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IMPROVING FARM MANAGEMENT DECISIONS BY ANALYZING PRODUCTION
EXPENDITURE ALLOCATIONS AND FARM PERFORMANCE STANDING

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
College of Agriculture, Food, and Environment
at the University of Kentucky

By

William Anthony Osborne

Elizabethtown, Kentucky

Director: Dr. Carl R. Dillon, Professor of Agricultural Economics

Lexington, Kentucky

2013

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ABSTRACT OF THESIS

IMPROVING FARM MANAGEMENT DECISIONS BY ANALYZING PRODUCTION EXPENDITURE ALLOCATIONS AND FARM PERFORMANCE STANDING

This study examines the potential effects of categorical increases in production expenditures on farm income performance according to farm standing. The objective of this study is to expose differences in anticipated net farm income return from production expenditure investments and the optimal expense allocation strategy for each performance level. Studying farm performance through segregation by utilizing a two-tier analysis and quantile regression acknowledges the possibility that managerial strategy can differ based on managerial ability. Study outcomes are useful to farm managers because they offer more prescription style results and interpretations than found in other farm performance studies. Study findings show that as managerial proficiency increases so does a manager's ability to extract higher returns from additional expenditures in certain input categories. Additionally, better managers are able to produce higher returns from more investment sources than their lower performing peers. Overall, study results and interpretations point to the importance of farm management ability as the key input for improving farm performance.

KEYWORDS: Quantile Regression, Farm Production Expenditures, Net Farm Income,
Two-Tier Analysis, Manager Performance

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ACKNOWLEDGMENTS

I would like to express my sincere gratitude to my advisor Dr. Carl Dillon for his patience, motivation, enthusiasm, knowledge and friendship. His guidance and insight helped me take a cluster of ideas and craft a focused piece of research of which I could be proud. I could not have asked for a better mentor to guide me during my graduate school experience and on my Master's thesis research.

Besides my advisor, I would like to thank the rest of my thesis committee: Dr. Steve Isaacs and Dr. Sayed Saghaian, for their encouragement, support and insightful comments. I would also like to thank the following faculty, staff, and colleagues for their individual contributions to my graduate experience: Dr. Allison Davis, Dr. Wuyang Hu, Dr. Cory Walters, Dr. Leigh Maynard, Dr. Timothy Woods, Jerry Pierce, Jonathan Shepherd, Tom Sikora, Marion Robert, Stephanie Johnson, Bruno Arthur, and Shang-Ho (Bruce) Yang.

I would like to thank my parents for all their support and instilling in me the importance of hard work and education.

Finally, I would like to thank my wife, Sara Osborne. Through all the good days and bad days and the moments of doubt, she offered her love, support and compassion that kept me going.

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Chapter One

Introduction and Review of Literature

Introduction

United States agriculture is commonly regarded as one of the most advanced and productive agricultural sectors in the world. While there is continued debate on the sustainability and direction of this technological progression, it's undeniable that the United States has played a major role in shaping modern agriculture. Significant innovation in the area farm productivity and efficiency has been a leading contributor of progress and structural changes in U.S. agriculture. Growth in productivity has been credited as being the main source for U.S. agricultural output tripling since 1948 as opposed to the U.S. economy in general which has benefited mostly from input growth (Ball and Wang, 2012).

Mechanization on the farm has made dramatic strides within the past century essentially displacing animal traction and even human labor for the most part. More concentrated utilization of farm machinery has allowed farmers to reduce their use of labor and to increase their use of purchased inputs including pesticides, fertilizers, and other chemicals (Abebe, et al., 1989). Farmers have increasingly adapted to using more machinery which has become larger, more specialized, and consequently more expensive. These substantial and essential investments have increased attention placed on cost control management research.

The Commonwealth of Kentucky is not usually associated with the well-known and high grain producing states of the Mid-West, but crop production plays a large in the state's agricultural economy. According to the 2012 USDA Annual Acreage Report, Kentucky had approximately six million acres in crop production while larger grain states like Nebraska, Kansas, and Illinois had close to 20 million or more acres assigned to grain production (USDA, 2012). Moreover, Kentucky farms on average are smaller than farms located in the Mid-West

and are smaller than the national average farm size. These circumstances potentially reinforce the need for solid management ability in the analysis of farm costs and the economies of size involved.

The key mission of this thesis is to utilize and analyze Kentucky farm-level data and provide sound information for farm businesses and managers on the effects of input costs on farm success. Specific objectives are to:

1. Analyze farm-level data using a two-tier categorization and statistical evaluations to determine significant expenditure patterns of farm performance sub-groups,
2. Develop an econometric framework and model to identify expense investments which return significant net farm income based on farm performance level, and
3. Provide interpretations and results from the empirical information as to narrow the gap between academic research and extension oriented publications.

Reaching these objectives will be accomplished through the writing of two separate but connected essays. Both essays will be linked through their focus on farm income, but will be differentiated by their approach which is meant to target different audiences. More elaboration on these formats will be presented later.

Data used in this research was collected by the Kentucky Farm Business Management (KFMB) Program out of the University of Kentucky. It is the hope that this thesis contributes to KFMB's mission to provide sound data resources for academic research which in turn can be utilized by member cooperators and by the general population. The ultimate goal is to provide research which helps Kentucky farmers become more successful.

The remainder of chapter one will be used to examine the relevant literature pertaining to the studies herein. Sections include farm management and decision making, production input management, determining cost and profit functions, and the utilization of quantile regression.

Farm Management and Decision Making

The study of farm management has been developing for close to a century and has changed its form and scope many times along the way. McCown, et al., (2006) examine the evolution of thought and practice in the field of farm management research and its struggle to remain pragmatic. They described a less than willing transition of farm management research from the early agricultural scientist to agricultural economist. The early agricultural economists argued that the field lacked a decisive decision-making structure and methods of practical allocation which could only be develop from sound economic theory (McCown, et al., 2006). This fundamental change in focus led to the development of basic, but crucially fundamental decision-making tools, thoughts, and assumptions which are the backbone of the field.

Farm management, more often than not, holds profit maximization as a critical assumption for studying managers and farm businesses alike. Although other studies have focused on other possible goals of firms and managers, maximizing profits lends itself to the basic need to survive and prosper. Spillman's focus on maximizing profit per acre led to his essential explanation of the law of diminishing returns (Spillman, 1924). The classical and lighthearted question here is, "Can you grow the entire world's food supply from one acre?" While the question begs for no thorough economic reasoning, it does clearly reveal the principle of diminishing returns to land and inputs. At some point in the biological production function of an agricultural product, corn for example, additional units of one or more inputs will become less effective and eventually counterproductive to the goal of increasing returns.

The inescapable effects of diminishing returns can further be described in the study of marginal economic concepts. Including prices of both inputs and outputs in the analysis of a production function often changes the desirable level of production based on the goal of profit maximization. The idea that a farmer should continue to increase input utilization as long as the inputs are generating more revenue than costs is the basis of marginal input cost (MIC) and marginal value product (MVP) analysis. Marginal analysis measures the marginal, or additional, value of output and compares it to the marginal cost of producing that output (Kay, et al., 2008). Using this decision-making criterion, producers should continue to expand input expenditures until the point where marginal cost equals marginal revenue. Operating on either side of this intersection point will lead to inefficiency. Understanding that profit and yield maximization levels of production are often different points in the production function is another key insight in farm management.

Marginal economics are addressed in this chapter because net farm income is used as the measure of success in this research. Net farm income, roughly being the difference between production expenses and production revenues, is able to show whether the value of products exceeded the costs of producing them or not. These findings will then help managers decide where to increase expenditures and will provide some estimate on the type of return they might experience.

The preceding section briefly detailed some of the basic principles needed for agricultural producers to make sound economic decisions. These central assessment aids have to be taken into consideration along with other decision-making criteria to operate a functional farm business. Agricultural production is often cited as one the riskiest types of business operations. Without set controls to evaluate and manage risk it is highly likely that a business will fail. Kay,

Edwards, and Duffy (2008) identify five different sources of risk faced by nearly every agribusiness: production and technical, price and market, financial, legal, and personal risk. While each type of risk is important in its own right, the focus on this thesis concerns risk born out of production and financial risks. Production risk, specifically controlling costs of production inputs, is covered in more depth in the proceeding section as well as how it is interrelated with financial risk.

It is important to note that it is impossible to totally eliminate all risk, but farm management research strives to identify, understand, evaluate, and prescribe methods of dealing with risk. Decades of research has provided agricultural producers with the tools and knowledge which have been critical to their survival and ability to thrive in an ever changing environment. Evolution in the degree of utilization and technological complexity of farm machinery is one example. Farm equipment comes in many forms and can represent a significant portion of any farm's equity and/or debt. Having numerous equipment options requires a machinery management strategy which is part of a larger decision-making plan and risk management approach.

Production Input Management

The indispensable and progressing role that production inputs and technology have played in agriculture has been a consistent topic of study over the decades. Some of the earliest economic research concentrated on the substitution relationship between machinery and labor. Growing competition from off-farm wages has increased the opportunity costs of farm labor and consequently made labor an expensive factor of production. As the U.S. has transformed from an agrarian based economy to one centered on manufacturing, services, and technology there has been an outmigration from the nation's heartland to more populous areas. More specifically,

these circumstances have increased the ratio of wages to machine cost, raised the optimal capital-labor ratio, and assuming constant labor per farm, stimulated an increase in farm size (Kislev and Peterson, 1982). Increased efficiency derived from farm machinery coupled with inflating labor wages has significantly changed the structure of U.S. farms. Farm labor in the U.S. peaked at 13 million workers in 1910 and has declined to approximately 6 million in 2012 (Steckel and White, 2012). This increasing dependency on farm machinery has allowed farmers realize the advantages of economies of size. This concept is used to explain the declining average costs of production per unit as the size of the firm or operation expands. Economies of size have consequently been used to explain the gravitation toward larger farm size over time in numerous studies (Ball and Heady, 1972, Gardner and Pope, 1978, Hall and LeVeen, 1978, Jensen, 1977).

The growing use of machinery and technology in agriculture has also been marked as a period of growing production input utilization such as fertilizer, pesticides, and fungicides (Abebe, et al., 1989). Advancements in farm machinery, agro-chemicals, and improved varieties of seed have enabled farmers to operate continually growing areas of farmland. In fact, the average farm size in the United States has increased from around 150 acres in 1910 to approximately 425 acres in 2010 (MacDonald, 2011). An expansion in farm size and increasing utilization of production inputs also escalates the amount assets and liabilities which farms have to manage. Producers are constantly faced with decisions on how to manage the acquisition of resources and how to employ them profitably.

Acquiring and utilizing up-to-date production inputs, although vital for any modern agricultural producer, comes at a cost. Farmers often have to make critical decisions when considering production inputs because of their necessity for normal farm operations and the considerable implications they can have on farm financials. Without careful planning producers

can easily put themselves in a position of being under- or over-supplied leading to inefficiencies. Long term and seasonal planning as well as thoughtful purchasing decisions are imperative. For instance, one study found that, according to a sample of Kansas farms from 2001-2003, machinery costs averaged between 30 to 40 percent of total farm costs and explained approximately one-third of the differences in profitability between farms (Dhuyvetter and Kastens, 2005).

Several other studies have been conducted to demonstrate the importance of cost control management on the farm. Mishra, El-Osta, and Johnson (1999) examined various factors to help explain success among cash grain farmers. They found that controlling variable costs of production, machinery cost, and farm ownership were the more important determinants for success above risk management strategies, government program participation, and education (Mishra, et al., 1999). Similarly, Sonka, Hornbaker, and Hudson (1989) found that controlling operating expenses was a key distinction between top and bottom performing farms in North Dakota. Wood, Johnson, and Ali (1987) also studied North Dakota farms, looking for management practices and performance factors which had an influence on earnings. As expected, numerous factors had an important impact including machinery cost control. Moreover, they found that farms with high machinery costs were often operating very inefficiently by using smaller horsepower tractors more intensively and had large investments in inadequate tractors and implements (Wood, et al., 1987). In the same year, Ali and Johnson produced a similar study specifically focusing on moderate sized North Dakota farms. Again, controlling machinery costs along with efficiently managing labor and producing high crop yields were significant determinants of financial success.

Burton and Abderrezak (1998) conducted a study which sought to estimate which farm characteristics are significant for having a profitable operation. Their results partially challenge conventional thinking on the relationship between degree of ownership and profitability. They demonstrated a positive relationship between profit and degree of non-ownership of real estate and machinery that indicates farmers who rent land and/or hire custom work are more successful than those that strictly own their assets (Burton Jr and Abderrezak, 1988). Differentiation of contractual costs between renting and purchasing can be far enough apart to encourage non-ownership strategies in the short-run (Garcia, et al., 1982). Garcia, Sonka, and Yoo also find similar results and speculate that farms prefer to rent and hire as a means of expanding quickly to take advantage of market opportunities. Being that production assets vital for farm operations are available both through traditional ownership and through renting/ hiring further complicates the decision-making process.

A common research strategy among agricultural economists is to conduct farm-level analyses that segregate farms into hierarchical categories. This is done for a few reasons, one being that it is an established format for research and another being that it is easy to translate back to the farmer for practical application. Dhuyvetter and Kastens periodically publish reports utilizing Kansas farm-level data with study periods as short as three years. In their publication, *Management Factors: What really matters?*, they examine broader ranges of the data in which to conduct their analysis. Their results support and improve upon previous research which has argued that cost management is a fundamental factor of farm success.

