend took greater risks and adopt new seed technology more quickly than operations previously ahead of them on the industry curve.
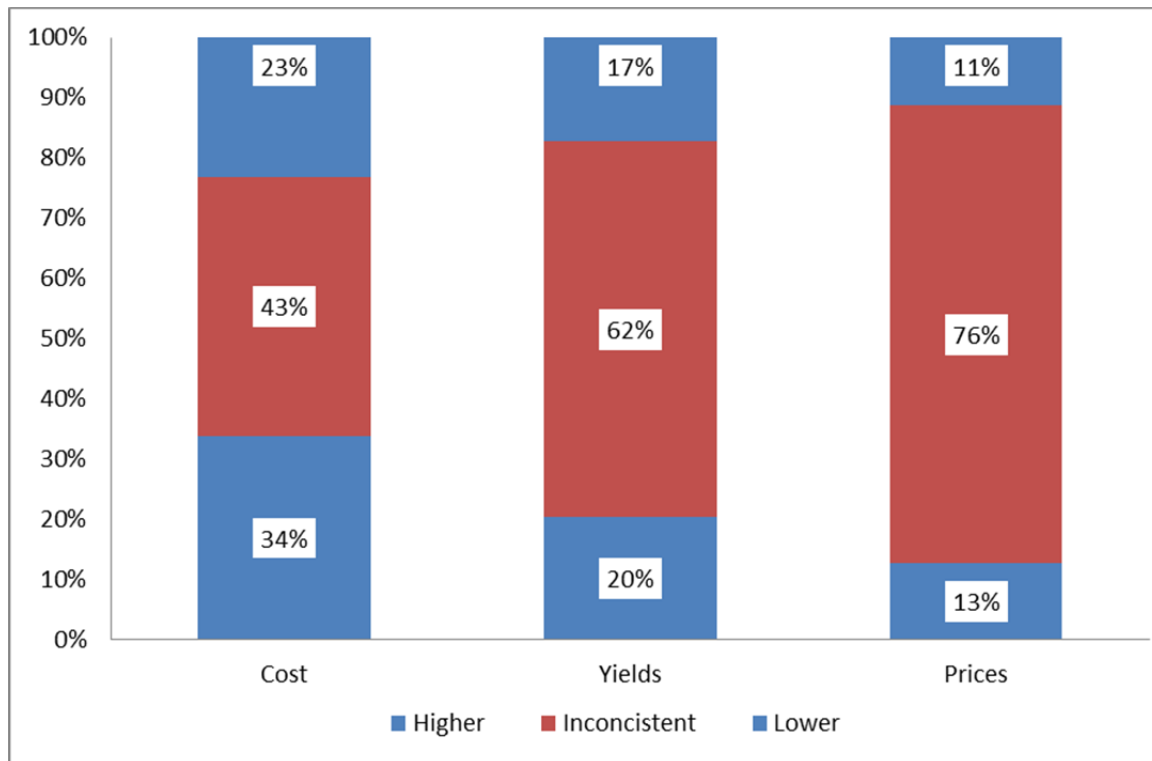
Results - Management Performances

The performance of farms suggests relative cost performances were the most feasible to maintain and relative price performances the least feasible to maintain. Despite year-over-year changes in production and market environments, the 57 percent of farms maintained higher or lower than average costs--suggesting that it is generally feasible for farms to maintain (Figure 8). Nevertheless, the 43 percent of farms with inconsistent performance suggests that there is a significant amount of randomness in farms relative cost management performance and therefore they are difficult to maintain.

Despite farms' efforts, few farms were able to maintain the preferred outcomes as 62 and 76 percent farms did not maintain their relative yield and price management performances, respectively. The year-to-year changes in climate and the local weather events make it difficult for farms to maintain their relative yield performances. Changes in the commodity market environments and the difficulty of beating the market make it difficult for farms to maintain their relative price management performances. The randomness of farms relative management performances is shown by the large share of farms with inconsistent relative management performances.

In summary few farms maintain their relative cost, yield, or price management performance over the 2001 to 2010 time period. However, out of the three, relative cost management was the most feasible relative attribute to maintain.

Figure 8: Consistency of Farm Management Performance Attributes over the 2001 to 2010 Period.

Comparing the Consistency of Relative Attributes

Generally speaking it was more feasible for farms to maintain their relative characteristics than their relative practices and management performances (Figure 9). The barriers to change and different preferences of farms enabled the largest shares of farms to maintain their relative characteristics. Many farms also maintained relative practices, but fewer than relative characteristics. There are fewer or smaller barriers to change in relative practices and therefore it is easier for farms to surpass others on industry trends. Also relevant, year-to-year changes in weather and pest problems, combined with the unique circumstances faced by each farm, might prevent farms from maintaining their relative practices.

The least feasible attribute for farms to maintain are relative management performances. The different environments that farms work through and the unique weather and pest problems

that all farm face makes it difficult for farms to maintain their relative attribute across time.

Farms might have had lower costs, higher yields, or higher prices in the 2001 to 2010 time

period, but it is not certain if they will be able to achieve the same result in the future.

Figure 9: Share of Farms with Consistent Relative Attributes
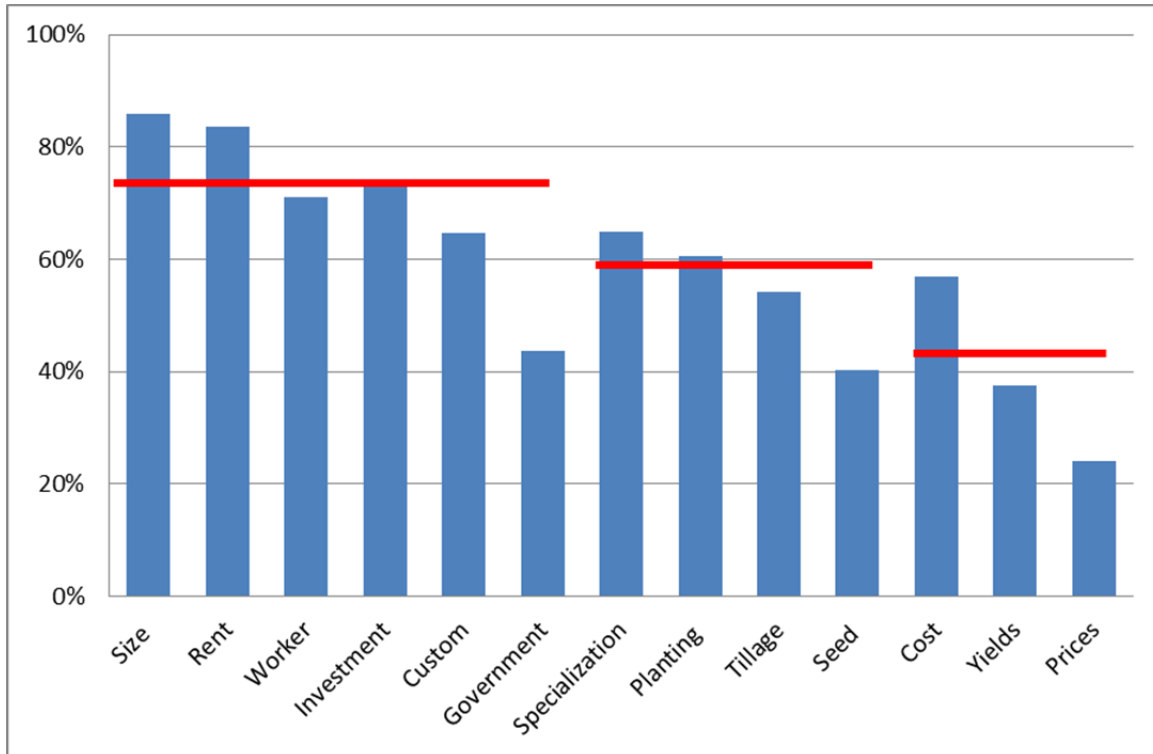
Consistency and Econometrics

The consistency results can be crossed with the econometric model results to shed light

on sources of relative net income per acre that farms are likely to maintain across time. The

econometric results identify sources of relative net incomes per acre. However, it important for

farms to maintain their relative net income per acre in order to be positioned to be competitive in

land markets, to outlast other operations through periods of unprofitability, and to produce crops

at long run equilibrium prices. Therefore farms should weigh the significance and value of

relative attributes by the feasibility of maintaining them across time. Table 9.4 shows regression

and consistency results. The share percentages in the right hand column are equal to share of farms that were either consistently below or above the local average.

Table 9:4 The Value and Consistency of Relative Attributes

Variable	Coefficient	Consistently Different
Farm Characteristics		
Main Crop Acres	0.08 **	85.9%
Rent	0.15 **	83.3%
Workers per Acre	-0.23 **	71.1%
Over Head and Equipment Investment	-0.05	74.4%
Custom Costs	-0.01	64.7%
Government Payments	0.34 **	43.7%
Farm Practices		
Specialization Index	-0.08	64.9%
Planting Intensity	0.41 **	60.5%
Tillage Index	0.05	54.3%
Seed Costs	-0.04	40.2%
Risk	0.13 **	
Management Abilities		
Costs	-0.46 **	56.8%
Yields	0.90 **	37.6%
Prices	0.69 *	24.0%

*significant at the 0.10 level
**significant at the 0.05 level

It is likely farms will maintain the sources of relative income from relative size and rental share, while slightly less likely farms will be able to maintain their relative planting intensity. More than 70 percent of farms maintained these relative characteristics, as barriers to change and different preferences help farms maintain them. Therefore, larger farms and farms that rent more acres are likely to maintain their $0.08/acre and $0.15/acre relative net incomes per acre for each one percent difference from the local average. A smaller, but large share of farms maintained their relative planting intensities. This suggest farm can maintain their relative attributes, but given practices have few barriers to change farms are less likely to maintain the source of $0.41/acre in relative net income than the relative size or rental effects.

While cost management was maintained by the majority of farms, few farms were able to maintain yields through different climates and few farm were able to consistently beat the market. Only 37.6 and 24.0 percent of farms maintained their relative yield and price management performance, respectively. Therefore, it is unlikely that farms will maintain their source of $0.90/acre and $0.69/acre of relative net income per acre. The significance and value of yield and price management shows that when farms achieve higher than average yields and prices they will outperform other operations. However, the inability for the majority of farms to maintain their yield and price management performances suggest farms will only randomly achieve these sources of relative net income per acre across time.

Results Summary

The results of the Value, Degree, and Consistency are summarized in presented in Table 9:5. Relative size, rental share, workers per acre, government payments, planting intensity, risk, and cost and yield management are attributes that are statistically significant (0.05 level) impacting relative net income per acre. While each coefficient is equal to its marginal effect on relative net income, the value of being in the top $1/3^{rd}$ accounts for the degree farms can distinguish each attribute. To complete the picture, the consistency results quantify the feasibility that farms will maintain any relative attribute across time.

Table 9:5 Results Summary

Variable	Coefficient ($/acre)	Standard Deviation (%)	Top 1/3rd ($/acre)	Consistency (%)
Characteristics				
Size	0.08 **	55.97	4.48	85.9
Rent	0.15 **	36.29	5.44	83.3
Workers per Acre	-0.23 **	39.02	8.97	71.1
Equipment Investment	-0.05	42.75	2.14	74.4
Custom Costs	-0.01	96.67	0.97	64.7
Government Payments	0.34 **	29.54	10.04	43.7
Practices				
Specialization Index	-0.08	23.73	1.90	64.9
Planting Intensity	0.41 **	14.06	5.76	60.5
Tillage Index	0.05	39.30	1.96	54.3
Seed Costs	-0.04	26.44	1.06	40.2
Risk	0.13 **	42.86	5.57	--
Management Performance				
Total Costs	-0.46 **	18.04	8.30	56.8
Yields	0.90 **	13.06	11.75	37.6
Prices	0.69 *	6.49	4.48	24.0

*significant at the 0.10 level

**significant at the 0.05 level

Farms that are larger than average, have fewer workers per acre, and rent more of their land are in good position to maintain relative net income per acre. Barriers to change and different preferences might explain why the majority of farms maintain these relative attributes across time. Farms need access to resources to grow their operations, while many operations may prefer to own their land and use a particular share of workers per acre. In either case, farms that were on the valuable side of average have benefited with higher net income per acre--related to economies of size, lower operating expenses, and a lower cost way to access land. Assuming these advantages last in the future, these farms are well positioned for success.

Farms might be able to quickly increase their relative net income by increasing their planting intensity. The variable's coefficient is significant at the 0.05 level, while the $0.41/acre

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value of one percent change is larger than all relative practices and characteristics. Compared to farms size and rent share it would also be easier to change, as a farm can switch their planting practices relatively quickly. The ease of change relative planting practices is supported by the few farms that maintained their planting intensity over the 2001 to 2010 period. The fewer operations that maintain their relative planting intensity suggest farms can surpass the average on the trend to use acres more intensively.

The results suggest that price management is not a large or sustainable source of relative net income per acre. The relative attribute is significant at the 0.10 level, but the degree farms can expect to distinguish their price management from the average is small. The standard deviation of price management is 6.49 percent; the smallest of all attributes. Partly as a result, the \$4.48/acre higher than average relative net income per acre farms achieve for being in the top $1/3^{rd}$ of marketers is less than the \$8.30/acre and \$11.75/acre relative net income for the same level of performance in cost and yield management. Additionally, only 24.0 percent of farms maintained their relative price management performance over 2001 to 2010. Farms might be able to market their crops at higher prices than other farms in one period, but it is unlikely they will do so consistently over time. Given the value, variability, and consistency of price management performances, farms are likely better off focusing on cost and yield management than price management.

