STUDIES ON THE ECONOMIC EFFICIENCY OF KANSAS FARMS

by

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B.A. University of Murcia, Spain, 1996
M.S. Kansas State University, 2003

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics
College of Agriculture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2008

Abstract

This study focused on the economic efficiency of Kansas farms. The goal was to investigate factors and how they might affect farms and their economic and production performance. Kansas was selected as the region of study for its large agricultural production and distinctive type of multiple-operation farms. Farms in the sample could produce three outputs, crops, livestock and custom work. Inputs for the farms included measures of capital, labor, land and purchased inputs. Production outputs were measured in bushels and tons; input quantities were computed from input expenditures applying an input price index taken from the US Department of Agriculture in real US dollars. The dataset consisted of a 10-year (1998-2007) panel of 456 multi-output farms belonging to the Kansas Farm Management Association (KFMA). Data Envelopment Analysis (DEA) techniques were used to construct a non-parametric efficiency frontier and calculate technical efficiency (TE), allocative efficiency (AE), scale efficiency (SE), and overall or economic efficiency (OE) for each farm and each year. A discretionary input oriented DEA technique was used to assess the effect of capital availability as a farm input and its impact on farms' efficiencies. Efficiency scores in this problem were compared to the farms' scores when the level of debt was accounted for as a farm input.

Panel data Tobit analysis was applied to the farms' inefficiency scores to investigate the causality of selected farm characteristics on technical, allocative, scale and overall inefficiencies. For the sampled farms and period, results confirmed that larger farms were more efficient than smaller ones. Farms specializing in livestock products, such as dairy and beef, were reported to be slightly more overall efficient than crop or mixed farms. Some economies of scope were found between custom work operations and crops. Financial structure of the farms was measured using the ratio of total debt to total assets for each farm. According to the results, larger leverage ratios increased all farm efficiencies. The positive effect of debt or capital availability in Kansas farms efficiencies was confirmed. The results of the technical efficiency discretionary DEA model agreed with this finding.

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Dedication

I dedicate this piece of work to my grandma, my "*Abuelititca Maria*", my spiritual pillar in this life and the next one. Grandma, finally!

To my sister, *my Mariucha* the most loving and generous person, without her emotional support and hard work I would not have been able to accomplish this task. To my parents, *Trinity and Paco*, for their endless encouragement. To my grandparents, uncles and cousins and all, because they were always encouraging and felt very close though they were miles away.

To *my Lord*;

Rejoice in the Lord always. I will say it again: Rejoice! Let your gentleness be evident to all. The Lord is near. Do not be anxious about anything, but in everything, by prayer and petition, with thanksgiving, present your request to God. Philippians 4:4-6

Many are the plans in a man's heart, but it is the Lord's purpose that prevails. Proverbs19:21

Preface

This dissertation considered explicitly the role of capital structure and other individual factors in determining the performance of a sample of 456 Kansas farms from 1998 to 2007. To meet these objectives, I relied on previous research on cost frontiers and performance measurement to establish the link between productive efficiency and farm and financial structure (Fried, Lovell and Schmidt 2005; Färe, Grosskopf and Margaritis 2005). Using this theoretical construct and a cost function, the distance from the best practice frontier and optimal behavior was calculated. Total debt was used to test the role of capital access and its relation to production efficiency, based on different theories including free cash flow, credit evaluation, embodied capital and agency costs. Total debt indicates capital availability to the farm. Financial variables, especially debt incurred to purchase inputs and the availability of capital, may affect the structure and organization of farm production. This dissertation contributes to the literature by assessing the effect of capital structure on a farm's distance from the best practice frontier.

CHAPTER 1 - Introduction and Objectives

1.1 General Overview

The level of technical efficiency of a particular farm is characterized by the relationship between observed production and some ideal or potential production. The measurement of farm specific technical efficiency is based upon deviation of observed output (or input) from the best production or efficient production frontier. A farm is perfectly efficient if its actual production lies on the minimum cost frontier. If the farm's production is above the frontier that farm is technically inefficient.

Measuring technical efficiency has been a focus of research since Farrell's (1957) definition of technical efficiency led to the development of methods for estimating the relative technical efficiency of firms. The common features of these estimation techniques are that information is extracted from a body of data to determine the best practice production frontier (Lewin and Lovell 1990). From this the relative measure of technical efficiency for the individual farm can be measured.

Production efficiency has been measured using parametric and nonparametric approaches. Parametric approaches involve the estimation of a stochastic production frontier, where the output of a farm is a function of a set of inputs, inefficiency, and random error. A disadvantage of this technique is the imposition of an explicit functional form and a distributional assumption on the error. In contrast, the nonparametric approach of Data Envelopment Analysis (DEA) does not impose parametric restrictions on the underlying technology and therefore is less prone to misspecification (Färe, Grosskopf and Lovell 1994).

There are around sixty thousand farms in Kansas who benefit from all advances in technology. An interesting and important question is: What are the main factors indirectly driving farms' efficiencies and inefficiencies in Kansas? Are these factors influencing different production efficiency measures in the same way? Further, is it possible to improve farming efficiency by knowing which factors most influence an economically successful farm?

The purpose of this dissertation is to investigate the overall efficiency of Kansas farms, given their production and other measures of performance. This study has two major goals. The first is to investigate the evolution of Kansas farm efficiencies and the factors affecting them in light of some important concerns regarding farming issues, specifically the effect of debt as the possible means to purchase inputs and long-term assets. The second goal is to quantify the effect of total farm debt on efficiencies. The next section specifies the purpose and supporting objectives for each of these goals.

In this dissertation, annual production efficiencies were estimated and analyzed for a sample of 456 multi-output, multi-input Kansas farms from 1998 to 2007. The dataset was provided by the Kansas Farm Management Association (KFMA). The data included farm-specific accounting information over the ten-year period of analysis. Information on production levels, inputs, financial and socio-economic factors were part of the information provided by each farm each year. Outputs were aggregated in seven categories reflecting the main crops produced in the area and the most common livestock operations. Inputs were aggregated into seven categories: land, labor, short-term and intermediate-term capital, and purchased inputs for livestock operations and crops operations. It is important to realize that these farms may produce all outputs together, a subset of the possible outputs, or any one of them. This implies that not all farms produce or use all outputs and/or inputs.

1.2 Introduction and Specific Objectives

1.2.1 Sources of Inefficiency in Kansas Farms

The production and cost frontier approaches have been widely used to measure efficiency in agricultural economics at the farm level. Efficiency analysis (and the identification of changes in efficiency) is conceptually different from identifying technical change. The first subject is the topic of this study. Efficiency studies are a useful way to diagnose problems and make recommendations based on empirical work and the economic theory of farm production. Many stakeholders are interested in the results of efficiency studies, including policy makers, farmers, and agribusinesses such as lenders or input suppliers. Efficiency analysis is important in the current era of rapidly changing technology and increasing input costs. Efficiency analysis makes it possible to assess farmers' relative performance, to enhance agricultural production to minimize costs through optimal input combinations, and to analyze the effect of farm characteristics on overall performance.

The majority of farm efficiency studies in agricultural economics focus on technical efficiency (Coelli, Rahman and Thirtle 2002). Technical efficiency is just one component of overall economic efficiency. However, in order to be economically efficient, a farm must first be technically efficient. Profit maximization requires a farm to produce the right mix and optimal output given the level of inputs employed (i.e. be technically efficient), to use the right mix of inputs in light of the relative price of each input (i.e. be allocatively efficient), and finally to produce the right level of output given the set of prices (i.e. be scale efficient) (Kumbhjaker and Lovell 2000).

This dissertation seeks to measure farm performance with more than one measure of efficiency to have a more comprehensive view of farm performance. Of particular interest is overall or economic efficiency, which accounts for relative market input prices and combines measures of technical, scale and allocative efficiency. These four measures provide a comprehensive look at the farm's performance from the input side and will be explained in detail in the next chapter.

As noted above, DEA is one technique to measure efficiency. DEA is a non-parametic linear programming method that constructs a "best practice" or "benchmark performance" frontier, to which each harm in a sample is compared. In this dissertation, farm-level technical efficiency will be estimated using DEA. The method compares the units of analysis[1] in terms of their use of inputs and their level of output "enveloping" all the data points to construct a relative best practice frontier. All the farms are compared in terms of the quantity of inputs used and the quantity of outputs produced. The best performers are those producing the most output with the least amount of inputs. These best performers in the sample lie on the best practice frontier and are given a score of one. Farms that lie above the frontier are technically inefficient, as they use more inputs than necessary to produce a given amount of output. The efficiency score for these farms is calculated as the radial reduction in inputs (i.e., reduction of all inputs by the same proportion) to the input levels needed for an efficient farm to produce the same output. Thus, farms whose scores are below one are assigned ratios based on the best performers' relevant production characteristics.

DEA does not impose any assumptions about the functional form of the production frontier and hence is less prone to mis-specification than econometric methods. With DEA, measures of efficiency are relative, as they refer to the sample from which they are calculated.

[1] This term is used interchangeably with "decision making units" (DMUs). Both terms refer to any group of firms, farms, or homogenous units whose performance can be analyzed among peers and who have a common production process that transforms inputs into outputs.

This is an advantage because accurate and detailed information on a large and representative sample of Kansas farms is available for this study from the Kansas Farm Management Association (KFMA) database. Various input and output characteristics of the farms were selected from the database to answer the research questions. Four measures of efficiency were calculated using DEA models. I am interested in the multi-output firm since Kansas farms often have two or more complementary operations, most commonly livestock and crops. I want to account for this factor in the calculation of efficiencies. A major advantage of the DEA method is that it accommodates multiple outputs and inputs. These four measures of efficiency offer a sharp view of farm's relative performance. The DEA method is explained more fully in Chapters 2 and 3.

In this dissertation, I used an input-oriented DEA analysis, where farms had seven outputs corresponding to the most common crops and livestock operations in Kansas. The specific outputs were wheat production, feed grain production, soybean production, hay and forage production, beef production, milk production, and custom work. I included seven inputs that represented the most important variable and operating farm costs. Inputs for both crop and livestock operations included in the cost function were expenses for labor, capital, land, livestock and dairy expenses, seed, fertilizer, and chemicals. Not all farms produced or used all outputs and/or inputs.

Much of the whole-farm data used in previous research came from accounting records of expenditures because most farmers kept information for income tax reporting and not necessarily for production decision making. Nevertheless, expenditure data allows researchers to consistently measure the farms' production records and management characteristics over time. Prices are easy to calculate with expenditure data and represent prices in a competitive market. Additionally, computers provide the processing power and the ability to measure efficiency more accurately by allowing researchers to use more complex linear programming algorithms on larger databases. For this study, the KFMA provided expenditure data from a sample of 456 Kansas farms for the ten consecutive years from 1998 to 2007 on farms inputs and outputs.

Once efficiencies were estimated using DEA methods annually for the 10-year sample from 1998 to 2007, a two-step procedure was used to determine and examine the determinants of inefficiencies in Kansas farms. The two-step procedure investigates the determinants of farm inefficiency by regressing a transformation of the efficiency scores against a vector of farm-specific characteristics. The following factors were specified as farm characteristics: size of operation (measured by gross income and/or net income), amount of unpaid labor, off farm income, percent of output income, percent of input expenditures, percent of owned acres, debt-to-asset ratio, operator's age, and operator's age. Because most farms in the sample were mostly cattle or crop farms, I also included the percentage of crop income, acres devoted to pasture grass and the percentage of labor devoted to crops to control for differences across operation types. The variable list is very comprehensive and it contains the socio-economic factors likely to influence farm production inefficiencies.

This sample of Kansas farms provided a very interesting and useful case study, as Kansas is a major agricultural producer. Kansas farms also can be small or large, and farms can operate multiple operations. In this dissertation the dataset not only contained production information but a range of socio-economic characteristics of the farm. I have the advantage of using detailed, farm-level panel data from Kansas farms in a Tobit model in order to measure the impact of the variables just mentioned and their effect on farm efficiencies. In econometric analysis, panel data helps identify better estimates of inefficiency because the approach accounts for individual farm factors that affect inefficiency which are otherwise difficult to account for, such as soil quality, and the type of farm management. Importantly, I can exploit the robustness of the data set to measure inefficiency scores and investigate their source in multi-product farms such as those found in Kansas. Previous studies have been conducted on efficiency of farms in Kansas (Featherstone, Langemeier and Ismet 1997; Langemeier and DeLano, 1999; Coffey and Featherstone, 2004). Although this dissertation is related to these previous studies on Kansas farms, its main contribution is the use of recent data on farms to calculate all efficiencies and their causes for multiple-output farms in Kansas for a 10-year period. In addition, the efficiencies were evaluated in light of financial, production and social factors. Specific objectives included:

- Calculate standard measures of efficiency, i.e. cost, technical, scale and allocative efficiency, using four input oriented multi-output/multi-input DEA approaches for a sample of 456 farms in Kansas for 10 consecutive years, from 1998 to 2007.
- Analyze distribution and trends of the four efficiency measures for the 10-year study period.
- Compare farms' efficiency scores across farms and years and identify the most efficient farms.

- Use a two-step procedure, i.e. a Tobit regression, to investigate the effect of important farm characteristics or factors on the efficiency of the multi-output farms in Kansas.
- Use results of the empirical estimation to shed light on and develop strategies that can improve Kansas farms' efficiency levels regarding the operational and social structure of the farming operation.

1.2.2 Impact of Debt on Efficiencies in Kansas Farms

Agriculture in Kansas is highly mechanized and according to Perry (2006) most irrigated Kansas crop farms use quite efficient irrigation methods such as center pivot systems. Fertilizer, herbicide and seeds are part of farm input variable expenses. Financial variables can represent the level of debt, especially debt incurred to purchase inputs, and the availability of capital to run a farming operation. Inputs are of better quality and higher priced due to technological advances, and new technology is a challenge for farmers today in a rapidly changing global marketplace where farmers have to be competitive. Stakeholders, who are increasingly concerned about the relationship between financial structure and production efficiency, are interested in determining the role that debt plays in farm efficiency.

This dissertation focused on the role that debt had on the efficiency of farm enterprises. Technical efficiency is related to management success in operating the farm and financial factors are part of the management decision-making process. Economic theory has proposed five competing and sometimes complementary theories on the relationship between finance and production efficiency. These theoretical explanations are: i) agency theory, ii) free cash flow, iii) credit evaluation, iv) embodied capital and v) adjustment cost. Some of the theories hypothesize a positive relation between debt and efficiency while other theories hypothesize a negative relation (Hadley et al. 2001, Davidova and Latruffe 2007). Table 1.1 summarizes the theories and their implications in relation to the level of farm debt and the farm's level of technical efficiency. The direction of the arrow indicates the direction of causality. In the credit evaluation approach, for example, the level of debt a farm has taken on is a result of technical efficiency, and thus, debt levels are endogenous to the financial structure; more efficient farms are less risky and therefore more likely to be accepted for a loan request. All these theories will be developed and explained in detail in Chapter 2.

In the field of farm efficiency and financial structure research, there have been few studies on the direction of the relation of production and financial farm variables (Hadley et al. 2001, p. 1). As in any globally competitive industry, farm managers are called upon to increase their focus on financial, management, and marketing decisions to achieve economic success. Technical efficiency is related to management success in operating the farm. This study investigated this issue in Kansas and to help develop management recommendations.

A non-discretionary DEA model was used to compare efficiency measures with the input-oriented DEA model, in which farms are compared to each other to assess efficiency while controlling for differences in debt levels. In the non-discretionary DEA model, the level of total debt is introduced as a fixed or non-controllable input, so that each farm is compared to other farms that have taken on the same or smaller levels of debt. The non-discretionary DEA model provides an extension to the efficiency literature by comparing farms using "environmental variables." In this dissertation, farms were compared in terms of all inputs in the input-oriented model, and in the non-discretionary model, farms were also compared in terms of capital availability to the farms that have an equal or smaller (i.e. worse) capital availability. Efficiency estimates[2] were obtained for a particularly large sample of Kansas farms that use several inputs to generate multiple outputs.

I calculated four efficiency measures using a non-discretionary or environmental DEA model. The influence of total debt on farms' efficiencies was studied. Total debt was selected to represent farm credit constraint because it is a common capital measure of investment capacity. All four measure of efficiencies (i.e., overall, technical, scale and allocative efficiencies) were estimated annually for the 10-year sample from 1998 to 2007. Once efficiencies had been estimated annually for the sample, the scores were further analyzed to determine the factors explaining how additional debt is translated into improved efficiency.

[2] If technical scores were systematically higher for farms with higher debt loads , this finding would support the credit evaluation, capital embodied, and free cash flow hypotheses. The difference between two hypotheses depends on whether or not debt levels were endogenous. A test similar to the Hausman test was applied to assess this research question (Davidova and Latruffe, 2007).

Table 1.1 Relationship between Technical Efficiency and Level of Farm Debt

Theoretical Approaches and Hypotheses about the Relationship between Indebtedness and Technical Efficiency	
Approach	Hypothesis
Agency Theory	Indebtedness→(-) Technical Efficiency
Free Cash Flow	Indebtedness→(+)Technical Efficiency
Credit Evaluation	Indebtedness←(+)Technical Efficiency
Embodied Capital	Indebtedness→(+)Technical Efficiency
Adjustment Cost	Indebtedness→(-) Technical Efficiency

Adapted from Davidova and Latruffe 2007, p. 273

The precise research goal was to determine if farms were able to achieve best practice efficiencies when constrained by total debt. Efficiency scores for the input-oriented DEA model and the non-discretionary DEA model were compared and differences in cost efficiency scores caused by the capital constraint were reported. In the case where the debt constraint was binding, the efficiency scores between the input-oriented DEA model and the non-discretionary DEA model will be different. The change in efficiency between the two DEA models was examined in light of specialization of the farms (i.e., output mix) and other factors. Specific objectives included:

- Calculate standard measures of efficiency, using four input oriented multi-output/multi-input DEA problems constrained by the farm's level of debt for a sample of 456 farms in Kansas for 10 consecutive years from 1998 to 2007.
- Compare efficiency scores for each farm between the input-oriented DEA and the non-discretionary DEA models. Determine if any farm is constrained by the amount of total debt, and how the total debt constraint has affected the level of efficiency scores for the farm.
- Use results of the analysis to shed light on and develop strategies that can improve Kansas farms' efficiency levels regarding the financial structure of the farming operation.

CHAPTER 2 - Literature Review

2.1 Production Economics

In order to assess farm efficiency in production economics, two complementary observations of the operator's behavior can be modeled depending on the research question and data availability. First, the operator theoretically behaves as a profit-maximizer or cost-minimizer when choosing the optimal bundle for the farming process. Second, the time horizon influences how many variables the producer can control. When the operator is planning for the long run, all inputs and outputs can be varied. On the contrary, when the time horizon is limited, the operator can choose to vary only some of the inputs, referred to as variable inputs. Other production factors, called fixed inputs, cannot be changed in this time horizon; fixed inputs may include such factors as the number of acres planted, or the choice of crop after the crop is planted. Farmers can make adjustments in fertilizer, herbicide or irrigation usage depending on the time of the season, or from one year to the next (i.e. in the short run). Fixed costs normally include: depreciation and interest paid (which represent part of the capital structure of the farm), and operating costs or overhead costs (which do not depend on production output). What is considered to be a fixed cost versus a variable cost of production varies in prior literature depending on the topic of interest.

This chapter follows Coelli, Rao and Battese (2005) and Chambers (1988) to explain how production economics and the concept of efficiency is intrinsically related to the estimation of a frontier because efficiency measurements can only be derived with respect to a benchmark, i.e., an ideal level of performance or best practice frontier. Production and efficiency measurement are so interlinked that it is impossible to accurately define efficiency measures without referring to production economic theory. The reason for the intertwined relationship is that efficiencies can only be estimated with respect to a best practice or optimal frontier. Production economics attempts to describe the outer frontier of technological possibilities by which inputs are transformed into outputs. Production economics thus provides the theoretical foundation for understanding and calculating benchmark performance. In estimating this unobservable benchmark or frontier, parametric and non-parametric methods have been used.

Parametric methods include econometric estimation of production or cost functions. They represent single-output technologies and estimate the production frontier or curve which traces out the maximum feasible output for different input levels conditional on the technology in use. Transformations can be applied to multiple-output technology. Both production and transformation functions yield optimal output given technology and resources. These functions are required to conform to specific theoretical properties so that technology can be simplified into a single output production function that specifies the maximum possible output for a given input vector: $y = f(x)$. Some properties commonly assumed about $f(x)$ include:

1. if $x' \geq x$ then $f(x') \geq f(x)$ (weak monotonicity);
2. if $x' > x$ then $f(x') > f(x)$ (strict monotonicity);
3. the input requirement set, $V(y) = \{x: f(x) \geq y\}$, is a convex set (quasi-concavity);
4. $f(\theta x + (1-\theta)x') \geq \theta f(x) + (1-\theta)f(x')$ for $\theta \in [0,1]$ (concavity);
5. $f(0,0,\ldots,0) = 0$ (weak essentiality);
6. $f(x_1, \ldots, x_{j-1}, 0, x_{j+1}, \ldots, x_n) = 0$ for all x_j (strict essentiality);
7. $V(y)$ is closed and non-empty;
8. $f(x)$ is finite, nonnegative, real-valued, and single-valued for all nonnegative and finite x;
9. $f(x)$ is everywhere continuous; and
10. $f(x)$ is everywhere twice-continuously differentiable (C^2) (Chambers 1988, pg. 9).

These functions need to be estimated econometrically and can take several functional forms, ranging from the relatively simple Cobb-Douglas to more flexible forms such the translog. Other functions related to production that can be econometrically estimated are cost functions, profit functions, and revenue functions. All of these can be formulated to account for multiple inputs and/or outputs. As in the case of production functions, these latter functions need to conform to properties in order to satisfy the economic concept they represent.

In a set theory orientation, any production technology is explained by output and input sets which need to satisfy some mathematical and economic properties to be an accurate representation of the production possibility frontier or curve. This approach is used in efficiency because of the direct relationship between technical efficiency and the input distance function[3]. Distance functions are alternative representations of production technology that model multiple-input and multiple-output technological relationships. The directional distance function is loosely related to production function. Formally:

[3] The input-oriented DEA problem for calculating technical efficiency under constant returns to scale is the inverse of the input distant function (Coelli et al. 2005, pg. 53).

$$\vec{D}_T(x, y; -g_x, g_y) = \sup\{\beta : (x - \beta g_x, y + \beta g_y) \in T\}$$

where $T = \{(x,y): f(x) \geq y\}$ is the set of technologically feasible points, β is the distance parameter, and $g = (-g_x, g_y)$ is called the directional vector. If $\beta = 0$, then (x, y) is efficient. If g_x set equal to 0, this is the output distance function which represents how much output would have to expand without changing the level of inputs before the point is on the efficient frontier. If g_y set equal to 0, this is the input distance function which represents how much input would have to contract without output changing before the point is on the efficient frontier. When $\beta = 0$, this yields the production function which can be used to analyze efficiency of certain points: if $\beta > 0$ then there is some type of inefficiency.

2.2 The Cost Function

This section will use production economic concepts to look at how farmers decide on the mix of inputs they wish to use. I will assume the case of a multiple-input multiple-output farm that has no influence on input prices—therefore input prices are given. The cost function for the farm can be written as $C=C(w,y)$, where w represents a vector of input prices and y represents the level of output. The cost minimization problem for this farm is the cost function (Chambers 1988):

$$C(w,y) = \min_x \; w \cdot x \text{ such that } x \in V(y)$$

where $V(y)$ is the input requirement set formed by the isoquant of the desired y. The cost function is the minimum cost of producing a given output level during a given time period expressed as a function of input prices and output.

The cost function satisfies the following properties (Chambers 1988):

1. Non-negativity: $C(w,y)>0$ for $w>0$ and $y>0$;
2. No fixed costs: $C(w,0)=0$;
3. Monotonicity in y: if $y' \geq y$, then $C(w,y') \geq C(w,y)$;
4. Monotonicity in w: if $w' \geq w$, then $C(w',y) \geq C(w,y)$;
5. Homogeneity of degree on in prices: $C(\lambda w,y)=\lambda C(w,y)$;
6. Concavity: $C(w,y)$ is concave in w; and

7. Contintuity: C(*w,y*) is continuous in *w*.

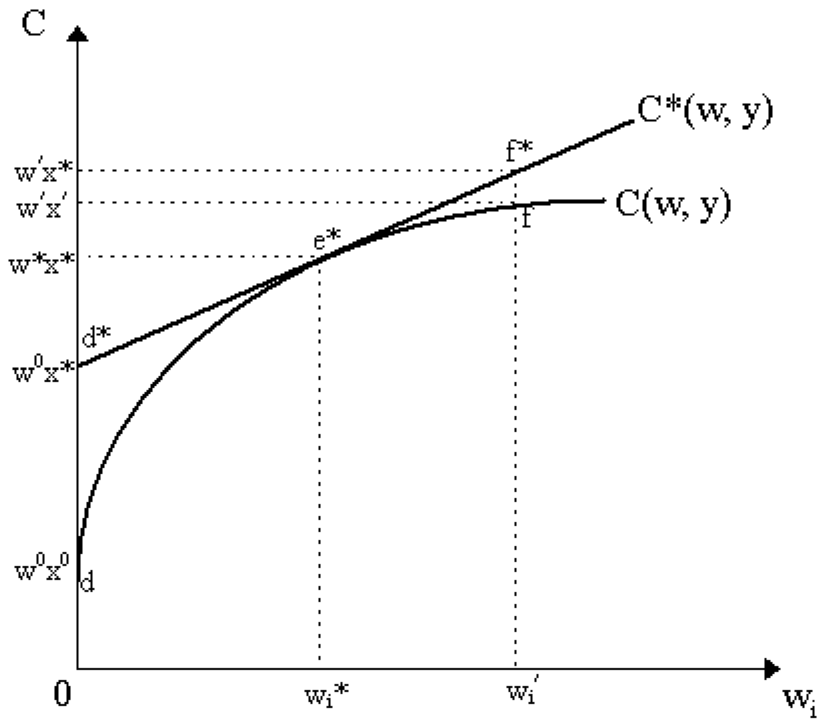
Suppose that we have no substitution production technology, so that the cost-minimizing point is always a particular input combination, call it *x**, regardless of the input prices. The corresponding cost function is shown in Figure 3.1 by C*(*w,y*). Because of the no substitution production technology, we have the cost-minimizing bundle *x** throughout, so as we increase the rental rate of the *i* th input, $w_{i,}$ the total costs of the bundle increase linearly. The cost of the bundle *x** at any particular set of input prices *w* is:

$$C^*(w, y) = wx^* = w_i x_i^* + \sum_{j=1}^{m-1} w_j x_j^*$$

where $w_i x_i^*$ are the total payments to the *i* th input and $\sum_{j=1}^{m-1} w_j x_j^*$ are the payments to the other inputs. Thus, increasing only w_i will increase total costs *wx** linearly, making C*(*w,y*) a linear function.

As we see in Figure 2.1, when $w_i=w_i^*$, costs are w^*x^* (point *e**) and when $w_i=w_i'$, costs are $w'x^*$ (point *f**). If we move away from the no substitution production technology and increase the degree of substitutability there will be different cost-minimizing bundles at different input prices. The new cost function is C(*w,y*) in Figure 2.1. Point *e** is cost-minimizing on both the linear cost function C*(*w,y*) and the new concave cost function C(*w,y*). If the input price of the *i*th input increases from w_i^* to w_i', costs increase to $w'x^*$ along the linear cost function, but along the concave cost function (which allows for input substitution) farmers will choose another cost-minimizing bundle *x*'. The costs of the new cost-minimizing bundle is less than that along the linear function C*(*w,y*) as depicted by the gap between *f** and *f*. This reflects input substitutability as farmers will choose an input combination *x*' with lower costs than *x** by substituting away from the inputs whose costs have risen.

Figure 2.1 Cost Function with Respect to One Input Price



Source: http://cepa.newschool.edu/het/essays/product/cost.htm

2.3 Measures of Efficiency

This section will use production economic concepts to define and measure production efficiencies. Overall efficiency requires that an organization be technically efficient, allocatively efficient, and scale efficient.[4] An overall efficient organization produces a given quantity, quality, and mix of outputs at minimum possible cost given existing technologies and prices. Technical efficiency refers to a firm's ability to transform physical inputs into outputs relative to the best practice frontier given current technology, irrespective of prices. Technical inefficiencies are largely the result of lack of managerial oversight of the production process (Kumbhakar and Lovell, 2000). Allocative efficiency measures whether the input mix, given technically efficient production for a set of output and input price levels, is chosen to minimize costs. Scale efficiency measures the extent to which a farm can take advantage of returns to scale by altering its size towards optimal scale; optimal scale is defined as the output level (or range of levels) where there are constant returns to scale[5] in the relationship between outputs and inputs. The four measures of efficiency discussed all have values ranging from 0 to 1. For example, overall efficiency occurs when a farm is operating on the minimum cost frontier.[6] The cost efficient farm will score 1 while farms operating above the best practice level are not fully cost efficient and will score between 0 and 1.

My discussion of efficiency measurement begins with Farrell (1957). He proposed that the efficiency of a firm consists of two components: technical efficiency, which reflects the ability of a firm to maximize output from a given set of inputs, and allocative efficiency, which reflects the ability of the firm to use inputs optimally given their respective prices and technology. These two measures are then combined to provide a measure of total cost (or economic) efficiency. The following discussion begins with Figure 2.2 which illustrates Farrell's (1957) concepts in input/input space (input-oriented measures) in a constant return to scale

[4] Overall efficiency is defined as the product of technical efficiency, allocative efficiency, and scale efficiency. I use the term "cost efficiency" to refer to the short-run measure that does not consider the inefficiencies due to the scale of operation. Cost efficiency is defined as technical efficiency multiplied by allocative efficiency.

[5] Returns to Scale: A technology can exhibit constant returns to scale if by multiplying all inputs by some factor, the level of output also increases by the same factor (i.e. the proportional increase ratio is 1 to 1). A technology exhibits decreasing (increasing) returns to scale if, after scaling all inputs, the level of output expands by less than (more than) the scaling factor.

[6] The choice of DEA model and theoretical assumption with respect to farmers' behavior depends very much on the focus of the study. A revenue maximizing DEA problem would allow the researcher to look at the farms' choice of outputs. However, since we are interested in inputs and farm performance, we have chosen a cost minimizing approach.

setting. I have chosen constant returns to scale to represent the farms' technology because the technology can then be depicted using the unit isoquant. The graph for any other output level would be identical to Figure 2.2 except that the units on the axes would be re-scaled.

The downward sloping curve passing through point *B* in Figure 2.2 is the unit isoquant, i.e., the combinations of inputs x_1 and x_2 needed to produce a unit of output under 100% efficient use of the technology (Coelli, Rao and Battese 2005, pg. 52). The downward sloping straight line passing through point *C* is the isocost line, which represents the relative price of the inputs. A fully cost-efficient firm would produce at the point of tangency between the unit isoquant and the isocost line (only the dot is shown in Figure 2.2). A firm producing at point *A* is neither technically nor allocatively efficient. It is not technically efficient because it uses input levels that lie above the unit isoquant. A technically efficient firm would use the input combination at point *B*. Technical efficiency is defined as the ratio of the length of ray *0B* to that of *0A*: $TE = 0B/0A$.

Producing at *B*, however, is still not allocatively efficient, as expenditures on inputs at *B* exceed those of the cost-efficient firm. The expenditures could be reduced to point *C* if inputs were used in their cost-minimizing combination. Allocative efficiency is defined as $AE = 0C/0B$.

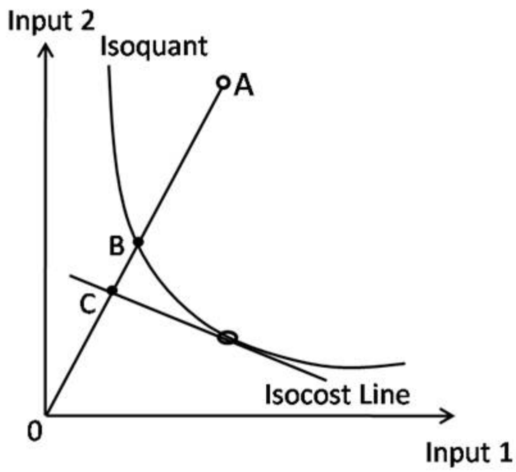
Cost efficiency of a firm operating at *A*, which takes into account both technical and allocative performance (Coelli, Rao and Battese 2005, pg. 52), is graphically depicted as $CE = 0C/0A$ and mathematically as $CE = (TE)\cdot(AE)$. If the assumption of constant returns to scale were relaxed, then the firm in question may also be inefficient due to non-optimal scale of its operations. The scale efficiency (*SE*) score reflects the amount costs could be reduced by changing the optimal scale. Overall efficiency (*OE*) can then be computed as $OE = (TE)\cdot(AE)\cdot(SE)$.

2.4 Methods of Measuring Efficiency

Methods to calculate efficiency scores can be grouped into two categories: those that use econometric techniques to estimate a stochastic frontier function (the Stochastic Frontier Approach, SFA), and those that use mathematical programming techniques to compute a frontier based on the observable data points (Data Envelopment Analysis, DEA).

SFA is a parametric method because it fits the data to a production or cost function using specific functional forms such as Cobb-Douglas, logarithmic, or quadratic. SFA is used to

Figure 2.2 Measures of Efficiency



estimate a stochastic best-practice frontier function where observations are allowed to depart from the frontier due to random shocks and/or inefficiency (Kumbhakar and Lovell, 2000). Some of the drawbacks of SFA include the need to specify a functional form to transform inputs into outputs. Production or cost functions of the Cobb-Douglas, quadratic, linear, log-linear or trans-logarithmic forms are the most common specifications. The functional form needs to conform to the production and mathematical properties of the function it is representing. Some specifications may be too restrictive on the technology they represent, such as the Cobb-Douglas form, whereas other forms are more flexible. These latter specifications are difficult to estimate econometrically because imposing (or testing for) mathematical properties such as curvature require special constraints on the parameters. Moreover, any of the production function econometric specifications can only account for one output, so in the case of multiple-output farms, an aggregate of outputs must be constructed. Thus, SFA methods lack the ability to disaggregate outputs and therefore the information contained in a detailed data set of different production outputs is lost.

A widely used non-parametric[7] approach to frontier analysis is Data Envelopment Analysis (DEA),[8] which was developed by Charnes, Cooper and Rhodes in 1978. DEA is based on the piece-wise lineal convex hull representation of frontiers as originally developed by Farrell (1957). It is a non-stochastic[9] technique that uses mathematical linear programming to construct a frontier from a sample of data points. Early contributors of the frontier estimation method included Boles (1966), Shephard (1970) and Afriat (1972), who suggested mathematical programming methods that could achieve the task, but the method did not receive wide attention until the article by Charnes, Cooper and Rhodes (1978), in which the term data envelopment analysis was first used (Coelli, Rao and Battese 2005). Since these pioneer studies, researchers have made continuous improvements in the field of frontier estimation and efficiency measurement.

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[7] Non-parametric refers to the characteristic that the method does not make or require any assumption on the functional form relating inputs into outputs.
[8] For a simple but illustrative application that explains some basics on the concept and estimation of efficiencies using the DEA method please refer to J.E. Beasley's at http://people.brunel.ac.uk/~mastjjb/jeb/or/dea.html.
[9] In general econometric terms, stochastic refers to the ability of a model for account for randomness or error term in the estimation of the parameters and account for white noise in the data (Greene, 2003).

DEA compares the firms or units of analysis in terms of their use of inputs and their level of output, "enveloping" all the data points to construct a best practice frontier[10]. Efficiency ratios are compared across firms. The best performers are assigned an efficiency of 1 and they lie on the frontier itself. The less efficient units have an efficiency score of less than 1 and lie inside the production possibility frontier (and above the minimum cost frontier).

DEA efficiency measures are relative, as they refer to the sample they are calculated from. These relative rankings can be fragile if the number of firms in the sample is small relative to the number of outputs and inputs being considered. In this dissertation the number of farms, S, were larger than the rule-of-thumb benchmark, $M \times N$, where M is the number of outputs and N is the number of inputs. Overall, DEA's flexibility in accommodating multiple outputs and inputs in different units with no need to express a specific technical relationship among them has been seen as an advantage.

In summary, DEA and SFA are different techniques used to estimate efficiency measures. Both techniques have their merits and disadvantages. Some studies have compared both approaches (see Sharma, Leung and Zaleski 1999; Wadud and White, 2000; Puig-Junoy and Argiles, 2000). In general, estimates from both methods differ quantitatively. DEA efficiency estimates are smaller than SFA estimates[11]; but the ordering or ranking of the decision making units (DMUs) according to their estimated efficiency scores has been shown to be similar in both methods (Sharma, Leung and Zaleski 1999; Wadud and White, 2000; Puig-Junoy and Argiles, 2000). Although the efficiency scores for each DMU did not coincide in all cases for both methods, the ranking of DMUs in terms of efficiency was highly correlated.

[10] In production analysis, a production, revenue or cost frontier can be used with this method. In Chapter 2, the section on Conceptual Model explains that we are taking a cost approach to calculate efficiency scores, and thus, a best practice cost frontier.

[11] See Puig-Junoy and Argiles (2000), p. 14 about commentaries on the comparison of DEA and SFA and the results of their study, p. 7.

2.5 Studies on Causes of Efficiencies in Agricultural Production

Kansas is the fourth largest exporting state in terms of value of agricultural exports in the U.S. A fair range of farm types, from livestock operations as well as crop enterprises and mixed farms, characterize Kansas agriculture. Kansas ranks first among all states in the export of wheat and its by-products, feeds and fodders and hides/skins. Kansas is also a major exporter of feed grains and products, live animals and meat (Economic Research Service 2008). These important factors justify the study of agriculture in the state, where agriculture is a major economic source of employment and revenue. This dissertation calculated production efficiencies for both livestock and crop farms in Kansas, and most importantly, examined some factors that may influence the farms' efficiency scores.

Once efficiency scores have been obtained, the factors that impact inefficiencies can be studied using two main approaches. Studies on factors affecting inefficiencies are mainly categorized according to the method researchers use to explain inefficiencies' causes. The first method is called a one-step procedure. The one-step procedure estimates efficiency scores and the causes of inefficiency simultaneously. Only econometric methods can be employed in this approach. The second method, the two-step procedure, first estimates the overall efficiency scores and then a Tobit model[12] is used to analyze the scores according to factors that may influence them such as farm size, farm financial structure, etc.

The literature on efficiency and its possible causes is extensive. Some studies focus on low-income countries, others on farm-specific operations. In this literature review, the studies and results focusing on Kansas farms are examined first.

Overall efficiency for multi-product Kansas farms has been addressed by authors such as Langemeier and DeLano (1999). They used DEA methods to estimate overall efficiency, along with allocative, scale and technical efficiencies for a sample of 195 Kansas farms from 1973 to 1996. Overall efficiency measures for the sampled farms were regressed against operator's age, farm size (using gross farm income as a proxy), and farm type according to the income source (i.e. crops, beef, dairy, swine, dry land, pasture, and mixed enterprise farm). Results indicated that age of operator was negatively related to overall efficiency and thus the implication is that younger operators are more efficient. Larger farms were found to be more efficient, as were

[12] A Tobit regression is an appropriate estimation technique when the value of the dependent variable is bounded either from above or below or both; such is the case of inefficiency scores which are bounded between 0 and 1.

specialized crop and dairy farms. The authors calculated the persistence over time (i.e. 24 years) of the farms' overall efficiency scores. Whereas some farms were consistently good performers, others were consistently bad; the authors found consistency in the ranking of farms over the sample period.

Other studies applying DEA to measure efficiency in Kansas include articles focusing on specific farm operations. Gow and Langemeier (1999) estimated scores of overall, allocative, scale and technical efficiency for a sample of 123 cattle backgrounding farms from 1995 to 1997 in Kansas. They used six inputs and one output for their calculations. The scores were examined in terms of farm characteristics including the degree of farm specialization or farm type, farm operator's age and farm size. Average overall efficiency for the farms indicated that farms could reduce their costs by 60 percent producing the same amount of output. Farms could also improve their performance by increasing production as much as 30 percent by updating their technology. Costs would also be reduced by 17 percent if farms use the most efficient size and by 30 percent if farms use the cost-minimizing amounts and combinations of inputs. In summary, the most efficient farms had 39 percent of their income derived from backgrounding operations, the age of the operator was in the range of 40 to 65 years old, and average gross income was around $250,000.

Morgan and Langemeier (2003) examined sustained competitive advantage[13] for a sample of 224 Kansas farms with continuous data from 1982 to 2001. They computed overall efficiency for each farm and year. They found that sixty farms exhibited significantly above average overall efficiency levels or had a "competitive advantage." Seventy-six farms exhibited statistically significant below overall efficiency levels or had a "competitive disadvantage." Statistical t-tests on the efficiency scores revealed that farms in the top category were significantly larger, received relatively more of their gross farm income from dairy and swine production, had significantly lower expense ratios, and had significantly higher profit margins.

Other studies have been applied to measure Kansas farms' livestock-related operations. Coffey and Featherstone (2004) used DEA on a sample of 106 Kansas farms in 1998 to investigate multiproduct and product-specific economies of scale. They used an input approach, with two outputs, crops and livestock, and seven inputs. Results relevant to this essay include the

[13] Morgan and Langemeier (2003) defined competitive advantage as a feature of a group of 60 farms out of a sample of 224 farms, which were identified using statistical tests as consistently having above average levels of overall efficiency over the 1982 to 2001 sample period.

finding that larger farms tend to expand to achieve increasing returns to scale, even though these farms do not achieve as much economies of scope[14], by avoiding producing more than one output as smaller farms do. In agreement with the latter statement, Purdy, Langemeier and Featherstone (1997) point out the complex relationship between specialization and financial performance. Larger farms that may engage in enterprise specialization are able to decrease risk[15], increase profits and enjoy product-specific economies of size; but they may miss out on economies of scope.

Kumbhakar et al. (1991) and Battese and Coelli (1995) used a one-step procedure; these studies have been the foundation for other studies applying SFA. These three models were the first to use the one-step procedure approach for multiple-output farms, and the one presented by Battese and Coelli (1995) was unique in that it used panel data. In Battese and Coelli (1995), the empirical estimation of a translog production function was applied to 10 cross-sections of data from paddy rice farms in India. As factors influencing technical efficiency Battese and Coelli (1995) investigated operator's age, education, and a time trend. The coefficients in their inefficiency model were all jointly statistically significant; their results suggested that older farmers were more inefficient than younger farmers, and that there was a decline in inefficiency over time.

Puig-Junoy and Argiles (2000) used both one- and two-step procedures on a panel of mixed farms in Spain. Their inefficiency model indicated that farms with a big share of rented land are significantly more inefficient. Hadley et al. (2001) tested the evidence linking production efficiency with financial variables. Their stochastic frontier model indicated a negative relationship between debt/asset ratios and technical efficiency.

Also in 2000, Wadub and White (2000) compared technical efficiency scores estimated using a one-stage SF approach and a two stage DEA approach for a sample of rice farms in Bangladesh. The coefficients estimated from both sources were highly and positively related in ranking. They included several socioeconomic factors such as operator's age, years of schooling, diesel irrigation fuel, plot size and soil degradation, to explain the difference in scores among farms. In all models, age, years of schooling and infrastructure (i.e. the use of diesel for

[14] Economies of scope are cost reductions associated with output diversification.
[15] Part of the literature on agricultural efficiency and finance focuses on the interrelation between production and marketing risk and enterprise diversification in order to reduce this risk inherent to agricultural products.

irrigation, due to costs and water charges extraction and capacity) were negatively related to technical inefficiency. Farmers with less soil degradation were more technically efficient.

Coelli, Rahman and Thirtle (2002) used DEA to calculate cost, technical, allocative and scale efficiency for a sample of 406 Bangladeshi rice farms. They divided the farms according to the type of rice grown, which depends on the season and so it is very much influenced by weather and other factors. For the two-step analysis, the efficiency scores of each measure for each output were regressed using a Tobit model against 12 farm characteristics: tenancy, education, family size, age, experience, infrastructure (i.e. roads and access to markets), working adults, land cultivated, soil fertility, non-farm income, extension support and training. They found that infrastructure, and non-farm income contributed significantly and positively to efficiency. Large families were generally found to be at a disadvantage, showing evidence of large unemployment. Other factors did not show a large impact on efficiency levels.

Dhugana, Nuthall and Nartea (2004) used a two-step approach to study inefficiency and its causes in a sample of Nepalese rice farms. They used a DEA approach to estimate overall, allocative, technical, and scale efficiencies for one-output, multi-input farms in the sample. With five inefficiency score estimates (overall efficiency, allocative efficiency, technical efficiency, pure technical efficiency and scale efficiency), the authors estimated a Tobit regression to explain the variations in the level of inefficiency among the farms. As factors affecting inefficiency in farms, they include farmer's age, education, gender, and share of non-paid labor. Age (as well as a quadratic age term to measure returns) and education were statistically different from zero. More recently, Masterson (2007) applied SFA and DEA to measure technical efficiency and productivity in a sample of 8,131 farms in Paraguay from 2000-2001. Surprisingly, in the case of Paraguay, the results suggest that land tenure affects technical and land productivity adversely. In line with other studies, assets contributed positively to technical efficiency. Family labor was found to decrease technical efficiency and productivity, similar to the finding from Bangladesh where unemployment is a big problem.

Based on previous studies, and despite the clear consistency and significance of results, the variables that have shown to be the most influential in explaining efficiency score variability across farms are farm financial variables (e.g. debt-to-asset ratio, level of debt), farm size, individual farm characteristics (e.g. age of operator, education, share of non-paid labor, share of land rented, and operator's risk attitude) and technology proxies (e.g. labor-to-capital ratio)

(Davidova and Latruffe 2003). However, the reasons that farms may become unprofitable can be related to intrinsic factors of production as well as environmental and more social ones such as health of the main operator, divorce and other non-production causes. Thus, more research is needed in the area (Featherstone et al. 2005).

As seen in this section, the literature on farm efficiencies and their causes is very extensive, but mostly focused on studying technical efficiency. Relatively few studies have been conducted explaining the variability in cost efficiency scores. As Coelli, Rahman and Thirtle (2002) points out, more studies need to include more efficiency measures than technical efficiency, which refers to use of the technology or transformation of inputs into outputs. Technical efficiency, as mentioned above, has been related to the study of management. Most studies offer only a partial picture of farm performance since they do not consider the mix of inputs (i.e., allocative efficiency), the scale of operation (i.e., scale efficiency), or minimum costs according to the production process and market prices (i.e., overall efficiency). While this dissertation uses a similar method to the many efficiency studies and its causes using a two-stage approach, it is innovative in that the analysis includes factors that affect all efficiency measures, giving a more general picture of performance than analyzing technical efficiency alone. This study's contribution to the literature is from the use of a large and detailed dataset, the study of all measures of efficiency, and the assessment of a comprehensive list of factors to explain differences of all efficiency estimates across farms.

2.6 Studies on Financial Farm Structure and Farm Efficiencies

Economic theory assumes that firms maximize profits through simultaneously maximizing revenues and minimizing costs. In perfect competition, the free entry and exit of firms tends toward firms producing at the point where price equals long run average costs and long run average costs are minimized. In his seminal paper, Leibenstein (1966) illustrated how different principal-agent objectives, inadequate motivation and incomplete contracts become sources of inefficiency measured by the discrepancy between maximum potential output and the firm's actual output. He termed this failure to attain the production or technological frontier as X-inefficiency.

Recent financial theories emphasize the importance of agency costs and other financial costs in the determination of the firm's capital structure (Jensen and Meckling 1976; Jensen

1986; Harris and Raviv 1991). While theoretical finance on capital structure has progressed, the practical applications of capital structure theories in the agricultural economics literature have been less satisfying. The main problem agricultural economics researchers face is that the theoretical determinants of capital structure, e.g. agency costs, credit evaluation and informational asymmetries, are not directly observable, and reliable farm data is difficult to acquire.

Färe, Grosskopf and Lee (1990) examined the impact of financial constraints on farm economic performance. They used DEA for expenditure-constrained profit maximization following Charnes, Cooper and Rhodes (1978) and Lee and Chambers (1986). Färe, Grosskopf and Lee's (1990) research found that a quarter of the farms in their sample were financially constrained. Their sample consisted of a cross-section of 82 rice farms in California in 1984; they take into account 9 inputs, including 6 variable and 3 fixed inputs. In addition, they found that financially constrained farms, on average, are more efficient than financially unconstrained farms. These findings led Whittaker and Morehart (1991) to analyze a sample of 107,982 Mid-western cash grain farms to measure the effect of farm financial structure on cost efficiency. Using farm expenditure data and a DEA approach, they calculated cost efficiency for the same sample with three different models: a financially unconstrained model, a debt-constrained model, and an asset-constrained model. Nearly 22 percent of the farms were constrained. The authors suggested adding uncertainty and risk to the model and a wider range of financial ratios.

The finance literature contains five theoretical justifications and a similar number of empirical approaches to study the relationship between financial structure and production efficiency. Free cash flow, agency costs, credit evaluation, embodied capital and adjustment considerations have been hypothesized as possible explanations for the relationship between financial leverage and farm-level efficiency.

The first approach, Jensen's (1986) free cash flow concept, suggests that debt obligations may motivate managers to become more efficient because of the stronger incentive between lenders and borrowers of debt servicing. The concept implies that farmers with higher debt obligations should be induced by lenders to exert greater effort (Barry and Robinson 2001), which would motivate farmers to become more efficient. Free cash flow therefore suggests a positive relationship between increased debt and efficiency. Nasr, Barry and Ellinger (1998), using non-parametric methods, found a positive relationship between efficiency and financial structure linked to the free cash flow concept for a sample of 154 Illinois farmers over the seven-year period 1988-1994. Giannakas, Schoney, and Tzouvelekas (2001) found support for the free cash flow concept in their applications to farm samples in Canada.

The second approach, agency theory, is based on Jensen and Meckling's (1976) agency cost concept, which suggests that the higher relative costs of external to internal funds may result in higher costs to borrowers. Lenders would only be interested in the payment of the debt borrowed. Firms then could be perceived sometimes as being interested in pursuing riskier business activities than lenders would prefer. When this occurs lenders may charge higher prices for debt capital and enforce greater control measures. Agency cost then implies the cost of monitoring, bonding, and adverse-incentive costs will be passed on by lenders to borrowers through interest rate adjustments, origination fees, collateral requirements, and other transfer mechanisms (Ellinger and Barry 1991). These costs, in turn, may reduce highly indebted farmer's technical efficiency when compared with farmers having less reliance on borrowed funds (Nasr, Barry, and Ellinger 1998). Support for the agency theory-cost model can be found in Featherstone and Al-Kheraiji's (1995) study of agricultural cooperatives. They found that debt levels increased short-run variable costs. The authors explained that as the level of farm indebtness increased, so did variables cost in the short-run. They explained this negative relation between debt and optimal cost performance to the costs that borrowers incur to satisfy lenders' requirement as money markets could be characterized by imperfect market information. However, Featherstone and Al-Kheraiji (1995) found a small, positive relationship between debt and total-factor productivity, suggesting differences in the effects of debt depending whether the debt is used for financing short-, intermediate-, or long-run assets. This last finding pointed to a positive relationship between long-term debt and production efficiency, contrasting the findings reported previously where debt increased variable short-run costs.

The third approach, the credit evaluation concept, postulates a positive relationship between financial leverage and farm efficiency. Banks prefer borrowers who are more technically efficient because banks evaluate loan applications according to the applicant's probability of repayment. In addition to collateral requirements, lenders screen borrowers according to various variables that characterize applicants' creditworthiness, such as profitability, liquidity, solvency, repayment capacity, financial efficiency, management and other variables (Ellinger, Splett and Barry 1992). Thus allowance of greater financial leverage by some managers could be associated with greater technical efficiency because of increased lender expectations of farm creditworthiness. Barry, Baker and Sanint (1991) tested for evidence of the credit evaluation concept in agricultural loans. The authors noted that agricultural lenders constrain capital loans more than operating loans because variations in a farmer's recent financial performance are often explained by factors beyond the farmer's control. This, in turn, suggests that the credit evaluation concept implies a positive relationship between intermediate- and long-term financial leverage and technical efficiency.

Chavas and Aliber (1993) suggest the fourth theory, the embodied capital hypothesis, which implies that farmers with higher debt levels invest in technological change which creates a positive relationship between debt and efficiency. Farmers use debt to invest in embodied technology, which is incorporated in new or improved products, processes, systems, and services that are offered in the marketplace. The value of embodied technology depends upon the ability of the farmer to obtain a sustainable advantage over competitors, thereby achieving higher efficiency. Chavas and Aliber (1993) found evidence of a positive and significant relation between long-term debt-to-asset ratios and the technical efficiency scores of a sample of Wisconsin Dairy farms.

The fifth theory, the adjustment hypothesis, was formulated by Paul, Johnston and Frengley (2000). It refers to markets that are transitioning from a more subsidized agriculture, such as farms in the old Soviet Union, to a more market-oriented one; this hypothesis implies a negative relation between debt and efficiency as less indebted farmers are supposed to be more technical efficient as they can adjust more easily to the new situation.[16]

Because of the differences reported in empirical applications, it is difficult to definitively characterize the effects of short-, intermediate-, and longer-term debt financing on farm efficiency. Agency-cost effects would suggest a negative relationship between short-term borrowing and farm efficiency. Adjustment theory also suggests a negative relation between intermediate and long term borrowing and farm efficiency. Conversely, embodied capital, cash flow and credit evaluation support a positive relationship between borrowing and farm efficiency. Both positive and negative debt effects on farm efficiency have been found in empirical work. Embodied capital, cash flow, agency costs and credit evaluation concepts have more consistent explanations of the positive effects of longer-term debt on farm efficiency. This

[16] For more information about these theories see Handley et al. (2001) and Davidova and Latruffe (2003).

result is expected because investment in assets which enhance farm productivity such as equipment and land require longer-term financing.

In Kansas, recent studies have examined the interaction of finance, management, and marketing decisions to identify economically successful farms. For example, Nivens, Kastens and Dhuyvetter (2002) focused on a sample of Kansas farms to study management factors and their influence on production costs as a way of increasing farm profitability. They found that competitive market prices are not as important as other variables when farms want to increase profitability. Rather, farm managers can enhance profitability by outperforming neighboring farms in terms of managing risk, lowering costs, and undertaking other management tools.

In the same fashion, several studies have been conducted in Kansas regarding the influence of financial factors on farm production and profit. Featherstone and Al- Kheraiji (1995) calculated a short-run variable cost function to investigate the relationship between debt and a firm's efficiency in agricultural cooperatives. Their results indicated that there is no strong evidence that debt is associated with "long-run, suboptimal capacity" (p. 871). Their findings conform to the agency theory-cost theory since their findings show that debt levels increased short-term costs. The most important finding was that there seems to be differences in the influence of debt in the short versus the long term. Bierlen and Featherstone (1998) investigated the effects of financial constraints (i.e. debt) in farm machinery investment. They concluded that there might be "a trade-off between financial stability and efficiency in production" (p. 434).

Hadley et al. (2001) suggested that empirical results have not supported each other; they also mentioned their uneasiness with the fact that the hypotheses do not exclude each other, i.e. the impact of financial farm structure on production efficiencies can be explained and supported empirically by more than one hypothesis. The stochastic frontier model developed by Hadley et al. (2001) found a negative relationship between debt/asset ratios and technical efficiency. They suggested results conform to the agency costs and adjustment cost theories, which corroborates the conditions of United Kingdom dairy farms and their recent trends; that is, adjustment from good to bad conditions.

In a 2005 paper, Lambert and Bayda implemented DEA techniques to calculate technical and scale efficiencies and the impact of financial ratios for a sample of 54 North Dakota crop farms, for each year from 1995 to 2001. They constrained their models by short, intermediate and long debt in the same way as Färe, Grosskopf and Lee (1990). The results of the Tobit models both for the technical efficiency scores and the scale efficiency scores indicated that technical efficiency was negatively related to short-term debt whereas it was positively related to intermediate and long term debt and loans. Along the same lines, intermediate and long term debt was positively related to scale efficiency, probably showing the importance of capital to expand in scale.

Hadley (2006) used SFA in a one-step procedure to investigate the impact of farm debt ratios on farm technical efficiency levels for a sample of multi-output farms from 1982 to 2002. For the inefficiency model, he included the ratio of total debt to total assets, and a measure of current liquidity or "current financial stress" which relates to short-term debt.

Davidova and Latruffe (2007) used DEA to calculate technical efficiency scores for a sample of 753 multi-output and multi-input individual and corporate Czech farms in 1999, divided into 4 sub-samples according to specialization and management. They used a Tobit to test for the influence of the debt-to-asset ratio. This capital structure measure was significantly and negatively related (except for crops) to technical inefficiency in their study. The findings are consistent with the agency theory and adjustment cost arguments, especially given the adjustment hardships for farms in the Czech Republic farms during the transition to a market economy.

Although there is evidence supporting the relation between farm financial ratios and the level of technical efficiency, the evidence is not conclusive. This dissertation considers the association between farm productive efficiency and financial structure in a group of multi-purpose farms in Kansas using a debt-constrained DEA model. This model allows the direct effect to be unambiguously interpreted since the effect is measured at the margin, holding constant all other inputs. This study was conceived as an extension of the work of Whittaker and Morehart (1991). Although the research on this topic is sparse, some different but related studies on farms in agricultural economics include Nasr, Barry and Ellinger (1998), Lambert and Bayda (2005), and Davidova and Latruffe (2007). All of the studies have highlighted and explored the importance of the relationship between all efficiencies and financial management such as financial structure. The motivation for this essay is that the relation between farm financial status and production is not well-understood, and that the research on the topic has produced a variety of results.

CHAPTER 3 - Methods

3.1 Model Overview

The first part of this chapter consists of a general overview of the models used in this research. The second part consists of the description of input-oriented DEA model used in essay 1, which provides an assessment of relative technical, allocative, scale and cost efficiencies of the farms. The third part consists of the description of the non-discretionary DEA model which is constrained by total debt. The last part consists of a description of the Tobit regression models that are employed to assess the influence of selected farm-specific factors on calculated farm efficiency scores.

The equivalence or mirror relationship between output maximization and input minimization in production economics is reflected in the formulation of the DEA model. An input-oriented DEA model minimizes input costs to achieve a given level of output. An output-oriented DEA model maximizes output given the existing levels of resources/inputs. The input DEA approach is well-suited to this study because detailed data on inputs are available. The input oriented DEA also is preferred over an output-oriented approach because it is computationally less demanding and therefore the problem can be solved with fewer constraints. Coelli, Rao and Battese (2005) provide an illustration of the method in several practical applications.

Technical, allocative, scale and overall efficiencies are estimated by employing DEA, the nonparametric mathematical programming approach for a frontier analysis of inputs and outputs introduced by Charnes, Cooper and Rhodes (1978). One of the main advantages of nonparametric approaches is that the construction of the production frontier does not require any assumption about the functional relationship between inputs and outputs. The DEA model uses input and output data from each farm to construct a nonparametric frontier such that all observed farms lie on or above the envelopment (cost) frontier. Therefore, the productive efficiency of each farm is measured relative to the productive efficiencies of all other farms in the sample.

3.2 Basic DEA Model

This section provides the mathematical formulation of the DEA problems to address the study's objectives. In the input-oriented model used in the dissertation, the objective is to select the cost-minimizing level of inputs given the output levels. The envelopment surface of the input-oriented models can be either constant returns-to-scale (CRS) or variable returns-to-scale (VRS). Input-oriented CRS models were developed by Charnes, Cooper and Rhodes (1978) and are referred to in the literature as CCR models.

The first DEA model used in this dissertation calculates efficiencies annually from 1998 to 2007 for 456 Kansas farms using expenditure data (except for land) to measure inputs and outputs. The use of expenditure data for frontier analysis and estimation of cost efficiency is explained in Ferrier and Lovell (1990). Table 4.1 contains a summary of the DEA problems used in accordance with VRS and CRS return to scale technology assumptions. The input-oriented linear programming DEA problems calculate the minimum total cost and technical efficiency given an $N \times 1$ vector of input prices, w, a vector of corresponding input quantities, x_s, for each of the $s = 1, \ldots, s$ farms, and an $M \times 1$ output vector, y_s, for each of the s farms.

Problems 1.1 through 1.4 calculate an efficiency measure for a single farm; each problem must be solved S times to obtain the complete set of efficiency measures for the sample. The scalars μ_s ($s = 1, 2, 3\ldots, S$) are coefficients chosen by the model to construct the best practice frontier for the farm being analyzed.[17] Under VRS, the frontier is a weighted combination of all farms in the sample. The frontier values of inputs and outputs for the farm being analyzed are on the right side of the first two constraints in each problem. The linear programs under VRS (problems 1.1 and 1.3) allow technology to have increasing, constant and/or decreasing returns to scale. The only difference between the VRS models (problems 1.1 and 1.3) and the CRS models (problems 1.2 and 1.4) is that the last constraint, $\sum_{s=1}^{S} \mu_s = 1$, is relaxed (i.e., omitted).