An analysis of 1987-1996 farm level data found that having lower costs was likely the most important and consistent determinant to increase profitability. Another study of Kansas farms from 2001-2010 also revealed that cost was the most significant factor which

differentiated farms within the sample (Dhuyvetter, et al., 2011). In fact, differences in machinery costs between high- and low-profit farms in a Kansas study was a main distinction between nonirrigated crop farms (Dhuyvetter and Smith, 2010). Research in farm cost management continues to be relevant to farmers even when commodity prices have maintained an unprecedented level.

There is probably no clearer example of the need for proper planning than the agricultural boom and bust of the 1970s and 1980s. High commodity prices encouraged increased production, boosted sales and income, and encouraged producers to invest in machinery and land, utilizing debt as the main source of capital. Farm machinery inventories increased to \$24 billion in 1981 from \$17 billion in 1973 while real farm debt increased \$85 billion during this period (Bierlen and Featherstone, 1998). Once supply equalized with demand and prices receded, U.S. farmers were not able to produce sufficient revenue to meet their debt obligations. Some observers of the current agricultural sector are concerned about a similar bubble building from exceptionally high commodity prices.

Increased cash prices have bolstered farm profits and incomes within recent years which, for good or bad, have put increased emphasis on crop marketing and increasing marginal revenue. Yet research, as discussed earlier in this section, has shown that costs management or pursuing means of lowering marginal costs can be a more significant and larger determinant of success. These facts support continued farm management research and the motivation of this specific thesis.

Cost and Profit Functions

Profit maximizing firms will strive to continually evaluate the costs of production in attempt to produce higher profits. As firms evaluate quantity and prices of inputs involved in

production they will likely make changes based on input costs and output prices. Substitution between inputs is often studied because prices and availability of agricultural inputs have changed noticeably over time. The substitution relationship between labor and machinery was noted in the previous section. Many researchers have studied these relationships as the structure of agriculture has shifted. Ray (1982) employs a translog cost function analysis to evaluate the elasticities of substitution between inputs among other goals. Results show that hired labor can be substituted in varying degrees with other inputs including capital, fertilizer, feed, and seed (Ray, 1982). Labor and fertilizer displayed the highest degree of substitution which corresponds with the increasing use of fertilizer and machinery over labor in modern agriculture.

Ray (1982) includes five cost categories in the study: 1) hired labor, 2) farm capital which includes real estate, motorized vehicles, and machinery; 3) fertilizers, 4) purchased inputs including seed, feed, and livestock; and 5) miscellaneous inputs which consist of pesticides and utility costs. While somewhat altered, this thesis utilizes four aggregate cost variables for study which mimic Ray's approach. Further explanation and detail of these four categories is given in the Explanatory Variables Selection and Data Description sections within chapters two and three.

Profit maximization is achieved when the difference between total cost and total revenue is at its greatest. This study uses net farm income per acre as the measurement of profit. Net farm income was selected for its documented use as a measure of farm success and performance (Haden and Johnson, 1989, Melichar, 1979, Mishra, et al., 1999, Seger and Lins, 1986). Generating positive net farm income is important for farm operations which need to satisfy current liabilities and hope to establish positive equity growth. Net farm income is calculated by subtracting total non-feed costs from gross farm returns, including gain/loss on the sale of capital

assets. Net farm income statistics used in this study are calculated and reported by the Kentucky Farm Business Management Program.

Quantile Regression

Quantile regression, as first introduced by Koenker and Bassett (1978), is a method of statistical analysis which has been growing in popularity among academic researchers. Its main distinction over its close relative, ordinary least squares (OLS) regression, is its use of the median rather than the mean as its measure of centrality (Koenker and Bassett Jr, 1978). The OLS method has long been utilized as a procedure for regression analysis, but its weaknesses are well documented. By minimizing the sum of square errors the OLS method can estimate the unidentified parameters of the mean function of the conditional distribution of the response variable. Quantile regression on the other hand minimizes the absolute residuals' sum by assigning different weights to the quantiles being examined (El-Osta, 2011).

While both methods are similar in that they specify a period of the conditional distribution as a linear function of the conditional variables, quantile regression provides a wealth of more detailed and sophisticated information about the dataset (Marroquin, 2008). The ability to measure regression curves for any number of specified quantiles makes it possible to retrieve results on the distribution for each point of time in the data, conditional on the specific time periods. Furthermore, it is possible to gather information about the changes of the entire conditional distribution over time and not just for the conditional mean or median.

Krüger summarizes the abilities of quantile regression in two key points. First, quantile regression has the capability to discover differences in the response of the dependent variable to changes in the independent variables which offers substantial information about the heterogeneity of the sample population. Second, because the median is the measure of centrality

in quantile regression, the derived coefficient estimates are more robust with respect to outliers of the dependent variable (Krüger, 2006).

Although the development and utilization of quantile regression is still in its initial stages compared to some of the tools employed in the field of statistics and econometrics, the literature base has been expanding rapidly in recent years. The field of economics research has likely dominated the use of quantile regression because of its unique and desirable characteristics presented earlier. Krüger (2006) observed U.S. manufacturing industries and their productivity dynamics using quantile regression. Results uncovered that productivity transitions between industries with high- and low-productivity levels are characterized by a significant degree of persistence. The relationship explains that in high-productivity industries the degree of persistence is higher than in those industries that have a lower level of productivity (Krüger, 2006). Coad and Roa (2008) applied the techniques of quantile regression to distinguish what factors are important determinants of firm growth for business in high-tech sectors. They found that the ability to innovate was a significant source of firm growth for a select group of overachieving firms (Coad and Rao, 2008). The authors elaborate on the notable characteristics of quantile regression over a standard regression which allowed them to treat these top-performers as a group of interest instead of outliers.

The use of quantile regression in the study of agriculture is a smaller but expanding area of research. Data used in research by agricultural economists often have similar issues with outliers and heterogeneity of the sample that general economic researchers encounter. These circumstances make quantile regression an excellent alternative to other linear based regression models. Hisham El-Osta (2011) recently utilized quantile regression to expand knowledge on the effects human capital has on the incomes of farm households. The operator's years of formal

education was used as a proxy to measure human capital investment. The author makes note of the extreme outliers which were present in the data and the appropriateness of the quantile method. In the results, El-Osta found that a conditional mean regression would have shown that higher educational attainment has a positive effect on all household incomes. Yet, quantile regression results point out that increased educational attainment for those farm operators on the fringe of the income distribution (.05th and .95th quantiles) had no effect on the incomes of those households (El-Osta, 2011). Similar semi-contradictory results between mean and median regressors were found concerning government payments.

Hennings and Katchova employed the unique statistical properties of quantile regression to examine the effects of different financial management strategies used by Illinois farms to maintain equity positions. More specifically, the median regression method enabled the authors to test whether the effect of a specific independent variable on equity growth varies based on the position of farm on the equity growth distribution (Hennings and Katchova, 2005). Financial management strategies included: asset management, financial management, revenue enhancement, and cost reduction. Results revealed that firm position on the equity distribution, in most cases, dictated which management strategies were employed by farms. Differentiation of strategy impact and magnitude varied by quantile, but also described some general conclusions. Overall, the quantile regression method was able to reveal characteristics of the sample population that would have been lost to a more general linear regression.

Quantile regression's abilities as a statistical tool make it an excellent resource for those dealing with heterogeneous data and wishing to study multiple sub-populations of the sample. These qualities lend themselves to accomplishing the goals of this thesis. Information and results

presented in the second essay will continue to expand the literature base and the possibilities of future quantile regression applications.

Chapter Two

Expenditure Characteristics and Distributions of Kentucky Grain Farmers: A Two Tier Performance Analysis

Introduction

United States agriculture has long been at the forefront of innovation and has led the proliferation of technology in the agrarian sciences. From the steel plow that broke the tough soils of the prairie to the adoption of precision agriculture technology that works the field of the Mid-West, the American farmer has been competing to grasp the gains of early adoption and efficient production. The momentum of transformation in the nation's farmland compels its toilers to invest in change or perish. Yet these investments (whether the newest line of machinery, the latest high yielding seed, the next farm expansion purchase, or the hiring of a crop specialist), come at a high price that risks the financial stability of an operation. Managers have to balance their ability to handle the fiscal weight of new investments with the potential revenue they stand to gain from such changes.

Historically high commodity prices within the past few years has increased emphasis on improving crop marketing strategies and has likely heightened pressure on farmers to increase yields further. As prices have pushed higher, the marginal revenue on each additional crop unit produced increases and entices farmers to produce more units. Under these conditions producers are motivated to increase input costs that are thought to amplify the units being produced. Increased costs are likely to be incurred until the point where the marginal cost equals marginal revenue and all potential profit has been realized.

Shifting focus on increasing crop revenue can potentially sway attention placed on resource management and cost control. Several studies have emphasized the importance of controlling farm costs as an important component for improving farm income (Dhuyvetter and

Kastens, 2005, Mishra, et al., 1999, Sonka, et al., 1989, Wood, et al., 1987). Farmers will likely become increasingly cost conscious into the future as the growth in global population increases demand for food and continues to strain resource availability.

A common technique for analyzing and presenting farm-level data is through the lens of stratification. This method has the advantage of testing information in defined categories of performance which can make data analysis and comparison between groups convenient. More importantly, its ease of use in practical application for study subjects, Kentucky farmers for instance, provides justification for this approach to agricultural research. Sample subjects commonly are divided into three categories based on research criteria. This study also applies this format for its proven usefulness and for compatibility with related studies. A more in-depth description of the data and econometric framework are provided in the next section.

This study utilizes data on Kentucky grain farmers in an attempt to provide meaningful information on the relationships between expense allocations and farm income. It should be noted that this study will not provide explicit answers for whether or not producers should alter their production expenses in specific ways. Rather, the framework of this research allows operators and managers to compare their farm income and expense category levels to the farms encompassed in the sample data which can provide a valuable starting point for farm performance evaluation. These research results and interpretations should serve as broad benchmarking for which managers can establish a baseline of reference to reflect on their own farms particular situation. Several changes in management strategy are possible if producers choose to act on the results.

The purpose of this study is to examine the income and farm expenditure relationships of Kentucky grain farmers. By utilizing a two-tier approach this study can identify expenditure

characteristics of the top managers and statistics of how each performance class allocates available capital resources. Specific objectives are: 1) develop a presentation framework that clearly presents income and expenditure information for reader application, 2) employ analytical tools for testing significant relationships, and 3) provide interpretation and recommendations for practical application.

Explanatory Variables Selection and Data Description

This section outlines the methodology employed to construct the variables considered in this study. Included are the descriptions of the constructed variables as well as the econometric models employed during the analysis.

The Kentucky Farm Business Management Program (KFBM) at the University of Kentucky provides record keeping based assistance and analysis for Kentucky farmers. Their mission is to support member cooperators and provide sound economic analysis to help farmers reach their desired goals. Programs like KFBM operate in other select states and have been sources of dependable data for decades. These programs take several steps to ensure the accuracy and integrity of their information.

This thesis employs selected data available through KFBM for years 2006 through 2011. Additional filters were applied to the dataset in order to focus the analysis. First, only KFBM certified farm records were considered for this study. Certification of farms ensures that the data is accurate and appropriate for academic research. Second, only farm operations designated by KFBM as “grain farms” were selected. Grain farms were selected as the focus because KFBM’s membership base is dominated by grain farmers; this leads to a larger study sample. Grain farms also require a sufficient amount of machinery to conduct normal operations which is a main area of interest for this research. Further, it is not uncommon in Kentucky to have farms that have

both grain and cattle components to their operations. Farms that generated 25% or more of their gross revenue from livestock operations above feed costs were excluded from the study (Kaase, et al., 2003).

Net farm income (NFI) is used as the performance measure in this study and was selected for its documented use as a measure of farm success (Haden and Johnson, 1989, Melichar, 1979, Mishra, et al., 1999, Seger and Lins, 1986). Generating positive net farm income is important for farm operations which need to satisfy current liabilities and hope to establish positive equity growth. Net farm income is calculated by subtracting total non-feed costs from gross farm returns, including gain/loss on the sale of capital assets. Net farm income can also be thought of as the return to the operator's opportunity cost of equity capital, management, and labor. Comparing net farm income and the costs of these foregone opportunities can be a useful tool for assessing true farm profitability.

Selected explanatory variables for this study were derived from the examination of several other models. Huffman and Evenson (1989) used four main variables (fertilizer, fuel, labor, and machinery services) and also included land expenditures, among other variables, to study demand and supply functions of multiproduct U.S. cash grain farms. Reports developed by University of Illinois Extension study state farmer's economic costs using six aggregate cost categories: Crop, Power, Building, Labor, Overhead, and Land (Schnitkey, 2001, Schnitkey and Lattz, 2003). Another report using data from the Kansas Farm Management Association (KFMA) disaggregated production costs further into finer categories to study characteristics of profitable farms. While the report described production expenses in greater detail they reflect expenses associated with crop, machinery, labor, land, interest, and other costs (Albright, 2002).

Selected variables of interest for this study include land, machinery, crop, and labor expense categories.

Each variable of interest used in this study aggregates several individual costs that represent a specific area of expenses for farms. These four expense/input categories were chosen to represent the essential factors of production necessary for conventional production agriculture. Land, capital, and labor are the traditional categories in which agricultural factors of production are discussed, but specifying crop inputs and machinery as distinct groups will allow for more precise testing. Disassembling some of the capital factors into separate research variables will be more beneficial when discussing the results in practical application. The rest of this section will examine and explain the components which comprise each expenditure category variable.

