AN EXAMINATION OF LABOR PRODUCTIVITY AND LABOR EFFICIENCY ON KANSAS FARMS

by

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Abstract

The objective of this thesis is to examine differences in labor efficiency and to find what is driving those differences among Kansas farms. The results provide a quantified understanding of the variation in labor productivity and labor efficiency relating to three categories of variables: farm characteristics, financial performance, and specialization.

This research uses regression estimates from a data set of 1,145 Kansas farms to quantify how farm characteristics are related to labor productivity and labor efficiency. There are two main models. Labor productivity, expressed as value of farm production divided by the number of workers, is regressed on three categories of variables: farm characteristics, financial performance, and specialization. Labor efficiency, expressed as labor costs divided by value of farm production, is also regressed on the same categories of variables.

The research found that farm size, managerial ability, and age were the most influential and significant variables in the labor productivity model. Farm size, managerial ability, and land tenure were the most influential and significant variables in the labor efficiency model.

Farm size is a variable important to both models, and when evaluated at $100,000 of VFP, labor productivity has a value of 152,122 and a labor efficiency value of 0.271 (all else constant). When evaluated at a VFP of $500,000, labor productivity and labor efficiency improve to values of 217,914 and 0.246, respectively.

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CHAPTER 1 - INTRODUCTION

According to the latest USDA Farm Report (Hoppe et al. 2007), United States farms have grown larger in the past two decades. Several factors are attributed to the decline of the small farm, but the most significant is the variability of profit margins due to increased input costs. This intuitively gives an economic advantage to large farms with economies of scale. These larger farms are viable businesses with favorable financial ratios while the smaller farms are less viable, and supplemented by significant amounts of off-farm income.

Profit margins vary drastically among farms. Profitability measures for U.S. farms by farm type in 2004 showed that small family farms had a negative rate of return on assets and equity (Hoppe et al. 2007). Because of increasing input costs in production agriculture today, farming efficiency has never been more important. Efficiency directly tied to labor has a significant impact on profit margins. There is a lack of research related to the labor efficiency of individual farms. By observing production agriculture, one can ascertain that labor costs are highly variable among farms. By quantifying how labor efficiency varies with specific farm characteristics, we can further understand the effects of labor efficiency on the Kansas economy as well as the individual farm.

You may wonder why, of all inputs, we chose to use labor as the examining variable. Merz and Yashiv (2007) explain that hiring and keeping workers is more important to the market value of the firm than capital stock. Assuming market value parallels with profitability, labor costs could be more important to profitability than capital. Furthermore, in KFMA data, labor and capital are typically higher cost items in the financial statements. A way to measure the differences in profitability is with efficiency. The specifics of labor efficiency have not been quantified at the farm level. Information pertaining to the factors impacting labor productivity and labor efficiency would be of interest to farmers, agribusiness personnel, and researchers.

Labor efficiency and productivity can be measured from an input or an output perspective. From an input perspective, labor efficiency can be measured by dividing labor cost by value of farm production. From an output perspective, labor productivity can be measured by dividing value of farm production by the number of workers.

According to the 2006 KFMA ProfitLink Summary (Langemeier and Herbel, 2006), labor efficiency differs among farm size categories. Labor efficiency, defined as labor cost divided by value of farm production, decreases significantly with increasing size. On average, Kansas farms have a labor efficiency of 23.5 percent. When it is divided into value of production size categories, labor efficiency varies drastically among groups of farms. Farms with less than $100,001 in sales have a labor efficiency of 39.5 percent. Farms with sales between $100,001 and $250,000 have a labor efficiency of 22.8 percent. Farms with sales between $250,001 and 500,000 have a labor efficiency of 17.5 percent. Farms with sales greater than $500,000 have a labor efficiency of 15.1 percent. This shows strong economies of size with respect to labor efficiency and motivates an interest in what specifically, at the farm level, makes the difference so large.

The objective of this thesis is to examine differences in labor efficiency and productivity, and to find what is driving those differences among Kansas farms. With the results, we will be able to understand the variation in labor efficiency and productivity and how they are related to three categories of variables: farm characteristics, financial performance, and specialization. Variables included in farm characteristics are value of farm production, operator age, and land tenure. Value of farm production is used to measure farm size. Variables included in the financial performance category include managerial ability, debt to asset ratio, and working capital. Variables included in the specialization category include an index of specialization that considers the level of diversification between crops and livestock, and some income variables that consider the value of production for each enterprise divided by total gross farm income. Enterprises existing in the data are wheat, soybeans, corn, grain sorghum, beef cattle, dairy cattle, swine and the level of off-farm income.

This thesis is organized into chapters. Chapter two provides a review of the relevant literature. Chapter three presents the empirical models utilized. Chapter four presents the data, and provides a brief statistical summary of the dependent and independent variables used in the analysis. Chapter five presents the empirical results. Chapter six discusses the conclusions and implications of the research.

CHAPTER 2 - LITERATURE REVIEW

This chapter summarizes previous literature that is relevant to labor efficiency and productivity. The first section describes labor efficiency measures. The second section describes the variables that can be used to explain changes in labor efficiency and productivity.

2.1. Labor Measures

Hoppe et al. (2007) uses the idea of a person equivalent to measure labor from an annual perspective. Specifically, a person equivalent is the equivalent amount of hours a person would work in a year (40 hours a week times 50 work weeks). In other words, one person equivalent would be similar to 2,000 hours per year. Residential/lifestyle, retirement, and limited-resource farms use the least amount of labor of all farm types, 1 person equivalent or less. Labor use increases to 1.5 person equivalents for low-sales farms (less than $100,000 in sales) and then climbs to 8.2 person equivalents for very large farms ($500,000 or more in sales). Nonfamily farms (2 percent of all U.S. farms) use on average 5.4 person equivalents. However, this estimate reflects a large labor use by relatively few farms. They also report that only 20 percent of nonfamily farms use more than 5 person equivalents of labor, while 46 percent use less than 1 person equivalent.

The labor used on farms can come from a variety of sources including operators and their spouses, secondary operators, hired labor, contract labor, and unpaid workers (Hoppe et al., 2007). Operators are a significant source of labor for most farm types. The operator, on average, provides 60 to 70 percent of the labor on small farms and nearly 50 percent of the labor on large family farms (250,000-499,999 in sales). Operators, on average, supply only 19 percent of labor on very large family farms and nonfamily farms.

2.1.1. Efficiency

As stated in the introduction, one way to measure farm labor efficiency is from a cost standpoint. The most reoccurring theme in the research regarding labor efficiency suggests that labor efficiency is simply the ratio of the labor input and its output (Nesius, 1951). Using this ideology, we can construct a simple ratio of value of labor divided by farm production.

Coelli et al. (2005) uses an example of measuring efficiency. Following the example, if a firm was technically efficient, this ratio would reflect the maximum output possibly attained from labor. Graphically, technical efficiency measures the distance a firm is from the production frontier. Allocative efficiency, the ability to use inputs in an optimal proportion given technology and prices, is also related to labor efficiency. If a firm is allocative efficient, it is using the most optimal allocation of inputs. By multiplying the two efficiency measures, we can arrive at total economic efficiency. We can use economic efficiency to measure profitability across similar firms.

2.1.2. Productivity

Productivity is typically measured in discrete units of outputs and inputs. Kumar and Russell (2002) decomposed labor productivity growth into three components: technological change, technological catch-up, and capital accumulation. They measured productivity growth with respect to labor for 57 countries. Technological change refers to a shift in the world production frontier, determined conceptually by potentially transferable technologies. Technological catch-up refers to movements closer to (or away from) the production frontier as countries adopt the "best practice" technologies and reduce technical and allocative inefficiencies. Capital accumulation refers to movements along the frontier. They found there was substantial evidence of technological catch-up, countries have moved toward the production frontier. Technological change was decidedly nonneutral, which made the rich countries richer as compared to the poor countries. Finally, the most substantial finding was that productivity growth was primarily linked to capital deepening, which reflects the tendency to use relatively more capital in the production process.

Willis and Wroblewski (2007) describe a standard Cobb-Douglas model to illustrate the relationship between productivity and compensation:

(2.1) $Y = A K^{1-\alpha} L^{\alpha}$

where (Y) is the amount of real output, expressed as a multiplicative function of the amount of labor (L) and physical capital (K) inputs. This equation suggests that labor is defined broadly to include the total number of hours worked for everyone in the economy. Capital represents the entire economy's capital resources. The variable (A) refers to a measure of total productivity that makes the inputs of the production process (K & L) more productive. The variable (α) represents the elasticity of the output with respect to labor, which is assumed to be less than 1. With this model, the most commonly used measure of productivity is labor productivity, which is the average amount of real output produced per hour of work. This would be represented as output divided by labor:

(2.2) $Y/L = A(K/L)^{1-\alpha}$

Based on this manipulation, increases in labor productivity could result from three sources: 1) an increase in total factor productivity (A); 2) an increase in the amount of capital (K), also called capital deepening; or 3) a decrease in the number of hours worked (L).

Fugile et al. (2007) examined the productivity growth in U.S. agriculture for the period of 1948 – 2004. They found that labor use declined by 3.2 percent per year but output per worker increased by 4.9 percent per year, enabling farm output to grow by an average annual rate of 1.7

percent. Increases in land, capital, and other nonlabor inputs per hour worked accounted for 60 percent of the growth in labor productivity, while total factor productivity growth accounted for 37 percent of the rise in labor productivity. Improvements in labor quality accounted for the remaining 3 percent during the period.

2.2. Factors Impacting Labor Efficiency and Productivity

In this section, the variables impacting labor efficiency and productivity are separated for organizational purposes. The categories of variables are farm size, financial performance, specialization, and farm & family characteristics.

2.2.1. Farm Size

Hall and LeVeen (1978) studied the relationship between farm size and production cost. They found the long run average cost curve is relatively flat after initially declining rapidly for a sample of California farms.

