The Effect of Land Quality on Agricultural Land Values

by

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Abstract

The average land price in Kansas has recently been through a period of large growth and decay, nearly doubling from 2010 to its peak in 2014, but falling from 2014 to 2017 in both real and nominal terms. However, there is anecdotal evidence that not all land prices are dropping at the same rate. Lower quality land prices seem to be dropping at a higher rate than the higher quality land prices. The goal of this analysis is to give analytical evidence to support the belief of different rates of price changes for different qualities of land. The hypothesis is that once the farm economy entered its period of negative growth, the producers that over-leveraged themselves needed to sell some of their assets to correct their balance sheets and that low quality land is the primary asset liquidated. The producers that did not over-leverage themselves would still be looking to purchase the right piece of land. This creates a surplus of less preferred low quality land on the market, while the supply and demand for the high quality land stays strong.

This analysis was completed using 56,291 observations on land sales from 33 years starting at the beginning of 1985 and continuing on through the middle of 2017. A real price per acre for the land weighted by the number of acres in each parcel was calculated for each quarter, as well as a variable with the price of land lagged one quarter. Data on real net farm income, the S&P 500, and 30-year fixed-rate mortgage interest rates were also collected and used to create averages for each of the 131 quarters analyzed in this work. Finally, a variable representing the percent of all sales in each quarter in the bottom 25 percent in quality of all land sales was created. Quarterly dummy variables were included to control for seasonality.

Two regressions were run with the only difference being the exclusion of the variable representing the bottom quality sales in the first in order to compare the results. Analysis of the first regression shows positive relationships between the dependent variable of the logged real

price per acre and the independent variables of the logged lagged real price per acre, real net farm income, the S&P 500, and land sold during the third quarter of the year compared to the first quarter. There is a negative relationship suggested between the logged land price and the 30-year fixed-rate mortgage interest rate. Inclusion of the variable representing sales of land in the bottom quartile of quality suggest results consistent with the first regression, with some of the variables becoming more statistically significant. More importantly, this analysis shows a negative relationship between average land price and the variable representing land quality. This shows that the average land price is affected by the quality of the land sold at a statistically significant level.

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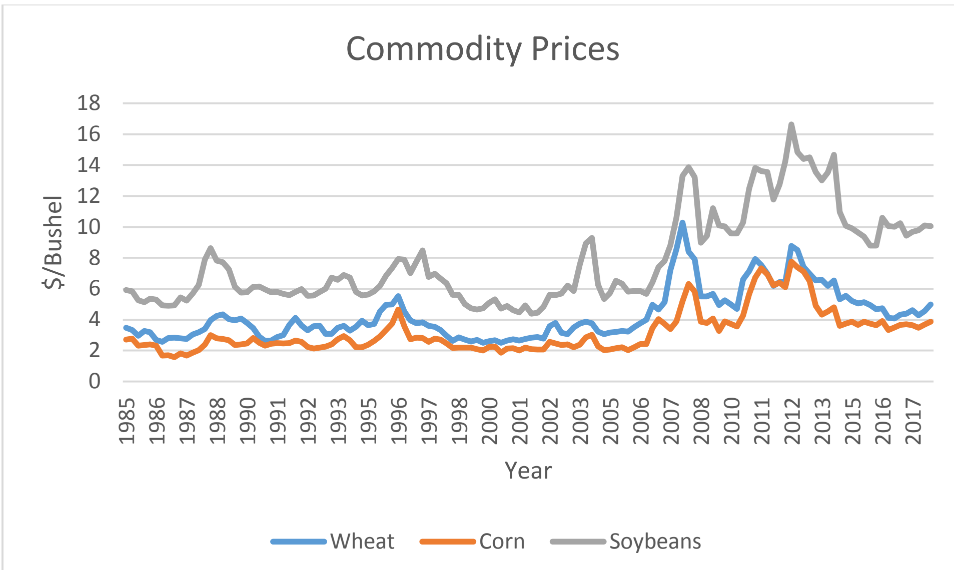
Chapter 1 - Introduction

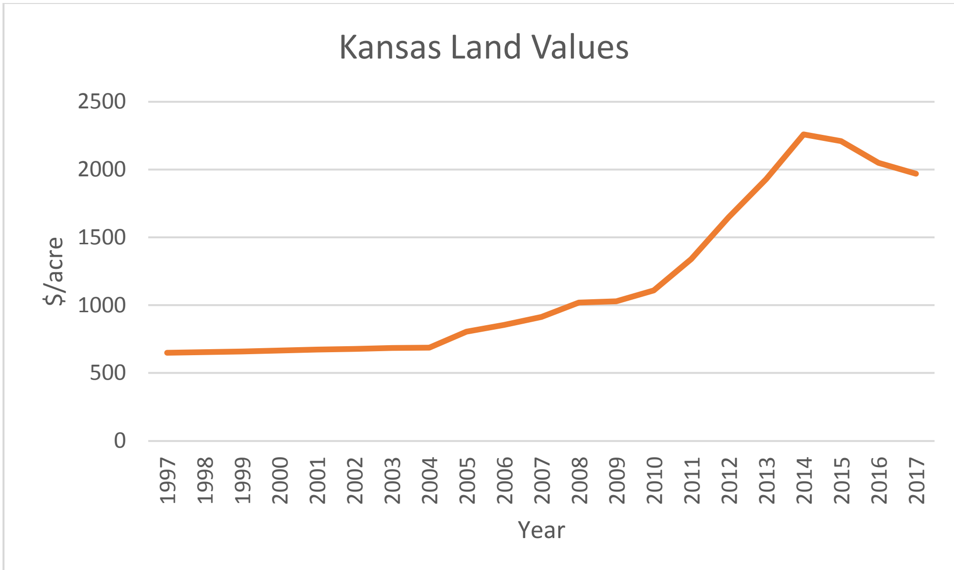
According to the Kansas Department of Agriculture, as of August 2017, agriculture accounted for nearly 250,000 jobs, or 13 percent of the workforce in the state, and approximately $67.5 billion, or 44.5 percent of the state's economy. Land is one of the largest inputs in Kansas agriculture with more than 46 million acres used for production agriculture, or about 87 percent of the entire land area in the state. This study will focus on agricultural land prices in Kansas.

Figure 1.1 - Average Commodity Prices 1985-2018 (Nominal)



Agricultural prices have recently reached historical highs with corn and soybean prices reaching their peaks in the third quarter of 2012 and wheat reaching its highest peak in 2008, but reaching a second peak in the same quarter as corn and soybeans. (Figure 1.1) Land prices also recently reached a peak in 2014, but have since declined. The price of land nearly doubled from 2010 to 2014. (Figure 1.2) Knowing that land has long cycles in its price, with the two most recent peaks coming in 1982 and 2014, identifying factors affecting the changes in price is important to producers. Because land is among the most expensive inputs in production agriculture, minimizing the risk associated with its purchase is paramount in establishing the producer's financial security and the profitability of their operation.