The econometrics results identify the source of relative net income, the degree results indicate the maximum relative net income farms can achieve from each relative attribute, and the consistency results identify the ability of farms to maintain relative attributes across time. These results can be used to support the strategic decision making of farms that are trying to outperform other operations. As back drop to farms vision, mission, and goals, farms should be aware of

how they position themselves for success, the degree they can expect to outperform other

operations, and how consistently they can maintain their sources of relative net income per acre.

Chapter 10 - Conclusion

The main objective of this research was to identify and analyze how farms can distinguish their net income per acre from other operations. There are many ways farms can achieve higher net income, but for this research the focus was on analyzing how farms can distinguish their performance from other farms by producing crops fundamentally differently than other operations. Fundamental differences include how farms access land and equipment resources, plant crops and control weeds, and focus their management efforts differently than other operations. To accomplish this, a set of relative attribute variables were created that measured differences between individual farm characteristics, practices, and management focuses from the average in their local KFMA region.

These variables and farms' relative net income per acre were calculated for 433 farms taken from the Kansas Farm Management Association database. Then, three methodologies were created and executed to quantity the value, degree, and consistency of relative attributes. The purpose of these sections were to first measure how farms could achieve higher than average net incomes by having different attributes than the local average. And, then quantify the degree farms can achieve and how consistency farms can maintain the sources of superior performance.

Data

The main source of data in this research was farm-level data from the Kansas Farm Management Association (KFMA). These data provided a sample of Kansas farming operations whose relative characteristics, practices, and management performances could be analyzed. Farms included in the analysis were required to have 10 years of complete crop and livestock information, allocate at least 50 percent of their labor to crop production, and plant at least 50 percent of their crop land to wheat, milo, soybeans, corn, and/or alfalfa. In total there were 433

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farms from the KFMA data set used in the analysis: including farms from the programs six production regions. Other data used in the analysis included historical crop budgets from Kansas Farm Management Guides and historical yield and price information from USDA NASS. These data were used to estimate farms' expected costs, yields, and prices which were used to calculate relative management variables. All information was checked for accuracy, as the initial sample of 580 farms with 10 years of information was reduced to 433 farms.

Methodology and Results

In the Value section, the relative net incomes of 433 Kansas crop farms were regressed over their relative characteristics, practices, and management performances. This measured whether farms have distinguished their net incomes by farming differently than other operations. Relative net income and relative attributes were averaged over a 10-year period to eliminate random weather events and pest problems from distorting the measure of farms performance. The local differences of farms in six KFMA regions were used to quantify the value of relative attributes. The econometric model was estimated with an OLS regression and White errors were used to mitigate the possible problem of heteroscedasticity.

The adjusted R-Squared of the regression was 40 percent. Farm size, share of rented acres, the value of overhead and equipment investment per acre, government payments, planting intensity, risk, and cost, yield, and price management focuses were all significant at the 0.05 level. The adjusted R-Squared and the significance of individual statistics indicate that relative attributes, which represent the different ways farms access resources, style of crop production, and management focuses, play a significant role in determining farm net income per acre relative to the local average (i.e., other farm operations).

In the Degree section, the standard deviations of farms' relative attributes were used to quantify the degree that farms can distinguish each relative attribute from other operations. The large sample of farms are assumed to have different preferences in terms of how they farm and therefore the degree they are different from one another is representative of the natural bounds of distinguished attributes. For each attribute, the standard deviations of farms' 10-year average relative attributes are computed to measure the variability of each relative attribute across farms. The variability of local differences quantifies the degree farms are different from local average and therefore the degree farms can distinguish each attribute from the local average.

The standard deviation of relative characteristics were about 40 percent, relative practices about 30 percent, and relative management performances about 15 percent. The larger variability of farms' relative characteristics suggests farms distinguish their size, rental share, and other characteristics to a larger degree than other attributes. The small variability of relative management performances suggest farms are only capable of distinguishing their average yield, cost, and management performance from other operations to a small degree. The results suggest the degree farms can distinguish their relative practices lies somewhere in the middle.

In the Consistency section the shares of farms that have consistent relative attributes across time are used to quantify how feasible it is for farms to maintain their relative attributes over time. The sample of 433 farms includes many different operations that worked through many different circumstances over the 2001 to 2010 time period. While any one operation may be able to maintain a relative attribute over a 10-year period, the performance of the 433 farms paints an unbiased picture of how capable farms are at maintaining each relative attribute across time. For each attribute statistical hypothesis testing is used determine the number of farms that did and did not maintain their relative attributes.

About 70 percent of farms maintained their relative characteristics, 60 percent maintained relative practices, and 40 percent maintained relative management performances. The results suggest farms are most capable of maintaining their relative characteristics over time and less capable of maintaining their relative practices and management performances.

Implications

Farms should be aware of how their characteristics, practices, and management performances compare with other operations. The OLS model explained 40 percent of the variability in farms relative net income with a number of relative attributes being statistically significant. This suggests that the way farms access resources, produce crops, and manage their operations impacts how their farm performs compared with other operations. The results also suggest that there are farms in Kansas that are better positioned than others to achieve the highest net farm income possible. Or from another perspective, there are farming operations in Kansas that could improve their performance by fundamentally re-positioning their operations. Given production technology, the agricultural industry environment, and the demand for crops, in regards to the competition with other farms, it is in an individual farms interest to analyze if they have positioned themselves to be as profitable as other operations.

Farms that are actively seeking to distinguish their net income from other operations should be aware of the degree and consistency with which they can maintain differences from other operations. Distinguishing a particular characteristic, practice, or management performance might result in higher net income per acre. However, if farms cannot distinguish an attribute to a large degree, the upside potential of the source of relative net income is limited. Similarly, distinguishing a particular attribute might result in a significantly higher net income per acre, but farms should be aware of how consistently they can maintain differences from other operations.

A distinguished attribute is only valuable as long as farms can maintain it. Therefore, farms should weight the value of relative attributes by the degree they can achieve them and how consistently they can maintain them.

Future Research

This research can be improved by incorporating additional information into the analysis. In the case of the calculation of farms' relative net incomes, the cost of interest and crop insurance should be included in the comparative performance. The cost of borrowing money and the cost of insurance are two key costs in crop production that were left out of the calculation of farms' comparative performance. Similarly, better information about farms tillage practices, input allocation, and the prices farms sell their crops at would improve the analysis. The tillage index, cost management variable, and price management variable require assumptions about the cost of inputs, what crops inputs are applied to, and the prices that farms sell their crops at. The measurement of these variables could be improved with better production level data. Lastly, soil quality and rainfall data could be incorporated in a variable to account for the share of farms performance determine by the quality of their resources and weather events. The incorporation of production environment data might improve the explanatory power and accuracy of the econometric model. In summary the collection of more specific production level information could improve the analysis.

Future research might also look more closely at the assumption that the value of relative characteristics, practices, and management focuses are equivalent across Kansas six KFMA regions. The normalization of relative attributes by local averages is expected to account for differences across the KFMA regions. Still, the econometric model assumes the effect of the percent difference between attributes and the average attribute in the region has the same effect

on relative net income per acre across KFMA regions with different production environments, agricultural economies, and nonagricultural economies. The distribution of error terms across the KFMA regions suggested this was not a problem, but a more thorough investigation might prove otherwise. A Chow Test could confirm or disprove if the value of relative attributes are equivalent across Kansas. If they are not equivalent across regions, the value of relative attributes would need to be analyzed within each KFMA region.

Apart from improving the analysis, the research could be taken one step further, by tracking the value of relative characteristics, practices, and management performances across multiple 10-year periods. Looking at 10-year times periods, incrementally year by year, it could be observed whether the value of relative attributes have changed or remained the same across time. Production technology, the agribusiness industry, and crop markets have and continue to change. With these changes, the value of particular relative attributes may have also changed. If a trend could be identified, this information would be useful for farms to predict what will be valuable in the future. In other words if particular attributes are becoming more or less valuable over time, farms could use this information to make better decisions about how to position their operation to be successful in the future.

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Appendix A - Dependent and Independent Variable Calculations

Dependent Variable - Net Farm Income per Acre

Relative Net Farm Income per Acre

$Relative\ Net\ Crop\ Income\ per\ Acre_{irt}$

$$= Net\ Crop\ Income\ per\ Acre_{irt} - \overline{Net\ Crop\ Income\ per\ Acre_{irt}}$$

$Net\ Crop\ Income\ per\ Acre_{irt}$ is equal to net income per acre of farm i in region r in year t.

$Net\ Crop\ Income\ per\ Acre_{irt}$ is equal to the average net income per acre of all farms in region

r in year t. The detailed of farms *Income* and *Expenses* is shown below.

Total Crop Income

The $Total\ Crop\ Income_{irt}$ for farm i in region r in year t is calculated as:

$Total\ Crop\ Income_{irt} = Grain\ Crop\ Income_{irt} + Hay\ and\ Forage\ Income_{irt} +$

$Cash\ Crop\ Income_{irt} + Governement\ Payments_{irt} + Insurance\ Payments_{irt} +$

$Feedincome_{irt,}$

where accrual crops incomes and cash government payments and cash insurance proceeds were

used to measure total crop incomes. Feed incomes, e_{irt} , is calculated for farms that reported

they had livestock to the KFMA. This variable is calculated as:

$Feedincome_{irt} = Grain\ Feed\ Income_{irt} + Hay\ and\ Silage\ Feed\ Income_{irt}$

$Grain\ Feed\ Income_{irt}$

$$= Grain\ Crop\ Beginning\ Inventories_{irt}$$

$$+ [wheat\ production_{irt} + corn\ productoin_{irt} + miloproduction_{irt}]$$

$$- Grain\ Crops\ Sales_{irt} - Grain\ Crop\ Ending\ Inventories_{irt}.$$

$Beginning$ and $Ending$ inventories, $Crop\ Production$, and $Crop\ Sales$ are in dollars. Grain income is equal to difference between beginning and ending inventories that is not accounted for in wheat, corn, and milo production or by gain sales. The residual value of grain that is not accounted for by production and sales is assumed to equal the value of grain feed to a farm's livestock. This calculation will be affected by changes in prices. An increase in price between the beginning and ending of the account year will overestimate the value of grain fed to livestock. A decrease in prices will underestimate the value of grain fed to livestock.

Similarly, the value of $Hay\ and\ Silage\ Feed\ Income_{irt}$ is also equal to change in hay and silage inventories. This is calculated as:

$$Hay\ and\ Silage\ Feed\ Income_{irt}$$
$$= Beginning\ Hay\ and\ Silage\ Invetories_{irt}$$
$$+ [Alfalfa\ Production_{irt} + Silage\ Production_{irt}] - Hay\ Sales_{irt}$$
$$- Ending\ Hay\ and\ Silage\ Inventories_{irt}.$$

$Beginning$ and $Ending$ inventories, $Production$, and $Sales$ are measured in dollars. As with grain incomes, changes in prices will cause an overestimation or under estimation of hay and silage feed incomes.

Total Crop Expenses

$Total\ Crop\ Expenses_{irt}$ for farm i in region r in year t are equal to:

$$Total\ Crop\ Expenses_{irt} = Cash\ Rent_{irt} + Own\ Land\ Rent_{irt} + Crop\ Labor\ Expenses_{irt} +$$
$$Machine\ Expenses_{irt} + Irregation\ Expenses_{irt} + Seed\ Expenses_{irt} +$$
$$Chemical\ Expenses_{irt} + Fertilizer\ Expenses_{irt} + Marketing\ Expenses_{irt}.$$

Accrual account practices are used to measure all farm i's expenses. For farm i, $Cash\ Rent_{irt}$ is calculated as total cash rent expense multiplied by the percent of rented acres that are planted to crops. Farms in Kansas rent crop and pasture land and in order to value the cost of cash crop land rent the following calculation is perform. The calculation of a farm's crop land cash rent is:

$$Crop\ Cash\ Rent_{irt} = Cash\ Rent_{irt} \times \frac{Total\ Rented\ Crop\ Acres_{irt}}{Total\ Rented\ Crop\ and\ Pasture\ Acres_{irt}}.$$

$Cash\ Rent_{irt}$ is measure by accrual accounting. Farms are also charged a rent on owned land. Charging farms an opportunity cost for owned land effectively analyzes management abilities of farms that do and not crop land. Each farm's own land rent, $Own\ Land\ Rent_{irt}$, is calculated using land prices and rent ratios estimated by Kansas Extension Economists. Each farm i's $Own\ Land\ Rent_{irt}$ is equal to:

$Own\ Rent_{irt} = (Value\ of\ Irrigated\ Crop\ Acres_{irt} \times Rent\ to\ Value\ Ratio_{irt}) +$

$(Value\ of\ Dryland\ Crop\ Acres_{irt} \times Rent\ to\ Value\ Ratio_{irt})$, where $Rent\ to\ Value\ Ratio_{irt}$ estimated by Kansas Extension Economists every five years are used to estimate an irrigated crop and dry land crop land cash rent for owned acres.