Purdy et al. (1997) measured farm income variability and financial performance for 320 farms in the KFMA. They confirmed that farm size was positively related to financial performance. The optimal farm size was substantially larger than the average farm size indicating that there was strong overall economies of scale for the sample.

Hoppe et al. (2007) indicates that variation in farm size can be measured using sales, acres, and labor use. They use these as tools to explain the distribution of agricultural production. They report that there are 1.4 million farms that account for 8% of total U.S. production. These farms are called limited-resource, retirement, and residential/lifestyle farms. Approximately 75 percent of these farms have sales of less than $10,000 with an average acres operated between 163 and 212.

Hoppe et al. (2007) also use median acres operated to indicate the size of a typical farm in a group because a few high-acreage farms may raise the average well above the acreage of most farms in the category. They report that 60 to 80 acres is a good representation of a limited-resource, retirement, or residential/lifestyle farm. Median acres operated for a small sales farm (< $100,000 in sales) was 145 acres. For larger farms, median acreage is 530 for medium sales farms and 1,055 acres for large scale farms.

Million dollar farms are farms that have gross sales of at least $1 million. Forty-two percent of very large family farms ($500,000 or more annual sales) and 9 percent of nonfamily farms are in this category. These farms make up less than 2 percent of all U.S. farms, but they account for 45 percent of the value of production.

2.2.1.1. Total Acres

Purdy et al. (1997) indicated that total acres were positively related to financial performance. Although total acres was significantly related to financial performance, it was not significantly related to income variability.

Villatoro (2007) indicated that total acres has been used extensively in the farm growth literature. Total acres is typically positively related to farm growth.

2.2.1.2. Value of Farm Production

Langemeier and Herbel (2007) use value of farm production (VFP) to examine the relationship between financial performance and farm size. VFP is the income to the business based on crop and livestock sales plus other receipts minus cost of items purchased for resale, such as feeder livestock, minus cost of purchased feed plus or minus changes in operating inventories. This accrual basis income reflects the value of production whether it is sold or not. As a size measure, VFP has an advantage over total acres because an acre of pasture is not equivalent to an acre of nonirrigated or irrigated crop land in terms of profitability or productivity.

2.2.1.3. Assets

According to Villatoro (2007), assets have commonly been used as a measure of firm size and firm growth. Total asset value is typically positively related to farm growth.

2.2.2. Financial Variables

This category of variables refers to factors that are derived from financial ratios. This section's variables look further into the financial statements of the farm to explain variation in efficiency.

2.2.2.1. Managerial Ability

May (1943) derived an empirical test for farm manager's ability levels. He ranked the group of farmers A – D with A being the most productive farmer group. Before assigning a class to the individual farmers, he analyzed their soil quality, livestock practices, cropping program, and general business ability so he could be as accurate as possible in measurement. He found that the class A farmers were 29% more productive and 49% more profitable than the D farmers with similar conditions. This shows that managerial ability is an important factor that influences efficiency.

Featherstone et al. (1997) performed a study using nonparametric production analysis to examine the efficiency of a sample of Kansas beef cow herds. They found that technical efficiency was higher than allocative and scale efficiency. Labor was found to be one of the most significant allocative efficiency problems. This prompts an interest in how important labor efficiency is to the total efficiency of all farms, but more importantly indicates that managerial ability is directly linked to the efficiency of farms.

Villatoro (2007) examined the relationship between farm growth rates (measured using total nominal assets, total real assets, total acres, and average workers) and farm characteristics. He concluded that managerial ability had a significant positive impact on the growth rate of assets and the average workers per year. Villatoro (2007) also explains a theory by Penrose (1959), which states that firms grow in response to human decisions. Growth must be preceded by research and planning which depends on human motivation and managerial ability. Because managerial ability is important for farm growth, it is plausible to also expect it to impact labor efficiency and productivity.

2.2.2.2. Leverage

Purdy et al. (1997) measured farm income variability and financial performance for 320 farms in the KFMA. They confirmed that leverage was negatively related to the return on owner's equity (ROE). Leverage had a positive and significant impact on the variability of financial performance.

Featherstone et al. (2005) provided a summary of optimal debt and financial structure articles. Gabriel and Baker (1980) introduced the concept of risk balancing in managing capital structure. They implied that a firm will balance business and financial risk to maintain an approximate level of overall risk. The authors indicated there isn't an optimal debt allocation suitable for all firms. Instead, optimal debt is contingent upon firm specific characteristics.

2.2.2.3. Liquidity

Villatoro (2007) examined the relationship between farm growth rates (measured using total nominal assets, total real assets, total acres, and average workers) and farm characteristics. He concluded that working capital had a significant positive impact on the growth rate of assets and average workers. Because liquidity is an important determinant of farm growth, it is plausible to expect it to also impact labor efficiency and productivity.

2.2.2.4. Capital Deepening

Willis and Wroblewski (2007) suggested that an increase in the amount of capital also called capital deepening, would increase labor productivity in a simple capital/labor Cobb-Douglas production model. Kumar and Russell (2002) found capital deepening to be an important determinant of labor productivity.

2.2.3. Specialization

Hoppe et al. (2007) reports that specialization varies by farm size. Small farms tend to specialize in raising beef cattle, other grazing livestock, or a variety of field crops. Poultry, hogs, and high value crops (vegetables, fruits, and tree nuts) tend to be produced on large-scale farms. Medium-sales farms and large family farms are most likely to specialize in grain.

With small farms, beef cattle are a common specialization which accounts for 34 to 41 percent of limited-resource, retirement, residential/lifestyle, and low-sales farms. Beef enterprises, typically cow-calf enterprises, offer several advantages to operators. To start off, cattle are less labor-intensive than many other enterprises, which could be attractive to an operator who is retired or holds a full-time job off the farm (Cash, 2002). Next, cattle enterprises tend to be low-cost, which limits cash requirements. Third, under the existing tax code, losses from farming can be written off against income from other sources (Freshwater and Reimer, 1995). Lastly, producing calves allows farmers to group their expenses and sales in different years to generate small profits in some years and large losses in others (Hoppe and Banker, 2006).

Among limited-resource, retirement, residential/lifestyle, and low-sales farms, two other specializations were common. Approximately 25 percent of the four groups specialized in "other field crops," which includes farms with all their crop acres in the Conservation Reserve Program and Wetlands Reserve Program. Another 20 percent of each group specializes in "other livestock," which includes grazing livestock other than cattle (such as horses, sheep, and goats.)

Some specializations are more common among medium-sales farms and large-scale farms. Farms specializing in cash grains account for about 40 percent of medium-sales and large family farms, while 11-16 percent of medium-sales and large scale farms specialize in dairy. They report that very large family farms are at least twice as likely as any other farm type to specialize in poultry or hogs, accounting for 75 percent of poultry production and 67 percent of hog production.

Production of high-value crops (vegetables, fruits, and tree nuts) is primarily associated with very large family farms and nonfamily farms, which account for 78 percent of the total. Less than 10 percent of any small farm type specializes in these crops. High-value crops can generate large sales per acre, but also require much more labor than cattle and can require more marketing expertise.

Family farms become more diversified as their size increases. Many small family farms specialize in a single commodity. Medium-sales and large-scale farms are more likely to produce multiple commodities: 60 percent of farms in these groups produce three or more commodities.

Purdy et al. (1997) used the Herfindahl index to measure the impact of specialization on farm income performance and variability. This index can be expressed as follows:

(2.3) $S_i = \Sigma_i X_i^2$

where S_i is specialization and X_i is crop income or livestock income divided by value of farm production. For example, a farm that reported 50 percent income from livestock and 50 percent income from crops would have a specialization index of 0.50. A diversified farm would have a lower index value and a highly specialized farm would have an index close to 1.

They found that specializing in livestock production (beef, swine, or dairy production) reduced the variability of financial performance. Further, specializing in swine, dairy, or crop production increases mean financial performance, and specializing in beef production decreased mean financial performance. The increase in mean financial performance associated with swine and dairy production was more likely the result of product-specific economies of scale, while the increase in mean financial performance associated with crop production was more likely the result of an increase in risk.

Villatoro (2007) examined the relationship between farm growth rates (measured using total nominal assets, total real assets, total acres, and average workers) and specialization. He concluded that the percentage of value of farm production derived from crops had a significant negative impact on the growth rate of assets and average workers. Based on his work, specialization is expected to impact labor efficiency and productivity.

2.2.4. Farm & Family Characteristics

This category of variables refers to characteristics of the family and farm. This section's variables look further into the make up of the farm to explain variation in efficiency and productivity.

2.2.4.1. Operator Age

Purdy et al. (1997) measured farm income variability and financial performance for 320 farms in the KFMA. They confirmed that age was negatively related to the return on owner's equity.

Tauer and Lordkipanidze (2000) used non-parametric programming and Malmquist indices to measure differences in farmer efficiency, technology use, and productivity with age. Their results showed that productivity of farmers appears to increase slightly and then decrease with age. Productivity differences appear to be due to technology use by age, with enhanced technology use occurring at mid-life. Also, there is a slight increase and then decrease in efficiency by age.

Villatoro (2007) examined the relationship between farm growth rates (measured using total nominal assets, total real assets, total acres, and average workers) and operator age. He concluded that operator age had a significant negative impact on the growth rate of assets.

2.2.4.2. Off-Farm Income

Goodwin and Mishra (2004) found that more intensive participation in off-farm labor markets tends to be associated with lower farm efficiency. Mishra and Goodwin (1997) examined the relationship between the supply of off-farm labor and farm income variability. They found that farmers and spouses with more farming experience were found to be less likely to work off the farm. Also, the off-farm labor supply of farmers and their spouses was positively correlated with off-farm experience. Operators of large farms were less likely to work off-farm. The off-farm labor supply of farmers and their spouses was found to be significantly higher for highly leveraged operations. Finally, farms that received more government support were less likely to pursue off-farm employment.

