Determining Land Values Using Ordinary Least Squares Regression

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ABSTRACT

Agricultural land values have increased by an average of 21 percent each year since 2010 until recently when commodity prices dropped substantially. The accompanying decrease in profitability raises concerns that current land prices are not sustainable. This study presents a regression analysis of land prices in Kansas using data from 2012 through June 2014. Regression allows valuation of individual characteristics of land parcels as well as time adjustments. Prices projected by the model trended upward through 2013, but decreased between the last quarter of 2013 and the first quarter of 2014, suggesting that prices for land may have peaked in 2013.

Introduction

Agricultural land values have been increasing at a rapid pace for the last several years. In Kansas, non-irrigated land has increased by an average of 21 percent each year since 2010. Similar growth in land values has occurred for irrigated cropland (24%) and pasture (15%) on an annual basis (Taylor & Dhuyvetter, 2014). These growth rates are likely driven by a combination of factors, including low interest rates for borrowers, low yields on investments (certificates of deposit, treasury bills), and high returns to farming. Returns to farming have been driven by high commodity prices and have allowed farmers to reinvest cash into their operations by purchasing more land as it becomes available.

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If returns to farming decline, will current land prices be sustainable? Early in the run-up in land values, lenders were warned about the potential for a land price bubble, which occurs when prices rise to unsustainable levels. Recognizing changes in market prices can be difficult depending on the amount of data available and the methods used to analyze the data. One approach is to average the price per acre from a sample of land sales that have occurred in an area over time (e.g., quarterly or monthly). The disadvantage of using average prices to track changes in price, over time, is that averages do not control for the type of land that is sold. Location, parcel size, and land quality characteristics can affect the price per acre. If the mix of land characteristics within the sample time period is not representative of all land sold, then a simple average may be biased.

Linear regression is an alternative method of analysis. Regressing the price per acre of each parcel in the sample on parcel-specific characteristics provides an average price estimate that controls for not only those characteristics, but also seasonal selling patterns. Price estimates from a linear regression model can give a clearer picture of the land market and help market participants understand and detect changing prices.

Literature Review

Regression has been widely used for many years in economic analysis. Postier et al. (1992) showed the use of regression for evaluating factors that affect the price of land. More recently, Wild (2009) argued that regression can be used to analyze datasets objectively to estimate a number of values of importance. Schurle, et al. (2013) used a regression model to show that USDA land values lag the market, as reflected by sales data. Stephens and Schurle (2013) used a regression model to estimate the value of rainfall, selling at auction, and time adjustments for land values using an index for the month of the sale to adjust for time. Wilson, et al. (2014) used regression to estimate the value of different types of cropland, which is valuable for appraisal work when puritan sales are difficult to find. Their analysis also used a linear time trend and dummy variables to estimate adjustments in prices over time. These articles demonstrate the usefulness of regression for estimating values that are used by appraisers.

Data

The sales data used for this study was collected by a Kansas agricultural lender for use in their appraisal department. The sales are from 2012, 2013, and the first half of 2014 and cover 39 counties in the eastern third of the state. There is an average of 40 sales per county. The sales data include the value of improvements, which was deducted from the total sale price to arrive at a dollar value per acre of land. Parcels that are less than 70 acres in size were removed from the dataset to prevent the influence of sale price of non-agricultural uses for small tracts of land. The average sale price across all counties and all years is $2,358.93 per acre. The average size of a parcel is 191.7 acres.

In addition to the sale price, parcel size, date of sale, and location of the land, the data include categories of land types found on the parcel that was sold. All cropland acres are classified into one of four categories (listed from best quality to worst): Bottom ground, class A, class B, and class C. These classifications are meant to convey the quality of the land for farming purposes and represent soil quality, slope, and water-holding capacity. Categories for pasture, recreational ground, and acres enrolled in CRP are separate from the cropland categories. The category designated as "other land" includes building sites, timberland, and roads or waste ground. Summary statistics of the data are presented in Table 1.

Statistical Methods

Analysis of a large number of land sales to determine the average value of land in the sample or isolate the value of individual characteristics is most easily accomplished using the Ordinary Least Squares (OLS) regression technique. Regression analysis is more accurate than taking a simple average because it accounts for the similarities and differences of measurable characteristics across parcels in a sample. For example, if a large proportion of the observed sales in a given time period are high-quality cropland, then the simple average of price across these sales will be inflated due to the higher price of high-quality land. Estimates from an OLS regression will account for the quality of ground and provide price estimates for each classification of land in the sample.