Similarly to cash and owned land rents, the cost crop labor costs, $Crop\ Labor\ Cost_{irt}$, needs to be backed out of a farm's recorded total labor costs. Crop labor expenses for farm i in year t is calculated as:

$$Crop\ Labor\ Cost_{irt} =$$
$$Crop\ Labor\ Percentage_{irt} \times (Manager\ Salary_{irt} + Hired\ Labor\ Cash\ Expense_{irt} + Opportunity\ cost\ of\ Family\ Labor_{irt}),$$

Farm i's $Crop\ Labor\ Percentage_{irt}$ is equal to the share of labor spent on crop related activities. The KFMA calculates each farm's crop labor percentage annually and it is based on the amount of crop acres and head of livestock (including dairy, cattle, swine, turkeys....) are

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farm has and on state labor standards. The KFMA's estimated farm manager salary is multiplied by the number of operators to account for the opportunity cost of an operator's unpaid management and labor.

The KFMA data also provides the annual variable, fixed, and opportunity costs of machinery for each farm. A farm i's machinery costs in year t are equal to:

$Machine\ Cost_{irt}$

$$= Repair\ Expesnes_{irt} + Fuel\ Expenses_{irt} + Auto\ Expenses_{irt}$$

$$+ Motor\ Vehicle\ Depreciation_{irt}$$

$$+ Machinery\ and\ Equipment\ Depreciation_{irt}$$

$$+ Net\ Custome\ Hire\ Expense_{irt}.$$

$Net\ Custome\ Hire\ Expense_{irt}$ is equal to farm $i's$ custom expense minus their custom incomes. Farms that provide custom planting, spraying, or harvesting services to other farmers will have underestimated machine costs.

Net Farm Income Discussion

When comparing the performance across farms, it is important to develop measurements that grade different types of operations by their economic performance rather than just their circumstance. Adjusted net farm income per acre is calculated to do that. It accounts for the value of crops fed to livestock, while charging owned land a rent and operator's a salary. Total crop income is calculated as,

$Total\ Crop\ Income_{irt}$

$$= Grain\ Crop\ Income_{irt} + Hay\ and\ Forage\ Income_{irt}$$

$$+ Cash\ Crop\ Income_{irt} + Governement\ Payments_{irt}$$

$$+ Insurance\ Payments_{irt} + Feedincome_{irt}.$$

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Crop, hay, and cash crop incomes are measured on an accrual accounting basis. Due to data availability, government and insurance payments are measured on a cash basis. Feed income is equal to the market value of crops fed to livestock. Total crop expenses are calculated as,

$$Total\ Crop\ Expenses_{irt}$$

$$= Cash\ Rent_{irt} + Own\ Land\ Rent_{irt} + Crop\ Labor\ Expenses_{irt}$$

$$+ Machine\ Expenses_{irt} + Irrigation\ Expenses_{irt} + Seed\ Expenses_{irt}$$

$$+ Chemical\ Expenses_{irt} + Fertilizer\ Expenses_{irt}$$

$$+ Marketing\ Expenses_{irt}.$$

Cash rent, machine, irrigation, seed, chemical, fertilizer, and marketing expenses are measured by accrual accounting. $Own\ Land\ Rent_{irt}$ represents a market value rent charged to farms for land that is owned. $Crop\ Labor\ Expenses_{irt}$ includes a \$50,000 charge for each operator's labor and management. Crop insurance and interest expenses were not included in expenses because this information was not available. The adjusted net farm income is normalized by crop acres planted:

$$Net\ Crop\ Income_{irt} = \frac{(Total\ Crop\ Income_{irt} - Total\ Crop\ Expenses_{irt})}{Plant\ Acres_{irt}}.$$

A farm's $Plant\ Acres_{irt}$ includes all crops planted, whether the acres were harvested or not.

The adjusted net farm income measures the Kansas farms' performance over one production cycle. Government and crop insurance payments are not measured on an accrual basis, but they should fall within a farm's production cycle. All other income and expenses are measured on an accrual basis. Therefore, farms net income represents their performance for one production cycle.

The adjusted net farm income measures each farm's financial performance evenly. The net income measure puts no operation at an advantage or disadvantage compared to other operations. Farms with livestock operations are credited income for crops grown and fed to livestock. Farms that rent and own land are both charged the market cost of land. Farms that rent land have the cost in cash rent expense and farms that own land are charged the market cost of renting land in their KAS region. All farm operations are charged the market value of their labor and management. At the same time no operations are charged interest expenses. The performance of farms that have to pay operating interest is measured the same way as the performance of farms that do not pay any operating interest. To summarize, all operations receive income for the crops they grow and are charged the market cost of land and operator's time.

Independent Variables

Characteristics

Size

$$Relative\ Size_{irt} = \frac{Main\ Crop\ Acres_{irt} - \overline{Main\ Crop\ Acres_{rt}}}{Main\ Crop\ Acres_{irt}} \times 100$$

$Main\ Crop\ Acres_{irt}$ is equal the total acres of irrigate and dryland wheat, milo, soybeans, corn, and alfalfa planted by farm i in year t. $\overline{Main\ Crop\ Acres_{rt}}$ is that average main crop acres of farms in region r in year t

Rent

$$Relative\ Rent_{irt} = \frac{Share\ of\ Rented\ Crop\ Land_{irt} - \overline{Share\ Rented\ Crop\ Land_{rt}}}{Share\ Rented\ Crop\ Land_{rt}} \times 100$$

$Share\ of\ Rented\ Crop\ Land_{irt}$ is equal to share of farm i's total acres were rented.

This is calculated as:

$$Share\ of\ Rented\ Crop\ Land_{irt} = \frac{Total\ Rented\ Crop\ Acres_{irt}}{Total\ Crop\ Acres_{irt}},$$

where $Total\ Rented\ Crop\ Acres_{irt}$ includes all irrigated and dry land rent crop land farm i

rented in year t and $Total\ Crop\ Acres_{irt}$ is the number of acres the farm i planted in year t.

$\overline{Share\ Rented\ Crop\ Land_{rt}}$ is the equal the average share of cropland the farms in region r

rented in year t.

Worker Productivity

$$Relative\ Workers\ per\ Acre_{irt} = \frac{Workers\ per\ Acre_{irt} - \overline{Workers\ Per\ Acre_{rt}}}{\overline{Workers\ Per\ Acre_{rt}}} \times 100$$

$Workers\ per\ Acre_{irt}$ is equal to farm i's number of crop workers per acres in year t. The

number of crop workers farm i had in year t is calculated as:

$$Crop\ Workers_{irt} = Crop\ Labor\ Percentage_{irt} \times Total\ Farm\ Workers_{irt}.$$

Farm i's $Crop\ Labor\ Percentage_{irt}$ which is calculated by the KFMA is used to determine how

much labor was allocated to crop production activities. The KFMA used livestock number, acres

planted to crops, and state labor standards to calculate each farm i's $Crop\ Labor\ Percentage_{irt}$.

Farm i's number of crop workers is then divided the number of their planter acres to calculate

their workers per acre:

$$Workers\ per\ Acre_{irt} = \frac{Crop\ Labor\ Percentage_{irt} \times Total\ Farm\ Workers}{Total\ Planted\ Acres},$$

where $\overline{Workers\ Per\ Acre_{rt}}$ is the average number of workers per acre of all farms in region (r)

in year (t).

Overhead and Equipment Investments

$Relative\ Investment_{irt}$

$$= \frac{Total\ Crop\ Machinery\ Investment\ per\ Acre_{irt} - \overline{Total\ Crop\ Machinery\ Investment\ per\ Acre_{rt}}}{\overline{Total\ Crop\ Machinery\ Investment\ per\ Acre_{rt}}}$$

$\times\ 100$

Farm $i's$ $Total\ Crop\ Machinery\ Investment\ per\ Acre_{irt}$ is calculated as:

$$Total\ Crop\ Machinery\ Investment\ per\ Acre_{irt} = \frac{Total\ Crop\ Machinery\ Investment_{irt}}{Total\ Planted\ Acres_{irt}},$$

where $Total\ Crop\ Machinery\ Investment_{irt}$ is equal to farm i's value of motor vehicles,

listed property, and machinery and equipment that are used for crop production in year *t*.

$\overline{Total\ Crop\ Machinery\ Investment_{rt}}$ is the average crop machinery investment per acre of all

farms in region *r* in year *t*.

Custom

$$Relative\ Custom_{irt} = \frac{Custom\ Share\ of\ Machinery\ Expenses_{irt} - \overline{Custom\ Share\ of\ Machinery\ Expense_{rt}}}{\overline{Custom\ Share\ of\ Machinery\ Expense_{rt}}} \times$$

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Farm $i's$ $Custom\ Share\ of\ Machinery\ Expenses_{irt}$ is calculated as,

$$Custom\ Share\ of\ Machinery\ Expenses_{irt} = \frac{Custom\ Hire\ Expenses_{irt}}{Total\ Machine\ Costs_{irt}},$$

where $Custom\ Machine\ Costs_{irt}$ is equal to farm $i's$ custom hire expenses in year *t* and

$Total\ Machine\ Costs_{irt}$ their total machine costs. $\overline{Custom\ Share\ of\ Machinery\ Expense_{rt}}$ is

equal to average $Custom\ Hire\ Expenses$ of all farms in region *r* in year *t*.

Government Payments

$Relative\ Government\ Payments_{irt}$

$$= \frac{Government\ Payments\ per\ Acre_{irt} - \overline{Goverment\ Payments\ per\ Acre_{rt}}}{\overline{Goverment\ Payments\ per\ Acre_{rt}}}$$

$$\times 100$$

Farm $i's$ $Government\ Payments\ per\ Acre_{irt}$ is calculated as:

$$Government\ Payments\ per\ Acre_{irt} = \frac{Government\ Payments_{irt}}{Total\ Planted\ Acres_{irt}},$$

where $Government\ Payments_{irt}$ is equal to government payments farm i received in year t as

measured by cash accounting. $\overline{Goverment\ Payments\ per\ Acre_{rt}}$ is equal the average

$Government\ Payments\ per\ Acre$ of all farms in region r received in year t.

Farm Practices

Specialization

$Relative\ Specialization_{irt}$

$$= \frac{Crop\ Herfindahl\ Index_{irt} - \overline{Crop\ Herfindahl\ Index_{rt}}}{\overline{Crop\ Herfindahl\ Index_{rt}}} \times 100$$

Each farm $i's$ $Crop\ Herfindahl\ Index_{irt}$ is calculated as:

$Crop\ Herfindahl\ Index_{irt} =$

$$\left(\frac{Wheat\ Acres_{irt}}{Main\ Crop\ Acres_{irt}}\right)^2 + \left(\frac{Milo\ Acres_{irt}}{Main\ Crop\ Acres_{irt}}\right)^2 + \left(\frac{Soybean\ Acres_{irt}}{Main\ Crop\ Acres_{irt}}\right)^2 + \left(\frac{Corn\ Acres_{irt}}{Main\ Crop\ Acres_{irt}}\right)^2 +$$

$$\left(\frac{Alfalfa\ Acres_{irt}}{Main\ Crop\ Acres_{irt}}\right)^2,$$

where $Main\ Crop\ Acres_{irt}$ is the total wheat, milo, soybean, corn, and alfalfa acres planted by

farm i in year t. $\overline{Crop\ Herfindahl\ Index_{irt}}$ is the average $Crop\ Herfindahl\ Index$ of all

farms in region r in year t.

Planting Intensity

$$Relative\ Plant_{irt} = \frac{Planting\ Intensity_{irt} - \overline{Planting\ Intensity_{rt}}}{Planting\ Intensity_{rt}} \times 100$$

Farm i's *Planting Intensity$_{irt}$* year t is calculated as:

$Planting\ Intensity_{irt}$

$$= (Dryland\ Corn\ Acres_{irt} + Dryland\ Milo\ Acres_{irt}$$

$$+ Dryland\ Soybean\ Acres_{irt} + Dryland\ Corn\ Acres_{irt}$$

$$+ Dryland\ Alfalfa\ Acres_{irt}) \times \frac{1}{Total\ Dryland\ Acres_{irt}},$$

where $Total\ Dryland\ Acres_{irt}$ includes rented and owned dry land crop acres.

$\overline{Planting\ Intensity_{rt}}$ is the average *Planting Intensity* of all farms in region r in year t.

Tillage Index

$$Relative\ Tillage\ Index_{irt} = \frac{Tillage\ Preference_{irt} + \overline{Tillage\ Preference_{irt}}}{Tillage\ Preference_{irt}} \times 100$$

Farm i's *Tillage Preference$_{irt}$* in year t is calculated as:

$Tillage\ Preference_{irt}$

$$= \frac{Crop\ Chemical\ Expenses_{irt}}{(Crop\ Chemical\ Expenses_{irt} + Crop\ Machinery\ Expenses_{irt} + Crop\ Labor\ Expenses_{irt})}.$$

Farm i's *Crop Chemical Expenses$_{irt}$* expenses in include their herbicide and pesticide costs in

year t. $\overline{Tillage\ Preference_{irt}}$ is average *Tillage Preference* of all farms in region r in year t.