Hoppe et al. (2007) reports that participation in off-farm work varies by farm type. On one end of the spectrum, neither the operator nor the spouse worked off farm on 73 percent of limited-resource and 65 percent of the retirement farms. On the other end of the spectrum, both the operator and spouse worked off farm on 64 percent of residential/lifestyle farms. For all other farm types, off-farm income was recorded in 49 to 62 percent of households in the sample. Hoppe et al. (2007) also reports that 46 percent of all farm households are dual-career, with the make-up of at least the spouse of the farmer engaged in off-farm work. Based on his work, off-farm income is expected to impact labor efficiency and productivity.

2.2.4.3. Tenure

Reimund and Gale (1992) suggest that renting land is a way to expand by controlling additional land without the debt and commitment of capital associated with ownership. Hoppe et. al. (2007) reports that about "two-thirds of medium-sales and large-scale farms are part owners, meaning that they own part of the land they operate and rent the rest. In addition, 14 percent of large-scale farms—versus 6 percent of all farms—are tenants that own none of the land they farm."

Purdy et al. (1997) indicated the percentage of acres owned was negatively related to financial performance. In an example from their study, a 10 percent increase in the mean percentage of acres owned would decrease ROE by 5.82 percent.

CHAPTER 3 - METHODOLOGY

This chapter presents the empirical models used for examining labor productivity and efficiency for Kansas farms. Section 3.1 discusses the labor productivity model and includes the expected signs. Section 3.2 discusses the labor efficiency model and includes the expected signs. Section 3.3 covers the potential econometric data problems with remedies.

3.1. Labor Productivity Model

To examine productivity, the following system of equations will be estimated:

(3.1) $(VFP/L)_i = f(KC/L)_i$

(3.2) $(KC/L)_i = f(VFP_i, AGE_i, AGESQ_i, TEN_i, MA_i, DA_i, WC_i, SPEC_i, WHT_i, SOY_i,$
$CORN_i, MILO_i, BEEF_i, DAIRY_i, SWINE_i, OFFINC_i)$

Equation 3.1 shows that VFP/L, which is value of farm production divided by the number of workers on the farm, is a function of the capital/labor ratio. In this model, capital includes everything that is not labor in the production process. Also, number of workers (L) is calculated in labor years, where a total of 12 months worked for one worker on the farm is equivalent to a value of 1 in the computation of L. Theoretically, we can assume a positive relationship by examining a two input production function where an increase or substitution for either input yields an increase in production. This was exhibited in Chapter 2, where Willis and Wroblewski (2007) manipulated the two input production function for labor productivity which is similar to equation 3.1. They state that increases in labor productivity could result from three sources: 1) an increase in total factor productivity; 2) an increase in the amount of capital (K), also called capital deepening; or 3) a decrease in the number of hours worked (L). From the theoretical standpoint, we think the capital labor ratio will be very significant in measuring productivity.

Equation 3.2 is the equation for the capital/labor ratio, which embodies the idea that this ratio is dependent on several variables. VFP represents value of farm production, which is a farm size measure. AGE is the age in years of the primary operator. AGESQ is operator age squared. TEN is the percent of owned acres to total operated acres. MA is managerial ability measured using the economic total expense ratio calculated as (total farm expenses + unpaid labor + opportunity charge on equity) divided by value of farm production. In this equation, unpaid labor represents labor costs that haven't been paid, family living expenses, and an opportunity cost for the farmer's time spent at another occupation. DA is the debt to asset ratio. WC is a working capital ratio calculated as current assets minus current liabilities divided by current assets. SPEC is the Herfindahl index where the variable in the index is computed as the square of the percentage of labor shares derived from crop production added to the square of percentage of labor shares derived from livestock (1 – percentage of labor shares derived from crop production). WHT is a continuous variable indicating the percentage of gross farm income consisting of wheat production. SOY is a continuous variable indicating the percentage of gross farm income consisting of soybean production. CORN is a continuous variable indicating the percentage of gross farm income consisting of corn production. MILO is a continuous variable indicating the percentage of gross farm income consisting of grain sorghum production. BEEF is a continuous variable indicating the percentage of gross farm income consisting of beef cattle production. DAIRY is a continuous variable indicating the percentage of gross farm income consisting of dairy cattle production. SWINE is a continuous variable indicating the percentage of gross farm income consisting of swine production. OFFINC is off-farm income coming from wages divided by gross farm income. Individual farms are represented by the subscript *i*.

The equations above represent a recursive system. In this recursive system, the impact of each independent variable on output per worker is indirect. For example, value of farm production impacts the capital/labor ratio and thus indirectly impacts output per worker. The direct impact of each independent variable defined in equation 3.2 on output per worker is examined using the following regression:

$$(3.3)\ (VFP/L)_i = f(VFP_i, AGE_i, AGESQ_i, TEN_i, MA_i, DA_i, WC_i, SPEC_i, WHT_i, SOY_i, CORN_i, MILO_i, BEEF_i, DAIRY_i, SWINE_i, OFFINC_i)$$

The two model specifications described above (the recursive system and the non-recursive system or equation 3.3) are used to examine both the indirect impact of each independent variable or the impact of each variable resulting from a change in the capital/labor ratio, and the direct impact of each independent variable on labor productivity. This research is primarily interested in the direct impacts. However, because farms often substitute capital for labor when adopting technologies, it is also important to examine the indirect impacts. The impact of each independent variable on output per worker should be consistent between the two models.

Table 3.1 contains the expected sign for each independent variable in equation 3.3. Information from chapter 2 was used to sign individual variables. It is important to note that expected signs are measured relative to the variables impact on labor productivity.

The expected sign on VFP is positive. This is intuitive because larger farms tend to produce more output per worker.

Table 3.1. Expected Signs of Independent Variables Used in the Labor Productivity Regressions.

Variable	**Definition**	**Expected sign**
VFP	Value of Farm Production (measure of farm size)	+
AGE	Age of operator	-
AGESQ	Age of operator squared	+
TEN	Percentage of owned acres	+
MA	Managerial ability (measured using the total economic expense ratio)	-
DA	Debt to asset ratio	+/-
WC	(Current assets minus current liabilities) divided by current assets	+
SPEC	Non-specific enterprise specialization index	+/-
WHT	Wheat income as a percent of Gross Farm Income	+/-
SOY	Soybeans income as a percent of Gross Farm Income	+/-
CORN	Corn income as a percent of Gross Farm Income	+/-
MILO	Grain sorghum income as a percent of Gross Farm Income	+/-
BEEF	Beef cattle income as a percent of Gross Farm Income	+/-
DAIRY	Dairy cattle income as a percent of Gross Farm Income	+/-
SWINE	Swine income as a percent of Gross Farm Income	+/-
OFFINC	Off-farm income from wages as a ratio of Gross Farm Income	-

The relationship between labor productivity and operator age is expected to be non-linear. The linear term is expected to have a negative coefficient. The quadratic term is expected to have a positive coefficient. These signs imply that farms managed by young operators are more productive. As an operator becomes older, productivity declines.

The expected sign on the tenure variable, TEN, is positive. Share leasing is common in Kansas. With share leasing, a portion of crop income is paid to the landlord. Thus, increasing the percentage of acres owned should lead to an increase in value of farm production.

The expected sign on the managerial ability variable, MA, is negative. A lower value of this variable is related to improved productivity. Farms that can control costs have more funds to use for increasing productivity and profitability.

The expected sign on the debt to asset ratio variable, DA, is ambiguous. A relatively higher debt to asset ratio may indicate that a farm is willing to take on debt to be more productive. However, if the ratio is high without increased productivity, this farm would be experiencing difficulty in paying back the debt, and therefore the expected sign would be negative.

Working capital, WC, reflects how liquid the farm's current assets are. This number is calculated as current assets minus current liabilities divided by current assets. We divide working capital by current assets so that there isn't any conflict between size and level of working capital. A low number would reflect a farm with low levels of liquidity. Thus, a farm with a higher WC value would be more liquid. The expected sign on the WC variable is positive. Increased liquidity would increase in a farm's flexibility and thus potentially augment output per worker.

The expected sign on the specialization index, SPEC, is ambiguous. This variable is used to examine whether specialization has an impact on productivity. A lower index value would indicate that there is more diversity between crops and livestock activities. Because of the index's mathematical properties, the values possible for the index are between 0.5 and 1. A farm with an index close to 1 would be highly specialized. A farm with an index close to 0.5 would be diversified. In terms of output per worker, it's hard to tell a priori if being specialized will add or subtract from productivity.

The expected signs for the variables referring to individual enterprises are ambiguous. The beef cattle enterprise is the only enterprise that the literature refers to possibly being negative to financial performance. Previous literature is not helpful in signing the coefficients for the other enterprises.

The expected sign on the off-farm income variable, OFFINC, is negative. This variable is used to capture the hypothesized decline in productivity from being absent from the farm. Farms with higher levels of off-farm income have less time to be productive on the farm. Productivity suffers when any part of production is neglected.