Machinery Expense Variable

The aggregate machinery expense variable was developed using eight components that reflect the cost of machinery acquisition and implementation costs for normal farm operations. These components help measure machinery expenses regardless of machinery acquisition strategy which can include outright ownership of machinery, hiring off-farm machinery services (also known as custom work), machinery rental, and/or equipment lease). In order to calculate some of these components an established value of machinery for each farm and each year was needed. This was accomplished by averaging the beginning of year (BOY) and end of year (EOY) fair market value (FMV) of the machinery owned by each farm. These fair market values for BOY and EOY are calculated and provided by KFBM. These average annual investment levels estimate the year to year value of individual farm's machinery inventory. These farm and year specific values are needed to estimate the cost of insurance, housing, and interest/opportunity costs associated machinery ownership.

Machinery specific housing and insurance expenditures are not collected by KFBM, but are lumped into general building and insurance cost records. The American Society of Agricultural and Biological Engineers (ASABE) periodically publishes updated standards, methods of research, and data. These standards are meant to create continuity and increase comparability between research studies. A section within the Agricultural Machinery Management Standard addresses other ownership costs of farm machinery. The standard recommends estimating insurance and housing costs by applying a rate of 0.25% and 0.75% to the machinery purchase price, respectively (ASABE, 2006). Machinery purchase price data is not available and applying these rates to average annual investment values could understate the actual costs.

In order to use the fair market values used by KFBM, instead of ASABE's purchase price approach, an adjustment to the 0.25% and 0.75% rates is needed. Given the KFBM depreciation methods, FMV averages about 76.6% of the purchase price across years. Consequently, the rates used for FMV are calculated as $0.25/0.766$ and $0.75/0.766$ or 0.326% and 0.979% for insurance and housing, respectively. Utilizing these rates ensures that insurance and housing costs are more accurately approximated.

Purchasing farm machinery with available liquid assets can put a severe strain on farm finances or is simply not possible for some operations. Utilizing credit is a popular option for most farms that cannot bear the cost of purchasing machinery outright. The associated cost of borrowed capital is important to consider in evaluating the true cost of machinery ownership. Operations with higher equity levels sometimes choose to use their own capital to purchase equipment. While these operations will not have interest and principal obligations to any creditors, they are sacrificing in terms of the opportunity cost of capital. Opportunity costs also

need to be reflected to estimate machinery expenditures. KFBM uses an established yearly interest rate on non-land loans. This fluctuating yearly rate is used to estimate both interest and opportunity costs. The associated yearly rates from 2006 to 2011 respectively are as follows: 7.5%, 8.25%, 6.2%, 5.4%, 5.4%, and 5.4%.

Owners of income generating assets have long enjoyed the benefits of depreciation allowances in the U.S. tax code. These provisions allow businesses or individuals to write off loss of asset value to potentially offset taxable gains. More recently, changes in depreciation policies have been more generous in hopes of spurring economic growth since the global financial crisis of 2008. Rising commodity prices have had many managers looking for ways to offset or minimize tax obligations and purchasing machinery has been a potential solution for some operations (Hadrich, et al., 2012). In fact, some managers are trading year old equipment for brand new equipment every year because of the structure of depreciation rules and allowances. Claimed depreciation values are recorded by KFBM and serve to reflect the portion of value of the assets used during the tax year. Farmers will need to consider these conditions as part of their machinery management plan as well as their maintenance and repair costs and the potential gain or loss on the sale of machinery.

Depending on the age and level of use of farm machinery repair and maintenance costs can vary widely. Holding onto older equipment and delaying purchasing new machinery will likely increase these costs. Farmers need to evaluate the cost of maintaining older equipment and the gain or loss they would experience from selling their machinery. Machinery management can become quite complex for some managers when they need to assess the benefits of making changes to machinery inventories. Tax implications, cost reductions, and potential increases in efficiency should all be factors in the decision-making process. Machinery specific depreciation,

machinery repairs and maintenance, and gain/loss on the sale of machinery are all separately tracked and recorded by KFBM.

Fuel and oil expenditures as well as hired machinery labor are the last components used for the machinery expense variable. Increasing energy costs are another factor for operators to consider when weighing the decision to hold onto old machinery or invest in newer models. Equipment manufacturers have responded within recent years with more fuel efficient machinery that still deliver the power needed for field operations. There has also been a push within the industry to showcase the efficiency which precision agriculture technology offers. The benefits of these systems not only reveal themselves in reduced costs associated with crop chemical expenses, but in more efficient field navigation. GPS technology allows farmer to reduce overlap which saves chemicals and fuel. Some operations might bypass ownership of equipment by hiring outside machinery otherwise known as custom work. Farmers utilizing custom work benefit from limited risk associated with a full machinery investment, but in turn are exposed to risks such as the availability and timeliness of custom work providers. In these agreements landowners usually pay for all the production inputs and a set fee or rate for the custom worker's services. The landowner receives all the crop and commodity payments unlike farmers who use a share cropping agreement. Custom work is an important component of the machinery expense variable so as to reflect expenses of farms which choose not to fully or only partially invest in a line of machinery.

In summary, eight expenditure components are used to estimate the yearly machinery expense for farms: interest/opportunity costs of ownership, insurance, housing, gain or loss in sales, depreciation, repairs and maintenance, fuel and oil, and custom work. These components

were chosen based on available information and the work of previous research (Beaton, et al., 2005, Gustafson, et al., 1988, Hadrich, et al., 2012, Kastens, 1997, Lazarus and Selley, 2002).

Land Expenditure Variable

The aggregate land expense variable was developed using four components that reflect the cost of land acquisition for normal farm operations. Farmers are most often able to acquire farmland for their operation through three different methods. One method is the outright ownership of farmland which includes full equity ownership and farmland that is owned through a combination of equity and debt. Managers who pursue ownership of the farmland they operate benefit in two distinct ways, through asset accumulation and increasing production security. When farmers rent land as opposed to purchasing it, payments are made to the landowner and the farmer builds zero equity in the landholdings. When purchased, principle payments on land mortgages will increase farm assets over time and provide collateral for future credit acquisition. Additionally, owning farmland provides security in that farmers can count on being able to produce on the farmland they own. Renting or share leasing farmland provides short-term farmland availability through the term of the contract. Yet several scenarios such as rental bidding wars and the sale of the farmland can arise in which the farmland is no longer available. This can create a situation where the manager is severely limited in options to produce on a scale which is efficient and profitable. On the other hand, land ownership can put a strain on the farm's finances with large down payments and potentially large payment obligations.

Share leasing farmland is a method which involves contract agreements on the cost sharing of inputs and the profit sharing of the outputs. Farmers engaging in share leasing benefit from spreading production risk to the landowner, but also must compensate the landowner

appropriately for the shared risk. Furthermore, these arrangements can become complicated in many aspects and can become burdensome.

The final method is cash renting farmland from a landowner. In these arrangements, landowners and tenants often agree upon a defined price per acre for a specified number of years detailed in a contract. The benefit for both parties involved is the simplicity of the arrangement compared to a share-lease agreement. Both parties also benefit from knowing their specific cost and revenue per acre. Renting land can provide more flexibility for farmers especially for new or beginning farmers that have little capital for purchasing land. Some of the drawbacks of renting as opposed to purchasing were previously mentioned in the advantages of owning farmland.

Accounting for these three main methods of landownership are encompassed in the aggregate land expenditure variable. Interest expense or opportunity costs of land ownership are calculated by KFBM to reflect the cost of farmland ownership. Property taxes are also recorded and are another associated cost of ownership. Expenses associated with cash renting or share leasing are included in the land expense variable. The aggregate land expense category reflects the cost of land utilization in agriculture no matter which method or combination of methods is used.

Crop Expenditure Variable

The crop expenditures per acre variable measures outflows of operating capital used on inputs related to crop production performance and quality. Seed, fertilizer, and chemical costs are the focus of many studies including crop inputs. The chemical expense component includes pesticides, herbicides, fungicides, nematicides, as well as other chemical applications. Additionally, the crop expenditure variable includes costs associated with drying grain, utilities,

and grain storage. These expenditures were included to reflect the out of field costs of grain production and marketing.

Drying and storing grain is an optional management strategy which seeks returns to storage. Farmers could choose to forego these extra costs and simply deliver to local elevators or buyers and accept grain quality discounts and either pre-determined pricing or cash market prices. Producers pursuing a grain storage strategy have additional costs of drying grain to maintain quality of stored grain and the cost of the actual storage vessels. Utility costs can also increase due to energy demand required to dry and store grain. On farm grain storage, as part of a larger hedging strategy, requires additional management aptitude and entails that manager can effectively deal with the cash-flow needs due to the delayed payment nature of storing grain. All crop expenditure variable components are recorded and reported by KFBM.

Labor Expenditure Variable

The labor expenditures per acre variable measures outflows of capital used on acquiring hired labor as well as accounting for the opportunity cost of operator and family labor. All three components are recorded or calculated by KFBM. Hired labor costs are simply recorded from the cash payments made to employees. Opportunity costs of operator and family labor are estimated by the KFBM program. Family labor is estimated using a single value for unpaid labor per person per year. The associated annual unpaid family labor amounts for 2006 to 2011 respectively are as follows: \$2,600, \$2,675, \$2,755, \$2,755, \$2,755, and \$2,700.

Calculating the opportunity cost of operator labor also requires the use of these yearly labor amounts. For operators these values represent a monthly value rather than an annual value, so multiplying the value by twelve will represent the opportunity of a year's foregone off-farm wages. Farms with more than one operator will also account for the unpaid labor of those

additional operators. While these opportunity costs are not direct cash expenses for the operation it is crucial to reflect the value of unpaid labor. Failing to do so would likely vastly underestimate the cost of labor for most operations.

Model Framework

This section includes details on the methods of the analysis used in this study. Differences between the characteristics and operating style of farms can vary to some extent, but farms are constrained by their need to consume inputs to generate outputs. Managers, whether knowingly or subconsciously, strive to operate their farms on the principles of marginal economics and seek to maximize profit. For various reasons some managers are better at ascertaining how to narrow the gap between farm expenditure and generating revenue. This analysis will study the spending decisions of Kentucky grain farms on four main expenditure categories. Research goals include discovering possible expenditure behaviors of top-performing managers and generating recommendations for farms that fall into the lower categories of performance.

Farm observations were first sorted by their net farm income per acre earnings. Net farm income per acre served as a proxy measure of success and performance. Farms were assigned a performance category title based on their position. The bottom 1/3rd, middle 1/3rd, and top 1/3rd of observations were designated as low-, middle-, and high-income farms, respectively. The study was conducted using 1,080 farm observations which evenly broke down to 360 observations per income category. With performance designations assigned, a similar sorting and assigning procedure was used for the four expense category variables. Farms were sorted by their expenses per acre on each variable category and were specified as a low, middle, or high

spender. These designations, while simple, will provide valuable insight during the analysis on farm income-level spending on input categories.

The analysis results are displayed in several tables for simplicity and ease of study. Each table has descriptive information on each farm income level's expenditure level. The mean, standard deviation, coefficient of variation, minimum, and maximum are provided to give some specific information on the spending practices of farmers. Also, the specific figures will give farmers basic points of reference to see where their operation falls within the dataset. Additionally, information will be provided on how many farms fell into a specific income line for a variable level section. This same information is also displayed on a percentage basis. Both figures are based on the 360 farms within the variable level section.

In this format, comparisons between variable expenditure sections become quite simple and valuable for deriving differences in spending behaviors. An additional analysis tool employed is a significance test of two proportions. The testing application will be used to tease out significant differences on the proportion on high performers with low expenditures compared to those with high expenditures for each variable category. This same method can be applied in numerous ways to measure significant differences of the other income categories' proportions. Yet, for the sake of simplicity and focus only testing of top managers will be presented. Results from the top managers will likely provide better insights on what expenditure habits are related to farm success.

The proportion test is conducted by computing a z-score for testing significance. The formula for calculating the z-score test is as follows:

$$\text{Equation 2.1.) } Z = \frac{\hat{p} - p_0}{\sqrt{\frac{p_0(1 - p_0)}{n}}}$$

where Z = number of standard deviations, \hat{p} = sample proportion one, p_0 = sample proportion two, and n = sample size. Significance was tested and reported at the 90%, 95%, and 99% confidence levels (Ott, 1984).

Another analysis tool used in this study is Duncan's new multiple range test (Duncan MRT). The test developed by David B. Duncan in 1955, is a multiple-comparison technique for obtaining all pairwise comparisons among t sample means (Ott, 1984). In application, the Duncan MRT test can be used to measure for significant differences in the mean values of variable expenditures. Two population means are defined as significantly different if the absolute value of their sample differences exceeds:

$$\text{Equation 2.2.) } W'_r = q'_\alpha(r, v) \sqrt{\frac{s_w^2}{n}}$$

where n is the number of observations in each sample mean, s_w^2 is the mean square within samples obtained from the analysis of variance table, v is the number of degrees of freedom for s_w^2 , and $q'_\alpha(r, v)$ is the critical value of the Studentized range required for Duncan's procedure when the means being compared are r steps apart.

Mean values associated with each income-level within a section can be compared for significance using Duncan's MRT test. Results will help identify if average expenditure levels differ between income groups and provide further indication of particular spending habits that favor successful farms.

Results

Table 2.1 presents the descriptive statistics for each variable used in this study by income classification and as an "All-Farms" grouping. The All-Farms statistics reflect the information of all farms used in this study. The mean, standard deviation, coefficient of variation, maximum,

and minimum of net farm income per acre and production expenditures in Table 2.1 are based on the data collected from participating Kentucky grain farmers by the Kentucky Farm Business Management program from 2006 to 2011. Note that high-income earners had the highest average expenditures in all cost categories, but a clear spending pattern is not present in the minimum and maximum expenditures for the study's top performers. Another interesting observation is that the middle-income group had the smallest standard deviation in every cost category. These statistics, among others, provide insight regarding the central tendency and variation of income and expenditures associated with income level and as a complete group.