[17] The vector formed by these scalars, μ, is an intensity vector of constants for the farm being analyzed indicating the way that other farms in the sample could be combined to construct the efficient frontier. Each element in the vector indicates the degree of participation of a given farm in the construction of the best practice frontier or "virtual reference farm" to which farm s is compared.

Table 3.1 Input-Oriented DEA Model- Basic Model

Variable Returns to Scale	Constant Returns to Scale
Problem 1.1: Cost Minimization	Problem 1.2: Cost Minimization
$Minimize_{x*,\mu} \sum_{j=1}^{N} w_j \bullet x_{js}*$	$Minimize_{x*,\mu} \sum_{j=1}^{N} w_j \bullet x_{js}*$
Subject to	*Subject to*
$y_{is} \leq \sum_{s=1}^{S} \mu_s \bullet y_{is}$ $\quad i=1, 2, 3 \ldots M$	$y_{is} \leq \sum_{s=1}^{S} \mu_s \bullet y_{is}$ $\quad i=1, 2, 3 \ldots M$
$x_{js} * \geq \sum_{s=1}^{S} \mu_s \bullet x_{js}$ $\quad j=1, 2, 3 \ldots N$	$x_{js} * \geq \sum_{s=1}^{S} \mu_s \bullet x_{js}$ $\quad j=1, 2, 3 \ldots N$
$\mu_s \geq 0$	$\mu_s \geq 0$
$\sum_{s=1}^{S} \mu_s = 1$	
Problem 1.3: Technical Efficiency Θ_s^{vrs}	Problem 1.4: Technical Efficiency Θ_s^{crs}
$Minimize_{k,\mu}\ \Theta_s^{vrs}$	$Minimize_{k,\mu}\ \Theta_s^{crs}$
Subject to	*Subject to*
$y_{is} \leq \sum_{s=1}^{S} \mu_s \bullet y_{is}$ $\quad i=1, 2, 3 \ldots M$	$y_{is} \leq \sum_{s=1}^{S} \mu_s \bullet y_{is}$ $\quad i=1, 2, 3 \ldots M$
$x_{js} \bullet \Theta_s \geq \sum_{s=1}^{S} \mu_s \bullet x_{js}$ $\quad j=1, 2, 3 \ldots N$	$x_{js} \bullet \Theta_s \geq \sum_{s=1}^{S} \mu_s \bullet x_{js}$ $\quad j=1, 2, 3 \ldots N$
$\mu_s \geq 0$	$\mu_s \geq 0$
$\sum_{s=1}^{S} \mu_s = 1$	

Notes: w is an $N \times 1$ vector of input prices for the $j=1, 2, 3 \ldots N$ inputs, x_s is a vector of corresponding input quantities for each of the $s = 1, 2, 3 \ldots, S$ farms, and y_s is the output vector for $i=1, 2, 3 \ldots M$ outputs for each of the $s = 1, 2, 3 \ldots, S$ farms.

Table 3.1 to explains the estimation of the efficiencies. The solution to problem 1.2 is the minimum costs under constant returns. Problem 1.1 gives the minimum costs under variable returns to scale for each farm. In each case, overall cost efficiency for each farm *s* is calculated as the ratio of the farm's minimum cost under constant returns to scale to the farm's observed total cost, i.e., $OE_s = (x_s^* \cdot w) / (x_s \cdot w)$, where x_s^* is farm *s*'s cost-minimizing input vector and x_s is farm s's observed input vector. The solutions to problems 1.3 and 1.4 are measures of technical efficiency for a given farm under VRS and CRS, respectively. In both the VRS and CRS case, technical efficiency for farm *s* is $TE_s = \Theta_s^*$, where Θ_s^* is the solution to the appropriate technical efficiency problem.

Allocative efficiency is calculated for each farm *s* as the ratio of the minimum cost under variable returns to scale (i.e. solution to problem 1.1) to farm observed costs weighted by the farm's (pure) technical efficiency. Another way to calculate this measure is $AE_s = CE_s/TE_s$. Scale efficiency is determined as the ratio of technical efficiency under constant returns to scale (i.e. solution to problem 1.4) to technical efficiency under variable returns to scale: $SE_s = TE_s^{crs}/TE_s^{vrs}$

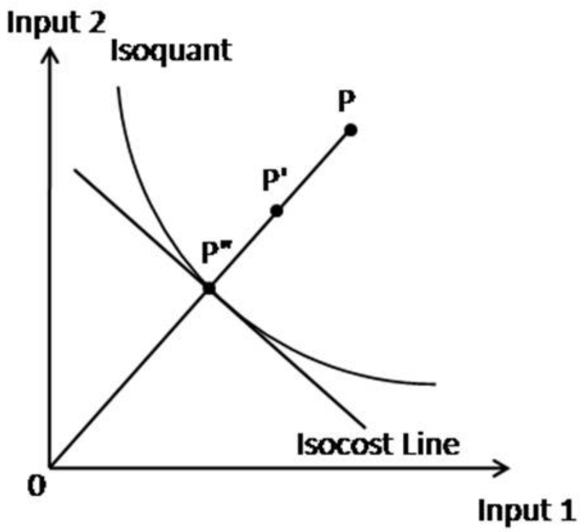
.

3.3 Non-Discretionary Empirical Model: Constrained DEA

The second model adds a total debt constraint to the input-oriented model discussed above to calculate efficiencies annually from 1998 to 2007 for 456 Kansas farms. The objective of the non-discretionary empirical model is to investigate how financial factors affect production performance. If farms are constrained by their level of debt or solvency, how does their performance compare to their counterparts?

Figure 3.1 illustrates the concept of the non-discretionary DEA model. It is an example of a single output, two-input DEA problem where P*''* is efficient and P is inefficient. The inefficiency at point P may be due partly to an inability for a farmer to obtain adequate debt financing. Therefore, farm P produces less than the theoretical maximum, even if discretionary inputs are used efficiently. In this example, if farm P received more favorable access to debt financing it

Figure 3.1 DEA and Non-Discretionary Inputs



would be observed a P'. At P', farm P would produce the same level of output using fewer inputs.

Total debt is used in essay two as the prime financial strategy affecting a farm's production efficiency, and especially cost efficiency. Conceptually, the set of farm inputs used in the production process (i.e. input quantities and the input mix) is strongly related to input prices. Total debt is made up of short-term debt, which is working capital used primarily to purchase inputs, intermediate debt, which is used to purchase equipment, and long-term debt, which is used to purchase buildings and land. Thus, total debt is expected to affect the structure and organization of farm economic performance.

The basic model and the non-discretionary DEA model, which is constrained by total farm debt, were both used to calculate and compare farms' technical efficiencies. Mathematically, the basic model was transformed into the non-discretionary model by adding debt capital measures. Debt capital is referred to as a non-discretionary variable because its level is constant. Each farm cannot (in the short run) optimize by changing this variable, and as such the model compares each farm to those that are in the same or worse "environment."[18] In Table 3.2, DEA non-discretionary problems are presented to illustrate the calculation of technical efficiency and minimum costs under different economies of scale assumptions. Let the scalar d_s denote the level of debt for farm s. The DEA model takes into account the level of farm debt for the farm being analyzed, d_s, which is not a choice variable in the problem.

Table 3.3 summarizes the two models implemented in terms of variables used and type of linear programming problem. Y is a matrix formed from the output vectors y_s, where the s th column of Y is the output vector of farm s; X is a corresponding matrix formed by the input vectors x_s, and $D = (d_1, \ldots, d_S)$ is the vector of debt levels. Note that non-discretionary model efficiencies are calculated from the same farms and years as the input-oriented model, with the same inputs and outputs. Thus, the only difference between models is that the non-discretionary model is financially constrained by total debt.

[18] An environmental input is a factor of production that cannot be instantly adjusted or controlled by the manager/farmer at the time. To measure short term efficiency, fixed inputs are introduced empirically in DEA problems this way.

Table 3.2 Non-Discretionary DEA with Added Debt Constraint

Accounting for Variable Returns to Scale	Accounting for Constant Returns to Scale
Problem 2.1: Cost Minimization	Problem 2.2: Cost Minimization
$Minimize_{x^*,\mu}\ \sum_{j=1}^{N} w_j \bullet x_{js}^{*\ vrs}$	$Minimize_{x^*,\mu}\ \sum_{j=1}^{N} w_j \bullet x_{js}^{*\ crs}$
Subject to	*Subject to*
$y_{is} \leq \sum_{s=1}^{S} \mu_s \bullet y_{js}$ $\quad i=1, 2, 3\ldots M$	$y_{is} \leq \sum_{s=1}^{S} \mu_s \bullet y_{is}$ $\quad i=1, 2, 3\ldots M$
$x_{js}{*} \geq \sum_{s=1}^{S} \mu_s \bullet x_{js}$ $\quad j=1, 2, 3\ldots N$	$x_{js}{*} \geq \sum_{s=1}^{S} \mu_s \bullet x_{js}$ $\quad j=1, 2, 3\ldots N$
$d_s \geq \sum_{s=1}^{S} \mu_s \bullet d_s$	$d_s \geq \sum_{s=1}^{S} \mu_s \bullet d_s$
$\mu_s \geq 0$	$\mu_s \geq 0$
$\sum_{s=1}^{S} \mu_s = 1$	
Problem 2.3: Technical Efficiency $\Theta_s^{\ vrs}$	Problem 2.4: Technical Efficiency $\Theta_s^{\ crs}$
$Minimize_{k,\mu}\ \Theta_s^{\ vrs}$	$Minimize_{k,\mu}\ \Theta_s^{\ crs}$
Subject to	*Subject to*
$y_{is} \leq \sum_{s=1}^{S} \mu_s \bullet y_{is}$ $\quad i=1, 2, 3\ldots M$	$y_{is} \leq \sum_{s=1}^{S} \mu_s \bullet y_{is}$ $\quad i=1, 2, 3\ldots M$
$x_{js} \bullet \Theta_s \geq \sum_{s=1}^{S} \mu_s \bullet x_{js}$ $\quad j=1, 2, 3\ldots N$	$x_{js} \bullet \Theta_s \geq \sum_{s=1}^{S} \mu_s \bullet x_{js}$ $\quad j=1, 2, 3\ldots N$
$d_s \geq \sum_{s=1}^{S} \mu_s \bullet d_s$	$d_s \geq \sum_{s=1}^{S} \mu_s \bullet d_s$
$\mu_s \geq 0$	$\mu_s \geq 0$
$\sum_{s=1}^{S} \mu_s = 1$	

Note: w is an $N \times 1$ vector of input prices for the $j=1, 2, 3\ldots N$ inputs, x_s is a vector of corresponding input quantities for each of the $s = 1, 2, 3\ldots, S$ farms, and y_s is the output vector for $i=1, 2, 3\ldots M$ outputs for each of the $s = 1, 2, 3\ldots, S$ farms.

Table 3.3 Comparisons of DEA Models

DEA Model	Variables	Description	Model Objectives
Input-Oriented	*Y, X*	*Y* is an $M \times S$ matrix of output quantities for the *S* farms *X* is an $N \times S$ matrix of input quantities	Technical Efficiency under VRS
Non-Discretionary	*Y, X, D*	*Y* is an $M \times S$ matrix of output quantities for the *S* farms *X* is an $N \times S$ matrix of input quantities *D* is a $1 \times S$ vector of total debt level for each farm s	Technical Efficiency under VRS, debt-constrained

Total debt level is a non-discretionary or environmental factor in this case because the farmer does not have any discretion over it. However, a new constraint is added to ensure that the best practice frontier so that it represents a “virtual farm” whose level of debt is equal or less than the farm being evaluated. Non-discretionary DEA calculates efficiencies by taking into account this non-production variable, presumed to limit the farms as the level of output does. Conceptually, this DEA model seeks to radially contract inputs given the fixed level of outputs and the fixed level of the farm’s own level of capital availability.

If efficiency scores differ between the unconstrained and the constrained models, this will be evidence constraint is binding for these farms. The magnitude of the change will indicate the importance of their relation.

The software used to solve the linear programming models is General Algebraic Modeling System (GAMS). Ramanathan 2003 points out that the software is especially suited to large and complex computations (page 125). Although earlier versions of the software were not as well suited for repeated linear programming formulations, newest versions include tools specifically designed to solve DEA problems. The algorithms used are *minos* and *conopt* which can be used for linear programming problems.

3.4 Panel Tobit Regression Analysis of Farm Efficiency and Inefficiency Scores

Once efficiency scores have been obtained, the factors that impact inefficiencies are studied using a Tobit regression model (referred in the literature as a one-step procedure efficiency analysis). The efficiency estimates were transformed into inefficiency estimates calculated as unity minus the efficiency. For example, technical efficiency, *TI*, was defined as *TI* = 1 – *TE.* The other inefficiency variables, *AI*, *SI*, and *OI*, were defined similarly. In this way inefficiency scores were bounded between zero and one [19].

Regarding the use of a Tobit model using Maximum Likelihood over the Ordinary Least Squares procedure, this choice is due to the fact that the latter model estimates would be biased and inconsistent. Since the observed dependent variable, inefficiencies (which are left censored for the 456 farms for each year y_{st} has a censored distribution, the Ordinary Least Square

[19] While the dependent variable is conceptually bounded from above (right-censored) at 1; none of the data points are on or near this bound, which would correspond to complete inefficiencies or zero efficiency.

estimates of the models may be biased because of the "unobserved values" of the dependent variable are not taken into account in the regression. The Tobit model could be regarded as a combination of a linear regression model and a probabilistic regression (i.e. Probit model). The likelihood function combines a probability density function and a conditional density function to account both for observed and non-observed values of the dependent variable. The reader is referred to Greene (2003), Baltagi (2001) for a detailed specification of the computational and statistical properties of these estimators; including specification of the log-likelihood function for the estimator, the computation of estimated errors, and the method of maximizing the likelihood function (this normally depends on the software package; Stata approximates the maximum log-likelihood function of the estimators using Gauss-Hermite quadrature method).

The dataset used in this study consisted of a panel of 456 farms observed over the 10-year period 1998 to 2007. The benefits of panel data, i.e. observation of the same 456 farms over a 10 year period of time, derives from the rich information provided by the combination of cross-sectional and time-series data. Baltagi[20] (2001, p. 5) listed the advantages of using models designed for panel data. The author argued for the benefits of controlling for the characteristics of this type of data in the models; he pointed that: "Panel data give more informative data, more variability, less collinearity among the variables, more degrees of freedom and more efficiency" (Baltagi, 2001, p. 6). In page 7, Baltagi mentioned specifically names of economists such as Kumbhakar who agree on the added explanatory power of panel data to estimate technical efficiency (p. 7), and by extension, all efficiencies.

Baltagi (2001)[21] also explained that panel Tobit models can include fixed or random effects. The first type models the individual, farm-specific effects as fixed parameters; that is; the method would be equivalent to creating as many dummy variables as the number of farms (units) to control for their fixed time-variant effect in the model. In the random effects panel data model, the individual specific effects are allowed to be random; thus allowing for variation of these influences across the "representative population". Sometimes, depending on the data at hand, and

[20] For more detailed information, the reader is encouraged to read Baltagi (2001) about panel data, characteristics, and models.

[21]Baltagi (2001, p14) explained very clearly the difference between a fixed effect versus a random effect panel data. Additionally, fixed effect models cannot model time invariant independent variables such as sex; whereas random effects can, though it assumes that the independent variables are independent of the individual effects. These two extreme requirements can be relaxed by mixing the two models through the use of dummy variables. He also explained that in the case the true model is a fixed effect model, the Ordinary Least Square estimates will be biased and inconsistent of the true regression parameters.

the number of farms (i.e. units or firms) it is possible to combine both models. In this study, some of the panel data Tobit models control both for year individual effects and fixed farm individual effects such as farm output specialty. These additional variables entered the Panel data Tobit model as dummy variables.

The random-effect Tobit[22] model, which is especially designed to deal with panel data and the possible collinearity between data cross-sections, was chosen to capture farms' individual-specific effects which are not included in the regression (such as farm quality of soil, evapotransporation, temperature, rainfall, type of crop, type of animal), assuming no correlation between the individual's specific effects and explanatory variables. The model is described as:

$y_{st}{*}= f\,(Z_s;\, \beta_s)$ *for s=1, 2, 3…S*

$y_{st}= y_{st}{*}$ *if* $y_{st}{*}>0,$ *or* $y_{st}=0$ *otherwise*

and it takes the specific following form:

$$y_{st}{*}= \alpha + \beta\, Z_{st} + u_s + v_{st}$$

where $y_{st}{*}$ is a vector of the farm cost inefficiency scores for the s=1, 2, 3… S farms. Cost inefficiency is a function of farm specific explanatory factors Z, and (α, β) are parameters to be estimated. In this formulation, the farm specific random effects or time invariant effects, u_s, are assumed to be independently and identically normally distributed with zero mean and variance σ^2_u, that is, u_s are iid $N(0, \sigma^2_u)$. The overall disturbances of the model, v_{st} , are iid $N(0, \sigma^2_v)$ and independent of u_s. The subscript t indexes the time period over the ten years, from 1998 to 2007.

In summary, the observed dependent variable y_{st} has a censored distribution since its value is censored at zero. As stated before, estimates of this model with Ordinary Least Squares would be biased. Additionally, the choice between a Tobit model and a Panel data Tobit model is justified since the Tobit model does not take into account the individual farm specific heterogeneity and the model may suffer from multicollinearity. A Log-likelihood test to determine if the random individual component of the model is significant was performed in every instance to confirm the appropriateness of the each model. In all instances, the random effects were significant at a 1% significance level.

[22]Fixed-Effect Tobit models can be used when the number of farms (i.e. units, farms) is sufficiently large to allow for the effects to be fixed (such as female versus male labor supply Tobit model); however, in this instance, with 456 farms and only 10 years, at this moment of time there does not exist a sufficient statistic to draw statistically the individual effects u_s, which allows the fixed-effect to be conditioned out of the likelihood function, as this the procedure to estimate this models; please see Baltagi (2001, p, 206 and 213).

This panel Tobit model for two-stage inefficiencies' estimates and causes has been reported in the literature to have some potential bias if the range of years considered is very small (Davidova and Latruffe, 2007; Greene, 2003). Ten years is considered adequate for efficiency analysis because of the relatively long time span. Greene (2003, page 768) also warns about the inability of the Tobit model to deal with heteroskedasticity which would arise from an unobserved relationship between the mean of the dependent variable and the variance of the model errors. Some authors have proposed some alternative Tobit models to correct for it when present, but no conclusive model has been formulated to avoid it and its possible effects even though this area has received attention in the last decade. As in the majority of studies on farms' efficiencies (and other businesses and fields of interest), random-effect Tobit models are customary in the efficiency literature. They are applied here although these limitations must be kept in mind.

CHAPTER 4 - Data

4.1 Data Source and Sampling Procedures

Whole-farm data from the Kansas Farm Management Association (KFMA) databank were used in the dissertation. The data were collected by farm management specialists who work with farmers in the six area associations (Figure 4.1) to be used for research and extension activities at Kansas State University and for filing income taxes. Specifically, a panel of 456 farms with continuous data from 1998 to 2007 was used in the models. The dataset contains financial and production data from farm management members of the KFMA.

The KFMA databank provides individual farm information on costs, revenue, production, and farm characteristics. The farms in our panel did not exit or enter farming during the sample period; all of them were in business and in the record system for each of the ten consecutive years of the study. The sampled farms are representative of mid-sized Kansas farms where owner-operators typically make the production decisions (Featherstone, Griebel and Langemeier 1992). Farms with asset values of zero (either for short-term assets such as inventories of inputs and outputs and long-term assets such as equipment and land) were not included in the original sample. These farms were excluded to ensure that the sampled farms are those where owners make production decisions. This exclusion eliminates, for example, observations where the owner is an absentee landlord who custom hires all the production or where the decision maker is an individual whose intention is to farm temporarily. The SAS code to extract the observations meeting these criteria is in Appendix B. The extracted data included 570 farms spanning all six area associations in Figure 4.1.

In order to ensure the accuracy of the farms' data, the extracted dataset was further screened based on production and financial criteria. Screening for production criteria were aimed at eliminating anomalous observations where essential inputs were reported in zero quantities. First, if a farm had zero seed expenditures in any individual year, the farm was deleted from the sample if its reported output that year included crop such as corn or grain sorghum, for which seed must be purchased annually[23]. Chemicals are also an essential input for most crops, but chemicals can be applied by custom hire, and these expenditures may be reflected in the machine

[23] In Kansas, it is a common management practice to retain some of the previous year's wheat production to be used as seed wheat for the next year. Thus wheat farms with zero seed purchases in any one year were retained in the sample

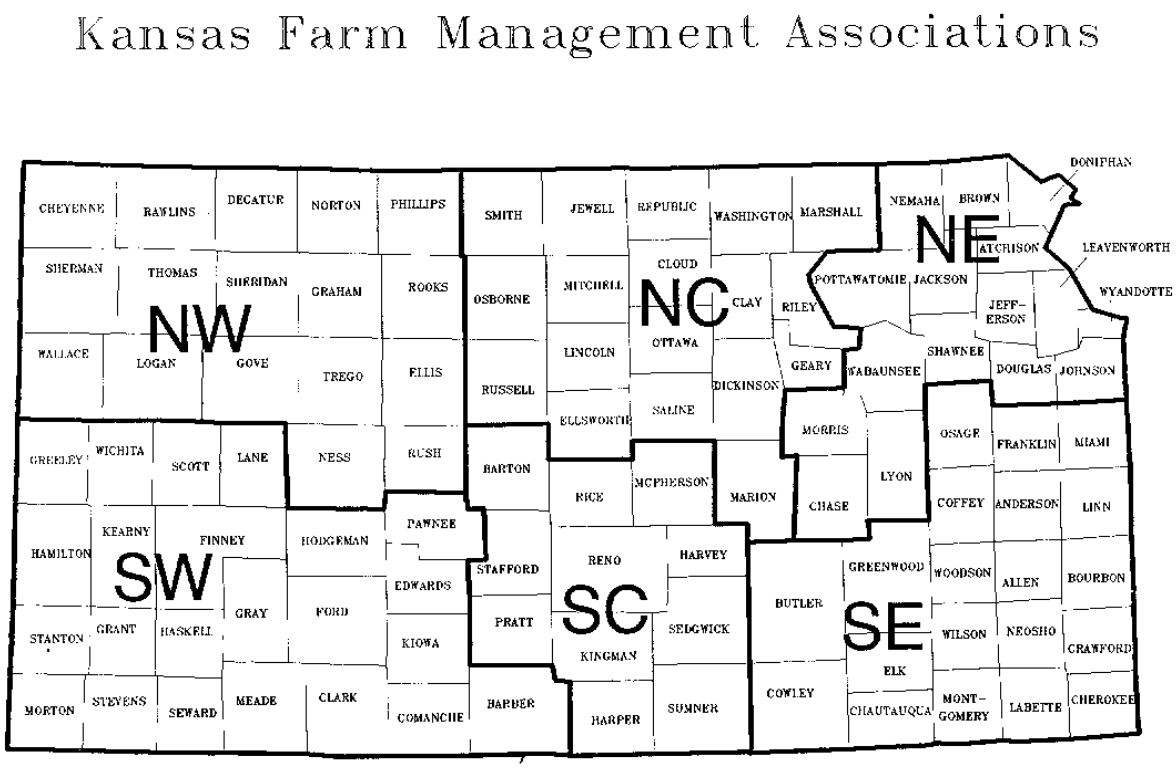
hire variable (capital) instead of the chemical variable. Thus, the variable for chemical purchases can be zero in some cases. A third essential input for crops is fertilizer. However, integrated farms with both crop and livestock enterprises can substitute commercial fertilizer inputs with organic fertilizer such as manure. Crop farms with zero expenditure on fertilizer in any year were deleted, unless the farm also had dairy or beef production, in which case the farm was retained with a zero recorded for fertilizer input. For livestock operations, essential inputs include feed and veterinary care. If a sampled farm for any year recorded expenditures on feed and veterinary, then the farm was retained only if it had dairy and/or beef output.

The financial screening criteria were aimed at eliminating insolvent farms that were likely to be in or in danger of entering bankruptcy. Such farms' decisions are likely to be driven by immediate financial survival rather than long-run profitability. To eliminate them, observations with total debt to total asset ratios higher than one were evaluated to determine the farm's solvency. Farms whose total debt to total asset ratio (maximum of 1.7) was more than one and fluctuated substantially from one year to the next were deleted from the sample.

A total of 114 farms were eliminated according to the criteria explained above, leaving a dataset with 570 – 114 = 456 observations for analysis. The variables in the final dataset were then manipulated in two major ways to construct variables consistent with the theoretical assumptions in the DEA model. First, while the DEA model requires output and input data in physical units, the output quantities in the KFMA databank are recorded as sales (revenue in nominal dollars) and input quantities reflect nominal dollar expenditures. Expenditures and sales from the KFMA farm members are recorded on an accrual accounting basis. The price deflator for personal consumption expenditures from the Federal Reserve Bank of St. Louis[24] was first used to convert these values into real 2007 dollars. Both input and output monetary quantities were then converted into implicit physical quantities by using 12-month averages of price indexes for input and output prices in Kansas using US Bureau of Labor Statistics Producer Price Indexes, 1989-2007. The price of labor was calculated as the ratio of labor costs divided by the

[24] http://research.stlouisfed.org/fred2/search/personal+consumption+expenditures/1

Figure 4.1 Kansas Farm Management Associations



number of workers[25]. The prices of land for non-irrigated crop land, irrigated crop land, and pasture land prices for each of the nine Kansas regions were obtained from the USDA National Agricultural Statistical Service. Data on the interest rate to compute the opportunity cost of owned assets were obtained from the Federal Reserve Bank of Kansas City[26].

The farms' depreciable assets, including listed property, motorized equipment, machinery equipment and buildings, were adjusted to reflect economic depreciation instead of tax depreciation because of changes that occurred in the calculation of tax depreciation in 1993 that permitted rapid depreciation rates of these assets[27]. Table 4.1 defines the depreciation methods used for each type of property.

[25] Workers include owner operator.
[26] http://www.kc.frb.org/agcrsurv/agrmain.htm
[27] In economics and accounting, economic depreciation is the change in market value of capital over a given period. It is calculated as the market price of the capital at the beginning of the period minus its market price at the end of the period. Economic depreciation differs from other accounting depreciation methods in that it is included in the calculation of implicit cost, and thus economic profit (http://en.wikipedia.org).

Table 4.1 Economic Depreciation Methods

Type of Property	Life-Method[1]	Salvage Value
Listed Property[2]		
All Property	5 Years; 100% DB[3]-20%	35%
Motorized Equipment		
Pickups, Autos	5 Years; 100% DB[3]-20%	35%
Tractors, Combines, Etc.	10 Years; 100% DB[3]-10%	35%
Machinery-Equipment		
Livestock Feeders, Planting/Cultivation Equipment	5 Years; 150% DB[3]-27.5%	20%
Tillage Equipment	15 Years; 150% DB[3]-10%	20%
All Other Machinery and Equipment	10 Years; 150% DB[3]-15%	20%
Buildings		
Grain and Hay Storage, Swine Buildings, Fences and Yards	10 Years; 200% DB[3]-20%	10%
All Other Buildings	20 Years; 200% DB[3]-10%	10%

[1] The mid-month convention was used to compute economic depreciation in the year that an asset was purchased.

[2] Listed property included computers, related peripheral equipment, cellular telephones and similar telecommunication equipment.

[3] DB is defined as declining balance.

4.2 Input and Output Categories and Data Aggregation

A basic assumption of efficiency analysis is that farmers are striving to use inputs in a manner that optimizes long-run efficiency. Sample farms can produce up to seven outputs and use up to eight inputs; although not all farms produce all outputs or use all inputs. Farm outputs include all major production crops produced in Kansas and two important Kansas livestock outputs, beef and dairy production. Farms specialize in crop or livestock production or a combination of both. Outputs for the sampled farms include:

- small grain production,
- feed grain production,
- oilseed production,
- hay and forage production,
- beef production,
- milk production, and
- custom work.

Small grain production includes production of barley, oats, rye, and wheat. Feed grain production refers to corn and grain sorghum production. Oilseed production aggregates production of soybeans, pinto beans, sugar beets, legume and grass seed, cotton, popcorn, sunflowers, tobacco, peanuts and rice, and miscellaneous cash crops. Hay and forage production entails production of alfalfa, brome and fescue, prairie hay and other, corn silage and other, straw, cereal and residue pasture and other miscellaneous hay and forage production. All beef enterprises are labeled as beef production, from feeding to breeding. Dairy production also includes milk production and other products. The last output, custom work, consists of income from farmers using their equipment to do farm work for other farmers.

Farm inputs include classical production economics categories of labor, capital, land and materials. Given this multi-output setting, not all farms use all input types. Inputs are categorized as:

- labor,
- capital,
- land (total acres),
- livestock and dairy expenses,
- seed,

- fertilizer, and
- chemicals.

The number of workers (paid and unpaid) on the farm, usually including the owner, are used as the labor input variable. The variable capital represents short-term and intermediate-term capital expenses. This input includes inventories of inputs and outputs, depreciation on intermediate-term assets, interest paid on short-term and intermediate-term liabilities, machinery and building repairs, machine hire, irrigation repairs and energy, fuel and oil expenses, and auto expenses. The land variable includes total farm acres operated (owned and rented), including irrigated and non-irrigated crop acres, and pasture acres. The variable livestock reflects expenditures on feed, veterinary, medicines and drugs, livestock marketing and breeding and other dairy expenses. Seed and fertilizer reflect expenses on seed, and fertilizer and lime, respectively. Expenses in herbicide and insecticide form the variable chemicals. The farms' total level of debt is used in the non-discretionary DEA models, which includes the annual real dollar value of short-term liabilities, combined with intermediate-term and long-term loan debt.

In addition to the above variables, other production and socio-economic variables were obtained for the statistical analysis of the farm efficiencies and their causes. Age of the operator, percentage of each input's expense to total expenses, farm output as a percent of income, and owned land as a percent of total land operated were variables used for analyzing the effect of input usage and output choice on efficiencies.

4.3 Production and Socio-Economic Characteristics of Farms

Table 4.2 provides definitions of the variables used in the dissertation, categorized by farm characteristics, inputs, outputs and efficiency measures (definitions for all the variables in the dataset can be found in Appendix A). Table 4.3 provides the means and standard deviations of the inputs and outputs, of variables that were used in the estimation of the relationship between farm financial performance and efficiency, and of the farm-specific variables that were hypothesized to influence technical efficiency. Average age of the primary farm operator (AGEOP) was 55 years. Average gross farm income (RGFI) was $302,645 from an average number of acres (LAND) of 1,806 using a total annual debt (TADEBT) of $257,911. The average economic total expense ratio (EXPR) was 1.15. An economic expense ratio above 1 indicates that the farms on average had farm expenses exceeding farm revenue (i.e., were incurring losses or were not covering all of their opportunity costs). Many farmers rely on off-farm income (OFFI) of $12,990, on average, and custom work (CUSTWORK) of $4,579, on average, to continue farming over the long run.

In Table 4.4 farms were divided into four gross income (RGFI) categories: those with less than $100,000 (14% of farms) in gross farm income, those with a gross farm income between $100,000 and $250,000 (41% of farms), those with a gross farm income between $250,000 and $500,000 (30% of farms), and those with a gross farm income above $500,000 (15% of farms). An interesting comparison can be made between farms with gross farm income less than $100,000 (small farms) and gross farm income greater than $500,000 (large farms). Notice that the number of farms in both categories is approximately the same (14% for small farms and 15% for large farms). However, that is where the similarity between the two groups ends. Small farms have older operators (61 compared with 54), higher economic total expense ratios (1.63 compared with 0.94), more off-farm income ($21,109 compared with $6,043) and a higher percentage of acres owned (46% compared with 33%) than large farms. Small farms spent less (16% versus 24% and 5% versus 15%) as a percent of total expenses on seed, fertilizer and chemicals (PCROPE) and livestock than large farms. However, the small farms spend more on labor (PLABORE) with 34% of total costs spent on labor versus 15% for large farms.[28] Other variables were similar across farms sizes.

Medium farms with gross income between 100,000 and 250,000 and 250,000 and 500,000 were similar across descriptive variables to large farms. Medium farms had more income from crops (PCROPI) (67%, 68% versus 63%) and less income from livestock (PLIVDI) than large farms (31%, 30% versus 36%). Medium farms with gross income between 100,000 and 250,000 spent less on crops (PCROPE) (21% versus 24%) and more on labor (PLABORE) (24% versus 17%) than farms with gross income between 250,000 and 500,000. The 250,000 to 500,000 farms spent about the same amount on crops and labor as the large farms.[29]

In Table 4.5 farms were categorized by farm specialization with crops farms (44% of farms) defined as farms with 80% or more of gross farm income derived from crop enterprises, livestock and dairy farms (12% of farms) defined as farms with 80% or more of gross farm

[28] T-test statistics for these variables ranged from a low of 21 to a high of 115 indicating that all of the means of the two farm groups were statistically different from each other at the $\alpha = 0.01$ level.
[29] T-test statistics for these variables ranged from a low of 4 to a high of 60 indicating that all of the means of the paired farm groups were statistically different from each other at the $\alpha = 0.01$ level.

income derived from livestock enterprises, and mixed enterprise farms (44% of farms) making up the remainder of the farm sample. These farms were similar across most of the variables; however, there are a few noticeable exceptions. Mixed farms had a higher off-farm income (OFFI) of $14,449 versus $11,833 for both crops farms and livestock and dairy farms. Gross farm income (RGFI) of $373,891 was higher for livestock and dairy farms than for crop farms ($312,885) and mixed enterprise farms ($272,857). Total farm debt (TADEB) of $303,566 was higher for livestock and dairy farms than for crop farms ($241,418) and mixed enterprise farms ($261, 513). Livestock and dairy farms generate more income than crop and mixed enterprise farms because they are larger and they require more debt financing because they require more land (for cow-calf operations) or capital (for dairies) per unit of output than crop or mixed farms.[30]

In Table 4.6 farms were divided into six total debt (TADEB) categories: those with no debt (11% of farms), those with less than $50,000 in debt (12% of farms), those with between $50,000 and $100,000 of debt (14% of farms), those with between $100,000 and $250,000 of debt (27% of farms), those with between $250,000 and $500,000 of debt (22% of farms) and those with over $500,000 of debt (14% of farms). Total farm debt is an especially important variable because it was used as a proxy for farm financial structure in the estimation of the relationship between farm financial performance and efficiency scores, and as a farm-specific variable that was hypothesized to influence efficiency in the Tobit models.

An interesting comparison can be made between farms with no debt or low-debt (with debt = 0 or less than 50,000 in debt) farms and high debt farms (with $250,000 to $500,000 and over $500,000 in debt). Low-debt farmers were older (AGEOP) (61, 57 versus 53, 53), had slightly higher total cost to farm income (EXPR) (1.28, 1.24 versus 1.06, 1.25), had higher crop expenses (PCROPE) (37%, 37% versus 23%, 22%), and higher labor costs (PLABORE) (28%, 26% versus 18%, 15%) than high-debt farmers. All other variables are similar among debt sizes.

These differences were expected. Quite often farmer are required to seek outside sources of capital in the form of debt capital because of the size of their capital requirements. Whether the farmer should use someone else's money for capital requirements and how much debt is appropriate are important questions to consider. A prudent farmer will monitor the financial

[30] T-test statistics for these variables ranged from a low of 6 to a high of 10 indicating that all of the means of the paired farm groups were statistically different from each other at the $\alpha = 0.01$ level.

health of the farm regularly and strive to maintain an appropriate amount of debt. Beginning farmers and existing farmers expanding their own farm operation need larger amounts of debt than older, more established farmers. However, the greater the debt the farmer uses in relation to his/her own funds (the debt/equity ratio) the greater the financial risk. Older farmers closer to retirement frequently do not want to take on the burden of extra risk to expand or to increase profitability through use of financial leverage[31]. It is important for older farmers planning for succession of the farm operation to determine and provide for how the farm assets will be distributed upon the farmer's death. However, it is equally critical that a farmer plan for how debt is handled after the farmer's death because a farmer's outstanding debts must be settled by the estate before most distributions can be made to his/her heirs. For these reasons, many farmers reduce the amount of debt of the farm operation as they get older.

[31] Financial leverage takes the form of a debt, the proceeds of which are reinvested with the intent to earn a greater rate of return than the cost of interest on the debt. If the farm's rate of return on assets is higher than the rate of interest on the debt, then its return on equity will be higher than if it did not borrow. On the other hand, if the farm's return on assets is lower than the interest rate, then its return on equity will be lower than if it did not borrow. Leverage allows greater potential returns to the farmer than otherwise would have been available. The potential for loss is also greater, because if the investment becomes worthless, the debt principal and all accrued interest on the debt still need to be repaid (http://en.wikipedia.org/wiki).

Table 4.2 Variable Definition by Category

Variable	Definition
Farm Characteristics	
AGEOP	Operator's Age ("Primary" Operator for Partnerships and Corporations)
EXPR	Total Cost of Production Divided by Total Farm Income Including Farming Operations, Government Payments, and Insurance Receipts
ID	From 1 to 456, Number of Farms
MFIAC	Real Gross Farm Income per Acre
OFFI	Income from Off-Farm Sources
PCAPE	Percent of Costs Spent on Capital
PCROPE	Percent of Costs Spent on Crop Expenses Including Seed, Fertilizer and Chemicals
PCROPI	Percent of Income from Crops
PCWKI	Percent of Income from Custom Work
PLABCROP	Percent of Labor Devoted To Crops
PLABORE	Percent of Costs Spent on Labor
PLANDE	Percent of Costs Spent on Land Cost
PLIVDE	Percent of Costs Spent on Livestock Expenses
PLIVDI	Percent of Income from Livestock
POWNA	Percent of Total Operated Acres that are Owned
RGFI	Real Gross Farm Income
TADEBT	Level of Total Annual Debt
YEAR	Year from 88 to 107, 1988-2007
Inputs	In Units
CAPITA	Capital Expenses
CHEMICA	Chemical
FERTILA	Fertilizer
LABOR	Number of Workers (Including Operator and Unpaid Workers)
LANDA	Total Operated Acres
LIVE	Livestock Expenses
SEED	Seed

Table 4.2 Continued

Variable	Definition
Input Prices Per Unit	In Real 2007 $
PCAPITAL	Short-term and Intermediate-term Capital
PCHEM	Chemical
PFERT	Fertilizer
PLABOR	Labor
PLAND	Cash Land Rent
PLIVE	Livestock
PSEED	Seed
Outputs	
CUSTWORK	Custom Work in Real 2007 $
DAIRY	Production of Diary Products in Pounds
FGPROD	Production of Feed Grain in Bushels
HFPROD	Production of Hay and Forage in Bushels
LIVE	Production of Livestock in Pounds
SGPROD	Production of Small Grain (Wheat) in Bushels
SOYPROD	Production of Oilseeds (Soybeans and Sunflowers) in Bushels

Table 4.3 Summary Statistics for 456 Kansas Farms from 1988 to 2007

Variable	Unit	Mean	Standard Deviation
Farm Characteristics			
AGEOP	# of Years	55	11
EXPR	%	1.15	0.35
MFIAC	Real 2007 $	33	79
OFFI	Real 2007 $	12,990	19,832
PCAPE	%	38	8
PCROPE	%	22	9
PCROPI	%	66	31
PCWKI	%	2	4
PLABORE	%	22	9
PLANDE	%	10	6
PLIVDE	%	8	12
PLIVDI	%	32	31
POWNA	%	35	27
RGFI	Real 2007 $	302,645	257,933
TADEBT	Real 2007 $	257,911	310,418
Inputs			
CAPITAL	# of Units/Acre	73	70
CHEM	# of Units/Acre	11	9
FERT	# of Units/Acre	17	14
LABOR	# of Workers	1.5	0.9
LAND	# of Acres	1,806	1,202
LIVE	# of Units	254	575
SEED	# of Units/Acre	118	126
Input Prices Per Unit			
PCAPITAL	Real 2007 $	38	8
PCHEM	Real 2007 $	11	8
PFERT	Real 2007 $	17	14

Table 4.3 Continued

Variable	Unit	Mean	Standard Deviation
PLABOR	Real 2007 $	22	9
PLAND	Real 2007 $	10	6
PLIVE	Real 2007 $	8	11
PSEED	Real 2007 $	12	13
<u>Outputs</u>			
CUSTWORK	Real 2007 $	4,579	14,625
DAIRY	# of Pounds	135,850	626,070
FGPROD	# of Bushels	23,422	37,887
HFPROD	# of Pounds	98	280
LIVE	# of Pounds	76,929	155,482
SGPROD	# of Bushels	11,575	13,850
SOYPROD	# of Bushels	7,160	10,884

Table 4.4 Summary Statistics Categorized by Gross Farm Income for 456 Kansas Farms from 1988 to 2007

		RGFI<100,000		100,000≥RGFI<250,000		250,000≥RGFI<500,000		RGFI≥500,000	
		14% of Farms		41% of Farms		30% of Farms		15% of Farms	
Variable	Units	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Farm Characteristics									
AGEOP	#	61	13	55	10	53	10	54	10
EXPR	%	1.63	0.46	1.17	0.26	1.02	0.21	0.94	0.27
OFFI	$	21,109	25,732	15,186	19,866	9,717	15,925	6,043	16,743
POWNA	%	46	30	36	26	30	25	33	29
RGFI	$	68,906	19,423	174,725	42,565	349,553	70,227	775,548	325,060
TADEB	$	78,345	87,644	166,515	145,260	295,776	248,310	598,636	532,298
Income from Outputs									
PCROPI	%	62	32	67	28	68	30	63	35
PCWKI	%	2	4	2	4	2	4	2	4
PLIVDI	%	36	33	31	29	30	31	36	36
Inputs									
LAND	acres	764	452	1,470	741	2,143	985	3,011	1,738
PCAPE	%	37	9	38	8	38	8	37	7
PCROPE	%	16	7	21	8	24	9	24	11
PLABORE	%	34	10	24	6	17	5	15	5
PLANDE	%	8	5	11	6	11	6	9	6
PLIVDE	%	5	6	6	8	9	13	15	16

Table 4.5 Summary Statistics Categorized by Farm Specialization for 456 Kansas Farms from 1988 to 2007

		Crop Farms 44% of Farms		Livestock and Dairy Farms 12% of Farms		Mixed Enterprise Farms 44% of Farms	
Variable	Units	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
<u>Farm Characteristics</u>							
AGEOP	#	55	11	56	11	55	11
EXPR	%	1.14	0.34	1.12	0.33	1.18	0.36
OFFI	$	11,833	18,990	11,833	17,885	14,449	21,032
POWNA	%	33	27	46	31	34	25
RGFI	$	312,885	247,716	373,891	331,378	272,857	239,425
TADEB	$	241,418	291,092	303,566	377,556	261,513	307,045
<u>Income from Outputs</u>							
PCROPI	%	94	6	9	6	55	17
PCWKI	%	2	3	0	1	2	5
PLIVDI	%	5	6	90	6	43	18
<u>Inputs</u>							
LAND	acres	1,677	1,004	1,683	1,512	1,966	1,264
PCAPE	%	39	8	34	7	38	7
PCROPE	%	27	8	9	5	19	7
PLABORE	%	21	8	22	9	23	9
PLANDE	%	11	6	6	5	11	6
PLIVDE	%	1	3	29	14	9	9

Table 4.6 Summary Statistics Categorized by Total Debt for 456 Kansas Farms from 1988 to 2007

		TADEB=0 11% of Farms		TADEB<50,000 12% of Farms		50,000≤ TADEB<100,000 14% of Farms	
Variable	Units	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Farm Characteristics							
AGEOP	#	61	13	57	11	55	12
EXPR	%	1.28	0.45	1.24	0.39	1.25	0.39
OFFI	$	8,108	14,936	14,016	19,492	15,621	21,792
POWNA	%	0.46	0.32	0.34	0.29	0.34	0.27
RGFI	$	228,216	192,119	191,959	150,087	207,936	158,134
TADEB	$	0	0	28,479	13,390	74,459	14,405
Income from Outputs							
PCROPI	%	0.63	0.33	0.69	0.32	0.69	0.30
PCWKI	%	0.01	0.03	0.02	0.04	0.02	0.04
PLIVDI	%	0.36	0.33	0.29	0.32	0.29	0.30
Inputs							
LAND	acres	1,491	1,006	1,245	889	1,455	929
PCAPE	%	0.37	0.08	0.37	0.08	0.38	0.08
PCROPE	%	0.19	0.09	0.20	0.09	0.21	0.09
PLABORE	%	0.28	0.11	0.26	0.09	0.25	0.08
PLANDE	%	0.08	0.06	0.10	0.06	0.10	0.06
PLIVDE	%	0.08	0.12	0.06	0.10	0.06	0.10

Table 4.6 Continued

Variable	Units	100,000≤TADEB< 250,000 27% of Farms Mean	Std. Dev.	250,000≤ TADEB< 500,000 22% of Farms Mean	Std. Dev.	TADEB≥500,000 14% of Farms Mean	Std. Dev.
Farm Characteristics							
AGEOP	#	54	10	53	9	53	9
EXPR	%	1.16	0.32	1.06	0.24	1.02	0.30
OFFI	$	15,968	22,037	12,716	19,147	8,015	15,941
POWNA	%	0.34	0.25	0.32	0.25	0.37	0.26
RGFI	$	242,976	169,551	340,102	202,766	603,916	399,507
TADEB	$	167,759	43,414	358,777	70,776	849,694	409,658
Income from Outputs							
PCROPI	%	0.68	0.29	0.66	0.30	0.59	0.33
PCWKI	%	0.02	0.05	0.02	0.05	0.01	0.03
PLIVDI	%	0.30	0.29	0.32	0.30	0.40	0.33
Inputs							
LAND	acres	1,639	1,022	1,966	1,019	2,941	1,583
PCAPE	%	0.38	0.08	0.38	0.07	0.38	0.08
PCROPE	%	0.22	0.09	0.23	0.10	0.22	0.10
PLABORE	%	0.23	0.08	0.18	0.06	0.15	0.05
PLANDE	%	0.11	0.06	0.11	0.06	0.10	0.06
PLIVDE	%	0.07	0.10	0.09	0.12	0.15	0.15

CHAPTER 5 - Results

5.1 Efficiency Scores from Basic DEA Model by Year

Efficiency estimates for the 456 sampled Kansas farms from the DEA problems per year and subsequent calculations are displayed in Table 5.1. All efficiencies (technical, allocative, scale and overall) range from 0 to 1; equivalently the scores can be reported as ranging from 0% to 100%. The models were run for each year from 1998 to 2007 individually (i.e. rather than the alternative of running the model with all ten years together. The first option gives an estimate of the cost frontier for each year, and thus, the cost frontier is not the same from year to year as it may reflects fluctuating conditions, and surely, it will reflect the effect of technical change over the years. If all the years are used to calculate the cost frontier, there is only one cost frontier, and all observations are measured with respect to it. It is theoretically expected that if all farms' economic efficiencies for the sample were calculated for the 10 years together, the most efficient ones would be the ones in 2007 where technological advances are highest.

Results for the 10 years analyzed show that the annual average technical efficiency for the sampled farms ranges from a minimum value of 0.86 (or 86%) in 2007 to a maximum of 93% in 2006; the mean technical efficiency over the period is 90%. For the sampled farms and the years considered, farms could have reduced their input costs by an average of 10% to produce the same level of output if they had been fully technically efficient. Statistically, farms' technical efficiency was on average 7% better in 2006 than it was in 2007[32]. Technical efficiency mostly captures managers' skills and abilities in operating the farm. The results indicate that some factors in 2007 were unexpected for operators, and thus, their production decisions were not as good as they had been in 2006.

Allocative efficiency reflects the farm's ability to choose the combination of inputs to minimize input costs, given prices, the farm's output level, and its current technology. That is, AE measures the farm's performance in finding the input mix where the input price ratio equals the marginal rate of substitution between inputs. The average estimate for the sampled period

[32] The t-test value is 22.7, with 9118 degrees of freedom; the null hypothesis states that there is no difference between the average technical efficiency in 2006 and in 2007. The null was rejected at a 5% significance level indicating that the difference between the means is more than 0.

and farms was 0.80; farms could have produced the same level of output and reduced their input costs by as much as 20% by becoming fully allocatively efficient. The minimum average score was 0.75 and it occurred in 2007, whereas the maximum average score was 0.83 in 2004. For both technical and allocative efficiency, the minimum average annual estimates were found in the year 2007. The cost-minimizing input combination seems to have changed dramatically this year, maybe due to the new high prices of fuel and feed inputs during this year.

Average technical efficiency estimates for the farms over the sample period are higher than allocative efficiency. The distribution of scores reveals that 63% of the farms had a technical efficiency score above or equal to 0.90, whereas only 52% of the farms had an allocative efficiency score above or equal to 0.80. Thus, in terms of overall efficiency, farms in the sample for the period studied are more allocatively inefficient than technically efficient.

The relative performance of the farms' observed scale of operation and an optimal size (i.e. where constant returns to scale is obtained) was evaluated with scale efficiency. The average scale efficiency estimate for the sample was 0.87; if the average farm were operating at optimal scale, it could have produced the same level of output while reducing its input costs by 13%. The distribution of scores indicates 65% of observations had a scale efficiency score equal or larger than 0.87. Table 5.1 shows that the minimum average score was .84 and it occurred in 2003 and 2002, whereas the maximum average score was 0.91 in 2005. A T-test statistic of 22.92 (9118) demonstrates that the difference in average scale efficiency scores was statistically higher in 2005 than in 2003.

Overall efficiency is the product of technical efficiency, allocative and scale efficiency. Thus, this efficiency measure is affected and depends on the three components just mentioned. Table 5.1 shows the average annual farms overall efficiency estimate over the 10 years analyzed. The average value for all years is 0.633, indicating that on average over the years farms have been inefficient. If farms had been operating at optimal scale and operating on the minimum cost frontier, the average farm could have reduced its costs by 36.7% while producing the same level of output. The distribution of scores also indicated that close to 50% of observations had an overall efficiency score higher or equal than the overall average. The minimum estimated value for the average overall efficiency of the 456 farms was 0.057, it occurred in 2002; the maximum average score was 0.69 in 2004. A t-test statistic of 30.11 (9118 degrees of freedom) indicates that the average overall scores for the farms are higher in 2002 than in 2004.

Table 5.1 Summary of Estimates for Technical (TE), Allocative (AE), Scale (SE) and Overall (OE) Efficiency from 1988 to 2007

	1998		1999		2000		2001		2002	
Efficiency	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
TE	0.91	0.13	0.89	0.13	0.89	0.14	0.93	0.11	0.89	0.14
AE	0.80	0.13	0.80	0.12	0.80	0.13	0.82	0.11	0.76	0.13
SE	0.86	0.14	0.85	0.16	0.85	0.16	0.90	0.11	0.84	0.15
OE	0.62	0.18	0.62	0.19	0.61	0.18	0.69	0.17	0.57	0.19

	2003		2004		2005		2006		2007	
Efficiency	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Efficiency	Mean	Std. Dev.	Mean	Std. Dev.
TE	0.88	0.14	0.92	0.13	0.91	0.12	0.93	0.12	0.86	0.17
AE	0.80	0.12	0.83	0.12	0.81	0.12	0.82	0.13	0.75	0.15
SE	0.84	0.16	0.90	0.13	0.91	0.13	0.90	0.13	0.87	0.16
OE	0.59	0.19	0.69	0.18	0.67	0.18	0.69	0.18	0.57	0.20

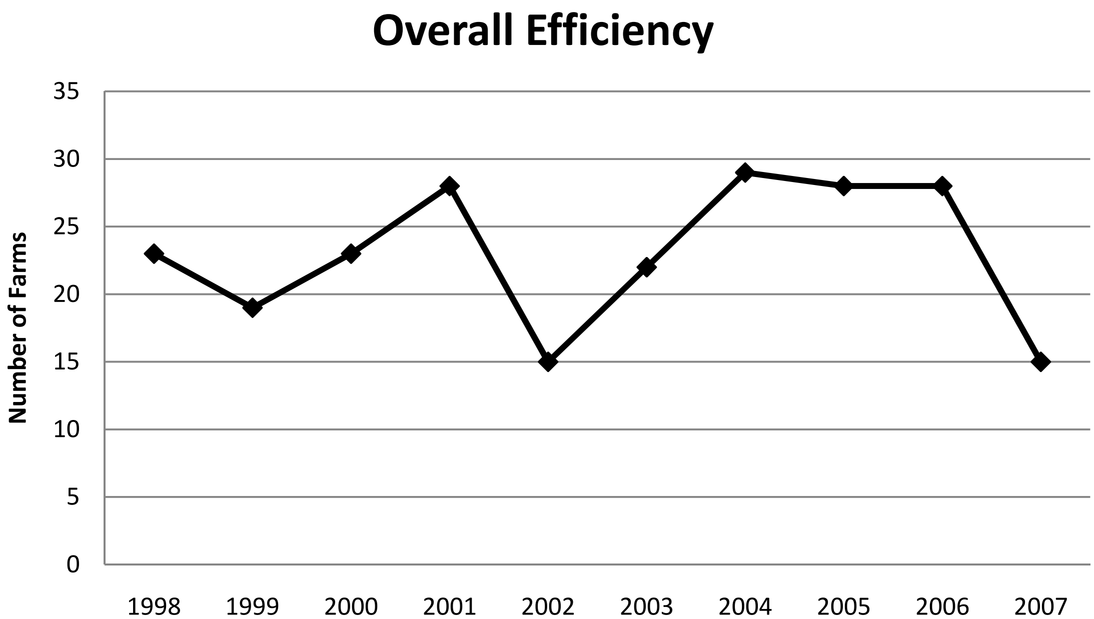
In terms of mean efficiency values across years, 2002 and 2007 seem to be the years when efficiencies were the lowest and thus furthest from the efficient frontier; the other extreme occurred in 2004, when some average efficiency measures (e.g., allocative and overall efficiency) reached their highest values. None of the farms in the data sample were technically, allocatively or overall efficient all 10 years of the study. Figure 5.1 traces the number of fully efficient farms by year. The percent of fully technically efficient farms is the highest among all efficiencies. Consistently every year, the percent of fully technically efficient farms is around 50% out of the 456 in the sample. The percent of fully allocative farms annually is around 10%; only around 5% of the farms were fully scale and overall efficient.

In general, results in Table 5.1 point to technical efficiency estimates as the highest of technical, allocative and scale efficiency contributing to overall efficiency. Scale efficiency scores are on average the second largest, and allocative scores are the smallest of the three measures. As overall efficiency depends on these three measures; it can be said that technical and scale influenced overall efficiency the most. Overall inefficiencies are then mainly due to allocative inefficiency. Overall efficiency takes into account inefficiencies due to the use of technology, input choice, and scale. These scores provide a complete evaluation of farm performance. In order to further investigate farms' overall efficiency and the characteristics of the most efficient ones, the following discussion groups farms according to their output specialization, their level of real gross income level as a proxy for size, and the level of farm debt. These categories were explained in Chapter 4, Section 4.3.

Among crop farms, which constitute around 44% of the total sample, 6% of the observations (out of the 44%) were fully overall efficient. Out of the livestock farms (12% out of the 456 farms), close to 7% of farms were fully overall efficient. Only 3.5% of all type mixed farms were overall efficient from 1998 to 2007. Overall efficiency results by farm output specialization seem to indicate that livestock and crop farms perform somewhat better than mixed ones, but these difference in efficiency were not statistically significant.

Regarding farm size, as approximated by farm real gross, farms were grouped into 4 categories consistently from group 1 (small farms) to group 4 (large farms) the percentage of fully overall efficient farms increased significantly. 102 observations were fully overall efficient among large farms, which represent close to 14% of farms in this 4th category. Conversely, only 1.2% of observations in the 1st category were fully overall efficient. In categories 2 and 3, fully

Figure 5.1 Number of Fully Efficient Farms (of 456 Farms) from 1988 to 2007



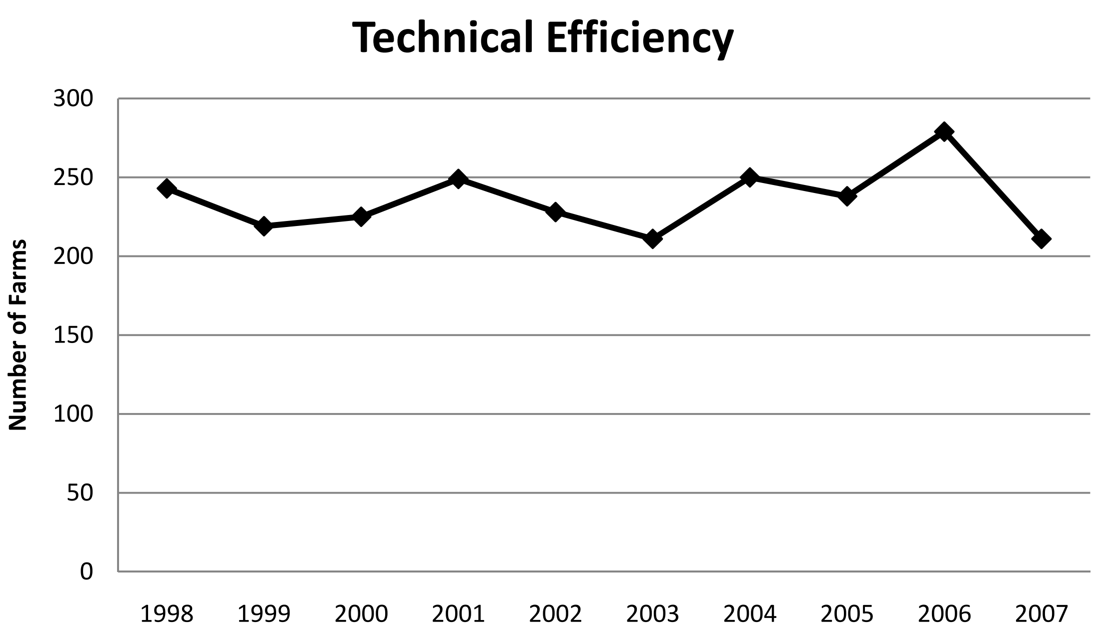
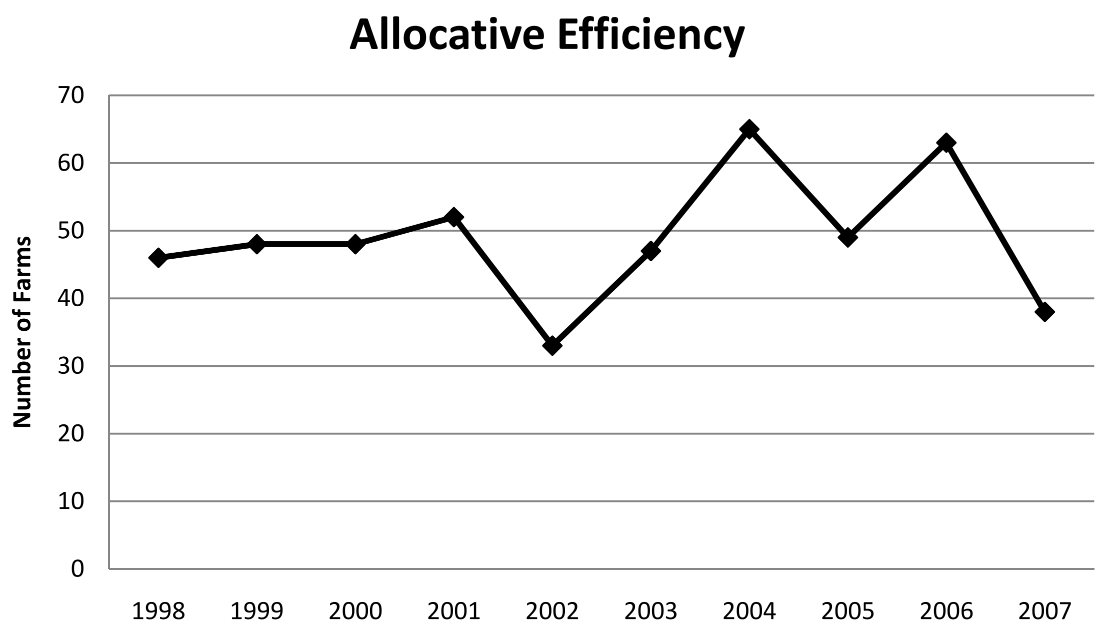
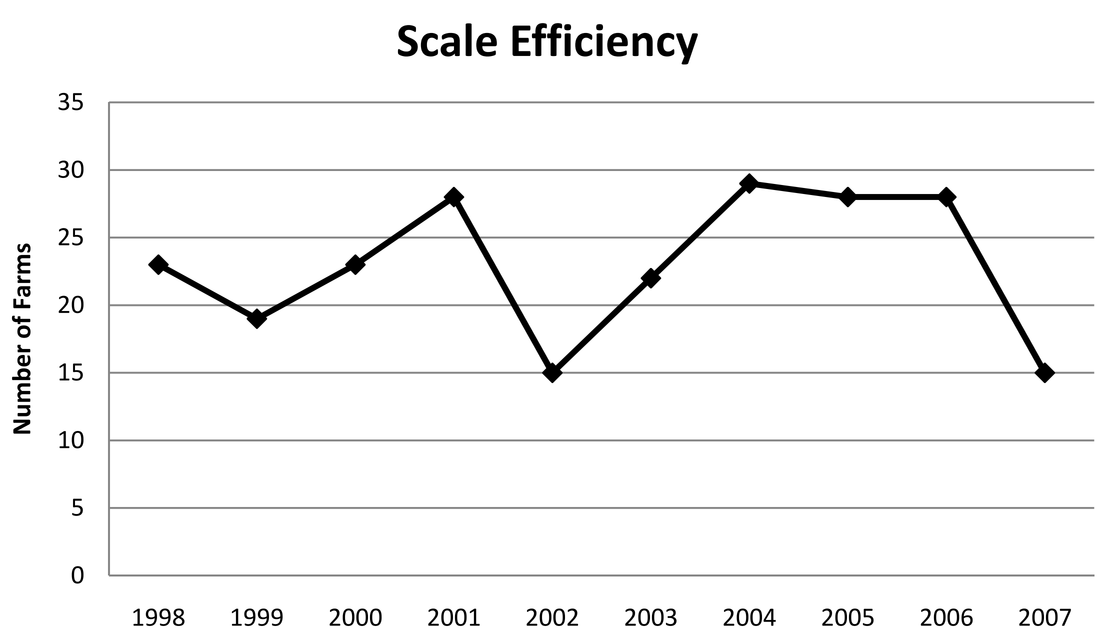


Figure 5.1 Continued





efficient observations accounted for 2.4% and 5% respectively, of all observations in these groups. These results suggest that size does influence overall efficiency in a positive way.