3.2. Labor Efficiency Model

To examine labor efficiency, the following equation will be estimated:

$$(3.4)\quad (LC/VFP)_i = f(VFP_i , AGE_i , AGESQ_i , TEN_i , MA_i , DA_i , WC_i , SPEC_i , WHT_i , SOY_i , CORN_i , MILO_i , BEEF_i , DAIRY_i , SWINE_i , OFFINC_i)$$

LC represents paid and unpaid labor costs. VFP represents value of farm production, which is a size measure. AGE is the age in years of the primary operator. AGESQ is operator age squared. TEN is the percent of owned acres to total operated acres. MA is managerial ability measured using the economic total expense ratio calculated as (total farm expenses +

unpaid labor + opportunity charge on equity) divided by value of farm production. In this equation, unpaid labor represents labor costs that haven't been paid, family living expenses, and an opportunity cost for the farmer's time spent at another occupation. DA is the debt to asset ratio. WC is the working capital calculated as current assets minus current liabilities divided by current assets. SPEC is the Herfindahl index where the variable in the index is computed as the square of the percentage of labor shares derived from crop production added to the square of the percentage of labor shares derived from livestock (1 – percentage of labor shares derived from crop production). WHT is a continuous variable indicating the percentage of gross farm income consisting of wheat production. SOY is a continuous variable indicating the percentage of gross farm income consisting of soybean production. CORN is a continuous variable indicating the percentage of gross farm income consisting of corn production. MILO is a continuous variable indicating the percentage of gross farm income consisting of grain sorghum production. BEEF is a continuous variable indicating the percentage of gross farm income consisting of beef cattle production. DAIRY is a continuous variable indicating the percentage of gross farm income consisting of dairy cattle production. SWINE is a continuous variable indicating the percentage of gross farm income consisting of swine production. OFFINC is off-farm income coming from wages divided by gross farm income. The subscript i represents individual farms.

Table 3.2 contains the expected sign for each independent variable. Information from chapter 2 was used to sign individual variables.

The expected sign on VFP is negative. If large farms can spread their labor over more acres, the cost per unit declines, indicating a negative relationship.

Table 3.2. Expected Signs of Independent Variables Used in the Labor Efficiency Regression.

Variable	Definition	Expected sign
VFP	Value of farm production (measure of size)	-
AGE	Age of operator	+
AGESQ	Age of operator squared	-
TEN	Percentage of owned acres	-
MA	Managerial ability (measured using the total economic expense ratio)	+
DA	Debt to asset ratio	+/-
WC	(Current assets minus current liabilities) divided by current assets	+/-
SPEC	Non-specific enterprise specialization index	+/-
WHT	Wheat income as a percent of Gross Farm Income	+/-
SOY	Soybeans income as a percent of Gross Farm Income	+/-
CORN	Corn income as a percent of Gross Farm Income	+/-
MILO	Grain Sorghum income as a percent of Gross Farm Income	+/-
BEEF	Beef cattle income as a percent of Gross Farm Income	+
DAIRY	Dairy cattle income as a percent of Gross Farm Income	+/-
SWINE	Swine income as a percent of Gross Farm Income	+/-
OFFINC	Off-farm income from wages as a ratio of Gross Farm Income	+

The relationship between labor efficiency and operator age is expected to be non-linear. The linear term is expected to have a positive coefficient. The quadratic term is expected to have a negative coefficient. Based on previous literature, efficiency is expected to be lower for older operators.

The expected sign on the tenure variable, TEN, is negative. Increasing the percentage of acres owned would lead to an increase in value of farm production and result in a reduction of the labor efficiency index.

The expected sign on the managerial ability variable, MA, is positive. A lower value of this variable is related to improved cost efficiency or ability to control costs. Farms that control costs have more funds to use for improvement.

The expected sign on the debt to asset ratio variable, DA, is ambiguous. A relatively higher debt to asset ratio may indicate that a farm is willing to take on debt and make improvements to lower costs. In this case, the sign on the debt to asset ratio variable would be negative. Conversely, a relatively higher debt to asset ratio may indicate that the farm has had difficulty making debt payments in the past. In this case, the sign on the debt to asset ratio would be positive because of the inefficient use of debt capital.

Working capital, WC, reflects how liquid the farm's current assets are. This number is calculated as current assets minus current loans or liabilities divided by current assets. We divide working capital by current assets so that there isn't any conflict between size and level of working capital. A low number would reflect a farm with low levels of liquidity. Thus, a farm with a higher WC values would be more liquid. Given this, the expected sign on the WC variable is ambiguous because of uncertainty associated with how WC affects cost efficiency.

The expected sign on the specialization index, SPEC, is ambiguous. This variable is used to examine whether specialization has an impact on efficiency. A lower value would indicate that a farm is more diverse. In terms of labor efficiency, it's hard to predict a priori whether specialization will improve or diminish efficiency.

The expected signs of the continuous variables referring to individual enterprises are ambiguous. The beef cattle enterprise is the only enterprise that the literature refers to possibly being negatively related to financial performance. If beef production reduces financial performance, its expected sign on labor efficiency would be positive.

The expected sign on the off-farm income variable, OFFINC, is positive. Farms with higher levels of off-farm income have less time and more money available for the farm. If this is the case, an operator may choose a more expensive, but less time consuming production technique that maintains production processes, but is detrimental to cost efficiency.

3.3. Econometric Issues

Equation 3.1 and 3.2 represent a recursive system. These regressions can be estimated with an ordinary least squares (OLS) technique because the equations exhibit recursive traits. Recursive models, as stated in Kennedy (1992), do not suffer from the simultaneous equation estimation bias. Simultaneous equation estimation bias occurs when a dependent variable is used as an independent variable in the system and is estimated with an inconsistent disturbance term which violates one of the assumptions of the classical linear regression model. A special case of simultaneous systems of equations is the recursive system, which has a unidirectional dependency among the endogenous variables. In this example, (VFP/L) depends on (K/L) but does not directly impact any of the (K/L) regressors; therefore there is no contemporaneous correlation between the disturbance and the regressors in the equation and OLS estimation is consistent. It is important to note that equation 3.1 will be estimated in logs to represent a Cobb Douglas production function.

There is a possibility in each equation that the data set may include some problems with heteroskedasticity and multicollinearity. Heteroskedasticity refers to the error term having an inconsistent variance across all observations, which is a violation of one of the assumptions of the classical linear regression model. To test and correct for heteroskedasticity, White's heteroskedasticity-consistent covariance matrix estimator will be used. White (1980) developed this technique to increase the accuracy of inferences drawn from statistical hypotheses in the presence of heteroskedasticity that does not rely on a formal model in its execution. After testing the significance of the models at the 5 percent level, (probability of Chi Square less than or equal to 5 percent), the model is corrected by changing the originally estimated standard errors to the heteroskedasticity corrected standard errors.

Multicollinearity refers to the independent variables being closely related to each other in the data set. This leads to estimation bias and a violation of one of the assumptions of the classical linear regression model. To test for multicollinearity, a correlation matrix will be constructed and the values of the off-diagonal coefficients will be examined. Values greater than 0.8 in absolute value are typically considered problematic (Kennedy, 1992). If indeed there is multicollinearity present, the most significant collinear variable may be dropped from the model.

CHAPTER 4 - DATA

The objective of this chapter is to explain the source and manipulation of the data used in this thesis. Section 4.1 explains the source of the data. Section 4.2 explains the details and manipulation of the data set to observe labor productivity and efficiency.

4.1. Data Source

The data source is from the Kansas Farm Management Data Bank. This data contains financial and production data from the members of the Kansas Farm Management Association (KFMA). The farms represented in the data set were members of the Kansas Farm Management Associations and provided continuous data over the sample period of 2002 through 2006. The farms in the data set represented all six associations (i.e., northeast, north central, northwest, southwest, south central and southeast). Cross-section data was created by computing five-year averages for each farm.

After completing the calculations for the regression variables from the data set, an analysis of the values of those variables took place. Outliers were determined and were not included in the data set after failing to meet any of the following six variable criterions:

- VFP/LC and must be less than 15
- MA must be less than 5
- DA must be less than 2

4.2. Summary Statistics

After removing the farms that did not meet the outlier criterions, the data set consisted of 1,045 farms from an original 1,050 farms. Table 4.1 presents the weighted average summary statistics for the variables in the data set and Table 4.2 presents the actual summary statistics.

Table 4.1. Weighted Average Summary Statistics.

Variable	Description	Mean
VFP/L	Value of Farm Production / Labor (number of workers)	180,403
KC/L	Capital Cost (total costs – labor cost) / Labor (number of workers)	171,401
LC/VFP	Labor Cost (paid and unpaid) / Value of Farm Production	0.206
VFP	Value of Farm Production (measure of farm size)	258,506.7
LC	Labor Cost (pad and unpaid)	53,439.6
KC	Capital Cost (total costs – labor cost)	245,386.2
L	Labor calculated as number of workers per year	1.432
AGE	Age of operator	55.4
AGESQ	Age of operator squared	3207.7
TEN	Percentage of owned acres	0.333
MA	Managerial ability (measured using the total economic expense ratio)	1.157
DA	Debt to asset ratio	0.294
WC	(Current assets minus current liabilities) divided by current assets	0.585
SPEC	Non-specific enterprise specialization index	0.653
WHT	Wheat income as a percent of Gross Farm Income	0.152
SOY	Soybeans income as a percent of Gross Farm Income	0.129
CORN	Corn income as a percent of Gross Farm Income	0.139
MILO	Grain sorghum income as a percent of Gross Farm Income	0.047
BEEF	Beef cattle income as a percent of Gross Farm Income	0.213
DAIRY	Dairy cattle income as a percent of Gross Farm Income	0.048
SWINE	Swine income as a percent of Gross Farm Income	0.041
OFFINC	Off-farm income from wages as a ratio of Gross Farm Income	0.054

Table 4.2. Summary Statistics.