Tables 2.2 through 2.5 contain descriptive information on the dataset. Each table describes the composition and distribution of the study population by research variable (Land, Machinery, Crop, and Labor). Within each table, cooperators are further separated by their level of expenditures on the specified variable. Additionally, the table provides a breakdown of the number of farm observations within that expenditure level based on their income category and what percentage they comprise of the variable expenditure level. In this two-tier approach it is possible for the same farm to be represented multiple times within the same income and/or expenditure classification. It is also possible for a farm to fluctuate between the multiple designations due to year to year farm performance variation. Further research could analyze the fluctuations in farm designation shifts and possible causal factors.

For easy referencing, variable levels within a table are described as sections and each row of information within the section is referred to as an income line. As an example examine the high-income line of information within the mid-level land expenditure section of Table 2.2. These farmers are in the top 1/3rd of net farm income earners and are in the middle 1/3rd of land expenditures for the dataset. On average, these farmers spend \$123.24 per acre on land

expenditures with a standard deviation of \$7.48 and a coefficient of variation of 6.07%. The minimum this group spent on land was \$109.63 and the maximum was \$135.12. The mid-level land expenditures section represents 360 farm observations of which 122 or 34% of them belong to the high-income earning farms.

Discussion and interpretations of results are addressed by expenditure variable category. An analysis of comparisons between and among variable expenditures is also included within the conclusion section.

Land Expenditures

In Table 2.2, land expenditures are sorted by expenditure level and descriptive information is provided about variable level expenditures by performance group. Within the low-land expenditure section, low-income farms make up a noticeably higher percentage of the group at 40%. Consider that farmland is divisible but is most often exchanged in larger quantities compared to residential or commercial real estate. Acquiring a considerable amount of land (whether through an outright purchase or rental agreement) is a serious decision for any operation. More often than not these exchanges are possible through the utilization of credit by the buyer or renter. Farms with a history of generating low income and possibly fewer assets to use as collateral might find it hard to qualify for the credit needed to expand their operation. These conditions could help explain why low-income farms make up more of the low-land expenditures. Additionally, it is possible that these farms operate on cheaper and consequently poorer quality ground which could be contributing to their inability to generate higher income. Farms with mid-level expenditures are more evenly distributed among the income-levels in the section.

Top-performing farms comprised a higher percentage of the farms that had high expenditures on land at 40%. In fact, significantly more farms have higher land expenditures than low land expenditures at the 95% confidence level. Top managers understand the importance of quality land and are able to extract higher income through better management practices. Top-performers also show evidence that they are cost conscious. The maximum paid by a top-performing farm (\$335.77) was the smallest amount in the land section and the average expense per acre (\$165.17) was second lowest only to mid-income farms (\$161.11). These findings show that top farms know how much they can spend on acquiring land and still generate income while not overspending. Top-managers also had the smallest standard deviation of the section (\$30.93) which possibly indicates thoughtful consideration and fact-based land acquisition as opposed to an emotionally driven decision making.

Low-income farms within this section had the highest average expense per acre at \$167.17, had the largest standard deviation of \$47.15, and had the greatest land expense observation of the study population at \$515.66 per acre. These low performing managers should reevaluate their strategies on land expenditures and use farm management decision-making tools to access the marginal economics involved. The marginal input costs of acquiring land for the low-managers are likely outpacing the marginal value they are able to generate from the cropland. Without a plan to lower land costs or a method to increase marginal revenue these farms will likely continue to produce low and possibly negative returns.

The Duncan MRT test shows that there are no significant differences in the mean values associated with variable-level expenditures at any income level. On average, regardless of income level, all farm's expenditures on land are not significantly different and may not be a defining characteristic of success. Thus, top-performing farms are not necessarily successful

because on average they pay more or less for farmland. These results point to the importance of management skill tailored to the farm's unique situation.

Machinery Expenditures

In Table 2.3, machinery expenditures are sorted by expenditure level and descriptive information is provided about variable level expenditures by performance group. An analysis of the low- and middle-machinery expense sections shows no significant differences in the mean expenditures for any income level. Top-performing farms were the smallest percentage in either section which corresponds to their majority composition (40%) in the high-expenditure section. Top performer's 40% proportion on high-machinery expenditures is significantly higher than the income classes' presence in the low-expenditure section at the 90% confidence level.

It is likely that top managers are better at efficiently and profitably managing their equipment inventory and expenses. Many farms own and operate several pieces of specialized machinery. Managing a large inventory of equipment without a sound acquisition strategy will almost certainly increase costs in the long-term. Selecting and implementing the most advantageous strategy is not an easy task and takes a manager that is committed. Farmers should consider four general machinery acquisition strategies: 1.) replacing frequently, 2.) replacing a piece of equipment every year, 3.) replacing when cash is available, or 4.) holding onto the equipment for a long period of time (Edwards, 2008). Each method has its own means of minimizing costs and mixing strategies may increase machinery. Hiring custom work is also another potential alternative for lowering the costs of any farm regardless of performance level. Top managers understand the implications that machinery investments have on their productivity and profitability, striving to implement an auspicious plan.

Results also indicate that top farms might be willing and able to spend on average more per acre on their machinery expenses than lower performing farms. Expenditures are likely directed toward acquisitions which will generate the highest marginal benefit. These purchases could include new or continued investment in precision agriculture technologies, more efficient machinery and implements, or utilizing custom work businesses as the most efficient option. Furthermore, top managers could have a greater understanding of the tax policies concerning income generating capital assets such as farm machinery. Using tax policies to their advantage, top managers are able to adjust their machinery expenses and inventories in ways that minimize their tax obligations. As top performers there is likely a need to offset larger profits and depreciating capital assets provides one outlet in the tax planning process. Recent congressional legislation has increased these tax opportunities in an effort to spur economic activity since the 2008 credit crisis. These tax policies have provided a variety of economic incentives that have encourage certain activities or investments by providing more favorable tax treatment relative to other activities or investments. Managers that are knowledge of these changes or have a support network to provide information on the evolving tax environment are more likely to take advantage of these market conditions.

According to the Duncan MRT test, there is no significant different in the mean values of low- and high-income farms within the high machinery expenditures section. Top managers likely spend more on machinery for all the reasons previously addressed. On the other hand, low-income farms spend nearly the same on machinery per acre, but are not generating nearly the same income. Low performing farms might not be able to spread the cost of machinery profitably over their operation due to the investment scale of machinery. It is as possible that they are not including a tax strategy when making machinery decisions as well. Poor managers

could also be investing in machinery that is beyond their needs or are drawn by the prospect of having new machinery. An appeal for certain brand of machinery, the “new paint” effect, or just another instance of keeping up with the Joneses are all fairly unquantifiable, but likely have some influence on purchasing decisions for most farmers. By focusing on the numbers, low- and middle-income managers would be less likely swayed by these common purchasing distractions. These managers should focus on profit maximization and critically evaluate their machinery strategy for improved cost-effectiveness.

Crop Expenditures

In Table 2.4, crop input expenditures are sorted by expenditure level and descriptive information is provided about variable level expenditures by performance group. An analysis of the low-crop expense section provides some interesting details. Top-performing farms spent significantly more (\$144.35) on average over low performing farms (\$126.53) on crop expenses. Additionally, the minimum observation for high-income farms (\$67.78) is noticeably much higher than the minimum expenditures of mid- and low- income farms (\$5.93 and \$1.89, respectively). These unusually low expenditure observations could reflect farms that experienced early growing season flooding which could have left fields fallow and/or enrolled in the Conservation Reserve Program (CRP). Severe flooding of major rivers in and around Kentucky did occur during the study period. Even top managers that are spending noticeably less than their high performing peers seem to understand the benefits of spending an adequate amount on crop expenses. Reducing the up-front cost of crop inputs creates temporary savings, but potentially sacrifices potential crop revenue from a decline in performance by harvest time. The standard deviation of this group is also much tighter (\$21.61) than the rest of the section possibly conveying the group has a stricter plan concerning crop inputs.

The mid-level expenditures section shows a tighter grouping of the income groups and there is no significant difference in the average expenditures between the income groups. At the high-level of crop expenditures, results from the Duncan MRT test show that the average expenditure levels between low- and middle-income farms (\$289.55 and \$266.51, respectively) are significantly different. Yet, these two lower performing farm classes' average crop expenditures are not significantly different from those of the top farms. Furthermore, poor performing farms spent the highest on average on crop inputs at \$289.55 and had the largest deviation of \$67.31. This evidence could suggest that simply spending money on crop inputs is not enough to generate higher income. Managers need to weigh the numerous factors that should affect when and how they use crop inputs. Forecasted weather, crop condition, and crop lifecycle stage among others are all possible considerations when utilizing crop inputs. Furthermore, managers that can effectively plan their future fertilizer consumption may be able to lock-in lower prices between peak fertilizer demand periods. Top managers are not only willing to spend more on crop inputs and use them judiciously, but understand how to use them efficiently to seek better returns.

Crop input manufacturers spend considerable amounts of money on research and marketing for their products which generates an immense amount of information for farmers to process. Deciphering facts from the sales pitch and understanding the true capabilities of crop inputs is likely a skill of top managers. Overall, good managers understand the marginal benefits of quality inputs and based on the results are more likely to spend more on inputs such as fertilizer, seed, and chemical because they have the ability to produce sufficient marginal value product. In fact, there are significantly more top performers spending high amounts than low amounts on crop inputs at the 99% confidence level.

Low-performing managers that are spending high amounts on crop inputs should take action to refine their production input plans. These managers' marginal costs on crop inputs are likely exceeding their ability to generate adequate marginal benefit. Contracting services and advice from crop specialists would be possible opportunities to help develop a more efficient plan of action. Under- or over-utilizing crop inputs can cause an excessive increase in costs and/or decreases in revenue that negatively impacts net farm income. Continually striving to narrow the gap between marginal input costs and marginal value product should be a goal of all managers. This pursuit will help managers discover the profitable input level and assist in the greater task of achieving greater farm performance.

Labor Expenditures

In Table 2.5, labor expenditures are sorted by expenditure level and descriptive information is provided about variable level expenditures by performance group. An analysis of the low- and middle-labor expense sections shows no significant differences in the mean expenditures for any income level. Top-performing farms were the smallest percentage in both the low- and mid-labor expenditure sections (26% and 32%, respectively) which corresponds to their majority composition in the high-expenditure section (41%). Top performer's 41% proportion on high-labor expenditures is significantly higher than the income classes' presence in the low-expenditure section at the 95% confidence level.

Focusing on the results in the high labor expenditure section yields some interesting observations. The Duncan MRT test demonstrates that the average labor expenditure levels between low- and middle-income farms (\$168.01 and \$158.12, respectively) are significantly different than the expenditures of top-performing farms (\$182.03). Results suggest that top managers are more likely and are more willing to spend on labor. It is possible that these

expenditures are not only focused on increasing the farm's quantity of labor, but increasing quality of labor. In order to focus on important management decisions and tasks, managers conceivably use their hired labor to complete important unskilled tasks on the farm. Freed from some of these time consuming and/or exhaustive tasks, managers are able to devote more time and attention to improving farm operations and increasing profitability. As managers remove themselves, in varying degrees, from the physical side of farm operations they also may well be able to deal with the lumpy nature of hiring additional full-time labor. Transitioning unskilled tasks to hired labor from managers will better utilize available farm resources.

Higher expenditures could also be focused toward quality labor as well as the quantity of labor. Crop consultants, agronomists, farm managers, and college educated children are all examples of investment in higher quality labor and human capital. Top managers are willing to pay for quality labor because of the perceived benefits of their skill and experience on farm income. These specialized services are able to supplement and expand the knowledge of farmers and can translate into better management decisions. Willingness to pay for this qualified advice is likely a trait of top farm managers.

Expanding labor, as opposed to crop input use, is potentially a more difficult task for some managers than others. Complications not only arise from the ability to fully utilize hired help, but from issues with managers trusting and communicating effectively with outside help. Human resource management is possibly an area of the farm business that many managers have never dealt with and is potentially a source of inefficiency. Complications related to labor management are possibly reflected in the noticeably higher measures of variability for all farm expenditures in Table 2.1. The standard deviation (\$109.68) and coefficient of variation

(119.66%) are the highest compared to the statistics of the other all farm expenditures potentially indicating that managers are the least confident in their ability to manage their labor resources.

Managers who lack human resource skills can suffer from high turnover rates or an inability to attract quality labor which can become problematic and detrimental to farm profitability. Both situations accompany unnecessarily increased labor costs as well as wasted time and resources invested in employee training and development. In a worst case scenario, insufficient labor availability during critical times of the growing season can quickly reduce yields and inflate costs associated with planting, crop maintenance, and harvest.

Conclusions

Examining farm expenditures based on expense levels and the composition of cooperators by income level has provided insight on the spending behaviors of Kentucky grain farmers. Furthermore, this empirical contribution has exposed significant differences between the average expenditures of performance classes and the apparent expense gravitation of top managers.

Analysis of the data revealed that high performance farms were significantly concentrated in the high expenditure section of each expense variable category. A significant majority of the best managers were willing to spend on all four of these expense categories and likely sought to improve returns with their expenditures. Managers that have high expenditures are not necessarily guaranteed sufficient returns on their investments. There are several instances pointed out within the tables of poor managers spending more or close to as much as the exceptional managers. These results bolster the arguments that managerial ability is key to farm success.