Among the 6 debt categories, fully overall efficient observations in categories 1 through 5 ranged from close to 3% to 6% within each group. 10% of farms in debt category 6 (representing the highest debt loads of more than half million dollars), were fully overall efficient, and this value was statistically different than those for the other debt groups. Thus, the level of debt does appear to influence overall efficiency, also implying it impacts technical, allocative and/or scale efficiency.

In summary, the type of farm in terms of output specialization, size as measured by real gross farm income, and total farm debt offered some reasons for the difference in value of farms' overall efficiency and their attainment of full overall efficiency. Section 5.3 in this Chapter is devoted to research socio-economic and individual farm factors that may influence farm efficiency scores in more detail using econometric methods.

5.2 Efficiency Scores in Debt-Constrained Model

This section presents efficiency scores when the level of farm debt is fixed. In this case, the level of debt, which is an approximation for the farm's capital availability, is regarded as a fixed input because it cannot be adjusted by the operator. Conceptually, this variable is similar to capturing and accounting for uncontrollable factors such as farm soil quality in the production process. As explained in Chapter 3, non-discretionary DEA models account for the direct effect on efficiencies of factors beyond the control of the operator. The level of total debt was used in this way to capture the direct effects of farm capital availability on production. The modified DEA model allows a reference farm to be compared in terms of their outputs, inputs, input prices to those farms that have a smaller or equal level of debt as the reference farm. Debt constrained farms can be thought of as not being able to achieve their potential due to their shortcoming in capital availability[33].

Table 5.2 provides summary statistics for the efficiency scores when the level of farm debt was fixed. Technical, allocative, scale and overall efficiencies and inefficiencies for the sample farms are listed for the two models, the basic and the debt-constrained model. The mean values for all farms all years revealed that on average, efficiency scores for the debt-constrained model were larger than those from the basic model. With the debt-constrained model, technical, allocative and scale efficiencies had mean values of 92%, 82%, and 89%, respectively. Each of the efficiencies had a mean which was 2% larger than the basic model. The average overall efficiency score under the debt-constrained model was 68%; which was 5% larger than the average overall efficiency score for the basic model.

[33] Specifically, the efficiencies under study correspond to the farm efficiencies scores obtained through the Non-discretionary DEA model or Debt-constrained DEA model. The farm efficiencies in these models were calculated as in the same way the basic DEA model. There were seven (discretionary) inputs and three outputs; however, this model was modified by adding the constrained that the farms were compared only to corresponding farms with the same or less level of debt. As pointed out before, the resulting the Debt-constrained model rendered farm efficiencies which were compared not only in terms of the discretionary inputs, but also in terms of their level of debt.

Table 5.2 Summary Statistics of Debt-Constrained Models for 456 Kansas Farms from 1988 to 2007

Model	Mean	Std. Dev.	Minimum	Maximum
Basic		Inefficiency Scores		
Technical	0.10	0.14	0	0.69
Allocative	0.20	0.13	0	0.83
Scale	0.13	0.15	0	0.94
Overall	0.37	0.19	0	0.99
Debt-Constrained		Inefficiency Scores		
Technical	0.08	0.13	0	0.69
Allocative	0.18	0.13	0	0.74
Scale	0.11	0.14	0	0.96
Overall	0.32	0.20	0	0.99
Basic		Efficiency Scores		
Technical	0.90	0.14	0.31	1
Allocative	0.80	0.13	0.17	1
Scale	0.87	0.15	0.06	1
Overall	0.63	0.19	0.01	1
Debt-Constrained		Efficiency Scores		
Technical	0.92	0.13	0.31	1
Allocative	0.82	0.13	0.26	1
Scale	0.89	0.14	0.04	1
Overall	0.68	0.20	0.01	1

For technical and overall efficiencies, these results are expected because of mathematical properties of the two linear programming problems from which the efficiencies are calculated. Compared to the basic models (see Table 5.1), the debt-constrained models (Table 5.2) impose an additional constraint requiring the farm under analysis to be compared to a “virtual reference farm” with the same or less debt. Otherwise the models are equivalent. Because both problems are minimization problems, the debt constrained problem must produce an objective value that is greater than that from the basic model. If the debt constraint does not bind, the solutions to the two types of problems are identical (by definition a non-binding constraint has no effect on the solution). If it does bind, this means the constraint is limiting the objective from reaching its previously low level. While TE and CE scores can only stay the same or increase, AE and SE may move in either direction because they are calculated as ratios of the TE and CE scores. To illustrate, note that AE can be calculated as AE = CE/TE. If, for example, adding debt constraints to the models caused a farm’s TE score to increase while leaving CE unchanged, its debt-constrained AE score would decrease. The opposite would be true if the farm’s TE score was unaffected while its CE score increased.

Table 5.2 also contains the average inefficiency scores for the sample for each model. The average sample inefficiencies for the basic model were larger than the ones for the debt-constrained model, imposed by the definition of inefficiencies as unity minus the farm efficiency score. The maximum values of inefficiencies were the same in both models for technical and scale efficiency; the maximum value for allocative inefficiency was larger in the basic model than in the debt-constrained one, however, it was the contrary for scale inefficiency.

Table 5.3 Summary Statistics of the Impact of Level of Debt on Efficiencies for 456 Kansas Farms from 1988 to 2007

Efficiency	Impact	Observations	Mean	Std. Dev.	Minimum	Maximum
Technical	Positive	877	0.09	0.09	0.01	0.48
	Negative	0				
	No Difference	3,683				
Allocative	Positive	1,590	0.07	0.09	2E-05	0.60
	Negative	464	-0.03	0.04	-0.27	-1E-07
	No Difference	2,506				
Scale	Positive	1,435	0.06	0.08	6E-08	0.56
	Negative	811	-0.03	0.05	-0.45	-2E-05
	No Difference	2,314				
Overall	Positive	2,002	0.10	0.11	6E-08	0.64
	Negative	0				
	No Difference	2,558				

Table 5.3 divides the sample into 3 groups for each efficiency measure: observations whose efficiency score increased under the debt-constrained model compared to the basic model, observations for which the debt-constrained efficiency score was lower than that under the basic model, and those for which the efficiency scores were the same in both models. The mean and other statistics in this table refer to the observed difference between efficiency scores according to the direction of the change. As discussed above, a farm's technical efficiency score from the debt constrained model can only be larger or identical to the score from the basic model. The mean technical efficiency score among the debt-constrained group (i.e., observations where the efficiency score rose) was 80%. The average increase in technical efficiency in this group was 9%. The mean technical efficiency for the unconstrained group (81% of the sample) was 92%. The difference in means across groups was statistically significant, implying that although constrained farms had higher technical efficiency scores when they are compared to farms with similar or worse debt levels, they still do not perform as well as unconstrained farms.

A similar story applies to overall efficiency. Again, mathematically, these scores can only increase or stay the same. The mean efficiency of constrained farms was 62%, while the mean efficiency for unconstrained farms was 63%. The difference between the means was significant at a 5% level. For constrained farms, their average efficiency score was 10% higher in the debt-constrained model than in the basic model.

In the case of allocative and scale efficiency, observations changed positively, negatively, and not at all. With respect to allocative efficiency, most observations were not constrained (55%); their mean allocative efficiency was 81%. 35% of observations were positively constrained in their allocative efficiencies; these observations' mean technical efficiency was 77%. Only 10% of the observations decreased their basic allocative scores; the average debt-constrained allocative efficiency for this group was 78%. Comparing scale efficiency scores between the debt-constrained model and the basic one gave these results: unconstrained farms had a mean scale efficiency of 87%, positively constrained farms had a mean scale efficiency of 84%, and negatively constrained farms had a mean scale efficiency of 89%. The difference in mean scale efficiencies between the latter two groups was statistically significant.

In general, Table 5.3 shows that for most efficiencies, except for scale efficiency, the farms that were not constrained by debt scored higher than the farms that were constrained. In the case of scale efficiency, negatively constrained farms performed the best. The farms that were constrained positively, despite the increase in efficiency accounted by the level of farm debt, scored lower than farms that were negatively constrained and their scored had decreased.

Farms in the sample showed that around 50% of all farms were debt-constrained, and thus they underutilized their level of debt relative to their optimal cost-efficient level or over utilized it. Farms constrained in the technical efficiency debt-constrained DEA model showed very low levels of the debt-to-asset ratio, around 0.10. Comparatively, unconstrained farms in the technical efficiency DEA model had a mean debt-to-asset ratio of .31. Such a gap in debt-to asset ratios suggests constrained farms were not using all their capital possibilities, maybe due to risk-aversion or price-uncertainty. Consistently, for all efficiencies reported in Table 5.3, non-debt constrained farms had a debt-to-asset ratio around 0.35; whereas constrained farms had a debt-to-asset ratio around 0.012.

5.3 Causes of Farm Inefficiencies and Efficiencies

The analysis continued with a two-step procedure where a series of panel Tobit models were used to regress DEA efficiency estimates on farm characteristics. The dependent variable in these regressions were the inefficiency scores (unity minus efficiency) from the basic DEA models reported in Section 5.1. The independent variables were financial, production, and socio-economic farm characteristics. Four models used socio-economic characteristics to measure their causality on inefficiency scores for technical efficiency, allocative efficiency, scale efficiency, and overall efficiency. In section 5.3.2, another set of four models used normalized input costs to measure the effect of input combination and allocation in the farms efficiencies.

Table 5.4 names and describes the variables used in these econometric Panel Tobit models. Table 5.5 gives summary statistics of the characteristics of farms selected as explanatory variables; these variables and the justifications for including them are described in detail below. The means reported are the overall average across all observations in the sample (all 456 farms for all 10 years, 1998-2007). The summary statistics provide a picture of the typical farm in the sample. The mean percentage of owned land is 35%, close to 80% of labor costs is devoted to crops, the farms earn an average of 32% with livestock operations, 66 with crop operations and a mean 2% with custom hire operations. The mean age for “older farmers” is 65. Farms have a mean debt of 28% of their assets; and the mean farm in the sample has as much as 30% of acreage as pasture grass. The mean farm in the sample spends $73 per acre in short and intermediate capital inputs. It spends equal proportions of total costs on land and fertilizer resources; and the average sample farm spends around $11 and $12 per acre in chemical and seed inputs respectively.

Table 5.4 Definition of Variables used in Basic DEA and Panel Tobit Models

Variable	Definition
AI	Allocative Inefficiency
CAPITA	Capital Costs per Acre
CHEMICA	Chemical Costs per Acre
FERTILA	Fertilizer Costs per Acre
LANDA	Land Costs per Acre
M55AGE	Variable for Operators Older than 55 Years
RNFICA	Net Farm Income per Acre
PCROPI	Percent of Income from Crops
PCWKI	Percent of Income from Custom Work
PLIVDI	Percent of Income from Livestock
OI	Overall Inefficiency
POWNA	Owned Acres as a Percent of Total Operated Acres
PPASTA	Pasture Acres as a Percent of Total Acres
SEEDA	Seed Costs per Acre
TDTA	Debt-to-Asset Ratio
OFFI	Off-farm Income
SI	Scale Inefficiency
TI	Technical Inefficiency
YEAR	Year from 88 to 107, 1988-2007

Table 5.5 Summary Statistics for Variables Included in Basic DEA and Panel Tobit Models

Variable	Unit	Mean	Std. Dev.
CAPITA	$	73	71
CHEMICA	$	11	9
FERTILA	$	17	14
LANDA	$	17	10
M55AGE	#	65	6
OFFI	$	12,990	19,832
PCROPI	%	0.66	0.31
PCWKI	%	0.02	0.04
PLABCROP	%	0.78	0.22
PLIVDI	%	0.32	0.31
POWNA	%	0.35	0.27
PPASTA	#	0.31	0.24
RNFICA	$	33	79
SEEDA	$	12	13
TDTA	%	0.28	0.23

5.3.1. Results of Causes of Inefficiencies

Four Tobit models of DEA Inefficiency estimates were performed to examine the farm characteristics that can influence farm inefficiencies. The influence of causality, positive (increasing) or negative (i.e. decreasing) and its magnitude were measured for a set of farm specific characteristics based on the literature review in Chapter 2. Farm inefficiencies are described in Section 5.2. The inefficiency are calculated as unity minus the farms' technical efficiency score yearly, the farms' allocative, scale and overall efficiency yearly; and all farms efficiency and inefficiency scores were derived using the for the basic DEA model.

The farm characteristics used as explanatory variables were selected based on the literature review in Chapter 2. The model includes 18 explanatory variables:

1. MFIAC, size of operation, measured by gross income per operated acre;
2. POWNA, the ratio of owned acres to operated acres;
3. OFFI, income from off-farm sources;
4. PLABCROP, percent of labor costs devoted to crops;
5. PLIVDI, percent of income from dairy and livestock operations;
7. PCWKI, percent of income from custom work;
8. M55AGE, combination of a dummy variable for farmers older than 55 years and their actual age;
9. TDTA, the ratio of debt-to-asset ratio;

10; PPASTA, percent of acres devoted to pasture grass;

11-18. YEAR 1998 to YEAR 2006, dummy year variables from 1998 to 2006 (the year 2007 is not included to avoid perfect collinearity.

Sections 3.4 and 5.1 pointed out how farm size could affect efficiency positively. Income as an approximation for farm size was preferred over total farm acreage since acreage could be a biased measure of size for multiple-enterprise farms. Gross income is hypothesized to increase efficiency. Income from off-farm sources is likely to influence how much time and incentive the operator has to spend on management activities, which may impact efficiency. The percentage of owned acres to operated acres is also included as it is likely to influence management decisions; owner operators may be more likely to have a longer-term planning horizon than those who rent most of their land.

Output specialization also is likely to affect efficiencies, so variables measuring the degree of farm specialization were introduced. The percentages of farm income from crops, livestock and custom work were included in the model. To avoid perfect collinearity, the percentage of income from crops, PCROPI, was eliminated from the model. Thus crop farms can be considered the “base” group in the model and the impact of adding another output to production was measured using the income variables related to livestock and custom work. As another indicator of specialization, the percentage of labor devoted to crops was also included in the model. The percent of pasture acres to total operated acres also can measure the allocation of the farm resources to the different enterprises. The impact of these specialization variables was hypothesized to depend on the efficiency measure being analyzed.

The financial structure of the farm was included in the analysis to capture the impact of financial position of the farm. As explained in Section2.6, the evidence regarding the impact of farms’ debt and the financing method is unresolved. Initial comparisons in Section 5.1 revealed some positive effect of the level of debt on farms’ overall efficiency. In Chapter 2, some compelling theories were considered to explain the effect, if any, of debt on efficiencies. Some of these theories implied a positive relationship between debt and efficiency while others implied a negative relationship. The direction of impact is thus indeterminate and may also differ across efficiency measures. A positive relationship between debt and efficiency would lend support, for example, to the embodied capital theory. Under this theory, the positive effect would reflect the benefits of the operators’ access to debt financing, which allows him or her to make timely purchases of variable inputs in the short run and investments in improved technologies and additional capital items to expand scale in the long run. However, the various theories are not mutually exclusive, so that a positive relationship would support other theories as well. This issue will be discussed again below based on the estimation results that follow.

The age variable accounted for older farmers as opposed to younger ones. Younger operators have fewer years of experience in managing the farm, which can influence the efficiencies in a negative way; however, one can also argue that younger operators tend to drive changes in technology. Older farmers, on the other hand, may be more eligible candidates for financial lenders as older operators tend to have more assets, and thus, more collateral and better prospects of repaying the loan. Again, the sign of this variable was undetermined, and it was most likely to depend on the efficiency measure being analyzed.

Finally, 8 year-specific dummies were introduced to account from efficiency measures changing from year to year as the optimal minimum cost frontier is calculated yearly. In addition, this variable accounted for time-varying factors such as weather, production pests or crop and livestock outbreaks and diseases. In consequence, the impact of this variable on each efficiency was difficult to hypothesize.

Tables 5.6 through 5.9 report the results of the technical inefficiency model, the allocative inefficiency model, the scale inefficiency model and the overall inefficiency model[34]. The tables include the estimated coefficients and their statistical significance, standard errors, z statistics, and significance level. The Z-test tests the null hypothesis that a given explanatory variable is statistically significant in explaining the variation in the dependent variable, given the other explanatory variables in the model. Most of the coefficients were statistically significant, although their significance level depended on the model. Also, the Tables report the number of observations for each model, the value of the log-likelihood function of the model and its significance, and finally, the log-likelihood ratio test for the significance of the panel effects.

First, in order to assess the causality of farm characteristics on the inefficiencies, including a comparison between the models, each characteristic's estimated coefficient was reported and compared by model. Because the dependent variables of the models were inefficiencies, negative signs imply that an increase in the levels of the explanatory variable would decrease levels of the corresponding inefficiency. For the sake of interpretation of the models, it should be noted that the base sample farm was a farm producing crops in 2007, thus, all effects of explanatory variables should be interpreted relative to the average farm in 2007.

[34] The Tables illustrate the results of a Panel Tobit estimation of each of the inefficiencies from the Basic DEA model and the farm characteristics described. The inefficiencies scores were the dependent variable; the farm specific characteristics were the independent or explanatory variables.

Table 5.6 Relationship between Technical Inefficiency and Farm Characteristics, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.5688*	0.1102	5.16	0
MFIAC	-0.0027*	0.0002	-17.97	0
POWNA	-0.0783*	0.0303	-2.59	0.01
OFFI	-5.09E-07	0	-1.36	0.173
PLABCROP	0.1132**	0.0512	2.21	0.027
PLIVDI	0.0128	0.0364	0.35	0.726
PCWKI	-0.9803*	0.1847	-5.31	0
M55AGE	-0.0058*	0.0015	-3.89	0
TDTA	-0.1256*	0.0395	-3.18	0.001
PPASTA	-0.0072	0.0417	-0.17	0.863
YEAR 1998	-0.1975*	0.0224	-8.8	0
YEAR 1999	-0.1412*	0.0212	-6.66	0
YEAR 2000	-0.1292*	0.0201	-6.43	0
YEAR 2001	-0.1879*	0.0199	-9.44	0
YEAR 2002	-0.1472*	0.0188	-7.83	0
YEAR 2003	-0.0651*	0.0174	-3.73	0
YEAR 2004	-0.1113*	0.0175	-6.36	0
YEAR 2005	-0.1488*	0.0173	-8.62	0
YEAR 2006	-0.1851*	0.0174	-10.61	0
N	4560			
Log Likelihood Function	-289.70*			
Wald Chi2 (18)	433.75			
Log L.R.T. Chibar2 (01) =	585.50*			

Note: * indicates significance at α = 0.01 level and ** at α = 0.05 level

Table 5.7 Relationship between Allocative Inefficiency and Farm Characteristics, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.3794*	0.0588	6.45	0
MFIAC	-0.0015*	0.0001	-21.95	0
POWNA	0.0095	0.0169	0.57	0.572
OFFI	-1.62E-07	0	-0.78	0.434
PLABCROP	0.0788*	0.0262	3	0.003
PLIVDI	0.0381**	0.0190	2	0.045
PCWKI	-0.5091*	0.0837	-6.08	0
M55AGE	-0.0013***	0.0008	-1.66	0.098
TDTA	-0.0555*	0.0211	-2.63	0.008
PPASTA	-0.0234	0.0223	-1.05	0.295
YEAR 1998	-0.1243*	0.0120	-10.34	0
YEAR 1999	-0.0900*	0.0115	-7.85	0
YEAR 2000	-0.0975*	0.0110	-8.86	0
YEAR 2001	-0.1343*	0.0107	-12.56	0
YEAR 2002	-0.0740*	0.0103	-7.16	0
YEAR 2003	-0.0897*	0.0097	-9.2	0
YEAR 2004	-0.1188*	0.0095	-12.53	0
YEAR 2005	-0.1038*	0.0094	-11.08	0
YEAR 2006	-0.1240*	0.0091	-13.56	0
N	4560			
Log Likelihood Function	1267.22*			
Wald Chi2 (18)	703.39			
Log L.R.T. Chibar2 (01) =	540.16*			

Note: * indicates significance at α = 0.01 level, ** at α = 0.05 level and *** at α = 0.10 level

Table 5.8 Relationship between Scale Inefficiency and Farm Characteristics, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	-0.0865	0.0670	-1.29	0.196
MFIAC	-0.0011*	0.0001	-18.99	0
POWNA	0.0595*	0.0176	3.37	0.001
OFFI	7.04E-07*	0	3.53	0
PLABCROP	0.0611*	0.0242	2.53	0.011
PLIVDI	0.1387*	0.0179	7.75	0
PCWKI	-0.2105*	0.0769	-2.74	0.006
M55AGE	0.0033*	0.0010	3.49	0
TDTA	-0.0445*	0.0218	-2.04	0.041
PPASTA	-0.0606*	0.0220	-2.76	0.006
YEAR 1998	-0.0398*	0.0117	-3.39	0.001
YEAR 1999	-0.0113	0.0111	-1.02	0.306
YEAR 2000	-0.0051	0.0104	-0.49	0.625
YEAR 2001	-0.0732*	0.0100	-7.36	0
YEAR 2002	0.0001	0.0095	0.01	0.995
YEAR 2003	0.0178**	0.0088	2.03	0.042
YEAR 2004	-0.0542*	0.0084	-6.44	0
YEAR 2005	-0.0820*	0.0082	-9.95	0
YEAR 2006	-0.0795*	0.0080	-9.97	0
N	4560			
Log Likelihood Function	1667.10*			
Wald Chi2 (18)	773.62			
Log L.R.T. Chibar2 (01) =	1273.83*			

Note: * indicates significance at α = 0.01 level and ** at α = 0.05 level

Table 5.9 Relationship between Overall Inefficiency and Farm Characteristics, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.4780*	0.0681	7.02	0
MFIAC	-0.0026*	0.0001	-35.65	0
POWNA	0.0120	0.0193	0.62	0.533
OFFI	4.72E-07**	0	2.02	0.043
PLABCROP	0.1206*	0.0291	4.14	0
PLIVDI	0.1128*	0.0214	5.26	0
PCWKI	-0.7539*	0.0930	-8.11	0
M55AGE	0.0007	0.0009	0.71	0.478
TDTA	-0.1231*	0.0241	-5.11	0
PPASTA	-0.0677*	0.0253	-2.67	0.008
YEAR 1998	-0.1665*	0.0134	-12.39	0
YEAR 1999	-0.1102*	0.0128	-8.6	0
YEAR 2000	-0.1042*	0.0122	-8.52	0
YEAR 2001	-0.2056*	0.0119	-17.29	0
YEAR 2002	-0.0981*	0.0115	-8.54	0
YEAR 2003	-0.0651*	0.0108	-6.05	0
YEAR 2004	-0.1579*	0.0104	-15.14	0
YEAR 2005	-0.1795*	0.0103	-17.39	0
YEAR 2006	-0.2010*	0.0101	-20	0
N	4560			
Log Likelihood Function	1246.2*			
Wald Chi2 (18)	1837.44			
Log L.R.T. Chibar2 (01) =	676.22*			

Note: * indicates significance at $\alpha = 0.01$ level and ** at $\alpha = 0.05$ level

Also, it should be noted that the estimated coefficients in the Tobit model are not equivalent to the expected marginal effects of the variables. The coefficients reflect the change in the dependent variable in response to each explanatory variable, conditional on the fact that the observation is not censored (in this case, conditional on an inefficiency score that is strictly positive). The marginal effects would account for the probability that the observation is not censored. The discussion below will present the regression coefficients and as such apply to the farms not on the efficiency frontier. However, in datasets such as ours, where there are relatively small number of censored observations, the coefficients and marginal effects are numerically similar. All marginal effects are reported in Appendix C.

The explanatory variables were found to have the following effects on inefficiency:

- MFIAC. The variable affected all inefficiencies negatively and was statistically significant in all 4 models. Overall and technical inefficiency decreased the most as the size of the farm increased. Conversely, allocative and scale inefficiency decreased the least as the size of the average sample farm increased. These results support the hypothesis that larger farms are more efficient.
- POWNA. This variables was statistically significant for technical and allocative inefficiency, but not for scale or overall inefficiency. The results indicate that as the ratio of owned acres increases, the level of technical inefficiency of our average crop farm in 2007 decreases; however, allocative inefficiency increased slightly.
- OFFI. Off-farm income was significant only for the scale and overall inefficiency model, and its magnitude was smaller[35] compared to the rest of the coefficients of the model.
- PLABCROP. The percent of labor costs devoted to crop outputs was significant and positive for all the models. The highest coefficient corresponded to the overall inefficiency model. The sign of the variable indicated that an increase in labor devoted to crops would increase all

[35] The effect is small in elasticity terms compared to the other variables, which is a valid way to compare across variables of differing magnitudes (see Appendix C).

inefficiencies. This could be interpreted as a sign that too much labor was allocated to crops for the sample average farm.

- PLIVDI. This variable was significant and positive for allocative, scale and overall inefficiencies. The largest value was for overall inefficiency. These results indicate that an increase in the livestock income would increase inefficiencies, suggesting diseconomies of scope between crop and livestock production.
- PCWKI. The percent of income from custom work per acre for the average sample farm was significant and negatively related to all inefficiencies. The magnitude of this variable's coefficients differed across models. The highest estimated coefficient corresponded to technical inefficiency. These results imply that custom work is a complement output to crop operations and economies of scope can be achieved by producing these outputs together.
- M55AGE. This variable was significant for all inefficiency models except for the overall inefficiency model. The magnitude of the coefficients are small in all models as compared to the rest of coefficients in the respective models. However, since age was measured in years and most of the other variables have values between zero and one, age elasticity ranged up to -0. 01; the effects were not so small when compared to other variables in terms of marginal effects[36].Additionally, results indicate that farmers older than 55 years are able to decrease technical and allocative inefficiency; however, older farmers increased scale inefficiency.
- TDTA. The liquidity variable was significant for all models. Higher levels of the ratio decreased all inefficiencies considerably. One explanation for these results is that lenders prefer borrowers with higher efficiency in production (i.e., the credit evaluation hypothesis). Another explanation is that debt levels affected efficiency favorably when assets grow, possibly through reinvestment in technology and long-term assets (i.e., the embodied

[36] See Appendix C for a report of corresponding marginal effects and elasticities.

capital hypothesis). The results of this variable are further discussed at the end of this section.

- PPASTA. The effect of pasture acre as percent of total operated farm acres was significant for all inefficiencies. An increase in the percent of pasture acres, as opposed to crop acres, decreased all inefficiencies for the sample mixed farm in 2007.
- YEAR 1998-YEAR 2006. All year dummies were significant in all models except the scale inefficiency model. In addition, in these three models, the yearly effects indicated that for all years the inefficiencies were reduced compared to 2007. The magnitude of the impact of the yearly variables was higher for most years for the technical and overall inefficiency models. The highest values across models were for the years 2001 and 2006.

In general, Table 5.6 through Table 5.8 suggest that most of the selected farm specific characteristics are significant in explaining farm inefficiencies. The percentage of income from custom hire work and the debt-to-asset ratio emerged as important factors that had a significant and positive impacts on all measures of efficiency. In general, the coefficient estimates on all variables were similar across the four models. The scale inefficiency model, in Table 5.8, was the most different among the models. First, the magnitude of the coefficients were relatively smaller than in the other models. Secondly, four of the year dummies are not significant (contrary to the rest of the models, where all were significant and shared the same sign). Also, there was some change in the direction of impact by some variables: the year 2003 increased scale inefficiency; the percent of acres owned also increased inefficiency, unlike technical efficiency. The results for the overall inefficiency model, Table 5.8, were similar in significance, magnitude and sign to most of the coefficients to the technical and allocative inefficiencies models. For overall inefficiency, all years decreased overall inefficiency. The overall largest effects on inefficiencies were the percent of income from custom work, percent of labor devoted to crop, size, age of operator , the years 2006, 2001, 2005, 1998, and 2004 respectively ; and finally the ratio of total debt to assets (Please, to look at the specific elasticity values, refer to Appendix C).

As pointed out in Chapter 2, the literature on finance and production has derived different hypothesis to explain the relation, if any, between efficiencies and the level of farm debt.

According to the regression analyses in this study, the total debt-to total asset ratio was found to have a positive effect on all efficiency scores. Three theories support these findings: credit evaluation, free cash flow, and embodied capital. All of them hypothesized a positive relationship between long term debt and a farms' technical efficiency. The first theory relates to lenders' expectations' on borrowers. Thus, efficiency is a cause of the level of debt. According to this, in Kansas, it could be the case that the most efficient farmers are given more credit capacity given lenders' high expectations of loan repayment. The second theory suggested that farmers who are indebted need to meet their repayment obligations; therefore, this fact can motivate them to improve their efficiencies. In this situation, Kansas farmers would be more in debt to achieve higher efficiency. The relationship between the first and second hypotheses is marked by a difference in the direction of causality between the level of debt and efficiency. The third and last theory emphasized the role of debt in adopting new technology. According to this latter hypothesis, farmers who invest the most, i.e. exploit higher capital availability and have higher debt levels, were able to apply new technologies and this contributes to them being more technically efficient. In this case, the level of debt and liquidity of the farm would be the cause for higher farm efficiency scores.

The theories can be distinguished by the direction of the causality between efficiency and financial leverage. Both the free cash flow and embodied capital theories posit that debt causes improved efficiency, while credit evaluation implies that efficiency causes more debt. Davidova and Latruffe (2007) implemented a procedure to test for exogeneity of the financial variable in Tobit models. The authors concluded that in their study, endogeneity of the financial variable could be rejected at a 5% significance level from his sample of individually owned farms (i.e. evidence against credit evaluation in their sample), but not from the state-owned farms. Baum's (1999) procedure for STATA to test to exogeneity in Tobit panel models was implemented in the present study. The null hypothesis that the total average debt to asset ratio is exogenous to the inefficiency estimates fails to be rejected at a 5 percent significance level. Thus, in this sample of mixed Kansas farms, the level of debt is exogenous and positively related to the farm's technical efficiency. The evidence here thus supports both the embodied capital theory, where more capitalized farms are able to incorporate newer and more productive technologies; and the evidence also point to the free cash flow theory where more indebted farmers feel forced to improve their efficiencies scores to respond to their debt repayment obligations. The same question answered with econometric methods, using a 2-step procedure, was also addressed in the previous section. There, all efficiency estimates when controlling for the level of debt showed on average than farms' efficiency increased. Both the non-parametric and parametric approaches have rendered the same results. The effect of debt, according to our sample, increases farm efficiencies.

5.3.2. Results of Input Usage on Efficiencies

The regressions above describe how farmer characteristics affect inefficiency, but they provide little insight on the behaviors of farmers that cause the inefficiency. Some farmers are likely to be less efficient than others because they make systematic errors in management, using excessive inputs in some categories while using too little in others. Following Featherstone, Langemeier, and Ismet (1997), I assess this question by performing panel Tobit regressions of the four types of DEA efficiency scores on input usage in different categories. The sets of inputs included all inputs used by the sampled farms to produce their outputs. They are expenditures per acre in land, capital, labor, seed, fertilizer and chemicals. Efficiency scores from the basic DEA problem are used as the dependent variables; they are technical efficiency, allocative efficiency, scale efficiency and overall efficiency respectively. Summary statistics of these scores were reported in Sections 5.1 and 5.2. The introduction to Section 5.3 contains a summary statistics of the input costs percents per acre for the sampled farms over the period examined.

Tables 5.10 to 5.13 describe Panel Tobit regressions in which efficiencies were regressed against seven categories of inputs utilized by the farms, and nine dummy variables to capture yearly unobserved factors such as weather, and crop and livestock diseases. These Tables correspond to a technical efficiency model, an allocative efficiency model, a scale efficiency model and an overall efficiency model. The Tables illustrate the results of the Panel Tobit estimation for each of the efficiencies and the farms' input usage. As in the previous section, the tables include the estimated coefficients and their statistical significance, standard errors, z statistics, and significance level. Tables report the number of observations for each model, the value of the log-likelihood function of the model and its significance, and finally, the log-likelihood ratio test for the significance of the panel effects.

In Table 5.10, results for the technical efficiency model show that three variables out of the 16 included in the model were not statistically significant. The input costs for land and livestock were not significant. All year dummies were significant except for the year 2003, and all influenced efficiency in a positive way; this could mean that over the period farms' technical efficiency has improved. This fact was theoretically expected as time usually increases the level of technology. The input costs that were significant were similarly small in magnitude. The findings support that an increase in the percent of the costs of labor increases technical efficiency slightly; the impact is more significant for an increase in the percent of livestock costs per acre. Theoretically, labor costs are mostly related to operators' cost or farms' profit; this explains the result that increasing costs to labor increased technical efficiency. The increase in technical efficiency as livestock costs increased was unexpected. With respect to the positive influence of livestock cost on technical efficiency, the finding could be seen in the light of results in Section 5.1 where specializing in livestock was slightly better than specializing in the other two outputs. The fact that this latter coefficient was low could be also the result of a biased problem in the specification of the variable. Percent of livestock costs per acre could be negatively biased with respect to the rest of the input variables considered since the beef and dairy expenses do not depend on operated acres as strongly (i.e. the correlation factor is considerably smaller) as crop and custom work inputs. Contrary to the effects of the variables just mentioned, the variables SEEDA, CHEMICA and FERTICA decreased the level of efficiency of the sampled farms, as input costs tend to affect farms technical efficiency. The largest effect in this model was the year 2006, maybe because it has been especially different from 2007, when some new industries such as ethanol production have affected the market for feed production and supply.

Table 5.10 Relationship between Technical Efficiency and Input Usage, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.8808*	0.0195	45.26	0
LANDA	0.0007	0.0007	1.01	0.313
LABORA	0.0008*	0.0003	2.9	0.004
LIVESA	0.0002	0.0002	1.11	0.268
CAPITA	0.0012*	0.0002	5.69	0
SEEDA	-0.0023*	0.0005	-4.43	0
CHEMICA	-0.0022*	0.0006	-3.48	0.001
FERTILA	-0.0010**	0.0004	-2.26	0.024
YEAR 1998	0.0508*	0.0141	3.6	0
YEAR 1999	0.0295**	0.0142	2.08	0.038
YEAR 2000	0.0339**	0.0140	2.42	0.016
YEAR 2001	0.0844*	0.0140	6.01	0
YEAR 2002	0.0387*	0.0139	2.79	0.005
YEAR 2003	0.0198	0.0136	1.45	0.146
YEAR 2004	0.0802*	0.0139	5.78	0
YEAR 2005	0.0710*	0.0136	5.22	0
YEAR 2006	0.1117*	0.0140	8	0
N	4560			
Log Likelihood Function	-900.02*			
Wald Chi2 (16)	255.44			
Log L.R.T. Chibar2 (01) =	1082.95*			

Note: * indicates significance at $\alpha = 0.01$ level and ** at $\alpha = 0.05$ level

Table 5.11 Relationship between Allocative Efficiency and Input Usage, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.7503*	0.0103	72.71	0
LANDA	0.0001	0.0004	0.15	0.878
LABORA	-0.0003**	0.0001	-2.51	0.012
LIVESA	0.0003*	0.0001	3.65	0
CAPITA	-0.0001	0.0001	-0.57	0.566
SEEDA	-0.0003	0.0003	-1.2	0.231
CHEMICA	0.0007**	0.0003	2	0.046
FERTILA	0.0005**	0.0002	2.09	0.037
YEAR 1998	0.0570*	0.0078	7.35	0
YEAR 1999	0.0571*	0.0078	7.28	0
YEAR 2000	0.0522*	0.0078	6.7	0
YEAR 2001	0.0805*	0.0077	10.46	0
YEAR 2002	0.0108	0.0077	1.4	0.162
YEAR 2003	0.0547*	0.0077	7.15	0
YEAR 2004	0.0932*	0.0076	12.21	0
YEAR 2005	0.0684*	0.0075	9.06	0
YEAR 2006	0.0798*	0.0076	10.55	0
N	4560			
Log Likelihood Function	2256.21*			
Wald Chi2 (16)	299.09			
Log L.R.T. Chibar2 (01) =	1180*			

Note: * indicates significance at α = 0.01 level and ** at α = 0.05 level

Table 5.12 Relationship between Scale Efficiency and Input Usage, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.8518*	0.0100	85.18	0
LANDA	0.0014*	0.0004	3.72	0
LABORA	-0.0008*	0.0001	-8.22	0
LIVESA	0.0003*	0.0001	4.43	0
CAPITA	0.0003*	0.0001	3.17	0.002
SEEDA	0.0002	0.0002	0.91	0.364
CHEMICA	0.0004	0.0003	1.41	0.158
FERTILA	-0.0001	0.0002	-0.73	0.464
YEAR 1998	-0.0123**	0.0061	-2.01	0.044
YEAR 1999	-0.0181*	0.0062	-2.92	0.003
YEAR 2000	-0.0189*	0.0062	-3.08	0.002
YEAR 2001	0.0342*	0.0061	5.63	0
YEAR 2002	-0.0295*	0.0061	-4.83	0
YEAR 2003	-0.0315*	0.0060	-5.22	0
YEAR 2004	0.0378*	0.0060	6.3	0
YEAR 2005	0.0439*	0.0060	7.36	0
YEAR 2006	0.0387*	0.0060	6.5	0
N	4560			
Log Likelihood Function	3567.45*			
Wald Chi2 (16)	563.66			
Log L.R.T. Chibar2 (01) =	2186.98*			

Note: * indicates significance at α = 0.01 level and ** at α = 0.05 level

Table 5.13 Relationship between Overall Efficiency and Input Usage, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.5536*	0.0138	40.01	0
LANDA	0.0010**	0.0005	1.98	0.047
LABORA	-0.0009*	0.0001	-6.51	0
LIVESA	0.0005*	0.0001	4.92	0
CAPITA	0.0003**	0.0001	2.11	0.035
SEEDA	-0.0003	0.0003	-0.85	0.396
CHEMICA	0.0006	0.0004	1.39	0.164
FERTILA	0.0002	0.0003	0.81	0.42
YEAR 1998	0.0600*	0.0098	6.1	0
YEAR 1999	0.0495*	0.0100	4.97	0
YEAR 2000	0.0388*	0.0099	3.92	0
YEAR 2001	0.1245*	0.0098	12.74	0
YEAR 2002	0.0087	0.0098	0.89	0.373
YEAR 2003	0.0293*	0.0097	3.01	0.003
YEAR 2004	0.1334*	0.0097	13.78	0
YEAR 2005	0.1141*	0.0096	11.89	0
YEAR 2006	0.1288*	0.0096	13.44	0
N	4560			
Log Likelihood Function	1567.11*			
Wald Chi2 (16)	582.59			
Log L.R.T. Chibar2 (01) =	1301.34*			

Note: * indicates significance at $\alpha = 0.01$ level and ** at $\alpha = 0.05$ level

Most of the variables in the Allocative Efficiency Model in Table 5.11 are significant and positive. All years have affected allocative efficiency positively (except for year 2002, which is not significant), implying that the allocative efficiency of the farms increased from year to year prior to 2007. Input costs which affect allocative efficiency in a positive way were LIVESA, CHEMICA, and FERTILA. These results indicated that livestock related inputs, chemicals and fertilizers were being over utilized; whereas labor and seed were being underutilized. Farms could then improve their allocative efficiency by reallocating the input usage. Variables in this model had magnitudes similar to the preceding model. The largest effect on allocative efficiency was the positive effect of year 2004. This year was mentioned in Section 5.1 as an especially good year for farms' efficiencies over the period studied.

The model of Scale Efficiency is illustrated in Table 5.12. Similar to the model were inefficiencies were explained in terms of their causes, this model shows how the same factors affect efficiency in different magnitudes and ways. All years but one were significant in this model; however, four out of the nine years considered had a negative influence on scale efficiency. Results suggest that farms in the latter years of the sample have decreased their level of scale efficiency with respect to the optimal yearly frontier. This fact would be mostly explained by examining the returns of scale of the sampled farms over the sampled period. Also, it is worth noticing the sharp movements in consolidation and adaptation of farms in recent years, which could be related to scale efficiency. The variables SEEDA, CHEMICA, FERTILA were not statistically significant, as the year 2001 was not. The input variables LANDA, LIVESA, and CAPITA increased the levels of scale efficiency of the sampled farms. Farms could increase costs of these inputs to increase their level of scale efficiency, and decrease labor costs since they affect scale efficiency negatively.

Table 5.13 summaries the results for the Overall Efficiency Model. As in most of the preceding models, all year dummies affect overall efficiency scores in a positive way. All years seem to have increased overall efficiency compared to 2007. The highest impacts were from the year 2001 and 2006. The input variables LANDA, LIVESA, and CAPITA increased the levels of overall efficiency of the sampled farms. The input variables LABORA and SEEDA decreased the levels of overall efficiency of the sampled farms. The variables CHEMICA, FERTILA, and YEAR 2002 were not statistically significant. In overall terms, the input usage variables have considerably smaller coefficients, especially when compared with yearly effects. These findings apply to all models explained in this section.

In summary, the models in this sub-section were consistent in that most of the yearly individual effects were significant and mostly were positively related to efficiencies. The models also showed that input usage affected efficiencies in different ways. For example labor costs affected technical efficiency in a positive way, but impacted overall efficiency in a negative way; the magnitude of the impact was similar in both cases Overall, only labor and seed expenditures could be lowered to improve the level of overall efficiency of the farms. However, the impact is quite small. Overall, the year 2004 was when overall efficiency of farms increased the most towards the optimal cost frontier.

CHAPTER 6 - Conclusions and Implications

The literature review described the results of prior research on farm efficiency covering numerous geographical regions of the United States and several other countries. These studies applied many different frontier approaches, both parametric and non-parametric. The efficiency estimates from non-parametric studies are similar to those from parametric frontier models, but the nonparametric methods generally yield lower mean efficiency estimates and seem to have greater dispersion than the results of the parametric models. The number of research questions addressed and answered have been considerable; new or modified methods and data sampling are the important contributions now at the research frontier.

In this dissertation, the efficiencies of 456 sampled farms, chosen to be representative of members of the KFMA, were analyzed from 1998 to 2007 using different factors to address the objectives stated in Chapter 1. In general, in this dissertation as well as in previous studies related to Kansas, efficiency scores for technical, allocative and scale efficiency were around 80% to 90%. Overall efficiency had lower scores, 68%, also in line with previous research conducted on Kansas farms. Unlike technical efficiency and other efficiency measures, overall efficiency scores have not been reported in many previous research articles. The similarity in efficiency values for farms across different studies suggests that estimates of mean efficiency for farms may be a reliable guide for policy and research purposes.

6.1 Implications of Sources of Inefficiency in Kansas Farms

The inefficiency Panel Tobit models helped us identify some causes that explain the sampled farms' inefficiency scores. By reciprocity of efficiency and inefficiency scores, the models gave insight into the factors which affected efficiencies the most, and in which direction.

The results of the farms' efficiencies have shown the importance of the link and influence of the size of the farm operation on the farms' efficiencies. Larger farms seemed to have a competitive advantage over smaller farms in terms of choosing and having access to more optimal input bundles for their operations. Larger farms were more technically, allocatively, scale, and overall efficient, lending robust support to the hypothesis that size is associated with improved efficiency. Farms specializing in livestock products such as dairy and beef were reported to be slightly more overall efficient than crop or mixed farms. The effect of the ratio of owned to operated acres depended very much on the efficiency measure considered. It was significant and positively related to technical efficiency, but negatively related to allocative efficiency. Off-farm income was not significant in explaining the efficiency scores. However, the percent of labor costs devoted to crop outputs indicated that too much labor was dedicated to crops, and that the multi-output representative Kansas farm could reduce all efficiencies by decreasing the costs of labor devoted to crop operation.

Very interestingly, results also showed a high degree of complementarity between farm crop operations and custom work, suggesting the existence of economies of scope between these two outputs. However, the results suggested diseconomies of scope between crop and livestock farm operations. Operators' age rendered different results. Older farmers achieved better farm technical and allocative efficiencies, but the effect was the opposite for scale efficiency. This result seemed to indicate that experience is important in choosing optimal input bundles, as well as managing the farm's operations (i.e. managerial skills). However, it seemed that younger farmers were best at deciding on the farm's scale of operation. The effect of pasture acres as opposed to crop acres was positive for all efficiencies. For the representative mixed Kansas farm, a decrease in crop acres would increase all efficiencies. This finding corroborates other evidence that livestock farms have a tendency to perform better than crop farms, and mixed farms.

The impact of the yearly variables on Kansas efficiencies was significant and mostly positive. The effect was higher for most years for technical and overall efficiency. The highest impacts across models for all years were for the years 2001 and 2006.

The financial leverage variable (debt to asset ratio) was significant for all models. Higher levels of the ratio increased all efficiencies considerably. These results could have different implications: They can imply that lenders prefer borrowers with higher efficiency in production (i.e. credit evaluation hypothesis). But also, these results might suggest that debt levels affected efficiency favorably when assets grow, possibly through reinvestment in technology and long-term assets (i.e. embodied capital hypothesis).

During the time period studied, it is clear that most farms invested heavily in equipment and infrastructure (as measured by the debt-to-asset ratio), and that this positively affected their overall efficiency scores. According to this hypothesis, farms that invest the more in capital farm stocks are the ones that promote technical change and end up in the best practice frontier (Chavas and Aliber 1993, "Embodied capital hypothesis"). This finding was supported by the fact that age was a positive factor in efficiency because age can be a proxy both for experience and for the probability of technological adoption on the farm. Thus, the difference between the two hypotheses in explaining the results could be the direction of the causality between efficiency and financial leverage. With the sampled farms used, the embodied capital hypothesis seemed to fit better the results of the positive influence of capital availability on efficiencies. More capitalized farms are able to incorporate newer and more productive technologies. The findings also lend support to the free cash flow theory, which suggests that more indebted farms are more efficient because of lender oversight.

The impact of debt on efficiency was also addressed in using non-econometric methods, particularly a discretionary DEA model. The results of this model agreed with the 2-step econometric results just discussed. In the DEA model, when debt is taken into account as one more factor of production, all average estimates of all efficiencies increased when controlling for the level of debt. Both the non-parametric and parametric approaches have rendered the same results. The effect of debt, according to our sample, increased farm efficiencies, especially technical and overall efficiencies.

Regarding efficiencies and the impact of input usage, the results of the Efficiency Panel Tobit models showed that input usage affected efficiencies in a different way. For example, labor costs affected technical efficiency in a positive way, but it affected overall efficiency in a negative way; the magnitude of the impact was similar in both cases. In regards to allocative efficiency, results indicated that livestock related costs and chemical and fertilizer costs were being over utilized; whereas labor and seed were being underutilized. As for scale efficiency, farms could increase expenditures on livestock, capital and land inputs to increase the farms level of scale efficiency. Additionally, the farms could decrease labor costs since they affect scale efficiency negatively. Finally, in the case of overall efficiency, only labor and seed expenditures could be lowered to improve the level of overall efficiency of the farms. In general, the year 2004 was when overall efficiency of farms increased the most towards the optimal cost frontier, the year 2006 was the second higher positive yearly impact.

6.2 Implications from the Impact of Debt on Efficiencies in Kansas Farms

The non-discretionary DEA models accounted for the direct effect on efficiencies of factors beyond the control of the operator. In this case, the level of total debt was used to capture the direct effects of farm capital availability, i.e. the level of debt on production efficiencies. The farm efficiencies calculated with this model are based on comparisons to other farms that have a lesser or equal level of debt.

The mean efficiency scores from this model were 92%, 82%, and 89%, for technical, allocative, and scale efficiency, respectively. Each of the efficiencies had a mean that was 2% higher than in the basic model. Similarly and according to the calculation of overall efficiency as a multiplicative function of the other three efficiencies, the average overall efficiency score was 68%; 5% larger than the average overall efficiency score for the basic model. In conclusion and for this sample of farms and years, farm's efficiencies systematically rose when controlling for the level of farm debt.

A detailed comparison of the changes in farms' efficiencies derived from the debt-constrained model and those efficiency estimates derived from the basic model, offered a unique characterization of the farms. Some farms' efficiencies were found to increase when accounting for the level of debt, that is, their efficiency score from the debt-constrained model was better than the corresponding one from the basic model. For some other farms, the level of debt impacted certain types of efficiencies negatively, decreasing them with respect to the basic model. And for the last group of farms, the level of debt did not impact at all their efficiency scores. This latter group of farms is referred as unconstrained farms because their fixed level of debt did not impede them to achieve their optimum. In terms of technical, allocative, scale and overall efficiency, close to 20%, 45%, 49 % and 44%, respectively, of farms in the whole sample were constrained by their level of debt.

Among the constrained farms, the technical and overall efficiency scores of all constrained farms increased compared to scores in the basic model. By the mathematical properties the DEA programming models, debt constraints can only change these efficiency measures in a positive direction or not at all. Nevertheless, even when controlling for their debt levels, these farms as a group were less efficient, both in terms of technical and overall efficiency, than unconstrained farms. For allocative and scale efficiency, some farms' efficiency scores changed positively when controlling for their level of debt while others' scores were impacted negatively. The majority of these farms changed in a positive way, and for an average 13% of farms, the effect of debt was negative. These results suggest that positively influenced debt-constrained farms could benefit from having and using more debt; and conversely, constrained farms were negatively influenced by their debt levels and were carrying "too much debt." Farms debt-constrained (for all efficiencies) showed very low levels of the debt-to-asset ratio, averaging around 0.12. Comparatively, unconstrained farms had a mean debt-to-asset ratio of 0.35 (for all efficiencies). Such a gap in debt-to asset ratios suggest that in general constrained farms were not using all their capital possibilities, as the DEA result suggest that most debt-constrained farms could increase their efficiency scores if they could take on more debt. The reasons for these farmers under-utilizing debt capital is a topic for future research, discussed in more detail below. Possible causes to investigate include risk-aversion, price uncertainty, and government programs. Another topic for investigation is why some debt-constrained farms have efficiency scores that are negatively impacted by debt.

6.3 Future Research

The management performance-efficiency literature on farms was among the least developed of the different types of applications of farm efficiency. Farm efficiency and factors such as debt, and other forms of "managerial skills" offers an opportunity to provide managers, policy makers, and lenders with information that may help identify input misallocation and improve farm performance. To further contribute to this field of research and complementing the purpose of this dissertation, some additions into the models could be of help in answering the research question.

First, the use of more financial ratios as a reflection of the financial performance of the farm would be of great interest regarding their impact on efficiencies. These additional ratios might include additional leverage ratios differentiated by the time frame (e.g., long versus intermediate term), and profit ratios. Other useful information to incorporate would be the effect of the source of finance and the different type of loans; crop sharing, bank intermediate loans and others could have different impacts on the efficiency of farm behavior regarding debt. Surely, incorporating operators' risk attitude (degree of risk aversion) into the problem could provide some insight into why some farmers with similar assets are more prone to obtain a loan, whereas others are less prone to. Government programs and their effects is another variable which could impact efficiencies and farmers' financial management. In this dissertation, Appendix D presents an exploratory study on farms that are debt-constrained versus these farms that are not. The sample of farms was divided to test why some farms increased their efficiency levels in face of debt levels, while some others do not. A detailed and conscientious study of technical, allocative, scale and overall efficiency focusing on the factors determining the positive or negative impact of debt and accounting for possible sampling bias selection would be of great interest and value.

A related question is the optimal level of debt that maximizes farm efficiency performance. Addressing this question would likely involve new or modified efficiency analysis techniques, which likely could shed new light on such issues as the influence of access to debt financing and how farms may misallocate inputs in order to comply with debt obligations

The field of efficiency estimation is undergoing a big transition. There are a number of important methodological developments in the broader efficiency literature under way that may help resolve some of the conflicts among methods. These improvements may make efficiency estimation more accurate, and help find the determinants of efficiency. For the nonparametric techniques, these developments include non-radial measures, the use of "composite" frontiers which embody the best parts of different decision making units, the use of output distance functions, measurement of confidence intervals, optimization of the number of constraints, and finding a statistical basis for the non-stochastic approaches. A re-sampling of the data sets may be useful to account for some of the random error in the farm accounting data sets.

Finally and throughout this dissertation, numerous studies on efficiency applied to agricultural economics problems have been discussed. Their results have been highly informative and helpful for interested parties. However, these methods are by no means limited to addressing problems related to agricultural economics. Efficiency analysis is used to investigate any production process, such as the transformation of doctors' number and hospital facilities into patients' recovery. Efficiency studies are an increasingly widespread tool to learn how to improve production processes. They are very actively used in fields such as health economics and the engineering sciences. Results from these applications influence many parties. In terms of applications, research on efficiency largely focused on using efficiency estimates and causality factors. These findings are used: (1) to inform government policy makers and concerned parties on industry efficiency and tendencies; (2) to address research issues by determining how efficiency varies according to selected factors and identifying the operators who make the most informed decisions; and (3) to improve managerial performance by identifying best-practice farms. Efficiency analysis has a promising future in many research areas.

REFERENCES

Afrait, S.N. (1972) "Efficiency Estimation of Production Functions", *International Economic Review*, 13, 568-598.

Barry, P.J., C.B. Baker and L.R. Sanint (1981) "Farmers' Credit Risks and Liquidity Management", *American Journal of Agricultural Economics*, 63, 216-227.

Barry, P.J. and L.J. Robinson (2001) "Agricultural Finance: Credit, Credit Constraints, and Consequences", *Handbook of Agricultural Economics: Agricultural Production*. B.L. Gardner and G.C. Rausser, eds. Amsterdam: Elsevier Science B.V.

Baltagi, B.H. (2001) Econometric Analysis of Panel Data John Wiley & Sons Ltd., West Sussex, England.

Battese, G.E. (1992) "Frontier Production Functions and Technical Efficiency: A Survey of Empirical Applications in Agricultural Economics". *Agricultural Economics*, 7, 185-208.

Battese, G.E. and T.J. Coelli (1992) "Frontier production functions: Technical Efficiency and Panel Data: With Application to Paddy Farmers in India", *J. of Productivity Analysis*, 3, 153-169.

Battese, G.E. and T.J. Coelli (1995) "A Model for Technical Efficiency Effects in a Stochastic Frontier Production Function for Panel Data", *Empirical Econ.*, 3, 153-169.

Baum, C. (1999) "Probexog-Tobexog: Stata Modules to Test Exogeneity in Probit/Tobit", Statistical Software Components, no. s401102, Boston College, at http://ideas.repec.org/c/boc/bocode/s401102.html.

Bierlen R. and A. M. Featherstone (1998) "Fundamental q, Cash Flow, and Investment: Evidence from Farm Panel Data", *Rev. of Econ. and Stat*., 80, 427-435.

Boles, J.N. 1966 "Efficiency Squared – Efficiency Computation of Efficiency Indexes", *Proceedings of the 39th Annual Meeting of the Western Farm Economics Association*, pp. 137-142.

Bravo-Ureta, B.E. and A.E. Pinheiro (1993) "Efficiency Analysis of Developing Country Agriculture: A review of the Frontier Function Literature", *Agriculture and Resource Economics Review, 22, 88-101*.

Chambers, R. G. (1988) Applied Production Analysis, Cambridge University Press, Cambridge.

Chavas, J.P. and M. Aliber (1993) "An Analysis of Economic Efficiency in Agriculture: A Non-Parametric Approach", *J. of Agr. And Resource Econ*., 18, 1-16.

Charnes A., B. Cooper, and Rhodes (1978) "Measuring the Efficiency of Decision Making Units", *European J. Operations Research*, 429-44.

Coffey, B.K. and A. Featherstone (2004) "Nonparametric Estimation of Multiproduct and Product-Specific Economies of Scale", KSU, Manhattan, KS. *Presented at SAEA Annual Meetings, Feb. 14-18, Tulsa, OK*.

Coelli, T.J., D.S.P. Rao and G.E. Battese (2005) An Introduction to Efficiency and Productivity Analysis, Kluwer Academic Publishers, Boston, US.

Coelli, T., S. Rahman, and C. Thirtle (2002) "Technical, Allocative, Cost and Scale Efficiencies in Bangladesh Rice Cultivation: A Non-parametric Approach", *J. of Agricultural Economics*, 53, 3, 607-626.

Coffey, B.K. and A. Featherstone (2004) "Nonparametric Estimation of Multiproduct and Product-Specific Economies of Scale", Selected Paper, Southern Agricultural Economics Association Meetings, February 14-18, Tulsa, Oklahoma

Davidova S. and L. Latruffe (2003) "Technical Efficiency and Farm Financial Management in Countries in Transition", Working Paper 03-10, INRA, France.

Davidova S. and L. Latruffe (2007) "Relationships between Technical Efficiency and Financial Management for Czech Republic Farms", *J. of Agricultural Economics,* 58 (2) 269-288.

Dhungana, B.R., P.L. Nuthall and G.V. Nartea (2004) "Measuring the Economic Inefficiency of Nepalese Rice Farms Using Data Envelopment Analysis", *Australian J. of Agr. and Resource Econ.*, 48 (2) 347-369.

Economic Research Service (2008) "Kansas Agricultural Exports Estimates for FY 2006". In State Fact Sheets: Kansas", United State Department of Agriculture, http://www.ers.usda.gov/stateFacts/KS.htm.

Ellinger, P.N. and P.J. Barry (1991) "Agricultural Credit Delivery Costs at Commercial Banks". *Agricultural Finance Review*, 51, 64-78.

Ellinger, P.N., N.S. Splett, and P.J. Barry (1992) "Consistency of Credit Evaluation Procedures at Agricultural Banks", *Agribusiness: An International Journal*, 8, 517-536.

Färe, R., S. Grosskopf and H. Lee (1990) "Nonparametric Approach to Expenditure- Constraint Profit Maximization", *Amer . J. Agr. Econ.*, 72, 574-81.

Färe, R., S. Grosskopf and C.A.K. Lovell (1994) *Production Frontiers*, Cambridge University Press, Cambridge.

Färe, R., S. Grosskopf and D. Margaritis (2005) "Efficiency and Productivity: Malmquist and More" in H.O. Fried, C.A.K. Lovell and S.S. Schmidt (eds.) *The Measurement of Productive Efficiency and Productivity Growth*, Oxford University Press, Oxford.

Farrell, M.J. (1957) "The Measurement of Productive Efficiency", *Journal of Royal Statistics Society,* 120, 11-37.

Featherstone, A.M., J.C. Griebel, and L.N. Langemeier (1992) "Comparison of the Farm Management Association Data to the USDA Farm Cost and Return Survey Data", Farm and Financial Management Newsletter, Department of Agricultural Economics, Kansas State University, Manhattan, April.

Featherstone, A. M., G.A. Ibendahl, J.R. Winter, and A. Spaulding (2005) "Farm Financial Structure", *Agricultural Finance Review*, 65(2), 97-117.

Featherstone, A.M. and A.A. Al- Kheraiji (1995) "Debt and Input Misallocation of Agricultural Supply and Marketing Cooperatives", *Applied Econ*., 27, 871-78.

Featherstone, A.M., M.R. Langemeier and M. Ismet (1997)"A Nonparametric Analysis of Efficiency for a Sample of Kansas Beef Cow Farms", *J. of Agricultural and Applied Economics*, 29, 1, July 1997:175-184.