The structure of the regression equation is based on a hedonic pricing model. A hedonic model estimates the implicit value of parcel-specific characteristics, such as land quality, parcel size, and county location, by measuring the contribution of each characteristic to the overall price of the land. For this study, the regression equation is specified as follows:

(1) *Sale Price = f (land classification, parcel size, sale year, sale quarter, county location)*

where the sale price per acre of a given parcel of land is defined as a linear function of the different land classifications found on that parcel, the size of the parcel in acres, the year and quarter in which the parcel sold, and the county where the parcel is located. Each of these parcel-specific characteristics is included in the model to control for differences across land that will affect sale price.

The linear regression model includes the number of acres from each land classification found on a parcel as a proportion of the total parcel acreage. The four cropland classifications (*BGround, ClassA, ClassB, and ClassC*) measure the impact of different cropland quality ratings on overall land price. The impact of the non-cropland classifications, including *Pasture, CRP, Recreation,* and *Other* land, will depend on the economic returns of those classifications relative to cropland. *Pasture* land was omitted from the regression to avoid perfect co-linearity in the estimation. As such, all the coefficients for the land classifications are interpreted relative to pasture land.

The size of each parcel is included in the model as both a linear and squared term. Small parcels tend to sell for higher per-acre prices than large tracts of land, likely because a larger number of potential buyers can pay cash or finance smaller acreages. Including the squared parcel size allows the size effect to dissipate as the parcels get very large.

The county in which a parcel is located was included to account for a variety of factors affecting price that change across the region. These factors include, but are not limited to: differences in county tax rates, proximity to urban areas, and rainfall patterns. Each of the 39 county dummy variables are specified as equal to one if a parcel was located in that county and zero otherwise. As with the land classification variables, one of the county dummy variables is omitted from the regression. The omitted county is Pottawatomie and all the remaining county variables are interpreted relative to this county. Pottawatomie was selected for omission because it has a good mix of all the different cropland classifications and is centrally located relative to the other counties considered in this analysis. The average sales price and number of sales observed per county is shown in Table 2.

To account for seasonal selling patterns, quarterly dummy variables are included in the model. Each quarter dummy variable is equal to one if a parcel is sold in that quarter and zero otherwise. These variables detect any changes in sale price that occur at the same time each year. Also included are annual dummy variables equal to one for the year in which a parcel sold and zero otherwise. The annual variables will measure year to year changes in price, holding all other factors constant. The omitted variables for season and year are the third quarter and 2014, respectively. Once the model is estimated, the model can predict average land prices for each of the ten quarters observed in the dataset, thus providing an overview of the trends in eastern Kansas agricultural land prices over the observed time period.

Results

Table 3 shows the results of the regression model. The coefficients are interpreted relative to the price of pasture in Pottawatomie County for the third quarter of 2014. The first seven variable coefficients show the adjustments to the price per acre of pasture for each of the types of land listed. Bottom ground cropland sells for $2,516.70 per acre more than pasture. Class A cropland is valued at $1,344.99 per acre more than pasture. Class B cropland is worth $1,317.31 more than pasture. These price differences represent the difference in productive capacity of the land for purposes of growing crops. Class C cropland, land under CRP contract, and recreation ground land do not tend to sell for a statistically different amount than pasture land, while the 'other' land category sells for slightly less per acre than pasture.

The variables we are most interested in for this report are the values for adjusting the price of land each year, and for each quarter within the year. Year 2014 was left out of the model, so the coefficients for *Y2012* and *Y2013* show the adjustments to price in year 2014. Prices were $447.99 lower in 2012 than in 2014, and they were $182.41 lower in 2013 than in 2014. Quarter 3 was left out of the model, so *Q1*, *Q2*, and *Q4* are the adjustments to the price in the third quarter. Land selling in the first quarter and second quarters do not sell for statistically different prices than land selling in the third quarter. However, prices in the fourth quarter are $187.37 per acre higher than third quarter prices. The tendency for land sold in the last quarter of the year to be higher priced than land sold in the first three quarters of the year is an annual pattern that is distinct from the overall annual upward trend in prices observed during the years analyzed in this study.