Spending sufficiently and judiciously on expenses requires careful thought and implementing the basic principles of agricultural management. It has been seen that top managers are spending significantly more on labor. Labor expenses are used to improve labor quantity and quality which allow managers to focus on the task of managing the farm. Redirecting unskilled tasks from the operator to hired labor liberates the manager to accomplish more management oriented task. Hiring quality labor and investing in human capital also contributes to the decision-making capacity of the farm. With more dedicated time and resources devoted to the actual planning, budgeting, and financial analysis of the farm operation, managers can focus on the marginal economics of their land strategy, machinery inventories, and crop input applications to increase profits. When their time is largely consumed with completing essential farm functions, managers may be making decisions using only intuition and past experience. This can possibly risk their ability to make gainful judgments. Simply implementing standard decision aids and budgeting tools would likely generate information that could increase returns and/or decrease costs per acre which, when magnified by the total size of the farm, could mean substantial improvement.

Agricultural research and information, in general, has become increasingly more accessible within the past decade through the proliferation of the internet. Farmers have access to information that can help them improve crop marketing decisions, shop for machinery and equipment, find information on service providers, and access information from any number of agricultural government agencies and departments. While accessing these tools and information sometimes poses challenges to the aging population of U.S. farmers, extension resources are available nationwide. Poor- and middle-managers would potentially benefit the most from

seeking continued support from their local and state agents. Implementing aforementioned agricultural management principles and tools could hold the keys to success for many producers.

It is unknown how long commodity prices will stay at their current high levels and opportunities to seize higher than normal profits could be fading. Managers that are serious about improving farm performance stand to gain in this unusual time in the agricultural sector. Low-income managers that work hard to improve their operation and are able to elevate themselves to the status of middle-managers will gain approximately \$128.98 per acre on average based on the data provided in Table 2.1. Additionally, middle-managers that want to improve the profitability of their operation stand to increase net farm income by \$174.15 per acre by striving to reach the performance level of the average top-performing farm. Both situations present the possibility of substantial gain through management ability enhancement. While managers are not able to control market prices or the weather over their fields, they are able to plan, budget, and manage the resources and risk that are inherent in production agriculture.

Table 2.1 Descriptive Statistics of Net Farm Income and Expenditures Per Acre

<i>Variable</i>	<i>Income Level</i>	<i>Mean</i>	<i>Standard Deviation</i>	<i>Coefficient of Variation</i>	<i>Minimum</i>	<i>Maximum</i>
Net Farm Income Per Acre ¹	High	332.70	113.52	35.18	213.34	1454.86
	Middle	158.55	31.61	19.94	101.95	213.24
	Low	29.57	72.12	243.93	-692.37	101.40
	All Farms	170.28	144.07	84.61	-692.37	1454.86
Land ²	High	131.09	38.14	29.10	19.83	335.77
	Middle	123.43	35.96	29.14	28.31	378.17
	Low	121.27	41.97	34.61	13.82	515.66
	All Farms	125.26	38.96	31.11	13.82	515.66
Machinery ³	High	167.00	89.66	53.69	18.52	842.38
	Middle	147.51	62.93	42.66	45.23	781.06
	Low	154.91	71.64	46.25	21.42	614.27
	All Farms	156.47	75.92	48.52	18.52	842.38
Crop ⁴	High	220.21	67.46	30.63	67.78	663.09
	Middle	193.17	62.29	32.25	5.93	448.25
	Low	196.29	79.18	40.34	1.89	639.86
	All Farms	203.22	70.97	34.92	1.89	663.09
Labor ⁵	High	106.26	132.52	124.71	8.45	1414.23
	Middle	80.63	80.08	99.31	17.91	953.74
	Low	88.09	108.79	123.50	7.00	1442.29
	All Farms	91.66	109.68	119.66	7.00	1442.29

Source: Information represents data collected and published by the Kentucky Farm Business Management Program of Kentucky grain farmers 2006-2011.

Note: All numbers are in US dollars per acre except for numbers under coefficient of variation.

¹ Net Farm Income Per Acre = (Total Gross Revenue – Total Non-Feed Costs ± Sale of Capital Assets) ÷ Total Operator Acres.

² Includes land interest/opportunity costs, property taxes, cash rent, and share leasing costs

³ Includes interest/opportunity costs, insurance, housing, gain/loss on sales, depreciation, repairs and maintenance, fuel and oil, and custom work.

⁴ Includes fertilizer, pesticides, seed, drying costs, utilities, and storage.

⁵ Includes hired labor, unpaid operator labor, and unpaid family labor.

Table 2.2 Land Expenditure Statistics by Utilization and Performance Level

<i>Variable</i>	<i>Variable Level</i>	<i>Income Level</i>	<i>Mean</i>	<i>Std Dev</i>	<i>CV</i>	<i>Min</i>	<i>Max</i>	<i>N</i>	<i>%</i>
Land ¹	Low	High	88.25 a	18.48	20.94	19.83	109.24	93	26%**
		Middle	88.75 a	17.04	19.20	28.31	109.30	122	34%
		Low	88.70 a	16.90	19.05	13.82	109.10	145	40%
	Middle	High	123.24 a	7.48	6.07	109.63	135.12	122	34%
		Middle	122.41 a	7.43	6.07	109.37	135.30	122	34%
		Low	122.31 a	7.50	6.13	109.31	135.06	116	32%
	High	High	165.17 a	30.93	18.73	135.73	335.77	145	40%**
		Middle	161.11 a	31.01	19.25	135.47	378.17	116	32%
		Low	167.64 a	47.15	28.13	135.56	515.66	99	28%

Source: Information represents data collected and published by the Kentucky Farm Business Management Program of Kentucky grain farmers 2006-2011.

Note: Significant difference testing of two proportions is verified at the 0.05 level indicated by **.

Note: Sections results with the same letters indicate no statistical difference.

Note: Means followed by same letter do not significantly differ according to the Duncan MRT Test. Only means within the same expenditure level section are compared to one another.

Note: All numbers are in US dollars per acre except for numbers under coefficient of variation, farm observation group size (N), and the farm observation percentage (%).

¹ Includes land interest/opportunity costs, property taxes, cash rent, and share leasing costs.

Table 2.3 Machinery Expenditure Statistics by Utilization and Performance Level

<i>Variable</i>	<i>Variable Level</i>	<i>Income Level</i>	<i>Mean</i>	<i>Std Dev</i>	<i>CV</i>	<i>Min</i>	<i>Max</i>	<i>N</i>	<i>%</i>
Machinery ¹	Low	High	99.31 a	19.96	20.10	18.52	123.22	102	28%*
		Middle	99.88 a	16.65	16.67	45.23	123.21	128	36%
		Low	97.17 a	21.27	21.89	21.42	122.98	130	36%
	Middle	High	142.79 a	11.38	7.97	123.80	164.56	113	31%
		Middle	141.93 a	12.06	8.50	123.23	166.05	133	37%
		Low	141.88 a	12.36	8.71	123.37	166.17	114	32%
	High	High	233.47 a	107.26	45.94	166.44	842.38	145	40%*
		Middle	216.59 b	78.26	36.13	166.52	781.06	99	28%
		Low	232.42 a	73.27	31.52	166.35	614.27	116	32%

Source: Information represents data collected and published by the Kentucky Farm Business Management Program of Kentucky grain farmers 2006-2011.

Note: Significant difference testing of two proportions is verified at the 0.1 level indicated by *.

Note: Sections results with the same letters indicate no statistical difference.

¹ Includes interest/opportunity costs, insurance, housing, gain/loss on sales, depreciation, repairs and maintenance, fuel and oil, and custom work.

Table 2.4 Crop Expenditure Statistics by Utilization and Performance Level

<i>Variable</i>	<i>Variable Level</i>	<i>Income Level</i>	<i>Mean</i>	<i>Std Dev</i>	<i>CV</i>	<i>Min</i>	<i>Max</i>	<i>N</i>	<i>%</i>
Crop ¹	Low	High	144.35 a	21.61	14.97	67.78	171.30	81	23%***
		Middle	134.14 ab	31.11	23.19	5.93	171.01	142	39%
		Low	126.53 b	39.35	31.10	1.89	170.85	137	38%
	Middle	High	196.65 a	14.65	7.45	171.59	224.24	127	35%
		Middle	198.60 a	15.58	7.84	171.89	224.71	112	31%
		Low	196.65 a	15.43	7.85	171.78	224.66	121	34%
	High	High	277.42 ab	60.60	21.84	224.81	663.09	152	42%***
		Middle	266.51 b	39.18	14.70	224.88	448.25	106	29%
		Low	289.55 a	67.31	23.25	226.04	639.86	102	28%

Source: Information represents data collected and published by the Kentucky Farm Business Management Program of Kentucky grain farmers 2006-2011.

Note: Significant difference testing of two proportions is verified at the 0.01 level indicated by ***.

Note: Sections results with the same letters indicate no statistical difference.

¹ Includes fertilizer, pesticides, seed, drying costs, utilities, and storage.

Table 2.5 Labor Expenditure Statistics by Utilization and Performance Level

<i>Variable</i>	<i>Variable Level</i>	<i>Income Level</i>	<i>Mean</i>	<i>Std Dev</i>	<i>CV</i>	<i>Min</i>	<i>Max</i>	<i>N</i>	<i>%</i>
Labor ¹	Low	High	39.57 a	9.69	24.49	8.45	51.90	95	26%**
		Middle	40.05 a	8.13	20.30	17.91	52.00	142	39%
		Low	38.92 a	8.80	22.61	7.00	51.88	123	34%
	Middle	High	63.56 a	8.27	13.01	52.13	84.04	116	32%
		Middle	63.79 a	8.50	13.32	52.21	83.37	118	33%
		Low	65.68 a	8.54	13.00	52.00	83.08	126	35%
	High	High	182.03 a	180.06	98.92	84.19	1414.23	149	41%**
		Middle	158.12 b	119.62	75.65	84.36	953.74	100	28%
		Low	168.01 b	169.51	100.89	84.44	1442.29	111	31%

Source: Information represents data collected and published by the Kentucky Farm Business Management Program of Kentucky grain farmers 2006-2011.

Note: Significant difference testing of two proportions is verified at the 0.05 level indicated by **.

Note: Sections results with the same letters indicate no statistical difference.

¹ Includes hired labor, unpaid operator labor, and unpaid family labor.

Chapter Three

A Quantile Econometric Analysis of Expenditure Allocation on Farm Management Performance of Kentucky Grain Farmers

Introduction

The success of agricultural producers has always been disproportionately influenced by a number of uncontrollable factors including two revenue components: output price and quantity. United States agricultural producers, for the most part, individually own an infinitesimal portion of market share and are subject to the limitations of homogeneous product production, which essentially negates any ability to alter markets. As price takers, farmers are no more able to manipulate markets than they are able to alter the weather. Growing season conditions have always played a critical role in determining the yields that farmers are able to produce. Globalization has expanded the influence of weather as linking economies have broken down the barriers of isolated commodity and financial markets. Weather events in South America almost instantly affect the price which western Kentucky farmers receive at their local elevator in this new global economy. Evolving agricultural markets have further limited the influence of the individual farmer.

Despite the formidable nature of the markets and the weather, farmers and other actors in the agricultural industry have long been developing tools and resources which seek to soften the severity of these factors. Drought-resistant seed, advanced irrigation systems, precision field technology, market hedging tools, and crop insurance are just a few of the resources farmers have turned to in an effort to reduce risk inherent in agricultural production. These investments in technology and capital assets also come at a cost which should be thoroughly evaluated by farmers.

An ability to generate profit is not only determined by the capability to produce revenue, but by controlling the costs of production. Some managers, for a variety of reasons, are better than others at determining what investments are more likely to have a greater marginal benefit than marginal cost to their operation. Evaluating the expected returns on expenditures provides a much clearer picture of expenditure allocations for farmers. Managers who efficiently distribute available capital will likely experience improved farm performance which can improve prospects for farm longevity.

This study implements a quantile regression methodology which seeks to evaluate expenditure prospects for different level managers based on farm performance. By categorizing and studying farms by performance level, more detailed results and recommendations can be discussed. Using estimates from an ordinary least squares model or similar models assumes that the results apply equally to subjects within the sample population. The quantile regression method has the advantage of allowing one to study sub-groups within the population and provided specific information instead of blanket recommendations. The expenditures of Kentucky grain farmers are the focus of this study and farms are segregated into three levels of performance. Expanded details on the data, the variables utilized, and the implementation of quantile regression analysis is embodied in the next two sections.

The key mission of this chapter is to analyze Kentucky farm-level data utilizing quantile regression to provide sound information for farm businesses and managers on the effects of input costs allocation on farm success based on performance level. Specific objectives are to:

1. Utilize quantile regression to further expand the statistical methodology's use in agricultural econometric research,

2. Develop an econometric framework to analyze farm-level data to determine expenditure categories which predict significant returns to net farm income based on farm performance,
3. Present interpretations and results from the empirical information which can be utilized and applied in production agriculture.

Quantile regression's use in the study of agricultural economics has been small but rapidly growing as an area of econometric research in the field (El-Osta, 2011, Hennings and Katchova, 2005, Marroquin, 2008, Sonka, et al., 1989). This study will further contribute to the growing work of quantile regression research in the field of agricultural economics, representing an innovative, seldom used application for conducting farm-level research.

Explanatory Variables Selection and Data Description

This section outlines the methodology employed to construct the variables considered in this study. Included are the descriptions of the constructed variables as well as the econometric models employed during the analysis.