Variable	Description	Mean	St. Dev.
VFP/L	Value of Farm Production / Labor (number of workers)	178,148	96,604
KC/L	Capital Cost (total costs – labor cost) / Labor (number of workers)	177,478	89,685
LC/VFP	Labor Cost (paid and unpaid) / Value of Farm Production	0.261	0.145
VFP	Value of Farm Production (measure of farm size)	258,274	240,732
LC	Labor Cost (paid and unpaid)	53,439	45,552
KC	Capital Cost (total costs – labor cost)	245,386	201,308
L	Labor calculated as number of workers per year	1.432	1.099
AGE	Age of operator squared	55.4	11.8
AGESQ	Age of operator squared	3208	1333
TEN	Percentage of owned acres	0.371	0.289
MA	Managerial ability (measured using the total economic expense ratio)	1.320	0.424
DA	Debt to asset ratio	0.340	0.291
WC	(Current assets minus current liabilities) divided by current assets	0.362	1.835
SPEC	Non-specific enterprise specialization index	0.778	0.189
WHT	Wheat income as a percent of Gross Farm Income	0.183	0.172
SOY	Soybeans income as a percent of Gross Farm Income	0.128	0.137
CORN	Corn income as a percent of Gross Farm Income	0.108	0.142
MILO	Grain sorghum income as a percent of Gross Farm Income	0.057	0.077
BEEF	Beef cattle income as a percent of Gross Farm Income	0.225	0.263
DAIRY	Dairy cattle income as a percent of Gross Farm Income	0.034	0.155
SWINE	Swine income as a percent of Gross Farm Income	0.014	0.084
OFFINC	Off-farm income from wages as a ratio of Gross Farm Income	0.100	0.233

The weighted averages of the variables in Table 4.1 are comparable to the KFMA benchmarks for the same variables (Langemeier and Herbel, 2006). In Table 4.1, large farms have relatively more impact on the variable computations. Table 4.2 represents the variables used in regression analysis for measuring labor productivity and efficiency.

4.2.1. Labor Productivity Dependent Variables

VFP/L was computed as value of farm production divided by the number of workers in the operation. This variable will be used as a dependent variable in the output per worker regressions. Labor was measured in total labor years for each operator, family member, and hired worker. The average number of workers for the sample of farms was 1.432. VFP/L has a mean of 178,148 and a standard deviation of 96,604. This variable has a value of skewness of 1.520 indicating a right-skewed distribution. Also, VFP and L have a correlation coefficient value of 0.787.

KC/L was computed as capital cost divided by the number of workers in the operation. This variable will be used as both an independent (output is a function of input) and dependent (input is regressed on farm characteristics) variable in the recursive labor productivity model discussed in chapter 3. Capital cost includes all expenses other than labor, including all factors of production and the opportunity cost of owned equity. KC/L has a mean of 177,478 and a standard deviation of 89,685. This variable has a value of skewness of 1.484 indicating a right-skewed distribution. KC and L have a correlation coefficient value of 0.739.

4.2.2. Labor Efficiency Dependent Variable

LC/VFP was computed as labor cost divided by value of farm production. This variable will be used as a dependent variable in the labor efficiency regression. LC/VFP has a mean of 0.261 and a standard deviation of 0.145. This variable has a value of skewness of 2.921

indicating a right-skewed distribution. The average LC/VFP value implies that the farms used 26.1% of value of farm production to compensate hired and unpaid labor. LC and VFP have a correlation coefficient value of 0.877.

4.2.3. Independent Variables

This section describes the independent variables used to examine variability in labor productivity and efficiency. It is organized into the following sub-sections: farm characteristic variables, financial variables, and specialization variables. These variables were calculated using the 5-year average of each farm.

4.2.3.1. Farm Characteristic Variables

VFP is the value of farm production for an individual farm in the data set. It is a size measuring variable indicating the market value of the farm's production throughout the year. In our sample of 1,045 farms, there were 232 farms with a VFP of less than $100,000. There were 482 farms with a VFP between $100,000 and $250,000. There were 320 farms with a VFP between 250,000 and 500,000, and 111 farms with a VFP greater than $500,000. From this distribution, the mean is 258,274 with a standard deviation of 240,732. It's important to note that the distribution of VFP is definitely skewed to the right. In fact, there are 40 farms that are 2+ standard deviations from the mean. 3 of the 18 farms that are 3+ standard deviations from the mean are greater than 8 standard deviations from the mean. On the other side, all 734 farms on the left side of the mean fall within 2- standard deviations. This might explain some of the reasons why Table 4.1 differs from Table 4.2 because the weighted average leans more heavily toward larger farms.

AGE and AGESQ are variables representing the farm operator's age. In our sample, there are 208 farms with operators 45 years or younger. There were 363 farms with operator age between 45 and 55 years. There were 322 farms between 55 and 65 years of age and 252 farms with an operator older than 65. The mean of the AGE distribution is 55.4 with a standard deviation of 11.8.

TEN is the percentage of owned acres; calculated as owned acres divided by total acres. This variable has a mean of 0.371 and a standard deviation of 0.289.

4.2.3.2. Financial Variables

MA is the variable used for managerial ability. MA is represented by the economic total expense ratio, which is calculated as follows: (total farm expense + unpaid labor + opportunity charge on owned equity) divided by value of farm production. Unpaid labor includes unpaid family labor, unpaid operator labor, and a management charge. The opportunity charge on owned equity is computed by multiplying owned equity, or net worth, by 8 percent. For this ratio, values of less than 1 mean that the farm is earning economic profits. For the sample, the mean is 1.32 with a standard deviation of 0.424. 125 farms in the sample had a ratio of less than one. This variable will without a doubt be a significant factor on labor productivity and efficiency regressions because of it being an "all encompassing" efficiency calculation.

DA represents the debt to asset ratio. It is calculated as total debt divided by total assets. This solvency variable is included to see how the ratio affects labor productivity and efficiency. DA has a mean of 0.340 and a standard deviation of 0.291.

WC is a liquidity measure. Working capital is calculated as current assets minus current liabilities, but to keep the variable from being biased towards larger farms, this amount is divided by current assets. WC has a mean of 0.362 and a standard deviation of 1.835.

4.2.3.3. Specialization Variables

SPEC is a specialization variable measuring how diversified each individual farm is between the production of crops and livestock. This variable uses the Herfindahl index and crop labor shares to compute the variable. For each farm, SPEC equals $\{(\text{crop labor shares})^2 + (1 - \text{crop labor shares})^2\}$. Because of the formula's properties, SPEC ranges from 0.5 to 1, where 0.5 is equally diversified between crops and livestock and 1 is totally specialized in either venture. SPEC has a mean of 0.778 and a standard deviation of 0.189. There were also 333 farms in the sample that were totally specialized (i.e., SPEC = 1).

For the remaining variables, specific enterprise incomes are divided by gross farm income to arrive at the percent of that farm's income derived from the enterprise. Gross farm income is calculated as value of farm production plus feed purchases. There is a total of eight "percent of income" variables included in the model. WHT is a variable pertaining to wheat production. SOY is a variable pertaining to soybean production. CORN is a variable pertaining to corn production. MILO is a variable pertaining to grain sorghum production. BEEF is a variable pertaining to beef cattle production. DAIRY is a variable pertaining to dairy cattle production. SWINE is a variable pertaining to swine production. Wheat and beef were the two most common enterprises. Finally, OFFINC is a variable representing the amount of off-farm income. On average, the ratio of off-farm income to gross farm income is approximately 10%.

CHAPTER 5 - RESULTS

The objective of this chapter is to summarize the results of this thesis. Section 5.1 explains the econometric adjustments to the models. Section 5.2 and 5.3 describe the results of the labor productivity and labor efficiency models, respectively.

5.1. Econometric Adjustments

It is important to note that during estimation, the dependent variables in model 3.2 and 3.4 (KC/L and VFP/L, respectively) were scaled down by a factor of 1,000 to ease interpretation of the results. Of the four models, equation 3.1 and 3.4 (log VFP/L and LC/VFP respectively) needed correction for heteroskedasticity. The Chi-Square test statistic for log VFP/L had a p-value of 0.003, indicating a significant level of heteroskedasticity. After correcting for heteroskedasiticy, the standard error on the intercept and the independent variable log KC/L changed from an original estimation of 0.186 and 0.015 to 0.221 and 0.018, respectively.

The Chi-Square test statistic for LC/VFP had a p-value of 0.0475, indicating a heteroskedastic error. After correcting for heteroskedasticity, the changes in standard errors for each variable in this model are shown in Table 5.1.

After constructing a correlation matrix for the independent variables in models 3.2, 3.3, and 3.4, all variables have a correlation coefficient of less than 0.8 except for the age and age squared, which is expected. Corrective action was not executed based on these correlation coefficient values (Kennedy, 1992). The independent variable correlation matrix is shown in Table 5.2. The off-diagonal elements show the variable correlation and the minimum and maximum columns are a quick reference to the boldly formatted values in each row.

Table 5.1. Standard Error Correction Due to Heteroskedasticity in Model 3.4.

Variable	**Original Estimate**	**Corrected Estimate**
INTERCEPT	0.05635	0.06750
VFP	1.345758E-8	1.41E-8
AGE	0.00169	0.00190
AGESQ	1.520E-5	1.80E-5
TEN	0.01124	0.01425
MA	0.00925	0.02248
DA	0.01162	0.01174
WC	0.00162	0.00161
SPEC	0.02192	0.02432
WHT	0.02465	0.03444
SOY	0.02570	0.02707
CORN	0.02839	0.02816
MILO	0.04269	0.04476
BEEF	0.02022	0.02808
DAIRY	0.02319	0.02582
SWINE	0.03714	0.03272
OFFINC	0.01304	0.02583

Table 5.2. Correlation Matrix of Independent Variables in Models 3.2, 3.3, and 3.4.