Seed Costs

$$Relative\ Seed\ Cost_{irt} = Seed\ Cost\ Performance_{irt} - \overline{Seed\ Cost\ Performance}_{rt}$$

The $Seed\ Cost\ Performance_{irt}$ of farm i in year t is measured by comparing a farm's actual seed cost to their expected costs given the crops they planted in year t. Farm i's $Seed\ Cost\ Performance$ is calculated as:

$Seed\ Cost\ Performance_{irt}$

$$= \frac{(Seed\ Cost\ per\ Acre_{irt} - Expected\ Seed\ Costs\ per\ Acre_{irt})}{Expected\ Seed\ Costs\ per\ Acre_{irt}} \times 100,$$

where

$$Cost\ per\ Acre_{irkt} = \frac{Total\ Costs_{irt}}{Total\ Planted\ Acres_{irt}},$$

and

$$Expected\ Main\ Crop\ Cost\ per\ Acre_{irkt} = \frac{Main\ Crop\ Expceted\ Costs_{irt}}{Main\ Crop\ Acres_{irt}}.$$

Farm i's $Main\ Crop\ Expceted\ Costs_{irt}$ are calculated using seed cost information from Kansas Management Guides and information about the farms acres of wheat, milo, corn, soybeans, and alfalfa (including irrigated and non-irrigate). $\overline{Seed\ Cost\ Performance}_{rt}$ is equal to the average $Seed\ Cost\ Performance$ of all farms in region r in year t.

Risk

$$Risk_i = \frac{Net\ Crop\ Income\ Standard\ Deviation_{ir} - \overline{Net\ Crop\ Income\ Standard\ Deviation_r}}{\overline{Net\ Crop\ Income\ Standard\ Deviation_r}} \times 100$$

Farm i's $Net\ Crop\ Income\ Standard\ Deviation_{ir}$ is calculated as:

$Net\ Crop\ Income\ Standard\ Deviation_{ir}$

$$= \sqrt{\frac{(\sum_{t=1}^{10} Net\ Crop\ Income_{irt} - \overline{Net\ Crop\ Income_{ir}})^2}{(10-1)}}$$

where $\overline{Net\ Crop\ Income_{ir}}$ is equal to farm (i)'s average income during the 2001 to 2010 time

period. $\overline{Net\ Crop\ Income\ Standard\ Deviation_r}$ is equal to average

$Net\ Crop\ Income\ Standard\ Deviation$ of farms net income over the ten year period in region

r.

Management Performances

Relative Cost Management Performance

Three steps a necessary to quantify a farm's cost management performance. Because

farms plant different amounts and shares of wheat, milo, corn, soybeans, and alfalfa, farm costs

cannot be compared outright. If this was done, farms that planted more expense crops would

considered to have higher input costs regardless of whether they had lower than expected costs

given their crops mix. Therefore, a farm's costs per acre were compared to a farms expected cost

per acre each year in order to first quantify a farm's cost management performance. Then, the

cost management performances of farms are compared to one another to determine a farms

relative cost management performance in each year.

In reverse order, the steps that are used to determine farm i's *Relative Cost Performance* are listed below. A farm i's *Relative Cost Performance* in year t is calculated as,

$$Relative\ Cost\ Performance_{irt} Cost_{irt}$$

$$= Cost\ Management\ Performance_{irt}$$

$$- \overline{Cost\ Management\ Performance}_{rt}.$$

where $\overline{Cost\ Management\ Performance}_{rt}$ is the average

$Cost\ Management\ Performance_{irt}$ of all farms in region r in year t. A farm i's

$Cost\ Management\ Performance_{irt}$ is measured by comparing their actual costs for

producing a set of crops k with the farm's expected costs for planting a set of crops k. This is

calculated as:

$$Cost\ Management\ Performance_{irt} = \frac{(Cost\ per\ Acre_{irkt} - Expected\ Costs\ per\ Acre_{irkt})}{Expected\ Costs\ per\ Acre_{irkt}} \times 100,$$

where

$$Cost\ per\ Acre_{irkt} = \frac{Total\ Costs_{irtk}}{Total\ Planted\ Acres_{irt}},$$

and

$$Expected\ Main\ Crop\ Cost\ per\ Acre_{irkt} = \frac{Main\ Crop\ Expected\ Costs_{irtk}}{Main\ Crop\ Acres_{irt}}.$$

Farm i's $Total\ Costs_{irtk}$ are measured with accrual accounting. Farm i's actual cost are

normalized by dividing their $Total\ Costs_{irtk}$ by the total planted acres,

$Total\ Planted\ Acres_{irt}$. Crop budgets published in Kansas Farm Management guides in year t

for each region r are used to estimate farm i's $Main\ Crop\ Expected\ Costs_{irtk}$ given the set of k

crops they plant in year t.

It is important to note that farms $Expected\ Costs_{irtk}$ are only calculated for the acres of irrigate and non-irrigated acres of wheat, milo, corn, soybeans, and alfalfa the farm planted. Farms in Kansas did plant crops outside of main crops (wheat, milo, soybeans, corn, and alfalfa) that include silage, sunflowers, barley, and others. For each farm, accrual expenses for all crops are aggregated into one account. The specific costs allocated to main crops were unknown which requires the assumption that the per acre cost of all crops are correlated to the per acre costs of main crop acres. It is assumed that farms that have lower total cost per acre will also have lower main crop cost per acre. The KFMA recently started recording individual crops costs (e.g. wheat seed, fertilizer, and herbicide expense) which will significantly improve the accuracy of quantifying each farm's $Cost\ Management\ Performance_{irt}$ in the future.

Relative Yield Management Performance

Similarly to quantifying farms' cost management performances, farms' yield management performances are calculated by fist comparing farms' yield management performance to yield expectations. Farm yield performance cannot be compared outright because farm plant different types and amounts of main crops. If this was done, farms that higher yielding crops (e.g. milo and corn) would be determined to have higher yield management performances.

Also, if farm i plants a smaller share of their total acres to a particular crop, it is necessary to weight the value of particular crop yield, in order to properly evaluate a farm's total yield performance. The yields of crops that take up more acres should be weighted more heavily when determining a farm i's yield performance. And, if a farm is in a county (c) that averages lower yields than other counties in a region, before a farm's yield performance is compared to the yield

performance of other farms in higher yielding counties in its region r, there should be handicap adjustment made.

Therefore the relative yield management performance of farm i that plants a set of crops k is calculated by comparing their weighted and handicapped yield performance for set of crops k to the weighted and handicapped yield performances of other farms in its region r in each year t. In reverse order, the steps that are used to determine farm's relative yield management performance are listed below.

The $Relative\ Yield\ Performance_{irt}$ of farm i in year t is calculated as,

$$Relative\ Yield\ Performance_{irt}$$

$$= Total\ Yield\ Performance_{irt} - \overline{Total\ Yield\ Performance_{rt}},$$

and where, $\overline{Yield\ Performance_{rt}}$ is the average $Total\ Yield\ Performance$ of farms in region r in year t. The $Total\ Yield\ Performance$ of farm i with crop mix k in year t is calculated as:

$$Total\ Yield\ Performance_{irtk}$$

$$= \left(\frac{Irrigate\ Wheat\ Yield\ Performance_{irt}}{Main\ Crop\ Acres_{irct}} \right)$$

$$+ \left(\frac{Dryland\ Wheat\ Yield\ Performance_{irt}}{Main\ Crop\ Acres_{irct}} \right)$$

$$+ \left(\frac{Irrigated\ Milo\ Yield\ Performance_{irt}}{Main\ Crop\ Acres_{irt}} \right) + \cdots$$

$$+ \left(\frac{Dryland\ Alfalfa\ Yield\ Performance_{irt}}{Main\ Crop\ Acres_{irt}} \right),$$

where dividing by farm i's $Main\ Crop\ Acres_{irt}$ weights the yield performance of individual crops based on the share of main crop acres planted to that particular crop. The total yield

performance of farms that plant different share of crops can be effectively quantified by weighting yields.

Farm i's $Dryland\ Wheat\ Yield\ Performance_{irt}$ will be used to explain how individual crop yield performance are calculated. The same set of steps, from crop production to determining farm i's crop yield performance, are used for each type of crop farm i plants in year t. The wheat yield performance of farm i is:

$$Dry\ Land\ Wheat\ Yield\ Performance_{icrt}$$

$$= \frac{(Dry\ Land\ Wheat\ Yield_{icrt} - Handicapped\ Expected\ Dryland\ Wheat\ Yield_{crt})}{Handicapped\ Expected\ Dryland\ Wheat\ Yield_{crt}} \times 100,$$

where

$$Dry\ Land\ Wheat\ Yield_{icrt} = \frac{Dryland\ Wheat\ Production_{icrt}}{Dryland\ Wheat\ Acres_{icrt}},$$

and the $Handicapped\ Expected\ Dryland\ Wheat\ Yield_{crt}$ is used to quantify the dry land wheat performance of each farm i in county c, in region r, and during year t. The handicapped yield performance is calculated as:

$$Handicapped\ Expected\ Dryland\ Wheat\ Yield_{icrt}$$

$$= \overline{Wheat\ Yield_{rt}} \times \frac{\overline{County\ Wheat\ Yield_{ct}}}{\overline{Wheat\ Yield_{rt}}},$$

where $\overline{Wheat\ Yield_{rt}}$ is the average wheat yield in farm i's region r and $\overline{County\ Wheat\ Yield_{ct}}$ is the average wheat yield in farm i's county c. The average wheat yield in farm i's county c is equal to the average yield recorded by the Kanas NASS office in year t. If farm i's the average county c yield is less than the average dry land wheat yield in the region r, then farm i's dry land wheat yield be adjusted upward.

The yield performances of farms in regions that average lower or higher yields consistently, or have yield effective by local weather or production environment events, can be effectively compared to yield management performance of farms in other counties in the region by making the yield handicapped adjustments. At the same time, it was observed that when farm yields have yields that move in opposite direction county averages their yield performances are either significantly increased or significantly reduced. This event occurred less the thirty times over the 2001 to 2010 period.

Relative Marketing Performance

Three steps a necessary to quantify each farm i's $Relative\ Marketing\ Performance_{irt}$ in year t. The prices received for crops are not compared across farms outright. The analysis did not have access to the actual prices that farms sold wheat, milo, soybean, corn, and alfalfa crops at on the market. Instead the recorded value of farms' total crop production is used to quantify farms' $Relative\ Marketing\ Performance$.

Similar to the calculation of farms relative cost and yield management performance because farms plant different amounts and shares crops, farm costs cannot be compared outright. If this was done, farms that planted more expense crops would be considered to have marketing management abilities. Therefore, a farm's value of crops per acre were compared to a farms expected value of crop production per acre each year in order to first calculate a farm's marketing management performance. Then, the marketing management performances of farms are compared to another to determine a farms relative marketing management performance in each year. In reverse order, the steps that are used to determine farms' $Relative\ Marketing\ Performance$ are listed below.

Farm i's $Relative\ Marketing\ Perfomrance_{irt}$ is calculated as:

$$Relative\ Marketing\ Perfomrance_{irt}$$

$$= Marketing\ Performance_{irt} - \overline{Marketing\ Performance_{irt}},$$

where $\overline{Marketing\ Performance_{irt}}$ is the average $Marketing\ Performance_{irt}$ of all farms

in region r in year t. A farm i's $Marketing\ Performance$ is measured by comparing the actual

value of farm i's set of crops k with the expect value their set of k crops. The calculation is:

$$Marketing\ Management\ Performance_{irt} =$$

$$\frac{(Value\ of\ Total\ Crop\ Production\ per\ Acre_{icrtk} - Expected\ Value\ of\ Crop\ Production\ per\ Acre_{icrtk})}{Expected\ Value\ of\ Crop\ Production\ per\ Acre_{icrtk}},$$

where

$$Value\ of\ Crop\ Production\ per\ Acre_{icrtk} =$$

$$\frac{(Gross\ Value\ of\ Total\ Crop\ Production_{icrtk} - Government\ Payments_{icrtk} - Insurance\ Payments_{icrtk})}{Total\ Planted\ Acres},$$

Farm i's $Gross\ Value\ of\ Total\ Crop\ Production_{icrtk}$ is recorded in the KFMA data base for

farm i and includes government and insurance payments. Government payments and insurance

payments are subtracted out to arrive at the value farm i's set of k crops that were produce in year

t. The $Expected\ Value\ of\ Crop\ Production\ per\ Acre_{icrtk}$ for farm i in county c in region r is

equal to:

$$Expected\ Value\ of\ Crop\ Production\ per\ Acre_{icrtk}$$

$$= \frac{(Main\ Crop\ Production_{icrtk} \times County\ Prices_{icrtk})}{Main\ Crop\ Acres_{icrtk}}.$$

$Main\ Crop\ Production_{icrtk}$ is the set of main crops k (including wheat, milo, corn, soybeans,

and alfalfa) produce by farm i in year t. These acres are multiplied the average county prices of

crops sold in county c in year t. These prices are prices published by the Kansas NASS office.

It is important to note that farms' $Gross\ Value\ of\ Total\ Crop\ Production_{icrtk}$ includes all crops produced by the farm: both main crops and other crops. For each farm, value of crop production is aggregated and measured in one account. The specific value particular main crops, and the set of main crops, were unknown. Similar to the $Cost\ Management\ Performance$ variable of farms, the total value of crops is compared to the expected value of their main crops. Farms in Kansas did plant crops outside of main crops (wheat, milo, soybeans, corn, and alfalfa) that include silage, sunflowers, barley, and others will have inflated $Marketing\ Management\ Performance$ as a result. As a sample a small share of total acres that are not planted to main crops. The effect this short fall has on the results should therefore be minimal. Better information about the value of wheat, milo, corn, soybeans, and alfalfa produce each year would improve the calculation of farms' $Relative\ Marketing\ Management\ Performance$.