Data from The Kentucky Farm Business Management Program (KFBM) at the University of Kentucky is utilized in this study. KFBM provides record keeping based assistance and analysis for Kentucky farmers by offering a reliable source of data about the program's cooperators. Programs like KFBM operate in numerous states and have been sources of dependable data for decades. These programs take several steps to ensure the accuracy and integrity of their data available for research purposes.

This chapter employs available data for years 2006 through 2011. To focus the research further additional filters were applied to the dataset. First, only KFBM certified farm records were considered for this study. Certification of farms ensures that the data is accurate and

appropriate for academic research. Second, only farm operations designated by KFBM as “grain farms” were selected. Grains farms were selected as the focus for two reasons: 1.) grain farms utilize traditional farm machinery to a greater extent compared to dairy, beef, and hog operations, and 2.) KFBM’s membership base is dominated by grain farmers which lends itself to a larger study sample. Further, it is not uncommon in Kentucky to have farms that have both grain and cattle components to their operations. Farms that generated 25% or more of their gross revenue from livestock operations above feed costs were excluded from the study (Kaase, et al., 2003).

Net farm income (NFI) is used as the dependent variable in this study and was selected for its documented use as a measure of farm success and performance (Haden and Johnson, 1989, Melichar, 1979, Mishra, et al., 1999, Seger and Lins, 1986). Generating positive net farm income is important for farm operations which need to satisfy current liabilities and hope to establish positive equity growth. Net farm income is calculated by subtracting total non-feed costs from gross farm returns, including gain/loss on the sale of capital assets. Net farm income can also be thought of as the return to the operator’s equity capital, management, and unpaid labor. Comparing net farm income with the opportunity of foregone non-farm wages and capital invested can be a useful tool for assessing true farm profitability.

Net farm income per acre, as a measure of financial success, is used as a proxy measure for management ability in this study. Managerial ability is defined as the skill, knowledge, and experience used to plan and coordinate the resources and activities of an operation in order to meet specific goals. While no specific variable was used to measure management abilities, this study relates farm income performance to the actions taken by managers in seeking the goal of profit maximization. It is possible and likely that some observed contributions to net income

performance are not directly linked management decisions (i.e. economies of farm size), but this study treats all income fluctuations as a result of management decision making.

Selected explanatory variables for this study were derived from the examination of several other models. Huffman and Evenson (1989) used four main variables (fertilizer, fuel, labor, and machinery services) and also included land expenditures, among other variables, to study demand and supply functions of multiproduct U.S. cash grain farms. Reports developed by University of Illinois Extension study state farmer's economic costs using seven aggregate cost categories: Crop, Power, Building, Labor, Overhead, and Land (Schnitkey, 2001, Schnitkey and Lattz, 2003). Another report using data from the Kansas Farm Management Association (KFMA) broke production costs into smaller categories to study characteristics of profitable farms. While the report described production expenses in greater detail they reflect expenses associated with crop, machinery, labor, land, interest, and other costs (Albright, 2002). Selected variables of interest for this study include: machinery, land, crop, and labor expense categories.

Model Framework

Two econometric models are employed in this study. The first is a fixed effects model and second is a fixed effects quantile regression. In the fixed effects model, which involves panel data for estimation, dummy variables are included to account for firm specific individual effects. The Hausman Test, developed by Jerry Hausman (1978), is a statistical assessment of whether or not the unobserved individual effect is correlated with the conditioning regressors in the model (Amini, et al., 2012). Significant test results reject the null hypothesis which suggests that the coefficients estimates are inconsistent when a fixed effects model is not used. Due to the circumstances the fixed effects model is used as the base model for comparisons with the quantile approach instead of an ordinary least squares model which is typically used.

The basic fixed effects model can be written:

$$\text{Equation 3.1) } y_{it} = \alpha_i + x'_{it}\beta + u_{it}$$

where y_{it} is the dependent variable (DV) where i = entity and t = time, α_i ($i=1\dots n$) is the unknown intercept for each entity (n entity-specific intercepts), x_{it} represents one of the independent variables (IV), β_1 is the coefficient for that IV, and u_{it} is the error term (Verbeek, 2008).

Quantile regression was developed by Koenker and Bassett (1978) and has the capability to identify differences in the response of the dependent variable to fluctuations in the independent variables which offers substantial information about sample population (Krüger, 2006). In essence, one is able to witness different marginal responses of the dependent variable to changes in the explanatory variables at various points in the distribution on the dependent variable. This unique characteristic of quantile regression makes it a valuable econometric tool which can greatly expand the detail that can be collected from the data. Quantile regression also has the advantage of working well with heterogeneous data because, unlike OLS, it does not assume normally distributed errors for the estimation of the coefficients and allows coefficients to adjust for different sub-sets of the sample (Hennings and Katchova, 2005). The Breusch-Pagan test was employed in this study and indicated that heteroskedasticity was present within the data. These findings support the use of quantile regression as an appropriate econometric tool.

While quantile regression is an excellent tool for dealing with heteroskedastic data it does not appropriately deal with the unobserved individual effects embedded within the data. Combining quantile regression and the fixed effects model has been a growing field of research (Abrevaya and Dahl, 2008, Canay, 2011, Galvao, 2011, Geraci and Bottai, 2007, Koenker, 2004,

Lamarche, 2010, Rosen, 2012). Merging methodologies to create a fixed effects quantile regression model provides subsequent results suitable for comparison to the fixed effects model. In this study, subjects are studied on the 0.25, 0.50, and the 0.75 quantiles. These specific quantiles were chosen to represent and study low-, middle-, and high-income farms, respectively. It is common within farm comparison studies and publications issued by programs like KFBM to have farms, managers, or cooperators segregated into sub-sets for study purposes. Often groups of three are developed to study a middle or average group with an additional sub-group on either side to measure the extremities of the data. This study replicates this approach for simplicity and comparability with other studies. Expanding the number of quantiles being studied is possible and is potentially an area for future research.

Creating three separate groups for analysis, subtly infers that there is an expected difference in the results between the groups. These differing results will highlight the usefulness of quantile regression especially if they expose significantly different strategy recommendations for low- and high-performing farms. For high performing farms it is expected that all the categorical expense variable signs will be positive. As the study samples best managers, it is anticipated that any increase in expenditures will be done efficiently. It is unlike these managers to make rash management decisions that are not likely to be marginally beneficial. Middle performing managers likely do enough research to remain profitable, but likely not to the extent which high-performers study.

Middle managers might also be eager to grow, expand, and desire to reach the operational capacity of high performing managers. It is hypothesized that middle managers will have negative signs associated with their net farm income returns to machinery and land. These two inputs of production agriculture could be defended as the most visual reflections of manager

success and could be speculated as the “essential” areas that need to be expanded for increased profitability by middle managers. Yet, these managers still have the knowledge and capacity to make thoughtful decisions. It is hypothesized that machinery and land will have negative coefficient signs although likely insignificant. Labor is expected to have a negative coefficient while the crop inputs variable has an anticipated positive coefficient. Farm labor is possibly one of the hardest production inputs to manage for all the reasons previously discussed in the chapter. This inherent difficulty in management is why the expected return to net farm income is negative. Crop inputs, on the other hand, are highly manageable especially in the hands of good managers. Middle managers are likely experienced in the use and application of crop inputs and understand how to utilize them efficiently. Any expansion of crop inputs expenditures is likely to produce positive net farm income.

Sample observations classified as low performing managers are considered to be managers who are unable to utilize their resources and operation profitability. For this reason the expected coefficient signs on land, machinery, and labor are negative. These production inputs often reflect larger investments that tend to be more complicated to manage efficiently. Crop inputs, on the other hand, are more flexible, accessible, and could represent the most direct option for positively impacting net farm income. It is hypothesized that the crop input variable will also be positive for low performing managers.

Results

Research results are included in this section and includes study findings related to the fixed effects models as wells as the quantile models. Before conducting the aforementioned models, essential statistical testing was necessary to ensure the validity of the research results. Testing for heteroskedasticity rejected the null hypothesis that the data exhibited constant

variance. This result is consistent with the differing coefficient results among the quantile estimations. These two indications support the use of quantile regression as an estimation tool. The Hausman test rejected the null hypothesis which suggests that coefficient estimates are inconsistent when the fixed effects model is not used. The Wooldridge test for autocorrelation and several multicollinearity tests indicated no serious statistical problems.

Descriptions of the composition of each categorical expense variable and their associated descriptive statistics are available in Tables 3.1 and 3.2, respectively. Average net farm income for the dataset is \$170.28 per acre, but has a range of income from -\$692.37 to \$1454.86 per acre with a standard deviation of \$144.07. Figure 3.1 provides a graphical depiction of the net farm income distribution by quantile. Notice that most net farm income observations fall within the \$0 to \$500 per acre range. The median, as opposed to the mean, is used as the measure of centrality in quantile regression which makes the model robust to the outliers that are present within the data. Averages and ranges of expenditure categories are also provided and reflect similar information published by KFBM.

Fixed Effects Regression

The Hausman test indicated that the fixed effects model was the appropriate model due to systematic difference in coefficients. Table 3.3 presents results from the fixed effects regression model. According to the results the machinery expenditures variable is the only significant variable influencing net farm income per acre. The results suggest that an additional dollar spent per acre on machinery expenditures would generate \$0.68 per acre in net farm income. More specifically, a one dollar per acre investment in machinery expenditures would produce a \$1.68 of revenue per acre, a net return of \$0.68 per acre.

Although insignificant, the sign of the land expenditures variable would suggest that farmers would experience a loss in net income of approximately \$0.08 for every dollar spent on land expenditures. Expenditure results on crop and labor were also insignificant, but suggest a return of \$0.03 and \$0.12 in net farm income per acre, respectively. Following the results of the fixed effects model would indicate that all farms, regardless of performance level, are able to increase net farm income per acre by increasing machinery expenditures. Assumed in this interpretation is that the increased expenditures are used in a relatively efficient manner by spending on investments which will bring some benefit to the operation. Simply spending money on new yet unnecessary machinery or implements will not likely increase income, but will potentially have the opposite effect. Exploring these findings with the use of quantile regression for comparison should create additional information for which to judge the outcomes of the fixed effects model.

Fixed Effects Quantile Regression

Low-performing Managers

The results from the model estimation of the 25th quantile in Table 3.4, which is a measure of low-income farmers, suggest that these farmers have no significant outlets to increase net farm income from additional expenditures on land, machinery, crop inputs, or labor. This studies use of net farm income per acre as a proxy for managerial ability seems to indicate that management proficiency is a critical input in order to extract returns from production inputs. No amount of increased expenditures will produce positive net farm income if these purchased inputs are not used efficiently.

While none of the coefficient estimates are significant the results can be used to highlight some interesting points. Land and labor can be difficult to manage efficiently because of the

lumpy nature of these inputs. Acquiring additional units of both of these resources usually requires a large investment. Farmland, while divisible, is usually exchanged in larger quantities than commercial or residential real estate. Farm labor is also difficult to acquire in small units when most hired employees might prefer to be hired full-time. Poor managers might find it difficult to efficiently manage these lumpy quantities of land and labor which could severely affect farm performance. Additionally, managers with little human resource experience might find it hard to work or communicate with hired labor. There are several resources available to farmers to improve utilization of their land and labor resources including online and local agricultural extension materials, enterprise budgeting aids, mentor farmers, for-profit farm management services and state programs such as KFBM.

Machinery and crop expenditures have a positive influence, yet insignificant, returning just \$0.23 and \$0.13 for every dollar spent, respectively. Since the model results indicate that no significant means of improving farm performance exists for the variables in questions, poor managers need to focus on their management strategies, resource allocation, and re-evaluating their decision-making process before turning to capital and credit investment in an attempt to increase farm income. Increasing expenditures on inefficiently used resources will likely only exacerbate problems. These farmers would benefit from education, working with their local extension agents, or possibly removing themselves from the operation.

Middle Managers

The results from the model estimation of the 50th quantile in Table 3.5, which is a measure of middle-income farmers, suggests that these farmers have a significant and substantial means of increasing net farm income by channeling increased expenditures into machinery. For every additional dollar spent on machinery, net farm income could increase by \$0.50. More specifically, a one dollar per acre investment in machinery expenditures would produce a \$1.50

of revenue per acre, a net return of \$0.50 per acre. Low income farmers are only able to generate around \$0.29 for their investment in machinery, a \$0.21 improvement per acre for middle managers. While the results favor additional expenditures on machinery it is crucial to allocate capital in the most efficient manner possible. Purchasing equipment which does not increase efficiency or satisfy any farm operation needs is likely to have a negative impact on net farm income. Increased costs associated with the purchase without any off-setting or superior returns from the machinery will likely be detrimental to generating higher income.

Farmers, regardless of income level, also need to consider the indivisible properties of certain resources like machinery. More specifically, machinery cannot ordinarily be applied in precise units due to the fact that machinery as a durable good is sold in discrete units. Therefore, it may be difficult for some farmers to increase machinery expenditures per acre in the small amounts they desire. Farmers in this situation could consider using custom work as an alternative to better meet their constrained needs. Custom work offers more flexibility in machinery applications and helps bypass the lumpy nature of farm machinery and equipment.