	VFP	AGE	AGESQ	TEN	MA	DA	WC	SPEC	WHT	SOY	CORN	MILO	BEEF	DAIRY	SWINE	OFFINC	**MIN**	**MAX**
VFP	1	-0.09988	-0.11655	-0.12370	**-0.41337**	0.09558	0.02599	0.01977	-0.13898	0.06796	**0.30829**	-0.09017	-0.14566	0.04108	0.2551	-0.26514	**-0.41337**	**0.30829**
AGE	-0.09988	1	**0.99024**	0.37582	0.43096	**-0.38071**	0.05829	0.00994	0.11097	-0.00469	-0.10920	-0.01764	0.08675	-0.09146	-0.02369	-0.04483	**-0.38071**	**0.99024**
AGESQ	-0.11655	**0.99024**	1	0.38856	0.45455	**-0.38320**	0.06295	0.02346	0.11662	-0.01565	-0.10992	-0.01707	0.08421	-0.09256	-0.02384	-0.04759	**-0.38320**	**0.99024**
TEN	-0.12370	**0.37582**	0.38856	1	**0.46543**	-0.37504	0.12547	-0.07345	-0.10303	-0.01682	-0.07062	-0.05980	0.09870	0.05889	0.04571	0.08608	**-0.37504**	**0.46543**
MA	**-0.41337**	0.43096	0.45455	**0.46543**	1	-0.35029	0.06792	-0.10906	0.02615	-0.10368	-0.22284	-0.06592	0.22460	-0.03666	-0.08748	0.35694	**-0.41337**	**0.46543**
DA	**0.09558**	-0.38071	-0.38320	-0.37504	-0.35029	1	**-0.38245**	0.06357	-0.03253	-0.05006	0.05351	0.00298	-0.06986	-0.02257	-0.02515	0.02694	**-0.3832**	**0.09558**
WC	0.02599	0.05829	0.06295	**0.12547**	0.06792	**-0.38245**	1	-0.15943	-0.13487	0.00906	0.00375	-0.08922	0.11140	0.05238	0.02036	-0.00695	**-0.38245**	**0.12547**
SPEC	0.01977	0.00994	0.02346	-0.07345	-0.10906	0.06357	-0.15943	1	**0.34253**	0.20164	0.32570	0.32351	**-0.66105**	-0.16247	-0.14950	-0.04105	**-0.66105**	**0.34253**
WHT	-0.13898	0.11097	0.11662	-0.10303	0.02615	-0.03253	-0.13487	0.34253	1	-0.29125	-0.28210	**0.45588**	**-0.34878**	-0.18536	-0.10203	-0.03390	**-0.34878**	**0.45588**
SOY	0.06796	-0.00469	-0.01565	-0.01682	-0.10368	-0.05006	0.00906	0.20164	-0.29125	1	**0.45575**	-0.07839	**-0.29871**	-0.14114	-0.02920	0.02084	**-0.29871**	**0.45575**
CORN	0.30829	-0.10920	-0.10992	-0.07062	-0.22284	0.05351	0.00375	0.32570	-0.28210	**0.45575**	1	-0.21177	**-0.35394**	-0.14229	-0.06507	-0.07698	**-0.35394**	**0.45575**
MILO	-0.09017	-0.01764	-0.01707	-0.05980	-0.06592	0.00298	-0.08922	0.32351	**0.45588**	-0.07839	-0.21177	1	**-0.30502**	-0.14476	-0.06863	-0.00295	**-0.30502**	**0.45588**
BEEF	-0.14566	0.08675	0.08421	0.09870	**0.22460**	-0.06986	0.11140	**-0.66105**	-0.34878	-0.29871	-0.35394	-0.30502	1	-0.15529	-0.08332	0.09823	**-0.66105**	**0.22460**
DAIRY	0.04108	-0.09146	-0.09256	0.05889	-0.03666	-0.02257	**0.05238**	-0.16247	**-0.18536**	-0.14114	-0.14229	-0.14476	-0.15529	1	-0.03598	-0.04336	**-0.18536**	**0.05889**
SWINE	**0.25510**	-0.02369	-0.02384	0.04571	-0.08748	-0.02515	0.02036	**-0.14950**	-0.10203	-0.0292	-0.06507	-0.06863	-0.08332	-0.03598	1	-0.04918	**-0.14950**	**0.25510**
OFFINC	**-0.26514**	-0.04483	-0.04759	0.08608	**0.35694**	0.02694	-0.00695	-0.04105	-0.03390	0.02084	-0.07698	-0.00295	0.09823	-0.04336	-0.04918	1	**-0.26514**	**0.35694**

5.2. Labor Productivity Results

Table 5.3 presents the labor productivity results. Models 3.1, 3.2, and 3.3 are exhibited with the dependent variable and independent variables in the left-most column, separated by spaces and an underline. Parameter estimate, standard error, elasticity, and significance are included in the table. In model 3.1, the parameter estimate for log KC/L is 0.994 and is also significant at the one percent level indicating an extremely good fit and significant relationship between log VFP/L and log KC/L. Based on this relationship, it is easy to see that model 3.2 and 3.3 are also similar when regressed on the independent farm variables. This validates the focus on equation 3.3 in the discussion below. Model 3.3 directly shows the relationship between the farm characteristic variables and labor productivity.

Labor productivity as a function of farm characteristics behaved as expected given the expected signs in chapter three. VFP was positive and significant at the one percent level. AGE was negative and significant at the five percent level. TEN was very significant (one percent level) and positively related to labor productivity. MA was negative and significant at the one percent level. SPEC was positive and significant at the five percent level. CORN was positive and significant at the one percent level. BEEF was also positive and significant at the ten percent level. DAIRY was negative and significant at the one percent level while SWINE was negative and significant at the one percent level.

By using the elasticities, it is easier to tell which variables have the most impact on the model. VFP had one of the largest elasticity values of 0.238 which along with its significance tells us that increasing size is a very important factor in improving labor productivity. This is intuitive because larger farms tend to have a higher degree of technologies available which

Table 5.3. Labor Productivity Regression Results.

Variable	Parameter Estimate	Standard Error	Elasticity	t-value	Significance
log (VFP/L) = log (KC/L)					
INTERCEPT	0.04319	0.22143		0.19505	
log KC/L	0.99471	0.01838	0.99638	54.11915	***
R^2 = 0.782					
(KC/L) = f (farm regressors)					
INTERCEPT	156.25334	45.49241		3.43471	***
VFP	0.00014045	0.00001086	0.20439	12.93278	***
AGE	-0.82030	1.36246	-0.22041	-0.60207	
AGESO	0.00103	0.01227		0.08394	
TEN	71.80380	9.07125	0.14993	7.91554	***
MA	-14.76547	7.47128	-0.10983	-1.97630	**
DA	-12.43929	9.37772	-0.02382	-1.32647	
WC	-0.73951	1.31148	-0.00151	-0.56387	
SPEC	20.21539	17.69143	0.08863	1.14267	
WHT	-2.66209	19.90010	-0.00275	-0.13377	
SOY	-10.85847	20.75154	-0.00785	-0.52326	
CORN	152.03021	22.91699	0.09249	6.63395	**
MILO	19.55426	34.46599	0.00627	0.56735	
BEEF	2.35236	16.32073	0.00298	0.14413	
DAIRY	-103.12794	18.72392	-0.01979	-5.50782	***
SWINE	-176.86912	29.98230	-0.01379	-5.89912	***
OFFINC	-14.65454	10.52947	-0.00827	-1.39176	
R^2 = 0.344					
(VFP/L) = f (farm regressors)					
INTERCEPT	236.35163	41.88510		5.64286	***
VFP	0.00016448	0.00001000	0.23846	16.44800	***
AGE	-2.54408	1.25443	-0.32394	-2.02808	**
AGESO	0.01356	0.01130		1.20000	
TEN	43.70583	8.35195	0.09091	5.23301	***
MA	-71.92527	6.87885	-0.53298	10.45600	***
DA	-5.95513	8.63412	-0.01136	-0.68972	
WC	0.05746	1.20748	0.00012	0.04759	
SPEC	41.34104	16.29108	0.18056	2.53765	**
WHT	10.80807	18.32213	0.01114	0.58989	
SOY	-15.08352	19.10605	-0.01086	-0.78946	
CORN	157.90771	21.09979	0.09570	7.48385	***
MILO	20.30260	31.73302	0.00648	0.63979	
BEEF	25.04382	15.02658	0.03158	1.66663	*
DAIRY	-81.25213	17.23921	-0.01553	-4.71322	***
SWINE	-141.50829	27.60487	-0.01099	-5.12621	***
OFFINC	-8.11990	9.69454	-0.00456	-0.83757	
R^2 = 0.521					

*** - significant at the 1% level

** - significant at the 5 % level

* - significant at the 10% level

considerably helps the productivity of labor.

AGE had a large absolute value of the elasticity with a value of -0.323, which shows it negatively impacting labor productivity. Parameter estimates show that AGE decreases at an increasing rate. This observation coincides with the literature and is also intuitive because productivity declines with age for numerous reasons, including the change in financial goals and decreased use of technology.

TEN was significant and positively related to labor productivity and had an elasticity value of 0.091. As ownership increases as a percent of total acres, labor productivity increases. This result is perhaps due to the fact that the operator is sharing less of his income with owners than other operators with a lower TEN rate.

MA was significant and negatively related to labor productivity which is very intuitive because it itself is an efficiency measure. MA had the second largest absolute value of the elasticity with a value of -0.532. Decreasing values of this measure suggest a higher level of efficiency which translates to a more productive farm in terms of labor.

SPEC had a positive and significant impact on labor productivity. This is intuitive because in a simple example, it is easier to master as well as effectively complete one activity than multiple activities holding everything constant. The results show that diversifying and specializing between crops and livestock has an impact on the makeup of the farm. Although the model states that improving specialization will increase labor productivity, farms may still choose to diversify to gain a lesser degree of risk involved in the production process.

CORN had a larger elasticity than all of the other "percent of income" variables. Its high degree of significance and large parameter estimate shows that corn might be a crop associated with significantly larger farm sizes, reflecting the notion that smaller farms cannot take advantage of the technological advances and capital impacts a large corn enterprise would require. Corn prices have increased and a lot of farms have moved into more corn production to acquire the attractive prices. This may be contributing to this result.

BEEF had a significant and positive relationship with labor productivity. Its elasticity value of 0.0315 is the second largest of any of the “percent-of-income” variables possibly because beef income makes up the largest percent (22 percent) of the data set’s average income. It’s a popular enterprise, and perhaps this enterprise is used to improve labor productivity while diversifying for risk management strategies.