Ferrier, G. D., and Lovell, C. A. K. (1990) "Measuring Cost Efficiency in Banking: Econometric and Linear Programming Evidence", *Journal of Econometrics*, vol. 46, 229-245.

Fried, H.O., D.A.K. Lovell and S.S. Schmidt (2005) "Efficiency and Productivity" in H.O. Fried, C.A.K. Lovell and S.S. Schmidt (eds.) *The Measurement of Productive Efficiency and Productivity Growth*, Oxford University Press.

Giannakas, K., R. Schoney and V. Tzouvelekas (2001) "Technical Efficiency, Technological Change and Output Growth of Wheat Farms in Saskatchewan", *Canadian Journal of Agricultural Economics*, 49, 135-152.

Gow, L. and M.R Langemeier (1999) "An Efficiency Analysis of Cattle Backgrounding in Kansas", KSU, Kansas. *Paper Presented at the Western Agr. Econ. Association Annual Meetings. July 11-14, Fargo, ND*.

Greene, W.H. (2003) Economic Analysis, 5th Edit., Prentice Hall, New Jersey.

Hadley, D., B. Shankar, C. Thirtle, and T. Coelli (2001) "Financial Exposure and Farm Efficiency: Evidence from the England and Wales Dairy Sector", *Paper Presented at the annual meetings of the American Agricultural Economics Association Annual Meetings, August 5-8, Chicago, Illinois*.

Hadley, D. (2006) "Patterns in Technical Efficiency and Technical Change at the Farm-level in England and Wales", 1982-2002. *J. of Ag. Econ.,* 57 (1) 81-100.

Hadley D., B Shankar, C. Thirtle and T. Coelli (2003) "Financial Exposure and Farm Efficiency: Evidence from the England and Wales Dairy Sector", Paper Presented at the annual meetings of the American Agricultural Association, Chicago, August 5-8 2001. Draft, please quote only with permission. Contact: Bhavani Shankar (b.shankar@reading.ac.uk).

Harris, M. and A. Raviv (1991) "The Theory of Capital Structure," *The Journal of Finance"*, vol. 46, pp. 297-355.

Jensen, M. (1986) "Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers," *American Economic Review*, vol. 76, pp.323-329.

Jensen, M. and W. Meckling (1976) "Theory of the Firm: Managerial Behavior, Agency Costs and Capital Structure," *J. of Finan. Econ.*, vol. 3, pp. 305-360.

Johnson, S.R., A. Bouzaher, A. Carriquiry, H. Jensen and P.G. Lakshminarayan (1994) "Production Efficiency and Agricultural Reform in Ukraine", *Amer. J. Agr. Econ.*, 76(3), 629-635.

Kansas Farm Management Association 1995 to 2004 Databank.

Kumbhakar S.C. and C.A.K. Lovell (2000) Stochastic Frontier Analysis, Cambridge University Press.

Kumbhakar, S. C., S. Ghosh, and J. T. McGuckin (1991) "A Generalized Production Frontier Approach for Estimating Determinants of Inefficiency in U.S. Dairy Farms". J. of Business and Economic Statistics, vol. 9 (3), 279-86.

Lambert, D.K. and V. V. Bayda (2005) "The Impacts of Farm Financial Structure on Production Efficiency". *J. of Agri. And Applied Economics,* 37 (1) 277-289.

Langemeier, M.R. and F.D. DeLano (1999) "Characteristics of Highly Efficient Farms". *Presented at the Western Agr. Econ. Association Annual Meetings. July 11-14, Fargo, ND*.

Lee, H., and R. Chambers (1986) "Expenditure Constraints and Profit Maximization in the U.S. Agriculture". *Amer. J. Agr. Econ*., 68, 857-65.

Lewin, A. Y. and C. A. K. Lovell (1990). Editors Introduction, *Journal of Econometrics*, 46, 3-5.

Liebenstein, H. (1966) "Allocative Efficiency vs. 'X-Efficiency" *American Economic Review*, vol. 56, 392-415.

Masterson, T. (2007) "Productivity, Technical Efficiency, and Farm Size in Paraguayan Agriculture", The Levy Economics Institute of Bard College, Working Paper No. 490.

Morgan, J.D. and M.R. Langemeier (2003) "Impact of Farm Size and Type of Competitive Advantage", Selected paper prepared for presentation at the Southern Agricultural Economics Annual Meeting, Mobile, Alabama, February 1-5.

Nasr, R.E., P.J. Barry, and P. N. Ellinger (1998) "Financial Structure and Efficiency of Grain Farms", *Agr. Finan. Review*, 58, 33-48.

Nivens, H.D., T.L. Kastens and K. C. Dhuyvetter (2002) "Payoffs to Farm Management: How Important is Crop Marketing?", *J. of Agr. And Applied Econ*., 34, 193-204.

Paul, C.J.M., W.T. Johnston and G.A.G. Frengley (2000) "Efficiency of New Zealand Sheep and Beef Farming: the impacts of regulatory reform", *Rev. of Econ. and Stat*., 82, 325-36.

Perry, C.A. (2006) "Effect of Irrigation Practices on Water Uses in the Groundwater Management Districts within the Kansas High Plains, 1991-2003", U.S. Geological Survey (USGA), Report Number 2006-5069.

Puig-Junoy, J. and J.M. Argiles (2000) "Measuring and Explaining Farm Inefficiency in a Panel Data Set of Mixed Farms", *Dept. of Econ. And Bus., Pompeu Fabra University, Working Paper, Barcelona, Spain*.

Purdy, B.M., M.R. Langemeier and A.M. Featherstone (1997) "Financial Performance, Risk, and Specialization", *J. of Agr. And Applied Econ*., 29 (1) 149-161.

Ramanathan, R. (2003) An Introduction to Data Envelopment Analysis, Sage Publications, London, pp. 1-28.

Ray, S.C. (2004) Data Envelopment Analysis: Theory and Techniques for Economics and Operational Research, *Cambridge University Press*, Cambridge.

Schmidt, P. and R.C. Sickles (1984) “Production Frontiers and Panel Data”, *J. of Bus. And Econ. Statistics*, 2 (4) 367-374.

Sharma, K.R., P. Leung, and H.M. Zaleski (1999) “Technical, Allocative and Economic Efficiencies in Swine Production in Hawaii: A Comparison of Parametric and Nonparametric Approaches”, *Agr. Econ.*, 20, 23-35.

Shepard, R.W. 1970 Theory of Cost and Production Functions, *Princeton University Press*, Princeton.

Tauer, L.W. and J.J. Hanchar (1995) “Non-parametric Technical Efficiency with K Firms, N. Inputs, and M Outputs: A Simulation”, *Agri. and Resource Econ. Review*, 24, 185-89.

Thiam, A., B.E. Bravo Ureta, and T.E. Rivas (2001) “Technical Efficiency in Developing Country Agriculture: A Meta-Analysis”, *Agr. Econ.*, 25**,** 235-43.

US Department of Agriculture (USDA) National Agricultural Statistics Service, Agricultural Input Prices at http://www.nass.usda.gov/Data_and_Statistics.

Varian, H.R. “Goodness-of-Fit in Optimizing Models”, *J. Econometrics*, 46, 125-40.

Wadud, A. and B. White (2000) “Farm Household Efficiency in Bangladesh: A Comparison of Stochastic Frontier and DEA Methods”, *Applied Econ*., 32, 165-73.

Wadud, A. (2003) “Technical, Allocative, and Economic Efficiency of farms in Bangladesh: A Stochastic Frontier and DEA Approach”, *J. of Developing Areas*, 37, No. 1.

Whittaker, G.W. and M.J. Morehart (1991) “Measuring the Effect of Farm Financial Structure on Cost Efficiency”, *Agricultural Finance Review*, 51, 95-103.

Appendix A - Kansas Farm Management Association Databank

The reader is encouraged to read Michael R. Langemeier, June 2003, "Kansas Farm Management Association SAS Data Bank Document. Contribution No. 03-420-D from the Kansas Agricultural Experiment Station, Kansas State University, Manhattan, KS 66506-4008. This publication contains a definition of the dataset and the variables included in the data bank. Most of the variables used in this dissertation are listed in the following table. For the definition of other variables not included below please refer to the above publication.

Variable	Definition
	Farm Characteristics
FARM	Farm ID Number
ID	From 1 to 456, Number of Farms
PCE	Producer Consumption Expenditure Index
V008	Business Organization Type
V010	Number of Unpaid Operators
V011	Number of Workers Including Operator, Family and Hired Labor
V012	Number of Family Dependents
V013	Operator's Age ("Primary" Operator for Partnerships and Corporations)
V340	Farmstead and Waste, Owned
V341	Farmstead and Waste, Rented
YEAR	Year From 88 to 107, 1988-2007
	Inputs
ACCOST	Actual/Observed Farm Costs (Same as Accostd)
ACCOSTD	Actual/Observed Farm Costs (Same as Accost)
BASSETS	Beginning Annual Total Assets
BCDEBT	Beginning Short-Term Debt
BCINV	Beginning Short-Term Assets
BDEBT	Beginning Annual Total Debt
CACRES	Total Crop Acres
CHEM	Units of Chemical Used
CRLAND	Total Crop Land

Variable	Definition
FGACRES	Acres of Feed Grain
HFACRES	Acres in Hay and Forage
LABOR	Number of Workers
LABORP	Price of Labor
LAND	Total Operated Acres
LIVE	Units of Livestock Used
OCAP	Capital Expenses
OCAPP	Price of Capital Expenses
PCAPE	Percent of Capital Expenses
PCROPE	Percent of Seed, Fertilizer and Chemical Expenses
PLABORE	Percent of Labor Expenses
PLANDE	Percent of Land Expenses
PLIVDE	Percent of Livestock Expenses
POWNA	Percent of Owned Acres
RCHEMC	Herbicide and Insecticide Cost
RCINSC	Insurance Cost
RDKDDEPR	Real Depreciation Cost
RENTC	Price of Land
RFERTC	Cost of Fertilizer
RINTC	Real Interest Cost
RLABORC	Cost of Labor
RLANDC	Total Cost of Land Computed As Weighted Farm-Specific Cash Price of Acres Times Total Acreage
RLIVEC	Livestock Input Cost
ROCAPC	Cost of Capital Expenses
RSEEDC	Cost of Seed
SACRES	Acres of Soybeans
SEED	Units of Seed Used
TACRES	Total Operated Land in Acres

Variable	Definition
V468	Percent of Labor Devoted To Crops
WACRES	Acres in Wheat
	<u>Outputs</u>
BEEF	Beef Production in Pounds
BEEFI	Income from Beef
CROPINC	Income from All Crops
DAIRY	Dairy Production in Pounds
DAIRYI	Income from Dairy
EXPR	Expenditure Ratio = Total Cost of Production Divided by Total Farm Income Including Farming Operations, Government Payments, and Insurance Receipts
FGINC	Income from Feed Grains
FGPROD	Production of Feed Grains in Bushels
HFINC	Income from Hay and Forage
HFPROD	Production of Hay and Forage in Tons
LIVDINC	Income from Dairy and Beef
OFFI	Income from Off-Farm Sources
PCROPI	Percent of Income from All Crop Operations
PCWKI	Percent of Income from Custom Work Operations
PLIVDI	Percent of Income from Dairy and Beef Operations
RCINSI	Insurance Income
RCWORK	Custom Work
RGFI	Gross Farm Income
RGOVTI	Real Income from Government Payments
RNFI	Net Farm Income
RVFP	Value of Farm Production
SINC	Income from Soybeans
SPROD	Production of Soybeans in Bushels
TINC	All Income: Crops, Dairy and Beef, and Custom Work
WINC	Income from Wheat
WPROD	Production of Wheat in Bushels

Appendix B - Codes

This appendix covers the different codes that were used in this dissertation. The first section corresponds to a SAS Code used to retrieve the original dataset form the KFMA databank. The second section consists of two GAMS codes to solve the DEA programs. The last section lists a STATA code used for the Tobit Analysis.

B.1 SAS Code to Retrieve Farms from the KFMA Databank

Next, a modified version of the SAS code by Dr. Langemeier, 2008 is shown. This code retrieves the farms and variables that meet the requirements listed in the Data Chapter. The code takes farms with continuous data from 1998 to 2007 on production and socio-economic farm factors. The code also shows how the variables are calculated. For a full version of the description of the dataset see Langemeier, 2003. For a short description of the main variables used, a descriptive table is provided in Appendix A.

```
/* lopez1m */

LIBNAME kfma10yr 'c:\';
data x1;
set kfma10yr.farm10;

libname crop10yr 'c:\';
data x2;
set crop10yr.crop10;

data x3; merge x1 x2; by farm;
if v001 = . then delete;
if v1261 = . then delete;

proc means; var year v005 v006 v1262 v1263 v1266 v1269 v1271 v1281;

data x4; set x3;

keep farm year pce
     rgovti rcinsi rcinsc
     bassets eassets aassets bdebt edebt adebt dtar
       bcinv ecinv acinv bcdebt ecdebt acdebt icr
     rgfi rvfp rnfi
     winc fginc sinc hfinc dairyi beefi
     wprod fgprod sprod hfprod dairy beef rcwork
     rlaborc rlivec rseedc rfertc rchemc rocapc rlandc
     laborp livep seedp fertp chemp ocapp rentc
     labor live seed fert chem ocap land
       v008 v010-v013 v324-v341 v468 offi expr
     pcropi pbeefi pdairyi plivei
```

```
     tacres cacres wacres fgacres sacres hfacres
     wheata wheatp wheaty corna cornp corny
     sorga sorgp sorgy soya soyp soyy
     pirrc pnirrc ppast
     powna crland lv
     cropinc livdinc tinc pcropi plivdi pcwki
     tacost expr pcrope plivde plabore pcape plande
     rintc dkddepr
     dum1 dum2 dum3 dum4 dum5 dum6 dum7;

/* Deletion of Farms */

if v007 >= 1 then delete;

if v001 = 3 then delete;

if v001 > 44 then delete;

if v001 = 7 or v001 = 8 or v001 = 9 or v001 = 23 or v001 = 24 or
     v001 = 25 or v001 = 30 or v001 = 32 or v001 = 43 then delete;

if v001 = 10 or v001 = 11 or v001 = 26 or v001 = 27 or v001 = 44 then delete;

if v001 = 12 or v001 = 13 or v001 = 29 or v001 = 31 or v001 = 34 then delete;

if v010 <= 0 then delete;
if v011 <= 0 then delete;

if (v262+v264+v266+v268) <= 0 then delete;
if (v263+v265+v267+v269) <= 0 then delete;
if v324 <= 0 then delete;

/*Delete, no dairy or beef operation but livestock expenses are high*/

if farm = 12395200 then delete;
if farm = 21200601 then delete;
if farm = 24804700 then delete;
if farm = 40790300 then delete;
if farm = 43494200 then delete;
if farm = 44691500 then delete;
if farm = 60907700 then delete;
if farm = 62402100 then delete;
if farm = 63104700 then delete;
if farm = 65288500 then delete;

/* Delete, beef output some years but high expenses for all years */

if farm = 25104900 then delete;
if farm = 38940800 then delete;
if farm = 40388100 then delete;
if farm = 58080400 then delete;
if farm = 65204403 then delete;

/* Delete farms with more than $10,000 of dairy production in
     discontinuous years or for a single year */

if farm = 11807200 then delete;
```

```
if farm = 11808201 then delete;
if farm = 12305200 then delete;
if farm = 12398300 then delete;
if farm = 13006300 then delete;
if farm = 12340100 then delete;
if farm = 11886202 then delete;
if farm = 20601502 then delete;
if farm = 22840300 then delete;
if farm = 24810900 then delete;
if farm = 41580400 then delete;
if farm = 48140102 then delete;
if farm = 48191100 then delete;
if farm = 61787000 then delete;
if farm = 62493000 then delete;
if farm = 63201701 then delete;

/* Delete observations where there is crop output but
     seed expenditures are zero;  observations are valid
     if they refer to wheat farms, hay and forage or/and
     beef/dairy */

if farm = 14730000 then delete;
if farm = 20650900 then delete;
if farm = 30201800 then delete;
if farm = 42540600 then delete;
if farm = 43400400 then delete;
if farm = 43494200 then delete;
if farm = 58010400 then delete;
if farm = 60403901 then delete;
if farm = 60404401 then delete;
if farm = 60811600 then delete;
if farm = 61170100 then delete;
if farm = 61182000 then delete;
if farm = 16582200 then delete;
if farm = 21230901 then delete;
if farm = 23340500 then delete;
if farm = 33505600 then delete;
if farm = 33590300 then delete;
if farm = 39305400 then delete;
if farm = 44600400 then delete;
if farm = 60502201 then delete;
if farm = 60809400 then delete;
if farm = 61787000 then delete;
if farm = 62203800 then delete;
if farm = 62704300 then delete;
if farm = 62980100 then delete;
if farm = 62989100 then delete;
if farm = 63200800 then delete;
if farm = 67203901 then delete;
if farm = 67290300 then delete;

/* Delete crop farms where fertilizer expenses are zero. If it is
     a dairy or beef farm, they can be using organic fertilizer
     like manure and they are regarded as valid */

if farm=23340500 then delete;
if farm=30201800 then delete;
```

```
if farm=39305400 then delete;
if farm=41691100 then delete;

/*Delete Farms whose total debt to total assets ratio is 1 or more than 1 and
they look suspicious*/
If farm=12303800 then delete;
If farm=12305600 then delete;
If farm=12395300 then delete;
If farm=14782100 then delete;
If farm=41300600 then delete;
If farm=45489000 then delete;
If farm=61094000 then delete;
If farm=61198100 then delete;


/* Defining 2000 to 2007 */

if year = 0 then year = 100;
if year = 1 then year = 101;
if year = 2 then year = 102;
if year = 3 then year = 103;
if year = 4 then year = 104;
if year = 5 then year = 105;
if year = 6 then year = 106;
if year = 7 then year = 107;

/* Implicit Price Deflator */

if year = 98 then pce = (117.59/95.98);
if year = 99 then pce = (117.59/97.57);
if year = 100 then pce = (117.59/100.00);
if year = 101 then pce = (117.59/102.09);
if year = 102 then pce = (117.59/103.54);
if year = 103 then pce = (117.59/105.60);
if year = 104 then pce = (117.59/108.39);
if year = 105 then pce = (117.59/111.59);
if year = 106 then pce = (117.59/114.67);
if year = 107 then pce = (117.59/117.59);

/* Assets and Debt */

cbinv = v182+v200+v212+v224+v230+v236+v242+v248
     +v254+v258+v260+v272+v458+v496+v498+v500+v502+v504;

ceinv = v185+v203+v215+v227+v233+v239+v245+v251
    +v257+v259+v261+v273+v459+v497+v499+v501+v503+v505;

cainv=(cbinv+ceinv)/2;

if year = 98 then bdepra = (v262+v264+v266+v268)*1.1185;
if year = 98 then edepra = (v263+v265+v267+v269)*1.1185;
if year = 99 then bdepra = (v262+v264+v266+v268)*1.0968;
if year = 99 then edepra = (v263+v265+v267+v269)*1.0968;
if year = 100 then bdepra = (v262+v264+v266+v268)*1.0771;
if year = 100 then edepra = (v263+v265+v267+v269)*1.0771;
if year = 101 then bdepra = (v262+v264+v266+v268)*1.0590;
if year = 101 then edepra = (v263+v265+v267+v269)*1.0590;
```

```
if year = 102 then bdepra = (v262+v264+v266+v268)*1.0424;
if year = 102 then edepra = (v263+v265+v267+v269)*1.0424;
if year = 103 then bdepra = (v262+v264+v266+v268)*1.0272;
if year = 103 then edepra = (v263+v265+v267+v269)*1.0272;
if year = 104 then bdepra = (v262+v264+v266+v268)*1.0131;
if year = 104 then edepra = (v263+v265+v267+v269)*1.0131;
if year >= 105 then bdepra = (v262+v264+v266+v268)*1.0000;
if year >= 105 then edepra = (v263+v265+v267+v269)*1.0000;

adepra = (bdepra+edepra)/2;

bblvstk = v188+v194+v206+v218;
eblvstk = v191+v197+v209+v221;
ablvstk = (bblvstk+eblvstk)/2;

bncar = v460+v477;
encar = v461+v478;
ancar = (bncar+encar)/2;

ainta = adepra + ablvstk + ancar;

if year = 98 then bolv = (577/535)*v270;
if year = 99 then bolv = (600/535)*v270;
if year = 100 then bolv = (625/625)*v270;
if year = 101 then bolv = (645/625)*v270;
if year = 102 then bolv = (665/625)*v270;
if year = 103 then bolv = (685/625)*v270;
if year = 104 then bolv = (715/625)*v270;
if year = 105 then bolv = (850/850)*v270;
if year = 106 then bolv = (940/850)*v270;
if year = 107 then bolv = (1090/850)*v270;

if year = 98 then eolv = (577/535)*v271;
if year = 99 then eolv = (600/535)*v271;
if year = 100 then eolv = (625/625)*v271;
if year = 101 then eolv = (645/625)*v271;
if year = 102 then eolv = (665/625)*v271;
if year = 103 then eolv = (685/625)*v271;
if year = 104 then eolv = (715/625)*v271;
if year = 105 then eolv = (850/850)*v271;
if year = 106 then eolv = (940/850)*v271;
if year = 107 then eolv = (1090/850)*v271;

aolv = (bolv+eolv)/2;

bassets = (cbinv+bdepra+bblvstk+bncar+bolv)*pce;
eassets = (ceinv+edepra+eblvstk+encar+eolv)*pce;
aassets = (cainv+adepra+ablvstk+ancar+aolv)*pce;

bdebt = (v454+v473+v456)*pce;
edebt = (v455+v474+v457)*pce;
adebt = ((bdebt+edebt)/2);
dtar = adebt/aassets;

bcinv = cbinv*pce;
ecinv = ceinv*pce;
acinv = cainv*pce;
```

```
bcdebt = v454*pce;
ecdebt = v455*pce;
acdebt = ((v454+v455)/2)*pce;
if acinv <= 0 then delete;
if acdebt < 0 then acdebt = 0;
icr = acdebt/acinv;

/* Income Items */

if v274 < 0 then v274 = 0;
if v275 < 0 then v275 = 0;
if v276 < 0 then v276 = 0;
if v277 < 0 then v277 = 0;
if v278 < 0 then v278 = 0;
if year > 97 then gfi = v005 + v586; else gfi = v005;
if year > 97 then vfp = v005; else vfp = gfi - v586;
cropi = (v282+v283+v284+v511);
     if cropi < 0 then cropi = 0;
livei = (v274+v275+v276+v277+v278+v279+v508+v509);
     if livei < 0 then livei = 0;
total = cropi+livei;
resid = gfi - total;
     if resid < 0 then resid = 0;
presid = resid/gfi;
     if presid > 0.50 then delete;
if gfi <= 0 then delete;
if vfp <= 0 then delete;

if cropi > 0 then pcropi = 1; else pcropi = 0;
if v274 > 0 then pbeefi = 1; else pbeefi = 0;
if (v275+v508) > 0 then pdairyi = 1; else pdairyi = 0;
if livei > 0 then plivei = 1; else plivei = 0;

cinsi = v1269;
cinsc = v598;
govti = v511;
cwork = v159 + v533 - v532;
wheat = v1261+v1264+v1265+v1266+v1267+v1268+v1270;
fg = v1262+v1263;
hf = v1271+v1272+v1273+v1274+v1275+v1276+v1277+v1278+v1279+v1280;
soy = v1281+v1282+v1283+v1284+v1285+v1286+v1287+v1288+v1289+v1290;

if cinsi < 0 then cinsi = 0;
if cinsc < 0 then cinsc = 0;
if govti < 0 then govti = 0;
if cwork < 0 then cwork = 0;
if wheat < 0 then wheat = 0;
if fg < 0 then fg = 0;
if hf < 0 then hf = 0;
if soy < 0 then soy = 0;

rgfi = gfi*pce;
rvfp = vfp*pce;
rnfi = v006*pce;

winc = wheat*pce;
fginc = fg*pce;
```

```
sinc = soy*pce;
hfinc = hf*pce;

if year = 98 then wprod = wheat/2.76;
if year = 99 then wprod = wheat/2.35;
if year = 100 then wprod = wheat/2.52;
if year = 101 then wprod = wheat/2.75;
if year = 102 then wprod = wheat/3.35;
if year = 103 then wprod = wheat/3.29;
if year = 104 then wprod = wheat/3.44;
if year = 105 then wprod = wheat/3.25;
if year = 106 then wprod = wheat/4.38;
if year = 107 then wprod = wheat/5.92;

if year = 98 then fgprod = fg/2.21;
if year = 99 then fgprod = fg/1.88;
if year = 100 then fgprod = fg/1.93;
if year = 101 then fgprod = fg/2.00;
if year = 102 then fgprod = fg/2.22;
if year = 103 then fgprod = fg/2.40;
if year = 104 then fgprod = fg/2.60;
if year = 105 then fgprod = fg/2.02;
if year = 106 then fgprod = fg/2.41;
if year = 107 then fgprod = fg/3.63;

if year = 98 then sprod = soy/5.82;
if year = 99 then sprod = soy/4.46;
if year = 100 then sprod = soy/4.71;
if year = 101 then sprod = soy/4.36;
if year = 102 then sprod = soy/4.90;
if year = 103 then sprod = soy/6.21;
if year = 104 then sprod = soy/7.46;
if year = 105 then sprod = soy/5.79;
if year = 106 then sprod = soy/5.51;
if year = 107 then sprod = soy/7.84;

if year = 98 then hfprod = hf/76.42;
if year = 99 then hfprod = hf/68.75;
if year = 100 then hfprod = hf/69.75;
if year = 101 then hfprod = hf/89.92;
if year = 102 then hfprod = hf/90.83;
if year = 103 then hfprod = hf/76.83;
if year = 104 then hfprod = hf/66.75;
if year = 105 then hfprod = hf/65.58;
if year = 106 then hfprod = hf/91.67;
if year = 107 then hfprod = hf/107.58;

ndairy = v275+v508;
dairyi = ndairy*pce;

/* Dairy Output and Income is Changed to zero if there is less than
     $10,000 of dairy production for a single year, no dairy production
     for any other year */

if farm=11401200 then dairyi=0;
if farm=11498100 then dairyi=0;
if farm=11800100 then dairyi=0;
```

```
if farm=12350000 then dairyi=0;
if farm=12395100 then dairyi=0;
if farm=13795300 then dairyi=0;
if farm=14006000 then dairyi=0;
if farm=14786200 then dairyi=0;
if farm=14797100 then dairyi=0;
if farm=20606701 then dairyi=0;
if farm=20650300 then dairyi=0;
if farm=22806100 then dairyi=0;
if farm=24850200 then dairyi=0;
if farm=24851000 then dairyi=0;
if farm=24890300 then dairyi=0;
if farm=25190300 then dairyi=0;
if farm=41305300 then dairyi=0;
if farm=41306100 then dairyi=0;
if farm=41691100 then dairyi=0;
if farm=43491100 then dairyi=0;
if farm=43494200 then dairyi=0;
if farm=44297100 then dairyi=0;
if farm=59902101 then dairyi=0;
if farm=59980300 then dairyi=0;
if farm=60401300 then dairyi=0;
if farm=61790200 then dairyi=0;
if farm=62103600 then dairyi=0;
if farm=62704300 then dairyi=0;
if farm=63194000 then dairyi=0;
if farm=64486100 then dairyi=0;
if farm=44600400 then dairyi=0;

if year = 98 then dairy = ndairy/0.1473;
if year = 99 then dairy = ndairy/0.1388;
if year = 100 then dairy = ndairy/0.1234;
if year = 101 then dairy = ndairy/0.1493;
if year = 102 then dairy = ndairy/0.1212;
if year = 103 then dairy = ndairy/0.1243;
if year = 104 then dairy = ndairy/0.1603;
if year = 105 then dairy = ndairy/0.1493;
if year = 106 then dairy = ndairy/0.1256;
if year = 107 then dairy = ndairy/0.1932;

nbeef = v274;
beefi = nbeef*pce;

if year = 98 then beef = nbeef/0.6248;
if year = 99 then beef = nbeef/0.6645;
if year = 100 then beef = nbeef/0.7185;
if year = 101 then beef = nbeef/0.7412;
if year = 102 then beef = nbeef/0.6870;
if year = 103 then beef = nbeef/0.8316;
if year = 104 then beef = nbeef/0.8459;
if year = 105 then beef = nbeef/0.9028;
if year = 106 then beef = nbeef/0.8874;
if year = 107 then beef = nbeef/0.9389;

rgovti = govti*pce;
rcinsi = cinsi*pce;
rcinsc = cinsc*pce;
```

```
rcwork = cwork*pce;

rtotali = winc+fginc+sinc+hfinc+dairyi+beefi+rcwork;

if wprod=0 then dum1=0; else dum1=1;
if fgprod=0 then dum2=0; else dum2=1;
if sprod=0 then dum3=0; else dum3=1;
if hfprod=0 then dum4=0; else dum4=1;
if beef=0 then dum5=0; else dum5=1;
if dairy=0 then dum6=0; else dum6=1;
if cwork=0 then dum7=0; else dum7=1;

/* Inputs and Expenses */

hlaborc = v574;

if year = 98 then operc = 32851;
if year = 99 then operc = 31258;
if year = 100 then operc = 31730;
if year = 101 then operc = 36332;
if year = 102 then operc = 36635;
if year = 103 then operc = 38989;
if year = 104 then operc = 41985;
if year = 105 then operc = 45816;
if year = 106 then operc = 46380;
if year = 107 then operc = 50261;

laborc = (hlaborc + (operc*v010));

if laborc <= 0 then delete;

rlaborc = laborc*pce;

laborp = rlaborc / v011;

labor = rlaborc/laborp;

livec = v582 + v586 + v587 + v588;
if livec=0 and ndairy>0 then delete;
if livec=0 and nbeef>0 then delete;
if livec < 0 then delete;

/* Livestock expenses changed to zero since these are not beef
     or dairy farms and their expenses are less than $5,000,
     in most cases between 0 and 1,000 */

if farm=11403402 then livec=0;
if farm=11440000 then livec=0;
if farm=11490100 then livec=0;
if farm=12082200 then livec=0;
if farm=12304500 then livec=0;
if farm=12395100 then livec=0;
if farm=14340000 then livec=0;
if farm=20206502 then livec=0;
if farm=20606702 then livec=0;
if farm=20630000 then livec=0;
if farm=20640300 then livec=0;
```

```
if farm=22601201 then livec=0;
if farm=22606800 then livec=0;
if farm=23307205 then livec=0;
if farm=23340302 then livec=0;
if farm=24805201 then livec=0;
if farm=24809200 then livec=0;
if farm=24809200 then livec=0;
if farm=24809500 then livec=0;
if farm=24809900 then livec=0;
if farm=24812100 then livec=0;
if farm=24850200 then livec=0;
if farm=25350400 then livec=0;
if farm=25360400 then livec=0;
if farm=25370200 then livec=0;
if farm=38921400 then livec=0;
if farm=39310400 then livec=0;
if farm=40300100 then livec=0;
if farm=40380400 then livec=0;
if farm=42596200 then livec=0;
if farm=43405700 then livec=0;
if farm=44505800 then livec=0;
if farm=58008303 then livec=0;
if farm=59930300 then livec=0;
if farm=60495000 then livec=0;
if farm=61085200 then livec=0;
if farm=61094000 then livec=0;
if farm=62288400 then livec=0;

if year = 98 then livep = (111)*pce;
if year = 99 then livep = (100)*pce;
if year = 100 then livep = (102)*pce;
if year = 101 then livep = (109)*pce;
if year = 102 then livep = (112)*pce;
if year = 103 then livep = (114)*pce;
if year = 104 then livep = (121)*pce;
if year = 105 then livep = (117)*pce;
if year = 106 then livep = (124)*pce;
if year = 107 then livep = (151)*pce;

rlivec = livec*pce;
live = rlivec/livep;

seedc = v580;

if seedc < 0 then delete;

if 0>=soy<1000 and seedc=0 then soy=0;
if 0>=fg<1000 and seedc=0 then fg=0 ;


if year = 98 then seedp = (122)*pce;
if year = 99 then seedp = (122)*pce;
if year = 100 then seedp = (124)*pce;
if year = 101 then seedp = (132)*pce;
if year = 102 then seedp = (142)*pce;
if year = 103 then seedp = (154)*pce;
if year = 104 then seedp = (158)*pce;
```

```
if year = 105 then seedp = (168)*pce;
if year = 106 then seedp = (182)*pce;
if year = 107 then seedp = (205)*pce;

rseedc = seedc*pce;
seed = rseedc/seedp;

fertc = v581;

if fertc < 0 then delete;

if year = 98 then fertp = (112)*pce;
if year = 99 then fertp = (105)*pce;
if year = 100 then fertp = (110)*pce;
if year = 101 then fertp = (123)*pce;
if year = 102 then fertp = (108)*pce;
if year = 103 then fertp = (124)*pce;
if year = 104 then fertp = (140)*pce;
if year = 105 then fertp = (164)*pce;
if year = 106 then fertp = (176)*pce;
if year = 107 then fertp = (208)*pce;

rfertc = fertc*pce;
fert = rfertc/fertp;

chemc = v585;

if chemc < 0 then delete;

if year = 98 then chemp = (122)*pce;
if year = 99 then chemp = (121)*pce;
if year = 100 then chemp = (120)*pce;
if year = 101 then chemp = (121)*pce;
if year = 102 then chemp = (119)*pce;
if year = 103 then chemp = (121)*pce;
if year = 104 then chemp = (121)*pce;
if year = 105 then chemp = (123)*pce;
if year = 106 then chemp = (128)*pce;
if year = 107 then chemp = (131)*pce;

rchemc = chemc*pce;
chem = rchemc/chemp;

udepr = v311+v312+v313;

if year = 98 then dkddepr = udepr*1.1185;
if year = 99 then dkddepr = udepr*1.0968;
if year = 100 then dkddepr = udepr*1.0771;
if year = 101 then dkddepr = udepr*1.0590;
if year = 102 then dkddepr = udepr*1.0424;
if year = 103 then dkddepr = udepr*1.0272;
if year = 104 then dkddepr = udepr*1.0131;
if year >= 105 then dkddepr = udepr;
rkddepr=dkddpr*pce;
intr = 0.08;

gpur = (v071+v103+v107+v111+v115);
```

```
if gpur < 0 then gpur = 0;

intc = (((livec+seedc+fertc+chemc)*0.5*intr)+
     (gpur*0.5*intr)+(ainta*intr));
rintc=intc*pce;

ocapc = v575 + v576 + v577 + v578 + v579 + v583 + v584 + v589 +
     v597 + dkddepr + intc;

rocapc = ocapc*pce;

if rocapc <=0 then delete;

if year = 98 then repairp = (119)*pce;
if year = 99 then repairp = (118)*pce;
if year = 100 then repairp = (120)*pce;
if year = 101 then repairp = (124)*pce;
if year = 102 then repairp = (127)*pce;
if year = 103 then repairp = (130)*pce;
if year = 104 then repairp = (134)*pce;
if year = 105 then repairp = (140)*pce;
if year = 106 then repairp = (145)*pce;
if year = 107 then repairp = (150)*pce;

if year = 98 then fuelp = (84)*pce;
if year = 99 then fuelp = (94)*pce;
if year = 100 then fuelp = (129)*pce;
if year = 101 then fuelp = (121)*pce;
if year = 102 then fuelp = (115)*pce;
if year = 103 then fuelp = (140)*pce;
if year = 104 then fuelp = (165)*pce;
if year = 105 then fuelp = (216)*pce;
if year = 106 then fuelp = (239)*pce;
if year = 107 then fuelp = (263)*pce;

if year = 98 then intp = (104)*pce;
if year = 99 then intp = (106)*pce;
if year = 100 then intp = (113)*pce;
if year = 101 then intp = (104)*pce;
if year = 102 then intp = (99)*pce;
if year = 103 then intp = (95)*pce;
if year = 104 then intp = (98)*pce;
if year = 105 then intp = (114)*pce;
if year = 106 then intp = (139)*pce;
if year = 107 then intp = (154)*pce;

repairs = v575 + v576 + v589;
energy = v578 + v579 + v583 + v584 + v597;
other = v577 + dkddepr + intc;
stotal = repairs + energy + other;
ocapp = ((repairs/stotal)*repairp) + ((energy/stotal)*fuelp) +
     ((other/stotal)*intp);
ocap = rocapc/ocapp;
land = v324;
/ *LAND PRICES FOR KANSAS CENTRAL REGION*/
/*Central- saline */
```

```
If 11400000  >= farm <= 11499999 and year = 98 then pnirrc = 36;
If 11400000  >= farm <= 11499999 and year = 99 then pnirrc = 35;
If 11400000  >= farm <= 11499999 and year = 100 then pnirrc = 35;
If 11400000  >= farm <= 11499999 and year = 101 then pnirrc = 34;
If 11400000  >= farm <= 11499999 and year = 102 then pnirrc = 34.4;
If 11400000  >= farm <= 11499999 and year = 103 then pnirrc = 34.1;
If 11400000  >= farm <= 11499999 and year = 104 then pnirrc = 35.5;
If 11400000  >= farm <= 11499999 and year = 105 then pnirrc = 35.5;
If 11400000  >= farm <= 11499999 and year = 106 then pnirrc = 36;
If 11400000  >= farm <= 11499999 and year = 107 then pnirrc = 35;

If 11400000  >= farm <= 11499999 and year = 98 then pirrc = 65;
If 11400000  >= farm <= 11499999 and year = 99 then pirrc = 64;
If 11400000  >= farm <= 11499999 and year = 100 then pirrc = 65;
If 11400000  >= farm <= 11499999 and year = 101 then pirrc = 65;
If 11400000  >= farm <= 11499999 and year = 102 then pirrc = 64;
If 11400000  >= farm <= 11499999 and year = 103 then pirrc = 63;
If 11400000  >= farm <= 11499999 and year = 104 then pirrc = 65;
If 11400000  >= farm <= 11499999 and year = 105 then pirrc = 66;
If 11400000  >= farm <= 11499999 and year = 106 then pirrc = 64;
If 11400000  >= farm <= 11499999 and year = 107 then pirrc = 67;

If 11400000  >= farm <= 11499999 and year = 98 then ppast = 12.7;
If 11400000  >= farm <= 11499999 and year = 99 then ppast = 13;
If 11400000  >= farm <= 11499999 and year = 100 then ppast = 12;
If 11400000  >= farm <= 11499999 and year = 101 then ppast = 12.3;
If 11400000  >= farm <= 11499999 and year = 102 then ppast = 12.4;
If 11400000  >= farm <= 11499999 and year = 103 then ppast = 12.4;
If 11400000  >= farm <= 11499999 and year = 104 then ppast = 13.1;
If 11400000  >= farm <= 11499999 and year = 105 then ppast = 13.3;
If 11400000  >= farm <= 11499999 and year = 106 then ppast = 13.8;
If 11400000  >= farm <= 11499999 and year = 107 then ppast = 14;

/* Central-Dickinson*/
If 11800000  >= farm <= 11899999 and year = 98 then pnirrc = 36;
If 11800000  >= farm <= 11899999 and year = 99 then pnirrc = 35;
If 11800000  >= farm <= 11899999 and year = 100 then pnirrc = 35;
If 11800000  >= farm <= 11899999 and year = 101 then pnirrc = 34;
If 11800000  >= farm <= 11899999 and year = 102 then pnirrc = 34.4;
If 11800000  >= farm <= 11899999 and year = 103 then pnirrc = 34.1;
If 11800000  >= farm <= 11899999 and year = 104 then pnirrc = 35.5;
If 11800000  >= farm <= 11899999 and year = 105 then pnirrc = 35.5;
If 11800000  >= farm <= 11899999 and year = 106 then pnirrc = 36;
If 11800000  >= farm <= 11899999 and year = 107 then pnirrc = 35;

If 11800000  >= farm <= 11899999 and year = 98 then pirrc = 65;
If 11800000  >= farm <= 11899999 and year = 99 then pirrc = 64;
If 11800000  >= farm <= 11899999 and year = 100 then pirrc = 65;
If 11800000  >= farm <= 11899999 and year = 101 then pirrc = 65;
If 11800000  >= farm <= 11899999 and year = 102 then pirrc = 64;
If 11800000  >= farm <= 11899999 and year = 103 then pirrc = 63;
If 11800000  >= farm <= 11899999 and year = 104 then pirrc = 65;
If 11800000  >= farm <= 11899999 and year = 105 then pirrc = 66;
If 11800000  >= farm <= 11899999 and year = 106 then pirrc = 64;
If 11800000  >= farm <= 11899999 and year = 107 then pirrc = 67;
If 11800000  >= farm <= 11899999 and year = 98 then ppast = 12.7;
If 11800000  >= farm <= 11899999 and year = 99 then ppast = 13;
```

```
If 11800000  >= farm <= 11899999 and year = 100 then ppast = 12;
If 11800000  >= farm <= 11899999 and year = 101 then ppast = 12.3;
If 11800000  >= farm <= 11899999 and year = 102 then ppast = 12.4;
If 11800000  >= farm <= 11899999 and year = 103 then ppast = 12.4;
If 11800000  >= farm <= 11899999 and year = 104 then ppast = 13.1;
If 11800000  >= farm <= 11899999 and year = 105 then ppast = 13.3;
If 11800000  >= farm <= 11899999 and year = 106 then ppast = 13.8;
If 11800000  >= farm <= 11899999 and year = 107 then ppast = 14;

/* Central-Marion*/
If 12300000  >= farm <= 12399999 and year = 98 then pnirrc = 36;
If 12300000  >= farm <= 12399999 and year = 99 then pnirrc = 35;
If 12300000  >= farm <= 12399999 and year = 100 then pnirrc = 35;
If 12300000  >= farm <= 12399999 and year = 101 then pnirrc = 34;
If 12300000  >= farm <= 12399999 and year = 102 then pnirrc = 34.4;
If 12300000  >= farm <= 12399999 and year = 103 then pnirrc = 34.1;
If 12300000  >= farm <= 12399999 and year = 104 then pnirrc = 35.5;
If 12300000  >= farm <= 12399999 and year = 105 then pnirrc = 35.5;
If 12300000  >= farm <= 12399999 and year = 106 then pnirrc = 36;
If 12300000  >= farm <= 12399999 and year = 107 then pnirrc = 35;

If 12300000  >= farm <= 12399999 and year = 98 then pirrc = 65;
If 12300000  >= farm <= 12399999 and year = 99 then pirrc = 64;
If 12300000  >= farm <= 12399999 and year = 100 then pirrc = 65;
If 12300000  >= farm <= 12399999 and year = 101 then pirrc = 65;
If 12300000  >= farm <= 12399999 and year = 102 then pirrc = 64;
If 12300000  >= farm <= 12399999 and year = 103 then pirrc = 63;
If 12300000  >= farm <= 12399999 and year = 104 then pirrc = 65;
If 12300000  >= farm <= 12399999 and year = 105 then pirrc = 66;
If 12300000  >= farm <= 12399999 and year = 106 then pirrc = 64;
If 12300000  >= farm <= 12399999 and year = 107 then pirrc = 67;

If 12300000  >= farm <= 12399999 and year = 98 then ppast = 12.7;
If 12300000  >= farm <= 12399999 and year = 99 then ppast = 13;
If 12300000  >= farm <= 12399999 and year = 100 then ppast = 12;
If 12300000  >= farm <= 12399999 and year = 101 then ppast = 12.3;
If 12300000  >= farm <= 12399999 and year = 102 then ppast = 12.4;
If 12300000  >= farm <= 12399999 and year = 103 then ppast = 12.4;
If 12300000  >= farm <= 12399999 and year = 104 then ppast = 13.1;
If 12300000  >= farm <= 12399999 and year = 105 then ppast = 13.3;
If 12300000  >= farm <= 12399999 and year = 106 then ppast = 13.8;
If 12300000  >= farm <= 12399999 and year = 107 then ppast = 14;

/* Central-Lincoln*/
If 16600000  >= farm <= 16699999 and year = 98 then pnirrc = 36;
If 16600000  >= farm <= 16699999 and year = 99 then pnirrc = 35;
If 16600000  >= farm <= 16699999 and year = 100 then pnirrc = 35;
If 16600000  >= farm <= 16699999 and year = 101 then pnirrc = 34;
If 16600000  >= farm <= 16699999 and year = 102 then pnirrc = 34.4;
If 16600000  >= farm <= 16699999 and year = 103 then pnirrc = 34.1;
If 16600000  >= farm <= 16699999 and year = 104 then pnirrc = 35.5;
If 16600000  >= farm <= 16699999 and year = 105 then pnirrc = 35.5;
If 16600000  >= farm <= 16699999 and year = 106 then pnirrc = 36;
If 16600000  >= farm <= 16699999 and year = 107 then pnirrc = 35;
If 16600000  >= farm <= 16699999 and year = 98 then pirrc = 65;
If 16600000  >= farm <= 16699999 and year = 99 then pirrc = 64;
If 16600000  >= farm <= 16699999 and year = 100 then pirrc = 65;
```

```
If 16600000  >= farm <= 16699999 and year = 101 then pirrc = 65;
If 16600000  >= farm <= 16699999 and year = 102 then pirrc = 64;
If 16600000  >= farm <= 16699999 and year = 103 then pirrc = 63;
If 16600000  >= farm <= 16699999 and year = 104 then pirrc = 65;
If 16600000  >= farm <= 16699999 and year = 105 then pirrc = 66;
If 16600000  >= farm <= 16699999 and year = 106 then pirrc = 64;
If 16600000  >= farm <= 16699999 and year = 107 then pirrc = 67;

If 16600000  >= farm <= 16699999 and year = 98 then ppast = 12.7;
If 16600000  >= farm <= 16699999 and year = 99 then ppast = 13;
If 16600000  >= farm <= 16699999 and year = 100 then ppast = 12;
If 16600000  >= farm <= 16699999 and year = 101 then ppast = 12.3;
If 16600000  >= farm <= 16699999 and year = 102 then ppast = 12.4;
If 16600000  >= farm <= 16699999 and year = 103 then ppast = 12.4;
If 16600000  >= farm <= 16699999 and year = 104 then ppast = 13.1;
If 16600000  >= farm <= 16699999 and year = 105 then ppast = 13.3;
If 16600000  >= farm <= 16699999 and year = 106 then ppast = 13.8;
If 16600000  >= farm <= 16699999 and year = 107 then ppast = 14;

/* Central-McPherson*/
If 22600000  >= farm <= 22699999 and year = 98 then pnirrc = 36;
If 22600000  >= farm <= 22699999 and year = 99 then pnirrc = 35;
If 22600000  >= farm <= 22699999 and year = 100 then pnirrc = 35;
If 22600000  >= farm <= 22699999 and year = 101 then pnirrc = 34;
If 22600000  >= farm <= 22699999 and year = 102 then pnirrc = 34.4;
If 22600000  >= farm <= 22699999 and year = 103 then pnirrc = 34.1;
If 22600000  >= farm <= 22699999 and year = 104 then pnirrc = 35.5;
If 22600000  >= farm <= 22699999 and year = 105 then pnirrc = 35.5;
If 22600000  >= farm <= 22699999 and year = 106 then pnirrc = 36;
If 22600000  >= farm <= 22699999 and year = 107 then pnirrc = 35;

If 22600000  >= farm <= 22699999 and year = 98 then pirrc = 65;
If 22600000  >= farm <= 22699999 and year = 99 then pirrc = 64;
If 22600000  >= farm <= 22699999 and year = 100 then pirrc = 65;
If 22600000  >= farm <= 22699999 and year = 101 then pirrc = 65;
If 22600000  >= farm <= 22699999 and year = 102 then pirrc = 64;
If 22600000  >= farm <= 22699999 and year = 103 then pirrc = 63;
If 22600000  >= farm <= 22699999 and year = 104 then pirrc = 65;
If 22600000  >= farm <= 22699999 and year = 105 then pirrc = 66;
If 22600000  >= farm <= 22699999 and year = 106 then pirrc = 64;
If 22600000  >= farm <= 22699999 and year = 107 then pirrc = 67;

If 22600000  >= farm <= 22699999 and year = 98 then ppast = 12.7;
If 22600000  >= farm <= 22699999 and year = 99 then ppast = 13;
If 22600000  >= farm <= 22699999 and year = 100 then ppast = 12;
If 22600000  >= farm <= 22699999 and year = 101 then ppast = 12.3;
If 22600000  >= farm <= 22699999 and year = 102 then ppast = 12.4;
If 22600000  >= farm <= 22699999 and year = 103 then ppast = 12.4;
If 22600000  >= farm <= 22699999 and year = 104 then ppast = 13.1;
If 22600000  >= farm <= 22699999 and year = 105 then ppast = 13.3;
If 22600000  >= farm <= 22699999 and year = 106 then ppast = 13.8;
If 22600000  >= farm <= 22699999 and year = 107 then ppast = 14;

/* Central-Barton*/
If 23300000  >= farm <= 23399999 and year = 98 then pnirrc = 36;
If 23300000  >= farm <= 23399999 and year = 99 then pnirrc = 35;
If 23300000  >= farm <= 23399999 and year = 100 then pnirrc = 35;
```

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If 23300000  >= farm <= 23399999 and year = 101 then pnirrc = 34;
If 23300000  >= farm <= 23399999 and year = 102 then pnirrc = 34.4;
If 23300000  >= farm <= 23399999 and year = 103 then pnirrc = 34.1;
If 23300000  >= farm <= 23399999 and year = 104 then pnirrc = 35.5;
If 23300000  >= farm <= 23399999 and year = 105 then pnirrc = 35.5;
If 23300000  >= farm <= 23399999 and year = 106 then pnirrc = 36;
If 23300000  >= farm <= 23399999 and year = 107 then pnirrc = 35;

If 23300000  >= farm <= 23399999 and year = 98 then pirrc = 65;
If 23300000  >= farm <= 23399999 and year = 99 then pirrc = 64;
If 23300000  >= farm <= 23399999 and year = 100 then pirrc = 65;
If 23300000  >= farm <= 23399999 and year = 101 then pirrc = 65;
If 23300000  >= farm <= 23399999 and year = 102 then pirrc = 64;
If 23300000  >= farm <= 23399999 and year = 103 then pirrc = 63;
If 23300000  >= farm <= 23399999 and year = 104 then pirrc = 65;
If 23300000  >= farm <= 23399999 and year = 105 then pirrc = 66;
If 23300000  >= farm <= 23399999 and year = 106 then pirrc = 64;
If 23300000  >= farm <= 23399999 and year = 107 then pirrc = 67;

If 23300000  >= farm <= 23399999 and year = 98 then ppast = 12.7;
If 23300000  >= farm <= 23399999 and year = 99 then ppast = 13;
If 23300000  >= farm <= 23399999 and year = 100 then ppast = 12;
If 23300000  >= farm <= 23399999 and year = 101 then ppast = 12.3;
If 23300000  >= farm <= 23399999 and year = 102 then ppast = 12.4;
If 23300000  >= farm <= 23399999 and year = 103 then ppast = 12.4;
If 23300000  >= farm <= 23399999 and year = 104 then ppast = 13.1;
If 23300000  >= farm <= 23399999 and year = 105 then ppast = 13.3;
If 23300000  >= farm <= 23399999 and year = 106 then ppast = 13.8;
If 23300000  >= farm <= 23399999 and year = 107 then ppast = 14;

/* Central-Rice*/
If 24800000  >= farm <= 24899999 and year = 98 then pnirrc = 36;
If 24800000  >= farm <= 24899999 and year = 99 then pnirrc = 35;
If 24800000  >= farm <= 24899999 and year = 100 then pnirrc = 35;
If 24800000  >= farm <= 24899999 and year = 101 then pnirrc = 34;
If 24800000  >= farm <= 24899999 and year = 102 then pnirrc = 34.4;
If 24800000  >= farm <= 24899999 and year = 103 then pnirrc = 34.1;
If 24800000  >= farm <= 24899999 and year = 104 then pnirrc = 35.5;
If 24800000  >= farm <= 24899999 and year = 105 then pnirrc = 35.5;
If 24800000  >= farm <= 24899999 and year = 106 then pnirrc = 36;
If 24800000  >= farm <= 24899999 and year = 107 then pnirrc = 35;

If 24800000  >= farm <= 24899999 and year = 98 then pirrc = 65;
If 24800000  >= farm <= 24899999 and year = 99 then pirrc = 64;
If 24800000  >= farm <= 24899999 and year = 100 then pirrc = 65;
If 24800000  >= farm <= 24899999 and year = 101 then pirrc = 65;
If 24800000  >= farm <= 24899999 and year = 102 then pirrc = 64;
If 24800000  >= farm <= 24899999 and year = 103 then pirrc = 63;
If 24800000  >= farm <= 24899999 and year = 104 then pirrc = 65;
If 24800000  >= farm <= 24899999 and year = 105 then pirrc = 66;
If 24800000  >= farm <= 24899999 and year = 106 then pirrc = 64;
If 24800000  >= farm <= 24899999 and year = 107 then pirrc = 67;

If 24800000  >= farm <= 24899999 and year = 98 then ppast = 12.7;
If 24800000  >= farm <= 24899999 and year = 99 then ppast = 13;
If 24800000  >= farm <= 24899999 and year = 100 then ppast = 12;
If 24800000  >= farm <= 24899999 and year = 101 then ppast = 12.3;
```

```
If 24800000  >= farm <= 24899999 and year = 102 then ppast = 12.4;
If 24800000  >= farm <= 24899999 and year = 103 then ppast = 12.4;
If 24800000  >= farm <= 24899999 and year = 104 then ppast = 13.1;
If 24800000  >= farm <= 24899999 and year = 105 then ppast = 13.3;
If 24800000  >= farm <= 24899999 and year = 106 then ppast = 13.8;
If 24800000  >= farm <= 24899999 and year = 107 then ppast = 14;

/* Central-, Russell, Ellsworth*/
If 16000000  >= farm <= 16499999 and year = 98 then pnirrc = 36;
If 16000000  >= farm <= 16499999 and year = 99 then pnirrc = 35;
If 16000000  >= farm <= 16499999 and year = 100 then pnirrc = 35;
If 16000000  >= farm <= 16499999 and year = 101 then pnirrc = 34;
If 16000000  >= farm <= 16499999 and year = 102 then pnirrc = 34.4;
If 16000000  >= farm <= 16499999 and year = 103 then pnirrc = 34.1;
If 16000000  >= farm <= 16499999 and year = 104 then pnirrc = 35.5;
If 16000000  >= farm <= 16499999 and year = 105 then pnirrc = 35.5;
If 16000000  >= farm <= 16499999 and year = 106 then pnirrc = 36;
If 16000000  >= farm <= 16499999 and year = 107 then pnirrc = 35;

If 16000000  >= farm <= 16499999 and year = 98 then pirrc = 65;
If 16000000  >= farm <= 16499999 and year = 99 then pirrc = 64;
If 16000000  >= farm <= 16499999 and year = 100 then pirrc = 65;
If 16000000  >= farm <= 16499999 and year = 101 then pirrc = 65;
If 16000000  >= farm <= 16499999 and year = 102 then pirrc = 64;
If 16000000  >= farm <= 16499999 and year = 103 then pirrc = 63;
If 16000000  >= farm <= 16499999 and year = 104 then pirrc = 65;
If 16000000  >= farm <= 16499999 and year = 105 then pirrc = 66;
If 16000000  >= farm <= 16499999 and year = 106 then pirrc = 64;
If 16000000  >= farm <= 16499999 and year = 107 then pirrc = 67;

If 16000000  >= farm <= 16499999 and year = 98 then ppast = 12.7;
If 16000000  >= farm <= 16499999 and year = 99 then ppast = 13;
If 16000000  >= farm <= 16499999 and year = 100 then ppast = 12;
If 16000000  >= farm <= 16499999 and year = 101 then ppast = 12.3;
If 16000000  >= farm <= 16499999 and year = 102 then ppast = 12.4;
If 16000000  >= farm <= 16499999 and year = 103 then ppast = 12.4;
If 16000000  >= farm <= 16499999 and year = 104 then ppast = 13.1;
If 16000000  >= farm <= 16499999 and year = 105 then ppast = 13.3;
If 16000000  >= farm <= 16499999 and year = 106 then ppast = 13.8;
If 16000000  >= farm <= 16499999 and year = 107 then ppast = 14;

/* Central-Ellis*/
If 53800000  >= farm <= 53899999 and year = 98 then pnirrc = 36;
If 53800000  >= farm <= 53899999 and year = 99 then pnirrc = 35;
If 53800000  >= farm <= 53899999 and year = 100 then pnirrc = 35;
If 53800000  >= farm <= 53899999 and year = 101 then pnirrc = 34;
If 53800000  >= farm <= 53899999 and year = 102 then pnirrc = 34.4;
If 53800000  >= farm <= 53899999 and year = 103 then pnirrc = 34.1;
If 53800000  >= farm <= 53899999 and year = 104 then pnirrc = 35.5;
If 53800000  >= farm <= 53899999 and year = 105 then pnirrc = 35.5;
If 53800000  >= farm <= 53899999 and year = 106 then pnirrc = 36;
If 53800000  >= farm <= 53899999 and year = 107 then pnirrc = 35;

If 53800000  >= farm <= 53899999 and year = 98 then pirrc = 65;
If 53800000  >= farm <= 53899999 and year = 99 then pirrc = 64;
If 53800000  >=  farm <= 53899999 and year = 100 then pirrc = 65;
If 53800000  >= farm <= 53899999 and year = 101 then pirrc = 65;
```

```
If 53800000  >= farm <= 53899999 and year = 102 then pirrc = 64;
If 53800000  >= farm <= 53899999 and year = 103 then pirrc = 63;
If 53800000  >= farm <= 53899999 and year = 104 then pirrc = 65;
If 53800000  >= farm <= 53899999 and year = 105 then pirrc = 66;
If 53800000  >= farm <= 53899999 and year = 106 then pirrc = 64;
If 53800000  >= farm <= 53899999 and year = 107 then pirrc = 67;

If 53800000  >= farm <= 53899999 and year = 98 then ppast = 12.7;
If 53800000  >= farm <= 53899999 and year = 99 then ppast = 13;
If 53800000  >= farm <= 53899999 and year = 100 then ppast = 12;
If 53800000  >= farm <= 53899999 and year = 101 then ppast = 12.3;
If 53800000  >= farm <= 53899999 and year = 102 then ppast = 12.4;
If 53800000  >= farm <= 53899999 and year = 103 then ppast = 12.4;
If 53800000  >= farm <= 53899999 and year = 104 then ppast = 13.1;
If 53800000  >= farm <= 53899999 and year = 105 then ppast = 13.3;
If 53800000  >= farm <= 53899999 and year = 106 then ppast = 13.8;
If 53800000  >= farm <= 53899999 and year = 107 then ppast = 14;

/* Central-Rush*/
If 57300000  >= farm <= 57399999 and year = 98 then pnirrc = 36;
If 57300000  >= farm <= 57399999 and year = 99 then pnirrc = 35;
If 57300000  >= farm <= 57399999 and year = 100 then pnirrc = 35;
If 57300000  >= farm <= 57399999 and year = 101 then pnirrc = 34;
If 57300000  >= farm <= 57399999 and year = 102 then pnirrc = 34.4;
If 57300000  >= farm <= 57399999 and year = 103 then pnirrc = 34.1;
If 57300000  >= farm <= 57399999 and year = 104 then pnirrc = 35.5;
If 57300000  >= farm <= 57399999 and year = 105 then pnirrc = 35.5;
If 57300000  >= farm <= 57399999 and year = 106 then pnirrc = 36;
If 57300000  >= farm <= 57399999 and year = 107 then pnirrc = 35;

If 57300000  >= farm <= 57399999 and year = 98 then pirrc = 65;
If 57300000  >= farm <= 57399999 and year = 99 then pirrc = 64;
If 57300000  >= farm <= 57399999 and year = 100 then pirrc = 65;
If 57300000  >= farm <= 57399999 and year = 101 then pirrc = 65;
If 57300000  >= farm <= 57399999 and year = 102 then pirrc = 64;
If 57300000  >= farm <= 57399999 and year = 103 then pirrc = 63;
If 57300000  >= farm <= 57399999 and year = 104 then pirrc = 65;
If 57300000  >= farm <= 57399999 and year = 105 then pirrc = 66;
If 57300000  >= farm <= 57399999 and year = 106 then pirrc = 64;
If 57300000  >= farm <= 57399999 and year = 107 then pirrc = 67;

If 57300000  >= farm <= 57399999 and year = 98 then ppast = 12.7;
If 57300000  >= farm <= 57399999 and year = 99 then ppast = 13;
If 57300000  >= farm <= 57399999 and year = 100 then ppast = 12;
If 57300000  >= farm <= 57399999 and year = 101 then ppast = 12.3;
If 57300000  >= farm <= 57399999 and year = 102 then ppast = 12.4;
If 57300000  >= farm <= 57399999 and year = 103 then ppast = 12.4;
If 57300000  >= farm <= 57399999 and year = 104 then ppast = 13.1;
If 57300000  >= farm <= 57399999 and year = 105 then ppast = 13.3;
If 57300000  >= farm <= 57399999 and year = 106 then ppast = 13.8;
If 57300000  >= farm <= 57399999 and year = 107 then ppast = 14;