Figure 1.2 - Average Kansas Land Values 1997-2017 (USDA/NASS)



According to anecdotal evidence from producers in Kansas, since land reached its peak in early 2014, higher quality land has for the most part held its value while the value of the lower quality land has declined sharply. It is hypothesized that, with the decreasing net farm incomes in recent years, some producers must liquidate part of their assets to help pay loans they took while their net farm incomes were high. The first assets to be sold when the producers were overleveraged would be their lowest quality assets. It is likely that people have a different willingness to pay for different quality land. With many producers selling lower quality land at the same time, the market for this lower quality land is flooded. Supply outpaces demand, and therefore the price of the lower quality land is dropping. Conversely, with the higher quality land, there are likely fewer sales, and the producers that did not overleverage themselves are still willing to pay for this land. Therefore, the price of the high quality land is holding steadier. This view largely concurs with popular media, in particular an article from the May 2018 publication of *The Progressive Farmer*. It notes that eighty percent of the buyers of farmland are farmers, and they will be the ones to bid if a good farm comes up for sale. The same article also suggests the lenders are putting pressure on the farmers who cannot cash-flow their operations. More recently, government institutions tasked with collecting information in the agricultural economy have become more interested in land quality. In particular, the Chicago Federal Reserve has started collecting information on “good quality” land in their survey data.

This thesis will examine these claims of an uneven decrease in land prices across quality. Land is an investment equal to the net present value of its future production (Melichar 1979; Alston 1986). Supposing land quality is an important factor in in the net production from the land, its inclusion in price models should help more accurately predict this price. Previous work on land price largely ignores this factor mostly due to the lack of information regarding land quality in their datasets. With this, landowners, prospective buyers, and financial institutions might more accurately predict the price of the land in question. This could give financial institutions such as banks a better estimate of what the prospective buyer might request for a loan and give the prospective purchaser an idea of whether or not the transaction would be a wise decision for their operation. The landowner could use this information to determine the value of assets either for legal purposes or to gauge whether or not to sell the land. Finally, this work could be used by researchers in further work on land values and the factors that affect its price change.

With this in mind, the goal of this thesis is to attempt to include a quality variable in a price model for agricultural land. This will be done using a time-series model of land prices in

Kansas from 1985 through 2017. Ordinary Least Squares (OLS) regressions will be used to determine the effect of lower quality land sales on price.

The rest of this thesis will be organized as follows. Chapter two will present a literature review examining previous works on land valuation that have used the same theoretical model as this thesis. Chapter three will present the methodology used to analyze this work. Chapter four will present the data and the variables used in the analysis. Chapter five will present the results from the analysis. Finally, chapter six will provide a conclusion that includes an interpretation of the results and how this work could be expanded.

Chapter 2 - Literature Review

A discounted net present value model is often used to estimate agricultural land values. This discounted sum of all future returns can be viewed as a measure of the productivity or profitability of the land. There are many different factors that could affect this profitability. Much work has attempted to determine the effects of these factors across diverse areas. Many works on agricultural asset pricing base their theoretical models on a similar model to this net present value model (Alston, 1986; Melichar, 1979; Taylor and Brester, 2005; Baird, 2010; Burt 1986). Many of these works have used a hedonic model. Rosen (1974) suggests that hedonic prices are the values of their utility-bearing attributes or characteristics, thus, a hedonic model is useful for land prices. This section of the thesis will delve into previous literature and analyze their methods and results.

Melichar (1979) did not attempt to value land in particular (although it is singled out). Instead, the goal of his work was to evaluate the value of agricultural assets in general. Farm assets had been increasing in value at a greater rate than farm income, and his work looked to uncover the source of this increase in value. His paper defines these capital gains as the annual change in the value of the physical asset less the total net investments and net transfers into the farming sector. These capital gains were then adjusted for inflation. Melichar argues that net farm income should not be compared to land prices because net farm income is an aggregate number while the land prices are per unit. Therefore, he replaces land prices with a different index reported by the USDA that reports farm production assets. The net farm income is also corrected to include net rental income and interest paid on farm debt.

A net present value model of a perpetual, constant-growth series of payments is used for this theoretical model to determine the price of the land. The argument is that if the growth factor is greater than zero, then the present value of the land will increase annually regardless of changes in the returns, growth, or discount rate. Melichar finds that after correcting the original data, the capital gains in both periods that were examined (1954-1967 and 1972-1978) fully explained the growth in the current return to assets and that other changes in the market mostly offset each other.

Alston (1986) noticed that, from 1960 to 1980, the price of farmland in the United States outpaced the consumer price index, a general measure of inflation over time. There were two competing ideas on the cause of this growth. The first argued that the growth over inflation can be attributed to increased real returns from the land. The second hypothesis argued that increases in the expected inflation rate cause increases in the real land price due to the U.S. tax system. The theoretical model in this work can be written as

$$P_t = \frac{V_t}{I_t} = \frac{N_t^*}{D_t^*}$$

where P is the real price of land, V is the land price, I is the GNP deflator, N is the expected real rents, and D is the discount factor. This equates net present value with the net benefits of owning land. This may also be viewed as equating the rate of return on land with the opportunity cost of investing in land, or the discount rate. The only difference in the previous hypotheses is whether the discount rate is constant (the first), or if increasing the inflation rate will decrease the discount rate and therefore lead to an increase in the real price of the land (the second).

A regression Alston uses based on this equation with data across eight states and then across several countries. The results from the regression using state level data indicate a negative relationship between inflation and land prices, although a small one. Alston suggests this relationship is due to the effects of inflation on risk premiums. The results from the model using the different countries and their different tax systems suggest inflation and different tax systems cannot explain the change in land prices. All of the evidence from these models would suggest that the effect of inflation on land prices is negligible.

Work by Reydon et.al. (2014) uses a net present value model to determine, and potentially forecast, the changes in land price in the Maranhão state of Brazil. They use a hedonic model to determine the effects of their variables. Some of the variables considered, all of which were either dummy variables or scaled between a minimum or maximum, include access to electricity, presence of improvements to the land, some land quality observations, and whether the land is being used for agriculture or not. The soil quality observations include if large rocks in the fields are present, preventing or hindering the use of mechanization, and a soil index ranging from 10 to 100. Because this work attempts to create a tool to forecast land prices instead of studying the effect of one variable, the results from the regression are all important considerations. The results of this attempt to forecast land prices show that there is a positive relationship between access to electricity, improvements on the land, fewer rocks impeding the use of mechanization, and increased soil quality. The only negative relationship found was between land prices and whether the land was in agricultural use or not. All of these signs were expected.

Baird (2010) attempts to find the effect on land in Montana from the amenities the land provides, arguing the advertisements for the land sales often list items such as the deer populations, the view, and opportunities for fly-fishing. Two hedonic models are used to identify the effects on the sales price of the land from 1999-2009, the first using total acres of the sale as an independent variable and the second using acres based on land use.

The first theoretical model used by Baird specifies the total price of the parcel as a function of the production characteristics, recreational amenities, existence of wildlife, characteristics of the view offered, and opportunities for development. As the size of the parcel increases, the total price is expected to increase, but at a decreasing rate, suggesting economies of size. The distance from towns and recreational areas are included as a proxy for recreational amenities. From these, a positive relationship is expected from the production characteristics, better views, access to wildlife, and development opportunities, while a negative relationship is expected with the distance from the recreational opportunities. The second model estimates the marginal impact of land usage on the price of the parcel. This usage is separated into CRP, dryland crop, irrigated crop, pasture, improved pasture, site, and unclassified acres in each parcel. The results have the expected signs with the exception of the presence of game animals besides deer.

Taylor and Brester (2005) used a hedonic net present value model to study the effect of US sugar policy on land prices in Montana. The model sets the price per acre of farmland on a vector of land characteristics including the expected returns from crop production, a measure of soil quality, a set of dummy variables indicating the county of the parcel, the population density of the county in which the parcel is found, the number of acres in the parcel sold, the squared value of the number of acres, and a set of dummy variables indicating the year in which the parcel was sold. A positive relationship is expected between the price per acre of the land and the expected returns, soil quality, and population density. A negative relationship is expected with the size of the parcel. After adjusting the price (a proxy for the expected returns) by the soil quality, the results are consistent the theorized results.