Appendix B - Hypothesis Testing

Appendix: Determining Consistency with Hypothesis Testing

The purpose of the consistency analysis is to compare the feasibility of maintaining different relative attributes over time. The share of all Kansas farms that maintain a relative attribute through the 2001 to 2010 time period suggests the feasibility that any farm can maintain the attribute in the future. In order to apply this theory, a methodology must be created to determine the share of farms that have or have not maintained each relative attribute over the 2001 to 2010 time period. More specifically, for every attribute, a method must be developed to determine if each farm has or has not consistently maintained each relative attribute over the 10-year period. The key point in the methodology is to determine whether each farm has or has not consistently maintained each of their relative attributes across time.

The methodology must combat two particular issues. First, the methodology must be able to discern farms that have and have not consistently distinguished their relative size, planting intensity, yield management, and other attributes from the local average. Second, the method must make this determination consistently across each relative characteristic, practice, and management performance. It must be consistent so that the feasibility of maintaining the various relative attributes can be compared. The method used to confront these two issues, is statistical hypothesis testing. For each farm, each average relative attribute will be tested to see if it is significantly different than zero over the 2001 to 2010 period. This will consistently determine if farms have or have not consistently maintained relative attributes across time.

The methodology must have a reasonable cut-off point for deciding when farms have or have not maintained their relative attributes. For relative characteristics, practices, and management performances, there will be a grey where it unclear whether farms have or have not

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maintained their relative attributes. If a farm is smaller than the local average in the first two

years, but then acquires acres in year three such that it is larger than average in the remaining

eight years, did they maintain their larger than average size over the 10-year period? If a farm

has higher planting intensity than average in seven years, but not in three, due to local weather or

pest problems, did they maintain their relative planting intensity? If a farm has higher yield

management performance than average in seven years when they face the same weather and pest

problems as other farms, but lower than average in three years because their crops were hailed

out, did they maintain their relative yield management performances? The method must create

threshold to determine if farms have or have not had characteristics and practices different from

the average enough times, while also accounting for the random events that affect the relative

management performances of farms.

The method must also be consistent across attributes so that the feasibility of maintaining

relative attributes can be compared to one another. The purpose of the feasibility section is to

compare the feasibility of maintaining different relative attributes across time. However, the

challenge of maintaining farms' relative size, planting intensity, and price management

performances are unique to each attribute. The number of years farms can be expected to achieve

a relative attribute compared to others may be different. A farm can be expected to maintain their

relative size or planting intensity in eight of ten years, but due to uncontrollable forces, farms

might only be able to distinguish their yield management performances in six out of ten years.

Therefore the number of years farms have maintained an attribute--whether it is six or eight--

may not be a good way to determine if farms have or have not maintained each attribute. A more

comprehensive method must be used to determine if farms have or have not consistently

maintained each relative attribute across time. The method must work well, and consistently so, across all attributes.

Statistical hypothesis testing is used to determine if each farm did or did not consistently maintain each of their relative attributes over the 2001 to 2010 period. Statistical hypothesis testing uses data and probability theory to determine if a result was unlikely to have occurred by chance alone. For this analysis, it will be use the relative attributes of farms over the 10-year period to determine if they each have or have not consistently maintained a relative attribute. In statistical hypothesis testing there is a null hypothesis, H_o, and an alternative hypothesis, H_1. For each attribute and each farm, the null hypothesis will be that the farm has not consistently maintained their relative attribute over the 2001 to 2010 time period and the alternative is that they have.

For each farm, the statistical significance of the average relative attribute over the 2001 to 2010 period is tested to determine if the attribute consistently deviated from the average (maintained) over the ten-year time period. The average relative attribute of a farm is calculated as:

$$\overline{Relative\ Attribute_i} = \frac{\sum_{i=1}^{10} Relative\ Attribute_{it}}{10},$$

where $Relative\ Attribute_{it}$ is the difference between the farm i's attribute and the local average in year t over the 2001 to 2010 time period. The null hypothesis and alternative hypothesis are expressed as:

$$H_0: \overline{Relative\ Attribute_i} = 0$$

$$H_1: \overline{Relative\ Attribute_i} \neq 0.$$

The H_0 is that farm's attribute is not significantly different than the local average of the 2001 to 2010 period. This equates to the farm not maintain their relative attribute over the period. The H_1

is that the farm's relative attribute is significantly different than the local average over the 2001 to 2010 time period. This equates to the farm has maintained their relative attribute over the period.

A two tailed t-test at the 95 percent confidence level is used to test the null hypothesis. The t-statistic for a particular farm i is:

$$t - statistic_i = \frac{\left(\overline{Relative\ Attribute_\iota} - H_0\right)}{\left(\dfrac{Std.Error\ (Relative\ Attribute_{it})}{\sqrt{n-1}}\right)},$$

where H_0 is that $\overline{Relative\ Attribute_\iota} = 0$, $Std.Error\ (Relative\ Attribute_{it})$ is the standard error of farm i's $Relative\ Attribute$ over the ten-year time period, and n is equal to 10 or the number of years in the 2001 to 2010 time period. The t-statistic for each farm and each attribute is compared to a t-critical value, which in this case is:

$$t - critical_{\frac{\alpha}{2},n-1} = t - critical_{0.025,9} = 2.262,$$

where α is the test's 0.05 level of significance and n is the test degrees of freedom. If the absolute value of *t-statistic* is less than *t-critical,* the null hypothesis is not rejected. If the absolute value of the *t-statistic* is greater than or equal to *t-critical*, then the null hypothesis is rejected. This is then translated into the farm has not (fail to reject) or has (reject) consistently maintained their relative attribute over the 2001 to 2010 time period.

The significance of average relative attributes is used to identify if farm have or have not consistently maintained a relative attribute over the 2001 to 2010 period. The average relative

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attribute and low standard deviation that results when a farm consistently maintains a relative attribute is also necessary for a farm to have an average relative attribute significantly different than zero. If a farm does not maintain its relative size over the ten-year period, its average relative size will be about zero and its standard deviation will be high. This will result in an average relative size that is not significantly different than zero. The null hypothesis will not be rejected. If a farm does maintain their relative size over the ten-year period, its average relative size will be greater (less) than zero and its standard deviation will be low. This will result in an average relative size that is significantly different than zero. The null hypothesis will be rejected. There is direct, one-to-one correlation between the significance of farm average relative attribute and how consistently farm maintained their relative attribute over the 2001 to 2010 period.

The 95 percent significance level is the consistent decision criteria used to determine when farms have or have not consistently maintained their relative attribute. The critical t-value sets a point that the calculated t-statistic must be equal to or greater than for the average relative attribute to be significantly different than zero. The t-statistic includes the farm's average relative attribute and its standard deviation. The smaller the average relative attribute and the larger the standard deviation, the smaller the t-test statistic will be. The higher the level of significance, the higher the t-critical value and therefore the greater the evidence that the farm's average relative attribute is significantly different than zero and therefore the farm has consistently maintained their relative attribute. Therefore, the significance level can be adjusted to make the breaking point more or less difficult for farms to achieve.

This logical, scientific process is used to determine if each relative attribute for an individual farm has been distinguished from the average of all farms in the region. Hypothesis testing allows for a degree of randomness in farms' performance. Farms do not have to be

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constantly on one side of the average to maintain their relative attribute. Farms can being

smaller than average or have lower than average yields in couple years and the test will still

show they maintain their relative attribute. The test allows for a degree of randomness of that is a

part of all farm performances across time. The same process is used across all variables and

therefore allows for the feasibility of different types of consistently maintained attributes to be

compared to one another. This makes for a practical and realistic assessment of whether farms

did or did not maintain their relative attribute.

Appendix C - Econometric Model Residuals
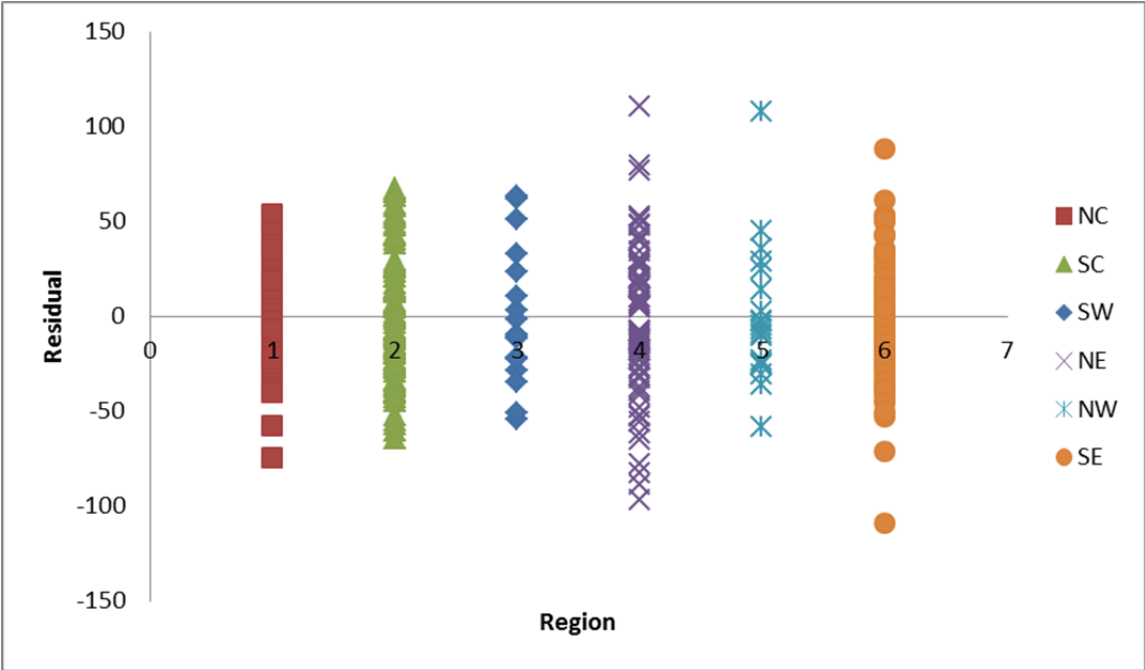
Figure 10: Residuals by Region

Figure 11: Residuals by Share of Wheat Acres

Figure 12: Residuals by Share of Milo Acres

Milo Acres as a Share of Total Acres
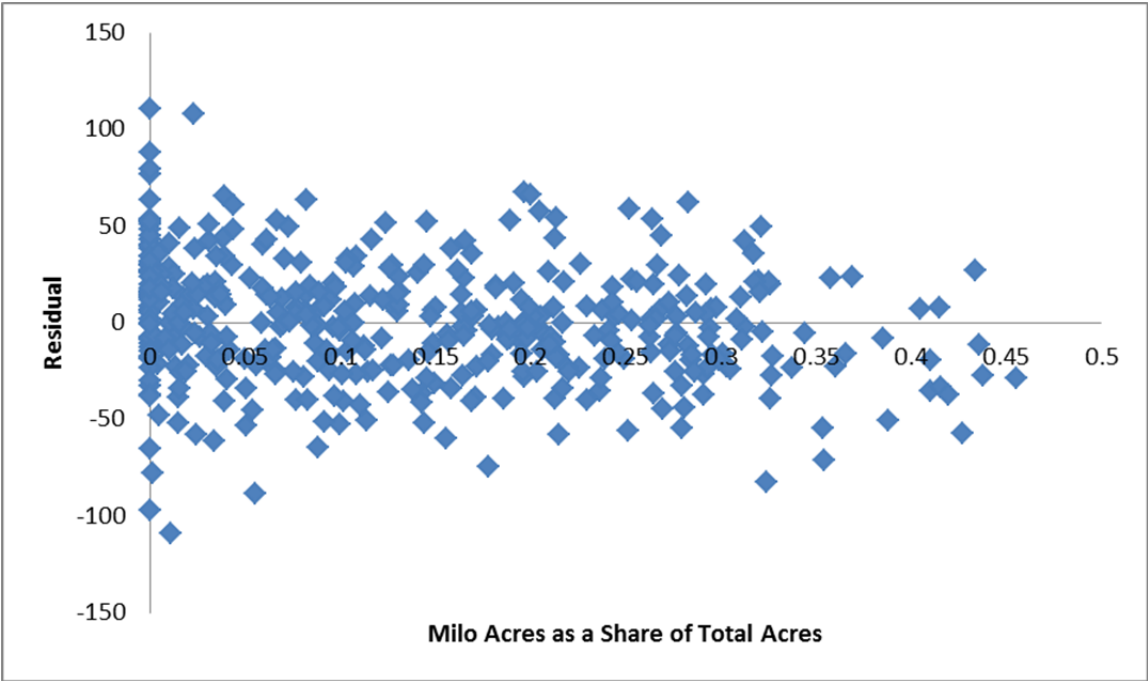
Figure 13: Residuals by Share of Soybeans Acres