/ *LAND PRICES FOR KANSAS NORTH CENTRAL REGION*/
/* North Central-Cloud, Washington, Republic, Clay, Jewell*/
If 13600000  >= farm <= 14399999 and year = 98 then pnirrc = 40;
If 13600000  >= farm <= 14399999 and year = 99 then pnirrc = 39;
If 13600000  >= farm <= 14399999 and year = 100 then pnirrc = 40;
```

```
If 13600000  >= farm <= 14399999 and year = 101 then pnirrc = 39;
If 13600000  >= farm <= 14399999 and year = 102 then pnirrc = 39;
If 13600000  >= farm <= 14399999 and year = 103 then pnirrc = 39;
If 13600000  >= farm <= 14399999 and year = 104 then pnirrc = 40.5;
If 13600000  >= farm <= 14399999 and year = 105 then pnirrc = 42;
If 13600000  >= farm <= 14399999 and year = 106 then pnirrc = 43;
If 13600000  >= farm <= 14399999 and year = 107 then pnirrc = 47;

If 13600000  >= farm <= 14399999 and year = 98 then pirrc = 75;
If 13600000  >= farm <= 14399999 and year = 99 then pirrc = 75;
If 13600000  >= farm <= 14399999 and year = 100 then pirrc = 76;
If 13600000  >= farm <= 14399999 and year = 101 then pirrc = 79;
If 13600000  >= farm <= 14399999 and year = 102 then pirrc = 76;
If 13600000  >= farm <= 14399999 and year = 103 then pirrc = 74;
If 13600000  >= farm <= 14399999 and year = 104 then pirrc = 74;
If 13600000  >= farm <= 14399999 and year = 105 then pirrc = 76;
If 13600000  >= farm <= 14399999 and year = 106 then pirrc = 76;
If 13600000  >= farm <= 14399999 and year = 107 then pirrc = 80;

If 13600000  >= farm <= 14399999 and year = 98 then ppast = 13.5;
If 13600000  >= farm <= 14399999 and year = 99 then ppast = 14;
If 13600000  >= farm <= 14399999 and year = 100 then ppast = 13.5;
If 13600000  >= farm <= 14399999 and year = 101 then ppast = 13.6;
If 13600000  >= farm <= 14399999 and year = 102 then ppast = 13.7;
If 13600000  >= farm <= 14399999 and year = 103 then ppast = 13.7;
If 13600000  >= farm <= 14399999 and year = 104 then ppast = 14.1;
If 13600000  >= farm <= 14399999 and year = 105 then ppast = 14.4;
If 13600000  >= farm <= 14399999 and year = 106 then ppast = 14.9;
If 13600000  >= farm <= 14399999 and year = 107 then ppast = 16;

/* North Central-Smith, Mitchell, Osborne*/
If 15000000  >= farm <= 15699999 and year = 98 then pnirrc = 40;
If 15000000  >= farm <= 15699999 and year = 99 then pnirrc = 39;
If 15000000  >= farm <= 15699999 and year = 100 then pnirrc = 40;
If 15000000  >= farm <= 15699999 and year = 101 then pnirrc = 39;
If 15000000  >= farm <= 15699999 and year = 102 then pnirrc = 39;
If 15000000  >= farm <= 15699999 and year = 103 then pnirrc = 39;
If 15000000  >= farm <= 15699999 and year = 104 then pnirrc = 40.5;
If 15000000  >= farm <= 15699999 and year = 105 then pnirrc = 42;
If 15000000  >= farm <= 15699999 and year = 106 then pnirrc = 43;
If 15000000  >= farm <= 15699999 and year = 107 then pnirrc = 47;

If 15000000  >= farm <= 15699999 and year = 98 then pirrc = 75;
If 15000000  >= farm <= 15699999 and year = 99 then pirrc = 75;
If 15000000  >= farm <= 15699999 and year = 100 then pirrc = 76;
If 15000000  >= farm <= 15699999 and year = 101 then pirrc = 79;
If 15000000  >= farm <= 15699999 and year = 102 then pirrc = 76;
If 15000000  >= farm <= 15699999 and year = 103 then pirrc = 74;
If 15000000  >= farm <= 15699999 and year = 104 then pirrc = 74;
If 15000000  >= farm <= 15699999 and year = 105 then pirrc = 76;
If 15000000  >= farm <= 15699999 and year = 106 then pirrc = 76;
If 15000000  >= farm <= 15699999 and year = 107 then pirrc = 80;

If 15000000  >= farm <= 15699999 and year = 98 then ppast = 13.5;
If 15000000  >= farm <= 15699999 and year = 99 then ppast = 14;
If 15000000  >= farm <= 15699999 and year = 100 then ppast = 13.5;
If 15000000  >= farm <= 15699999 and year = 101 then ppast = 13.6;
```

```
If 15000000  >= farm <= 15699999 and year = 102 then ppast = 13.7;
If 15000000  >= farm <= 15699999 and year = 103 then ppast = 13.7;
If 15000000  >= farm <= 15699999 and year = 104 then ppast = 14.1;
If 15000000  >= farm <= 15699999 and year = 105 then ppast = 14.4;
If 15000000  >= farm <= 15699999 and year = 106 then ppast = 14.9;
If 15000000  >= farm <= 15699999 and year = 107 then ppast = 16;

/* North Central- Ottawa*/
If 16500000  >= farm <= 16599999 and year = 98 then pnirrc = 40;
If 16500000  >= farm <= 16599999 and year = 99 then pnirrc = 39;
If 16500000  >= farm <= 16599999 and year = 100 then pnirrc = 40;
If 16500000  >= farm <= 16599999 and year = 101 then pnirrc = 39;
If 16500000  >= farm <= 16599999 and year = 102 then pnirrc = 39;
If 16500000  >= farm <= 16599999 and year = 103 then pnirrc = 39;
If 16500000  >= farm <= 16599999 and year = 104 then pnirrc = 40.5;
If 16500000  >= farm <= 16599999 and year = 105 then pnirrc = 42;
If 16500000  >= farm <= 16599999 and year = 106 then pnirrc = 43;
If 16500000  >= farm <= 16599999 and year = 107 then pnirrc = 47;

If 16500000  >= farm <= 16599999 and year = 98 then pirrc = 75;
If 16500000  >= farm <= 16599999 and year = 99 then pirrc = 75;
If 16500000  >= farm <= 16599999 and year = 100 then pirrc = 76;
If 16500000  >= farm <= 16599999 and year = 101 then pirrc = 79;
If 16500000  >= farm <= 16599999 and year = 102 then pirrc = 76;
If 16500000  >= farm <= 16599999 and year = 103 then pirrc = 74;
If 16500000  >= farm <= 16599999 and year = 104 then pirrc = 74;
If 16500000  >= farm <= 16599999 and year = 105 then pirrc = 76;
If 16500000  >= farm <= 16599999 and year = 106 then pirrc = 76;
If 16500000  >= farm <= 16599999 and year = 107 then pirrc = 80;

If 16500000  >= farm <= 16599999 and year = 98 then ppast = 13.5;
If 16500000  >= farm <= 16599999 and year = 99 then ppast = 14;
If 16500000  >= farm <= 16599999 and year = 100 then ppast = 13.5;
If 16500000  >= farm <= 16599999 and year = 101 then ppast = 13.6;
If 16500000  >= farm <= 16599999 and year = 102 then ppast = 13.7;
If 16500000  >= farm <= 16599999 and year = 103 then ppast = 13.7;
If 16500000  >= farm <= 16599999 and year = 104 then ppast = 14.1;
If 16500000  >= farm <= 16599999 and year = 105 then ppast = 14.4;
If 16500000  >= farm <= 16599999 and year = 106 then ppast = 14.9;
If 16500000  >= farm <= 16599999 and year = 107 then ppast = 16;

/* North Central- Phillips*/
If 55800000  >= farm <= 55899999 and year = 98 then pnirrc = 40;
If 55800000  >= farm <= 55899999 and year = 99 then pnirrc = 39;
If 55800000  >= farm <= 55899999 and year = 100 then pnirrc = 40;
If 55800000  >= farm <= 55899999 and year = 101 then pnirrc = 39;
If 55800000  >= farm <= 55899999 and year = 102 then pnirrc = 39;
If 55800000  >= farm <= 55899999 and year = 103 then pnirrc = 39;
If 55800000  >= farm <= 55899999 and year = 104 then pnirrc = 40.5;
If 55800000  >= farm <= 55899999 and year = 105 then pnirrc = 42;
If 55800000  >= farm <= 55899999 and year = 106 then pnirrc = 43;
If 55800000  >= farm <= 55899999 and year = 107 then pnirrc = 47;

If 55800000  >= farm <= 55899999 and year = 98 then pirrc = 75;
If 55800000  >= farm <= 55899999 and year = 99 then pirrc = 75;
If 55800000  >= farm <= 55899999 and year = 100 then pirrc = 76;
If 55800000  >= farm <= 55899999 and year = 101 then pirrc = 79;
```

```
If 55800000  >= farm <= 55899999 and year = 102 then pirrc = 76;
If 55800000  >= farm <= 55899999 and year = 103 then pirrc = 74;
If 55800000  >= farm <= 55899999 and year = 104 then pirrc = 74;
If 55800000  >= farm <= 55899999 and year = 105 then pirrc = 76;
If 55800000  >= farm <= 55899999 and year = 106 then pirrc = 76;
If 55800000  >= farm <= 55899999 and year = 107 then pirrc = 80;

If 55800000  >= farm <= 55899999 and year = 98 then ppast = 13.5;
If 55800000  >= farm <= 55899999 and year = 99 then ppast = 14;
If 55800000  >= farm <= 55899999 and year = 100 then ppast = 13.5;
If 55800000  >= farm <= 55899999 and year = 101 then ppast = 13.6;
If 55800000  >= farm <= 55899999 and year = 102 then ppast = 13.7;
If 55800000  >= farm <= 55899999 and year = 103 then ppast = 13.7;
If 55800000  >= farm <= 55899999 and year = 104 then ppast = 14.1;
If 55800000  >= farm <= 55899999 and year = 105 then ppast = 14.4;
If 55800000  >= farm <= 55899999 and year = 106 then ppast = 14.9;
If 55800000  >= farm <= 55899999 and year = 107 then ppast = 16;

/* North Central- Rooks*/
If 57000000  >= farm <= 57099999 and year = 98 then pnirrc = 40;
If 57000000  >= farm <= 57099999 and year = 99 then pnirrc = 39;
If 57000000  >= farm <= 57099999 and year = 100 then pnirrc = 40;
If 57000000  >= farm <= 57099999 and year = 101 then pnirrc = 39;
If 57000000  >= farm <= 57099999 and year = 102 then pnirrc = 39;
If 57000000  >= farm <= 57099999 and year = 103 then pnirrc = 39;
If 57000000  >= farm <= 57099999 and year = 104 then pnirrc = 40.5;
If 57000000  >= farm <= 57099999 and year = 105 then pnirrc = 42;
If 57000000  >= farm <= 57099999 and year = 106 then pnirrc = 43;
If 57000000  >= farm <= 57099999 and year = 107 then pnirrc = 47;

If 57000000  >= farm <= 57099999 and year = 98 then pirrc = 75;
If 57000000  >= farm <= 57099999 and year = 99 then pirrc = 75;
If 57000000  >= farm <= 57099999 and year = 100 then pirrc = 76;
If 57000000  >= farm <= 57099999 and year = 101 then pirrc = 79;
If 57000000  >= farm <= 57099999 and year = 102 then pirrc = 76;
If 57000000  >= farm <= 57099999 and year = 103 then pirrc = 74;
If 57000000  >= farm <= 57099999 and year = 104 then pirrc = 74;
If 57000000  >= farm <= 57099999 and year = 105 then pirrc = 76;
If 57000000  >= farm <= 57099999 and year = 106 then pirrc = 76;
If 57000000  >= farm <= 57099999 and year = 107 then pirrc = 80;

If 57000000  >= farm <= 57099999 and year = 98 then ppast = 13.5;
If 57000000  >= farm <= 57099999 and year = 99 then ppast = 14;
If 57000000  >= farm <= 57099999 and year = 100 then ppast = 13.5;
If 57000000  >= farm <= 57099999 and year = 101 then ppast = 13.6;
If 57000000  >= farm <= 57099999 and year = 102 then ppast = 13.7;
If 57000000  >= farm <= 57099999 and year = 103 then ppast = 13.7;
If 57000000  >= farm <= 57099999 and year = 104 then ppast = 14.1;
If 57000000  >= farm <= 57099999 and year = 105 then ppast = 14.4;
If 57000000  >= farm <= 57099999 and year = 106 then ppast = 14.9;
If 57000000  >= farm <= 57099999 and year = 107 then ppast = 16;

/ *LAND PRICES FOR KANSAS SOUTH CENTRAL REGION*/
/* South Central- Sedgwick, Reno, Sumner*/
If 20200000  >= farm <= 21299999 and year = 98 then pnirrc = 35;
If 20200000  >= farm <= 21299999 and year = 99 then pnirrc = 32;
If 20200000  >= farm <= 21299999 and year = 100 then pnirrc = 33;
```

```
If 20200000  >= farm <= 21299999 and year = 101 then pnirrc = 33;
If 20200000  >= farm <= 21299999 and year = 102 then pnirrc = 32.9;
If 20200000  >= farm <= 21299999 and year = 103 then pnirrc = 33;
If 20200000  >= farm <= 21299999 and year = 104 then pnirrc = 34.5;
If 20200000  >= farm <= 21299999 and year = 105 then pnirrc = 35.5;
If 20200000  >= farm <= 21299999 and year = 106 then pnirrc = 35.5;
If 20200000  >= farm <= 21299999 and year = 107 then pnirrc = 37;

If 20200000  >= farm <= 21299999 and year = 98 then pirrc = 69;
If 20200000  >= farm <= 21299999 and year = 99 then pirrc = 68;
If 20200000  >= farm <= 21299999 and year = 100 then pirrc = 68;
If 20200000  >= farm <= 21299999 and year = 101 then pirrc = 72;
If 20200000  >= farm <= 21299999 and year = 102 then pirrc = 72;
If 20200000  >= farm <= 21299999 and year = 103 then pirrc = 69;
If 20200000  >= farm <= 21299999 and year = 104 then pirrc = 73;
If 20200000  >= farm <= 21299999 and year = 105 then pirrc = 74;
If 20200000  >= farm <= 21299999 and year = 106 then pirrc = 74;
If 20200000  >= farm <= 21299999 and year = 107 then pirrc = 78;

If 20200000  >= farm <= 21299999 and year = 98 then ppast = 11.8;
If 20200000  >= farm <= 21299999 and year = 99 then ppast = 11;
If 20200000  >= farm <= 21299999 and year = 100 then ppast = 10.9;
If 20200000  >= farm <= 21299999 and year = 101 then ppast = 11.1;
If 20200000  >= farm <= 21299999 and year = 102 then ppast = 11.2;
If 20200000  >= farm <= 21299999 and year = 103 then ppast = 11.2;
If 20200000  >= farm <= 21299999 and year = 104 then ppast = 11.3;
If 20200000  >= farm <= 21299999 and year = 105 then ppast = 11.8;
If 20200000  >= farm <= 21299999 and year = 106 then ppast = 11.5;
If 20200000  >= farm <= 21299999 and year = 107 then ppast = 12.4;

/* South Central- Harvey*/
If 22800000  >= farm <= 22899999 and year = 98 then pnirrc = 35;
If 22800000  >= farm <= 22899999 and year = 99 then pnirrc = 32;
If 22800000  >= farm <= 22899999 and year = 100 then pnirrc = 33;
If 22800000  >= farm <= 22899999 and year = 101 then pnirrc = 33;
If 22800000  >= farm <= 22899999 and year = 102 then pnirrc = 32.9;
If 22800000  >= farm <= 22899999 and year = 103 then pnirrc = 33;
If 22800000  >= farm <= 22899999 and year = 104 then pnirrc = 34.5;
If 22800000  >= farm <= 22899999 and year = 105 then pnirrc = 35.5;
If 22800000  >= farm <= 22899999 and year = 106 then pnirrc = 35.5;
If 22800000  >= farm <= 22899999 and year = 107 then pnirrc = 37;

If 22800000  >= farm <= 22899999 and year = 98 then pirrc = 69;
If 22800000  >= farm <= 22899999 and year = 99 then pirrc = 68;
If 22800000  >= farm <= 22899999 and year = 100 then pirrc = 68;
If 22800000  >= farm <= 22899999 and year = 101 then pirrc = 72;
If 22800000  >= farm <= 22899999 and year = 102 then pirrc = 72;
If 22800000  >= farm <= 22899999 and year = 103 then pirrc = 69;
If 22800000  >= farm <= 22899999 and year = 104 then pirrc = 73;
If 22800000  >= farm <= 22899999 and year = 105 then pirrc = 74;
If 22800000  >= farm <= 22899999 and year = 106 then pirrc = 74;
If 22800000  >= farm <= 22899999 and year = 107 then pirrc = 78;

If 22800000  >= farm <= 22899999 and year = 98 then ppast = 11.8;
If 22800000  >= farm <= 22899999 and year = 99 then ppast = 11;
If 22800000  >= farm <= 22899999 and year = 100 then ppast = 10.9;
If 22800000  >= farm <= 22899999 and year = 101 then ppast = 11.1;
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If 22800000  >= farm <= 22899999 and year = 102 then ppast = 11.2;
If 22800000  >= farm <= 22899999 and year = 103 then ppast = 11.2;
If 22800000  >= farm <= 22899999 and year = 104 then ppast = 11.3;
If 22800000  >= farm <= 22899999 and year = 105 then ppast = 11.8;
If 22800000  >= farm <= 22899999 and year = 106 then ppast = 11.5;
If 22800000  >= farm <= 22899999 and year = 107 then ppast = 12.4;

/* South Central- Harper, Pratt, Kingman, Stafford*/
If 25100000  >= farm <= 25999999 and year = 98 then pnirrc = 35;
If 25100000  >= farm <= 25999999 and year = 99 then pnirrc = 32;
If 25100000  >= farm <= 25999999 and year = 100 then pnirrc = 33;
If 25100000  >= farm <= 25999999 and year = 101 then pnirrc = 33;
If 25100000  >= farm <= 25999999 and year = 102 then pnirrc = 32.9;
If 25100000  >= farm <= 25999999 and year = 103 then pnirrc = 33;
If 25100000  >= farm <= 25999999 and year = 104 then pnirrc = 34.5;
If 25100000  >= farm <= 25999999 and year = 105 then pnirrc = 35.5;
If 25100000  >= farm <= 25999999 and year = 106 then pnirrc = 35.5;
If 25100000  >= farm <= 25999999 and year = 107 then pnirrc = 37;

If 25100000  >= farm <= 25999999 and year = 98 then pirrc = 69;
If 25100000  >= farm <= 25999999 and year = 99 then pirrc = 68;
If 25100000  >= farm <= 25999999 and year = 100 then pirrc = 68;
If 25100000  >= farm <= 25999999 and year = 101 then pirrc = 72;
If 25100000  >= farm <= 25999999 and year = 102 then pirrc = 72;
If 25100000  >= farm <= 25999999 and year = 103 then pirrc = 69;
If 25100000  >= farm <= 25999999 and year = 104 then pirrc = 73;
If 25100000  >= farm <= 25999999 and year = 105 then pirrc = 74;
If 25100000  >= farm <= 25999999 and year = 106 then pirrc = 74;
If 25100000  >= farm <= 25999999 and year = 107 then pirrc = 78;

If 25100000  >= farm <= 25999999 and year = 98 then ppast = 11.8;
If 25100000  >= farm <= 25999999 and year = 99 then ppast = 11;
If 25100000  >= farm <= 25999999 and year = 100 then ppast = 10.9;
If 25100000  >= farm <= 25999999 and year = 101 then ppast = 11.1;
If 25100000  >= farm <= 25999999 and year = 102 then ppast = 11.2;
If 25100000  >= farm <= 25999999 and year = 103 then ppast = 11.2;
If 25100000  >= farm <= 25999999 and year = 104 then ppast = 11.3;
If 25100000  >= farm <= 25999999 and year = 105 then ppast = 11.8;
If 25100000  >= farm <= 25999999 and year = 106 then ppast = 11.5;
If 25100000  >= farm <= 25999999 and year = 107 then ppast = 12.4;

/* South Central- Barber, Pawnee*/
If 36700000  >= farm <= 36999999 and year = 98 then pnirrc = 35;
If 36700000  >= farm <= 36999999 and year = 99 then pnirrc = 32;
If 36700000  >= farm <= 36999999 and year = 100 then pnirrc = 33;
If 36700000  >= farm <= 36999999 and year = 101 then pnirrc = 33;
If 36700000  >= farm <= 36999999 and year = 102 then pnirrc = 32.9;
If 36700000  >= farm <= 36999999 and year = 103 then pnirrc = 33;
If 36700000  >= farm <= 36999999 and year = 104 then pnirrc = 34.5;
If 36700000  >= farm <= 36999999 and year = 105 then pnirrc = 35.5;
If 36700000  >= farm <= 36999999 and year = 106 then pnirrc = 35.5;
If 36700000  >= farm <= 36999999 and year = 107 then pnirrc = 37;

If 36700000  >= farm <= 36999999 and year = 98 then pirrc = 69;
If 36700000  >= farm <= 36999999 and year = 99 then pirrc = 68;
If 36700000  >= farm <= 36999999 and year = 100 then pirrc = 68;
If 36700000  >= farm <= 36999999 and year = 101 then pirrc = 72;
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If 36700000  >= farm <= 36999999 and year = 102 then pirrc = 72;
If 36700000  >= farm <= 36999999 and year = 103 then pirrc = 69;
If 36700000  >= farm <= 36999999 and year = 104 then pirrc = 73;
If 36700000  >= farm <= 36999999 and year = 105 then pirrc = 74;
If 36700000  >= farm <= 36999999 and year = 106 then pirrc = 74;
If 36700000  >= farm <= 36999999 and year = 107 then pirrc = 78;

If 36700000  >= farm <= 36999999 and year = 98 then ppast = 11.8;
If 36700000  >= farm <= 36999999 and year = 99 then ppast = 11;
If 36700000  >= farm <= 36999999 and year = 100 then ppast = 10.9;
If 36700000  >= farm <= 36999999 and year = 101 then ppast = 11.1;
If 36700000  >= farm <= 36999999 and year = 102 then ppast = 11.2;
If 36700000  >= farm <= 36999999 and year = 103 then ppast = 11.2;
If 36700000  >= farm <= 36999999 and year = 104 then ppast = 11.3;
If 36700000  >= farm <= 36999999 and year = 105 then ppast = 11.8;
If 36700000  >= farm <= 36999999 and year = 106 then ppast = 11.5;
If 36700000  >= farm <= 36999999 and year = 107 then ppast = 12.4;

/* South Central- Kiowa*/
If 38500000  >= farm <= 38599999 and year = 98 then pnirrc = 35;
If 38500000  >= farm <= 38599999 and year = 99 then pnirrc = 32;
If 38500000  >= farm <= 38599999 and year = 100 then pnirrc = 33;
If 38500000  >= farm <= 38599999 and year = 101 then pnirrc = 33;
If 38500000  >= farm <= 38599999 and year = 102 then pnirrc = 32.9;
If 38500000  >= farm <= 38599999 and year = 103 then pnirrc = 33;
If 38500000  >= farm <= 38599999 and year = 104 then pnirrc = 34.5;
If 38500000  >= farm <= 38599999 and year = 105 then pnirrc = 35.5;
If 38500000  >= farm <= 38599999 and year = 106 then pnirrc = 35.5;
If 38500000  >= farm <= 38599999 and year = 107 then pnirrc = 37;

If 38500000  >= farm <= 38599999 and year = 98 then pirrc = 69;
If 38500000  >= farm <= 38599999 and year = 99 then pirrc = 68;
If 38500000  >= farm <= 38599999 and year = 100 then pirrc = 68;
If 38500000  >= farm <= 38599999 and year = 101 then pirrc = 72;
If 38500000  >= farm <= 38599999 and year = 102 then pirrc = 72;
If 38500000  >= farm <= 38599999 and year = 103 then pirrc = 69;
If 38500000  >= farm <= 38599999 and year = 104 then pirrc = 73;
If 38500000  >= farm <= 38599999 and year = 105 then pirrc = 74;
If 38500000  >= farm <= 38599999 and year = 106 then pirrc = 74;
If 38500000  >= farm <= 38599999 and year = 107 then pirrc = 78;

If 38500000  >= farm <= 38599999 and year = 98 then ppast = 11.8;
If 38500000  >= farm <= 38599999 and year = 99 then ppast = 11;
If 38500000  >= farm <= 38599999 and year = 100 then ppast = 10.9;
If 38500000  >= farm <= 38599999 and year = 101 then ppast = 11.1;
If 38500000  >= farm <= 38599999 and year = 102 then ppast = 11.2;
If 38500000  >= farm <= 38599999 and year = 103 then ppast = 11.2;
If 38500000  >= farm <= 38599999 and year = 104 then ppast = 11.3;
If 38500000  >= farm <= 38599999 and year = 105 then ppast = 11.8;
If 38500000  >= farm <= 38599999 and year = 106 then ppast = 11.5;
If 38500000  >= farm <= 38599999 and year = 107 then ppast = 12.4;

/* South Central- Commanche*/
If 39000000  >= farm <= 39099999 and year = 98 then pnirrc = 35;
If 39000000  >= farm <= 39099999 and year = 99 then pnirrc = 32;
If 39000000  >= farm <= 39099999 and year = 100 then pnirrc = 33;
If 39000000  >= farm <= 39099999 and year = 101 then pnirrc = 33;
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If 39000000  >= farm <= 39099999 and year = 102 then pnirrc = 32.9;
If 39000000  >= farm <= 39099999 and year = 103 then pnirrc = 33;
If 39000000  >= farm <= 39099999 and year = 104 then pnirrc = 34.5;
If 39000000  >= farm <= 39099999 and year = 105 then pnirrc = 35.5;
If 39000000  >= farm <= 39099999 and year = 106 then pnirrc = 35.5;
If 39000000  >= farm <= 39099999 and year = 107 then pnirrc = 37;

If 39000000  >= farm <= 39099999 and year = 98 then pirrc = 69;
If 39000000  >= farm <= 39099999 and year = 99 then pirrc = 68;
If 39000000  >= farm <= 39099999 and year = 100 then pirrc = 68;
If 39000000  >= farm <= 39099999 and year = 101 then pirrc = 72;
If 39000000  >= farm <= 39099999 and year = 102 then pirrc = 72;
If 39000000  >= farm <= 39099999 and year = 103 then pirrc = 69;
If 39000000  >= farm <= 39099999 and year = 104 then pirrc = 73;
If 39000000  >= farm <= 39099999 and year = 105 then pirrc = 74;
If 39000000  >= farm <= 39099999 and year = 106 then pirrc = 74;
If 39000000  >= farm <= 39099999 and year = 107 then pirrc = 78;

If 39000000  >= farm <= 39099999 and year = 98 then ppast = 11.8;
If 39000000  >= farm <= 39099999 and year = 99 then ppast = 11;
If 39000000  >= farm <= 39099999 and year = 100 then ppast = 10.9;
If 39000000  >= farm <= 39099999 and year = 101 then ppast = 11.1;
If 39000000  >= farm <= 39099999 and year = 102 then ppast = 11.2;
If 39000000  >= farm <= 39099999 and year = 103 then ppast = 11.2;
If 39000000  >= farm <= 39099999 and year = 104 then ppast = 11.3;
If 39000000  >= farm <= 39099999 and year = 105 then ppast = 11.8;
If 39000000  >= farm <= 39099999 and year = 106 then ppast = 11.5;
If 39000000  >= farm <= 39099999 and year = 107 then ppast = 12.4;

/* South Central- Edwards*/
If 37900000  >= farm <= 37999999 and year = 98 then pnirrc = 35;
If 37900000  >= farm <= 37999999 and year = 99 then pnirrc = 32;
If 37900000  >= farm <= 37999999 and year = 100 then pnirrc = 33;
If 37900000  >= farm <= 37999999 and year = 101 then pnirrc = 33;
If 37900000  >= farm <= 37999999 and year = 102 then pnirrc = 32.9;
If 37900000  >= farm <= 37999999 and year = 103 then pnirrc = 33;
If 37900000  >= farm <= 37999999 and year = 104 then pnirrc = 34.5;
If 37900000  >= farm <= 37999999 and year = 105 then pnirrc = 35.5;
If 37900000  >= farm <= 37999999 and year = 106 then pnirrc = 35.5;
If 37900000  >= farm <= 37999999 and year = 107 then pnirrc = 37;

If 37900000  >= farm <= 37999999 and year = 98 then pirrc = 69;
If 37900000  >= farm <= 37999999 and year = 99 then pirrc = 68;
If 37900000  >= farm <= 37999999 and year = 100 then pirrc = 68;
If 37900000  >= farm <= 37999999 and year = 101 then pirrc = 72;
If 37900000  >= farm <= 37999999 and year = 102 then pirrc = 72;
If 37900000  >= farm <= 37999999 and year = 103 then pirrc = 69;
If 37900000  >= farm <= 37999999 and year = 104 then pirrc = 73;
If 37900000  >= farm <= 37999999 and year = 105 then pirrc = 74;
If 37900000  >= farm <= 37999999 and year = 106 then pirrc = 74;
If 37900000  >= farm <= 37999999 and year = 107 then pirrc = 78;

If 37900000  >= farm <= 37999999 and year = 98 then ppast = 11.8;
If 37900000  >= farm <= 37999999 and year = 99 then ppast = 11;
If 37900000  >= farm <= 37999999 and year = 100 then ppast = 10.9;
If 37900000  >= farm <= 37999999 and year = 101 then ppast = 11.1;
If 37900000  >= farm <= 37999999 and year = 102 then ppast = 11.2;
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If 37900000  >= farm <= 37999999 and year = 103 then ppast = 11.2;
If 37900000  >= farm <= 37999999 and year = 104 then ppast = 11.3;
If 37900000  >= farm <= 37999999 and year = 105 then ppast = 11.8;
If 37900000  >= farm <= 37999999 and year = 106 then ppast = 11.5;
If 37900000  >= farm <= 37999999 and year = 107 then ppast = 12.4;

/ *LAND PRICES FOR KANSAS NORTH EAST REGION*/
/* North East- Marshall*/
If 12000000  >= farm <= 12099999 and year = 98 then pnirrc = 55;
If 12000000  >= farm <= 12099999 and year = 99 then pnirrc = 59;
If 12000000  >= farm <= 12099999 and year = 100 then pnirrc = 59;
If 12000000  >= farm <= 12099999 and year = 101 then pnirrc = 62;
If 12000000  >= farm <= 12099999 and year = 102 then pnirrc = 60;
If 12000000  >= farm <= 12099999 and year = 103 then pnirrc = 59.5;
If 12000000  >= farm <= 12099999 and year = 104 then pnirrc = 62.5;
If 12000000  >= farm <= 12099999 and year = 105 then pnirrc = 64.5;
If 12000000  >= farm <= 12099999 and year = 106 then pnirrc = 69;
If 12000000  >= farm <= 12099999 and year = 107 then pnirrc = 70;

If 12000000  >= farm <= 12099999 and year = 98 then pirrc = 75;
If 12000000  >= farm <= 12099999 and year = 99 then pirrc = 80;
If 12000000  >= farm <= 12099999 and year = 100 then pirrc = 80.32;
If 12000000  >= farm <= 12099999 and year = 101 then pirrc = 85;
If 12000000  >= farm <= 12099999 and year = 102 then pirrc = 83.38;
If 12000000  >= farm <= 12099999 and year = 103 then pirrc = 81;
If 12000000  >= farm <= 12099999 and year = 104 then pirrc = 83;
If 12000000  >= farm <= 12099999 and year = 105 then pirrc = 83;
If 12000000  >= farm <= 12099999 and year = 106 then pirrc = 84;
If 12000000  >= farm <= 12099999 and year = 107 then pirrc = 85;

If 12000000  >= farm <= 12099999 and year = 98 then ppast = 16.5;
If 12000000  >= farm <= 12099999 and year = 99 then ppast = 16;
If 12000000  >= farm <= 12099999 and year = 100 then ppast = 15.4;
If 12000000  >= farm <= 12099999 and year = 101 then ppast = 15.2;
If 12000000  >= farm <= 12099999 and year = 102 then ppast = 15.3;
If 12000000  >= farm <= 12099999 and year = 103 then ppast = 15.2;
If 12000000  >= farm <= 12099999 and year = 104 then ppast = 16.1;
If 12000000  >= farm <= 12099999 and year = 105 then ppast = 17.6;
If 12000000  >= farm <= 12099999 and year = 106 then ppast = 18.1;
If 12000000  >= farm <= 12099999 and year = 107 then ppast = 18.6;

/* North East- Riley*/
If 13000000  >= farm <= 13099999 and year = 98 then pnirrc = 55;
If 13000000  >= farm <= 13099999 and year = 99 then pnirrc = 59;
If 13000000  >= farm <= 13099999 and year = 100 then pnirrc = 59;
If 13000000  >= farm <= 13099999 and year = 101 then pnirrc = 62;
If 13000000  >= farm <= 13099999 and year = 102 then pnirrc = 60;
If 13000000  >= farm <= 13099999 and year = 103 then pnirrc = 59.5;
If 13000000  >= farm <= 13099999 and year = 104 then pnirrc = 62.5;
If 13000000  >= farm <= 13099999 and year = 105 then pnirrc = 64.5;
If 13000000  >= farm <= 13099999 and year = 106 then pnirrc = 69;
If 13000000  >= farm <= 13099999 and year = 107 then pnirrc = 70;

If 13000000  >= farm <= 13099999 and year = 98 then pirrc = 75;
If 13000000  >= farm <= 13099999 and year = 99 then pirrc = 80;
If 13000000  >= farm <= 13099999 and year = 100 then pirrc = 80.32;
If 13000000  >= farm <= 13099999 and year = 101 then pirrc = 85;
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If 13000000  >= farm <= 13099999 and year = 102 then pirrc = 83.38;
If 13000000  >= farm <= 13099999 and year = 103 then pirrc = 81;
If 13000000  >= farm <= 13099999 and year = 104 then pirrc = 83;
If 13000000  >= farm <= 13099999 and year = 105 then pirrc = 83;
If 13000000  >= farm <= 13099999 and year = 106 then pirrc = 84;
If 13000000  >= farm <= 13099999 and year = 107 then pirrc = 85;

If 13000000  >= farm <= 13099999 and year = 98 then ppast = 16.5;
If 13000000  >= farm <= 13099999 and year = 99 then ppast = 16;
If 13000000  >= farm <= 13099999 and year = 100 then ppast = 15.4;
If 13000000  >= farm <= 13099999 and year = 101 then ppast = 15.2;
If 13000000  >= farm <= 13099999 and year = 102 then ppast = 15.3;
If 13000000  >= farm <= 13099999 and year = 103 then ppast = 15.2;
If 13000000  >= farm <= 13099999 and year = 104 then ppast = 16.1;
If 13000000  >= farm <= 13099999 and year = 105 then ppast = 17.6;
If 13000000  >= farm <= 13099999 and year = 106 then ppast = 18.1;
If 13000000  >= farm <= 13099999 and year = 107 then ppast = 18.6;

/* North East- Brown, Nemaha, Pottawatomie, Jackson, Doniphan, Jefferson*/
If 42500000  >= farm <= 44699999 and year = 98 then pnirrc = 55;
If 42500000  >= farm <= 44699999 and year = 99 then pnirrc = 59;
If 42500000  >= farm <= 44699999 and year = 100 then pnirrc = 59;
If 42500000  >= farm <= 44699999 and year = 101 then pnirrc = 62;
If 42500000  >= farm <= 44699999 and year = 102 then pnirrc = 60;
If 42500000  >= farm <= 44699999 and year = 103 then pnirrc = 59.5;
If 42500000  >= farm <= 44699999 and year = 104 then pnirrc = 62.5;
If 42500000  >= farm <= 44699999 and year = 105 then pnirrc = 64.5;
If 42500000  >= farm <= 44699999 and year = 106 then pnirrc = 69;
If 42500000  >= farm <= 44699999 and year = 107 then pnirrc = 70;

If 42500000  >= farm <= 44699999 and year = 98 then pirrc = 75;
If 42500000  >= farm <= 44699999 and year = 99 then pirrc = 80;
If 42500000  >= farm <= 44699999 and year = 100 then pirrc = 80.32;
If 42500000  >= farm <= 44699999 and year = 101 then pirrc = 85;
If 42500000  >= farm <= 44699999 and year = 102 then pirrc = 83.38;
If 42500000  >= farm <= 44699999 and year = 103 then pirrc = 81;
If 42500000  >= farm <= 44699999 and year = 104 then pirrc = 83;
If 42500000  >= farm <= 44699999 and year = 105 then pirrc = 83;
If 42500000  >= farm <= 44699999 and year = 106 then pirrc = 84;
If 42500000  >= farm <= 44699999 and year = 107 then pirrc = 85;

If 42500000  >= farm <= 44699999 and year = 98 then ppast = 16.5;
If 42500000  >= farm <= 44699999 and year = 99 then ppast = 16;
If 42500000  >= farm <= 44699999 and year = 100 then ppast = 15.4;
If 42500000  >= farm <= 44699999 and year = 101 then ppast = 15.2;
If 42500000  >= farm <= 44699999 and year = 102 then ppast = 15.3;
If 42500000  >= farm <= 44699999 and year = 103 then ppast = 15.2;
If 42500000  >= farm <= 44699999 and year = 104 then ppast = 16.1;
If 42500000  >= farm <= 44699999 and year = 105 then ppast = 17.6;
If 42500000  >= farm <= 44699999 and year = 106 then ppast = 18.1;
If 42500000  >= farm <= 44699999 and year = 107 then ppast = 18.6;

/* North East- Wyandotte*/
If 40100000  >= farm <= 40199999 and year = 98 then pnirrc = 55;
If 40100000  >= farm <= 40199999 and year = 99 then pnirrc = 59;
If 40100000  >= farm <= 40199999 and year = 100 then pnirrc = 59;
If 40100000  >= farm <= 40199999 and year = 101 then pnirrc = 62;
```

```
If 40100000  >= farm <= 40199999 and year = 102 then pnirrc = 60;
If 40100000  >= farm <= 40199999 and year = 103 then pnirrc = 59.5;
If 40100000  >= farm <= 40199999 and year = 104 then pnirrc = 62.5;
If 40100000  >= farm <= 40199999 and year = 105 then pnirrc = 64.5;
If 40100000  >= farm <= 40199999 and year = 106 then pnirrc = 69;
If 40100000  >= farm <= 40199999 and year = 107 then pnirrc = 70;

If 40100000  >= farm <= 40199999 and year = 98 then pirrc = 75;
If 40100000  >= farm <= 40199999 and year = 99 then pirrc = 80;
If 40100000  >= farm <= 40199999 and year = 100 then pirrc = 80.32;
If 40100000  >= farm <= 40199999 and year = 101 then pirrc = 85;
If 40100000  >= farm <= 40199999 and year = 102 then pirrc = 83.38;
If 40100000  >= farm <= 40199999 and year = 103 then pirrc = 81;
If 40100000  >= farm <= 40199999 and year = 104 then pirrc = 83;
If 40100000  >= farm <= 40199999 and year = 105 then pirrc = 83;
If 40100000  >= farm <= 40199999 and year = 106 then pirrc = 84;
If 40100000  >= farm <= 40199999 and year = 107 then pirrc = 85;

If 40100000  >= farm <= 40199999 and year = 98 then ppast = 16.5;
If 40100000  >= farm <= 40199999 and year = 99 then ppast = 16;
If 40100000  >= farm <= 40199999 and year = 100 then ppast = 15.4;
If 40100000  >= farm <= 40199999 and year = 101 then ppast = 15.2;
If 40100000  >= farm <= 40199999 and year = 102 then ppast = 15.3;
If 40100000  >= farm <= 40199999 and year = 103 then ppast = 15.2;
If 40100000  >= farm <= 40199999 and year = 104 then ppast = 16.1;
If 40100000  >= farm <= 40199999 and year = 105 then ppast = 17.6;
If 40100000  >= farm <= 40199999 and year = 106 then ppast = 18.1;
If 40100000  >= farm <= 40199999 and year = 107 then ppast = 18.6;

/* North East- Leavenworth*/
If 40700000  >= farm <= 40799999 and year = 98 then pnirrc = 55;
If 40700000  >= farm <= 40799999 and year = 99 then pnirrc = 59;
If 40700000  >= farm <= 40799999 and year = 100 then pnirrc = 59;
If 40700000  >= farm <= 40799999 and year = 101 then pnirrc = 62;
If 40700000  >= farm <= 40799999 and year = 102 then pnirrc = 60;
If 40700000  >= farm <= 40799999 and year = 103 then pnirrc = 59.5;
If 40700000  >= farm <= 40799999 and year = 104 then pnirrc = 62.5;
If 40700000  >= farm <= 40799999 and year = 105 then pnirrc = 64.5;
If 40700000  >= farm <= 40799999 and year = 106 then pnirrc = 69;
If 40700000  >= farm <= 40799999 and year = 107 then pnirrc = 70;

If 40700000  >= farm <= 40799999 and year = 98 then pirrc = 75;
If 40700000  >= farm <= 40799999 and year = 99 then pirrc = 80;
If 40700000  >= farm <= 40799999 and year = 100 then pirrc = 80.32;
If 40700000  >= farm <= 40799999 and year = 101 then pirrc = 85;
If 40700000  >= farm <= 40799999 and year = 102 then pirrc = 83.38;
If 40700000  >= farm <= 40799999 and year = 103 then pirrc = 81;
If 40700000  >= farm <= 40799999 and year = 104 then pirrc = 83;
If 40700000  >= farm <= 40799999 and year = 105 then pirrc = 83;
If 40700000  >= farm <= 40799999 and year = 106 then pirrc = 84;
If 40700000  >= farm <= 40799999 and year = 107 then pirrc = 85;

If 40700000  >= farm <= 40799999 and year = 98 then ppast = 16.5;
If 40700000  >= farm <= 40799999 and year = 99 then ppast = 16;
If 40700000  >= farm <= 40799999 and year = 100 then ppast = 15.4;
If 40700000  >= farm <= 40799999 and year = 101 then ppast = 15.2;
If 40700000  >= farm <= 40799999 and year = 102 then ppast = 15.3;
```

```
If 40700000  >= farm <= 40799999 and year = 103 then ppast = 15.2;
If 40700000  >= farm <= 40799999 and year = 104 then ppast = 16.1;
If 40700000  >= farm <= 40799999 and year = 105 then ppast = 17.6;
If 40700000  >= farm <= 40799999 and year = 106 then ppast = 18.1;
If 40700000  >= farm <= 40799999 and year = 107 then ppast = 18.6;

/* North East- Atchison*/
If 41500000  >= farm <= 41599999 and year = 98 then pnirrc = 55;
If 41500000  >= farm <= 41599999 and year = 99 then pnirrc = 59;
If 41500000  >= farm <= 41599999 and year = 100 then pnirrc = 59;
If 41500000  >= farm <= 41599999 and year = 101 then pnirrc = 62;
If 41500000  >= farm <= 41599999 and year = 102 then pnirrc = 60;
If 41500000  >= farm <= 41599999 and year = 103 then pnirrc = 59.5;
If 41500000  >= farm <= 41599999 and year = 104 then pnirrc = 62.5;
If 41500000  >= farm <= 41599999 and year = 105 then pnirrc = 64.5;
If 41500000  >= farm <= 41599999 and year = 106 then pnirrc = 69;
If 41500000  >= farm <= 41599999 and year = 107 then pnirrc = 70;

If 41500000  >= farm <= 41599999 and year = 98 then pirrc = 75;
If 41500000  >= farm <= 41599999 and year = 99 then pirrc = 80;
If 41500000  >= farm <= 41599999 and year = 100 then pirrc = 80.32;
If 41500000  >= farm <= 41599999 and year = 101 then pirrc = 85;
If 41500000  >= farm <= 41599999 and year = 102 then pirrc = 83.38;
If 41500000  >= farm <= 41599999 and year = 103 then pirrc = 81;
If 41500000  >= farm <= 41599999 and year = 104 then pirrc = 83;
If 41500000  >= farm <= 41599999 and year = 105 then pirrc = 83;
If 41500000  >= farm <= 41599999 and year = 106 then pirrc = 84;
If 41500000  >=  farm <= 41599999 and year = 107 then pirrc = 85;

If 41500000  >= farm <= 41599999 and year = 98 then ppast = 16.5;
If 41500000  >= farm <= 41599999 and year = 99 then ppast = 16;
If 41500000  >= farm <= 41599999 and year = 100 then ppast = 15.4;
If 41500000  >= farm <= 41599999 and year = 101 then ppast = 15.2;
If 41500000  >= farm <= 41599999 and year = 102 then ppast = 15.3;
If 41500000  >= farm <= 41599999 and year = 103 then ppast = 15.2;
If 41500000  >= farm <= 41599999 and year = 104 then ppast = 16.1;
If 41500000  >= farm <= 41599999 and year = 105 then ppast = 17.6;
If 41500000  >= farm <= 41599999 and year = 106 then ppast = 18.1;
If 41500000  >= farm <= 41599999 and year = 107 then ppast = 18.6;

/ *LAND PRICES FOR KANSAS EAST CENTRAL REGION*/
/* East Central- Geary*/
If 14700000  >= farm <= 14799999 and year = 98 then pnirrc = 39;
If 14700000  >= farm <= 14799999 and year = 99 then pnirrc = 39;
If 14700000  >= farm <= 14799999 and year = 100 then pnirrc = 42;
If 14700000  >= farm <= 14799999 and year = 101 then pnirrc = 41;
If 14700000  >= farm <= 14799999 and year = 102 then pnirrc = 41.5;
If 14700000  >= farm <= 14799999 and year = 103 then pnirrc = 41.5;
If 14700000  >= farm <= 14799999 and year = 104 then pnirrc = 42.5;
If 14700000  >= farm <= 14799999 and year = 105 then pnirrc = 44;
If 14700000  >= farm <= 14799999 and year = 106 then pnirrc = 50.5;
If 14700000  >= farm <= 14799999 and year = 107 then pnirrc = 50;

If 14700000  >= farm <= 14799999 and year = 98 then pirrc = 67;
If 14700000  >= farm <= 14799999 and year = 99 then pirrc = 66;
If 14700000  >= farm <= 14799999 and year = 100 then pirrc = 67.35;
If 14700000  >= farm <= 14799999 and year = 101 then pirrc = 71.27;
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If 14700000  >= farm <= 14799999 and year = 102 then pirrc = 68.97;
If 14700000  >= farm <= 14799999 and year = 103 then pirrc = 67;
If 14700000  >= farm <= 14799999 and year = 104 then pirrc = 71;
If 14700000  >= farm <= 14799999 and year = 105 then pirrc = 73;
If 14700000  >= farm <= 14799999 and year = 106 then pirrc = 76;
If 14700000  >= farm <= 14799999 and year = 107 then pirrc = 78;

If 14700000  >= farm <= 14799999 and year = 98 then ppast = 16.8;
If 14700000  >= farm <= 14799999 and year = 99 then ppast = 18;
If 14700000  >= farm <= 14799999 and year = 100 then ppast = 16.9;
If 14700000  >= farm <= 14799999 and year = 101 then ppast = 17;
If 14700000  >= farm <= 14799999 and year = 102 then ppast = 16.8;
If 14700000  >= farm <= 14799999 and year = 103 then ppast = 16.9;
If 14700000  >= farm <= 14799999 and year = 104 then ppast = 17.6;
If 14700000  >= farm <= 14799999 and year = 105 then ppast = 17.9;
If 14700000  >= farm <= 14799999 and year = 106 then ppast = 18.4;
If 14700000  >= farm <= 14799999 and year = 107 then ppast = 19.4;

/* East Central- Shawnee*/
If 40300000  >= farm <= 40399999 and year = 98 then pnirrc = 39;
If 40300000  >= farm <= 40399999 and year = 99 then pnirrc = 39;
If 40300000  >= farm <= 40399999 and year = 100 then pnirrc = 42;
If 40300000  >= farm <= 40399999 and year = 101 then pnirrc = 41;
If 40300000  >= farm <= 40399999 and year = 102 then pnirrc = 41.5;
If 40300000  >= farm <= 40399999 and year = 103 then pnirrc = 41.5;
If 40300000  >= farm <= 40399999 and year = 104 then pnirrc = 42.5;
If 40300000  >= farm <= 40399999 and year = 105 then pnirrc = 44;
If 40300000  >= farm <= 40399999 and year = 106 then pnirrc = 50.5;
If 40300000  >= farm <= 40399999 and year = 107 then pnirrc = 50;

If 40300000  >= farm <= 40399999 and year = 98 then pirrc = 67;
If 40300000  >= farm <= 40399999 and year = 99 then pirrc = 66;
If 40300000  >= farm <= 40399999 and year = 100 then pirrc = 67.35;
If 40300000  >= farm <= 40399999 and year = 101 then pirrc = 71.27;
If 40300000  >= farm <= 40399999 and year = 102 then pirrc = 68.97;
If 40300000  >= farm <= 40399999 and year = 103 then pirrc = 67;
If 40300000  >= farm <= 40399999 and year = 104 then pirrc = 71;
If 40300000  >= farm <= 40399999 and year = 105 then pirrc = 73;
If 40300000  >= farm <= 40399999 and year = 106 then pirrc = 76;
If 40300000  >= farm <= 40399999 and year = 107 then pirrc = 78;

If 40300000  >= farm <= 40399999 and year = 98 then ppast = 16.8;
If 40300000  >= farm <= 40399999 and year = 99 then ppast = 18;
If 40300000  >= farm <= 40399999 and year = 100 then ppast = 16.9;
If 40300000  >= farm <= 40399999 and year = 101 then ppast = 17;
If 40300000  >= farm <= 40399999 and year = 102 then ppast = 16.8;
If 40300000  >= farm <= 40399999 and year = 103 then ppast = 16.9;
If 40300000  >= farm <= 40399999 and year = 104 then ppast = 17.6;
If 40300000  >= farm <= 40399999 and year = 105 then ppast = 17.9;
If 40300000  >= farm <= 40399999 and year = 106 then ppast = 18.4;
If 40300000  >= farm <= 40399999 and year = 107 then ppast = 19.4;

/* East Central- Lyon*/
If 41300000  >= farm <= 41399999 and year = 98 then pnirrc = 39;
If 41300000  >= farm <= 41399999 and year = 99 then pnirrc = 39;
If 41300000  >= farm <= 41399999 and year = 100 then pnirrc = 42;
If 41300000  >= farm <= 41399999 and year = 101 then pnirrc = 41;
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If 41300000  >= farm <= 41399999 and year = 102 then pnirrc = 41.5;
If 41300000  >= farm <= 41399999 and year = 103 then pnirrc = 41.5;
If 41300000  >= farm <= 41399999 and year = 104 then pnirrc = 42.5;
If 41300000  >= farm <= 41399999 and year = 105 then pnirrc = 44;
If 41300000  >= farm <= 41399999 and year = 106 then pnirrc = 50.5;
If 41300000  >= farm <= 41399999 and year = 107 then pnirrc = 50;

If 41300000  >= farm <= 41399999 and year = 98 then pirrc = 67;
If 41300000  >= farm <= 41399999 and year = 99 then pirrc = 66;
If 41300000  >= farm <= 41399999 and year = 100 then pirrc = 67.35;
If 41300000  >= farm <= 41399999 and year = 101 then pirrc = 71.27;
If 41300000  >= farm <= 41399999 and year = 102 then pirrc = 68.97;
If 41300000  >= farm <= 41399999 and year = 103 then pirrc = 67;
If 41300000  >= farm <= 41399999 and year = 104 then pirrc = 71;
If 41300000  >= farm <= 41399999 and year = 105 then pirrc = 73;
If 41300000  >= farm <= 41399999 and year = 106 then pirrc = 76;
If 41300000  >= farm <= 41399999 and year = 107 then pirrc = 78;

If 41300000  >= farm <= 41399999 and year = 98 then ppast = 16.8;
If 41300000  >= farm <= 41399999 and year = 99 then ppast = 18;
If 41300000  >= farm <= 41399999 and year = 100 then ppast = 16.9;
If 41300000  >= farm <= 41399999 and year = 101 then ppast = 17;
If 41300000  >= farm <= 41399999 and year = 102 then ppast = 16.8;
If 41300000  >= farm <= 41399999 and year = 103 then ppast = 16.9;
If 41300000  >= farm <= 41399999 and year = 104 then ppast = 17.6;
If 41300000  >= farm <= 41399999 and year = 105 then ppast = 17.9;
If 41300000  >= farm <= 41399999 and year = 106 then ppast = 18.4;
If 41300000  >= farm <= 41399999 and year = 107 then ppast = 19.4;

/* East Central- Douglas, Johnson*/
If 41600000  >= farm <= 41999999 and year = 98 then pnirrc = 39;
If 41600000  >= farm <= 41999999 and year = 99 then pnirrc = 39;
If 41600000  >= farm <= 41999999 and year = 100 then pnirrc = 42;
If 41600000  >= farm <= 41999999 and year = 101 then pnirrc = 41;
If 41600000  >= farm <= 41999999 and year = 102 then pnirrc = 41.5;
If 41600000  >= farm <= 41999999 and year = 103 then pnirrc = 41.5;
If 41600000  >= farm <= 41999999 and year = 104 then pnirrc = 42.5;
If 41600000  >= farm <= 41999999 and year = 105 then pnirrc = 44;
If 41600000  >= farm <= 41999999 and year = 106 then pnirrc = 50.5;
If 41600000  >= farm <= 41999999 and year = 107 then pnirrc = 50;

If 41600000  >= farm <= 41999999 and year = 98 then pirrc = 67;
If 41600000  >= farm <= 41999999 and year = 99 then pirrc = 66;
If 41600000  >= farm <= 41999999 and year = 100 then pirrc = 67.35;
If 41600000  >= farm <= 41999999 and year = 101 then pirrc = 71.27;
If 41600000  >= farm <= 41999999 and year = 102 then pirrc = 68.97;
If 41600000  >= farm <= 41999999 and year = 103 then pirrc = 67;
If 41600000  >= farm <= 41999999 and year = 104 then pirrc = 71;
If 41600000  >= farm <= 41999999 and year = 105 then pirrc = 73;
If 41600000  >= farm <= 41999999 and year = 106 then pirrc = 76;
If 41600000  >= farm <= 41999999 and year = 107 then pirrc = 78;

If 41600000  >= farm <= 41999999 and year = 98 then ppast = 16.8;
If 41600000  >= farm <= 41999999 and year = 99 then ppast = 18;
If 41600000  >= farm <= 41999999 and year = 100 then ppast = 16.9;
If 41600000  >= farm <= 41999999 and year = 101 then ppast = 17;
If 41600000  >= farm <= 41999999 and year = 102 then ppast = 16.8;
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If 41600000  >= farm <= 41999999 and year = 103 then ppast = 16.9;
If 41600000  >= farm <= 41999999 and year = 104 then ppast = 17.6;
If 41600000  >= farm <= 41999999 and year = 105 then ppast = 17.9;
If 41600000  >= farm <= 41999999 and year = 106 then ppast = 18.4;
If 41600000  >= farm <= 41999999 and year = 107 then ppast = 19.4;

/* East Central- Morris, Wabaunsee, Chase*/
If 45400000  >= farm <= 48199999 and year = 98 then pnirrc = 39;
If 45400000  >= farm <= 48199999 and year = 99 then pnirrc = 39;
If 45400000  >= farm <= 48199999 and year = 100 then pnirrc = 42;
If 45400000  >= farm <= 48199999 and year = 101 then pnirrc = 41;
If 45400000  >= farm <= 48199999 and year = 102 then pnirrc = 41.5;
If 45400000  >= farm <= 48199999 and year = 103 then pnirrc = 41.5;
If 45400000  >= farm <= 48199999 and year = 104 then pnirrc = 42.5;
If 45400000  >= farm <= 48199999 and year = 105 then pnirrc = 44;
If 45400000  >= farm <= 48199999 and year = 106 then pnirrc = 50.5;
If 45400000  >= farm <= 48199999 and year = 107 then pnirrc = 50;

If 45400000  >= farm <= 48199999 and year = 98 then pirrc = 67;
If 45400000  >= farm <= 48199999 and year = 99 then pirrc = 66;
If 45400000  >= farm <= 48199999 and year = 100 then pirrc = 67.35;
If 45400000  >= farm <= 48199999 and year = 101 then pirrc = 71.27;
If 45400000  >= farm <= 48199999 and year = 102 then pirrc = 68.97;
If 45400000  >= farm <= 48199999 and year = 103 then pirrc = 67;
If 45400000  >= farm <= 48199999 and year = 104 then pirrc = 71;
If 45400000  >= farm <= 48199999 and year = 105 then pirrc = 73;
If 45400000  >= farm <= 48199999 and year = 106 then pirrc = 76;
If 45400000  >= farm <= 48199999 and year = 107 then pirrc = 78;

If 45400000  >= farm <= 48199999 and year = 98 then ppast = 16.8;
If 45400000  >= farm <= 48199999 and year = 99 then ppast = 18;
If 45400000  >= farm <= 48199999 and year = 100 then ppast = 16.9;
If 45400000  >= farm <= 48199999 and year = 101 then ppast = 17;
If 45400000  >= farm <= 48199999 and year = 102 then ppast = 16.8;
If 45400000  >= farm <= 48199999 and year = 103 then ppast = 16.9;
If 45400000  >= farm <= 48199999 and year = 104 then ppast = 17.6;
If 45400000  >= farm <= 48199999 and year = 105 then ppast = 17.9;
If 45400000  >= farm <= 48199999 and year = 106 then ppast = 18.4;
If 45400000  >= farm <= 48199999 and year = 107 then ppast = 19.4;

/* East Central- Franklin*/
If 62100000  >= farm <= 62199999 and year = 98 then pnirrc = 39;
If 62100000  >= farm <= 62199999 and year = 99 then pnirrc = 39;
If 62100000  >= farm <= 62199999 and year = 100 then pnirrc = 42;
If 62100000  >= farm <= 62199999 and year = 101 then pnirrc = 41;
If 62100000  >= farm <= 62199999 and year = 102 then pnirrc = 41.5;
If 62100000  >= farm <= 62199999 and year = 103 then pnirrc = 41.5;
If 62100000  >= farm <= 62199999 and year = 104 then pnirrc = 42.5;
If 62100000  >= farm <= 62199999 and year = 105 then pnirrc = 44;
If 62100000  >= farm <= 62199999 and year = 106 then pnirrc = 50.5;
If 62100000  >= farm <= 62199999 and year = 107 then pnirrc = 50;

If 62100000  >= farm <= 62199999 and year = 98 then pirrc = 67;
If 62100000  >= farm <= 62199999 and year = 99 then pirrc = 66;
If 62100000  >= farm <= 62199999 and year = 100 then pirrc = 67.35;
If 62100000  >= farm <= 62199999 and year = 101 then pirrc = 71.27;
If 62100000  >= farm <= 62199999 and year = 102 then pirrc = 68.97;
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If 62100000  >= farm <= 62199999 and year = 103 then pirrc = 67;
If 62100000  >= farm <= 62199999 and year = 104 then pirrc = 71;
If 62100000  >= farm <= 62199999 and year = 105 then pirrc = 73;
If 62100000  >= farm <= 62199999 and year = 106 then pirrc = 76;
If 62100000  >= farm <= 62199999 and year = 107 then pirrc = 78;

If 62100000  >= farm <= 62199999 and year = 98 then ppast = 16.8;
If 62100000  >= farm <= 62199999 and year = 99 then ppast = 18;
If 62100000  >= farm <= 62199999 and year = 100 then ppast = 16.9;
If 62100000  >= farm <= 62199999 and year = 101 then ppast = 17;
If 62100000  >= farm <= 62199999 and year = 102 then ppast = 16.8;
If 62100000  >= farm <= 62199999 and year = 103 then ppast = 16.9;
If 62100000  >= farm <= 62199999 and year = 104 then ppast = 17.6;
If 62100000  >= farm <= 62199999 and year = 105 then ppast = 17.9;
If 62100000  >= farm <= 62199999 and year = 106 then ppast = 18.4;
If 62100000  >= farm <= 62199999 and year = 107 then ppast = 19.4;

/* East Central- Osage, Miami*/
If 62900000  >= farm <= 63199999 and year = 98 then pnirrc = 39;
If 62900000  >= farm <= 63199999 and year = 99 then pnirrc = 39;
If 62900000  >= farm <= 63199999 and year = 100 then pnirrc = 42;
If 62900000  >= farm <= 63199999 and year = 101 then pnirrc = 41;
If 62900000  >= farm <= 63199999 and year = 102 then pnirrc = 41.5;
If 62900000  >= farm <= 63199999 and year = 103 then pnirrc = 41.5;
If 62900000  >= farm <= 63199999 and year = 104 then pnirrc = 42.5;
If 62900000  >= farm <= 63199999 and year = 105 then pnirrc = 44;
If 62900000  >= farm <= 63199999 and year = 106 then pnirrc = 50.5;
If 62900000  >= farm <= 63199999 and year = 107 then pnirrc = 50;