Bastian, et.al. (2001) used geographic information systems (GIS) to create a hedonic model of environmental amenities and agricultural land values in Wyoming. The net present value was used to estimate the land values, and some of the characteristics included were the soil quality, capital improvements, water supply, and location with respect to markets. There are other uses for land besides agriculture, with development, recreation, access to public lands, and open space being mentioned. This goal of this study was to model land as a function of both the productive characteristics if it were used for agriculture and the amenity attributes the land would be used for if not for agriculture. This is done by incorporating parcel specific GIS information. Wyoming, for the purposes of this study is assumed to be a large, rural, and heterogeneous market that is split into two regions based on the accessible amenities.

This hedonic regression finds that the demand for rural recreational amenities, open space, and scenery will continue to increase as the population continues to move to less urban areas. The more of these amenities the land provides, the higher the price will be. The parcels that possess these amenities but are currently used for agricultural purposes are therefore more likely to be put into residential development.

Weersink, et.al. (1999) studied the effect of agricultural policy on farmland values in Ontario. This work estimates the separate effects of market returns and government support programs on agricultural land values. The theory in this paper uses a net present value to estimate land prices. The difference from previous work is the inclusion of government subsidies as a source of income in addition to farm production. In the analysis, a time-series model is used and finds that the two revenue sources are viewed differently by the farmers. The government subsidies are discounted at a lower rate than the farm production is, which suggests farmers view these government payments as a more stable source of income than their actual production.

All of these previous works used the net present value theoretical model to price land. Additionally, they all mostly used hedonic models in their analyses. These hedonic models provide a good analysis of the cross-section of the data. However, with the data used in this analysis of land prices collapsed as it has been, a time-series model is utilized. Although the models are different, it is useful to identify the variables the hedonic models have used, as they might be transferable to the time-series models.

Chapter 3 - Methodology

This section will describe the methods used to analyze how land prices are affected by the quality of the land. This initially includes the theoretical framework for how this study values land. The theoretical framework is followed by an explanation of the time-series model used to acquire results explaining the effects of different variables on land price. Finally, an explanation of omitted variables and omitted variable bias follows the set-up of the regression model.

Theoretical Framework

As established in previous works, net present value is described as a discounted value of the net returns from the land subject to some discount rate as the theoretical model (Melichar 1979; Alston 1986; Taylor and Brester 2005). This is set up theoretically as:

$$P_0 = \sum_{n=0}^{\infty} \frac{R_n}{(1 + i_n)^n}$$

where P is the present value of land, R is the annual return from the land net of input costs and taxes, i is the expected rate of return on land from cash rents (or discount rate), and n is the number of periods (years) from today. It is assumed that both the net returns and the capitalization rate will vary annually, but in the long run are assumed to be constant. However, because land is, as shown, an asset with an infinite lifespan, this definition can be simplified further to

$$P = \frac{R}{i}$$

where the variables are defined as above (Brealey, et al. 2012). This statement is made with the strong assumptions that in the long run, both the expected returns from the land and discount rate being constant.

There are many factors that affect the net returns to land, and most are difficult to forecast. There have been numerous studies that have analyzed many of these factors, some of which include inflation, government payments, farm enlargement, technological improvement, government supported prices (Alston; Pope, et al; Weersink, et al.). While these are important factors to consider, they are not specific to each land sale. The characteristics specific to the land play an important role in the productivity of that parcel.

Time-Series Model

Using a time series of Kansas land prices constructed from individual land parcel sales, an Ordinary Least Squares model is estimated. A vector of land characteristics and variables from tangentially related markets (x_i) is considered for their effects on the price of land $P(X)$. This gives us:

$$P(X) = P(x_1, x_2, \dots, x_n).$$

There were many explanatory variables considered for inclusion in this base model. A one-quarter-lagged price variable is included to indicate the effect of the price of land in the past will have some effect on the price of land today. This explanatory variable is expected to have a positive sign in the regression. A net farm income variable is included, as farmers with access to funds would be expected to be more willing to pay a premium on the piece of land they want. This variable is expected to have a positive sign in the regression. S&P 500 index values are included in the analysis to show expected returns from an alternative source of investment to land. This variable is expected to have a positive sign. Better returns on other investments gives the buyer higher access to funds, increasing their willingness to pay. The interest rate for a fixed rate 30-year mortgage is included, as it is unlikely a farmer will have the funds to pay for the entire purchase immediately, and this is the interest rate likely to be incurred on the loan. This sign is expected to be negative. A higher interest rate effectively makes a purchase more expensive than one with a lower interest rate, potentially leading to a lower bid for the land. Dummy variables are included for each of the quarters of the year except the first (used as the base) in order to help control for seasonality in the sales. A positive sign can be expected in the results for the first and third quarters, as this is when many farmers experience a cash inflow due to the completion of spring and fall harvests. Consequently, since the first quarter is used as a base, it might be expected that there is no significance to the third quarter dummy results and a negative sign on the second and fourth quarter dummy variables. This equation shows the form this regression will take:

$$lnwppa = \beta_0 + \beta_1 * lnlagwppa + \beta_2 * rnfi + \beta_3 * SPAdjClose + \beta_4 * frm30y + \beta_5 * q2 + \beta_6 * q3 + \beta_7 * q4 + \varepsilon$$

where the dependent variable *lnwppa* is the logged land price per acre, *lnlagwppa* is the same variable as the dependent, only it is lagged one period, *rnfi* is the net farm income adjusted to current price levels, *SPAdjClose* is the average S&P 500 index level for each period, *frm30y* is the average 30-year fixed-rate mortgage interest rates for each period, *q2*, *q3*, and *q4* are dummy variables indicating the quarter of the year, each β is the estimated effect on the dependent variable from its respective variable, and ε is the error term.

The Omitted Variable Case

The main argument of this study is that previous work omitted a variable that could help explain why Kansas producers have observed that higher quality land prices are holding steady compared to lower quality land prices. To explain this phenomenon, the quality of land was divided into four quartiles and a variable that measured the sales of land with soil quality in the bottom quartile as a percent of total land sales was created (*psales25*). This would indicate the error term ε from the time-series regression model takes the form (Wooldridge, 2011):

$$\varepsilon = \gamma * psales25 + v$$

Arguing that there is an omitted variable in the first regression would indicate the error term ε is correlated with the explanatory variables if the land quality variable is correlated with land price. These relationships can be shown as:

$$psales25 = \delta_0 + \delta_1 * lnlagwppa + \delta_2 * rnfi + \delta_3 * SPAdjClose + \delta_4 * frm30y + \delta_5 * q2 + \delta_6 * q3 + \delta_7 * q4 + u$$

where each δ is the estimated effect of its corresponding explanatory variable on the land quality variable. These δ values can therefore be calculated using a regression set up in this manner and will show the bias due to omitting the land quality variable. With this information, the original regression can be rewritten to include the land quality variable as:

$$lnwppa = (\beta_0 + \gamma * \delta_0) + (\beta_1 + \gamma * \delta_0) * lnlagwppa + (\beta_2 + \gamma * \delta_0) * rnfi + (\beta_3 + \gamma * \delta_0) * SPAdjClose + (\beta_4 + \gamma * \delta_0) * frm30y + (\beta_5 + \gamma * \delta_0) * q2 + (\beta_6 + \gamma * \delta_0) * q3 + (\beta_7 + \gamma * \delta_0) * q4 + \gamma * psales25 + v + \gamma * u$$