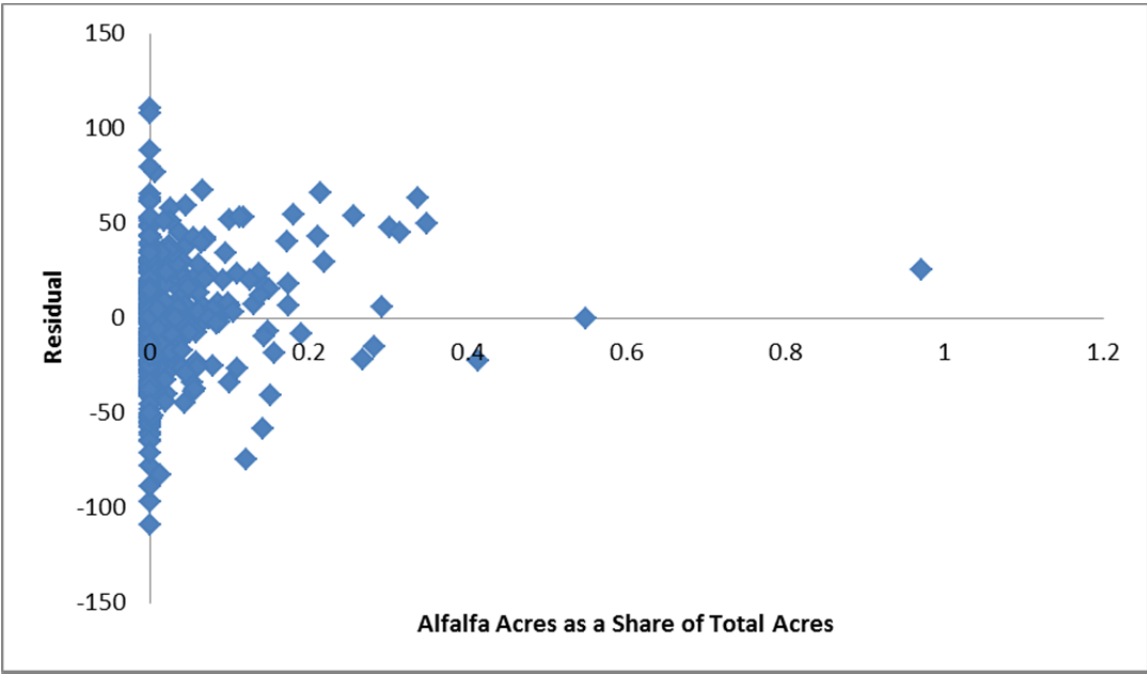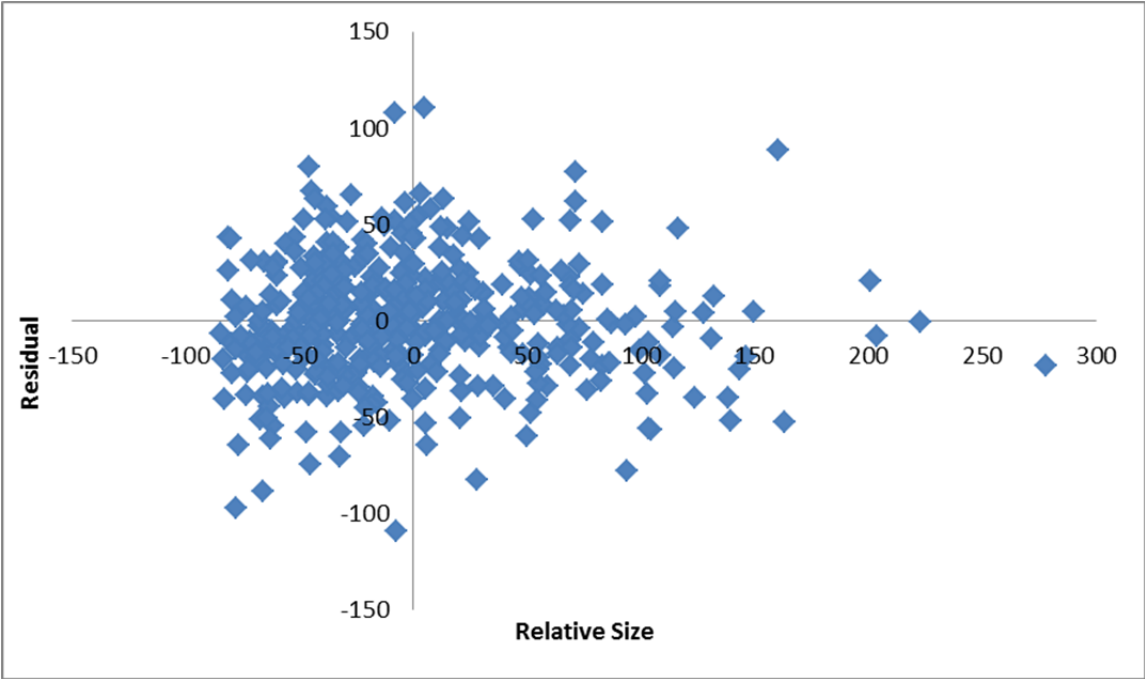Soybean Acres as a Share of Total Acres
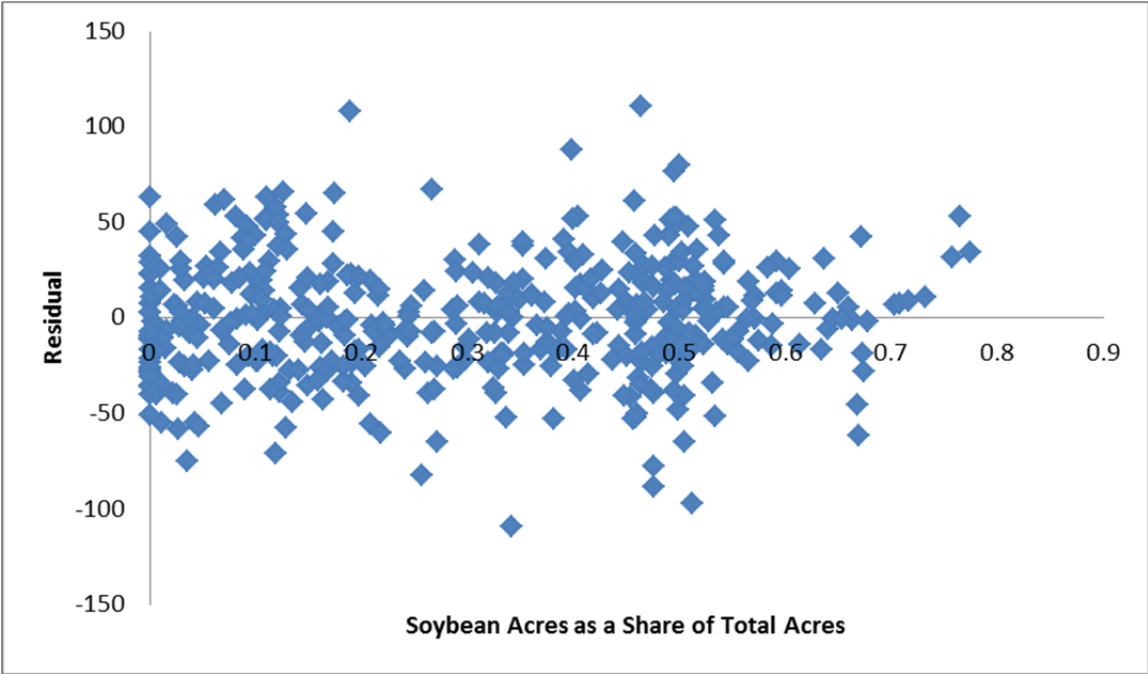
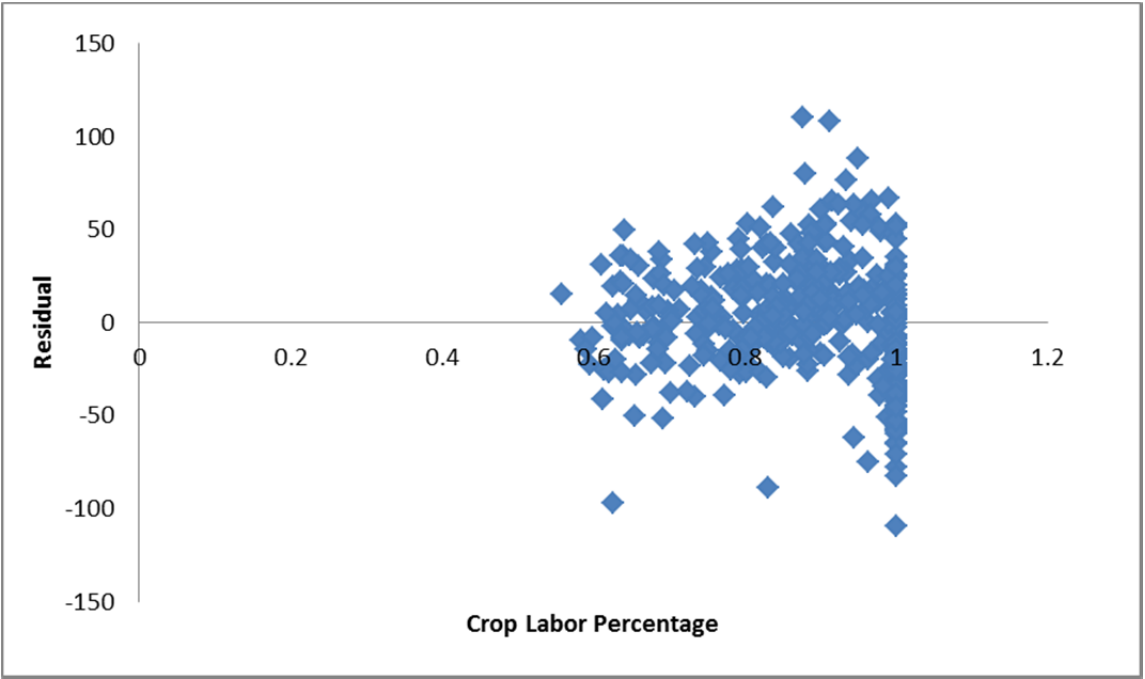**Figure 14: Residuals by Share of Corn Acres**
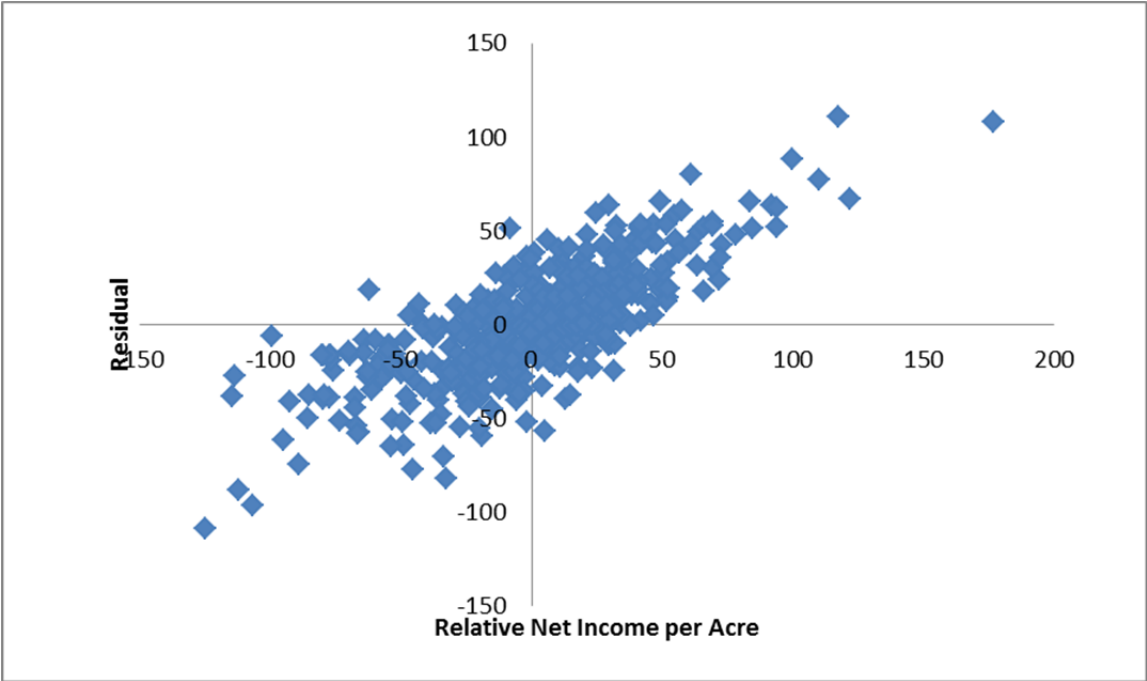

Figure 15: Residuals by Share of Alfalfa Acres

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Figure 16: Residuals by Farm Size

Figure 17: Residuals by Crop Labor Percentage

Figure 18: Residuals by Relative Net Income

Residuals by Relative Net Income

Appendix D - Data Checks

Preliminary Data Check

The preliminary data check analyzes the accuracy of farm characteristics, crop production information, crop income data, and cash and accrual expense records. The preliminary data check also narrows the scope of farms that are included in the sample. Only farms that allocate 50 percent of labor of crop production and plant a majority of the acres to main crops are kept in the sample. The study analyzes farms that allocated at least 50 percent of their labor to crop enterprises. Cattle, dairy, and other farms types that do not plant crops or allocate less than 50 percent of their labor to crop production are excluded from the analysis. Farms are eliminated for have missing, inaccurate, or questionable production, income, and cost information.

Farm Type

At least 50 percent of farm labor must be allocated to crop production in order for a farm to be eligible for the analysis. Each farm's crop labor percentage is calculated by the KFMA office and uses a combination of crop acres, livestock numbers, and state labor standards. Dairy, cattle, swine, turkey, and other types of livestock are included in livestock numbers. The majority of farms eliminated had crop labor percentage consistently less than the 50-percent benchmark.

The study focus on analyzing farms that plant major Kansas crops that have historical production costs, yield, and price information. All farms in the sample must plant at least 50% of their crop acres to wheat, milo, soybeans, corn, or alfalfa. Farms do not have to plant each type of crop, but every year MC acres must account for at least 50% of total planted acres. Because the research is done to disseminate information to Kansas crop producers, the focus is on analyzing farms that plant the major crops in the state. Directly related to their prevalence, local

and regional historical yield, cost, and price information is available for these crops. Historical crop information is used to calculate expected production costs, yields, and prices for each farm. Calculating cost, yield, and price expectations is important for comparing the performance of farms that plant different types, amounts, and shares of crops

From this point forward, wheat, milo, soybeans, corn, and alfalfa will be referred to as main crops (MC) and used to describe farm acres and production. Other crops, which could include sunflowers, barley, oats, silage, other hay, and other crops, will be referred to as other crops (OC).