If 62900000  >= farm <= 63199999 and year = 98 then pirrc = 67;
If 62900000  >= farm <= 63199999 and year = 99 then pirrc = 66;
If 62900000  >= farm <= 63199999 and year = 100 then pirrc = 67.35;
If 62900000  >= farm <= 63199999 and year = 101 then pirrc = 71.27;
If 62900000  >= farm <= 63199999 and year = 102 then pirrc = 68.97;
If 62900000  >= farm <= 63199999 and year = 103 then pirrc = 67;
If 62900000  >= farm <= 63199999 and year = 104 then pirrc = 71;
If 62900000  >= farm <= 63199999 and year = 105 then pirrc = 73;
If 62900000  >= farm <= 63199999 and year = 106 then pirrc = 76;
If 62900000  >= farm <= 63199999 and year = 107 then pirrc = 78;

If 62900000  >= farm <= 63199999 and year = 98 then ppast = 16.8;
If 62900000  >= farm <= 63199999 and year = 99 then ppast = 18;
If 62900000  >= farm <= 63199999 and year = 100 then ppast = 16.9;
If 62900000  >= farm <= 63199999 and year = 101 then ppast = 17;
If 62900000  >= farm <= 63199999 and year = 102 then ppast = 16.8;
If 62900000  >= farm <= 63199999 and year = 103 then ppast = 16.9;
If 62900000  >= farm <= 63199999 and year = 104 then ppast = 17.6;
If 62900000  >= farm <= 63199999 and year = 105 then ppast = 17.9;
If 62900000  >= farm <= 63199999 and year = 106 then ppast = 18.4;
If 62900000  >= farm <= 63199999 and year = 107 then ppast = 19.4;

/* East Central- Coffey, Linn, Anderson*/
If 64400000  >= farm <= 65299999 and year = 98 then pnirrc = 39;
If 64400000  >= farm <= 65299999 and year = 99 then pnirrc = 39;
If 64400000  >= farm <= 65299999 and year = 100 then pnirrc = 42;
If 64400000  >= farm <= 65299999 and year = 101 then pnirrc = 41;
If 64400000  >= farm <= 65299999 and year = 102 then pnirrc = 41.5;
```

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If 64400000  >= farm <= 65299999 and year = 103 then pnirrc = 41.5;
If 64400000  >= farm <= 65299999 and year = 104 then pnirrc = 42.5;
If 64400000  >= farm <= 65299999 and year = 105 then pnirrc = 44;
If 64400000  >= farm <= 65299999 and year = 106 then pnirrc = 50.5;
If 64400000  >= farm <= 65299999 and year = 107 then pnirrc = 50;

If 64400000  >= farm <= 65299999 and year = 98 then pirrc = 67;
If 64400000  >= farm <= 65299999 and year = 99 then pirrc = 66;
If 64400000  >= farm <= 65299999 and year = 100 then pirrc = 67.35;
If 64400000  >= farm <= 65299999 and year = 101 then pirrc = 71.27;
If 64400000  >= farm <= 65299999 and year = 102 then pirrc = 68.97;
If 64400000  >= farm <= 65299999 and year = 103 then pirrc = 67;
If 64400000  >= farm <= 65299999 and year = 104 then pirrc = 71;
If 64400000  >= farm <= 65299999 and year = 105 then pirrc = 73;
If 64400000  >= farm <= 65299999 and year = 106 then pirrc = 76;
If 64400000  >= farm <= 65299999 and year = 107 then pirrc = 78;

If 64400000  >= farm <= 65299999 and year = 98 then ppast = 16.8;
If 64400000  >= farm <= 65299999 and year = 99 then ppast = 18;
If 64400000  >= farm <= 65299999 and year = 100 then ppast = 16.9;
If 64400000  >= farm <= 65299999 and year = 101 then ppast = 17;
If 64400000  >= farm <= 65299999 and year = 102 then ppast = 16.8;
If 64400000  >= farm <= 65299999 and year = 103 then ppast = 16.9;
If 64400000  >= farm <= 65299999 and year = 104 then ppast = 17.6;
If 64400000  >= farm <= 65299999 and year = 105 then ppast = 17.9;
If 64400000  >= farm <= 65299999 and year = 106 then ppast = 18.4;
If 64400000  >= farm <= 65299999 and year = 107 then ppast = 19.4;

/ *LAND PRICES FOR KANSAS SOUTH EAST REGION*/
/* South East - Crawford, Montgomery, Cowley, Butler, Cherokee, Labette,
Bourbon*/
If 60400000  >= farm <= 61799999 and year = 98 then pnirrc = 35;
If 60400000  >= farm <= 61799999 and year = 99 then pnirrc = 37;
If 60400000  >= farm <= 61799999 and year = 100 then pnirrc = 36;
If 60400000  >= farm <= 61799999 and year = 101 then pnirrc = 37;
If 60400000  >= farm <= 61799999 and year = 102 then pnirrc = 36.5;
If 60400000  >= farm <= 61799999 and year = 103 then pnirrc = 36.4;
If 60400000  >= farm <= 61799999 and year = 104 then pnirrc = 38.5;
If 60400000  >= farm <= 61799999 and year = 105 then pnirrc = 38.5;
If 60400000  >= farm <= 61799999 and year = 106 then pnirrc = 40;
If 60400000  >= farm <= 61799999 and year = 107 then pnirrc = 41;

If 60400000  >= farm <= 61799999 and year = 98 then pirrc = 67;
If 60400000  >= farm <= 61799999 and year = 99 then pirrc = 66;
If 60400000  >= farm <= 61799999 and year = 100 then pirrc = 66.35;
If 60400000  >= farm <= 61799999 and year = 101 then pirrc = 70.21;
If 60400000  >= farm <= 61799999 and year = 102 then pirrc = 67.94;
If 60400000  >= farm <= 61799999 and year = 103 then pirrc = 66;
If 60400000  >= farm <= 61799999 and year = 104 then pirrc = 68;
If 60400000  >= farm <= 61799999 and year = 105 then pirrc = 68;
If 60400000  >= farm <= 61799999 and year = 106 then pirrc = 69;
If 60400000  >= farm <= 61799999 and year = 107 then pirrc = 70;

If 60400000  >= farm <= 61799999 and year = 98 then ppast = 16.5;
If 60400000  >= farm <= 61799999 and year = 99 then ppast = 17.3;
If 60400000  >= farm <= 61799999 and year = 100 then ppast = 16.4;
If 60400000  >= farm <= 61799999 and year = 101 then ppast = 15.5;
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```
If 60400000  >= farm <= 61799999 and year = 102 then ppast = 15.2;
If 60400000  >= farm <= 61799999 and year = 103 then ppast = 15.3;
If 60400000  >= farm <= 61799999 and year = 104 then ppast = 15.4;
If 60400000  >= farm <= 61799999 and year = 105 then ppast = 15.4;
If 60400000  >= farm <= 61799999 and year = 106 then ppast = 16.2;
If 60400000  >= farm <= 61799999 and year = 107 then ppast = 17.6;

/* South East - Neosho, Allen, Wilson*/
If 62200000  >= farm <= 62799999 and year = 98 then pnirrc = 35;
If 62200000  >= farm <= 62799999 and year = 99 then pnirrc = 37;
If 62200000  >= farm <= 62799999 and year = 100 then pnirrc = 36;
If 62200000  >= farm <= 62799999 and year = 101 then pnirrc = 37;
If 62200000  >= farm <= 62799999 and year = 102 then pnirrc = 36.5;
If 62200000  >= farm <= 62799999 and year = 103 then pnirrc = 36.4;
If 62200000  >= farm <= 62799999 and year = 104 then pnirrc = 38.5;
If 62200000  >= farm <= 62799999 and year = 105 then pnirrc = 38.5;
If 62200000  >= farm <= 62799999 and year = 106 then pnirrc = 40;
If 62200000  >= farm <= 62799999 and year = 107 then pnirrc = 41;

If 62200000  >= farm <= 62799999 and year = 98 then pirrc = 67;
If 62200000  >= farm <= 62799999 and year = 99 then pirrc = 66;
If 62200000  >= farm <= 62799999 and year = 100 then pirrc = 66.35;
If 62200000  >= farm <= 62799999 and year = 101 then pirrc = 70.21;
If 62200000  >= farm <= 62799999 and year = 102 then pirrc = 67.94;
If 62200000  >= farm <= 62799999 and year = 103 then pirrc = 66;
If 62200000  >= farm <= 62799999 and year = 104 then pirrc = 68;
If 62200000  >= farm <= 62799999 and year = 105 then pirrc = 68;
If 62200000  >= farm <= 62799999 and year = 106 then pirrc = 69;
If 62200000  >= farm <= 62799999 and year = 107 then pirrc = 70;

If 62200000  >= farm <= 62799999 and year = 98 then ppast = 16.5;
If 62200000  >= farm <= 62799999 and year = 99 then ppast = 17.3;
If 62200000  >= farm <= 62799999 and year = 100 then ppast = 16.4;
If 62200000  >= farm <= 62799999 and year = 101 then ppast = 15.5;
If 62200000  >= farm <= 62799999 and year = 102 then ppast = 15.2;
If 62200000  >= farm <= 62799999 and year = 103 then ppast = 15.3;
If 62200000  >= farm <= 62799999 and year = 104 then ppast = 15.4;
If 62200000  >= farm <= 62799999 and year = 105 then ppast = 15.4;
If 62200000  >= farm <= 62799999 and year = 106 then ppast = 16.2;
If 62200000  >= farm <= 62799999 and year = 107 then ppast = 17.6;

/* South East - Greenwood*/
If 63200000  >= farm <= 63299999 and year = 98 then pnirrc = 35;
If 63200000  >= farm <= 63299999 and year = 99 then pnirrc = 37;
If 63200000  >= farm <= 63299999 and year = 100 then pnirrc = 36;
If 63200000  >= farm <= 63299999 and year = 101 then pnirrc = 37;
If 63200000  >= farm <= 63299999 and year = 102 then pnirrc = 36.5;
If 63200000  >= farm <= 63299999 and year = 103 then pnirrc = 36.4;
If 63200000  >= farm <= 63299999 and year = 104 then pnirrc = 38.5;
If 63200000  >= farm <= 63299999 and year = 105 then pnirrc = 38.5;
If 63200000  >= farm <= 63299999 and year = 106 then pnirrc = 40;
If 63200000  >= farm <= 63299999 and year = 107 then pnirrc = 41;

If 63200000  >= farm <= 63299999 and year = 98 then pirrc = 67;
If 63200000  >= farm <= 63299999 and year = 99 then pirrc = 66;
If 63200000  >= farm <= 63299999 and year = 100 then pirrc = 66.35;
If 63200000  >= farm <= 63299999 and year = 101 then pirrc = 70.21;
```

```
If 63200000  >= farm <= 63299999 and year = 102 then pirrc = 67.94;
If 63200000  >= farm <= 63299999 and year = 103 then pirrc = 66;
If 63200000  >= farm <= 63299999 and year = 104 then pirrc = 68;
If 63200000  >= farm <= 63299999 and year = 105 then pirrc = 68;
If 63200000  >= farm <= 63299999 and year = 106 then pirrc = 69;
If 63200000  >= farm <= 63299999 and year = 107 then pirrc = 70;

If 63200000  >= farm <= 63299999 and year = 98 then ppast = 16.5;
If 63200000  >= farm <= 63299999 and year = 99 then ppast = 17.3;
If 63200000  >= farm <= 63299999 and year = 100 then ppast = 16.4;
If 63200000  >= farm <= 63299999 and year = 101 then ppast = 15.5;
If 63200000  >= farm <= 63299999 and year = 102 then ppast = 15.2;
If 63200000  >= farm <= 63299999 and year = 103 then ppast = 15.3;
If 63200000  >= farm <= 63299999 and year = 104 then ppast = 15.4;
If 63200000  >= farm <= 63299999 and year = 105 then ppast = 15.4;
If 63200000  >= farm <= 63299999 and year = 106 then ppast = 16.2;
If 63200000  >= farm <= 63299999 and year = 107 then ppast = 17.6;

/* South East - Chautauqua, Elk, Woodson*/
If 66300000  >= farm <= 67299999 and year = 98 then pnirrc = 35;
If 66300000  >= farm <= 67299999 and year = 99 then pnirrc = 37;
If 66300000  >= farm <= 67299999 and year = 100 then pnirrc = 36;
If 66300000  >= farm <= 67299999 and year = 101 then pnirrc = 37;
If 66300000  >= farm <= 67299999 and year = 102 then pnirrc = 36.5;
If 66300000  >= farm <= 67299999 and year = 103 then pnirrc = 36.4;
If 66300000  >= farm <= 67299999 and year = 104 then pnirrc = 38.5;
If 66300000  >= farm <= 67299999 and year = 105 then pnirrc = 38.5;
If 66300000  >= farm <= 67299999 and year = 106 then pnirrc = 40;
If 66300000  >= farm <= 67299999 and year = 107 then pnirrc = 41;

If 66300000  >= farm <= 67299999 and year = 98 then pirrc = 67;
If 66300000  >= farm <= 67299999 and year = 99 then pirrc = 66;
If 66300000  >= farm <= 67299999 and year = 100 then pirrc = 66.35;
If 66300000  >= farm <= 67299999 and year = 101 then pirrc = 70.21;
If 66300000  >= farm <= 67299999 and year = 102 then pirrc = 67.94;
If 66300000  >= farm <= 67299999 and year = 103 then pirrc = 66;
If 66300000  >= farm <= 67299999 and year = 104 then pirrc = 68;
If 66300000  >= farm <= 67299999 and year = 105 then pirrc = 68;
If 66300000  >= farm <= 67299999 and year = 106 then pirrc = 69;
If 66300000  >= farm <= 67299999 and year = 107 then pirrc = 70;

If 66300000  >= farm <= 67299999 and year = 98 then ppast = 16.5;
If 66300000  >= farm <= 67299999 and year = 99 then ppast = 17.3;
If 66300000  >= farm <= 67299999 and year = 100 then ppast = 16.4;
If 66300000  >= farm <= 67299999 and year = 101 then ppast = 15.5;
If 66300000  >= farm <= 67299999 and year = 102 then ppast = 15.2;
If 66300000  >= farm <= 67299999 and year = 103 then ppast = 15.3;
If 66300000  >= farm <= 67299999 and year = 104 then ppast = 15.4;
If 66300000  >= farm <= 67299999 and year = 105 then ppast = 15.4;
If 66300000  >= farm <= 67299999 and year = 106 then ppast = 16.2;
If 66300000  >= farm <= 67299999 and year = 107 then ppast = 17.6;

/ *LAND PRICES FOR KANSAS NORTH WEST REGION*/
/* North West- Decatur*/
If 57400000  >= farm <= 57499999 and year = 98 then pnirrc = 31;
If 57400000  >= farm <= 57499999 and year = 99 then pnirrc = 30;
If 57400000  >= farm <= 57499999 and year = 100 then pnirrc = 32;
```

```
If 57400000  >= farm <= 57499999 and year = 101 then pnirrc = 32.5;
If 57400000  >= farm <= 57499999 and year = 102 then pnirrc = 32.5;
If 57400000  >= farm <= 57499999 and year = 103 then pnirrc = 32.5;
If 57400000  >= farm <= 57499999 and year = 104 then pnirrc = 34.5;
If 57400000  >= farm <= 57499999 and year = 105 then pnirrc = 35;
If 57400000  >= farm <= 57499999 and year = 106 then pnirrc = 34;
If 57400000  >= farm <= 57499999 and year = 107 then pnirrc = 35;

If 57400000  >= farm <= 57499999 and year = 98 then pirrc = 66;
If 57400000  >= farm <= 57499999 and year = 99 then pirrc = 67;
If 57400000  >= farm <= 57499999 and year = 100 then pirrc = 68;
If 57400000  >= farm <= 57499999 and year = 101 then pirrc = 74;
If 57400000  >= farm <= 57499999 and year = 102 then pirrc = 67;
If 57400000  >= farm <= 57499999 and year = 103 then pirrc = 66;
If 57400000  >= farm <= 57499999 and year = 104 then pirrc = 70;
If 57400000  >= farm <= 57499999 and year = 105 then pirrc = 72;
If 57400000  >= farm <= 57499999 and year = 106 then pirrc = 74;
If 57400000  >= farm <= 57499999 and year = 107 then pirrc = 83;

If 57400000  >= farm <= 57499999 and year = 98 then ppast = 9.5;
If 57400000  >= farm <= 57499999 and year = 99 then ppast = 10;
If 57400000  >= farm <= 57499999 and year = 100 then ppast = 10;
If 57400000  >= farm <= 57499999 and year = 101 then ppast = 9.7;
If 57400000  >= farm <= 57499999 and year = 102 then ppast = 9.7;
If 57400000  >= farm <= 57499999 and year = 103 then ppast = 9.7;
If 57400000  >= farm <= 57499999 and year = 104 then ppast = 9.7;
If 57400000  >= farm <= 57499999 and year = 105 then ppast = 9.8;
If 57400000  >= farm <= 57499999 and year = 106 then ppast = 9.6;
If 57400000  >= farm <= 57499999 and year = 107 then ppast = 10.5;

/* North West- Graham, Rawlins, Thomas, Sherman, Cheyenne*/
If 57600000  >= farm <= 58299999 and year = 98 then pnirrc = 31;
If 57600000  >= farm <= 58299999 and year = 99 then pnirrc = 30;
If 57600000  >= farm <= 58299999 and year = 100 then pnirrc = 32;
If 57600000  >= farm <= 58299999 and year = 101 then pnirrc = 32.5;
If 57600000  >= farm <= 58299999 and year = 102 then pnirrc = 32.5;
If 57600000  >= farm <= 58299999 and year = 103 then pnirrc = 32.5;
If 57600000  >= farm <= 58299999 and year = 104 then pnirrc = 34.5;
If 57600000  >= farm <= 58299999 and year = 105 then pnirrc = 35;
If 57600000  >= farm <= 58299999 and year = 106 then pnirrc = 34;
If 57600000  >= farm <= 58299999 and year = 107 then pnirrc = 35;

If 57600000  >= farm <= 58299999 and year = 98 then pirrc = 66;
If 57600000  >= farm <= 58299999 and year = 99 then pirrc = 67;
If 57600000  >= farm <= 58299999 and year = 100 then pirrc = 68;
If 57600000  >= farm <= 58299999 and year = 101 then pirrc = 74;
If 57600000  >= farm <= 58299999 and year = 102 then pirrc = 67;
If 57600000  >= farm <= 58299999 and year = 103 then pirrc = 66;
If 57600000  >= farm <= 58299999 and year = 104 then pirrc = 70;
If 57600000  >= farm <= 58299999 and year = 105 then pirrc = 72;
If 57600000  >= farm <= 58299999 and year = 106 then pirrc = 74;
If 57600000  >= farm <= 58299999 and year = 107 then pirrc = 83;

If 57600000  >= farm <= 58299999 and year = 98 then ppast = 9.5;
If 57600000  >= farm <= 58299999 and year = 99 then ppast = 10;
If 57600000  >= farm <= 58299999 and year = 100 then ppast = 10;
If 57600000  >= farm <= 58299999 and year = 101 then ppast = 9.7;
```

```
If 57600000  >= farm <= 58299999 and year = 102 then ppast = 9.7;
If 57600000  >= farm <= 58299999 and year = 103 then ppast = 9.7;
If 57600000  >= farm <= 58299999 and year = 104 then ppast = 9.7;
If 57600000  >= farm <= 58299999 and year = 105 then ppast = 9.8;
If 57600000  >= farm <= 58299999 and year = 106 then ppast = 9.6;
If 57600000  >= farm <= 58299999 and year = 107 then ppast = 10.5;

/* North West- Sheridan*/
If 58700000  >= farm <= 58799999 and year = 98 then pnirrc = 31;
If 58700000  >= farm <= 58799999 and year = 99 then pnirrc = 30;
If 58700000  >= farm <= 58799999 and year = 100 then pnirrc = 32;
If 58700000  >= farm <= 58799999 and year = 101 then pnirrc = 32.5;
If 58700000  >= farm <= 58799999 and year = 102 then pnirrc = 32.5;
If 58700000  >= farm <= 58799999 and year = 103 then pnirrc = 32.5;
If 58700000  >= farm <= 58799999 and year = 104 then pnirrc = 34.5;
If 58700000  >= farm <= 58799999 and year = 105 then pnirrc = 35;
If 58700000  >= farm <= 58799999 and year = 106 then pnirrc = 34;
If 58700000  >= farm <= 58799999 and year = 107 then pnirrc = 35;

If 58700000  >= farm <= 58799999 and year = 98 then pirrc = 66;
If 58700000  >= farm <= 58799999 and year = 99 then pirrc = 67;
If 58700000  >= farm <= 58799999 and year = 100 then pirrc = 68;
If 58700000  >= farm <= 58799999 and year = 101 then pirrc = 74;
If 58700000  >= farm <= 58799999 and year = 102 then pirrc = 67;
If 58700000  >= farm <= 58799999 and year = 103 then pirrc = 66;
If 58700000  >= farm <= 58799999 and year = 104 then pirrc = 70;
If 58700000  >= farm <= 58799999 and year = 105 then pirrc = 72;
If 58700000  >= farm <= 58799999 and year = 106 then pirrc = 74;
If 58700000  >= farm <= 58799999 and year = 107 then pirrc = 83;

If 58700000  >= farm <= 58799999 and year = 98 then ppast = 9.5;
If 58700000  >= farm <= 58799999 and year = 99 then ppast = 10;
If 58700000  >= farm <= 58799999 and year = 100 then ppast = 10;
If 58700000  >= farm <= 58799999 and year = 101 then ppast = 9.7;
If 58700000  >= farm <= 58799999 and year = 102 then ppast = 9.7;
If 58700000  >= farm <= 58799999 and year = 103 then ppast = 9.7;
If 58700000  >= farm <= 58799999 and year = 104 then ppast = 9.7;
If 58700000  >= farm <= 58799999 and year = 105 then ppast = 9.8;
If 58700000  >= farm <= 58799999 and year = 106 then ppast = 9.6;
If 58700000  >= farm <= 58799999 and year = 107 then ppast = 10.5;

/* North West- Norton*/
If 56100000  >= farm <= 56199999 and year = 98 then pnirrc = 31;
If 56100000  >= farm <= 56199999 and year = 99 then pnirrc = 30;
If 56100000  >= farm <= 56199999 and year = 100 then pnirrc = 32;
If 56100000  >= farm <= 56199999 and year = 101 then pnirrc = 32.5;
If 56100000  >= farm <= 56199999 and year = 102 then pnirrc = 32.5;
If 56100000  >= farm <= 56199999 and year = 103 then pnirrc = 32.5;
If 56100000  >= farm <= 56199999 and year = 104 then pnirrc = 34.5;
If 56100000  >= farm <= 56199999 and year = 105 then pnirrc = 35;
If 56100000  >= farm <= 56199999 and year = 106 then pnirrc = 34;
If 56100000  >= farm <= 56199999 and year = 107 then pnirrc = 35;

If 56100000  >= farm <= 56199999 and year = 98 then pirrc = 66;
If 56100000  >= farm <= 56199999 and year = 99 then pirrc = 67;
If 56100000  >= farm <= 56199999 and year = 100 then pirrc = 68;
If 56100000  >= farm <= 56199999 and year = 101 then pirrc = 74;
```

```
If 56100000  >= farm <= 56199999 and year = 102 then pirrc = 67;
If 56100000  >= farm <= 56199999 and year = 103 then pirrc = 66;
If 56100000  >= farm <= 56199999 and year = 104 then pirrc = 70;
If 56100000  >= farm <= 56199999 and year = 105 then pirrc = 72;
If 56100000  >= farm <= 56199999 and year = 106 then pirrc = 74;
If 56100000  >=  farm <= 56199999 and year = 107 then pirrc = 83;

If 56100000  >= farm <= 56199999 and year = 98 then ppast = 9.5;
If 56100000  >= farm <= 56199999 and year = 99 then ppast = 10;
If 56100000  >= farm <= 56199999 and year = 100 then ppast = 10;
If 56100000  >= farm <= 56199999 and year = 101 then ppast = 9.7;
If 56100000  >= farm <= 56199999 and year = 102 then ppast = 9.7;
If 56100000  >= farm <= 56199999 and year = 103 then ppast = 9.7;
If 56100000  >= farm <= 56199999 and year = 104 then ppast = 9.7;
If 56100000  >= farm <= 56199999 and year = 105 then ppast = 9.8;
If 56100000  >= farm <= 56199999 and year = 106 then ppast = 9.6;
If 56100000  >= farm <= 56199999 and year = 107 then ppast = 10.5;

/ *LAND PRICES FOR KANSAS WEST CENTRAL REGION*/
/* West Central- Wallace*/
If 59900000  >= farm <= 59999999 and year = 98 then pnirrc = 27;
If 59900000  >= farm <= 59999999 and year = 99 then pnirrc = 29;
If 59900000  >= farm <= 59999999 and year = 100 then pnirrc = 29;
If 59900000  >= farm <= 59999999 and year = 101 then pnirrc = 32;
If 59900000  >= farm <= 59999999 and year = 102 then pnirrc = 30;
If 59900000  >= farm <= 59999999 and year = 103 then pnirrc = 29.7;
If 59900000  >= farm <= 59999999 and year = 104 then pnirrc = 30.5;
If 59900000  >= farm <= 59999999 and year = 105 then pnirrc = 31.5;
If 59900000  >= farm <= 59999999 and year = 106 then pnirrc = 30;
If 59900000  >= farm <= 59999999 and year = 107 then pnirrc = 31;

If 59900000  >= farm <= 59999999 and year = 98 then pirrc = 65;
If 59900000  >= farm <= 59999999 and year = 99 then pirrc = 64;
If 59900000  >=  farm <= 59999999 and year = 100 then pirrc = 63.44;
If 59900000  >= farm <= 59999999 and year = 101 then pirrc = 68;
If 59900000  >= farm <= 59999999 and year = 102 then pirrc = 65;
If 59900000  >= farm <= 59999999 and year = 103 then pirrc = 63;
If 59900000  >= farm <= 59999999 and year = 104 then pirrc = 65;
If 59900000  >= farm <= 59999999 and year = 105 then pirrc = 65;
If 59900000  >= farm <= 59999999 and year = 106 then pirrc = 70;
If 59900000  >=  farm <= 59999999 and year = 107 then pirrc = 78;

If 59900000  >= farm <= 59999999 and year = 98 then ppast = 9.2;
If 59900000  >= farm <= 59999999 and year = 99 then ppast = 9;
If 59900000  >= farm <= 59999999 and year = 100 then ppast = 9.3;
If 59900000  >= farm <= 59999999 and year = 101 then ppast = 9.2;
If 59900000  >= farm <= 59999999 and year = 102 then ppast = 9.3;
If 59900000  >= farm <= 59999999 and year = 103 then ppast = 9.3;
If 59900000  >= farm <= 59999999 and year = 104 then ppast = 9.7;
If 59900000  >= farm <= 59999999 and year = 105 then ppast = 9.8;
If 59900000  >= farm <= 59999999 and year = 106 then ppast = 10;
If 59900000  >= farm <= 59999999 and year = 107 then ppast = 10.1;

/* West Central- Wichita*/
If 30200000  >= farm <= 30299999 and year = 98 then pnirrc = 27;
If 30200000  >= farm <= 30299999 and year = 99 then pnirrc = 29;
If 30200000  >= farm <= 30299999 and year = 100 then pnirrc = 29;
```

```
If 30200000  >= farm <= 30299999 and year = 101 then pnirrc = 32;
If 30200000  >= farm <= 30299999 and year = 102 then pnirrc = 30;
If 30200000  >= farm <= 30299999 and year = 103 then pnirrc = 29.7;
If 30200000  >= farm <= 30299999 and year = 104 then pnirrc = 30.5;
If 30200000  >= farm <= 30299999 and year = 105 then pnirrc = 31.5;
If 30200000  >= farm <= 30299999 and year = 106 then pnirrc = 30;
If 30200000  >= farm <= 30299999 and year = 107 then pnirrc = 31;

If 30200000  >= farm <= 30299999 and year = 98 then pirrc = 65;
If 30200000  >= farm <= 30299999 and year = 99 then pirrc = 64;
If 30200000  >= farm <= 30299999 and year = 100 then pirrc = 63.44;
If 30200000  >= farm <= 30299999 and year = 101 then pirrc = 68;
If 30200000  >= farm <= 30299999 and year = 102 then pirrc = 65;
If 30200000  >= farm <= 30299999 and year = 103 then pirrc = 63;
If 30200000  >= farm <= 30299999 and year = 104 then pirrc = 65;
If 30200000  >= farm <= 30299999 and year = 105 then pirrc = 65;
If 30200000  >= farm <= 30299999 and year = 106 then pirrc = 70;
If 30200000  >= farm <= 30299999 and year = 107 then pirrc = 78;

If 30200000  >= farm <= 30299999 and year = 98 then ppast = 9.2;
If 30200000  >= farm <= 30299999 and year = 99 then ppast = 9;
If 30200000  >= farm <= 30299999 and year = 100 then ppast = 9.3;
If 30200000  >= farm <= 30299999 and year = 101 then ppast = 9.2;
If 30200000  >= farm <= 30299999 and year = 102 then ppast = 9.3;
If 30200000  >= farm <= 30299999 and year = 103 then ppast = 9.3;
If 30200000  >= farm <= 30299999 and year = 104 then ppast = 9.7;
If 30200000  >= farm <= 30299999 and year = 105 then ppast = 9.8;
If 30200000  >= farm <= 30299999 and year = 106 then ppast = 10;
If 30200000  >= farm <= 30299999 and year = 107 then ppast = 10.1;

/* West Central- Greeley*/
If 30500000  >= farm <= 30599999 and year = 98 then pnirrc = 27;
If 30500000  >= farm <= 30599999 and year = 99 then pnirrc = 29;
If 30500000  >= farm <= 30599999 and year = 100 then pnirrc = 29;
If 30500000  >= farm <= 30599999 and year = 101 then pnirrc = 32;
If 30500000  >= farm <= 30599999 and year = 102 then pnirrc = 30;
If 30500000  >= farm <= 30599999 and year = 103 then pnirrc = 29.7;
If 30500000  >= farm <= 30599999 and year = 104 then pnirrc = 30.5;
If 30500000  >= farm <= 30599999 and year = 105 then pnirrc = 31.5;
If 30500000  >= farm <= 30599999 and year = 106 then pnirrc = 30;
If 30500000  >= farm <= 30599999 and year = 107 then pnirrc = 31;

If 30500000  >= farm <= 30599999 and year = 98 then pirrc = 65;
If 30500000  >= farm <= 30599999 and year = 99 then pirrc = 64;
If 30500000  >= farm <= 30599999 and year = 100 then pirrc = 63.44;
If 30500000  >= farm <= 30599999 and year = 101 then pirrc = 68;
If 30500000  >= farm <= 30599999 and year = 102 then pirrc = 65;
If 30500000  >= farm <= 30599999 and year = 103 then pirrc = 63;
If 30500000  >= farm <= 30599999 and year = 104 then pirrc = 65;
If 30500000  >= farm <= 30599999 and year = 105 then pirrc = 65;
If 30500000  >= farm <= 30599999 and year = 106 then pirrc = 70;
If 30500000  >= farm <= 30599999 and year = 107 then pirrc = 78;

If 30500000  >= farm <= 30599999 and year = 98 then ppast = 9.2;
If 30500000  >= farm <= 30599999 and year = 99 then ppast = 9;
If 30500000  >= farm <= 30599999 and year = 100 then ppast = 9.3;
If 30500000  >= farm <= 30599999 and year = 101 then ppast = 9.2;
```

```
If 30500000  >= farm <= 30599999 and year = 102 then ppast = 9.3;
If 30500000  >= farm <= 30599999 and year = 103 then ppast = 9.3;
If 30500000  >= farm <= 30599999 and year = 104 then ppast = 9.7;
If 30500000  >= farm <= 30599999 and year = 105 then ppast = 9.8;
If 30500000  >= farm <= 30599999 and year = 106 then ppast = 10;
If 30500000  >= farm <= 30599999 and year = 107 then ppast = 10.1;

/* West Central- Scott, Lane*/
If 39600000  >= farm <= 39799999 and year = 98 then pnirrc = 27;
If 39600000  >= farm <= 39799999 and year = 99 then pnirrc = 29;
If 39600000  >= farm <= 39799999 and year = 100 then pnirrc = 29;
If 39600000  >= farm <= 39799999 and year = 101 then pnirrc = 32;
If 39600000  >= farm <= 39799999 and year = 102 then pnirrc = 30;
If 39600000  >= farm <= 39799999 and year = 103 then pnirrc = 29.7;
If 39600000  >= farm <= 39799999 and year = 104 then pnirrc = 30.5;
If 39600000  >= farm <= 39799999 and year = 105 then pnirrc = 31.5;
If 39600000  >= farm <= 39799999 and year = 106 then pnirrc = 30;
If 39600000  >= farm <= 39799999 and year = 107 then pnirrc = 31;

If 39600000  >= farm <= 39799999 and year = 98 then pirrc = 65;
If 39600000  >= farm <= 39799999 and year = 99 then pirrc = 64;
If 39600000  >= farm <= 39799999 and year = 100 then pirrc = 63.44;
If 39600000  >= farm <= 39799999 and year = 101 then pirrc = 68;
If 39600000  >= farm <= 39799999 and year = 102 then pirrc = 65;
If 39600000  >= farm <= 39799999 and year = 103 then pirrc = 63;
If 39600000  >= farm <= 39799999 and year = 104 then pirrc = 65;
If 39600000  >= farm <= 39799999 and year = 105 then pirrc = 65;
If 39600000  >= farm <= 39799999 and year = 106 then pirrc = 70;
If 39600000  >= farm <= 39799999 and year = 107 then pirrc = 78;

If 39600000  >= farm <= 39799999 and year = 98 then ppast = 9.2;
If 39600000  >= farm <= 39799999 and year = 99 then ppast = 9;
If 39600000  >= farm <= 39799999 and year = 100 then ppast = 9.3;
If 39600000  >= farm <= 39799999 and year = 101 then ppast = 9.2;
If 39600000  >= farm <= 39799999 and year = 102 then ppast = 9.3;
If 39600000  >= farm <= 39799999 and year = 103 then ppast = 9.3;
If 39600000  >= farm <= 39799999 and year = 104 then ppast = 9.7;
If 39600000  >= farm <= 39799999 and year = 105 then ppast = 9.8;
If 39600000  >= farm <= 39799999 and year = 106 then ppast = 10;
If 39600000  >= farm <= 39799999 and year = 107 then ppast = 10.1;

/* West Central- Trego*/
If 58300000  >= farm <= 58399999 and year = 98 then pnirrc = 27;
If 58300000  >= farm <= 58399999 and year = 99 then pnirrc = 29;
If 58300000  >= farm <= 58399999 and year = 100 then pnirrc = 29;
If 58300000  >= farm <= 58399999 and year = 101 then pnirrc = 32;
If 58300000  >= farm <= 58399999 and year = 102 then pnirrc = 30;
If 58300000  >= farm <= 58399999 and year = 103 then pnirrc = 29.7;
If 58300000  >= farm <= 58399999 and year = 104 then pnirrc = 30.5;
If 58300000  >= farm <= 58399999 and year = 105 then pnirrc = 31.5;
If 58300000  >= farm <= 58399999 and year = 106 then pnirrc = 30;
If 58300000  >= farm <= 58399999 and year = 107 then pnirrc = 31;

If 58300000  >= farm <= 58399999 and year = 98 then pirrc = 65;
If 58300000  >= farm <= 58399999 and year = 99 then pirrc = 64;
If 58300000  >= farm <= 58399999 and year = 100 then pirrc = 63.44;
If 58300000  >= farm <= 58399999 and year = 101 then pirrc = 68;
```

```
If 58300000  >= farm <= 58399999 and year = 102 then pirrc = 65;
If 58300000  >= farm <= 58399999 and year = 103 then pirrc = 63;
If 58300000  >= farm <= 58399999 and year = 104 then pirrc = 65;
If 58300000  >= farm <= 58399999 and year = 105 then pirrc = 65;
If 58300000  >= farm <= 58399999 and year = 106 then pirrc = 70;
If 58300000  >= farm <= 58399999 and year = 107 then pirrc = 78;

If 58300000  >= farm <= 58399999 and year = 98 then ppast = 9.2;
If 58300000  >= farm <= 58399999 and year = 99 then ppast = 9;
If 58300000  >= farm <= 58399999 and year = 100 then ppast = 9.3;
If 58300000  >= farm <= 58399999 and year = 101 then ppast = 9.2;
If 58300000  >= farm <= 58399999 and year = 102 then ppast = 9.3;
If 58300000  >= farm <= 58399999 and year = 103 then ppast = 9.3;
If 58300000  >= farm <= 58399999 and year = 104 then ppast = 9.7;
If 58300000  >= farm <= 58399999 and year = 105 then ppast = 9.8;
If 58300000  >= farm <= 58399999 and year = 106 then ppast = 10;
If 58300000  >= farm <= 58399999 and year = 107 then ppast = 10.1;

/* West Central- Gove, Logan*/
If 58800000  >= farm <= 59599999 and year = 98 then pnirrc = 27;
If 58800000  >= farm <= 59599999 and year = 99 then pnirrc = 29;
If 58800000  >= farm <= 59599999 and year = 100 then pnirrc = 29;
If 58800000  >= farm <= 59599999 and year = 101 then pnirrc = 32;
If 58800000  >= farm <= 59599999 and year = 102 then pnirrc = 30;
If 58800000  >= farm <= 59599999 and year = 103 then pnirrc = 29.7;
If 58800000  >= farm <= 59599999 and year = 104 then pnirrc = 30.5;
If 58800000  >= farm <= 59599999 and year = 105 then pnirrc = 31.5;
If 58800000  >= farm <= 59599999 and year = 106 then pnirrc = 30;
If 58800000  >= farm <= 59599999 and year = 107 then pnirrc = 31;

If 58800000  >= farm <= 59599999 and year = 98 then pirrc = 65;
If 58800000  >= farm <= 59599999 and year = 99 then pirrc = 64;
If 58800000  >= farm <= 59599999 and year = 100 then pirrc = 63.44;
If 58800000  >= farm <= 59599999 and year = 101 then pirrc = 68;
If 58800000  >= farm <= 59599999 and year = 102 then pirrc = 65;
If 58800000  >= farm <= 59599999 and year = 103 then pirrc = 63;
If 58800000  >= farm <= 59599999 and year = 104 then pirrc = 65;
If 58800000  >= farm <= 59599999 and year = 105 then pirrc = 65;
If 58800000  >= farm <= 59599999 and year = 106 then pirrc = 70;
If 58800000  >= farm <= 59599999 and year = 107 then pirrc = 78;

If 58800000  >= farm <= 59599999 and year = 98 then ppast = 9.2;
If 58800000  >= farm <= 59599999 and year = 99 then ppast = 9;
If 58800000  >= farm <= 59599999 and year = 100 then ppast = 9.3;
If 58800000  >= farm <= 59599999 and year = 101 then ppast = 9.2;
If 58800000  >= farm <= 59599999 and year = 102 then ppast = 9.3;
If 58800000  >= farm <= 59599999 and year = 103 then ppast = 9.3;
If 58800000  >= farm <= 59599999 and year = 104 then ppast = 9.7;
If 58800000  >= farm <= 59599999 and year = 105 then ppast = 9.8;
If 58800000  >= farm <= 59599999 and year = 106 then ppast = 10;
If 58800000  >= farm <= 59599999 and year = 107 then ppast = 10.1;

/* West Central- Ness*/
If 57500000  >= farm <= 57599999 and year = 98 then pnirrc = 27;
If 57500000  >= farm <= 57599999 and year = 99 then pnirrc = 29;
If 57500000  >= farm <= 57599999 and year = 100 then pnirrc = 29;
If 57500000  >= farm <= 57599999 and year = 101 then pnirrc = 32;
```

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If 57500000  >= farm <= 57599999 and year = 102 then pnirrc = 30;
If 57500000  >= farm <= 57599999 and year = 103 then pnirrc = 29.7;
If 57500000  >= farm <= 57599999 and year = 104 then pnirrc = 30.5;
If 57500000  >= farm <= 57599999 and year = 105 then pnirrc = 31.5;
If 57500000  >= farm <= 57599999 and year = 106 then pnirrc = 30;
If 57500000  >= farm <= 57599999 and year = 107 then pnirrc = 31;

If 57500000  >= farm <= 57599999 and year = 98 then pirrc = 65;
If 57500000  >= farm <= 57599999 and year = 99 then pirrc = 64;
If 57500000  >= farm <= 57599999 and year = 100 then pirrc = 63.44;
If 57500000  >= farm <= 57599999 and year = 101 then pirrc = 68;
If 57500000  >= farm <= 57599999 and year = 102 then pirrc = 65;
If 57500000  >= farm <= 57599999 and year = 103 then pirrc = 63;
If 57500000  >= farm <= 57599999 and year = 104 then pirrc = 65;
If 57500000  >= farm <= 57599999 and year = 105 then pirrc = 65;
If 57500000  >= farm <= 57599999 and year = 106 then pirrc = 70;
If 57500000  >= farm <= 57599999 and year = 107 then pirrc = 78;

If 57500000  >= farm <= 57599999 and year = 98 then ppast = 9.2;
If 57500000  >= farm <= 57599999 and year = 99 then ppast = 9;
If 57500000  >= farm <= 57599999 and year = 100 then ppast = 9.3;
If 57500000  >= farm <= 57599999 and year = 101 then ppast = 9.2;
If 57500000  >= farm <= 57599999 and year = 102 then ppast = 9.3;
If 57500000  >= farm <= 57599999 and year = 103 then ppast = 9.3;
If 57500000  >= farm <= 57599999 and year = 104 then ppast = 9.7;
If 57500000  >= farm <= 57599999 and year = 105 then ppast = 9.8;
If 57500000  >= farm <= 57599999 and year = 106 then ppast = 10;
If 57500000  >= farm <= 57599999 and year = 107 then ppast = 10.1;

/ *LAND PRICES FOR KANSAS SOUTH WEST REGION*/
/* South West- Hamilton, Haskell*/
If 30000000  >= farm <= 30199999 and year = 98 then pnirrc = 23;
If 30000000  >= farm <= 30199999 and year = 99 then pnirrc = 26;
If 30000000  >= farm <= 30199999 and year = 100 then pnirrc = 25;
If 30000000  >= farm <= 30199999 and year = 101 then pnirrc = 25.5;
If 30000000  >= farm <= 30199999 and year = 102 then pnirrc = 25.6;
If 30000000  >= farm <= 30199999 and year = 103 then pnirrc = 25.6;
If 30000000  >= farm <= 30199999 and year = 104 then pnirrc = 26.5;
If 30000000  >= farm <= 30199999 and year = 105 then pnirrc = 26.5;
If 30000000  >= farm <= 30199999 and year = 106 then pnirrc = 26;
If 30000000  >= farm <= 30199999 and year = 107 then pnirrc = 28;

If 30000000  >= farm <= 30199999 and year = 98 then pirrc = 67;
If 30000000  >= farm <= 30199999 and year = 99 then pirrc = 66;
If 30000000  >= farm <= 30199999 and year = 100 then pirrc = 66;
If 30000000  >= farm <= 30199999 and year = 101 then pirrc = 72;
If 30000000  >= farm <= 30199999 and year = 102 then pirrc = 72;
If 30000000  >= farm <= 30199999 and year = 103 then pirrc = 69;
If 30000000  >= farm <= 30199999 and year = 104 then pirrc = 73;
If 30000000  >= farm <= 30199999 and year = 105 then pirrc = 74;
If 30000000  >= farm <= 30199999 and year = 106 then pirrc = 75;
If 30000000  >= farm <= 30199999 and year = 107 then pirrc = 85;

If 30000000  >= farm <= 30199999 and year = 98 then ppast = 8.6;
If 30000000  >= farm <= 30199999 and year = 99 then ppast = 9;
If 30000000  >= farm <= 30199999 and year = 100 then ppast = 8.5;
If 30000000  >= farm <= 30199999 and year = 101 then ppast = 8.5;
```

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If 30000000  >= farm <= 30199999 and year = 102 then ppast = 8.8;
If 30000000  >= farm <= 30199999 and year = 103 then ppast = 8.7;
If 30000000  >= farm <= 30199999 and year = 104 then ppast = 8.7;
If 30000000  >= farm <= 30199999 and year = 105 then ppast = 8.7;
If 30000000  >= farm <= 30199999 and year = 106 then ppast = 8.7;
If 30000000  >= farm <= 30199999 and year = 107 then ppast = 8.7;

/* South West- Grant, Stanton*/
If 30300000  >= farm <= 30499999 and year = 98 then pnirrc = 23;
If 30300000  >= farm <= 30499999 and year = 99 then pnirrc = 26;
If 30300000  >= farm <= 30499999 and year = 100 then pnirrc = 25;
If 30300000  >= farm <= 30499999 and year = 101 then pnirrc = 25.5;
If 30300000  >= farm <= 30499999 and year = 102 then pnirrc = 25.6;
If 30300000  >= farm <= 30499999 and year = 103 then pnirrc = 25.6;
If 30300000  >= farm <= 30499999 and year = 104 then pnirrc = 26.5;
If 30300000  >= farm <= 30499999 and year = 105 then pnirrc = 26.5;
If 30300000  >= farm <= 30499999 and year = 106 then pnirrc = 26;
If 30300000  >= farm <= 30499999 and year = 107 then pnirrc = 28;

If 30300000  >= farm <= 30499999 and year = 98 then pirrc = 67;
If 30300000  >= farm <= 30499999 and year = 99 then pirrc = 66;
If 30300000  >= farm <= 30499999 and year = 100 then pirrc = 66;
If 30300000  >= farm <= 30499999 and year = 101 then pirrc = 72;
If 30300000  >= farm <= 30499999 and year = 102 then pirrc = 72;
If 30300000  >= farm <= 30499999 and year = 103 then pirrc = 69;
If 30300000  >= farm <= 30499999 and year = 104 then pirrc = 73;
If 30300000  >= farm <= 30499999 and year = 105 then pirrc = 74;
If 30300000  >= farm <= 30499999 and year = 106 then pirrc = 75;
If 30300000  >= farm <= 30499999 and year = 107 then pirrc = 85;

If 30300000  >= farm <= 30499999 and year = 98 then ppast = 8.6;
If 30300000  >= farm <= 30499999 and year = 99 then ppast = 9;
If 30300000  >= farm <= 30499999 and year = 100 then ppast = 8.5;
If 30300000  >= farm <= 30499999 and year = 101 then ppast = 8.5;
If 30300000  >= farm <= 30499999 and year = 102 then ppast = 8.8;
If 30300000  >= farm <= 30499999 and year = 103 then ppast = 8.7;
If 30300000  >= farm <= 30499999 and year = 104 then ppast = 8.7;
If 30300000  >= farm <= 30499999 and year = 105 then ppast = 8.7;
If 30300000  >= farm <= 30499999 and year = 106 then ppast = 8.7;
If 30300000  >= farm <= 30499999 and year = 107 then ppast = 8.7;

/* South West- Ford*/
If 33500000  >= farm <= 33599999 and year = 98 then pnirrc = 23;
If 33500000  >= farm <= 33599999 and year = 99 then pnirrc = 26;
If 33500000  >= farm <= 33599999 and year = 100 then pnirrc = 25;
If 33500000  >= farm <= 33599999 and year = 101 then pnirrc = 25.5;
If 33500000  >= farm <= 33599999 and year = 102 then pnirrc = 25.6;
If 33500000  >= farm <= 33599999 and year = 103 then pnirrc = 25.6;
If 33500000  >= farm <= 33599999 and year = 104 then pnirrc = 26.5;
If 33500000  >= farm <= 33599999 and year = 105 then pnirrc = 26.5;
If 33500000  >= farm <= 33599999 and year = 106 then pnirrc = 26;
If 33500000  >= farm <= 33599999 and year = 107 then pnirrc = 28;

If 33500000  >= farm <= 33599999 and year = 98 then pirrc = 67;
If 33500000  >= farm <= 33599999 and year = 99 then pirrc = 66;
If 33500000  >= farm <= 33599999 and year = 100 then pirrc = 66;
If 33500000  >= farm <= 33599999 and year = 101 then pirrc = 72;
```

```
If 33500000  >= farm <= 33599999 and year = 102 then pirrc = 72;
If 33500000  >= farm <= 33599999 and year = 103 then pirrc = 69;
If 33500000  >= farm <= 33599999 and year = 104 then pirrc = 73;
If 33500000  >= farm <= 33599999 and year = 105 then pirrc = 74;
If 33500000  >= farm <= 33599999 and year = 106 then pirrc = 75;
If 33500000  >= farm <= 33599999 and year = 107 then pirrc = 85;

If 33500000  >= farm <= 33599999 and year = 98 then ppast = 8.6;
If 33500000  >= farm <= 33599999 and year = 99 then ppast = 9;
If 33500000  >= farm <= 33599999 and year = 100 then ppast = 8.5;
If 33500000  >= farm <= 33599999 and year = 101 then ppast = 8.5;
If 33500000  >= farm <= 33599999 and year = 102 then ppast = 8.8;
If 33500000  >= farm <= 33599999 and year = 103 then ppast = 8.7;
If 33500000  >= farm <= 33599999 and year = 104 then ppast = 8.7;
If 33500000  >= farm <= 33599999 and year = 105 then ppast = 8.7;
If 33500000  >= farm <= 33599999 and year = 106 then ppast = 8.7;
If 33500000  >= farm <= 33599999 and year = 107 then ppast = 8.7;

/* South West- Meade, Gray*/
If 38600000  >= farm <= 38999999 and year = 98 then pnirrc = 23;
If 38600000  >= farm <= 38999999 and year = 99 then pnirrc = 26;
If 38600000  >= farm <= 38999999 and year = 100 then pnirrc = 25;
If 38600000  >= farm <= 38999999 and year = 101 then pnirrc = 25.5;
If 38600000  >= farm <= 38999999 and year = 102 then pnirrc = 25.6;
If 38600000  >= farm <= 38999999 and year = 103 then pnirrc = 25.6;
If 38600000  >= farm <= 38999999 and year = 104 then pnirrc = 26.5;
If 38600000  >= farm <= 38999999 and year = 105 then pnirrc = 26.5;
If 38600000  >= farm <= 38999999 and year = 106 then pnirrc = 26;
If 38600000  >= farm <= 38999999 and year = 107 then pnirrc = 28;

If 38600000  >= farm <= 38999999 and year = 98 then pirrc = 67;
If 38600000  >= farm <= 38999999 and year = 99 then pirrc = 66;
If 38600000  >= farm <= 38999999 and year = 100 then pirrc = 66;
If 38600000  >= farm <= 38999999 and year = 101 then pirrc = 72;
If 38600000  >= farm <= 38999999 and year = 102 then pirrc = 72;
If 38600000  >= farm <= 38999999 and year = 103 then pirrc = 69;
If 38600000  >= farm <= 38999999 and year = 104 then pirrc = 73;
If 38600000  >= farm <= 38999999 and year = 105 then pirrc = 74;
If 38600000  >= farm <= 38999999 and year = 106 then pirrc = 75;
If 38600000  >= farm <= 38999999 and year = 107 then pirrc = 85;

If 38600000  >= farm <= 38999999 and year = 98 then ppast = 8.6;
If 38600000  >= farm <= 38999999 and year = 99 then ppast = 9;
If 38600000  >= farm <= 38999999 and year = 100 then ppast = 8.5;
If 38600000  >= farm <= 38999999 and year = 101 then ppast = 8.5;
If 38600000  >= farm <= 38999999 and year = 102 then ppast = 8.8;
If 38600000  >= farm <= 38999999 and year = 103 then ppast = 8.7;
If 38600000  >= farm <= 38999999 and year = 104 then ppast = 8.7;
If 38600000  >= farm <= 38999999 and year = 105 then ppast = 8.7;
If 38600000  >= farm <= 38999999 and year = 106 then ppast = 8.7;
If 38600000  >= farm <= 38999999 and year = 107 then ppast = 8.7;

/* South West- Clark, Stevens, Hodgeman, Morton*/
If 39100000  >= farm <= 39499999 and year = 98 then pnirrc = 23;
If 39100000  >= farm <= 39499999 and year = 99 then pnirrc = 26;
If 39100000  >= farm <= 39499999 and year = 100 then pnirrc = 25;
If 39100000  >= farm <= 39499999 and year = 101 then pnirrc = 25.5;
```

```
If 39100000  >= farm <= 39499999 and year = 102 then pnirrc = 25.6;
If 39100000  >= farm <= 39499999 and year = 103 then pnirrc = 25.6;
If 39100000  >= farm <= 39499999 and year = 104 then pnirrc = 26.5;
If 39100000  >= farm <= 39499999 and year = 105 then pnirrc = 26.5;
If 39100000  >= farm <= 39499999 and year = 106 then pnirrc = 26;
If 39100000  >= farm <= 39499999 and year = 107 then pnirrc = 28;

If 39100000  >= farm <= 39499999 and year = 98 then pirrc = 67;
If 39100000  >= farm <= 39499999 and year = 99 then pirrc = 66;
If 39100000  >= farm <= 39499999 and year = 100 then pirrc = 66;
If 39100000  >= farm <= 39499999 and year = 101 then pirrc = 72;
If 39100000  >= farm <= 39499999 and year = 102 then pirrc = 72;
If 39100000  >= farm <= 39499999 and year = 103 then pirrc = 69;
If 39100000  >= farm <= 39499999 and year = 104 then pirrc = 73;
If 39100000  >= farm <= 39499999 and year = 105 then pirrc = 74;
If 39100000  >= farm <= 39499999 and year = 106 then pirrc = 75;
If 39100000  >= farm <= 39499999 and year = 107 then pirrc = 85;

If 39100000  >= farm <= 39499999 and year = 98 then ppast = 8.6;
If 39100000  >= farm <= 39499999 and year = 99 then ppast = 9;
If 39100000  >= farm <= 39499999 and year = 100 then ppast = 8.5;
If 39100000  >= farm <= 39499999 and year = 101 then ppast = 8.5;
If 39100000  >= farm <= 39499999 and year = 102 then ppast = 8.8;
If 39100000  >= farm <= 39499999 and year = 103 then ppast = 8.7;
If 39100000  >= farm <= 39499999 and year = 104 then ppast = 8.7;
If 39100000  >= farm <= 39499999 and year = 105 then ppast = 8.7;
If 39100000  >= farm <= 39499999 and year = 106 then ppast = 8.7;
If 39100000  >= farm <= 39499999 and year = 107 then ppast = 8.7;

/* South West- Finney*/
If 37100000  >= farm <= 37199999 and year = 98 then pnirrc = 23;
If 37100000  >= farm <= 37199999 and year = 99 then pnirrc = 26;
If 37100000  >= farm <= 37199999 and year = 100 then pnirrc = 25;
If 37100000  >= farm <= 37199999 and year = 101 then pnirrc = 25.5;
If 37100000  >= farm <= 37199999 and year = 102 then pnirrc = 25.6;
If 37100000  >= farm <= 37199999 and year = 103 then pnirrc = 25.6;
If 37100000  >= farm <= 37199999 and year = 104 then pnirrc = 26.5;
If 37100000  >= farm <= 37199999 and year = 105 then pnirrc = 26.5;
If 37100000  >= farm <= 37199999 and year = 106 then pnirrc = 26;
If 37100000  >= farm <= 37199999 and year = 107 then pnirrc = 28;

If 37100000  >= farm <= 37199999 and year = 98 then pirrc = 67;
If 37100000  >= farm <= 37199999 and year = 99 then pirrc = 66;
If 37100000  >= farm <= 37199999 and year = 100 then pirrc = 66;
If 37100000  >= farm <= 37199999 and year = 101 then pirrc = 72;
If 37100000  >= farm <= 37199999 and year = 102 then pirrc = 72;
If 37100000  >= farm <= 37199999 and year = 103 then pirrc = 69;
If 37100000  >= farm <= 37199999 and year = 104 then pirrc = 73;
If 37100000  >= farm <= 37199999 and year = 105 then pirrc = 74;
If 37100000  >= farm <= 37199999 and year = 106 then pirrc = 75;
If 37100000  >= farm <= 37199999 and year = 107 then pirrc = 85;

If 37100000  >= farm <= 37199999 and year = 98 then ppast = 8.6;
If 37100000  >= farm <= 37199999 and year = 99 then ppast = 9;
If 37100000  >= farm <= 37199999 and year = 100 then ppast = 8.5;
If 37100000  >= farm <= 37199999 and year = 101 then ppast = 8.5;
If 37100000  >= farm <= 37199999 and year = 102 then ppast = 8.8;
```

```
If 37100000  >= farm <= 37199999 and year = 103 then ppast = 8.7;
If 37100000  >= farm <= 37199999 and year = 104 then ppast = 8.7;
If 37100000  >= farm <= 37199999 and year = 105 then ppast = 8.7;
If 37100000  >= farm <= 37199999 and year = 106 then ppast = 8.7;
If 37100000  >= farm <= 37199999 and year = 107 then ppast = 8.7;

/* South West- Seward*/
If 38400000  >= farm <= 38499999 and year = 98 then pnirrc = 23;
If 38400000  >= farm <= 38499999 and year = 99 then pnirrc = 26;
If 38400000  >= farm <= 38499999 and year = 100 then pnirrc = 25;
If 38400000  >= farm <= 38499999 and year = 101 then pnirrc = 25.5;
If 38400000  >= farm <= 38499999 and year = 102 then pnirrc = 25.6;
If 38400000  >= farm <= 38499999 and year = 103 then pnirrc = 25.6;
If 38400000  >= farm <= 38499999 and year = 104 then pnirrc = 26.5;
If 38400000  >= farm <= 38499999 and year = 105 then pnirrc = 26.5;
If 38400000  >= farm <= 38499999 and year = 106 then pnirrc = 26;
If 38400000  >= farm <= 38499999 and year = 107 then pnirrc = 28;

If 38400000  >= farm <= 38499999 and year = 98 then pirrc = 67;
If 38400000  >= farm <= 38499999 and year = 99 then pirrc = 66;
If 38400000  >= farm <= 38499999 and year = 100 then pirrc = 66;
If 38400000  >= farm <= 38499999 and year = 101 then pirrc = 72;
If 38400000  >= farm <= 38499999 and year = 102 then pirrc = 72;
If 38400000  >= farm <= 38499999 and year = 103 then pirrc = 69;
If 38400000  >= farm <= 38499999 and year = 104 then pirrc = 73;
If 38400000  >= farm <= 38499999 and year = 105 then pirrc = 74;
If 38400000  >= farm <= 38499999 and year = 106 then pirrc = 75;
If 38400000  >= farm <= 38499999 and year = 107 then pirrc = 85;

If 38400000  >= farm <= 38499999 and year = 98 then ppast = 8.6;
If 38400000  >= farm <= 38499999 and year = 99 then ppast = 9;
If 38400000  >= farm <= 38499999 and year = 100 then ppast = 8.5;
If 38400000  >= farm <= 38499999 and year = 101 then ppast = 8.5;
If 38400000  >= farm <= 38499999 and year = 102 then ppast = 8.8;
If 38400000  >= farm <= 38499999 and year = 103 then ppast = 8.7;
If 38400000  >= farm <= 38499999 and year = 104 then ppast = 8.7;
If 38400000  >= farm <= 38499999 and year = 105 then ppast = 8.7;
If 38400000  >= farm <= 38499999 and year = 106 then ppast = 8.7;
If 38400000  >= farm <= 38499999 and year = 107 then ppast = 8.7;

/* South West- Kearny*/
If 39800000  >= farm <= 39899999 and year = 98 then pnirrc = 23;
If 39800000  >= farm <= 39899999 and year = 99 then pnirrc = 26;
If 39800000  >= farm <= 39899999 and year = 100 then pnirrc = 25;
If 39800000  >= farm <= 39899999 and year = 101 then pnirrc = 25.5;
If 39800000  >= farm <= 39899999 and year = 102 then pnirrc = 25.6;
If 39800000  >= farm <= 39899999 and year = 103 then pnirrc = 25.6;
If 39800000  >= farm <= 39899999 and year = 104 then pnirrc = 26.5;
If 39800000  >= farm <= 39899999 and year = 105 then pnirrc = 26.5;
If 39800000  >= farm <= 39899999 and year = 106 then pnirrc = 26;
If 39800000  >= farm <= 39899999 and year = 107 then pnirrc = 28;

If 39800000  >= farm <= 39899999 and year = 98 then pirrc = 67;
If 39800000  >= farm <= 39899999 and year = 99 then pirrc = 66;
If 39800000  >= farm <= 39899999 and year = 100 then pirrc = 66;
If 39800000  >= farm <= 39899999 and year = 101 then pirrc = 72;
If 39800000  >= farm <= 39899999 and year = 102 then pirrc = 72;
```

```
If 39800000  >= farm <= 39899999 and year = 103 then pirrc = 69;
If 39800000  >= farm <= 39899999 and year = 104 then pirrc = 73;
If 39800000  >= farm <= 39899999 and year = 105 then pirrc = 74;
If 39800000  >= farm <= 39899999 and year = 106 then pirrc = 75;
If 39800000  >= farm <= 39899999 and year = 107 then pirrc = 85;

If 39800000  >= farm <= 39899999 and year = 98 then ppast = 8.6;
If 39800000  >= farm <= 39899999 and year = 99 then ppast = 9;
If 39800000  >= farm <= 39899999 and year = 100 then ppast = 8.5;
If 39800000  >= farm <= 39899999 and year = 101 then ppast = 8.5;
If 39800000  >= farm <= 39899999 and year = 102 then ppast = 8.8;
If 39800000  >= farm <= 39899999 and year = 103 then ppast = 8.7;
If 39800000  >= farm <= 39899999 and year = 104 then ppast = 8.7;
If 39800000  >= farm <= 39899999 and year = 105 then ppast = 8.7;
If 39800000  >= farm <= 39899999 and year = 106 then ppast = 8.7;
If 39800000  >= farm <= 39899999 and year = 107 then ppast = 8.7;
/* Percent of inputs*/

towna = v328+v331+v337+v340;
lv=(v270 + v271)/2;
if towna= 0 and lv>0 then delete;
owna = v328+v331+v337;

acrest = v327 + v330 + v336;

if acrest > 0 then rentc = (((v327/acrest)*pirrc) +
     ((v330/acrest)*pnirrc) + ((v336/acrest)*ppast))*pce;
     else rentc = 0;

if rentc = . then delete;

/*if owna > 0 then rate = (((v331)/owna)*0.053) +
     ((v328/owna)*0.060) + ((v337/owna)*0.030); else rate = 0.000;

orent = rate*(aolv);

if owna > 0 then rentc = (orent*pce)/owna;
if owna = 0 and v592 > 0 then rentc = ((v592*pce)/v326);
if owna = 0 and v592 <= 0 then rentc = 0;
if rentc = 0 then prentc = 1; else prentc = 0; */

rlandc = (land*rentc);
crland=(v329*pirrc)+ (v332*pnirrc) + (v338*ppast);



/* Farm Characteristics */
Powna=(owna/land);
Tacost=rlaborc+rlivec+rseedc+rfertc+rchemc+rocapc+rlanc;
expr = tacost/(rtotali+rgovti+rcinsi);
/* Percent of outputs*/
cropinc=(winc + fginc + hfinc + sinc);
livdinc=dairyi+ beefi;
tinc=cropinc+livdinc+rcwork;
pcropi=cropinc/tinc;
plivdi=livdinc/tinc;
pcwki=rcwork/tinc;
```

```
/* Percent of inputs*/

Plabore=rlaborc/tacost;
Pcape= rocapc/tacost;
Plande=crland/tacost;
Pcrope=(rseedc+rfertc+rchemc)/tacost;
Plivde=rlivec/tacost;

tacres = v324;
cacres = v333;
wacres = v363+v366+v405+v408;
fgacres = v369+v372+v375+v378;
sacres = v381+v384+v387+v390+v417+v420;
hfacres = v393+v396+v399+v402+v411+v414;

wheata = v363+v366;
corna = v369+v372;
sorga = v375+v378;
soya = v381+v384;

wheatp = v423+v424+v425+v426;
cornp = v427+v428+v429+v430;
sorgp = v431+v432+v433+v434;
soyp = v435+v436+v437+v438;

if wheata > 0 then wheaty = wheatp/wheata; else wheaty = .;
if corna > 0 then corny = cornp/corna; else corny = .;
if sorga > 0 then sorgy = sorgp/sorga; else sorgy = . ;
if soya > 0 then soyy = soyp/soya; else soyy = .;

offi = v030*pce;

proc sort; by farm;

data x5; set x4;
proc means noprint; var farm; by farm; output out=aaa n=nyears;
proc sort data=aaa; by farm;

libname ml10yr 'c:\';
data ml10yr.lopez10; merge x4 aaa; by farm;
if nyears < 10 then delete;

proc sort; by farm year;

proc means maxdec=4; var farm year pce
     rgovti rcinsi rcinsc
     bassets eassets aassets bdebt edebt adebt dtar
       bcinv ecinv acinv bcdebt ecdebt acdebt icr
     rgfi rvfp rnfi
       winc fginc sinc hfinc dairyi beefi
     wprod fgprod sprod hfprod dairy beef rcwork
     rlaborc rlivec rseedc rfertc rchemc rocapc rlandc
     laborp livep seedp fertp chemp ocapp rentc
     labor live seed fert chem ocap land
       v008 v010-v013 v324-v341 v468 offi
```

```
     pcropi pbeefi pdairyi plivei
     tacres cacres wacres fgacres sacres hfacres
     wheata wheatp wheaty corna cornp corny
     sorga sorgp sorgy soya soyp soyy
       pirrc pnirrc ppast
     powna crland lv
     cropinc livdinc tinc pcropi plivdi pcwki
     tacost expr pcrope plivde plabore pcape plande
     rintc dkddepr
     dum1 dum2 dum3 dum4 dum5 dum6 dum7;

run;
```

B.2 GAMS Codes

This section includes the GAMS codes to calculate technical efficiency under constant and variable returns to scale, and minimum costs under variable and constant returns to scale. Two programs were used to solve the specific DEA problems. The program for the input-oriented model, where all inputs are variable and there are no environmental effects. The program for the debt-constraint model, where total annual debt is introduced in the DEA problems formulation as a non-discretionary or environmental variable. In both codes, a matrix of input quantities for the 456 farms, a matrix of input prices for the farms, and output quantities are firstly entered. Results are collected at the end of the program. These results will be used to calculate efficiencies later.