The dummy variable coefficients for each county reflect the price adjustments relative to the county that was left out of the model (Pottawatomie County). Land values vary substantially across the 39 counties. For example, Doniphan County (*Cnty13*) prices were $2,925.99 per acre higher than the prices in Pottawatomie County. On the other extreme, Allen (*Cnty1*) prices were $968.58 per acre lower than Pottawatomie County.

Figure 1 presents both model-predicted prices and simple average prices for each quarter. The use of simple average prices to determine market trends might not tell the full story of what the market is doing. If large quantities of either low-priced or high-priced land sell during a given period, the average will shift in that direction. However, the predicted average price from a regression model that controls for the quality of land being sold in all periods will give a more accurate reflection of the land market and avoid bias in evaluating price trends.

The use of dummy variables for each quarter observed controls for seasonal effects in the land market. In Kansas, land prices tend to be stronger in the last quarter of the year as compared to the first, second, and third quarters. This seasonal pattern is distinct from the overall upward trend in prices that is observed for the time period in this study. Figure 2 shows the regression model's predicted price for each quarter. The interesting result from this figure is that the predicted prices for Quarters 1 and 2 of 2014 are both lower than the predicted price in the last quarter of 2013. This is the first time in the periods observed that the upward trend in prices has not been stronger than the season pattern effect.

Another way to view the relationship between the upward time trend and the seasonal pattern is by examining the percentage change in predicted prices over time. Figure 3 shows the percentage change in the predicted prices between each quarter in the data. Quarter 9, the first quarter in 2014, shows a 2.1 percent decrease in predicted price over the last quarter in 2013. The 1.0 percent increase in the second quarter of 2014 still does not bring projected prices up to the level at the end of 2013. This may indicate that the land market peaked in 2013, and 2014 will be the first year of weaker land prices.

Summary

This study presents an analysis of recent pricing patterns for farmland in Kansas. A dataset of land sales that occurred between January 2012 and June 2014 across 39 eastern Kansas counties is analyzed in a linear regression framework. The results of this study, while applicable for Eastern Kansas, will be of limited value to other states due to differences in the local land markets, quality of land, and earning potential from both agricultural and non-agricultural uses. Despite this limitation, the Kansas data provide an example of the usefulness of OLS regression estimation for analyzing both parcel-specific characteristic values and market-wide season and year impacts.

Results of the study indicate that land prices have a seasonal fluctuation where prices are low in the first quarter of the year and higher in the last quarter of the year. The overall trend for prices has been upward, with positive percentage changes in land prices for each quarter through the end of 2013. However, a negative price change occurred between the last quarter of 2013 and the first quarter of 2014 which could be an indication of a softening of the land market. The results of this study may be sensitive to other factors not considered in the analysis, including interest rates and net farm incomes. Additional land sales observations across both time and space would be needed to confirm a market downturn for this region of Kansas.

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Figure 1. Comparison of regression model predicted prices and simple average prices.