There are 580 farms in the KFMA data base that allocate 50 percent of labor to crop production and plant MC on at least 50 percent of their crop acres every year from 2001 through 2010. Table 10:1 shows that 31% of these farms are in the SE region and only 12% are in the two Western Kansas regions. There are also a significant number of farms in the SC, NC, and NE regions. The number of farms in each region is relevant because of the region average process. If this sample was used to perform the analysis, the region averages in SE and NC, Kansas would be more reliable than those of SW and NW, Kansas.

Table 10:1 Distribution of Farms across KFMA Regions after Farm Type Filters

Region	Number of Farms*	Share of Sample
North Central (NC)	112	19%
South Central (SC)	124	21%
Southwest (SW)	34	6%
Northeast (NE)	97	17%
Northwest (NW)	36	6%
Southeast (SE)	177	31%
Total	580	100%

*Each farm has ten years of observations.

Production Information

Farms with questionable yield information are eliminated from the sample. A filter system identified farms with negative yields or yields beyond subjectively determined maximum levels. Farms with yields outside the Table 10:2 minimums and maximums are removed from the sample. Maximum yields were developed by analyzing the yields of farms in the sample and discussing yield possibilities with Kevin Dhuyvetter. A small set of farms were eliminated due to inaccurate crops acres information.

Table 10:2 Yield Constraints by Crop

Crop	Minimum	Maximum
Irrigated Wheat	0	130
Dry Land Wheat	0	130
Irrigated Corn	0	300
Dry Land Corn	0	225
Irrigated Milo	0	200
Dry land Milo	0	200
Irrigated Soybeans	0	120
Dry Land Soybeans	0	120
Irrigated Alfalfa	0	13
Dry Land Alfalfa	0	10

*yield constraints are held constant across the six KFMA regions

The accuracy of each farm's rented crop land and dry land crop records were checked. Irrigated and non-irrigated crop rented acres must sum to within five acres of total rented crop acres. The buffer is created to allow for rounding and other minor errors. No farms were eliminated for inaccurate rented acres information. If total dry land crop acres are recorded as zero then farms must have zero dry land wheat, milo, soybean, corn, and alfalfa acres. No farms were eliminated for inaccurate dry land crop acres information. These two checks are executed to affirm the accuracy of farm information used in the analysis and the credibility of farms kept in the sample.

For the 2001 to 2010 period, there are three farms in the sample that have on year of missing labor information. Calculating missing or inaccurate production and cost information is more difficult because of changing crop rotations. For the total number of workers for these three farms, there is a practical and simple solution to preserve the size of the sample.

Three methods are used to estimate missing *total number of workers* information. If a farm is missing the worker variable in between, and including, the second and ninth year of the time window, the farm's *total number of workers* is estimated by taking the average of prior and following year. In other words, if the prior and following year of information is available, a linear interpolation process is used to estimate the number of farm workers. The calculation for *total number of* workers for farm i with no record in year two, three, four, five, six, seven, eight is:

$$Number\ of\ Workers_{i,t=2,3,\dots,8} = \frac{Number\ of\ Workers_{i,t-1} + Number\ of\ Workers_{i,t+1}}{2}.$$

If the number of works for a farm i is missing in the first or last year of the period, farm j's previous or following year's *total number of workers* variable is used as an estimate for the current year. If farm j is missing *total number of workers* in year one, then farm j's *total number of worker* is estimated as:

$$Number\ of\ Workers_{1j} = Number\ of\ Workers_{i+1,j}.$$

If farm j is missing in year ten, then the estimation is

$$Number\ of\ Workers_{1j} = Number\ of\ Workers_{i-1,j}.$$

The linear interpolation process is used if applicable and the adjacent year methods are used when necessary.

Farm Income

Total crop income includes grain, hay, and cash crop income, government payments, insurance proceeds, and income from crops fed to livestock. Accrual income records are used for grain, hay, and silage. Accrual government payments are used if they are available; otherwise cash government payments are used. Cash proceeds from crop insurance are also included in crop income.

Grain and Hay Accrual Incomes

Farms with livestock are allowed to have negative accrual grain and hay incomes. For farms that feed livestock there is a logical reason for negative grain and hay accrual incomes. Using accrual grain incomes as an example, farms that feed a significant share of their beginning grain inventory and grain production to livestock will have negative accrual grain income. The calculation for accrual grain income for farm *i* in year *t* equals:

$Accrual\ Grain_{it} = Ending\ Grain\ Inventory_{it} - Begining\ Grain\ Inventory_{it} +$

$Grain\ Sales_{it}.$

When grain is fed to cattle there are no grain sales to counter the decrease in grain inventories, resulting in a negative grain accrual income. The same circumstance exists for accrual hay income, which supports the decisions to allow farms with livestock to have significantly negative accrual grain and hay incomes. In order to correctly measure accrual crop income for farms that feed livestock, each farm's feed income is calculated. This credits farms for grain and hay production that is fed to livestock. If a farm's crop income is still negative after compensating for feed income, it is removed from the sample.

Cash Crop Incomes

Farms with significantly negative accrual cash crop income are removed from the

sample. Price changes between the beginning and ending of the year can create negative accrual

crop incomes. Accrual cash crop incomes for farm *i* in year *t* are calculated as:

$Accrual\ Cash\ Crop\ Income_{it} =$

$Ending\ Cash\ Crop\ Inventory_{it} - Begining\ Cash\ Crop\ Inventory_{it} + Cash\ Crop\ Sales_{it}.$

Because beginning and ending inventories are calculated with market prices, a decrease in prices

can result in a negative accrual income. Ending inventories will be deflated by the price decrease

and result in a negative accrual grain income. Negative accrual income can also results from

missing beginning or ending inventory information, cash grain sales, or beginning or ending

accounts receivable information. In order to identify accrual income that results from price

changes and accrual incomes that result from missing information, the absolute value of each

farm's negative accrual value is compared to the farm's total value of farm production. If the

absolute value of income is less than 10 percent of total farm income, the negative accrual

income is assumed to be the result of price changes between the beginning and ending of the

year. If the absolute value of accrual income is greater than 10 percent of the value of total farm

production, the farm is assumed to have questionable income data and is deleted from the

sample.

Farms that do not feed livestock that have significantly negative accrual grain and hay

incomes are removed from the sample for missing or inaccurate income information. It is

assumed that farms do not feed livestock if they have no recorded livestock information and have

zero accrual income from beef, dairy, poultry, or livestock product sales. For this set of farms

that only produce crops, negative accrual grain and hay incomes can results from changing

prices, missing information, or inaccurate information. The 10 percent rule used to differentiate

negative accrual cash incomes caused by prices changes and missing or inaccurate data is applied

to negative accrual grain and hay incomes. Using grain as an example, if the absolute value of

farm's negative accrual grain income is less than 10 percent of the farms' total value of farm

production, the negative accrual incomes is assumed to be a function of price changes. Farms

with negative accrual grain incomes that fall into this category are kept in the sample. On the

other hand, if the absolute value of a farm's negative accrual grain income is greater than 10% of

the farm's total value of farm production, the farm is removed from the sample. The same

procedure is used for negative accrual hay incomes. Farms with significantly negative accrual

incomes are assumed to have missing or inaccurate information. The majority of the small set of

farms removed for significantly negative accrual grain and hay incomes have one year of

negative accrual incomes

Farms with negative accrual government payments, negative insurance proceeds, or

negative total crop incomes were eliminated from the sample. There is no logical reason for

negative government payments or insurance payments, nor could the specific source of the

negative values be identified. These farms are removed for what is assumed to be missing or

inaccurate information.

Farms with at least one livestock enterprise that have negative *total crop income* are also

removed from the sample. The total crop income calculation for farm *i* in year *t* is:

$Total\ Crop\ Income_{it} =$

$Grain\ Income_{it} + Hay\ and\ Forage\ Income_{it} + Cash\ Crop\ Income_{it} +$

$Government\ Payments_{it} + Insurance\ Proceeds_{it} + Feed\ Income_{it}.$

As discussed earlier, farms that feed livestock are allowed to have significantly negative accrual

grain and hay incomes. For farms that feed livestock, a calculated feed income compensates for

grain and hay fed to livestock. This credits farms with crop income and reduces the possibility that *total crop income* is negative. Therefore, for farms with at least one livestock enterprise, negative *total crop income* is assumed to be the result of missing or inaccurate information. Farms that feed livestock are removed for missing or inaccurate information if their *total crop income* is less than zero.

Farms without livestock operations are also removed if they have negative *total crop income*. Farms that do not have livestock operations are allowed to negative grain, hay, and cash crop incomes if the absolute value of negative accrual grain, hay, or cash crop incomes is less than 10 percent of total farm income. As explained earlier, changing prices between the beginning and ending of a year can cause negative accrual income for each crop category. However if a farms total crop income, which includes grain, hay, and grain crop income and government payment and insurance payments, is negative, the farm is removed from the sample. If a farm has negative accrual grain, hay, and cash crop income, the probability that inaccurate or missing data are causing negative accrual values increases. Removing farms with negative total crop income reduces the probability that farms with missing income information are kept in the sample.

Gross Value of Crop Production

The gross value of a farm's crop production is recorded in the KFMA database. For a particular year, this is equal to the total value of crops produced, insurance proceeds, and government payments. In order to estimate the prices at which farmers sell crops, insurance proceeds and government payments are subtracted from the gross value of crops produced. The procedure used to measure the marketing performance of farms is also an opportunity to check the accuracy of each farm's recorded *Gross Value of Crop Production, Government Payments,*

and Insurance Proceeds records. For farm *i* in year *t*, the gross value of crop production is equal to:

$$Gross\ Value\ of\ Crop\ Production_{it}$$

$$= Value\ of\ Crop\ Prodction_{it} + Governemnt\ Payments_{it}$$

$$+ Insurance\ Proceeds_{it}$$

In order to analyze the comparative price performance of farms, the *Value of Crops Produced* is calculated as:

$$Value\ of\ Crop\ Production_{it} =$$

$$Gross\ Value\ of\ Crop\ Production_{it} - Insurance\ Proceeds_{it} - Government\ Payments_{it}.$$

This process estimates the market value of crops produced on a farm during a particular year. Farms with a negative calculated *Value of Crop Production* are eliminated from the sample

Crop Expenses

Crop production expense requirements were created for different types of farms and different types of production expenses. There are crop production expenses that can be zero: including hired labor, cash rent, custom hire expenses, irrigation costs, chemical costs, fertilizer costs, machine repair costs, and marketing costs. Farms that do not use hired labor will have zero hired labor costs, farms that do not rent land will have zero cash rent costs, and farms that do not apply fertilizer will have zero fertilizer costs. Farms that plant only wheat, soybean, and alfalfa may also have zero seed costs. It is unlikely, but farm can have zero machine repair costs. Wheat and soybean production can be used for seed and alfalfa is not planted every year, while herbicide, insecticide, and fertilizer are applied at each farmer's discretion. Accrual seed cost, custom hire expenses, and marketing costs can even be negative under particular circumstances. However, other costs are impossible to circumvent. Every farm is required to have positive

machine costs and fuel cost. Given the different possible negative, zero, and necessary crop expenses, a set of parameters are developed for each type of cost to eliminate farms with possible inaccurate crop expense data.

Farms with negative or zero total machine costs or fuel costs are removed from the sample. Out of the 10 farms eliminated for questionable machine cost information, half of them are eliminated for missing machine costs information. Many of these farms also have missing fuel costs, machine repair costs, and depreciation costs.

Cash rent, hired labor, chemical, fertilizer, machine repair costs, and irrigation expense are allowed to be zero, but not negative. Farms are eliminated from the sample for negative accrual cash rent, hired labor, chemical, and fertilizer expenses. A portion of these negative values are explained by missing beginning or ending inventories, cash payments, and beginning and ending prepaid expenses, but the majority of recorded expenses were negative for unfound reasons. Analyzing aggregate farm costs across multiple years of production is very subjective due to changing crop rotations and acres planted. The missing total number of workers information is an easy fix, but crop expenses present a more complicated problem. Because farm plant different crop rotations each year, missing crop expense information cannot be calculated with simple linear interpolation processes. Due to this complexity, even though many farms may only have a single year of and one piece of negative accrual crop expense information, these farms are still removed from the sample.

Depreciation, custom hire, seed expense, and marketing were dealt with in their own particular ways.

Depreciation

Farms with inaccurate and missing depreciation cost information were eliminated from the sample. Farms are removed if they that have negative machinery and equipment depreciation costs. The KFMA calculates an economic depreciation cost for farms. The calculation can result in a zero depreciation cost, but not a negative depreciation cost. There is no logical reason for negative machinery and equipment depreciation. Farms with negative depreciation costs are eliminated for inaccurate depreciation information and farms with missing depreciation costs are also eliminated from the sample. Farms report three types of deprecation costs to the KFMA: motor vehicle and listed property, machinery and equipment, and building. If a farms has zero depreciation cost across the three categories for a particular year, it is assumed they did not report depreciation information. For the 2001 to 2010 sample, three farms are removed for having missing, or unreported, depreciation information.