Table 3.1 - Expected Sign on Variables

	Omitted Variable Regression	**Regression Showing the Bias**	**Regression Including Land Quality**
Dependent Variable	Land Price	Sales of Low Quality land	Land Price
Explanatory Variables	Expected Sign		
Average Price per Acre Lagged One Period	Positive	Positive	Positive
Net Farm Income	Positive	Positive	Positive
S&P 500	Positive	Positive	Positive
30-Year Fixed-Rate Mortgage Interest Rates	Negative	Negative	Negative
Sales of Low Quality Land	N/A	N/A	Negative
Second Quarter Dummy	Negative	Neutral	Negative
Third Quarter Dummy	Neutral	Neutral	Neutral
Fourth Quarter Dummy	Negative	Neutral	Negative

Omitted variables will create bias in the other variables used in the regression if there is any correlation between the two variables. A strong positive relationship is expected between the price of the land and the price of the land lagged one period. The hypothesis of this study is that having more low quality land sold in a period will decrease the price of the land overall. Because of this, a negative correlation is expected between the lagged price of land and the higher percentages of low quality land being sold. This should cause a downward bias on the coefficient on the lagged land price in the regression with the omitted variable, causing the same coefficient in the included variable regression to be higher.

The net farm income is expected to have a positive relationship with the price of the land, and therefore a negative correlation between the net farm income and the land quality variable. The S&P 500 likely has a negative correlation with the land quality variable. A higher S&P 500 likely indicates a better economy in general, so farmers are more likely to purchase the higher quality land, although this relationship might not be very strong. Both the S&P 500 value and net farm income variables are expected to have a negative bias on the regression that does not include the land quality variable, although the S&P 500 coefficient could end up being neutral. If interest rates are lower, farmers are more likely to purchase the lower quality land, as it becomes a less risky investment in that case. Therefore, it is expected to be positively correlated with the land quality variable, and the interest rate variable in the omitted variable regression should be lower than in the regression that includes the missing variable. The time of the year is unlikely to be correlated with the land quality variable, so it is expected there should be no difference between the regressions with and without the land quality variable for different times of the year.

Chapter 4 - Data

This study utilizes multiple cross-sectional data collected across Kansas from 1985 through 2017. This section describes the sources of the data, its collection method, and the variables identified in the methods section.

Sources

The primary source of data in this study was the Kansas Department of Revenue Division of Property Valuation (PVD). The PVD has collected 124,013 records of land sales in Kansas dating from the beginning of January 1985 through the end of September 2017. This dataset has many variables of interest on each sale, including the date of the sale, the coordinates of the parcel, the total price, the total number of acres, the number of irrigated, dryland, native grass, tame grass, and homestead acres, precipitation, and the average water-holding capacity of the parcel. This study is interested in how soil quality affects land prices. Including irrigated land values would distort this study as it is valued higher due to its access to water, and not necessarily its land quality. Therefore, observations that did not total fifty percent or more pasture or dry farmland were dropped. In an effort to avoid sales for urban development, sales of fewer than forty acres were dropped. Finally, any observations were dropped if they were missing any vital information such as a record of the water-holding capacity or composition of the land.

This study seeks to identify trends in the most recent cycle in land price. Because the price of land is the variable of interest, a price per acre variable must be used. The recorded price per acre variable was deemed unreliable on many observations, reporting negative land values up to a value greater than $1,000,000 per acre for pasture in some cases. Likewise, creating a price per acre simply by dividing the total price by the total number of acres returns values greater than $1,000,000 per acre. Many of the recorded sales occurred on the same day for the same amount across geographically close parcels. From this, it was presumed that any sales occurring on the same date for the same amount were from the same sale. Thus, it is possible to more accurately calculate the true price per acre for the sale using:

$$P_i = \frac{TP_i}{\sum_{i=1}^{I} TA_i}$$

where P is the price per acre, TP is the total amount paid for the sale, TA is the total number of acres in each parcel, and i identifies the parcels in the sale. For each of the other quantifiable variables of interest, a weighted average was created for each of the observations using the following formula:

$$X_i = \sum_{i=1}^{n} \frac{X_i * TA_i}{\sum_{i=1}^{I} TA_i}$$

where X is the variable of interest and the others defined as before.

Farming operation characteristics were collected from the Kansas Farm Management Association (KFMA). The KFMA records this information from 2,645 producers across the state of Kansas and reports them annually for statewide and KFMA regions. Within each of these classifications, the characteristics are reported for each quartile based on net farm income. Variables of interest primarily include net farm income and number of crop acres per operation.

Previous work has shown that inflation has little or no effect on land prices (Alston, 1986), so this study adjusts all prices to the current price levels. Monthly consumer price index numbers were collected from the United State Department of Labor Bureau of Labor Statistics. Other sources were used for missing variables. Quarterly short term interest rate (three-month CD rate) information was gathered from the Organisation for Economic Co-Operation and

Development (OECD). Daily S&P 500 data were collected from Yahoo! Finance. Weekly thirty year fixed rate mortgage data were collected from Freddie Mac. Each of these variables were converted to a quarterly average before merging them with the original PVD data.

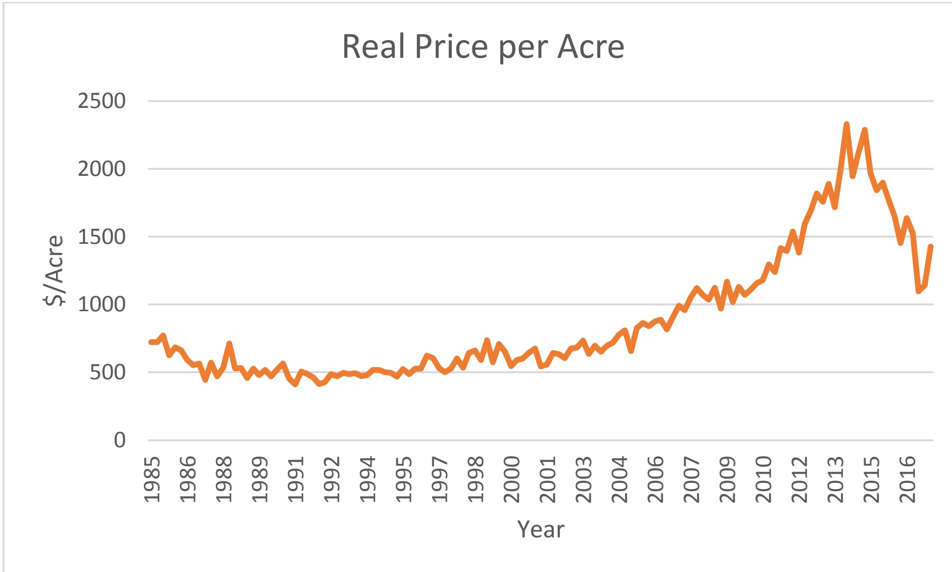
Variable Summaries

As with the variables created above, each of the primary variables were converted to quarterly averages. Due to this aggregation, the multiple cross sectional data is transformed into time series data. The dependent variable in this model is the (logged) weighted price per acre. This was calculated using a similar weighting formula as before:

$$WP_t = \sum_{i=1}^{I} \frac{RP_i * A_i}{\sum_{i=1}^{n} A_{it}}$$

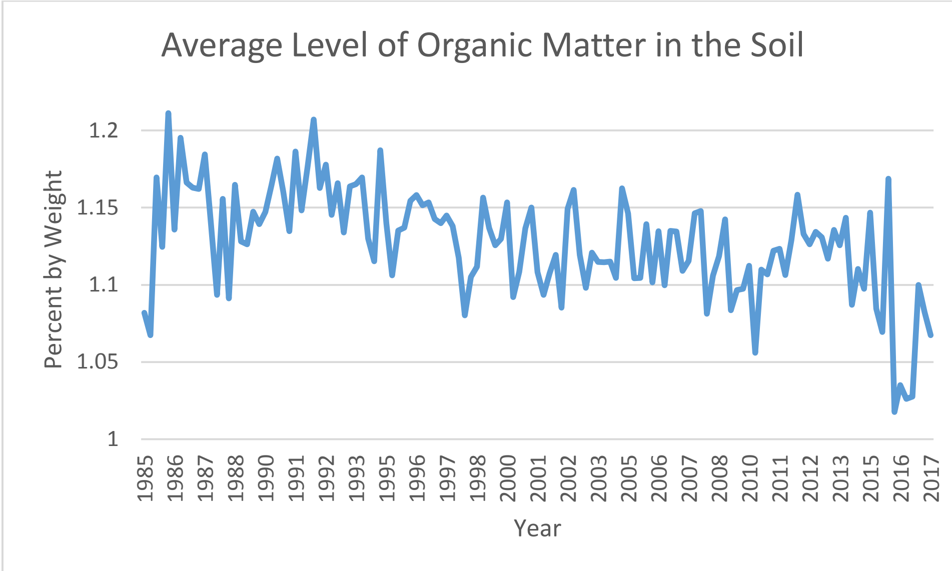
In this equation, WP is the weighted price per acre, RP is the real price per acre of the sale i in 2017 dollars, A is the number of acres in the sale i, t is the time period, and I is the total number of sales. These data were collapsed into averages by quarter. The average sales price ranged from a low of $421.72 in the first quarter of 1991 to a high of $2340.16 in the first quarter of 2014. The beginning of this dataset includes a short downward trend from a previous cycle that ends at the beginning of 1987. From then, the price increases until it reaches its peak in 2014. From that point, the price decreases at a steady, but rapid pace. (Figure 4.1) To attempt to normalize the data, the price has been logged for use as the dependent variable and as a lagged explanatory variable.

Figure 4.1 - Average Price of Land in Kansas, 1985-2017



The quality of the land is inherently important when deciding what the land is worth. The mean organic matter level of the land in the sale is used as a proxy for soil quality with the understanding that organic matter is just one part of what affects quality. This organic matter variable is reported as a weighted percentage of the soil in the parcel. The weighted average per quarter was calculated as previously shown. The mean organic matter variable has a mean of 1.127 percent, reaches a maximum of 1.211 percent in the first quarter of 1986, and a minimum of 1.018 percent in the first quarter of 2016. There is a slight downward trend in the level of organic matter from the start to the end of this data. (Figure 4.2)

Figure 4.2 - Average Organic Matter Level of Land Sold in Kansas, 1985-2017



It is assumed that the recorded soil quality of 56,291 sales across the state over this 30-year time period provides a good view of the true land quality of the state of Kansas. Therefore, these data were sorted into quartiles based soil quality. The bottom 25% of observations include any sales with organic matter lower than 0.829 percent of soil composition by weight. The third quartile falls between an organic matter level of 0.829 and 1.065 percent. The second is between 1.065 and 1.419 percent, while the top quartile is anything over 1.419 percent.

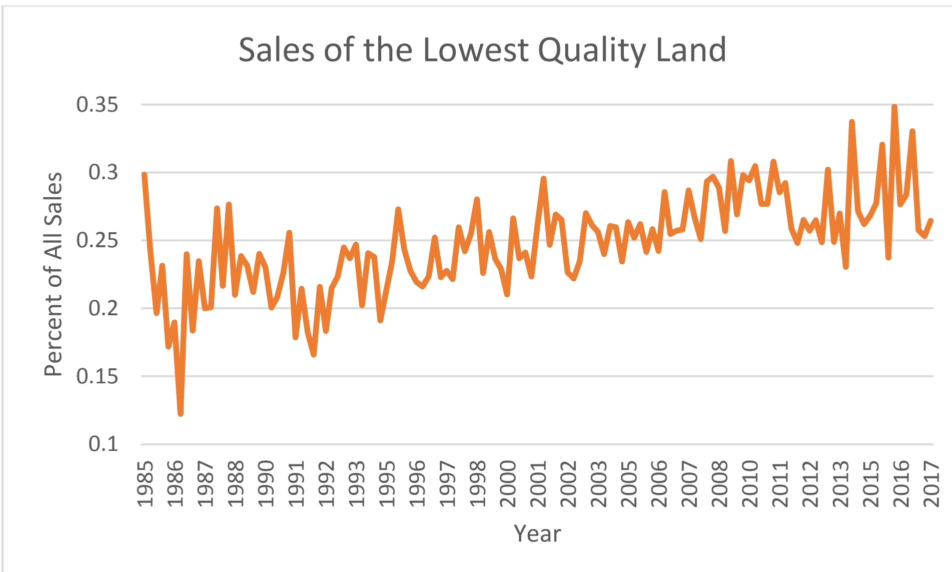
To put this quality term into a useful variable for a time-series regression, and because this study aims to compare the bottom quality sales to the other sales, a variable representing the sales in each quarter of land in the bottom quartile was created (*psales25*). This was calculated using

$$psales25_t = \frac{TS25_t}{TS_t}$$

where *psales25* is the percent of sales of land in the bottom quartile of quality, *TS25* is the total number of sales of land with the bottom quartile of quality, and *TS* is the total number of land sales in time period *t*. The percent of sales in the bottom quartile range from a high of 34.86

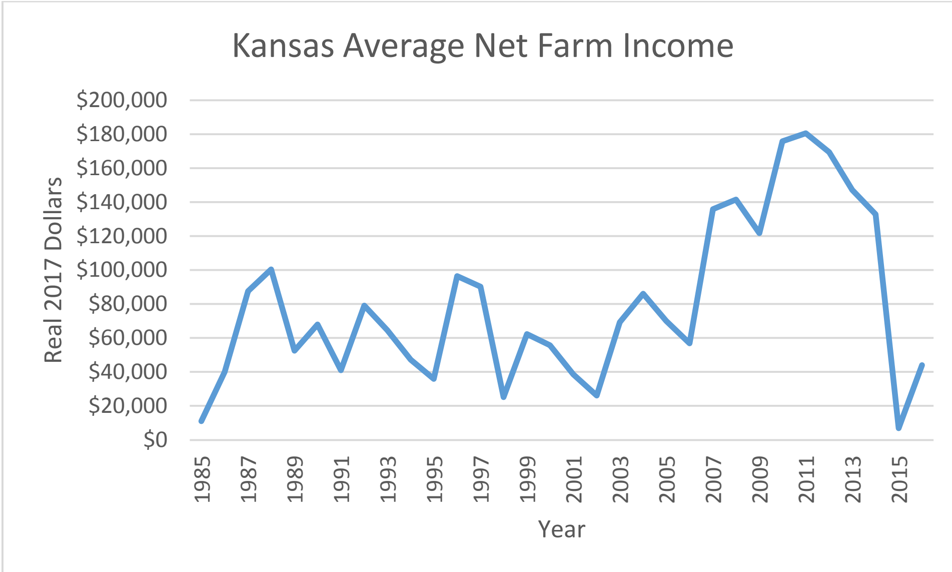
percent in the first quarter of 2016 to a low of 12.23 percent in the third quarter of 1986. As would be expected from knowing the average quality of land has been trending downward over the 30-year timeline, the percent of sales of the bottom quality land has been trending upward. (Figure 4.3)