B.2.1 GAMS Code for Input-Oriented DEA Model

The following is the GAMS Code for basic model (discretionary or non-environmental model. This model was estimated 10 times, each time for each independent year from 1998 to 2007. Here there is the example for the model to estimate technical efficiency and minimum costs for the 456 farms for the year 2007.

```
***************************************************************
*NONPARAMETRIC EFFICIENCY APPROACH FOR  KANSAS FARMS
*TECHNICAL EFFICIENCY UNDER VRS
*INPUT ORIENTED COST MINIMIZATION UNDER VRS AND CRTS
*INCREASING/DECREASING RETURNS TO SCALE
*NON-ENVIRONMENTAL OR DISCRETIONARY MODEL
***************************************************************
* A SAMPLE OF 456 KANSAS FAMS
* AS OUTPUTS= 7: SG,FG,SG,HY,BEEF, DAIRY,CW
* AS INPUTS=7:   LAND, LABOR, CAPITAL, LIVESTOCK, SEED, FERTI, CHEM
* NO ENVIRONMENTAL OR DISCRETIONARY VARIABLES
OPTION DECIMALS=5;
```

```
SETS
K OBSERVATION /F1*F456/
N INPUTS /X1, X2, X3, X4, X5, X6, X7/
J OUTPUTS /Y1, Y2, Y3, Y4, Y5, Y6, Y7/
IT /IT1*IT456/
*S DISINPUT /DX1/
*****************************
*INCLUDE DATA IN THIS SECTION
*****************************
TABLE X(K,N) INPUT LEVELS
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\INP.PRN";

TABLE Y(K,J) OUTPUT LEVES
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\OUT.PRN";

TABLE XP(K,N) INPUT PRICES
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\PINP.PRN";

TABLE YIT(IT,J) ITERATION FOR OUTPUT LEVELS
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\ITOUT.PRN";

TABLE XIT(IT,N) ITERATION FOR INPUT LEVELS
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\ITINP.PRN";

TABLE XPIT(IT,N)  ITERATION FOR INPUT PRICES
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\ITPINP.PRN";

**************************
*PARAMETER I IS FOR INPUTS
*PARAMETER O IS FOR OUTPUTS
**************************
```

```
PARAMETER I(N)
/X1 1
 X2 1
 X3 1
 X4 1
 X5 1
 X6 1
 X7 1/;
PARAMETER IP(N)
/X1 1
 X2 1
 X3 1
 X4 1
 X5 1
 X6 1
 X7 1/;
PARAMETER O(J)
/Y1 1
 Y3 1
 Y4 1
 Y5 1
 Y6 1
 Y7 1/ ;
PARAMETER OP(J)
/Y1 1
 Y3 1
 Y4 1
 Y5 1
 Y6 1
 Y7 1/ ;
```

POSITIVE VARIABLES

Z(K) INTENSITY MEASURE

OI(N) OPTIMAL INPUT LEVEL

VARIABLES

TE TECHNICAL EFFICIENCY

LAMBDA TECHNICAL EFFIECIENCY

COSTTC COST UNVER COSNTANT RETURNS TO SCALE

COSTTV COST UNDER VARIABEL RETURNS TO SCALE

COSTTOP COST UNDER NONDECREASING RETURNS TO SCALE

****

*CREATING PARAMTERS FOR EFFICIENCY ESTIMATION AND INTENSITY VALUES

****

PARAMETER

ZVAL(IT,K) Z VALUES

PARAMETER

TCOSTTV(IT) TOTAL COST UNDER VARIABLE RETURN TO SCALE FOR FARM I

PARAMETER

TCOSTTC(IT) TOTAL COST UNVER CONSTANT RETURN TO SCALE

PARAMETER

TCOSTTOP(IT) TOTAL COST UNDER NONDECREASING RETURNS TO SCALE

PARAMETER

TEM(IT) TECHNICAL EFFICIENCY MEASURE

PARAMETER

OPTIN(IT,N) OPTIMAL INPUT LEVEL VALUES

PARAMETER

ACOST(IT) ACTUAL COST OF INPUTS FOR FARMS

```
***********************************************************************
*SETTING UP NAMES FOR OBJECTIVE FUNCTION AND CONSTRAINTS
EQUATIONS
***********************************************************************
*TECHNICAL EFFICIENCY MEASURE  -VRS
***********************************************************************
EQUATIONS
OBJL LAMBDA OBJECTIVE FUNCTION
CON1A INPUT CONSTRAINT FOR TECHNICAL EFFICIENCY
CON2A OUTPUT CONSTRAINT
CON3A Z CONSTRAINT EQUALS ONE;
OBJL..TE=E=LAMBDA;
CON1A(N)..SUM(K,X(K,N)*Z(K))=L=I(N)*LAMBDA;
CON2A(J)..SUM(K,Y(K,J)*Z(K))-O(J)=G=0;
CON3A..SUM(K,Z(K))=E=1;
MODEL L /OBJL, CON1A, CON2A, CON3A/;
***********************************************************************
*MIN COST UNDER CRST    -COSTTC
***********************************************************************
EQUATIONS
OBJTC COST UNDER CONSTANT RETURNS TO SCALE
CON2B OUTPUT CONSTRAINT
CON3B INPUT CONSTRAINT;
OBJTC.. COSTTC=E=SUM(N,IP(N)*OI(N));
CON2B(J)..SUM(K,Y(K,J)*Z(K))-O(J)=G=0;
CON3B(N)..SUM(K,X(K,N)*Z(K))=L=OI(N);
MODEL CTC /OBJTC, CON2B, CON3B/;
***********************************************************************
*Ci(w,y,Tv)      MIN COST VRS
***********************************************************************
```

```
EQUATIONS
OBJTV COST UNDER VARIABLE RETURN TO SCALE
CON2C OUTPUT CONSTRAINT
CON4C INPUT CONSTRAINT
CON3C Z CONSTRAINT EQUALS ONE;
OBJTV.. COSTTV=E=SUM(N,IP(N)*OI(N));
CON2C(J)..SUM(K,Y(K,J)*Z(K))-O(J)=G=0;
CON4C(N)..SUM(K,X(K,N)*Z(K))=L=OI(N);
CON3C..SUM(K,Z(K))=E=1;
MODEL CTV /OBJTV, CON4C,CON2C, CON3C/;

*********************************************************************
*Ci(w,y,T*)      MIN COST N-DECREA RTS
*********************************************************************
EQUATIONS
OBJTOP COST UNDER NONDECREASING RETURNS TO SCALE
CON2D OUTPUT CONSTRAINT
CON4D INPUT CONSTRAINT
CON5D Z CONSTRAINT LESS THAN ONE;
OBJTOP.. COSTTOP=E=SUM(N,IP(N)*OI(N));
CON2D(J)..SUM(K,Y(K,J)*Z(K))-O(J)=G=0;
CON4D(N)..SUM(K,X(K,N)*Z(K))=L=OI(N);
 CON5D..SUM(K,Z(K))=L=1;
MODEL CTOP /OBJTOP, CON4D, CON2D, CON5D/;
*********************************************************************
*LOOP
*********************************************************************
LOOP(IT,
O(J)=YIT(IT,J);
I(N)=XIT(IT,N);
IP(N)=XPIT(IT,N);
```

```
SOLVE L USING NLP MINIMIZING LAMBDA;
SOLVE CTOP USING NLP MINIMIZING COSTTOP;
SOLVE CTV USING NLP MINIMIZING COSTTV;
SOLVE CTC USING NLP MINIMIZING COSTTC;
ACOST(IT)= SUM(N,XIT(IT,N)*XPIT(IT,N));
OPTIN(IT,N)=OI.L(N);
ZVAL(IT,K)=Z.L(K);
TEM(IT)=LAMBDA.L;
TCOSTTOP(IT)=COSTTOP.L;
TCOSTTV(IT)=COSTTV.L;
TCOSTTC(IT)=COSTTC.L;
);
*********************************************************************
* SAVING RESULTS
*********************************************************************
FILE ALLBASIC/C:\DATA\DISSJUL\RESULTS\99\ALLBA.PRN/
PUT ALLBASIC;
ALLBASIC.PC=5 ;
PUT "ID" "TE" "MCOSTNDRS" "MCOSTVRS" "MCOSTCRS" "ACOST" "X1" "X2"
"X3" "X4" "x5" "X6" "X7" ;
PUT/
LOOP(IT, PUT IT.TL,@5,TEM(IT),TCOSTTOP(IT),TCOSTTV(IT),TCOSTTC(IT),
ACOST(IT),
LOOP(N, PUT OI.L(N))
PUT/);

*********************************************************************
*USE A SPREADSHEET TO ESTIMATE RHO, ALPHA, AND BETHA
*********************************************************************
```

B.2.2 GAMS Code for Non-Discretionary DEA Model

The following is the GAMS code for debt-constraint model- discretionary or non environmental model. This model was estimated 10 times, each time for each independent year from 1998 to 2007.

```
*****************************************************************
*NONPARAMETRIC APPROACH  FOR  KANSAS FARMS
*TECHNICAL EFFICIENCY
*INPUT ORIENTED COST MINIMIZATION
*INCREASING/DECREASING RETURNS TO SCALE
*NON-DISCRETIONARY-ENVIRONMENTAL MODEL
*****************************************************************



* A SAMPLE OF 456 KANSAS FAMS
* AS OUTPUTS= 7: SG,FG,SG,HY,BEEF, DAIRY,CW
* AS INPUTS=7:LAND, LABOR, CAPITAL, LIVESTOCK, SEED, FERTI, CHEM
* TOTAL ANNUAL Debt AS A  NON-DISCRETIONARY OR ENVIRONMENTAL
VARIABLE, ALL PRICES IN REAL $2007

OPTION DECIMALS=5;



SETS
K OBSERVATION /F1*F456/
N INPUTS /X1, X2, X3, X4, X5, X6, X7/
J OUTPUTS /Y1, Y2, Y3, Y4, Y5, Y6, Y7/
IT /IT1*IT456/
S DISINPUT /DX1/
```

```
*****************************
*INCLUDE DATA IN THIS SECTION
*****************************
TABLE X(K,N) INPUT LEVELS
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\INP.PRN";

TABLE Y(K,J) OUTPUT LELVES
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\OUT.PRN";

TABLE XP(K,N) INPUT PRICES
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\PINP.PRN";

TABLE YIT(IT,J)
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\ITOUT.PRN";

TABLE XIT(IT,N)
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\ITINP.PRN";

TABLE XPIT(IT,N)
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\ITPINP.PRN";

TABLE DI(IT,s) DISCRETIONARY VARIABLE
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\ITDIS.PRN";

TABLE D(K,S)
$INCLUDE "C:\DATA\DISSJUL\FILES\2007\DIS.PRN";


**************************
*PARAMETER I IS FOR INPUTS
*PARAMETER O IS FOR OUTPUTS
```

```
***************************
PARAMETER I(N)
/X1 1
 X2 1
 X3 1
 X4 1
 X5 1
 X6 1
 X7 1/;

PARAMETER IP(N)
/X1 1
 X2 1
 X3 1
 X4 1
 X5 1
 X6 1
 X7 1/;

PARAMETER O(J)
/Y1 1
 Y2 1
 Y3 1
 Y4 1
 Y5 1
 Y6 1
 Y7 1/ ;

PARAMETER OP(J)
/Y1 1
 Y2 1
```

```
 Y3 1
 Y4 1
 Y5 1
 Y6 1
 Y7 1/ ;

PARAMETER DX(S)
/DX1 1/;
POSITIVE VARIABLES
Z(K) INTENSITY MEASURE
OI(N) OPTIMAL INPUT LEVEL

VARIABLES
TE TECHNICAL EFFICIENCY
LAMBDA TECHNICAL EFFIECIENCY
COSTTC COST UNVER COSNTANT RETURNS TO SCALE
COSTTV COST UNDER VARIABEL RETURNS TO SCALE
COSTTOP COST UNDER NONDECREASING RETURNS TO SCALE
*********************************************************************
*CREATING PARAMTERS FOR EFFICIENCY ESTIMATION AND INTENSITY
VALUES
***********************************************************************
PARAMETER
ZVAL(IT,K) Z VALUES
PARAMETER
TCOSTTV(IT) TOTAL COST UNDER VARIABLE RETURN TO SCALE FOR FARM
i

PARAMETER
TCOSTTC(IT) TOTAL COST UNVER CONSTANT RETURN TO SCALE
PARAMETER
```

```
TCOSTTOP(IT) TOTAL COST UNDER NONDECREASING RETURNS TO SCALE
PARAMETER
TEM(IT) TECHNICAL EFFICIENCY MEASURE
OPTIN(IT,N) OPTIMAL INPUT LEVEL VALUES
PARAMETER
ACOST(IT) ACTUAL COST OF INPUTS FOR FARMS
**********************************************************************
*SETTING UP NAMES FOR OBJECTIVE FUNCTION AND CONSTRAINTS
EQUATIONS
**********************************************************************
***********************************************************************
*TECHNICAL EFFICIENCY  MEASURE  -VRS
***********************************************************************
EQUATIONS
OBJL LAMBDA OBJECTIVE FUNCTION
CON1A INPUT CONSTRAINT FOR TECHNICAL EFFICIENCY
CON2A OUTPUT CONSTRAINT
CON3A Z CONSTRAINT EQUALS ONE
CON4A  DISCRETIONARY CONSTRAINT;

OBJL..TE=E=LAMBDA;
CON1A(N)..SUM(K,X(K,N)*Z(K))=L=I(N)*LAMBDA;
CON4A(S)..SUM(K,D(K,s)*Z(K))=L=DX(S);
CON2A(J)..SUM(K,Y(K,J)*Z(K))-O(J)=G=0;
CON3A..SUM(K,Z(K))=E=1;

MODEL L /OBJL, CON1A, CON2A, CON3A, CON4A/;

***********************************************************************
*MIN COST UNDER CRST    -COSTTC
***********************************************************************
```

```
EQUATIONS
OBJTC COST UNDER CONSTANT RETURNS TO SCALE
CON2B OUTPUT CONSTRAINT
CON3B INPUT CONSTRAINT
CON4B NON-DISC CONSTRAINT;

OBJTC.. COSTTC=E=SUM(N,IP(N)*OI(N));
CON2B(J)..SUM(K,Y(K,J)*Z(K))-O(J)=G=0;
CON4B(S)..SUM(K,D(K,s)*Z(K))=L=DX(S);
CON3B(N)..SUM(K,X(K,N)*Z(K))=L=OI(N);

MODEL CTC /OBJTC, CON2B, CON3B,CON4B/;
*********************************************************************
*Ci(w,y,Tv)     MIN COST VRS
*********************************************************************
EQUATIONS
OBJTV COST UNDER VARIABLE RETURN TO SCALE
CON2C OUTPUT CONSTRAINT
CON4C INPUT CONSTRAINT
CON3C Z CONSTRAINT EQUALS ONE
CON5C NON-DISC CONSTRAINT;
OBJTV.. COSTTV=E=SUM(N,IP(N)*OI(N));
CON2C(J)..SUM(K,Y(K,J)*Z(K))-O(J)=G=0;
CON4C(N)..SUM(K,X(K,N)*Z(K))=L=OI(N);
CON5C(S)..SUM(K,D(K,s)*Z(K))=L=DX(S);
CON3C..SUM(K,Z(K))=E=1;

MODEL CTV /OBJTV, CON4C,CON2C, CON3C, CON5C/;
*********************************************************************
*Ci(w,y,T*)     MIN COST N-DECREA RTS
*********************************************************************
```

```
EQUATIONS
OBJTOP COST UNDER NONDECREASING RETURNS TO SCALE
CON2D OUTPUT CONSTRAINT
CON4D INPUT CONSTRAINT
CON5D Z CONSTRAINT LESS THAN ONE
CON3D NON-DISC CONSTRAINT;
OBJTOP.. COSTTOP=E=SUM(N,IP(N)*OI(N));
CON2D(J)..SUM(K,Y(K,J)*Z(K))-O(J)=G=0;
CON4D(N)..SUM(K,X(K,N)*Z(K))=L=OI(N);
CON3D(S)..SUM(K,D(K,s)*Z(K))=L=DX(S);
CON5D..SUM(K,Z(K))=L=1;

MODEL CTOP /OBJTOP, CON4D, CON2D, CON3D, CON5D/;
*************************************************************************
*LOOP
*************************************************************************
LOOP(IT,
O(J)=YIT(IT,J);
I(N)=XIT(IT,N);
DX(S)=DI(IT,S);
IP(N)=XPIT(IT,N);

SOLVE L USING NLP MINIMIZING LAMBDA;
SOLVE CTOP USING NLP MINIMIZING COSTTOP;
SOLVE CTV USING NLP MINIMIZING COSTTV;
SOLVE CTC USING NLP MINIMIZING COSTTC;


ACOST(IT)= SUM(N,XIT(IT,N)*XPIT(IT,N));
OPTIN(IT,N)=OI.L(N);
ZVAL(IT,K)=Z.L(K);
```

```
TEM(IT)=LAMBDA.L;
TCOSTTOP(IT)=COSTTOP.L;
TCOSTTV(IT)=COSTTV.L;
TCOSTTC(IT)=COSTTC.L;
);
*********************************************************************
* SAVING RESULTS
**********************************************************************
FILE ALLBASIC/C:\DATA\DISSJUL\RESULTSNDIS\2007\ALLNBA.TXT/
PUT ALLBASIC;
ALLBASIC.PC=5 ;
PUT "ID" "TE" "MCOSTNDRS" "MCOSTVRS" "MCOSTCRS" "ACOST" "X1" "X2"
"X3" "X4" "x5" "X6" "X7" ;
PUT/
LOOP(IT, PUT IT.TL,@5,TEM(IT),TCOSTTOP(IT),TCOSTTV(IT),TCOSTTC(IT),
ACOST(IT),
LOOP(N, PUT OI.L(N))
PUT/);

*********************************************************************
*USE A SPREADSHEET TO ESTIMATE ALLOCATIVE, SCALE AND OVERALL
EFFICIENCY
```

B.3 STATA Code to Conduct Tobit Regression Analysis

STATA Code

--Identifying the dataset as a panel data---

```
iis (n)
tis(year
```

---Summary statistics: All, by efficiencies, inefficiencies and differentials by year---

```
sum
sum te oe se oe ti ai si oi ted aed sed oed if year ==98
sum te oe se oe ti ai si oi ted aed sed oed if year ==99
sum te oe se oe ti ai si oi ted aed sed oed if year ==100
sum te oe se oe ti ai si oi ted aed sed oed if year ==101
sum te oe se oe ti ai si oi ted aed sed oed if year ==102
sum te oe se oe ti ai si oi ted aed sed oed if year ==103
sum te oe se oe ti ai si oi ted aed sed oed if year ==104
sum te oe se oe ti ai si oi ted aed sed oed if year ==105
sum te oe se oe ti ai si oi ted aed sed oed if year ==106
sum te oe se oe ti ai si oi ted aed sed oed if year ==107
```

---Summary statistics: Farms by Output Specialization in terms of Net Gross Farm Income---

```
sum if  plivdi>.8
sum if  pcropi>.8
sum if  plivdi<.8 & pcropi<.8
sum te ae se oe ted aed sed oed if typecrop==1
sum te ae se oe ted aed sed oed if typelivest==1
sum te ae se oe ted aed sed oed if typemixed==1
```

---Summary statistics: Farms by Size in terms of Net Gross Farm Income---

```
sum if   rgfi<100000
sum if  rgfi>100000 & rgfi<250000
sum if  rgfi>250000 & rgfi<500000
sum if  rgfi>500000
```

---Summary statistics of Fully Efficient Farms in Both Models, by year---

```
sum if te==1 & year==98
sum if te==1 & year==99
sum if te==1 & year==100
sum if te==1 & year==101
sum if te==1 & year==102
sum if te==1 & year==103
sum if te==1 & year==104
sum if te==1 & year==105
sum if te==1 & year==106
sum if te==1 & year==107

sum if ted==1 & year==98
sum if ted==1 & year==99
sum if ted==1 & year==100
sum if ted==1 & year==101
sum if ted==1 & year==102
sum if ted==1 & year==103
sum if ted==1 & year==104
sum if ted==1 & year==105
sum if ted==1 & year==106
sum if ted==1 & year==107

sum if ae==1 & year==98
sum if ae==1 & year==99
sum if ae==1 & year==100
sum if ae==1 & year==101
sum if ae==1 & year==102
sum if ae==1 & year==103
sum if ae==1 & year==104
sum if ae==1 & year==105
sum if ae==1 & year==106
sum if ae==1 & year==107

sum if aed==1 & year==98
sum if aed==1 & year==99
```

```
sum if aed==1 & year==100
sum if aed==1 & year==101
sum if aed==1 & year==102
sum if aed==1 & year==103
sum if aed==1 & year==104
sum if aed==1 & year==105
sum if aed==1 & year==106
sum if aed==1 & year==107

sum if se==1 & year==98
sum if se==1 & year==99
sum if se==1 & year==100
sum if se==1 & year==101
sum if se==1 & year==102
sum if se==1 & year==103
sum if se==1 & year==104
sum if se==1 & year==105
sum if se==1 & year==106
sum if se==1 & year==107

sum if sed==1 & year==98
sum if sed==1 & year==99
sum if sed==1 & year==100
sum if sed==1 & year==101
sum if sed==1 & year==102
sum if sed==1 & year==103
sum if sed==1 & year==104
sum if sed==1 & year==105
sum if sed==1 & year==106
sum if sed==1 & year==107

sum if oe==1 & year==98
sum if oe==1 & year==99
sum if oe==1 & year==100
sum if oe==1 & year==101
sum if oe==1 & year==102
sum if oe==1 & year==103
```

```
sum if oe==1 & year==104
sum if oe==1 & year==105
sum if oe==1 & year==106
sum if oe==1 & year==107

sum if oed==1 & year==98
sum if oed==1 & year==99
sum if oed==1 & year==100
sum if oed==1 & year==101
sum if oed==1 & year==102
sum if oed==1 & year==103
sum if oed==1 & year==104
sum if oed==1 & year==105
sum if oed==1 & year==106
sum if oed==1 & year==107

sum if te==ted
sum if ae==aed
sum if se==sed
sum if oe==oed

sum if te~=ted
sum if ae~=aed
sum if se~=sed
sum if oe~=oed

sum if bdebt==0
sum if bdebt~=0 & bdebt<50000
sum if bdebt>50000 & bdebt<100000
sum if bdebt>100000 & bdebt<250000
sum if bdebt>250000 & bdebt<500000
sum if  bdebt>500000
```

--First essay Panel data Tobits and Tobit test statistics---

```
xttobit ti powna offi v468 plivdi pcwki m55age  tdta  rnfiac  ppasta year1  year2 year3 year4 year5 year6 year7 year8 year9, ll(0) tobit
xttobit ai powna offi v468 plivdi pcwki m55age  tdta  rnfiac  ppasta year1  year2 year3 year4 year5 year6 year7 year8 year9, ll(0) tobit
xttobit si powna offi v468 plivdi pcwki m55age  tdta  rnfiac  ppasta year1  year2 year3 year4 year5 year6 year7 year8 year9, ll(0) tobit
xttobit oi powna offi v468 plivdi pcwki m55age  tdta  rnfiac  ppasta year1  year2 year3 year4 year5 year6 year7 year8 year9, ll(0) tobit

xttobit ti rnfi  ppasta offi tdta m55age  v468  pcropi year1 year2 year3 year4 year5 year6 year7 year8 year9 , ll(0) tobit
xttobit ai rnfi  ppasta offi tdta m55age  v468  pcropi year1 year2 year3 year4 year5 year6 year7 year8 year9 , ll(0)  tobit
xttobit si rnfi  ppasta offi tdta m55age  v468  pcropi year1 year2 year3 year4 year5 year6 year7 year8 year9, ll(0) tobit
xttobit oi rnfi  ppasta offi tdta m55age  v468  pcropi year1 year2 year3 year4 year5 year6 year7 year8 year9, ll(0) tobit
year7 year8 year9
```

--Second essay Panel data Tobits and Tobit test statistics--

```
xttobit tincons livdincp cropincp cwincp tdta cdca rnfiac offipg roa bassets year, ll(0) tobit
xttobit ticons livdincp cropincp cwincp tdta cdca rnfiac offipg roa bassets year, ll(0) tobit
xttobit aincons livdincp cropincp cwincp tdta cdca rnfiac offipg roa bassets year, ll(0) tobit
xttobit aicons livdincp cropincp cwincp tdta cdca rnfiac offipg roa bassets year, ll(0) tobit
xttobit sincons livdincp cropincp cwincp tdta cdca rnfiac offipg roa bassets year, ll(0) tobit
xttobit sicons livdincp cropincp cwincp tdta cdca rnfiac offipg roa bassets year, ll(0) tobit
xttobit oincons livdincp cropincp cwincp tdta cdca rnfiac offipg roa bassets year, ll(0) tobit
xttobit oicons livdincp cropincp cwincp tdta cdca rnfiac offipg roa bassets year, ll(0) tobit

. ttesti 4560 .93 .12 4560 .86 .17
ttesti 4560 .83 .12 4560 .75  .15
ttesti 4560 .91 .13 4560 .84  .16
ttesti 4560 .69 .18 4560 .57  .20
…..

.estat hettest, rhs
```

Appendix C - Marginal Effects and Elasticities Corresponding to the Inefficiency Basic DEA Models (Section 5.3)

C.1 Stata Description of Marginal Effects and Elasticity Calculations

Stata numerically calculates the marginal effects or the elasticities and their standard errors after estimation. Exactly what **mf*x*** can calculate is determined by the previous estimation command and the **predict (***predict_option***)** option (next section on panel Tobit models is below). By default, **mf*x*** calculates the marginal effects or elasticities at the means of the independent variables. Some disciplines use the term partial effects, rather than marginal effects, for what is computed by **mf*x***. The option **varlist (***varlist***)** specifies the variables for which to calculate marginal effects (elasticities). The default is all variables. The way of calculating marginal effects is: 1. **dyd*x*** specifies that marginal effects be calculated. This is the default. 2. **eye*x*** specifies that elasticities be calculated in the form of d(lny)/d(lnx). 3. **dye*x*** specifies that elasticities be calculated in the form of d(*y*)/d(ln*x*). **eyd*x*** specifies that elasticities be calculated in the form of d(ln*y*)/d(*x*). The option **nodiscrete** treats dummy variables as continuous. If **nodiscrete** is not specified, the marginal effect of a dummy variable is calculated as the discrete change in *y* as the dummy variable changes from 0 to 1. This option is irrelevant to the computation of the elasticities because all the dummy variables are treated as continuous when computing elasticities (www.stata.com). Marginal effect computation for panel tobit models, commands xtintreg and xttobit are:

1. The marginal effects for the probability of being uncensored are: mfx compute, predict(pr0(*a*, *b*)), where *a* is the lower limit for left censoring and *b* is the upper limit for right censoring.
2. The marginal effects for the expected value of *y* conditional on being uncensored are mfx compute, predict(e0(*a*, *b*)), where a is the lower limit for left censoring and *b* is the upper limit for right censoring.
3. The marginal effects for the unconditional expected value of *y* are: mf*x* compute, predict(ys(*a*, *b*)), where *a* is the lower limit for left censoring and *b* is the upper limit for right censoring.

C.2 Tables of Marginal Effects and Elasticities

C. Panel data Tobit for Basic DEA Technical Inefficiencies, followed by a report of their marginal effects according to option 1, 2, and 2, respectively.

Table C.1 Marginal Effects for the Probability of the Dependent Variable being Uncensored

Y = Pr (0<ti<0.69 (predict pr0(0, 0.69)) = 0.4762

Variable	dy/dx	Std. Dev.	z	P>z	X	Elasticities
RNFIAC	-0.0048	0.0003	-16.5000	0.0000	33.4187	-0.3403
POWNA	-0.1401	0.0541	-2.5900	0.0100	0.4469	-0.1315
OFFI	0.0000	0.0000	-1.3600	0.1740	9877.9900	-0.0189
V468	0.2024	0.0918	2.2100	0.0270	0.7872	0.3345
PLIVDI	0.0228	0.0650	0.3500	0.7250	0.3225	0.0155
PCWKI	-1.7530	0.3367	-5.2100	0.0000	0.0157	-0.0578
M55AGE	-0.0103	0.0027	-3.8300	0.0000	64.5455	-1.3995
TDTA	-0.2246	0.0709	-3.1700	0.0020	0.2226	-0.1050
PPASTA	-0.0128	0.0746	-0.1700	0.8630	0.3292	-0.0089
YEAR1*	-0.3143	0.0292	-10.7600	0.0000	0.0750	-0.0495
YEAR2*	-0.2369	0.0321	-7.3900	0.0000	0.0792	-0.0394
YEAR3*	-0.2190	0.0313	-6.9900	0.0000	0.0835	-0.0384
YEAR4*	-0.3032	0.0272	-11.1400	0.0000	0.0882	-0.0562
YEAR5*	-0.2466	0.0285	-8.6500	0.0000	0.0954	-0.0494
YEAR6*	-0.1147	0.0301	-3.8100	0.0000	0.1044	-0.0251
YEAR7*	-0.1916	0.0285	-6.7200	0.0000	0.1086	-0.0437
YEAR8*	-0.2499	0.0265	-9.4400	0.0000	0.1134	-0.0595
YEAR9*	-0.3025	0.0250	-12.1000	0.0000	0.1214	-0.0771

Table C.2 Marginal Effects for the Expected Value of the Dependent Variable Conditional on being Uncensored

Y = Pr (ti0<oi<0.69 (predict e(0, 0.69) = 0.1711

Variable	dy/dx	Std. Dev.	Z	P>z	X	Elasticities
RNFIAC	-0.0009	0.0001	-17.1900	0.0000	33.4187	-0.1805
POWNA	-0.0267	0.0103	-2.5900	0.0100	0.4469	-0.0697
OFFI	0.0000	0.0000	-1.3600	0.1730	9877.9900	-0.0100
V468	0.0386	0.0175	2.2100	0.0270	0.7872	0.1774
PLIVDI	0.0044	0.0124	0.3500	0.7260	0.3225	0.0082
PCWKI	-0.3340	0.0629	-5.3100	0.0000	0.0157	-0.0307
M55AGE	-0.0020	0.0005	-3.9200	0.0000	64.5455	-0.7423
TDTA	-0.0428	0.0134	-3.1900	0.0010	0.2226	-0.0557
PPASTA	-0.0024	0.0142	-0.1700	0.8630	0.3292	-0.0047
YEAR1*	-0.0548	0.0050	-10.9000	0.0000	0.0750	-0.0240
YEAR2*	-0.0416	0.0053	-7.7800	0.0000	0.0792	-0.0192
YEAR3*	-0.0385	0.0052	-7.3900	0.0000	0.0835	-0.0188
YEAR4*	-0.0530	0.0046	-11.4200	0.0000	0.0882	-0.0273
YEAR5*	-0.0433	0.0048	-9.0900	0.0000	0.0954	-0.0241
YEAR6*	-0.0208	0.0052	-3.9900	0.0000	0.1044	-0.0127
YEAR7*	-0.0341	0.0048	-7.0900	0.0000	0.1086	-0.0216
YEAR8*	-0.0440	0.0045	-9.8600	0.0000	0.1134	-0.0292
YEAR9*	-0.0532	0.0043	-12.3800	0.0000	0.1214	-0.0377

Table C.3 Marginal Effects for the Unconditional Expected Value of the Dependent Variable

Y = E (ti*0<ti<0.69 (predict ys(0, 0.69)) = 0.0820

Variable	dy/dx	Std. Dev.	z	P>z	X	Elasticities
RNFIAC	-0.0013	0.0001	-15.7500	0.0000	33.4187	-0.5264
POWNA	-0.0373	0.0145	-2.5800	0.0100	0.4469	-0.2033
OFFI	0.0000	0.0000	-1.3600	0.1730	9877.9900	-0.0293
V468	0.0539	0.0245	2.2000	0.0280	0.7872	0.5175
PLIVDI	0.0061	0.0173	0.3500	0.7260	0.3225	0.0239
PCWKI	-0.4669	0.0882	-5.2900	0.0000	0.0157	-0.0895
M55AGE	-0.0028	0.0007	-3.9300	0.0000	64.5455	-2.1649
TDTA	-0.0598	0.0188	-3.1800	0.0010	0.2226	-0.1624
PPASTA	-0.0034	0.0199	-0.1700	0.8630	0.3292	-0.0137
YEAR1*	-0.0663	0.0054	-12.3400	0.0000	0.0750	-0.0606
YEAR2*	-0.0528	0.0061	-8.6300	0.0000	0.0792	-0.0510
YEAR3*	-0.0495	0.0061	-8.1000	0.0000	0.0835	-0.0504
YEAR4*	-0.0650	0.0052	-12.5300	0.0000	0.0882	-0.0699
YEAR5*	-0.0550	0.0056	-9.8900	0.0000	0.0954	-0.0640
YEAR6*	-0.0280	0.0068	-4.1600	0.0000	0.1044	-0.0357
YEAR7*	-0.0445	0.0059	-7.5500	0.0000	0.1086	-0.0590
YEAR8*	-0.0561	0.0054	-10.4900	0.0000	0.1134	-0.0776
YEAR9*	-0.0662	0.0051	-12.9500	0.0000	0.1214	-0.0980

D. Panel data Tobit for Basic DEA Allocative Inefficiencies, followed by a report of their marginal effects according to option 1, 2, and 3, respectively.

Table C.4 Marginal Effects for the Probability of the Dependent Variable being Uncensored

Y = Pr(0<ai<0.8296788) (predict pr0(0, 0.8296788)) = 0.9414

Variable	dy/dx	Std. Dev.	Z	P>z	X	Elasticities
RNFIAC	-0.00138	0.00013	-11	0	33.4187	-0.0491
POWNA	0.008777	0.01554	0.56	0.572	0.446888	0.0042
OFFI	-1.49E-07	0	-0.78	0.434	9877.99	-0.0016
V468	0.072425	0.0247	2.93	0.003	0.787249	0.0606
PLIVDI	0.03499	0.01768	1.98	0.048	0.322472	0.0120
PCWKI	-0.46809	0.08417	-5.56	0	0.015712	-0.0078
M55AGE	-0.00123	0.00076	-1.61	0.107	64.5455	-0.0841
TDTA	-0.05106	0.01978	-2.58	0.01	0.222642	-0.0121
PPASTA	-0.02151	0.02062	-1.04	0.297	0.329245	-0.0075
YEAR1*	-0.20333	0.03135	-6.49	0	0.074953	-0.0162
YEAR2*	-0.12777	0.02434	-5.25	0	0.079222	-0.0108
YEAR3*	-0.14239	0.02453	-5.8	0	0.083491	-0.0126
YEAR4*	-0.22452	0.02906	-7.73	0	0.088235	-0.0210
YEAR5*	-0.09674	0.01927	-5.02	0	0.095351	-0.0098
YEAR6*	-0.12446	0.02029	-6.14	0	0.104364	-0.0138
YEAR7*	-0.18379	0.02347	-7.83	0	0.108634	-0.0212
YEAR8*	-0.15097	0.02106	-7.17	0	0.113378	-0.0182
YEAR9*	-0.19278	0.02275	-8.47	0	0.121442	-0.0249

Table C.5 Marginal Effects for the Expected Value of the Dependent Variable Conditional on being Uncensored

Y = E(ai0<ai<0.8296788) (predict e0(0, 0.8296788)) = 0.2151

Variable	dy/dx	Std. Dev.	z	P>z	X	Elasticities
RNFIAC	-0.00119	0.00006	-20.71	0	33.4187	-0.1848
POWNA	0.007539	0.01332	0.57	0.571	0.446888	0.0157
OFFI	-1.28E-07	0	-0.78	0.434	9877.99	-0.0059
V468	0.062215	0.02078	2.99	0.003	0.787249	0.2277
PLIVDI	0.030057	0.01503	2	0.046	0.322472	0.0451
PCWKI	-0.40211	0.06679	-6.02	0	0.015712	-0.0294
M55AGE	-0.00105	0.00063	-1.66	0.097	64.5455	-0.3162
TDTA	-0.04386	0.01668	-2.63	0.009	0.222642	-0.0454
PPASTA	-0.01848	0.01764	-1.05	0.295	0.329245	-0.0283
YEAR1*	-0.08364	0.00668	-12.52	0	0.074953	-0.0291
YEAR2*	-0.06364	0.00711	-8.95	0	0.079222	-0.0234
YEAR3*	-0.06835	0.00671	-10.19	0	0.083491	-0.0265
YEAR4*	-0.08959	0.00593	-15.12	0	0.088235	-0.0368
YEAR5*	-0.05366	0.00679	-7.9	0	0.095351	-0.04035
YEAR6*	-0.06391	0.0062	-10.31	0	0.104364	-0.05176
YEAR7*	-0.08161	0.00566	-14.41	0	0.108634	-0.07051
YEAR8*	-0.0728	0.00583	-12.49	0	0.113378	-0.06137
YEAR9*	-0.08504	0.00552	-15.4	0	0.121442	-0.07421

Table C.6 Marginal Effects for the Unconditional Expected Value of the Dependent Variable

Y = E(ai*<ai<0.8296788) (predict ys(0, 0.8296788)) = 0.2025

Variable	dy/dx	Std. Dev.	z	P>z	X	Elasticities
RNFIAC	-0.00142	0.00006	-21.87	0	33.4187	-0.2339
POWNA	0.008985	0.01588	0.57	0.571	0.446888	0.0198
OFFI	-1.53E-07	0	-0.78	0.434	9877.99	-0.0075
V468	0.074145	0.02471	3	0.003	0.787249	0.2883
PLIVDI	0.035821	0.0179	2	0.045	0.322472	0.0571
PCWKI	-0.47921	0.079	-6.07	0	0.015712	-0.0372
M55AGE	-0.00126	0.00076	-1.66	0.097	64.5455	-0.4003
TDTA	-0.05227	0.01986	-2.63	0.008	0.222642	-0.0575
PPASTA	-0.02202	0.02102	-1.05	0.295	0.329245	-0.0358
YEAR1*	-0.10765	0.0091	-11.83	0	0.074953	-0.0399
YEAR2*	-0.08038	0.00947	-8.49	0	0.079222	-0.0315
YEAR3*	-0.08664	0.00896	-9.67	0	0.083491	-0.0357
YEAR4*	-0.11555	0.00798	-14.49	0	0.088235	-0.0504
YEAR5*	-0.06701	0.00886	-7.56	0	0.095351	-0.04964
YEAR6*	-0.08042	0.00815	-9.87	0	0.104364	-0.06445
YEAR7*	-0.10415	0.00749	-13.9	0	0.108634	-0.08947
YEAR8*	-0.09216	0.00767	-12.02	0	0.113378	-0.07714
YEAR9*	-0.10853	0.00723	-15	0	0.121442	-0.09435

E. Panel data Tobit for Basic DEA Scale Inefficiencies, followed by a report of their marginal effects according to option 1, 2, and 3, respectively.

Table C.7 Marginal Effects for the Probability of the Dependent Variable being Uncensored

Y = Pr(0<si<0.940343) (predict pr0(0, 0.9403438)) = 0.8594

Variable	dy/dx	Std. Dev.	z	P>z	X	Elasticities
RNFIAC	-0.00184	0.00014	-13.2	0	33.4187	-0.0715
POWNA	0.095544	0.02877	3.32	0.001	0.446888	0.0497
OFFI	1.13E-06	0	3.48	0.001	9877.99	0.0130
V468	0.098129	0.03916	2.51	0.012	0.787249	0.0899
PLIVDI	0.222653	0.03141	7.09	0	0.322472	0.0835
PCWKI	-0.33783	0.12452	-2.71	0.007	0.015712	-0.0062
M55AGE	0.005349	0.00149	3.59	0	64.5455	0.4017
TDTA	-0.07146	0.03523	-2.03	0.042	0.222642	-0.0185
PPASTA	-0.0973	0.03579	-2.72	0.007	0.329245	-0.0373
YEAR1*	-0.07229	0.02458	-2.94	0.003	0.074953	-0.0063
YEAR2*	-0.01885	0.01927	-0.98	0.328	0.079222	-0.0017
YEAR3*	-0.0083	0.01734	-0.48	0.632	0.083491	-0.0008
YEAR4*	-0.14455	0.02472	-5.85	0	0.088235	-0.0148
YEAR5*	9.09E-05	0.0152	0.01	0.995	0.095351	0.0000
YEAR6*	0.027073	0.01248	2.17	0.03	0.104364	0.0033
YEAR7*	-0.10121	0.01888	-5.36	0	0.108634	-0.0128
YEAR8*	-0.16332	0.02096	-7.79	0	0.113378	-0.0215
YEAR9*	-0.15682	0.01989	-7.88	0	0.121442	-0.0222

Table C.8 Marginal Effects for the Expected Value of the Dependent Variable Conditional on being Uncensored

Y = E(si0<si<0.940343) (predict e0(0, 0.9403438)) = 0.1860

Variable	dy/dx	Std. Dev.	z	P>z	X	Elasticities
RNFIAC	-0.00075	0.00004	-16.71	0	33.4187	-0.1343
POWNA	0.038855	0.01153	3.37	0.001	0.446888	0.0933
OFFI	4.60E-07	0	3.5	0	9877.99	0.0244
V468	0.039906	0.01584	2.52	0.012	0.787249	0.1689
PLIVDI	0.090546	0.01179	7.68	0	0.322472	0.1570
PCWKI	-0.13739	0.05038	-2.73	0.006	0.015712	-0.0116
M55AGE	0.002175	0.00064	3.4	0.001	64.5455	0.7548
TDTA	-0.02906	0.01427	-2.04	0.042	0.222642	-0.0348
PPASTA	-0.03957	0.01439	-2.75	0.006	0.329245	-0.0700
YEAR1*	-0.02455	0.00673	-3.65	0	0.074953	-0.0099
YEAR2*	-0.00728	0.00697	-1.04	0.296	0.079222	-0.0031
YEAR3*	-0.0033	0.00669	-0.49	0.622	0.083491	-0.0015
YEAR4*	-0.04313	0.0052	-8.29	0	0.088235	-0.0205
YEAR5*	0.000037	0.00619	0.01	0.995	0.095351	0.0000
YEAR6*	0.011908	0.00603	1.97	0.048	0.104364	0.0067
YEAR7*	-0.03293	0.00474	-6.95	0	0.108634	-0.0192
YEAR8*	-0.04805	0.00441	-10.9	0	0.113378	-0.0293
YEAR9*	-0.04684	0.00437	-10.72	0	0.121442	-0.0306

Table C.9 Marginal Effects for the Unconditional Expected Value of the Dependent Variable

Y = E(si*<si<0.940343) (predict ys(0, 0.9403438)) = 0.1599

Variable	dy/dx	Std. Dev.	z	P>z	X	Elasticities
RNFIAC	-0.00098	0.00005	-18.09	0	33.4187	-0.2057
POWNA	0.051165	0.01516	3.37	0.001	0.446888	0.1430
OFFI	6.05E-07	0	3.52	0	9877.99	0.0374
V468	0.052549	0.02082	2.52	0.012	0.787249	0.2588
PLIVDI	0.119233	0.01538	7.75	0	0.322472	0.2405
PCWKI	-0.18091	0.06619	-2.73	0.006	0.015712	-0.0178
M55AGE	0.002864	0.00083	3.44	0.001	64.5455	1.1565
TDTA	-0.03827	0.01877	-2.04	0.041	0.222642	-0.0533
PPASTA	-0.0521	0.01892	-2.75	0.006	0.329245	-0.1073
YEAR1*	-0.03303	0.00927	-3.56	0	0.074953	-0.0155
YEAR2*	-0.00964	0.00931	-1.04	0.3	0.079222	-0.0048
YEAR3*	-0.00436	0.00887	-0.49	0.623	0.083491	-0.0023
YEAR4*	-0.05877	0.00726	-8.09	0	0.088235	-0.0324
YEAR5*	4.87E-05	0.00814	0.01	0.995	0.095351	0.0000
YEAR6*	0.015523	0.00776	2	0.045	0.104364	0.0101
YEAR7*	-0.04449	0.00652	-6.82	0	0.108634	-0.0302
YEAR8*	-0.06553	0.00606	-10.82	0	0.113378	-0.0465
YEAR9*	-0.06379	0.00597	-10.69	0	0.121442	-0.0485

F. Panel data Tobit for Basic DEA Overall Inefficiencies, followed by a report of their marginal effects according to option 1, 2, and 3, respectively.

Table C.10 Marginal Effects for the Probability of the Dependent Variable being Uncensored

Y = Pr (0<oi<0.989 (predict pr0(0, 0.989839)) = 0.9958

Variable	dy/dx	Std. Dev.	z	P>z	X	Elasticities
RNFIAC	-0.00022	0.00004	-5.3	0	33.4187	-0.0073
POWNA	0.000995	0.00162	0.62	0.538	0.446888	0.0004
OFFI	3.90E-08	0	1.9	0.058	9877.99	0.0004
V468	0.009974	0.00304	3.28	0.001	0.787249	0.0079
PLIVDI	0.009326	0.00258	3.61	0	0.322472	0.0030
PCWKI	-0.06233	0.01348	-4.62	0	0.015712	-0.0010
M55AGE	5.53E-05	0.00008	0.72	0.472	64.5455	0.0036
TDTA	-0.01018	0.00274	-3.72	0	0.222642	-0.0023
PPASTA	-0.0056	0.00238	-2.35	0.019	0.329245	-0.0019
YEAR1*	-0.05272	0.01189	-4.43	0	0.074953	-0.0040
YEAR2*	-0.02221	0.00607	-3.66	0	0.079222	-0.0018
YEAR3*	-0.01985	0.00537	-3.7	0	0.083491	-0.0017
YEAR4*	-0.08377	0.01494	-5.61	0	0.088235	-0.0074
YEAR5*	-0.01745	0.0046	-3.79	0	0.095351	-0.0017
YEAR6*	-0.00883	0.0027	-3.27	0.001	0.104364	-0.0009
YEAR7*	-0.04352	0.00838	-5.2	0	0.108634	-0.0047
YEAR8*	-0.05721	0.01004	-5.7	0	0.113378	-0.0065
YEAR9*	-0.073	0.01155	-6.32	0	0.121442	-0.0089

Table C.11 Marginal Effects for the Expected Value of the Dependent Variable Conditional on being Uncensored

Y = Pr (oi0<oi<0.989 (predict e(0, 0.989839)) = 0.3888

Variable	dy/dx	Std. Dev.	z	P>z	X	Elasticities
RNFIAC	-0.00254	0.00007	-34.82	0	33.4187	-0.2186
POWNA	0.011645	0.01869	0.62	0.533	0.446888	0.0134
OFFI	4.56E-07	0	2.02	0.043	9877.99	0.0116
V468	0.116668	0.0282	4.14	0	0.787249	0.2362
PLIVDI	0.109098	0.02069	5.27	0	0.322472	0.0905
PCWKI	-0.7291	0.0904	-8.07	0	0.015712	-0.0295
M55AGE	0.000647	0.00091	0.71	0.478	64.5455	0.1074
TDTA	-0.11903	0.02329	-5.11	0	0.222642	-0.0682
PPASTA	-0.06547	0.02448	-2.67	0.007	0.329245	-0.0554
YEAR1*	-0.15045	0.01083	-13.89	0	0.074953	-0.0290
YEAR2*	-0.10277	0.01127	-9.12	0	0.079222	-0.0209
YEAR3*	-0.09744	0.01086	-8.97	0	0.083491	-0.0209
YEAR4*	-0.18155	0.00907	-20.02	0	0.088235	-0.0412
YEAR5*	-0.09204	0.01032	-8.92	0	0.095351	-0.07182
YEAR6*	-0.06193	0.00999	-6.2	0	0.104364	-0.04235
YEAR7*	-0.14429	0.00876	-16.47	0	0.108634	-0.12712
YEAR8*	-0.16212	0.00846	-19.16	0	0.113378	-0.14554
YEAR9*	-0.17957	0.00811	-22.15	0	0.121442	-0.16368

Table C.12 Marginal Effects for the Unconditional Expected Value of the Dependent Variable

Y = E (oi*0<oi<0.989 (predict ys(0, 0.989839)) = 0.3872

Variable	dy/dx	Std. Dev.	z	P>z	X	Elasticities
RNFIAC	-0.00262	0.00007	-35.62	0	33.4187	-0.2260
POWNA	0.01199	0.01925	0.62	0.533	0.446888	0.0138
OFFI	4.70E-07	0	2.02	0.043	9877.99	0.0120
V468	0.12013	0.02903	4.14	0	0.787249	0.2442
PLIVDI	0.112335	0.02134	5.26	0	0.322472	0.0936
PCWKI	-0.75073	0.09268	-8.1	0	0.015712	-0.0305
M55AGE	0.000667	0.00094	0.71	0.478	64.5455	0.1111
TDTA	-0.12256	0.02396	-5.11	0	0.222642	-0.0705
PPASTA	-0.06742	0.02522	-2.67	0.008	0.329245	-0.0573
YEAR1*	-0.16319	0.0127	-12.85	0	0.074953	-0.0316
YEAR2*	-0.10898	0.01249	-8.72	0	0.079222	-0.0223
YEAR3*	-0.10307	0.01195	-8.62	0	0.083491	-0.0222
YEAR4*	-0.19989	0.0109	-18.33	0	0.088235	-0.0456
YEAR5*	-0.09708	0.01125	-8.63	0	0.095351	-0.0239
YEAR6*	-0.06468	0.01063	-6.08	0	0.104364	-0.0174
YEAR7*	-0.15526	0.00998	-15.55	0	0.108634	-0.0436
YEAR8*	-0.17581	0.00976	-18.02	0	0.113378	-0.0515
YEAR9*	-0.19616	0.00939	-20.88	0	0.121442	-0.0615

Appendix D - Effects of Total Debt on Technical Inefficiency

This section is a preliminary and exploratory study to characterize the main factors which affect technical inefficiency when the level of farm debt was accounted for as a non-discretionary factor to account for capital availability as a farm input; in this way, direct effect of the level of farms debt on efficiencies was measured. The efficiencies under study correspond to the farm efficiencies scores obtained through the non-discretionary or debt-constrained DEA model. The farm efficiencies in these models were calculated as in the same way the basic DEA model for the seven discretionary inputs; however, this model is modified by adding the constraint that the farms were compared only to corresponding farms with the same or less level of debt. The resulting debt-constrained model rendered farms efficiencies which were compared not only in terms of the discretionary inputs, but also in terms of their level of debt.

Technical, allocative, scale and overall efficiencies and inefficiencies for the sample farms were described in Section 5.2. In this section, a comparison between farm efficiencies scores before and after adjusting for farms' debt levels was also detailed.

According to the comparison of results in the just mentioned section (Table 5.4), it was noted that the difference farms efficiency scores differed according to the efficiency under study. Regarding technical and overall efficiency scores, the difference between them across models was zero or positive. Thus, if the difference was zero; it implied that the level of debt had no impact the efficiency of these farms. If the difference was more than zero; this suggested that the level of debt for these farms was positively influencing the farms efficiency scores. However, regarding allocative and scale efficiency scores and the difference between them across models, an additional alternative was found. A small percentage of the farms had a difference of scores for these efficiencies that was negative, meaning that for these farms, the level of debt had impacted their efficiencies but in a negative way. Thus, differential scores between the basic model and the debt-constrained model were zero or positive for the technical and overall efficiency of sampled farms. However, the differential scores were zero, positive or negative for allocative and scale efficiency of the sampled farms. In Appendix E, summary statistics for farms under these categories and their efficiency were reported. In total, there are 4 summary statistics for non-debt-constrained farms by efficiency, 4 summary statistics for positively constrained debt farms by efficiency, and 2 summary statistics for negatively constrained debt farms corresponding to allocative and scale efficiency of the farms.

In order to characterize farms that are debt-constrained from those that are not, further analysis was pursued. Based on the results of the previous farms statistics on the technical efficiency of the farms and the impact of the variables on each of them, the debt-constrained efficiency scores are divided into two groups: farms whose technical efficiency scores were not constrained (i.e. the level of debt did not impact the efficiency of these farms), and farms whose technical efficiency scores were constrained and adjusted for their level of debt (i.e. the level of debt did impact the efficiency of the farms). In the latter case, the efficiency scores derived from the basic model are different than the efficiency scores derived from the debt-constrained model. These two subsets of farms from the debt-constrained model, and the pooled sample of all farms (i.e. the scores of the debt-constrained model) were regressed against a vector of socio-economic characteristics using Panel data Tobit models to elicit the causes of inefficiencies in light of farms' capital availability. The following step consisted on comparing the coefficient estimates of the three Panel Tobit models to report differences, if any, of the impact of the selected farm characteristics. The econometric estimation of these models was a preliminary study since these models do not account for a possible sampling selection bias as the same sample is divided into two groups.

Table D.1 and Table D.2 provide a definition and summary statistics, respectively, of the variables used in these Panel Tobit models. Technical efficiencies and inefficiencies from the basic and the debt-constrained model are also reported. Additionally, summary statistics on the farm efficiencies in the debt-constrained model versus the non-constrained farms efficiencies are also listed. The factors considered to investigate which farms are prone to be debt-constrained and which may not where: 1. Farms output specialization: LIVDINCP, CROPINCP, CWINCP; 2. Financial ratios: TDTA, CDCA, ROA, BASSETS; 3. Other farm characteristics: RNFIAC, OFFIPG, and a time trend, YEAR.