Custom Expenses

Farms with significantly negative accrual custom expenses are removed from the sample. It is common for farms in Kansas to swap machine work. Farmers that swap machine work can have negative accrual custom expense. If the costs of the traded custom services are not equal or there is an open account at the end of the period, small negative accrual expenses can result. To compensate for this possibility, negative accrual custom costs are only eliminated if the absolute value of accrual custom expenses is greater than 10 percent of total machine costs. This is a similar method that is used to eliminate farms with inaccurate accrual income information.

Seed Expense:

It is possible, although unlikely, that wheat and soybean farms can have negative accrual seed costs. Wheat and soybean production can be used for seed in future crop production. If a

share of wheat or soybean production is put into seed inventories, ending inventories will increase without a counter balancing cash seed cost. This can result in negative accrual seed costs. The equation for accrual seed expense for farm i in year t is:

$$Accrual\ Seed\ Expense_{it} = Beginning\ Inventory_{it} + Cash\ Seed_{it} - Ending\ Inventorry_{it}$$

In calculating accrual seed expense, ending inventories are subtracted from total of *Cash Seed* costs and *Beginning Inventories*. If a farm saves a significant amount of wheat and soybean production for future seed, ending inventories can increase enough to cause a negative accrual seed cost. Negative accrual seed costs are most likely for wheat farms that save seed wheat regularly. While some producers plant bin run (i.e., production from previous year) seed for soybeans, the use of Round-up Ready soybeans has drastically reduced the use of own soybean seed. A significant number of farms that produce wheat and soybeans with negative accrual seed cost have high ending seed inventories.

Farms with negative accrual seeds costs are still removed from the model. Negative accrual seed expenses can also be caused by inaccurate and missing information. Inaccurate and missing cash payments, beginning, or ending inventories can also create negative seed costs. Wheat and soybean farms with negative accrual seed costs did have high ending inventories, but there was no definite way to identify whether inaccurate beginning inventories, missing seed purchases, or saved crop production created large ending inventories. Due to the importance of seed cost to the analysis and the possibility that missing or inaccurate records are causing negative seed costs, all farms with negative accrual cost are removed.

Farms with planted acres of milo and corn and zero seed costs are removed from the sample. Farms cannot produce their own milo and corn seeds. Farms with only wheat, soybean, and alfalfa acres and zero seed costs are kept in the sample.

Marketing

Farms with missing marketing information are removed from the sample. Farms with zero marketing costs and negative marketing cost and negative marketing costs are kept in the sample. Gains and losses on future trades are included in marketing cost, making it possible to have negative, zero, and positive marketing costs.

Preliminary Data Check Summary

The preliminary data check reduced the data sample from 580 farms with tens of data by 23% to 445 farms (Table 10:3). The reduction in farms varied somewhat by region. the NC region retained the most farms (81%) and the SW region retained the least (56%). The distribution of farms across sample did not change significantly. This affirms that farms in different regions were analyzed equivalently. The SE and SC regions still have the most farms, while the western regions have the fewest. The number of farms in the SW and NW will decrease the reliability of findings in those regions.

Table 10:3 Distribution of Farms by KFMA Region after Preliminary Filters

Region	Number of Farms*	Share of Sample
North Central (NC)	91	20%
South Central (SC)	98	22%
Southwest (SW)	19	4%
Northeast (NE)	78	18%
Northwest (NW)	22	5%
Southeast (SE)	137	31%
Total	445	100%

*Each farm has ten years of observations.

Explanatory Variable Checks

The explanatory variable check analyzes farm information after it has been combined, normalized, and compared to region averages. Farms with farm characteristics, production practices, and management performances that are four standard deviations from the region

averages are analyzed to determine if differences are a function of calculation errors or inaccurate information.

For the 2001 to 2010 time period all farm with explanatory variables 4 standard deviations from their region average are analyzed for inaccurate information. Missing or inaccurate data can cause particular different farm characteristics (farm size, share of acres rented, etc.) and strong or weak management performance (i.e., cost management, yield performance, etc.) to appear that are not appropriate. They can also be cause by farms that have significantly different farm characteristics, farm practices, and management abilities. Farms with outlying farm size, shares of land rented, workers per acre, labor costs, seed costs, chemical costs, fertilizer costs, custom hire expense, machine costs, fuels costs, depreciation costs, total crop costs, yields, marketing performance, government payments, and risk are analyzed to identify possible calculation and data problems.

A set of information for each outlying farm (planted acres, net farm income, machine and seed costs, and the gross value of crops) is analyzed for accuracy. This information is checked for each of the ten years in the period. The majority of farms with outlying variables are not found to have missing or inaccurate information. A set of farms are removed for great than 1,000 acre changes in planted crop acres and questionable *value of crop production* information. Different procedures are used to remove different types of possible inaccurate information. Farms are removed individually for questionable planted acres information, while a benchmark is create to remove farms with outlying *marketing performances* information.

Standard Method

A standard method is used to identify farms with extreme explanatory variables that result from potentially inaccurate information. This method is applied across all explanatory

variables and net farm income per acre. For each explanatory variable, the following method is

used to identify farms with outlying characteristics, production practices, and management

performances. Farm i in region r is flagged and analyzed if

$$|Explantory\ Variable_{irt}|$$

$$> |\overline{Explantory\ Variable_{irt}}| + 4 \times Std.(Explanatory\ Variable_{rt}),$$

where $Std.(Explanatory\ Variable_{rt}$ is the standard deviation of $Explanatory\ Variable\ i$ in

region r in year t. This procedure is executed across every farm, in every regain, in each year

during the ten-year time window.

According to Chebyshev's Theorem, 93.75 percent of a population, regardless of the

distribution, is within four standard deviations from the population mean. Therefore, this process

identifies farms with significantly different planted crop acres, shares of land rented, workers per

acre, labor costs, seed costs, chemical costs, fertilizer costs, machine costs, fuels costs, total crop

costs, government payments, and year-to-year changes in net incomes. The total crop income and

expenses, crop production, and crop acres information are used to check the accuracy and

consistency of the information for each outlying farm.

For the 2001 to 2010 time period, farms with outlying net income, production costs,

production practices, and government payments explanatory variables are not found to have

missing or inaccurate information. Farms with outlying shares of land rented, workers per acre,

labor costs, seed costs, chemical costs, fertilizer costs, custom hire expense, machine costs, fuels

costs, depreciation costs, total crop costs, yields, marketing performance, government payments,

and risk are analyzed to identify possible calculation and data problems.

No farms that have outlying net farm income or government payments relative to region

averages are removed from the sample. Net farm income is used to measure each farm's

financial performance. This variable is crucial to valuing different types of farm characteristics, production practices, and management abilities. For the 2001 to 2010 period there is one farm with a net farm income that is four standard deviations larger than the region average, but the farm's income, production costs, value of crop production, and acre information are logical and consistent with other years of performance. This farm is not eliminated from the sample. Government payments four standard deviation from the region mean appeared to result from poor yield performance. No information was determined missing, inaccurate, or questionable for net income and government payment outliers.

No farms are eliminated for outlier crop production costs. Farms with particularly high labor costs were either small farms with full-time operators or large farms with a large number of hired workers. Particularly high seed costs were caused by what appeared to be random, bulk seed purchases. Farms with significantly higher chemical and fertilizer cost than region averages have income, crop production expenses, and value of crop production information that are consistent with other years.

Planted Acres

The accuracy of planted acres information is checked to prevent the miscalculation of net crop income, per acre production costs, and farm size. Planted acres and main crop (MC) acres are used to normalize net farm income, crop costs, and measure the value of farm size. Missing or inaccurate planted acres or MC acre information will affect the calculation of multiple income, cost, and farm characteristic variables. Because MC acres are a subset of planted acres, checking planting acre information also effectively checks the accuracy of MC acre records. Two procedures are used to identify farm with possible inaccurate crop acres information. Year-to-

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year changes in planted crop acres and the relationship between a farm's planted acres and its region average planted acres are used to identify farms with possible incorrect acres information.

If there are errors in acres information (e.g., unreported crop acres, miscalculated total acres) there may be a significant change in crop acres. The year-to-year changes in farm acres are analyzed over three periods to check for missing or inaccurate planted acres information. If the average change in planted acres over a three-year period is greater than 50 percent of a farms average planted acres in year one and year three a farm is flagged and analyzed further for potential data errors. Mathematically, farm i in year t is flagged if

$$\frac{|pla_{i,t-1}-pla_{it}|+|pla_{i,t}-pla_{i,t+1}|}{2} > \left(\frac{1}{2}\right) \times \frac{(pla_{i,t-1}+pla_{i,t+1})}{2},$$

where,

$pla_{i,t-1,}$ *is planted acres on farm* (i) *in year* $(t-1)$,

$pla_{i,t}$ *is planted acres on farm* (i) *in year* (t), and

$pla_{i,t+1}$ *is planted acres on farm* (i) *in year* $(t+1)$.

The 50 percent of the average farm size benchmark was created from trial and error process using farms in the 2001 to 2010 sample period. Flagging farms changes equal to a smaller percentage of average farm size identifies too many farms with minor year-to-year changes. The 50 percent benchmark identifies farms with significant changes in acres--including increases and decreases.

In the 2001 to 2010 period one farm is removed due to possible inaccurate planted acres information. The year-to-year changes procedure identifies a set of farms with single 1,000 acre swings in planted acres. The one farm removed had a nine thousand acre increase in wheat acres in one year.

Farms with planted acres significantly greater than region averages are also analyzed for incorrect information and comparative values. Equivalent to the standard outlier procedure, a farm is flagged and analyzed if total planted acres are four standard deviations larger or smaller than the region's average total planted acres. For the 2001 to 2010 period, farm size outliers have comparable characteristics, incomes, and costs to other farms in the region. All planted acres outliers are kept in the model.

Marketing

Farms with a *marketing performance* four standard deviations from the region average are flagged and analyzed. To estimate *marketing performance*, each farm's *value of crop production* is compared to a calculated *expected value of crop production*. The complete calculation is a function of farm production, crop values, and crop acres information and historical county price information. A more detailed description of the *marketing* explanatory variable is in the methodology section.

Low yields create inconsistencies in *value of crop production, insurance proceeds, and government payments* for a small set of farms. A set of *marketing performance outliers* have questionable *values of crop production, insurance proceeds, and government payments* information. During a year of low yields, the value of farm production is illogically high compared to the *expected value of crops* even when compensating for large insurance and government payments. This is particularly true for 2007, the year when a late spring freeze significantly damaged a large portion of the wheat crop. Insurance payments and government payments from the prior year could have been allocated to the current production cycle, explaining for the high gross value of crop production variables in a given year. High insurance payments did occur in the year of and following year of a poor yield performance.

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Farms with *marketing performance* great than 100 percent or less than negative 100

percent are removed from the sample. A farm will have a 100 percent *marketing performance* if

the *value of crop production* is twice the *expected value of farm production.* The outlier process

found that farms with *marketing performances* in excess of ± 100 percent have discrepancies

across their crop values, insurance proceeds, and government payments information. In the 2001

to 2010 period, nine farms have *value of crop production* records 120% to 455% greater than

their *expected value of crop production*. During years of extreme *marketing performance,* these

farms have large insurance payments and low yields, suggesting a discrepancy in evaluating the

gross value crop farm production had occurred. The 100 percent price performance cut-off

eliminates a set of farm's whose quantitative marketing performance is affected by evaluation of

insurance and government payments.

Yields

Farms with outlying *yield indexes* have crop yields that tend to move in the opposite

direction of county and region average yields. Each farms yield performance is quantified by a

yield index. The *yield index* allows the comparison of farms' yield performance compared to

other producers in the region after accounting for different types of crops produced and acres of

each. Farmer's yield index is a function of their own yields, their county's historical yields (as

recorded by NASS), and the regions' average recorded county yield. If a farm's yields are higher

or lower than their county's averages, and if their county has inversely low or high average yield

compared to the region average, a farm's yield index increases or decreases exponentially. Farms

with strong yield performances when county averages are low and region averages are strong

will have very large yield indexes. No yield outliers are removed from the sample. All farms

with outlier *yield indexes* have farm incomes, production costs, crop values that affirm the strong

or weak yield performances.

Data Filter Results

The two stage filter process reduces the sample size by 41 percent to 433 farms (Table

10:4). The majority of the sample was eliminated by farm type filters. Each farm in the sample is

required to allocate at least of 50 percent of their labor to crop production and plant at least 50

percent of their crop land to wheat, milo, soybeans, corn, and/or alfalfa. Out of 740 farms, only

580 farms fit these description criteria. A larger set of farms are also eliminated for negative or

missing accrual crop income, crop production expenses, and machine depreciation information.

Only 445 farms remained after the preliminary data checks. A significantly smaller set of farms

was eliminated by the explanatory variable data checks. One farm is eliminated for inaccurate

planted acres information and eleven farms are eliminated for questionable information about the

value of crop production.

Table 10:4 Distribution of Farms by KFMA Region after Data Filters

Region	Number of Farms*	Share of Sample
North Central (NC)	91	21%
South Central (SC)	94	22%
Southwest (SW)	17	4%
Northeast (NE)	76	18%
Northwest (NW)	20	5%
Southeast (SE)	135	31%
Total	433	100%

The remaining farms are believed to have ten years of accurate crop production, crop

income, and crop expenses information. As Table 10:4 shows, the distribution of farms across

regions does not change significantly. The largest shares of farms are still in the SE, while the

smallest shares of farms are in the Western KFMA regions.