Figure 4.3 - Land with Low Quality Soil as a Percent of All Land Sold in Kansas, 1985-2017



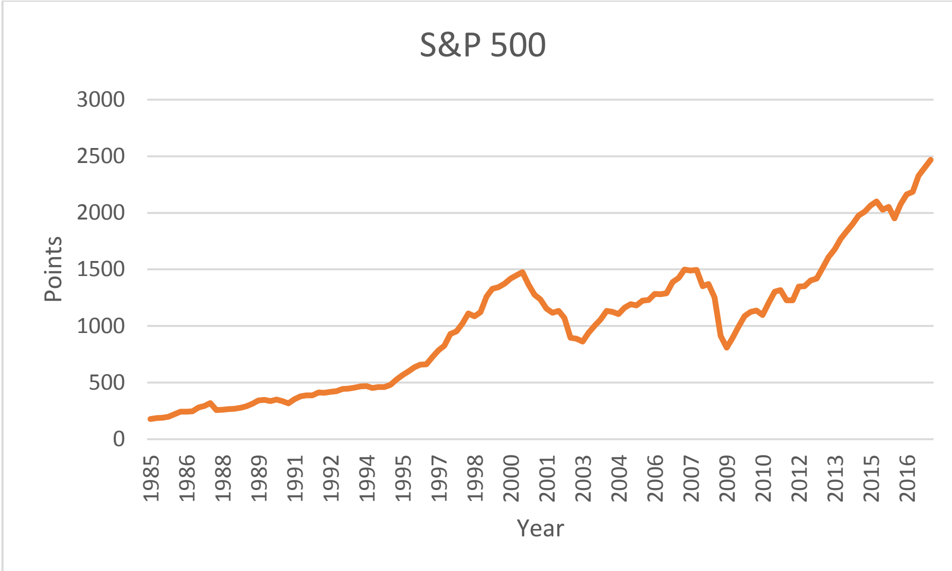
Using net farm income numbers in conjunction with the consumer price index numbers, a real net farm income number was generated. This is included because it is expected producers have a higher willingness to pay for land if their income is higher. These numbers are only recorded annually. The statewide average real net farm income has a mean of $80,078 and ranges from a low of $6,958 in 2015 to a high of $180,721 in 2011. Unlike the weighted price per acre, there is no clear trend in this dataset until 2002, with large variation from year to year. There is a strong upward trend from 2002 through 2011 followed by a significant downturn since. (Figure 4.4)

Figure 4.4 - Average Net Farm Incomes in Kansas, 1985-2017



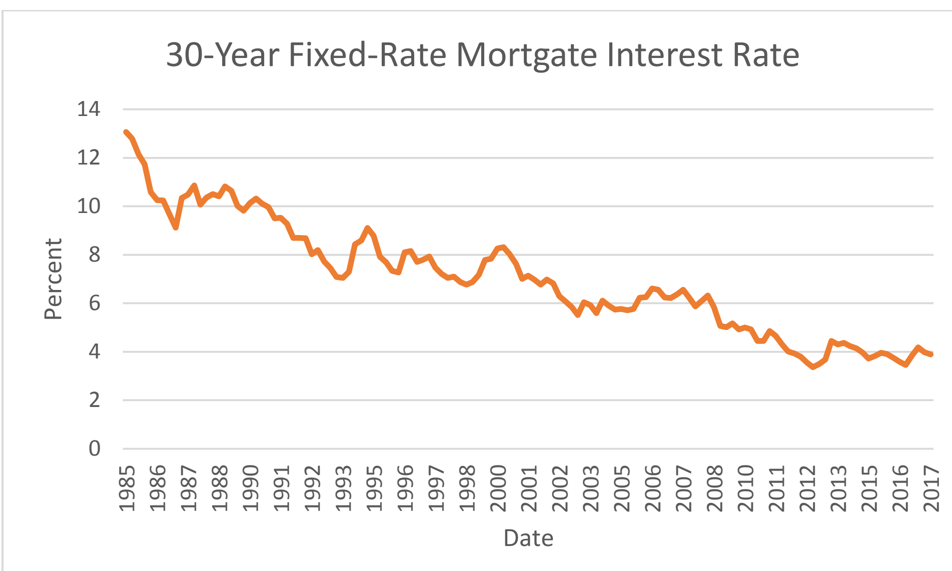
S&P 500 index was included as an alternative investment in place of purchasing land. In the time period being analyzed, this data has increased in value from 177.10 points in the first quarter of 1985 to 2467.18 points in the most recent record of the third quarter of 2017. There were two notable peaks: one in the third quarter of 2000 reaching a peak of 1475.98 points and one in second quarter of 2007 reaching a peak of 1497.18 points. These were followed by rapid decreases bottoming out in the first quarter of 2003 with a low of 860.76 points and the first quarter of 2009 with a low of 807.67 points respectively. Since the low in 2009, the S&P 500 has grown fairly steadily to the aforementioned current level. (Figure 4.5)

Figure 4.5 - Quarterly S&P 500 Numbers, 1985-2017



Fixed-rate 30-year mortgage rates were included, as this is likely the rate the producers would have to accept on any loans to purchase the land. This rate started out at a high of 13.06 percent and has generally declined at a rate of roughly 0.05 percent per quarter or 0.2 percent per year to a low of 3.36 percent in the fourth quarter of 2012. (Figure 4.6) The most recent record in the third quarter of 2017 is a rate of 3.88percent.

Figure 4.6 – Average Quarterly 30-Year Fixed-Rate Mortgage Interest Rates, 1985-2017



Because both dry farmland and pasture are being analyzed, the dry farmland variable was included, making pasture the base result. Statewide, dry farmland accounted for 54.1 percent of all sales while pasture accounted for 43.0 percent in this dataset. This has remained mostly steady throughout the period of this study. The minimum percentage of all land sales pasture accounted for was 35.7 percent in the first quarter of 1985 while the maximum was 47.9 percent in the fourth quarter of 1993. Likewise, dry farmland accounted for 47.7 percent at its minimum in the fourth quarter of 1993 and topped out at 60.8 percent in the third quarter of 1985. This study does not entirely eliminate the sales with irrigated land, but as a percent of sales per quarter, irrigated land averages 1.04 percent, never exceeds the 2.2 percent from the first quarter of 1985 and bottoms out with 0.18 percent in the third quarter of 2015. Homestead acres are attributed to the remaining acres sold.

Table 4.1- Variable Summaries

VARIABLES	N	mean	sd	min	max
Average Price per Acre ($)	131	882.7	474.8	411.3	2,330
Logged Average Price per Acre	131	6.664	0.469	6.019	7.754
Logged Average Price per Acre Lagged One Period	130	6.660	0.468	6.019	7.754
Organic Material (% by weight)	131	1.127	0.0352	1.018	1.211
Net Farm Income ($)	128	80,023	47,657	6,956	180,616
S&P 500	131	1,008	582.6	177.1	2,467
30-Year Fixed-Rate Mortgage Interest Rates (%)	131	6.992	2.320	3.359	13.06
Low Quality Land Sales as Percent of Total Sales	131	0.248	0.0358	0.122	0.349

Quartile Data Summaries

It can be useful to view some of these data based on which quality quartile they belong in. Summary statistics for the mean organic matter, weighted average price per acre, size of the sale, and the percent of the total sales of land in each KFMA region for each quartile have been calculated.