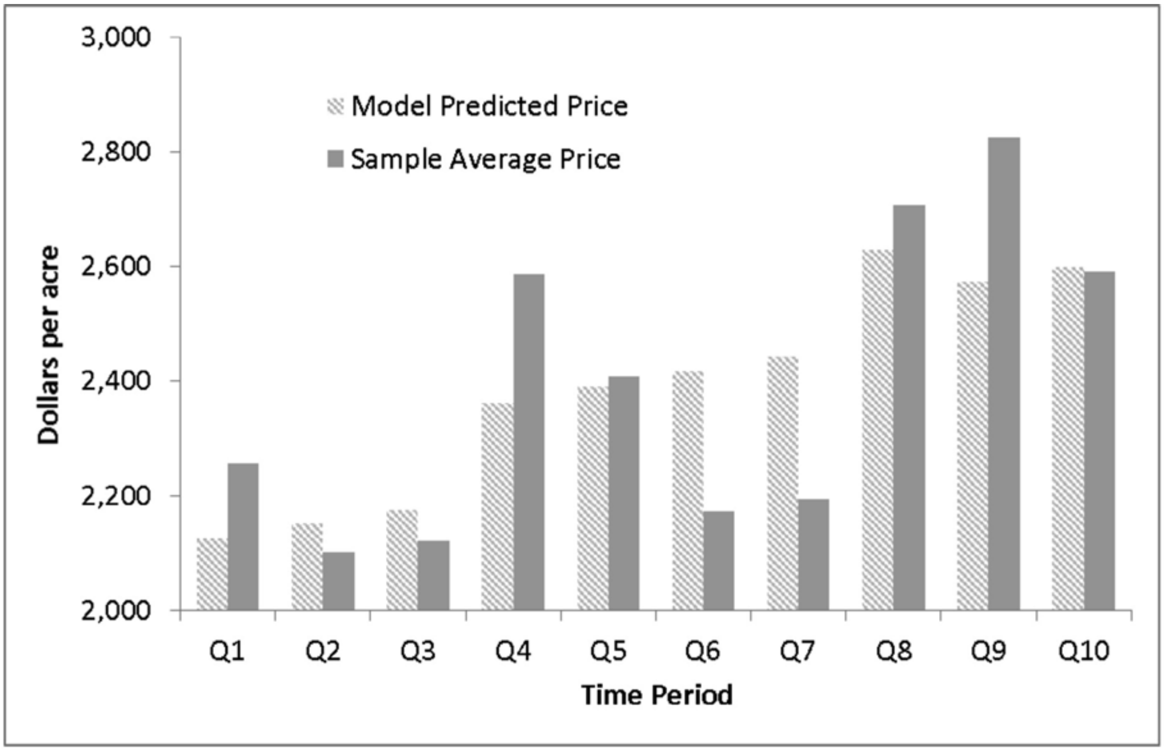

Figure 2. Regression model predicted prices by year.

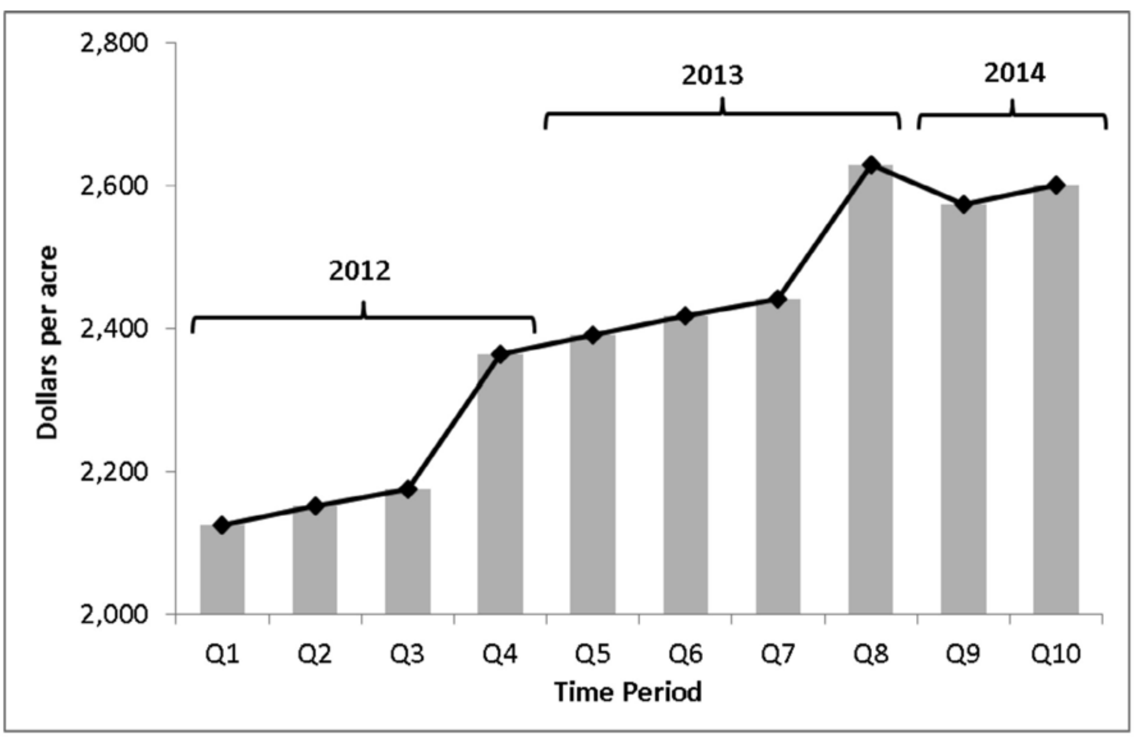

Figure 3. Percentage change in regression model predicted prices by year.