Table D.1 Definitions for Variables used in Debt-Constrained and Panel Tobit Models

Variable	Definition
AI	Allocative Inefficiency, Basic Model
AICONS	Allocative Inefficiency for Farms Constrained by Debt Levels
AID	Allocative Inefficiency, Debt-Constrained Model
AINCONS	Allocative Inefficiency for Farms Non-Constrained by Debt Levels
BASSETS	Total Annual Assets
CDCA	Ratio of Short-term Debt to Short-term Assets
CROPINCP	Income from Crop operations per Gross Farm Income
CWINCP	Income from Custom Work Operations per Gross Farm Income
LIVDINCP	Income from Livestock Operations per Gross Farm Income
OI	Overall Inefficiency, Basic Model
OICONS	Overall Inefficiency for Farms Constrained by Debt Levels
OID	Overall Inefficiency, Debt-Constrained Model
OINCONS	Overall Inefficiency for Farms Non-Constrained by Debt Levels
OFFIPG	Off-farm Income per Gross Farm Income
RNFIAC	Gross Farm Income per Acre
ROA	Return on Assets, Ratio of Interest Cost plus Net Farm Income Divided by Total Assets
SI	Scale Inefficiency, Basic Model
SICONS	Scale Inefficiency for Farms Constrained by Debt Levels
SID	Scale Inefficiency, Debt-Constrained Model
SINCONS	Scale Inefficiency for Farms Non-Constrained by Debt Levels
TDTA	Ratio of Total Debt to Total Assets
TI	Technical Inefficiency, Basic Model
TICONS	Technical Inefficiency for Farms Constrained by Debt Levels
TID	Technical Inefficiency, Debt-Constrained Model
TINCONS	Technical Inefficiency for Farms Non-Constrained by Debt Levels
YEAR	Year from 88 to 107, 1988-2007

Table D.2 Summary Statistics for Variables Included in Debt-Constrained and Panel Tobit Models

Variable	Unit	Mean	Std. Dev.
BASSETS	$	1,010,649	790,855
CDCA	%	0.74	4.13
CROPINCP	%	0.53	0.26
CWINCP	%	0.01	0.03
LIVDINCP	%	0.28	0.29
MFIAC	$	33	79
OFFIPG	%	0.10	0.21
ROA	%	0.10	0.09
TDTA	%	0.28	0.23
TI	#	0.10	0.14
TICONS	#	0.20	0.12
TID	#	0.08	0.13
TINCONS	#	0.08	0.13
YEAR	#		

In this dissertation, the interest is to focus on technical efficiency and the impact of farms' debt levels on it; thus, in this section results to address this question are the goal and are the ones that are reported and compared. Table D.3 through Table D.6 report Tobit results where only the dependent variable varied: technical efficiency scores of constrained farms, technical efficiency scores of non-constrained farms, and technical efficiency scores of all farms in the sample (i.e. 456). Table D.3 reports the coefficients of the selected farm characteristics in the technical inefficiency of farms that were debt constrained. All coefficients are significant expect for BASSETS and ROA. All output measures decreased technical inefficiency, as expected. The largest coefficient, indicating a larger impact, was CWINCP. Indeed, TDTA, the ratio of total debt-to assets decreased technical inefficiency, but by a smaller magnitude. The positive influence of the long term leverage ratio on technical efficiency was supported by studies such as Bierlen and Featherstone (1998), Lambert and Bayda (2005), Davidova and Latruffe (2007). The effect was even smaller, but of the same sign (i.e. reducing technical inefficiency) for the variables RNFIAC and OFFIPG; indicating that larger farms are more technical efficient (even when constrained by their current/fixed level of debt), and that off-farm income could reduced technical inefficiencies, probably because of the extra money provided to the household. Over the years, the time trend indicated that technical inefficiency increased, this fact was not expected. Interestingly, the ratio of current debt-to current assets increased technical efficiency. Bayda (2003) reported not significant effects by this variable, and Featherstone and Al-Kheraiji(1995), Handley et al. (2001), Lambert and Bayda (2005), and Davidova and Latruffe (2007) reported a negative effect of short-term debt in technical efficiency.

The results for Technical Inefficiency model for the Non-Debt constrained farms in the Debt-constrained model is reported in Table D.4. All the variables in the model are significant except for CDCA. The results for the specialization variables was much smaller in magnitude in the preceding model when farms where debt-constrained. However, the sign and significance for all the specialization variables were the same in both models. Similarly, RNFIAC and OFFIPG decreased technical inefficiency. ROA and BASSETS both decreased technical inefficiency in this model. The magnitude of the coefficient of ROA is the highest in this model, indicating that it had the most impact on technical inefficiency scores. YEAR had a similar impact, and sign in

Table D.3 Relationship between Technical Inefficiency for Debt-Constrained Farms, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	-0.29**	0.13	-2.29	0.022
LIVDINCP	-0.33*	0.03	-12.27	0
CROPINCP	-0.35*	0.03	-11.95	0
CWINCP	-0.70*	0.18	-3.97	0
TDTA	-0.09*	0.04	-2.63	0.009
CDCA	3.79E-03***	0	1.79	0.074
RNFIAC	-1.28E-03*	0	-7.43	0
OFFIPG	-0.08*	0.02	-3.43	0.001
ROA	-0.10	0.08	-1.28	0.202
BASSETS	-5.19E-09	0	-0.6	0.546
YEAR	0.01*	0	6.21	0
N	878			
Log Likelihood Function	756.12*			
Wald Chi2 (10)	321.29			
Log L.R.T. Chibar2 (01) =	66.71*			

Note: * indicates significance at α = 0.01 level,** at α = 0.05 level and *** at α = 0.10 level

Table D.4 Relationship between Technical Inefficiency for Non-Debt Constrained Farms, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	-0.86*	0.14	-6.37	0
LIVDINCP	-0.68*	0.04	-19.35	0
CROPINCP	-0.63*	0.03	-18.63	0
CWINCP	-2.31*	0.20	-11.81	0
TDTA	0.23*	0.03	8.47	0
CDCA	-1.34E-03	0	-0.64	0.522
RNFIAC	-7.74E-05***	0	-1.63	0.103
OFFIPG	-0.08*	0.03	-2.68	0.007
ROA	-1.15*	0.06	-18.62	0
BASSETS	-1.76E-08**	0	-2.06	0.039
YEAR	0.01*	0	10.12	0
N	3680			
Log Likelihood Function	-615.69*			
Wald Chi2 (10)	889.02			
Log L.R.T. Chibar2 (01) =	795.67*			

Note: * indicates significance at α = 0.01 level, ** at α = 0.05 level and *** at α = 0.10 level

Table D.5 Relationship between Technical Inefficiency for Basic Model, Panel Tobit Model

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	-0.44*	0.10	-4.34	0
LIVDINCP	-0.57*	0.03	-20.85	0
CROPINCP	-0.56*	0.03	-21.72	0
CWINCP	-1.75	0.15	-11.99	0.238
TDTA	-0.03	0.02	-1.18	0.896
CDCA	-1.36E-04*	0	-0.13	0
RNFIAC	-1.67E-04*	0	-4.05	0.001
OFFIPG	-0.08*	0.02	-3.4	0
ROA	-1.02*	0.05	-21.77	0
BASSETS	-3.28E-08*	0	-4.29	0
YEAR	0.01*	0	10.12	0
N	4560			
Log Likelihood Function	-458.49*			
Wald Chi2 (10)	1204.01			
Log L.R.T. Chibar2 (01) =	1226.47*			

Note: * indicates significance at $\alpha = 0.01$ level

Table D.6 Relationship between Technical Inefficiency Debt-Constrained Model, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	-0.51*	0.11	-4.62	0
LIVDINCP	-0.63*	0.03	-21.12	0
CROPINCP	-0.60*	0.03	-21.18	0
CWINCP	-1.94*	0.16	-12.07	0
TDTA	0.13*	0.02	5.7	0
CDCA	-2.33E-04	0	-0.21	0.833
RNFIAC	-1.38E-04*	0	-2.8	0.005
OFFIPG	-0.08*	0.03	-3.23	0.001
ROA	-1.02*	0.05	-19.67	0
BASSETS	-2.72E-08*	0	-3.53	0
YEAR	0.01*	0	9.49	0
N	4560			
Log Likelihood Function	-660.09*			
Wald Chi2 (10)	1075.75			
Log L.R.T. Chibar2 (01) =	1095*			

Note: * indicates significance at $\alpha = 0.01$ level

this model as in the preceding one, indicating that in the case of non-debt constrained farms, technical inefficiency over the years was increasing. There are only two, put important differences between coefficients in these two models, the debt constrained farms in their level of technical inefficiency and the non-debt constrained farms model. The TDTA coefficient indicate that higher levels of TDTA increased the technical inefficiency of the farms. This finding did not coincide with the ones obtained in the technical inefficiency for the basic model; and it disagreed with the findings in the model for technical inefficiency for debt-constrained farms. The CDCA variable was insignificant in this model, implying that leverage does not impact farm production.

Results for the Technical Inefficiency Panel Tobit for all farms in the Debt-constrained model are reported in Table D.6. All variables were statistically significant except for CDCA. All variables decreased technical inefficiency scores except for the trend YEAR and the TDTA ratio. Both of these variables showed that an increase in them would increase the level of technical inefficiency.

In terms of sign and significance, the coefficients estimated in model reproduced in Table D.3, Table D.4 and Table D.6 were similar. Models in Table D.4 and in Table D.6 for the non-constrained debt farms and the pooled sample are the most similar: all variables are significant and when they increase their levels, the level of technical efficiency decreases; except for the trend variable and the leverage (TDTA) ratio, which both increased technical inefficiency scores as they increase. In both models CDCA was insignificant. The magnitude of the impact of the variables was similar in both models. The coefficients for CWINCP and RNFIAC were statistically smaller in the pooled model when compared to corresponding coefficients in the non-debt constrained farms model. Only the impact of TDTA was statistically smaller in the pooled model. A similar comparison between models in Table D.4 and Table D.3 suggest that, contrary to the preceding comparison, the coefficients for most of the variables in the pooled model were statistically larger than the ones reported in the farms' debt-constrained sample.

Results of the comparison of models with the three sub-set of technical efficiencies showed that coefficients for the selected variables were mostly significant and the same sign in the three models, however, the magnitude differed between them. In general, highest coefficients corresponded to the non debt-constrained farms, followed by the pooled sample farms; and the smallest variable impacts were reported in the debt-constrained farms model. Interestingly, the leverage ratio had a different sign for debt-constrained farms model and the other two models.

Table D.5 reports the results of the technical inefficiencies for the basic Panel Tobit model. In this model, the coefficients for CWINCP and TDTA are insignificant. The sign and significance of the coefficients in this model as compared to those in Table D.5 for the technical inefficiencies for the pooled Debt-constrained Panel Tobit were similar. However, TDTA was insignificant in the pooled debt-constrained efficiency model, whereas it was significant and positive for technical inefficiency in the basic technical inefficiency model. Thus, further conclusion can be reached on the characteristics of farms that are impacted by the of liquidity variable.

Table D.7 Definition of Variables used in Essay Two Tobit Models

Variable	Definition
AI	Allocative Inefficiency, Basic Model
AICONS	Allocative Inefficiency for Farms Constrained by Debt Levels
AID	Allocative Inefficiency, Debt-Constrained Model
AINCONS	Allocative Inefficiency for Farms Non-Constrained by Debt Levels
BASSETS	Total Annual Assets
CDCA	Ratio of Short-term Debt to Short-term Assets
CROPINCP	Income from Crop operations per Gross Farm Income
CWINCP	Income from Custom Work Operations per Gross Farm Income
LIVDINCP	Income from Livestock Operations per Gross Farm Income
OE	Overall Inefficiency, Basic Model
OECONS	Overall Inefficiency for Farms Constrained by Debt Levels
OED	Overall Inefficiency, Debt-Constrained Model
OENCONS	Overall Inefficiency for Farms Non-Constrained by Debt Levels
OFFIPG	Off-farm Income per Gross Farm Income
RNFIAC	Gross Farm Income per Acre
ROA	Return on Assets, Ratio of Interest Cost + Net Farm Income / Total Assets
SI	Scale Inefficiency, Basic Model
SICONS	Scale Inefficiency for Farms Constrained by Debt Levels
SID	Scale Inefficiency, Debt-Constrained Model
SINCONS	Scale Inefficiency for Farms Non-Constrained by Debt Levels
TDTA	Ratio of Total Debt to Total Assets
TI	Technical Inefficiency, Basic Model
TICONS	Technical Inefficiency for Farms Constrained by Debt Levels
TID	Technical Inefficiency, Debt-Constrained Model
TINCONS	Technical Inefficiency for Farms Non-Constrained by Debt Levels
YEAR	Year from 88 to 107, 1988-2007

Table D.8 Relationship between Allocative Inefficiency for Non-Debt Constrained Farms, Panel Tobit Model

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	-0.26*	0.09	-2.8	0.005
LIVDINCP	-0.24*	0.02	-10.34	0
CROPINCP	-0.24*	0.02	-10.79	0
CWINCP	-1.24*	0.11	-11.62	0
TDTA	0.09*	0.02	4.82	0
CDCA	4.73E-04	0	0.94	0.345
RNFIAC	-2E-04*	0	-5.38	0
OFFIPG	-0.04*	0.02	-2.71	0.007
ROA	-0.68*	0.04	-16.48	0
BASSETS	-1.64E-08	0	-2.9	0.004
YEAR	0.01*	0	7.23	0
N	2506			
Log Likelihood Function	924.33*			
Wald Chi2 (10)	662.93			
Log L.R.T. Chibar2 (01) =	365.78*			

Note: * indicates significance at $\alpha = 0.01$ level

Table D.9 Relationship Between Allocative Inefficiency for Debt-Constrained Farms, Panel Tobit Model

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	-0.19*	0.08	-2.49	0.013
LIVDINCP	-0.19*	0.02	-10.81	0
CROPINCP	-0.19*	0.02	-10.3	0
CWINCP	-0.56*	0.10	-5.92	0
TDTA	-0.04*	0.02	-1.91	0.056
CDCA	-3.82E-03*	0	-2.77	0.006
RNFIAC	-9.7E-04*	0	-11.53	0
OFFIPG	-0.02	0.02	-1.42	0.155
ROA	-0.05	0.04	-1.31	0.191
BASSETS	2.49E-08*	0	4.69	0
YEAR	0.01*	0	7.43	0
N	2052			
Log Likelihood Function	1895.67*			
Wald Chi2 (10)	475.06			
Log L.R.T. Chibar2 (01) =	233.22*			

Note: * indicates significance at α = 0.01 level

Table D.10 Relationship between Allocative Inefficiency Basic Model, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	-0.08	0.06	-1.31	0.19
LIVDINCP	-0.21*	0.02	-13.04	0
CROPINCP	-0.21*	0.01	-13.82	0
CWINCP	-0.98*	0.07	-13.32	0
TDTA	-0.02***	0.01	-1.69	0.09
CDCA	-7.69E-07	0	0	0.999
RNFIAC	-2.4E-04*	0	-9.03	0
OFFIPG	-0.03*	0.01	-2.58	0.01
ROA	-0.47*	0.03	-18.14	0
BASSETS	-1.17E-08*	0	-2.72	0.006
YEAR	0.01*	0	8.36	0
N	4560			
Log Likelihood Function	2593.18*			
Wald Chi2 (10)	1002.55			
Log L.R.T. Chibar2 (01) =	832.34*			

Note: * indicates significance at α = 0.01 level and *** at α = 0.10 level

Table D.11 Relationship between Allocative Inefficiency Debt-Constrained Model, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	-0.22*	0.07	-3.29	0.001
LIVDINCP	-0.25*	0.02	-14.25	0
CROPINCP	-0.27*	0.02	-16.12	0
CWINCP	-1.21*	0.08	-14.52	0
TDTA	0.09*	0.01	6.47	0
CDCA	3.56E-05	0	0.08	0.94
RNFIAC	-2.2E-04*	0	-7.76	0
OFFIPG	-0.03***	0.01	-1.88	0.06
ROA	-0.58*	0.03	-19.92	0
BASSETS	-1.83E-08*	0	-3.84	0
YEAR	0.01*	0	9.56	0
N	4560			
Log Likelihood Function	1818.84*			
Wald Chi2 (10)	1129.91			
Log L.R.T. Chibar2 (01) =	793.44*			

Note: * indicates significance at α = 0.01 level and *** at α = 0.10 level

Table D.12 Relationship between Scale Inefficiency for Non-Debt Constrained Farms, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.36*	0.07	4.99	0
LIVDINCP	-0.18*	0.02	-9.34	0
CROPINCP	-0.24*	0.02	-14.38	0
CWINCP	-0.74*	0.09	-8.34	0
TDTA	-0.02	0.02	-0.99	0.322
CDCA	2.24E-04	0	0.57	0.571
RNFIAC	-3.4E-05	0	-1.55	0.122
OFFIPG	0.18*	0.01	13.66	0
ROA	-0.44*	0.03	-13.54	0
BASSETS	-2.47E-08*	0	-4.66	0
YEAR	-4.5E-05	0	-0.06	0.951
N	2314			
Log Likelihood Function	1710.24*			
Wald Chi2 (10)	825.24			
Log L.R.T. Chibar2 (01) =	747.01*			

Note: * indicates significance at $\alpha = 0.01$ level

Table D.13 Relationship between Farms Scale Inefficiency for Debt-Constrained Farms, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.18*	0.07	2.66	0.008
LIVDINCP	-0.09*	0.02	-5.13	0
CROPINCP	-0.18*	0.02	-10.79	0
CWINCP	-0.30*	0.08	-3.51	0
TDTA	-0.12*	0.02	-6.18	0
CDCA	1.49E-03	0	1.63	0.103
RNFIAC	-5.3E-04*	0	-7.07	0
OFFIPG	0.16*	0.02	10.26	0
ROA	-0.09	0.03	-2.59	0.009
BASSETS	-3.51E-08*	0	-5.88	0
YEAR	1.38E-03**	0	1.98	0.047
N	2244			
Log Likelihood Function	2139.96*			
Wald Chi2 (10)	567.94			
Log L.R.T. Chibar2 (01) =	978.05*			

Note: * indicates significance at α = 0.01 level and ** at α = 0.05

Table D.14 Relationship between Scale Inefficiency Basic Model, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.35*	0.05	7.12	0.00
LIVDINCP	-0.13*	0.01	-9.47	0.00
CROPINCP	-0.22*	0.01	-18.01	0.00
CWINCP	-0.52*	0.06	-8.53	0.00
TDTA	-0.06*	0.01	-4.59	0.00
CDCA	5.18E-04	0	1.48	0.14
RNFIAC	-8.7E-05*	0	-4.14	0.00
OFFIPG	0.17*	0.01	16.29	0.00
ROA	-0.31*	0.02	-14.82	0.00
BASSETS	-2.63E-08*	0	-6.19	0.00
YEAR	-1.0E-04	0	-0.21	0.84
N	4560			
Log Likelihood Function	3871.75*			
Wald Chi2 (10)	1250.04			
Log L.R.T. Chibar2 (01) =	1906.17*			

Note: * indicates significance at $\alpha = 0.01$ level

Table D.15 Relationship between Scale Inefficiency Debt-Constrained Model, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.32*	0.05	6.13	0
LIVDINCP	-0.19*	0.01	-13.23	0
CROPINCP	-0.26*	0.01	-20.48	0
CWINCP	-0.70*	0.06	-10.8	0
TDTA	0.02***	0.01	1.68	0.092
CDCA	5.66E-04	0	1.54	0.124
RNFIAC	-7.7E-05*	0	-3.5	0
OFFIPG	0.17*	0.01	15.69	0
ROA	-0.36*	0.02	-16.23	0
BASSETS	-2.12E-08*	0	-5.01	0
YEAR	2.13E-04	0	0.4	0.686
N	4560			
Log Likelihood Function	3326.27*			
Wald Chi2 (10)	1358.03			
Log L.R.T. Chibar2 (01) =	1481.24*			

Note: * indicates significance at $\alpha = 0.01$ level and *** at $\alpha = 0.10$ level

Table D.16 Relationship between Overall Inefficiency for Non-Debt Constrained Farms, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.02	0.10	0.22	0.829
LIVDINCP	-0.52*	0.02	-21.16	0
CROPINCP	-0.54*	0.02	-24.13	0
CWINCP	-1.81*	0.11	-16.03	0
TDTA	-0.01	0.02	-0.42	0.677
CDCA	4.95E-04	0	0.91	0.365
RNFIAC	-1.71E-04*	0	-5.49	0
OFFIPG	0.09*	0.02	5.6	0
ROA	-1.09*	0.04	-26.4	0
BASSETS	-4.21E-08*	0	-6.79	0
YEAR	9.05E-03*	0	9.45	0
N	2557			
Log Likelihood Function	1148.66*			
Wald Chi2 (10)	1908.27			
Log L.R.T. Chibar2 (01) =	454.3*			

Note: * indicates significance at α = 0.01 level

Table D.17 Relationship between Overall Efficiency for Debt-Constrained Farms, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.03	0.09	0.34	0.735
LIVDINCP	-0.37*	0.02	-16.84	0
CROPINCP	-0.42*	0.02	-17.94	0
CWINCP	-1.37*	0.10	-13.66	0
TDTA	-0.23*	0.02	-10.4	0
CDCA	-6.3E-04	0	-0.53	0.598
RNFIAC	-1.73E-03*	0	-17.51	0
OFFIPG	0.07*	0.02	3.72	0
ROA	-0.26*	0.05	-5.7	0
BASSETS	-3.35E-08*	0	-5.78	0
YEAR	8.12E-03*	0	8.48	0
N	2001			
Log Likelihood Function	1483.48*			
Wald Chi2 (10)	1628.95			
Log L.R.T. Chibar2 (01) =	159.08*			

Note: * indicates significance at $\alpha = 0.01$ level

Table D.18 Relationship between Overall Inefficiency Basic Model, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.18*	0.07	2.73	0.006
LIVDINCP	-0.45*	0.02	-25.22	0
CROPINCP	-0.49*	0.02	-29.68	0
CWINCP	-1.60*	0.08	-19.86	0
TDTA	-0.08*	0.01	-5.27	0
CDCA	5.52E-04	0	1.13	0.257
RNFIAC	-2.9E-04*	0	-9.86	0
OFFIPG	0.09*	0.01	6.91	0
ROA	-0.90*	0.03	-31.42	0
BASSETS	-4.08E-08*	0	-8.42	0
YEAR	0.01*	0	10.47	0
N	4650			
Log Likelihood Function	2488.85*			
Wald Chi2 (10)	3072			
Log L.R.T. Chibar2 (01) =	837.9*			

Note: * indicates significance at α = 0.01 level

Table D.19 Relationship between Overall Inefficiency Debt-Constrained Model, Panel Tobit Analysis

Explanatory Variables	Coefficient	Standard Error	Z Statistic	P > Z
INTERCEPT	0.06	0.08	0.82	0.415
LIVDINCP	-0.51*	0.02	-25.89	0
CROPINCP	-0.56*	0.02	-30.32	0
CWINCP	-1.87*	0.09	-20.49	0
TDTA	0.12*	0.02	7.2	0
CDCA	6.18E-04	0	1.15	0.25
RNFIAC	-2.56E-04*	0	-7.92	0
OFFIPG	0.10*	0.01	6.92	0
ROA	-0.99*	0.03	-30.83	0
BASSETS	-3.61E-08*	0	-6.71	0
YEAR	0.01*	0	10.41	0
N	4650			
Log Likelihood Function	1743.90*			
Wald Chi2 (10)	2895.62			
Log L.R.T. Chibar2 (01) =	833.88*			

Note: * indicates significance at $\alpha = 0.01$ level

Appendix E - Definition of Variables and Results of DEA Models and Summary Statistics for Debt-Constrained Samples

Table E.1 Definition of Variables used for Summary Statistics of DEA Results

Variable	Definition
	General Farm Characteristics
ID	From 1 to 456
INTEXPR	Ratio of Interest Cost by Depreciation
M55AGE	Variable for Operators Older than 55 Years
MNFI	Real Net Farm Income
OFFI	Off-farm Income
RGFI	Real Gross Farm Income
RNFIAC	Real Net Farm Income per Acre
RVFP	Real Value of Farm Production
TDTA	Beginning Total Debt to Beginning Total Asset Ratio
TYPECROP	Dummy Variable for Farms with more than 80% of Income from Crops
TYPELIVE	Dummy Variable for Farms with more than 80% of Income from Livestock
TYPEMIX	Dummy Variable for Farms not in the Other Two Categories
V013	Operators Age
V468	Percent of Labor Costs Devoted to Crop Operations
YEAR	Year, from 98 to 107
	Inputs and Outputs, Units and Percents
CACRES	Total Acres Devoted to Crops
CAPITA	Capital Costs per Acre
CHEMICA	Chemical Costs per Acre
FERTILA	Fertilizer Cost per Acre
LABORA	Labor Costs per Acre
LAND	Total Operated Acres
LANDA	Land Costs per Acre
LIVESA	Livestock Costs per Acre
PCAPE	Percent of Short-term and Intermediate-term Capital

Table E.1 Continued

Variable	Definition
PCROPE	Percent of Crop Costs
PCROPI	Percent of Income from Crop Operations
PCWKI	Percent of Income from Custom Work
PLABORE	Percent of Labor Costs
PLANDE	Percent of Land Costs
PLIVDE	Percent of Livestock Costs
PLIVDI	Percent of Income from Livestock Operations
POWNA	Percent of Acres Owned
PPASTA	Percent of Acres Devoted to Pasture
SEEDA	Seed Costs per Acre
	Inefficiencies, Basic and Constrained Model
AE	Allocative Efficiency
AED	Allocative Efficiency Debt-Constrained Model
OE	Overall Efficiency
OED	Overall Efficiency Debt-Constrained Model
SE	Scale Efficiency
SED	Scale Efficiency Debt-Constrained Model
TE	Technical Efficiency
TED	Technical Efficiency Debt-Constrained Model
	Inefficiencies, Debt-Constrained and Non-Debt Constrained
AI	Allocative Inefficiency
AID	Allocative Inefficiency Debt-Constrained Model
OI	Overall Inefficiency
OID	Overall Inefficiency Debt-Constrained Model
SI	Scale Inefficiency
SID	Scale Inefficiency Debt-Constrained Model
TI	Technical Inefficiency
TID	Technical Inefficiency Debt-Constrained Model

Table E.1 Continued

Variable	Definition
	<u>Differential Efficiency Values for Basic and Debt-Constrained Model</u>
DAE	Difference between AE and AED
DOE	Difference between OE and OED
DSE	Difference between SE and SED
DTE	Difference between TE and TED
	<u>Non-Constrained and Constrained Farms by Efficiency</u>
AICONS	Allocative Efficiency Score for Constrained Farms in AE Scores
AINCONS	Allocative Efficiency Score for Non-Constrained Farms in AE Scores
OICONS	Overall Efficiency Score for Constrained Farms in OE Scores
OINCONS	Overall Efficiency Score for Non-Constrained Farms in OE Scores
SICONS	Scale Inefficiency Score for Constrained Farms in SE Scores
SINCONS	Scale Inefficiency Score for Non-Constrained Farms in SE Scores
TICONS	Technical Efficiency Score for Constrained Farms in TE Scores
TINCONS	Technical Efficiency Score for Non-Constrained Farms in TE Scores

Table E.2 Summary Statistic for Farms with No Change in Technical Efficiency Score

Variable	Obs.	Mean	Std. Dev.	Min	Max
		General Farm Characteristics			
YEAR	3,683			98	107
M55AGE	3,683	64	6	56	87
V013	3,683	55	11	21	87
TDTA	3,683	0.32	0.24	0	1.19
V468	3,683	0.78	0.23	0	1
RGFI	3,683	313,130	272,450	11,264	2,813,310
RVFP	3,683	285,790	238,784	9,109	2,672,675
RMFI	3,683	60,985	91,729	-287,988	966,614
OFFI	3,683	13,136	20,049	0	188,129
TYPECROP	3,683	0.43			
TYPELIVE	3,683	0.14			
TYPEMIX	3,683	0.43			
INTEXPR	3,683	0.13	0.08	0.01	1.50
RNFIAC	3,683	35	86	-3,991	627
		Inputs and Outputs, Units and Percents			
LAND	3,683	1,819	1,271	24	10,016
CACRES	3,683	1,191	856	0	9,472
PPASTA	3,683	0.30	0.25	0	1
POWNA	3,683	0.36	0.27	0	1
PLIVDI	3,683	0.33	0.32	0	1
PCWKI	3,683	0.02	0.04	0	0.41
PCROPI	3,683	0.65	0.32	0	1
PLABORE	3,683	0.22	0.09	0.03	0.69
CPAPE	3,683	0.38	0.08	0.13	0.72
PLANDE	3,683	0.10	0.06	0	0.67
PCROPE	3,683	0.21	0.10	0	0.58
PLIVDE	3,683	0.09	0.12	0	0.61
LANDA	3,683	17	10	0	64
CAPITA	3,683	75	78	6	3,239
CHEMICA	3,683	10	9	0	175
FERTILA	3,683	17	15	0	448
SEEDA	3,683	12	14	0	542
LIVESA	3,683	26	82	0	2,704
LABORA	3,683	43	53	5	2,397

Table E.2 Continued

Variable	Obs.	Mean	Std. Dev.	Min	Max
		Efficiencies, Basic and Constrained Model			
TE	3,683	0.92	0.13	0.31	1
TED	3,683	0.92	0.13	0.31	1
AE	3,683	0.81	0.13	0.17	1
AED	3,683	0.83	0.13	0.26	1
SE	3,683	0.87	0.15	0.06	1
SED	3,683	0.88	0.14	0.04	1
OE	3,683	0.65	0.20	0.01	1
OED	3,683	0.68	0.21	0.01	1
		Inefficiencies, Basic and Constrained Model			
TI	3,683	0.08	0.13	0	0.69
OI	3,683	0.35	0.20	0	0.99
AI	3,683	0.19	0.13	0	0.83
SI	3,683	0.13	0.15	0	0.94
TID	3,683	0.08	0.13	0	0.69
AID	3,683	0.17	0.13	0	0.74
SID	3,683	0.12	0.14	0	0.96
OID	3,683	0.32	0.21	0	0.99
		Differential Efficiency Values for Debt-Constrained Model			
DTE	3,683	0	0	0	0
DAE	3,683	-0.02	0.06	-0.60	0
DSE	3,683	-0.01	0.05	-0.56	0.36
DOE	3,683	-0.03	0.08	-0.64	0
		Constrained Farms but not by Efficiency			
AINCONS	2,506	0.18	0.14	0	0.69
AICONS	1,176	0.22	0.13	0	0.83
TICONS	0				
TINCONS	3,683	0.08	0.13	0	0.69
SICONS	1,437	0.14	0.15	0	0.94
SINCONS	2,245	0.12	0.15	0	0.82
OICONS	1,241	0.32	0.18	0	0.86
OINCONS	2,441	0.36	0.20	0	0.99

Table E.3 Summary Statistics for Farms with Positive Change in Technical Efficiency

Variable	Obs.	Mean	Std. Dev.	Min	Max
		General Farm Characteristics			
YEAR	877			98	107
M55AGE	877	65	6	56	83
V013	877	56	11	26	83
TDTA	877	0.11	0.13	0	0.89
V468	877	0.80	0.19	0.19	1
RGFI	877	258,248	178,235	12,552	1,759,560
RVFP	877	243,012	161,532	11,757	1,558,810
RMFI	877	48,751	63,132	-121,976	423,565
OFFI	877	12,364	18,896	0	111,986
TYPECROP	877	0.45			
TYPELIVE	877	0.06			
TYPEMIX	877	0.49			
INTEXPR	877	0.14	0.07	0.04	1.09
RNFIAC	877	27	34	-93	182
		Inputs and Outputs, Units and Percents			
LAND	877	1,751	849	310	6,472
CACRES	877	1,168	631	182	5,109
PPASTA	877	0.31	0.22	0	0.91
POWNA	877	0.32	0.27	0	1
PLIVDI	877	0.28	0.26	0	1
PCWKI	877	0.01	0.03	0	0.21
PCROPI	877	0.71	0.26	0	1
PLABORE	877	0.22	0.08	0.08	0.51
CPAPE	877	0.38	0.07	0.2	0.61
PLANDE	877	0.11	0.05	0	0.39
PCROPE	877	0.23	0.08	0.04	0.54
PLIVDE	877	0.06	0.08	0	0.46
LANDA	877	17	9	0	52
CAPITA	877	65	28	15	258
CHEMICA	877	11	7	0	52
FERTILA	877	17	10	0	92
SEEDA	877	12	9	0	67
LIVESA	877	12	28	0	327
LABORA	877	37	20	6	154

Table E.3 Continued

Variable	Obs.	Mean	Std. Dev.	Min	Max
		Efficiencies, Basic and Constrained Model			
TE	877	0.80	0.12	0.35	0.99
TED	877	0.89	0.12	0.36	1
AE	877	0.77	0.10	0.39	1
AED	877	0.79	0.12	0.36	1
SE	877	0.87	0.13	0.23	1
SED	877	0.90	0.11	0.17	1
OE	877	0.54	0.14	0.07	1
OED	877	0.64	0.16	0.07	1
		Inefficiencies, Basic and Constrained Model			
TI	877	0.20	0.12	0.01	0.65
OI	877	0.46	0.14	0.10	0.93
AI	877	0.23	0.10	0.01	0.61
SI	877	0.13	0.13	0	0.77
TID	877	0.11	0.12	0	0.64
AID	877	0.21	0.12	0	0.64
SID	877	0.10	0.11	0	0.83
OID	877	0.36	0.16	0	0.93
		Differential Efficiency Values for Debt-Constrained Model			
DTE	877	-0.09	0.09	-0.48	-0.01
DAE	877	-0.02	0.09	-0.49	0.27
DSE	877	-0.03	0.09	-0.47	0.45
DOE	877	-0.09	0.11	-0.61	0
		Constrained Farms but not by Efficiency			
AINCONS	0				
AICONS	877	0.23	0.10	0.01	0.61
TICONS	877	0.20	0.12	0.01	0.65
TINCONS	0				
SICONS	808	0.13	0.13	0	0.77
SINCONS	69	0.12	0.13	0	0.53
OICONS	760	0.45	0.13	0.10	0.89
OINCONS	117	0.48	0.14	0.20	0.93

Table E.4 Summary Statistics for Farms with No Change in Allocative Efficiency Scores

Variable	Obs.	Mean	Std. Dev.	Min	Max
			General Farm Characteristics		
YEAR	2,506			98	107
M55AGE	2,506	64	6	56	87
V013	2,506	54	10	26	87
TDTA	2,506	0.39	0.22	0.00	1.19
V468	2,506	0.77	0.23	0.00	1.00
RGFI	2,506	331,269	295,738	11,264	2,813,310
RVFP	2,506	300,025	256,554	9,109	2,672,675
RMFI	2,506	59,900	98,271	-287,988	966,614
OFFI	2,506	13,947	20,717	0	188,129
TYPECROP	2,506	0.42			
TYPELIVE	2,506	0.15			
TYPEMIX	2,506	0.43			
INTEXPR	2,506	0.13	0.08	0.01	1.50
RNFIAC	2,506	33	100	-3,991	627
			Inputs and Outputs, Units and Percents		
LAND	2,506	1,848	1,314	24	10,016
CACRES	2,506	1,208	878	0	9,472
PPASTA	2,506	0.31	0.25	0	1
POWNA	2,506	0.37	0.26	0	1
PLIVDI	2,506	0.34	0.32	0	1
PCWKI	2,506	0.02	0.05	0	0.41
PCROPI	2,506	0.64	0.32	0	1
PLABORE	2,506	0.21	0.08	0.04	0.66
CPAPE	2,506	0.38	0.08	0.13	0.72
PLANDE	2,506	0.10	0.06	0	0.67
PCROPE	2,506	0.21	0.10	0	0.58
PLIVDE	2,506	0.10	0.12	0	0.57
LANDA	2,506	17	9	0	59
CAPITA	2,506	77	90	6	3,239
CHEMICA	2,506	11	9	0	175
FERTILA	2,506	18	15	0	448
SEEDA	2,506	12	15	0	542
LIVESA	2,506	30	92	0	2,704
LABORA	2,506	43	60	5	2,397

Table E.4 Continued

Variable	Obs.	Mean	Std. Dev.	Min	Max
		Efficiencies, Basic and Constrained Model			
TE	2,506	0.90	0.14	0.34	1
TED	2,506	0.90	0.14	0.34	1
AE	2,506	0.82	0.14	0.31	1
AED	2,506	0.82	0.14	0.31	1
SE	2,506	0.87	0.15	0.18	1
SED	2,506	0.88	0.15	0.18	1
OE	2,506	0.65	0.21	0.09	1
OED	2,506	0.66	0.21	0.09	1
		Inefficiencies, Basic and Constrained Model			
TI	2,506	0.10	0.14	0	0.66
OI	2,506	0.35	0.21	0	0.91
AI	2,506	0.18	0.14	0	0.69
SI	2,506	0.13	0.15	0	0.82
TID	2,506	0.10	0.14	0	0.66
AID	2,506	0.18	0.14	0	0.69
SID	2,506	0.12	0.15	0	0.82
OID	2,506	0.34	0.21	0	0.91
		Differential Efficiency Values for Debt-Constrained Model			
DTE	2,506	0	0	0	0
DAE	2,506	0	0	0	0
DSE	2,506	-5E-03	0.03	-0.46	0
DOE	2,506	-5E-03	0.03	-0.46	0
		Constrained Farms but not by Efficiency			
AINCONS	2,506	0.18	0.14	0	0.69
AICONS	0				
TICONS	0				
TINCONS	2,506	0.10	0.14	0	0.66
SICONS	261	0.17	0.17	0	0.68
SINCONS	2,245	0.12	0.15	0	0.82
OICONS	261	0.29	0.21	0	0.78
OINCONS	2,245	0.35	0.21	0	0.91

Table E.5 Summary Statistics for Farms with Negative Change in Allocative Efficiency

Variable	Obs.	Mean	Std. Dev.	Min	Max
		General Farm Characteristics			
YEAR	464			98	107
M55AGE	464	65	6	56	83
V013	464	55	11	26	83
TDTA	464	0.13	0.13	0	0.89
V468	464	0.80	0.18	0.21	1
RGFI	464	250,716	180,265	12,552	1,759,560
RVFP	464	235,140	160,670	11,757	1,558,810
RMFI	464	40,204	56,226	-121,976	338,674
OFFI	464	13,664	19,823	0	107,103
TYPECROP	464	0.43			
TYPELIVE	464	0.06			
TYPEMIX	464	0.51			
INTEXPR	464	0.14	0.08	0.04	1.09
RNFIAC	464	24	35	-93	289
		Inputs and Outputs, Units and Percents			
LAND	464	1,744	837	296	,472
CACRES	464	1,163	603	182	4,240
PPASTA	464	0.31	0.22	0	0.86
POWNA	464	0.31	0.26	0	1
PLIVDI	464	0.29	0.26	0	1
PCWKI	464	0.01	0.03	0	0.21
PCROPI	464	0.70	0.26	0	1
PLABORE	464	0.21	0.07	0.08	0.5
CPAPE	464	0.38	0.06	0.21	0.58
PLANDE	464	0.11	0.05	0	0.39
PCROPE	464	0.23	0.08	0.05	0.54
PLIVDE	464	0.06	0.08	0	0.4
LANDA	464	17	9	0	51
CAPITA	464	65	28	15	258
CHEMICA	464	11	8	0	52
FERTILA	464	17	11	1	92
SEEDA	464	12	10	0	67
LIVESA	464	12	26	0	287
LABORA	464	36	20	6	187

Table E.5 Continued

Variable	Obs.	Mean	Std. Dev.	Min	Max
		Efficiencies, Basic and Constrained Model			
TE	464	0.78	0.13	0.35	1
TED	464	0.87	0.13	0.36	1
AE	464	0.78	0.10	0.39	1
AED	464	0.74	0.11	0.36	1
SE	464	0.86	0.14	0.23	1
SED	464	0.89	0.12	0.17	1
OE	464	0.53	0.14	0.07	1
OED	464	0.58	0.14	0.07	1
		Inefficiencies, Basic and Constrained Model			
TI	464	0.22	0.13	0	0.65
OI	464	0.47	0.14	0.15	0.93
AI	464	0.22	0.10	0	0.61
SI	464	0.14	0.14	0	0.77
TID	464	0.13	0.13	0	0.64
AID	464	0.26	0.11	0	0.64
SID	464	0.11	0.12	0	0.83
OID	464	0.42	0.14	0	0.93
		Differential Efficiency Values for Debt-Constrained Model			
DTE	464	-0.09	0.09	-0.48	0
DAE	464	0.04	0.04	0	0.27
DSE	464	-0.03	0.07	-0.40	0.14
DOE	464	-0.05	0.07	-0.38	0
		Constrained Farms but not by Efficiency			
AINCONS	0				
AICONS	464	0.22	0.10	0	0.61
TICONS	463	0.22	0.13	0.01	0.65
TINCONS	1	0	0	0	0
SICONS	395	0.14	0.14	0	0.77
SINCONS	69	0.12	0.13	0	0.53
OICONS	358	0.47	0.14	0.15	0.89
OINCONS	106	0.48	0.14	0.20	0.93

Table E.6 Summary Statistics for Farms with Positive Change in Allocative Efficiency

Variable	Obs.	Mean	Std. Dev.	Min	Max
			General Farm Characteristics		
YEAR	1,590			98	107
M55AGE	1,590	66	7	56	87
V013	1,590	56	11	21	87
TDTA	1,590	0.15	0.17	0	1.07
V468	1,590	0.79	0.22	0	1
RGFI	1,590	272,684	201,380	24,929	1,404,635
RVFP	1,590	254,757	185,031	24,120	1,371,337
RMFI	1,590	62,116	74,261	-238,608	590,478
OFFI	1,590	11,286	18,243	0	145,603
TYPECROP	1,590	0.46			
TYPELIVE	1,590	0.10			
TYPEMIX	1,590	0.45			
INTEXPR	1,590	0.13	0.07	0.02	1.36
RNFIAC	1,590	37	42	-201	349
			Inputs and Outputs, Units and Percents		
LAND	1,590	1,757	1,101	137	9,548
CACRES	1,590	1,161	773	0	6,148
PPASTA	1,590	0.31	0.24	0	1
POWNA	1,590	0.34	0.28	0	1
PLIVDI	1,590	0.30	0.30	0	1
PCWKI	1,590	0.02	0.04	0	0.28
PCROPI	1,590	0.68	0.30	0	1
PLABORE	1,590	0.23	0.10	0.03	0.69
CPAPE	1,590	0.38	0.08	0.17	0.63
PLANDE	1,590	0.11	0.06	0	0.34
PCROPE	1,590	0.21	0.09	0.01	0.52
PLIVDE	1,590	0.07	0.11	0	0.61
LANDA	1,590	17	10	0	64
CAPITA	1,590	68	37	9	361
CHEMICA	1,590	10	9	0	70
FERTILA	1,590	17	12	0	119
SEEDA	1,590	11	10	0	110
LIVESA	1,590	17	46	0	550
LABORA	1,590	42	30	5	330

Table E.6 Continued

Variable	Obs.	Mean	Std. Dev.	Min	Max
		Efficiencies, Basic and Constrained Model			
TE	1,590	0.93	0.11	0.31	1
TED	1,590	0.95	0.10	0.31	1
AE	1,590	0.78	0.12	0.17	1
AED	1,590	0.85	0.13	0.26	1
SE	1,590	0.87	0.14	0.06	1
SED	1,590	0.90	0.13	0.04	1
OE	1,590	0.63	0.17	0.01	1
OED	1,590	0.73	0.18	0.01	1
		Inefficiencies, Basic and Constrained Model			
TI	1,590	0.07	0.11	0	0.69
OI	1,590	0.37	0.17	0.01	0.99
AI	1,590	0.22	0.12	0	0.83
SI	1,590	0.13	0.14	0	0.94
TID	1,590	0.05	0.10	0	0.69
AID	1,590	0.15	0.13	0	0.74
SID	1,590	0.10	0.13	0	0.96
OID	1,590	0.27	0.18	0	0.99
		Differential Efficiency Values for Debt-Constrained Model			
DTE	1,590	-0.02	0.06	-0.42	0.28
DAE	1,590	-0.07	0.09	-0.60	0
DSE	1,590	-0.02	0.09	-0.56	0.45
DOE	1,590	-0.10	0.12	-0.64	0
		Constrained Farms but not by Efficiency			
AINCONS	0				
AICONS	1,590	0.22	0.12	0	0.83
TICONS	415	0.17	0.11	0	0.61
TINCONS	1,175	0.03	0.09	0	0.69
SICONS	1,590	0.13	0.14	0	0.94
SINCONS	0				
OICONS	1,383	0.36	0.16	0.01	0.86
OINCONS	207	0.39	0.18	0.03	0.99

Table E.7 Summary Statistics for Farms for No Change in Scale Efficiency

Variable	Obs.	Mean	Std. Dev.	Min	Max
		General Farm Characteristics			
YEAR	2,314			98	107
M55AGE	2,314	63	6	56	86
V013	2,314	54	10	26	86
TDTA	2,314	0.41	0.22	0	1.19
V468	2,314	0.77	0.23	0	1
RGFI	2,314	328,828	287,114	11,264	2,813,310
RVFP	2,314	297,513	248,236	9,109	2,672,675
RMFI	2,314	56,302	94,157	-287,988	966,614
OFFI	2,314	14,184	20,951	0	188,129
TYPECROP	2,314	0.42			
TYPELIVE	2,314	0.15			
TYPEMIX	2,314	0.43			
INTEXPR	2,314	0.13	0.07	0.01	1.50
RNFIAC	2,314	31	102	-3,991	627
		Inputs and Outputs, Units and Percents			
LAND	2,314	1,834	1,214	24	10,016
CACRES	2,314	1,201	825	17	9,472
PPASTA	2,314	0.30	0.24	0	0.97
POWNA	2,314	0.37	0.26	0	1
PLIVDI	2,314	0.34	0.32	0	1
PCWKI	2,314	0.02	0.04	0	0.41
PCROPI	2,314	0.64	0.32	0	1
PLABORE	2,314	0.21	0.08	0.04	0.58
CPAPE	2,314	0.38	0.08	0.13	0.72
PLANDE	2,314	0.10	0.06	0	0.67
PCROPE	2,314	0.22	0.10	0	0.55
PLIVDE	2,314	0.10	0.12	0	0.57
LANDA	2,314	17	9	0	59
CAPITA	2,314	78	91	6	3,239
CHEMICA	2,314	11	9	0	175
FERTILA	2,314	18	15	0	448
SEEDA	2,314	12	15	0	542
LIVESA	2,314	30	93	0	2,704
LABORA	2,314	43	61	5	2,397

Table E.7 Continued

Variable	Obs.	Mean	Std. Dev.	Min	Max
		Efficiencies, Basic and Constrained Model			
TE	2,314	0.89	0.14	0.34	1
TED	2,314	0.89	0.14	0.34	1
AE	2,314	0.81	0.13	0.31	1
AED	2,314	0.81	0.13	0.31	1
SE	2,314	0.88	0.15	0.18	1
SED	2,314	0.88	0.15	0.18	1
OE	2,314	0.64	0.21	0.09	1
OED	2,314	0.64	0.21	0.09	1
		Inefficiencies, Basic and Constrained Model			
TI	2,314	0.11	0.14	0	0.66
OI	2,314	0.36	0.21	0	0.91
AI	2,314	0.19	0.13	0	0.69
SI	2,314	0.12	0.15	0	0.82
TID	2,314	0.11	0.14	0	0.66
AID	2,314	0.19	0.13	0	0.69
SID	2,314	0.12	0.15	0	0.82
OID	2,314	0.36	0.21	0	0.91
		Differential Efficiency Values for Debt-Constrained Model			
DTE	2,314	-8E-04	0.01	-0.15	0
DAE	2,314	7E-04	0.01	0	0.12
DSE	2,314	0	0	0	0
DOE	2,314	0	0	0	0
		Constrained Farms but not by Efficiency			
AINCONS	2,245	0.19	0.13	0	0.69
AICONS	69	0.26	0.11	0.08	0.61
TICONS	69	0.20	0.12	0.01	0.50
TINCONS	2,245	0.10	0.14	0	0.66
SICONS	0				
SINCONS	2,314	0.12	0.15	0	0.82
OICONS	0				
OINCONS	2,314	0.36	0.21	0	0.91

Table E.8 Summary Statistics for Farms with a Positive Change in Scale Efficiency

Variable	Obs.	Mean	Std. Dev.	Min	Max
		General Farm Characteristics			
YEAR	1,435			98	107
M55AGE	1,435	66	7	56	87
V013	1,435	57	11	21	87
TDTA	1,435	0.13	0.16	0	1.07
V468	1,435	0.79	0.21	0	1
RGFI	1,435	262,910	223,939	12,552	1,759,560
RVFP	1,435	245,404	204,068	11,757	1,558,810
RMFI	1,435	60,925	81,530	-238,608	887,884
OFFI	1,435	11,100	17,733	0	116,255
TYPECROP	1,435	0.42			
TYPELIVE	1,435	0.10			
TYPEMIX	1,435	0.48			
INTEXPR	1,435	0.14	0.09	0.03	1.36
RNFIAC	1,435	35	43	-125	312
		Inputs and Outputs, Units and Percents			
LAND	1,435	1,744	1,215	137	9,573
CACRES	1,435	1,132	839	0	6,373
PPASTA	1,435	0.32	0.25	0	1
POWNA	1,435	0.35	0.29	0	1
PLIVDI	1,435	0.32	0.30	0	1
PCWKI	1,435	0.02	0.04	0	0.34
PCROPI	1,435	0.66	0.30	0	1
PLABORE	1,435	0.24	0.10	0.06	0.69
CPAPE	1,435	0.38	0.08	0.16	0.61
PLANDE	1,435	0.10	0.06	0	0.39
PCROPE	1,435	0.21	0.09	0.01	0.58
PLIVDE	1,435	0.07	0.10	0	0.61
LANDA	1,435	16	10	0	54
CAPITA	1,435	66	41	13	978
CHEMICA	1,435	10	8	0	53
FERTILA	1,435	16	12	0	117
SEEDA	1,435	11	10	0	84
LIVESA	1,435	16	46	0	920
LABORA	1,435	42	29	5	303

Table E.8 Continued

Variable	Obs.	Mean	Std. Dev.	Min	Max
		Efficiencies, Basic and Constrained Model			
TE	1,435	0.91	0.13	0.35	1
TED	1,435	0.95	0.11	0.36	1
AE	1,435	0.80	0.13	0.27	1
AED	1,435	0.85	0.14	0.36	1
SE	1,435	0.85	0.15	0.23	1
SED	1,435	0.91	0.12	0.27	1
OE	1,435	0.62	0.18	0.11	1
OED	1,435	0.73	0.19	0.18	1
		Inefficiencies, Basic and Constrained Model			
TI	1,435	0.09	0.13	0	0.65
OI	1,435	0.38	0.18	0	0.89
AI	1,435	0.20	0.13	0	0.73
SI	1,435	0.15	0.15	0	0.77
TID	1,435	0.05	0.11	0	0.64
AID	1,435	0.15	0.14	0	0.64
SID	1,435	0.09	0.12	0	0.73
OID	1,435	0.27	0.19	0	0.82
		Differential Efficiency Values for Debt-Constrained Model			
DTE	1,435	-0.04	0.07	-0.48	0
DAE	1,435	-0.04	0.09	-0.45	0.27
DSE	1,435	-0.06	0.08	-0.56	0
DOE	1,435	-0.11	0.12	-0.64	0
		Constrained Farms but not by Efficiency			
AINCONS	261	0.11	0.14	0	0.58
AICONS	1,174	0.22	0.12	0	0.73
TICONS	514	0.20	0.12	0	0.65
TINCONS	921	0.03	0.09	0	0.55
SICONS	1,435	0.15	0.15	0	0.77
SINCONS	0				
OICONS	1,435	0.38	0.18	0	0.89
OINCONS	0				

Table E.9 Summary Statistics for Farms with Negative Change in Scale Efficiency

Variable	Obs.	Mean	Std. Dev.	Min	Max
		General Farm Characteristics			
YEAR	811			98	107
M55AGE	811	65	6	56	84
V013	811	55	11	27	84
TDTA	811	0.19	0.18	0	1.03
V468	811	0.80	0.21	0.05	1
RGFI	811	298,245	213,304	27,999	1,404,635
RVFP	811	277,966	190,864	26,141	1,371,337
RMFI	811	61,428	74,818	-212,036	571,863
OFFI	811	12,929	19,830	0	145,603
TYPECROP	811	0.50			
TYPELIVE	811	0.09			
TYPEMIX	811	0.41			
INTEXPR	811	0.12	0.06	0.02	0.65
RNFIAC	811	35	42	-201	349
		Inputs and Outputs, Units and Percents			
LAND	811	1,834	1,138	147	9,548
CACRES	811	1,242	751	40	6,148
PPASTA	811	0.28	0.23	0	0.97
POWNA	811	0.31	0.26	0	1
PLIVDI	811	0.27	0.29	0	1
PCWKI	811	0.02	0.04	0	0.26
PCROPI	811	0.71	0.29	0	1
PLABORE	811	0.22	0.09	0.03	0.57
CPAPE	811	0.38	0.07	0.2	0.63
PLANDE	811	0.11	0.06	0	0.3
PCROPE	811	0.23	0.09	0.02	0.48
PLIVDE	811	0.07	0.11	0	0.56
LANDA	811	18	10	0	64
CAPITA	811	70	39	9	361
CHEMICA	811	12	9	0	70
FERTILA	811	18	13	0	119
SEEDA	811	12	11	0	110
LIVESA	811	18	48	0	530
LABORA	811	40	29	5	330

Table E.9 Continued

	Variable	Obs.	Mean	Std. Dev.	Min
			Efficiencies, Basic and Constrained Model		
TE	811	0.91	0.13	0.31	1
TED	811	0.93	0.11	0.31	1
AE	811	0.77	0.11	0.17	1
AED	811	0.82	0.12	0.26	1
SE	811	0.90	0.13	0.06	1
SED	811	0.87	0.13	0.04	1
OE	811	0.63	0.16	0.01	1
OED	811	0.67	0.17	0.01	1
			Inefficiencies, Basic and Constrained Model		
TI	811	0.09	0.13	0	0.69
OI	811	0.37	0.16	0	0.99
AI	811	0.23	0.11	0	0.83
SI	811	0.10	0.13	0	0.94
TID	811	0.07	0.11	0	0.69
AID	811	0.18	0.12	0	0.74
SID	811	0.13	0.13	0	0.96
OID	811	0.33	0.17	0	0.99
			Differential Efficiency Values for Debt-Constrained Model		
DTE	811	-0.03	0.06	-0.46	0.28
DAE	811	-0.05	0.09	-0.60	0.22
DSE	811	0.03	0.05	0.00	0.45
DOE	811	-0.04	0.07	-0.43	0
			Constrained Farms but not by Efficiency		
AINCONS	0				
AICONS	811	0.23	0.11	0	0.83
TICONS	295	0.19	0.12	0	0.60
TINCONS	516	0.04	0.09	0	0.69
SICONS	811	0.10	0.13	0	0.94
SINCONS	0				
OICONS	567	0.35	0.14	0	0.86
OINCONS	244	0.40	0.18	0	0.99

Table E.10 Summary Statistics for Farms with Positive Change in Overall Efficiency

Variable	Obs.	Mean	Std. Dev.	Min	Max
		General Farm Characteristics			
YEAR	2,002			98	107
M55AGE	2,002	66	7	56	87
V013	2,002	57	11	21	87
TDTA	2,002	0.14	0.16	0	1.07
V468	2,002	0.79	0.21	0	1
RGFI	2,002	277,553	221,373	12,552	1,759,560
RVFP	2,002	259,184	201,004	11,757	1,558,810
RMFI	2,002	62,843	80,492	-238,608	887,884
OFFI	2,002	11,194	17,931	0	116,255
TYPECROP	2,002	0.44			
TYPELIVE	2,002	0.09			
TYPEMIX	2,002	0.46			
INTEXPR	2,002	0.13	0.08	0.03	1.36
RNFIAC	2,002	36	42	-125	312
		Inputs and Outputs, Units and Percents			
LAND	2,002	1,798	1,206	137	9,573
CACRES	2,002	1,181	822	0	6,373
PPASTA	2,002	0.31	0.24	0	1
POWNA	2,002	0.34	0.28	0	1
PLIVDI	2,002	0.30	0.30	0	1
PCWKI	2,002	0.02	0.04	0	0.34
PCROPI	2,002	0.68	0.29	0	1
PLABORE	2,002	0.23	0.09	0.03	0.69
CPAPE	2,002	0.38	0.08	0.16	0.61
PLANDE	2,002	0.11	0.06	0	0.39
PCROPE	2,002	0.21	0.09	0.01	0.58
PLIVDE	2,002	0.07	0.10	0	0.61
LANDA	2,002	17	10	0	64
CAPITA	2,002	67	40	9	978
CHEMICA	2,002	10	8	0	70
FERTILA	2,002	17	12	0	119
SEEDA	2,002	11	10	0	110
LIVESA	2,002	16	46	0	920
LABORA	2,002	41	28	5	303

Table E.10 Continued

Variable	Obs.	Mean	Std. Dev.	Min	Max
		Efficiencies, Basic and Constrained Model			
TE	2,002	0.91	0.13	0.31	1
TED	2,002	0.95	0.11	0.31	1
AE	2,002	0.79	0.12	0.27	1
AED	2,002	0.84	0.13	0.36	1
SE	2,002	0.87	0.14	0.23	1
SED	2,002	0.90	0.12	0.27	1
OE	2,002	0.63	0.17	0.11	1
OED	2,002	0.72	0.18	0.14	1
		Inefficiencies, Basic and Constrained Model			
TI	2,002	0.09	0.13	0	0.69
OI	2,002	0.37	0.17	0	0.89
AI	2,002	0.21	0.12	0	0.73
SI	2,002	0.13	0.14	0	0.77
TID	2,002	0.05	0.11	0	0.69
AID	2,002	0.16	0.13	0	0.64
SID	2,002	0.10	0.12	0	0.73
OID	2,002	0.28	0.18	0	0.86
		Differential Efficiency Values for Debt-Constrained Model			
DTE	2,002	-0.04	0.07	-0.48	0.28
DAE	2,002	-0.05	0.09	-0.60	0.27
DSE	2,002	-0.03	0.09	-0.56	0.45
DOE	2,002	-0.10	0.11	-0.64	0
		Constrained Farms but not by Efficiency			
AINCONS	261	0.11	0.14	0	0.58
AICONS	1,741	0.22	0.11	0	0.73
TICONS	761	0.19	0.12	0	0.65
TINCONS	1,241	0.03	0.09	0	0.69
SICONS	2,002	0.13	0.14	0	0.77
SINCONS	0				
OICONS	2,002	0.37	0.17	0	0.89
OINCONS	0				

Table E.11 Summary Statistics for Farms with No Change in Overall Efficiency

Variable	Obs.	Mean	Std. Dev.	Min	Max
		General Farm Characteristics			
YEAR	2,558			98	107
M55AGE	2,558	63	6	56	86
V013	2,558	54	10	26	86
TDTA	2,558	0.39	0.22	0	1.19
V468	2,558	0.77	0.23	0	1
RGFI	2,558	322,283	281,761	11,264	2,813,310
RVFP	2,558	292,081	243,892	9,109	2,672,675
RMFI	2,558	55,401	91,850	-287,988	966,614
OFFI	2,558	14,396	21,098	0	188,129
TYPECROP	2,558	0.43			
TYPELIVE	2,558	0.14			
TYPEMIX	2,558	0.43			
INTEXPR	2,558	0.13	0.07	0.01	1.50
RNFIAC	2,558	31	98	-3,991	627
		Inputs and Outputs, Units and Percents			
LAND	2,558	1,812	1,199	24	10,016
CACRES	2,558	1,191	814	17	9,472
PPASTA	2,558	0.30	0.24	0	0.97
POWNA	2,558	0.37	0.26	0	1
PLIVDI	2,558	0.33	0.32	0	1
PCWKI	2,558	0.02	0.04	0	0.41
PCROPI	2,558	0.65	0.31	0	1
PLABORE	2,558	0.21	0.08	0.04	0.58
CPAPE	2,558	0.38	0.08	0.13	0.72
PLANDE	2,558	0.10	0.06	0	0.67
PCROPE	2,558	0.22	0.10	0	0.55
PLIVDE	2,558	0.09	0.12	0	0.57
LANDA	2,558	17	9	0	61
CAPITA	2,558	77	88	6	3,239
CHEMICA	2,558	11	9	0	175
FERTILA	2,558	18	15	0	448
SEEDA	2,558	12	15	0	542
LIVESA	2,558	29	90	0	2,704
LABORA	2,558	43	60	5	2,397

Table E.11 Continued

Variable	Obs.	Mean	Std. Dev.	Min	Max
		Efficiencies, Basic and Constrained Model			
TE	2,558	0.89	0.14	0.34	1
TED	2,558	0.90	0.14	0.34	1
AE	2,558	0.81	0.13	0.17	1
AED	2,558	0.81	0.13	0.26	1
SE	2,558	0.87	0.15	0.06	1
SED	2,558	0.87	0.15	0.04	1
OE	2,558	0.64	0.20	0.01	1
OED	2,558	0.64	0.20	0.01	1
		Inefficiencies, Basic and Constrained Model			
TI	2,558	0.11	0.14	0	0.66
OI	2,558	0.36	0.20	0	0.99
AI	2,558	0.19	0.13	0	0.83
SI	2,558	0.13	0.15	0	0.94
TID	2,558	0.10	0.14	0	0.66
AID	2,558	0.19	0.13	0	0.74
SID	2,558	0.13	0.15	0	0.96
OID	2,558	0.36	0.20	0	0.99
		Differential Efficiency Values for Debt-Constrained Model			
DTE	2,558	0.00	0.01	-0.20	0
DAE	2,558	0.00	0.01	-0.24	0.20
DSE	2,558	0.00	0.01	0	0.14
DOE	2,558	0	0	0	0
		Constrained Farms but not by Efficiency			
AINCONS	2,245	0.19	0.13	0	0.69
AICONS	313	0.22	0.12	0	0.83
TICONS	117	0.21	0.13	0.01	0.60
TINCONS	2,441	0.10	0.14	0	0.66
SICONS	244	0.17	0.17	0	0.94
SINCONS	2,314	0.12	0.15	0	0.82
OICONS	0				
OINCONS	2,558	0.36	0.20	0	0.99