Top Quartile				
Variable	**mean**	**sd**	**min**	**max**
Organic Matter (% by weight)	1.697	0.217	1.419	3.781
Average Price per Acre ($)	1,204	549.5	487.6	2,789
Size of Sale (Acres)	257.3	452.6	40	12,774
% Sales in NW KFMA Region	0.0124	0.0107	0	0.0857
% Sales in SW KFMA Region	0.00233	0.00426	0	0.018
% Sales in NC KFMA Region	0.14	0.0399	0.0353	0.286
% Sales in SC KFMA Region	0.0345	0.0192	0	0.0909
% Sales in NE KFMA Region	0.257	0.0504	0	0.387
% Sales in SE KFMA Region	0.535	0.0562	0.424	0.875
Second Quartile				
Variable	**mean**	**sd**	**min**	**max**
Organic Matter (% by weight)	1.227	0.097	1.065	1.419
Average Price per Acre ($)	999.2	621.9	320.1	2,963
Size of Sale (Acres)	265.3	296.5	40	8,346
% Sales in NW KFMA Region	0.0688	0.0285	0.0115	0.172
% Sales in SW KFMA Region	0.0291	0.0182	0	0.111
% Sales in NC KFMA Region	0.298	0.06	0.157	0.448
% Sales in SC KFMA Region	0.149	0.0413	0.0323	0.274
% Sales in NE KFMA Region	0.162	0.0448	0.0676	0.314
% Sales in SE KFMA Region	0.274	0.0689	0.093	0.436
Third Quartile				
Variable	**mean**	**sd**	**min**	**max**

Organic Matter (% by weight)	0.927	0.0692	0.829	1.065
Average Price per Acre ($)	871.2	505.6	326.3	2,367
Size of Sale (Acres)	316.2	399.5	40	20,155
% Sales in NW KFMA Region	0.297	0.0591	0.139	0.455
% Sales in SW KFMA Region	0.175	0.0468	0.0702	0.283
% Sales in NC KFMA Region	0.18	0.0493	0.0333	0.3
% Sales in SC KFMA Region	0.145	0.0421	0.0455	0.28
% Sales in NE KFMA Region	0.069	0.0266	0	0.131
% Sales in SE KFMA Region	0.116	0.0446	0	0.263

Bottom Quartile

Variable	**mean**	**sd**	**min**	**max**
Organic Matter (% by weight)	0.652	0.166	0	0.829
Average Price per Acre ($)	760.8	367.2	345.3	2,203
Size of Sale (Acres)	353.7	728.5	40	28,519
% Sales in NW KFMA Region	0.218	0.0497	0.114	0.429
% Sales in SW KFMA Region	0.356	0.0599	0.0714	0.495
% Sales in NC KFMA Region	0.058	0.0236	0	0.123
% Sales in SC KFMA Region	0.256	0.0581	0.0638	0.423
% Sales in NE KFMA Region	0.0347	0.0221	0	0.123
% Sales in SE KFMA Region	0.0601	0.0294	0	0.191

A cursory look at this data shows trends in the data. As is expected based on how the quartiles are created, the organic matter in the soil decreases from the top quartile to the bottom. The average price also decreases, matching up with the hypothesis. The average size of the sale increases as from the top quartile to the bottom, and this suggests there may be economies of size when selling land. However, this cannot be captured by this study as the data in the analysis is collapsed into averaged by quarter. Tracking the sales in each region can mostly show the distribution of the quality of land in Kansas. As was expected, the largest percent of land sales in the bottom quarter came from the northwest, southwest and south central parts of Kansas while the majority of the sales of the top quality land belong to the other three regions.

Chapter 5 - Results

This section will detail the results from the time-series models that have been run. The results from the first model that excludes the land quality variable are reported first. The results of the regression measuring the omitted variable bias as well as the time-series regression that includes the land quality variable are reported following the omitted variable regression.

Results from the Omitted Variable Regression

As was described in the methods section, this study compares two similar Ordinary Least Squares regressions, with the second including a proposed omitted variable that describes land quality. The original regression will ensure the original variables are useful in this analysis, as well as show the effect of including the quality variable in the analysis. The dependent variable is the logged weighted price per acre of pasture and dry farmland for the state of Kansas. Variables in the original regression used to explain changes to this price include the logged lagged price, the real net farm income, the sale occurring in the third quarter of the year (July 1 – September 30), the S&P 500 closing prices, the 30-year fixed rate mortgage rate, and dummy variables to account for the quarter of the year of the sale with sales in the first quarter of the year being the base. This regression appears to give quality results that, from the adjusted R-squared value, explain 94.8percent of the variation in the recorded price.

The estimate for the logged lagged land price (*lnlagwppa*) is significant at the 10 percent level and indicates that a 1% change in the price of land today would cause a 0.85% change in the price of land next quarter in the same direction. The magnitude and direction of the lagged variable would appear to be logical, as land is an asset that will not lose all of its value overnight, and therefore changes in its values would be smoothed over time.

The coefficient for the average real net farm income per farm for the state (*rnfi*) is significant at the 10 percent level but is very small, showing that moving the real net farm income by $1000 would only change the price of land by 0.0702% in the same direction. In this study, this results in approximately $0.62 per acre change in the price of land when using the average of the dataset. The direction of the coefficient makes sense. An increase in net farm income can largely be attributed to increases in net returns to land, proving that land should indeed be valued higher. That the magnitude of this coefficient is so small is unexpected. There are many factors to be accounted for in net farm income, so this coefficient was expected to be small, but not as small as what was found.

The S&P 500 adjusted closing numbers (*SPAdjClose*) were included to show a possible return on an alternative investment. This coefficient is not significant at the 10 percent level, although it is close. It suggests that a 100 point move in the S&P 500 would result in a 0.64% move in the land price in the same direction, which results in a move of approximately $5.65 per acre from the mean price. Both the magnitude and direction of this coefficient would seem to make sense. With the S&P 500 being used as an estimate on returns for a substitute investment, the return on investment in land must increase as the returns from an alternative investment increase. If this is not the case, the investor would leave the land market and invest in the alternative as it has better returns.

The coefficient on 30-year fixed rate mortgage rates (*frm30y*) is not statistically significant at the 10 percent level. However, analyzing this coefficient can still be beneficial. It suggests that a 1% move in the mortgage rates would result in a 1% move in land price in the opposite direction. The direction of the move would seem to be correct. If the interest rate on the mortgage taken on the land is lower, this decreases the amount the purchaser would be required to pay on the land in the future. This can be thought of as effectively decreasing the price being paid for the land. Therefore, the investor would be willing to pay more for the land to match what they truly believe the land is worth.

The dummy variables representing the quarters of the year (*q2*, *q3*, and *q4* with *q1* being base) were included to control for seasonality. The results show that the second and fourth quarters of the year are statistically no different from the first quarter. However, there is a positive effect from the sale of the land occurring in the third quarter of the year. Land sold from the beginning of July though the end of September can be expected to sell 5.5% higher than any other time of the year. This can be explained by producers having access to cash upon the completion of the spring wheat harvest.