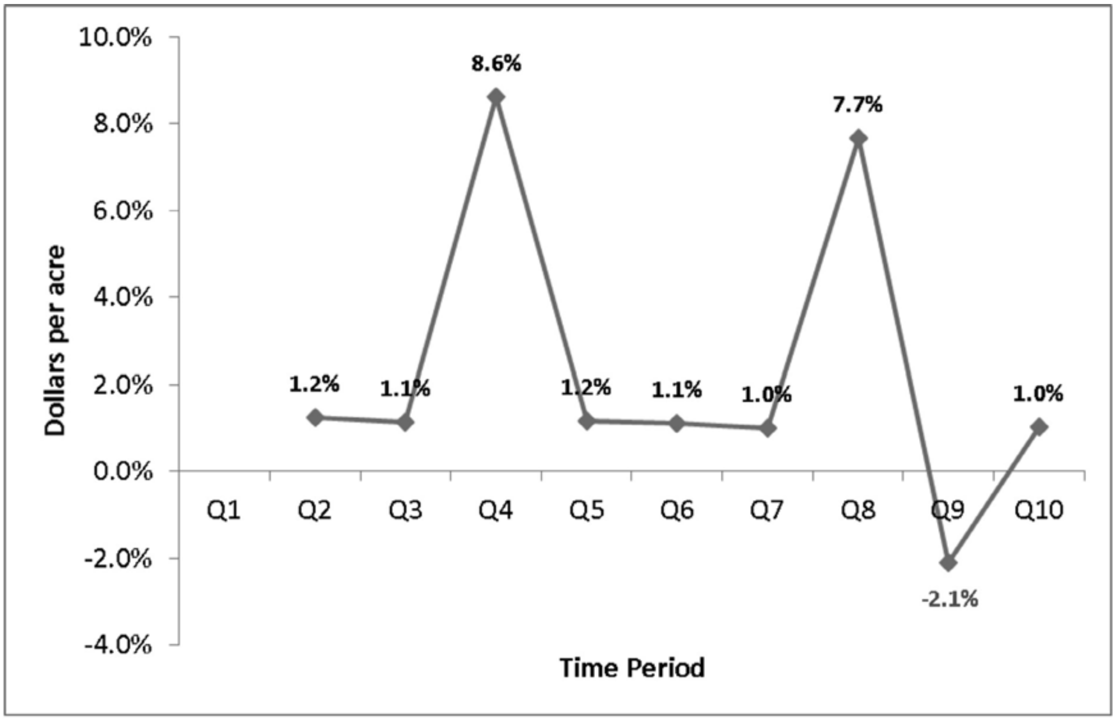

Table 1. Summary statistics of model parameters

Variable	Description	Mean	Standard Deviation	Minimum	Maximum
Price	Price of agricultural land sold ($/ac)	2,358.93	1,363.38	800.00	10,256.41
BGround	Bottom ground land (% of total acres)	0.05	0.17	0.00	1.00
*ClassA**	Class A land (% of total acres)	0.20	0.29	0.00	1.00
ClassB	Class B land (% of total acres)	0.08	0.18	0.00	0.99
ClassC	Class C land (% of total acres)	0.02	0.09	0.00	0.91
Pasture	Grazing land (% of total acres)	0.47	0.41	0.00	1.00
CRP	Land under CRP contract (% of total acres)	0.03	0.11	0.00	0.94
Recreation	Land suitable for recreation (% of total acres)	0.12	0.24	0.00	1.00
Other	All other land in parcel (% of total acres)	0.04	0.07	0.00	1.00
Size	Total parcel size (acres)	191.70	319.15	70.00	8,743.00
$Size^2$	Total parcel size squared (acres)	138,541.00	2,053,581.00	4,900.00	76,400,000.00
Y2012	Binary variable equal to one if sold in 2012	0.49	0.50	0	1
Y2013	Binary variable equal to one if sold in 2013	0.40	0.49	0	1
*Y2014**	Binary variable equal to one if sold in 2014	0.11	0.31	0	1
Q1	Binary variable equal to one if sold in first quarter of the calendar year	0.33	0.47	0	1
Q2	Binary variable equal to one if sold in second quarter of the calendar year	0.23	0.42	0	1
*Q3**	Binary variable equal to one if sold in third quarter of the calendar year	0.18	0.38	0	1
Q4	Binary variable equal to one if sold in fourth quarter of the calendar year	0.27	0.44	0	1

Table 1. Summary statistics of model parameters (cont'd.)