DAIRY was negative and significantly related to labor productivity. The dairy enterprise is very labor intensive, and it is intuitive to find that it would have a negative parameter estimate because of this.

SWINE was negative and significantly related to labor productivity. It is not surprising to see that this is similar to the dairy enterprise in terms of being very labor intensive which supports a negative coefficient.

Table 5.4 shows the comparative statics of the labor productivity model, 3.3. This table shows the impact of changing one variable and its impact on the predicted model while holding the remaining variables constant. Changing one variable and keeping the others constant makes the significance of the changing variable quantifiable and interpretable.

The shaded rows in Table 5.4 report the effect of a standard deviation increase or decrease on the labor productivity variable, while keeping all other variables fixed at their means. The right-most columns show the actual deviation and percent deviation. The white rows in Table 5.4 show discrete changes of some of the more significant variables in the

Table 5.4. Labor Productivity Model (3.3) Comparative Statics.

Variable	Target	Parameter Estimate	Mean	Standard Deviation	Predicted Model	-1 St. Dev.	+1 St. Dev.	Prediction Deviation	Percent Deviation
VFP		1.64E-04	258,273.55	240,732.20	178.15470	138.55907	217.75033	39.59563	22.23%
	evaluated at 100,000				152.12187			-26.03283	-14.61%
	evaluated at 200,000				168.56987			-9.58483	-5.38%
	evaluated at 300,000				185.01787			6.86317	3.85%
	evaluated at 400,000				201.46587			23.31117	13.08%
	evaluated at 500,000				217.91387			39.75917	22.32%
AGE		-2.54408	55.39354	11.80473	178.15470	190.11018	166.19922	-11.95548	-6.71%
AGESQ		0.01356	3,207.67	1,333.09	178.15470	190.11018	166.19922	-11.95548	-6.71%
	at age 40				195.51708			17.36238	9.75%
	at age 50				182.28028			4.12558	2.32%
	at age 60				171.75548			-6.39922	-3.59%
	at age 70				163.94268			-14.21202	-7.98%
TEN		43.70583	0.37057	0.28906	178.15470	165.52104	190.78836	12.63366	7.09%
MA		-71.92527	1.32012	0.42371	178.15470	208.62982	147.67958	-30.47512	-17.11%
	-40% of mean value				216.13462			37.97993	21.32%
	-20% of mean value				197.14466			18.98996	10.66%
	+20% of mean value				159.16474			-18.98996	-10.66%
	+40% of mean value				140.17477			-37.97993	-21.32%
DA		-5.95513	0.33988	0.29098	178.15470	179.88754	176.42186	-1.73284	-0.97%
WC		0.05746	0.36174	1.83546	178.15470	178.04923	178.26016	0.10547	0.06%
SPEC		41.34104	0.77808	0.18874	178.15470	170.35182	185.95758	7.80288	4.38%
	equally diverse value of 0.5				166.65841			-11.49629	-6.45%
	specialized value of 1				187.32893			9.17423	5.15%
WHT		10.80807	0.18366	0.17115	178.15470	180.00455	176.30485	-1.84985	-1.04%
	specialized value of 1				179.79518			1.64049	0.92%
SOY		-15.08352	0.12829	0.13736	178.15470	180.22654	176.08286	-2.07184	-1.16%
	specialized value of 1				153.90359			24.25110	13.61%
CORN		157.90771	0.10797	0.14155	178.15470	155.80357	200.50582	22.35113	12.55%
	specialized value of 1				326.89482			148.74013	83.49%
MILO		20.30260	0.05690	0.07719	178.15470	176.58758	179.72181	1.56712	0.88%
	specialized value of 1				189.28971			11.13502	6.25%
BEEF		25.04382	0.22465	0.26300	178.15470	171.56811	184.74129	6.58659	3.70%
	specialized value of 1				194.03093			15.87624	8.91%
DAIRY		-81.25213	0.03405	0.15530	178.15470	190.77287	165.53653	-12.61817	-7.08%
	specialized value of 1				87.73498			-90.41971	-50.75%
SWINE		-141.50829	0.01384	0.08445	178.15470	190.10564	166.20376	-11.95094	-6.71%
	specialized value of 1				27.47882			-150.67587	-84.58%
OFFINC		-8.11990	0.10015	0.23306	178.15470	180.04711	176.26229	-1.89241	-1.06%
	without supplemented off-farm income				178.96792			0.81322	0.46%

regression. These calculations also use specific values of the variable in question, while keeping everything else constant. VFP is discretely changed for a target of potential values from $100,000 to $500,000. MA is also discretely varied between a 40 percent increase and decrease from the mean. SPEC is evaluated at the extreme values of being equally split in production of livestock and crops or totally specialized in either. The "percentage-of-income" variables are also evaluated at the extreme point of total specialization or 100 percent of income. These unique discrete changes allow only one enterprise in the production process. This means all other "percent-of-income" variables are excluded, and the remaining variables remain held constant at their means.

Note that this table does not take into account the degree of correlation between the variables. The calculations are made only by altering one variable's mean and keeping the other variables constant at their respective means. This analysis is used to further illustrate the significant impact of each variable on the predicted model, based on the model estimates.

When examining VFP comparative statics, increasing the mean by one standard deviation yields a 22.23 percent increase in labor productivity. When considering a VFP of $100,000, labor productivity drops 14.61 percent below the mean. A VFP value of $500,000 yields a labor productivity growth of 22.32 percent above the mean.

AGE has a mean value of 55.39, and when that value is increased one standard deviation, labor productivity declines 6.71 percent. Observing operator age from 40 to 70, it is apparent that at a younger age, (less than the mean value) labor productivity increases and as an operator ages, productivity declines. This result is consistent with Tauer and Lordkipandidze (2000).

One of the most significant variables in the labor productivity model was MA. Managerial ability expressed as the economic total expense ratio has a drastic impact on labor productivity. When the mean ratio of 1.320 is increased one standard deviation, labor productivity declines by 17.11 percent which is equivalent to decreasing labor productivity by more than $30,000. To quantify labor productivity for very poorly managed farms, an MA value of twice the mean yields a decrease of 53.30 percent in labor productivity. To examine the majority of the farms in the data set, a discrete range of (+/-) forty percent from the mean was considered. A 20 percent decrease to MA yielded a 10.66 percent increase in labor productivity and a 40 percent decrease yielded a 21.32 percent increase. In dollars, 10.66 percent is approximately $19,000 and 21.32 percent is approximately $38,000.

SPEC had a mean value of 0.778. When increased by one standard deviation, labor productivity increased 4.38 percent. When examined at the extreme mean values of 0.5 and 1, labor productivity decreased 6.45 percent (approximately $11,500) and increased 5.15 percent (approximately $9,000), respectively.

CORN drastically changes labor productivity because of its large parameter estimate. CORN has a mean value of 0.108, and when it is increased by a standard deviation, labor productivity increases by 12.55 percent (approximately $22,000). When evaluated at the extreme of total specialization in corn, labor productivity increases by 83.49 percent (approximately $149,000).

BEEF has a mean value of 0.224, and when it is increased by a standard deviation, labor productivity increases by 3.70 percent. When evaluated at the extreme point of total specialization in beef production, labor productivity increases by 8.91 percent (approximately $16,000).

DAIRY and SWINE both fall into the category of very labor intensive enterprises. DAIRY has a mean value of 0.107. Labor productivity decreases by 7.08 percent when the mean increases by a standard deviation. Evaluated at the extreme point of total specialization, labor productivity decreases by 50.75 percent (approximately $90,000). SWINE has a mean value of 0.014 and when it is increased by a standard deviation, labor productivity decreases by 6.71 percent (approximately $12,000). When evaluated at the extreme point of total specialization, labor productivity decreases by 84.58 percent (approximately $151,000).

5.3. Labor Efficiency Results

Table 5.5 shows the labor efficiency model regression results. Model 3.4 is shown in the same fashion as table 5.3, which shows the parameter estimate, standard error, elasticity and significance of each independent variable.

Labor efficiency as a function of farm characteristics behaved as expected given the expected signs in chapter three. VFP was negative and significant at the one percent level. TEN was negative and significant at the one percent level. MA was positive and significant at the one percent level. DA was negative and significant at the one percent level. CORN was negative and significant at the ten percent level. MILO was negative and significant at the one percent level. DAIRY and SWINE were both positive and significant at the one percent level.

VFP was very significant and also negatively related to efficiency indicating that farm size was definitely associated with labor efficiency. This relationship most certainly has a strong effect with economies of scale indicating that there are cheaper labor costs when spanned across larger entities.

AGE was not significant. In terms of labor efficiency, age did not appear to be a strong factor like it was for labor productivity.

Table 5.5. Labor Efficiency Regression Results (Model 3.4).

Variable	Parameter Estimate	Standard Error	Elasticity	t-ratio	Significance
INTERCEPT	0.01655	0.06750		0.24519	
VFP	-6.24193E-8	1.41E-8	-0.06166	-4.42690	***
AGE	-0.00237	0.00190	-0.49328	-1.24737	
AGESQ	0.00002085	0.01425		0.00146	
TEN	-0.08768	0.02248	-0.12427	-3.90036	***
MA	0.25140	0.01174	1.26933	21.41397	***
DA	-0.01114	0.00161	-0.01448	-6.91925	***
WC	-0.00002485	0.02432	-0.00003	-0.00102	
SPEC	0.03161	0.03444	0.09407	0.91783	
WHT	0.03632	0.02707	0.02551	1.34171	
SOY	-0.03905	0.02816	-0.01916	-1.38672	
CORN	-0.07942	0.04476	-0.03280	-1.77435	*
MILO	-0.07401	0.02808	-0.01611	-2.63568	***
BEEF	0.03384	0.02582	0.02908	1.31061	
DAIRY	0.12668	0.03272	0.01650	3.87164	***
SWINE	0.17615	0.02583	0.00932	6.81959	***
OFFINC	0.01844	0.06750	0.00706	0.27319	

R^2 = 0.617

*** - significant at the 1% level

** - significant at the 5 % level

* - significant at the 10% level

TEN was negative and significant. The elasticity value of -0.124 suggests that this variable was relatively important in explaining variation in labor efficiency. Apparently, in the same way as labor productivity improves with less sharing of the profits with land owners, efficiency improves because more of the output (dollars) is considered in VFP.