Other expense categories are insignificant, but have some interesting findings. It seems that the managing abilities of middle-income farmers allow them to more effectively use some resources. Crop expenditures will generate around \$0.14 in net income per acre a one cent improvement over low-income farmers. Land expenditures create positive returns of \$0.34 per acre, a \$0.46 improvement over low income farmers. Labor expenditures have a greater negative impact on these farmers with a loss of \$0.35 in net income per acre for every additional dollar spent. Based on the findings, middle managers might see more success by reducing their expenditures on labor and redirecting those funds into machinery. Redirecting one dollar from labor into machinery would generate \$0.85 of net income per acre. Increasing labor costs and

expanding utility of farm machinery, partnered with the escalating use of crop inputs overtime, has favored investments in machinery and equipment as opposed to labor.

Top Managers

The results from the model estimation of 75th quantile in Table 3.5, which is a measure of high-income farmers, suggests that these farmers have a significant means of increasing net farm income by increasing expenditures on machinery and land. For every additional dollar spent on machinery, net farm income will increase \$0.67 per acre. This is the highest return on machinery expenditures of the farm-income categories studied. High-income farms are able to generate \$0.17 and \$0.38 more in net income per acre over middle- and low-income farms, respectively. Take note of the general trend of machinery coefficients across quantiles presented in Figure 3.2b. Estimated growth in net farm income per acre from increased machinery expenditures generally trends upward starting at the 20th quantile and levels out approximately at the 70th quantile. Highlighted in this figure is the general indication that as managerial performance level increases so does the ability to realized better returns from increased machinery investments. Yet, as indicated in Figure 3.2b, the increasing returns from machinery investments level off around the 70th quantile. Top managers above this 70th level are likely handling their equipment in a highly efficient manner and should continue to look for individual means of improvement.

For every additional dollar spent on land, net farm income will increase \$0.65 per acre. This is the highest return on land expenditures and the only significant finding for land of the farm-income categories studied. High-income farms are able to generate \$0.31 and \$0.77 in net income per acre over middle- and low-income farms, respectively. These results suggest that only the best managers should consider expanding their operations by utilizing more land. While it is not impossible, middle- and low-income generating farms would likely not see a significant

increase in net income by expanding the land they operate. Take note of the general trend of land expenditure coefficients across quantiles presented in Figure 3.2a. Estimated growth in net farm income per acre from increased land expenditures generally trends upward starting at the 20th quantile. Highlighted in this figure is the general indication that as managerial performance level increases so does the ability to realized better returns from increased land investments.

Significant machinery and land expenditure variables for high performing managers seemingly supports previous conclusions concerning the managerial ability needed to efficiently utilize discrete natured assets. Top managers are able to address these issues in a profitable method through proper planning.

Crop expenditures, while insignificant, have lower returns compared to middle- and low-income farms. While not a large difference the results are interesting. It's possible that the high-income farms, which mostly likely have the best managers, have already allocated crop expenditures in a highly efficient manner which leaves little opportunity for short-term improvement. These farms still generate nearly the same net-income per acre on additional crop expenditures, but have better means of allocating their capital profitably. Labor is also an insignificant and negative means of increasing net farm income per acre. While the effect of spending additional capital on labor is less detrimental for high-income than middle income farms, resources would be best directed into machinery rather than labor. Redirecting one dollar from labor into machinery would generate \$0.97 of net income per acre.

The opposite sign relationship between machinery and labor expenditures exists at each quantile level studied. The general declining trend of labor expenditure coefficients across quantiles is presented in Figure 3.2d. Estimated growth in net farm income per acre from increased labor expenditures generally trends downward starting at the 15th quantile. Highlighted

in this figure is the general indication that as managerial performance level increases there is a tendency to not seek increased net farm income from labor expenditures.

Labor expenditures consistently offered a negative effect on net farm income while machinery expenditures boasted a positive influence. The substitution relationship between labor and machinery has been extensively studied in the past and seems to surface within this research as well. Notice the opposite trends between machinery expenditure in Figure 3.2b and labor expenditures in Figure 3.2d. While it is important to note that not all the signs on the labor and machinery coefficients are significant, the general relationship presented between the two cost variables coincides with accepted nature of these two factors of production. The results seem to suggest that any farmer, regardless of income or performance level, would benefit from evaluating a shift in resources from labor to machinery. Improved machinery capabilities can displace some needs for farm labor and can improve efficiency at which the farm operates. Each farm will need to analyze its own situation to determine the optimal machinery to labor use relationship.

Fixed Effects Regression vs. Quantile Regression Fixed Effects Results

This section will address the different findings of the fixed effects model and the fixed effects quantile regression. Table 3.7 presents the coefficient estimates for each model and two measures of significance. The asterisks are used to denote coefficients that are significantly different from zero at the 5% significance level. The solid diamonds are used to denote quantile regression coefficients that are significantly different than the estimates generated by the fixed effects model at the 5% significance level. Information embodied within Table 3.7 can also be viewed graphically in the sub-figures contained in Figure 3.2. When the fluctuating coefficient line estimates venture outside of the dashed confidence interval of the fixed effects estimates,

then the estimates are significantly different. When these significant differences occur the advanced diagnostic properties of quantile regression are revealed. The ability to identify differences in the response of the dependent variable to fluctuations in the independent variables provides substantially more information about the dataset. Study specific differences between the two models are provided below.

The fixed effects model suggests that Kentucky farmers could only significantly increase net farm income per acre by increasing expenditures on machinery. Furthermore, this model estimates a return of \$0.68 per additional dollar in machinery expenditures. On the other hand, quantile regression estimates demonstrate that a farm's position on the net farm income distribution has an effect on where expenditures should be distributed. In fact, only those farms in the middle- and high-income categories are expected to experience a significant impact from increased machinery expenditures. Additionally, the magnitude of this impact also differs by income group. The fixed effects coefficient for machinery (0.682) would noticeably overestimate the expected returns for middle- and low-income farms. Strictly following the results of the fixed effects regression model would likely lead to inefficient expense distribution for these two lower performing farm levels.

Furthermore, the fixed effects regression model results suggest that increasing expenditures on land would cause a negative effect on net farm income. Yet, this is not the case for high-income farms that have the management capacity to run a larger operation. Increasing land expenditures for farms in the 75th quantile is a significant means of increasing net farm income. Again, the quantile model shows its usefulness in providing more in-depth analysis of the data.

Other insignificant, but noticeable differences between the two models include the underestimated returns from increased crop expenditures provided by the fixed effects regression

model. While this model only estimated an approximate \$0.03 increase in NFI from an additional dollar in expenses the quantile estimated returns around \$0.13 for each farm-income group. Sign differences for labor expenses are another visible distinction between the two models. The fixed effects regression estimate for labor is positive, but estimates in the quantile model are all negative.

Conclusions

This empirical study's use of quantile regression highlighted the positive attributes of this methodology and made a case for its future inclusion in farm-level analyses. Quantile regression not only compensated for heterogeneity within the dataset, but emphasized how linear model estimates, like the fixed effects model, are not always a suitable technique for analyzing farm performance. Results from the fixed effects model predict that increasing machinery expenditures is the only significant method for increasing net farm income per acre. However, this method is not necessarily appropriate for all farms as demonstrated by the fixed effects quantile regression. Machinery expenditures were only significant for middle- and high-performing farms and land expenditures were revealed to be important for high-performers as well. Differences revealed between these two models showcases a possibility of future research which can provide more customized information and recommendations based on the unique situation of a firm.

The information gathered and presented in this study is particularly useful not only for the farmers of Kentucky, but for other actors involved in production agriculture. Extension agents within and outside the Commonwealth can apply these findings as they continue to support their county producers. Evidence from this study detracts from the notion that unspecific, untargeted education or broad-spectrum recommendations should not be made indiscriminately

of farm standing. This study finds that poor-performing managers have no significant expense outlets for increasing net farm income. Attributing these findings to farmers' inability to make informed management decision makes a case for implementing fundamental farm management principles based extension education. Creating better farm managers opens up new avenues of expansion for operations. Yet, middle- and high-performing farm managers are already utilizing this knowledge to varying degrees and could benefit more from targeted education. Programs and resources from agents and industry professionals covering topics such as human resource management, managing machinery inventories, or budgeting farm expansions would be more beneficial for these higher level managers. Participation in programs and extension research would likely increase if producers felt they were getting more customized advice and assistance.

Policymakers should also be interested in the results on this study as well. Decisions on how research funding and program grants are allocated should be based on maximizing benefit and directing money where it is needed most. If policymakers are interested in helping farms that are struggling in relatively good times for the agricultural sector, they need to focus on poor-performing farm specifically. With more detailed recommendations, like those provided in this study, it becomes clearer that education assistance is potentially needed more than machinery subsidization or tax incentives to lift up these distressed farms. Evaluating the needs of sub-groups instead of the entire population has the ability to not only produce better results with a more targeted approach, but will better utilize programming funds which are often scarce and threatened by competition.

The rapid progression of United States agriculture will continue to open up opportunities for willing and able producers, but will also present challenges for those who cannot persevere. Management abilities will become more and more essential as farms continue to grow and have

revenue, costs, assets, and liabilities that parallel those of small corporations. The days of the small family farm seem to be passing, for good or for worse, and farm managers are going to need the help of agricultural research and education to make the transition.

Table 3.1 Variable Description

<i>Variable</i>	<i>Description of Variable</i>
NFI	(Gross Farm Returns - Total Non-Feed Costs plus Interest on Equity Capital and Unpaid Farm Labor & Management) / Operator Acres.
Land	Interest/Opportunity cost, taxes, cash rent, and leasing cost.
Machinery	Interest/Opportunity cost, Insurance, Housing, Gain/Loss on Sales, Depreciation, Repairs & Maintenance, Fuel & Oil, and Hired Machine Hire and Lease.
Crop	Fertilizer, Pesticides, Seed, Drying, Utilities, and Storage.
Labor	Hired Labor, Unpaid Operator Labor, and Unpaid Family Labor.

Table 3.2 Variable Definition and Descriptive Statistics

<i>Variable</i>	<i>Variable Description</i>	<i>Mean</i>	<i>Std. Dev.</i>	<i>Min</i>	<i>Max</i>
NFI ¹	Net Farm Income Per Acre	170.28	144.07	-692.37	1454.86
Land ²	Land Expenditures	125.26	38.96	13.82	515.66
Machinery ³	Machinery Expenditures	156.47	75.92	18.52	842.38
Crop ⁴	Crop Expenditures	203.22	70.97	1.89	663.09
Labor ⁵	Labor Expenditures	91.66	109.68	7.00	1442.29

Note: All numbers values are in US \$ per acre

¹ (gross farm returns - total non-feed costs plus interest on equity capital and unpaid farm labor & management) / operator acres.

² Includes interest/opportunity cost, taxes, cash rent, and leasing cost.

³ Includes interest/opportunity cost, insurance, housing, gain/loss on sales, depreciation, repairs & maintenance, fuel & oil, and hired machine hire and lease.

⁴ Includes fertilizer, pesticides, seed, drying, utilities, and storage.

⁵ Includes hired labor, unpaid operator labor, and unpaid family labor.

Table 3.3 Net Farm Income Per Acre Fixed Effects Regression Results

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Err.</i>	<i>z</i>	<i>P> z </i>	<i>95% Confidence Interval</i>	
Land ¹	-0.081	0.169	-0.48	0.630	-0.413	0.250
Machinery ²	0.682	0.120	5.70	0.000	0.447	0.917
Crop ³	0.031	0.090	0.34	0.731	-0.147	0.209
Labor ⁴	0.120	0.124	0.96	0.336	-0.124	0.363
Constant	56.504	23.275	2.43	0.015	10.814	102.194

¹ Includes interest/opportunity cost, taxes, cash rent, and leasing cost.

² Includes interest/opportunity cost, insurance, housing, gain/loss on sales, depreciation, repairs & maintenance, fuel & oil, and hired machine hire and lease.

³ Includes fertilizer, pesticides, seed, drying, utilities, and storage.

⁴ Includes hired labor, unpaid operator labor, and unpaid family labor.

Table 3.4 Net Farm Income Per Acre Quantile Regression 25th Results

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Err.</i>	<i>t</i>	<i>P> t </i>	<i>95% Confidence Interval</i>	
Land ¹	-0.120	0.316	-0.38	0.704	-0.740	0.500
Machinery ²	0.292	0.229	1.27	0.203	-0.158	0.742
Crop ³	0.129	0.126	1.03	0.306	-0.118	0.377
Labor ⁴	-0.096	0.332	-0.29	0.774	-0.747	0.556
Constant	-32.989	73.889	-0.45	0.655	-178.034	112.056

¹ Includes interest/opportunity cost, taxes, cash rent, and leasing cost.

² Includes interest/opportunity cost, insurance, housing, gain/loss on sales, depreciation, repairs & maintenance, fuel & oil, and hired machine hire and lease.

³ Includes fertilizer, pesticides, seed, drying, utilities, and storage.

⁴ Includes hired labor, unpaid operator labor, and unpaid family labor.

Table 3.5 Net Farm Income Per Acre Quantile Regression 50th Results

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Err.</i>	<i>t</i>	<i>P> t </i>	<i>95% Confidence Interval</i>	
Land ¹	0.339	0.320	1.06	0.289	-0.288	0.967
Machinery ²	0.503	0.214	2.35	0.019	0.083	0.922
Crop ³	0.138	0.128	1.08	0.280	-0.113	0.390
Labor ⁴	-0.351	0.354	-0.99	0.322	-1.045	0.344
Constant	-96.609	196.539	-0.49	0.623	-482.416	289.198

¹ Includes interest/opportunity cost, taxes, cash rent, and leasing cost.

² Includes interest/opportunity cost, insurance, housing, gain/loss on sales, depreciation, repairs & maintenance, fuel & oil, and hired machine hire and lease.

³ Includes fertilizer, pesticides, seed, drying, utilities, and storage.