Cnty1	Allen County (binary variables)	0.02	0.13	0	1
Cnty2	Anderson County	0.01	0.12	0	1
Cnty3	Atchison County	0.01	0.12	0	1
Cnty4	Bourbon County	0.04	0.19	0	1
Cnty5	Brown County	0.03	0.17	0	1
Cnty6	Chase County	0.02	0.13	0	1
Cnty7	Chautauqua County	0.02	0.15	0	1
Cnty8	Cherokee County	0.02	0.12	0	1
Cnty9	Clay County	0.04	0.19	0	1
Cnty10	Coffey County	0.03	0.16	0	1
Cnty11	Crawford County	0.03	0.16	0	1
Cnty12	Dickinson County	0.05	0.21	0	1
Cnty13	Doniphan County	0.01	0.12	0	1
Cnty14	Douglas County	0.02	0.13	0	1
Cnty15	Elk County	0.01	0.10	0	1
Cnty16	Franklin County	0.02	0.13	0	1
Cnty17	Geary County	0.02	0.13	0	1
Cnty18	Greenwood County	0.04	0.19	0	1
Cnty19	Jackson County	0.04	0.20	0	1
Cnty20	Jefferson County	0.03	0.16	0	1
Cnty21	Labette County	0.04	0.19	0	1
Cnty22	Leavenworth County	0.01	0.11	0	1
Cnty23	Linn County	0.02	0.14	0	1
Cnty24	Lyon County	0.04	0.19	0	1
Cnty25	Marion County	0.05	0.21	0	1
Cnty26	Marshall County	0.03	0.17	0	1
Cnty27	Miami County	0.02	0.14	0	1
Cnty28	Montgomery County	0.02	0.14	0	1
Cnty29	Morris County	0.02	0.15	0	1
Cnty30	Nemaha County	0.03	0.17	0	1
Cnty31	Neosho County	0.02	0.15	0	1
Cnty32	Osage County	0.04	0.19	0	1
*Cnty33**	Pottawatomie County	0.03	0.17	0	1
Cnty34	Riley County	0.02	0.13	0	1
Cnty35	Shawnee County	0.01	0.10	0	1
Cnty36	Wabaunsee County	0.03	0.17	0	1
Cnty37	Washington County	0.03	0.18	0	1
Cnty38	Wilson County	0.03	0.16	0	1
Cnty39	Woodson County	0.03	0.16	0	1

*Variable is omitted from the linear regression. There are 1,632 observations in the