Given the fact that MA is an efficiency measure, it was not surprising to find that this variable was important in explaining variation in labor efficiency. This variable had the largest absolute value of the elasticity.

DA is very significant but the parameter estimate is surprisingly small. There are many ways to interpret the outcome of this variable which would be farm specific in detail. An increase in debt, relative to assets, could mean that the extra debt will be used to gain technological advantages in the production process, hence, improving labor efficiency.

CORN is significant at the ten percent level while MILO is significant at the 1 percent level. Both of these crops' parameter estimates improve labor efficiency with increased levels of income derived from them, but they could be influenced by the level of technology or even a specific farm type that is required for its production.

DAIRY and SWINE are positive and significant. This is intuitive because these two enterprises demand more labor relative to other enterprises used in the research.

Table 5.6 shows the comparative statics of the labor efficiency model, 3.4. This table is presented in an identical fashion to Table 5.4, with shaded rows for standard deviation changes and white rows for discrete changes.

Increased levels of VFP improve labor efficiency. In the same manner as labor productivity, the mean value being increased by one standard deviation yields an improvement in

Table 5.6. Labor Efficiency Model (3.4) Comparative Statics.

Variable	Target	Parameter Estimate	Mean	Standard Deviation	Predicted Model	-1 St. Dev.	+1 St. Dev.	Prediction Deviation	Percent Deviation
VFP		-6.24E-08	258,273.55	240732.20	0.26129	0.27631	0.24626	-0.01503	-5.75%
	evaluated at 100,000				0.27117			0.00988	3.78%
	evaluated at 200,000				0.26492			0.00364	1.39%
	evaluated at 300,000				0.25868			-0.00260	-1.00%
	evaluated at 400,000				0.25244			-0.00885	-3.39%
	evaluated at 500,000				0.24620			-0.01509	-5.77%
AGE		-0.00237	55.39354	11.80473	0.26129	0.26147	0.26110	-0.00018	-0.07%
AGESQ		0.00002	3207.67	1333.09000	0.26129	0.26147	0.26110	-0.00018	-0.07%
	at age 40				0.26425			0.00296	1.13%
	at age 50				0.25931			-0.00197	-0.75%
	at age 60				0.25855			-0.00274	-1.05%
	at age 70				0.26195			0.00067	0.26%
TEN		-0.08768	0.37057	0.28906	0.26129	0.28663	0.23594	-0.02534	-9.70%
MA		0.25140	1.32012	0.42371	0.26129	0.15477	0.36781	0.10652	40.77%
	-40% of mean value				0.12854			-0.13275	-50.81%
	-20% of mean value				0.19491			-0.06638	-25.40%
	+20% of mean value				0.32766			0.06638	25.40%
	+40% of mean value				0.39404			0.13275	50.81%
DA		-0.01114	0.33988	0.29098	0.26129	0.26453	0.25804	-0.00324	-1.24%
WC		-0.00002	0.36174	1.83546	0.26129	0.26133	0.26124	-0.00005	-0.02%
SPEC		0.03161	0.77808	0.18874	0.26129	0.25532	0.26725	0.00597	2.28%
	equally diverse value of 0.5				0.25250			-0.00879	-3.36%
	specialized value of 1				0.26830			0.00701	2.68%
WHT		0.03632	0.18366	0.17115	0.26129	0.26750	0.25507	-0.00622	-2.38%
	specialized value of 1				0.29955			0.03826	14.64%
SOY		-0.03905	0.12829	0.13736	0.26129	0.26665	0.25592	-0.00536	-2.05%
	specialized value of 1				0.22418			-0.03711	-14.20%
CORN		-0.07942	0.10797	0.14155	0.26129	0.27253	0.25004	-0.01124	-4.30%
	specialized value of 1				0.18381			-0.07748	-29.65%
MILO		-0.07401	0.05690	0.07719	0.26129	0.26700	0.25557	-0.00571	-2.19%
	specialized value of 1				0.18922			-0.07207	-27.58%
BEEF		0.03384	0.22465	0.26300	0.26129	0.25239	0.27019	0.00890	3.41%
	specialized value of 1				0.29707			0.03578	13.69%
DAIRY		0.12668	0.03405	0.15530	0.26129	0.24161	0.28096	0.01967	7.53%
	specialized value of 1				0.38991			0.12862	49.23%
SWINE		0.17615	0.01384	0.08445	0.26129	0.24641	0.27616	0.01488	5.69%
	specialized value of 1				0.43938			0.17809	68.16%
OFFINC		0.01844	0.10015	0.23306	0.26129	0.25699	0.26558	0.00430	1.64%
	without supplemented off-farm income				0.25621			-0.00507	-1.94%

labor efficiency of 5.75 percent (a change from 0.261 to 0.246). When considering a VFP value of $100,000, labor efficiency deteriorates 3.78 percent. A VFP value of $500,000 yields a labor efficiency improvement of 5.77 percent.

MA drastically changes the predicted model's value. Because this variable is so significant to the model's outcome, one standard deviation increase in the mean yields a 40.77 percent increase in the labor efficiency index (i.e., a substantial deterioration in labor efficiency). Improving the economic total expense ratio by 40 percent yields an improvement of 50.81 percent. That same 50.81 percent improvement brings labor costs to approximately 13 percent of total VFP which is a drastic improvement from the original labor efficiency value of 26 percent of total VFP.

When the means of CORN and MILO are increased by one standard deviation, the overall effect it has on labor efficiency is an improvement of 4.30 percent and 2.19 percent, respectively. When both crops are considered for total specialization, labor efficiency improves to 29.65 percent and 27.58 percent, respectively. Specialization in corn and grain sorghum production improves the original labor efficiency prediction of approximately 0.26 to approximately 0.18 and 0.19, respectively.

When the means of DAIRY and SWINE are increased by one standard deviation, labor efficiency declines 7.53 percent and 5.69 percent, respectively. When both enterprises are considered for total specialization, labor efficiency further deteriorates to 0.492 and 0.682, respectively.

CHAPTER 6 - CONCLUSIONS

This chapter summarizes this thesis and provides conclusions and implications for the research. Section 6.1 provides the summary and chief results of the research and section 6.2 provides some ideas for further research.

6.1. Thesis Synopsis

The objective of this thesis was to examine differences in labor efficiency and to find what is driving those differences among Kansas farms. With the results, we are able to have a quantified understanding of the variation in labor productivity and labor efficiency relating to three categories of variables: farm characteristics, financial performance, and specialization. There is prevalent research discussing technological catch-up, technological change, and capital deepening, in terms of efficiency and productivity, but where the research is thin is how productivity and efficiency is directly tied to an input, such as labor.

This research uses regression estimates from a data set of 1,145 Kansas farms to quantify how farm variables are related to labor productivity and labor efficiency. There are two main models for emphasis. Labor productivity, expressed as value of farm production divided by the number of workers, is regressed on three categories of variables: farm characteristics, financial performance, and specialization. Labor efficiency, expressed as labor costs divided by value of farm production, is also regressed on the same categories of variables.

Variables included in farm characteristics category are value of farm production, operator age, and land tenure. Value of farm production is used to measure farm size. Variables included in the financial performance category include managerial ability, debt to asset ratio, and working capital. Variables included in the specialization category include an index of specialization that considers the level of diversification between crops and livestock, and income variables that consider the value of production for each enterprise divided by total gross farm income. Enterprises existing in the data are wheat, soybeans, corn, grain sorghum, beef cattle, dairy cattle, swine, and the level of off-farm income.

In the labor productivity model, value of farm production, age, and managerial ability were the three most influential and significant variables. Increasing farm size was estimated to have a positive impact on labor productivity. As age increased, labor productivity declined at an increasing rate. Managerial ability, expressed as the economic total expense ratio, had a negative impact on labor productivity because a higher ratio value indicates higher production expenses relative to value of farm production.

In the labor efficiency model, value of farm production, managerial ability, and land tenure were the most influential and significant variables. Increasing farm size was estimated to improve labor efficiency. An increase in managerial ability was estimated to deteriorate labor efficiency with the same logic that labor productivity suffered; a higher ratio value indicates higher expenses relative to value of farm production. An increase in land tenure was estimated to improve labor efficiency. This is intuitive because operators with higher tenure rates share less VFP with landlords, and more VFP improves labor efficiency.

6.2. Further Research Ideas

An increase in relevant financial variables would help gain an understanding of the most important parts of the financial statements that heavily impact labor productivity and efficiency. Similarly, managerial ability is a significant and influential variable, but finding a way to extract which part of the ratio is the driver of change would be beneficial for interpretation at the farm level.

A different and more applicable approach to capturing liquidity in the models would be to use the inverted current ratio instead of the working capital index proposed in this thesis. This is easier to compute and an easier interpretation of liquidity.

On the production side, adding a no-till or reduced tillage variable into the models could segregate efficiencies or inefficiencies that are hidden in the crop enterprise variables. Also, the inclusion of a soil quality variable would be great to include so an understanding of the variability of labor efficiency and its relationship to soil quality could be developed.

Another variable to take into account in future research is the operator's production experience (number of years). This information could aid in the accuracy of what is being estimated with the age and age squared variables as well as having an interpretive value by itself.

Any sort of deeper analysis that can extract more variability between farm characteristics would be beneficial in gaining an understanding of which parts of agriculture are contributing to or hindering the welfare of labor productivity and efficiency. Finally, replicating this analysis repeatedly in the future would be beneficial to see how things are changing in terms of labor efficiency as we adapt newer production procedures and technologies.

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