Omitted Variable Bias

The second regression was run identical to the first with the exception of the inclusion of a variable describing the sales of the lowest quality of land. This is included as a means to explain the phenomenon producers are currently experiencing where lower quality land is decreasing at a faster rate than higher quality land. The results show that including this variable improves the regression, offering proof that land quality is important to include when analyzing land price. The explanation of the variation in the price of land increases marginally from 94.8 percent to 95 percent

Including this variable controlling for the percent of the total sales per quarter that were of the lowest quality had a mostly negligible effect on the other variables used in the original regression. None of the signs on the original variables changed. The variable controlling for changes in the S&P 500 becomes statistically significant, and the 30-year fixed rate mortgage variable moves much closer to the 10 percent significance level. The logged lagged weighted price coefficient increases by .012 suggesting an increase in the effect on the logged weighted price of 0.12 percent over the previous regression. The real net farm income variable increases the price of the land by 0.0042 percent per $1000 increase in income over the previous results. The S&P 500 variable moves the price by 0.136% per 100 point move more than the previous. Finally, a 1% move in the 30-year fixed rate mortgage variable increases the change in price by 0.44% more.

The inclusion of the variable describing the percent of total sales per quarter of the lowest 25% of all land sold in Kansas since 1985 (*psales25*) is statistically significant at the 10% level. These results suggest that a 10% change in the quality variable, which is comparable to the change seen from 2016 to 2017, results in a 9.1% change in the price of land in the opposite direction. This makes sense, because lower quality land is less productive than its higher quality counterparts. Therefore, if more low quality land is sold, the average price for that period should decrease.

Table 5.1 - Regression Results

	Omitted Variable Regression	Regression Measuring Bias	Regression with Land Quality Variable
Dependent Variable	**lnwppa**	**psales25**	**lnwppa**
Explanatory Variables			
lnlagwppa	0.8479***	0.0135	0.8601***
	(0.0397)	(0.0098)	(0.0391)
rnfi	0.0000***	0.0000	0.0000***
	(0.0000)	(0.0000)	(0.0000)
SPAdjClose	0.0001	0.0000	0.0001*
	(0.0000)	(0.0000)	(0.0000)
frm30y	-0.0100	-0.0048**	-0.0144
	(0.0093)	(0.0023)	(0.0093)
psales25			-0.9057**
			(0.3626)
q2	0.0152	0.0115*	0.0256
	(0.0273)	(0.0067)	(0.0270)
q3	0.0534*	0.0056	0.0585**
	(0.0272)	(0.0067)	(0.0267)
q4	0.0005	0.0012	0.0016
	(0.0272)	(0.0067)	(0.0266)
Constant	0.9506***	0.1683**	1.1031***
	(0.2661)	(0.0658)	(0.2675)
Observations	127	127	127
Adjusted R-squared	0.9476	0.4528	0.9498

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Chapter 6 - Conclusion

This work has attempted to explain how the quality of the land impacts its price. This question was brought on by anecdotal evidence from producers in Kansas that during the current period of price change, while the average price of land in the state has decreased overall, the higher quality parcels have held their prices mostly constant or even increasing in some areas, while the lower quality land has experienced a sharp drop in price. Identifying the effect of land quality on its price will help everyone involved with the sale. The seller would be able to set a more realistic expected price, the purchaser would have a better idea of whether they can afford the parcel in advance of the sale, and any bank or other agent a loan might be acquired from would have a better idea of whether they would want to offer a loan for the parcel. The rest of this section will review the model and results and end with a look toward future work possible as a result of this study.

Review of the Study

Two time-series models were run to identify the effect the quality variable would have on the price of land. In these regressions, the dependent variable was the logged real price per acre of the land. This dependent variable was created by deflating the total price of the parcel divided by the total acres in the sale, and then taking the log of that price. The independent variables include a one-quarter lag of the dependent variable, the real net farm income average for the state, S&P 500 adjusted closing numbers, 30-year fixed-rate mortgage interest rates, and quarterly dummies to account for seasonality. These independent variables were used in both regressions, the first regression without a land quality variable to create a base set of results to compare the second regression against.

The base results from the original regression show that the lagged price accounts for approximately 84 percent of the movement in the price of land. The real net farm income, S&P 500 closing numbers, and the third quarter dummy variable were all statistically significant at the five-percent level (with the exception of the S&P 500 numbers, but it is close at the ten-percent level) and had positive effects on the logged price of land. The other variables in the base results had no statistically significant effect on the land price, although the interest rates indicate a possible negative effect.

The quality variable created was a percentage of total sales that were in the bottom quartile of all sales each year based on quality. This last independent variable was included in the second regression and the effect of this variable on the logged price of land, as well as the changes in the other independent variables was observed. The lagged land price, real net farm income, S&P 500, and the third quarter dummy variable are all statistically significant at the five percent level, and all increased in magnitude after the quality independent variable was included. The interest rate also increased in magnitude, and becomes statistically significant at the fifteen percent level. As expected, increasing the percent of low-quality land sold in a period is statistically significant at the five-percent level, and has a negative effect on the price of land. The results from the second regression indicate that a one percent increase in the total sales of land that were in the bottom twenty-five percent of all sales based on quality results in a decrease in the price of land by approximately 0.91%. This study shows that higher organic material levels in the soil of a parcel of agricultural land should indicate a higher value than that of a parcel with lower organic material.

This study set out to identify the effect of land quality on land prices in Kansas, and this goal has been accomplished. There is empirical evidence that lower quality land is worth less than its higher quality counterparts. While almost every producer instinctively knows this, there is now empirical work they can reference. Previous research has tried to control for land quality, or defined land quality in different ways. This work is different in that actual land characteristics are used to define quality, and not proximity to a point of sale or other attraction.

This work can be useful for producers, lenders, investors, and appraisers. Land values have decreased overall. However, this study shows it is largely driven by sales of poor quality land. With a divergence in the value of land, lenders would still be willing to give loans for high quality land that will hold its value into the future while being more cautious in giving out loans on low quality land that might lose much of its value in the near future. Investors and producers looking at investing in land might find a piece of land they would like to purchase. This work can help them determine whether that land is as good of a deal as they were hoping. Finally, appraisers can use this study to create a better average price for the land.

Future Work

The results from this work lead to many other questions and paths for follow-up work. The most obvious of these would be to identify a better proxy for land quality than organic material. While this is an important part of the quality of the land, there are other factors that need to be addressed, such as the composition of the soil that is sand, silt, and clay, the slope of the land, and the amount of expected rainfall. One source that could be used for this improvement is in the PVD data already used. The average water-holding capacity variable in this dataset took many of these factors into account. This was the variable that would have ideally been used in this work had there not been issues with its calculation that were discovered. A second source is the USDA Natural Resources Conservation Service (NRCS). The NRCS categorizes soil into different categories such as Kipson, Wabash, and Pawnee soil types. These could be included as a series of categorical variables and could find the value of each type of soil.

A second possibility for future work includes trying to localize the research to a smaller level. The land in Kansas is more consistent across the state than when analyzing the United States as a whole. However, even within Kansas, there is a large variation in the quality of land. Southeast Kansas receives the most rain while Northeast Kansas regularly produces the highest yields on non-irrigated land due to its combination of higher rainfall than Western Kansas and better soil quality than Southeast Kansas. Similar analyses at smaller levels, such as the KFMA regions, would allow for more accurate and applicable results for those in those locales.

This analysis only accounted for the effects from the bottom quartile of land sales. Future work could incorporate results from different ranges in quality. Quartiles were chosen subjectively, so for example ten percent increments could be analyzed. This study only focused on the bottom quartile to explain what the producers in Kansas were experiencing. Future work could include how the price changes with the other three quartiles. Finally, the work did not include majority irrigated land in its analysis. Including this could have major implications in the western part of the state that sits over the Ogallala aquifer.

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