Table 2. County-level land prices and observations

Variable	County Name	Average Sale Price	Standard Deviation	Number of Sales
Cnty1	Allen	1,554.71	448.73	30
Cnty2	Anderson	1,617.05	444.59	22
Cnty3	Atchison	3,516.83	1,121.40	22
Cnty4	Bourbon	1,457.41	241.58	63
Cnty5	Brown	5,513.33	2,176.82	49
Cnty6	Chase	1,980.40	527.93	29
Cnty7	Chautauqua	1,313.23	199.99	38
Cnty8	Cherokee	1,825.00	498.49	25
Cnty9	Clay	3,316.79	1,615.78	60
Cnty10	Coffey	1,824.12	518.40	43
Cnty11	Crawford	1,655.54	320.89	43
Cnty12	Dickinson	2,769.72	941.46	79
Cnty13	Doniphan	5,628.26	1,766.66	23
Cnty14	Douglas	2,998.07	1,108.33	30
Cnty15	Elk	1,449.75	307.96	16
Cnty16	Franklin	2,492.42	599.59	29
Cnty17	Geary	1,605.99	531.78	26
Cnty18	Greenwood	1,552.66	427.89	63
Cnty19	Jackson	2,234.86	766.45	68
Cnty20	Jefferson	2,278.53	586.54	43
Cnty21	Labette	1,681.40	404.23	59
Cnty22	Leavenworth	3,158.34	808.13	19
Cnty23	Linn	1,950.95	477.25	35
Cnty24	Lyon	1,785.12	683.88	60
Cnty25	Marion	2,319.61	842.21	74
Cnty26	Marshall	4,195.55	1,439.62	46
Cnty27	Miami	3,366.56	1,386.17	32
Cnty28	Montgomery	1,587.92	409.97	33
Cnty29	Morris	1,709.10	602.68	38
Cnty30	Nemaha	4,260.62	1,482.62	51
Cnty31	Neosho	1,541.11	467.71	40
Cnty32	Osage	1,629.59	377.00	58
*Cnty33**	Pottawatomi	2,309.59	1,001.96	50
Cnty34	Riley	2,362.39	937.11	28
Cnty35	Shawnee	2,646.43	1,385.75	18
Cnty36	Wabaunsee	1,647.68	858.29	51
Cnty37	Washington	2,882.19	986.58	54
Cnty38	Wilson	1,557.36	249.59	41
Cnty39	Woodson	1,656.01	595.70	44

Table 3. Parameter estimates from linear regression model

Variable	Coefficient		Standard Error	T Statistic
BGround	2,516.70	*	117.42	21.43
ClassA	1,344.99	*	74.18	18.13
ClassB	1,317.31	*	123.42	10.67
ClassC	-118.13		243.42	-0.49
CRP	-49.88		168.55	-0.30
Recreation	56.95		83.98	0.68
Other	-3.88	*	1.67	-2.32
Size	-0.12		0.12	-1.00
$Size^2$	0.00		0.00	1.29
Y2012	-447.99	*	68.22	-6.57
Y2013	-182.41	*	68.98	-2.64
Q1	-50.50		57.69	-0.88
Q2	-24.29		59.73	-0.41
Q4	187.37	*	57.57	3.25
Cnty1	-968.58	*	171.10	-5.66
Cnty2	-767.21	*	192.14	-3.99
Cnty3	977.63	*	200.79	4.87
Cnty4	-785.01	*	141.54	-5.55
Cnty5	2,681.99	*	155.67	17.23
Cnty6	-377.75	**	172.90	-2.18
Cnty7	-713.88	*	162.58	-4.39
Cnty8	-749.87	*	182.30	-4.11
Cnty9	375.54	*	143.57	2.62
Cnty10	-592.34	*	154.52	-3.83
Cnty11	-771.40	*	154.17	-5.00
Cnty12	-135.97		138.29	-0.98
Cnty13	2,925.99	*	196.20	14.91
Cnty14	246.45		171.30	1.44
Cnty15	-713.56	*	212.26	-3.36
Cnty16	-95.59		173.72	-0.55
Cnty17	-694.89	*	178.05	-3.90
Cnty18	-582.71	*	141.23	-4.13
Cnty19	72.33		140.59	0.51
Cnty20	0.83		155.88	0.01
Cnty21	-779.54	*	142.74	-5.46
Cnty22	615.90	*	201.51	3.06
Cnty23	-562.71	*	163.78	-3.44
Cnty24	-583.98	*	141.76	-4.12
Cnty25	-246.62	***	136.99	-1.80
Cnty26	1,284.48	*	154.26	8.33
Cnty27	1,020.53	*	166.81	6.12
Cnty28	-902.29	*	165.49	-5.45
Cnty29	-821.16	*	160.54	-5.12
Cnty30	1,622.17	*	156.66	10.35
Cnty31	-866.97	*	156.79	-5.53
Cnty32	-639.33	*	142.67	-4.48
Cnty34	-42.21		173.69	-0.24
Cnty35	-160.63		203.59	-0.79
Cnty36	-562.36	*	146.89	-3.83
Cnty37	318.21	*	148.28	2.15
Cnty38	-871.44	*	156.36	-5.57
Cnty39	-612.81	*	152.84	-4.01
Constant	2,265.81	*	131.72	17.20
R squared	0.72			
No. of Observations	1,632			

Note: The *, **, and *** respresent the level of statistical significance for the coefficient with 1%, 5%, and 10% significance, respectively.