⁴ Includes hired labor, unpaid operator labor, and unpaid family labor.

Table 3.6 Net Farm Income Per Acre Quantile Regression 75th Results

<i>Variable</i>	<i>Coefficient</i>	<i>Std. Err.</i>	<i>t</i>	<i>P> t </i>	<i>95% Confidence Interval</i>	
Land ¹	0.654	0.264	2.47	0.014	0.134	1.172
Machinery ²	0.665	0.221	3.00	0.003	0.230	1.099
Crop ³	0.124	0.188	1.04	0.298	-0.109	0.356
Labor ⁴	-0.317	0.463	-0.68	0.494	-1.226	0.592
Constant	-34.668	206.475	-0.17	0.867	-439.980	370.644

¹ Includes interest/opportunity cost, taxes, cash rent, and leasing cost.

² Includes interest/opportunity cost, insurance, housing, gain/loss on sales, depreciation, repairs & maintenance, fuel & oil, and hired machine hire and lease.

³ Includes fertilizer, pesticides, seed, drying, utilities, and storage.

⁴ Includes hired labor, unpaid operator labor, and unpaid family labor.

Table 3.7 Quantile Regression Coefficients at Different Quantiles

Farm Expenditure Categories	Fixed Effects Regression	Quantile Regression at the 25th Quantile	Quantile Regression at the 50th Quantile	Quantile Regression at the 75th Quantile
Land ¹	-0.081	-0.120	0.339 [♦]	0.654 ^{*♦}
Machinery ²	0.681 [*]	0.292 [♦]	0.503 [*]	0.665 [*]
Crop ³	0.031	0.129	0.138	0.124
Labor ⁴	0.120	-0.096	-0.351 [♦]	-0.317 [♦]
Constant	56.504 [*]	-32.989	-96.609	-34.668

*: Significantly different quantile regression coefficient from zero at the 5% significance level.

♦: Significantly different quantile regression coefficient from the fixed effects regression coefficients at the 5% significance level.

¹ Includes interest/opportunity cost, taxes, cash rent, and leasing cost.

² Includes interest/opportunity cost, insurance, housing, gain/loss on sales, depreciation, repairs & maintenance, fuel & oil, and hired machine hire and lease.

³ Includes fertilizer, pesticides, seed, drying, utilities, and storage.

⁴ Includes hired labor, unpaid operator labor, and unpaid family labor.

Figure 3.1 Distribution of Net Farm Income Per Acre by Quantile

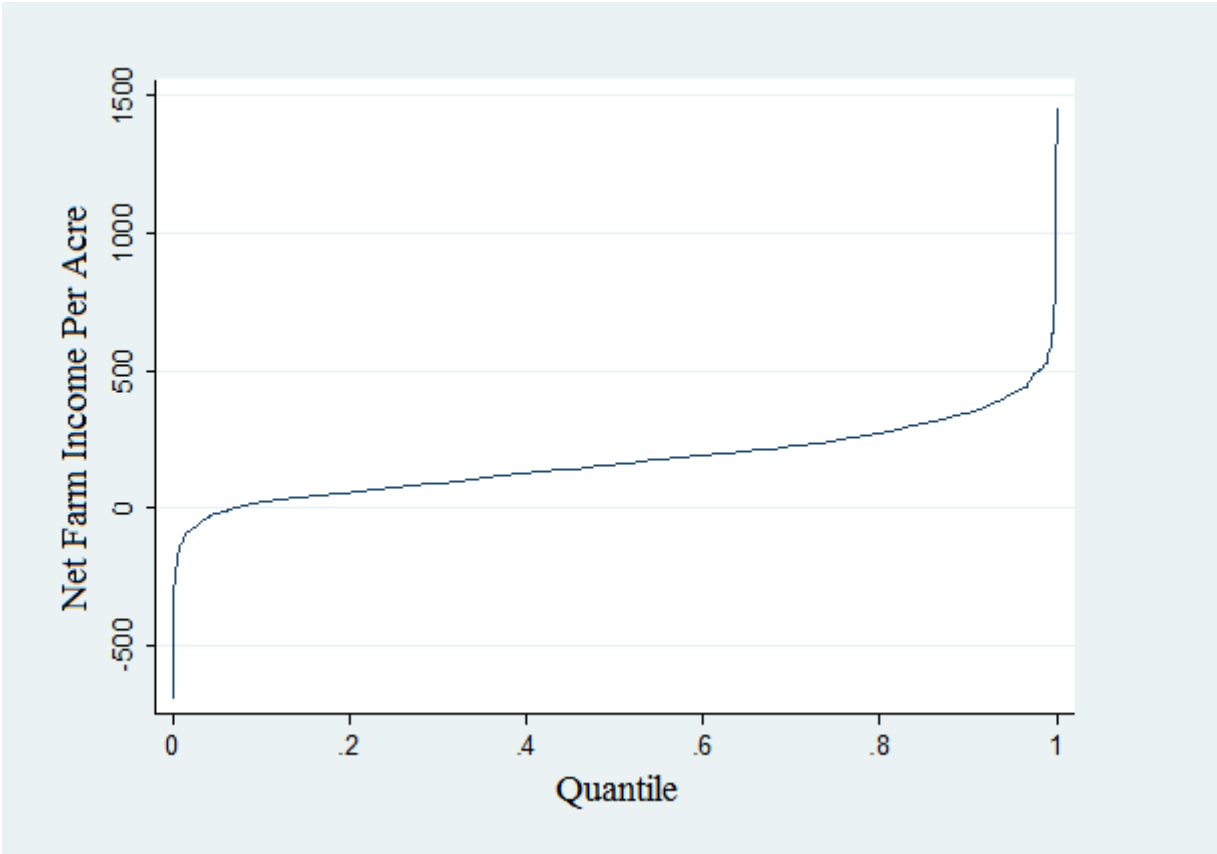
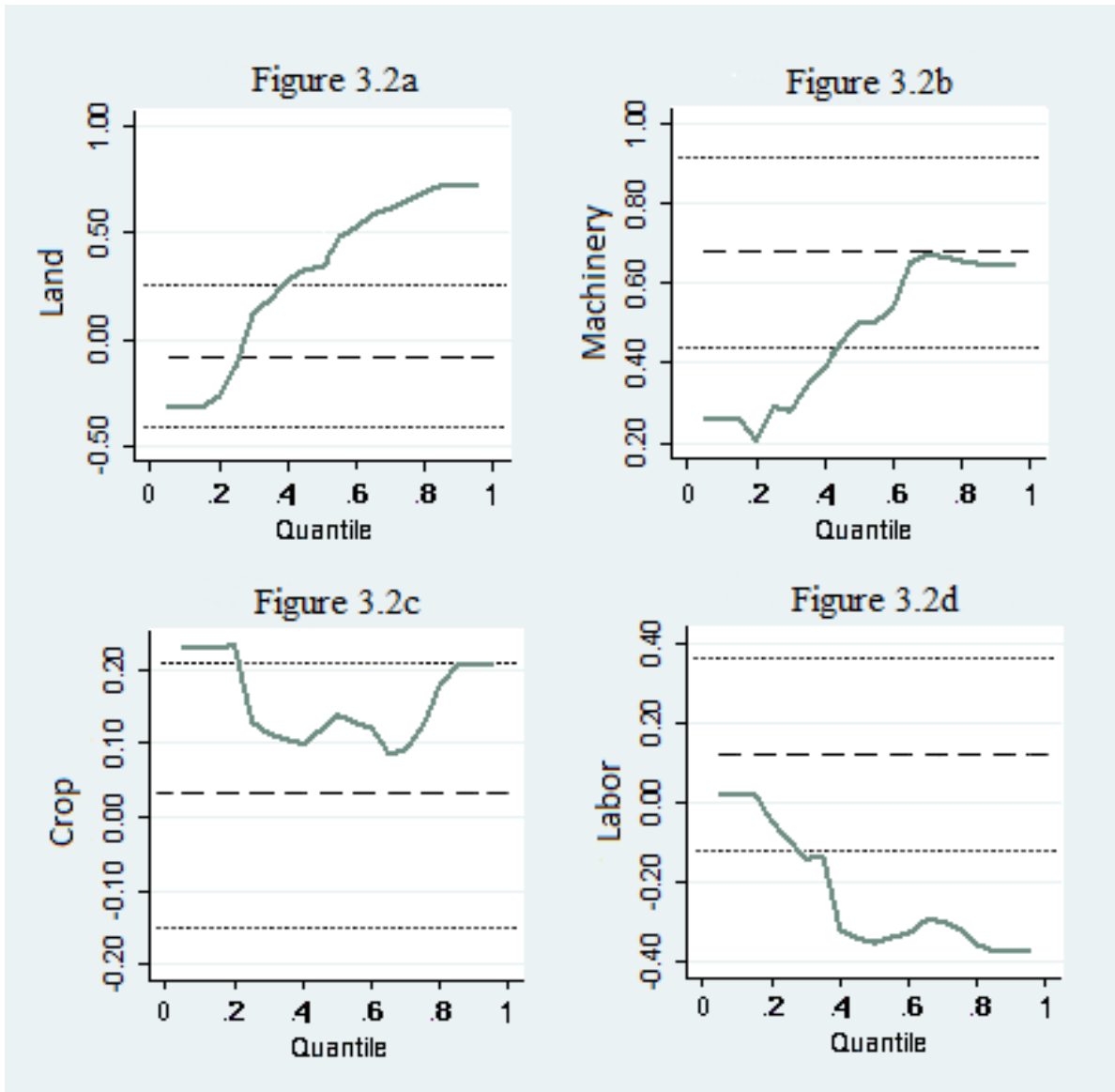


Figure 3.2 Expenditure Variable Quantile Regression Results



Chapter Four

Summary and Conclusions

This thesis has utilized data on Kentucky grain farmers to explore relationships between farm expenditures and net farm income based on the success level of the operations. This has been accomplished through two separate, yet complementary essays. The first essay employed the use of a two tier approach that segregated farm observations by their variable level use and performance classification. The second essay implemented quantile regression in an effort to produce more specific recommendations on means of increasing net farm income. Approaching the data in this manner allowed for more specific information based on the categorical performance level of farms.

These essays complement each other by their comparable use of three performance groups as a basis for the analyses. Format consistency between essays allows for expanded comparison of the research results and helps streamline use for practical application. This is an important feature as one of the thesis's specific goals is to produce academic research which has realistic applications for Kentucky grain producers. Using two separate methods of analyzing the allocation of farm expenditures has created a complementary analysis.

The first essay, using the two-tier approach, allows farmers to easily discover which category of performance they belong to on the basis of income and individual variable expenditure levels. Farmers are able to analyze the expenditure characteristics of their respective groups as well as the attributes of the top performers. This informal benchmark style analysis can help farmers study their position among their peers and make inferences on their management choices. Statistical tests are also conducted to reveal significant differences in mean expenditures between income groups and the distribution of top manager's level of

expenditures. The second essay, utilizing quantile regression, expands on this format to estimate where producers could significantly increase net farm income through amplified expenditures. Results find that the expenditure strategy recommended for the best farms within the sample are not necessarily the most appropriate strategy for lower performing farm levels. The categorical approach used in both essays proved to be exceptionally helpful in providing more customized results for farms based on their performance level.

Model results and interpretations between the two essays both maintain that management ability is the key characteristic of top performers. In the first essay, results showed that the best manager were spending significantly more in each variable category and in certain cases were not spending significantly more on average than lower performing managers. Outcomes from the results indicate that top managers are willing and able to spend money on production inputs because they have an ability to utilize these inputs efficiently. The second essay supported these conclusions in that top managers were the only group able to realize significant returns to net farm income from both land and machinery expenditures. Middle-managers were only able to acquire significant returns from machinery, while results indicate that low-level managers have no significant expense outlets from increasing net farm income. An ability to plan, purchase, and allocate resources effectively has been shown to be a critical quality in the best managers. Farm managers aspiring to improve the performance of their operations should seeks about educational resources or expert help in an effort to develop the management skills necessary for profitable decision-making.

Several opportunities exist for future research based on this study's findings and methodologies. While the sample data used in these two analyses provided a solid base for research, expanding the data with additional Kentucky farm observations and/or the

observations of farmers in other states would be beneficial for continued research. Expanding the number of performance categories used in future research would support the idea of more customized applicable research. Both essays within the thesis used three levels of performance, but expanding levels of analysis could survey the research sample better. Additionally, changes to the research variables themselves could be an avenue for future researchers. Expanding the number of variables, variable component reorganization, and alternative measure of success are all possibilities. Top performers were a main focus of the analyses in both essays, but future research could seek to find if these top performers are achieving consistent high performance from year to year or whether they drop into a lower classification from time to time.

Overall, this thesis has built on the contributions of previous researchers and incorporated aspects of farm-level research which can be regarded as a pioneering endeavor. This contribution to the literature represents a foundational application of farm-level data using a two-tier and quantile regression analysis while offering evidence that managerial ability is the key to farm success.

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VITA

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In August of 2007, the author was admitted to the Graduate School at the University of Kentucky. He served as a research assistant in the spring of 2012 and as a teaching assistant for AEC 302: Principles of Agricultural Management in the fall of 2012 and spring of 2013. The author competed in the Student Food Marketing Contest at the 53rd Annual Food Distribution Research Society meeting in October 2012. He also presented selected papers entitled “Factors Affecting Demand for Farm Machinery 1960-2010” and “The Expansion of Food Retail in Developing Countries and Its Effects on the Hunger Index” at the Southern Agricultural Economics Association annual meeting in February 2013.

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