Agricultural Land and the Small Parcel Size Premium Puzzle

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ABSTRACT. *Per acre prices of agricultural land increase as parcel sizes decrease. The puzzle is why all agricultural land is not sold in small parcels. Small parcels tend to be close to residential areas and close to quality roads. The small parcel premium lessens as parcels are more distant from urban areas. This suggests that much of the small parcel premium is due to parcels being purchased based on nonagricultural use values. Thus, an explanation of the small parcel premium puzzle is that land with low nonagricultural use values may not have a small parcel premium.* (JEL Q15, R14)

I. INTRODUCTION

This study seeks to provide a greater understanding of the extent and causes of the per acre premium for small parcels of agricultural land. Considerable research has shown that price per acre of agricultural land is inversely related to parcel size (Jennings and Kletke 1977; Hepner 1985; Miller 2006; Tsoodle, Golden, and Featherstone 2006; Guiling, Brorsen, and Doye 2009; Ma and Swinton 2012). This small parcel premium raises the question of why more agricultural land is not sold in small parcels.

Breaking large tracts into smaller parcels is a form of fragmentation, but it is typically fragmentation of land ownership rather than fragmentation of land use. Prior research has primarily focused on fragmentation of land use (Brabec and Smith 2002; Irwin and Bockstael 2001; Kjelland et al. 2007; Lewis, Plantinga, and Wu 2009). Fragmentation of ownership is an alternative research direction.

We offer a theory to explain why price per acre decreases with parcel size. The primary theoretical argument is that returns from some uses such as a home site are associated with owning a parcel and increase little with parcel size. Sengupta and Osgood (2003) find that buyers of land for exurban or residential land use tend to prefer smaller parcels. The purchase of a parcel for exurban use does not automatically remove that parcel from agricultural production; some may purchase in the hopes to live a "rural lifestyle." Often, purchasers become "hobby farmers"[1] (Sengupta and Osgood 2003). As a parcel's size increases, so too does the likelihood that the parcel will be used for agricultural production (Koontz 2001; Carrión-Flores, Flores-Lagunes, and Guci 2009).

The major policy concern associated with the fragmentation of agricultural land is agricultural productivity. From a farmer or rancher's perspective, the smaller a land parcel becomes, the more costly it may become to produce agricultural products from it. Although Theobald (2005) notes that there is no set point at which a parcel becomes small enough to prevent agricultural production, should the parcel size become small enough, production would become cost prohibitive (Jabarin and Epplin 1994). Previous research relating land fragmentation and agricultural productivity has focused on countries where the fragmentation is more severe than in the United States and has found that fragmentation reduced agricultural productivity in

[1] Farms with less than $10,000 in yearly sales are typically considered recreational.

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China (Nguyen, Cheng, and Findlay 1996), Spain (del Corral, Perez, and Roibas 2011), Rwanda (Mathias 2010), and Nigeria (Austin, Ulunma, and Sulaiman 2012).

Agricultural productivity is not the only concern. Wildlife management (Wilkins et al. 2003), soil conservation, and public road access become more of a problem as land ownership is fragmented.

To advance understanding of the small parcel size premium, data from agricultural land sales in Oklahoma are used to estimate the effect of parcel size on agricultural land prices. The small parcel size premium is confirmed. Results show that parcel size decreases near urban areas. As urban proximity and access to roads increase, the small parcel premium increases, as well as the price per acre. No clear time trend in the size of parcels could be found.

II. THEORY

A theory of agricultural land parcel size needs to explain why small parcels have a higher per acre price than larger parcels. It also needs to explain why this is not always the case. Dating back to the time of classical economists, capitalization theory has been used to determine the value of land (Morton 1970). The capitalization formula is

$$\textit{Agricultural Land Value} = \textit{Returns}/\textit{Discount Rate}. \quad [1]$$

Since land can have multiple uses, the capitalization formula can be more formally expressed as

$$V_t = \sum\nolimits_{\tau=t}^{\infty} \sum\nolimits_{k=1}^{K} R_{k\tau}/\rho_\tau, \quad [2]$$

where V_t is the value of the parcel in year t, $R_{k\tau}$ is the expected return from the kth land use conditional on information available at time t, and ρ_τ is the discount rate in year τ. Here returns can be from agricultural use, recreational use, exurban land use, or urban conversion. Rural residential development is a form of exurban land use (Theobald 2005; Newburn and Berck 2006). If the urban conversion option is chosen, it is irreversible; returns from urban conversion are a one-time return and all other returns end. Agricultural land values include the value of the option of converting the land to urban use at some point in the future (Capozza and Helsley 1989; Plantinga, Lubowski, and Stavens 2002). Like most past land value models, our empirical model is a hedonic pricing model based on [2]. A hedonic pricing model is a regression of price against characteristics that represent the different types of returns.

The returns from owning land parcels are typically viewed as being realized on a per acre basis. For agricultural uses, the per acre basis clearly makes sense. However, the benefits of some uses may require only a parcel of some minimum size. For example, if the owner's main goal is purchasing land to build a house and acquire space to keep a horse, then a few acres are sufficient. Should the owner want a spot to build a fishing pond or produce for a farmer's market, then 40 acres may be plenty. If the owner's goal is to keep a small herd of cows, then 80 to 160 acres is enough. In some cases, the owner may simply want to own some land. As exemplified in these cases, the returns to some uses do not increase much with parcel size beyond a specific point. Kjelland et al. (2007) used county-level data and found that small parcels were more frequent in counties with high population densities and high land prices.

Not all parcels will have returns associated with the parcel rather than returns on a per acre basis. In rural areas with either poor roads or little potential for deer hunting or other recreational activities, all the value will be due to the parcel's agricultural returns, which should not decrease as parcel size increases.

Another factor that may play a role in determining small parcel premiums is the number of bidders. Land is sold both by auction and by negotiated sale. Auction theory of both private-value auctions and affiliated-value first-price auctions has shown that prices increase with the number of bidders (McAfee and McMillan 1987). Because of capital or borrowing constraints and risk aversion, the number of bidders likely decreases with parcel size. Therefore, reduced competition may explain some of the reduced prices for larger parcels.

The discussion so far has focused on the demand side, with strong arguments as to why the demand is greater for smaller parcels. Throughout the years, researchers have sought to model the supply of agricultural land. The inelasticity of farmland supply has prohibited them from developing an appropriate model (Weersink et al. 1999; Burt 1986). Quantity supplied for agricultural parcels is fixed in any given year. Simply using the number of land sales in a year is not a suitable alternative for quantity supplied because in a given year, a parcel may be put up for sale but not sold. Here it would be part of the supply and yet would not be counted among land sales. While the amount of farmland available for sale may change over time, the amount is relatively independent of farmland prices (Burt 1986). Supply of land by parcel size is a more difficult problem than supply of land in general and is an issue that has not been addressed in this previous literature.

There may be additional reasons that sellers do not choose smaller parcel sizes. Land is not a liquid asset. Selling commissions average 5% (U.S. Department of Justice 2009), legal costs such as bringing the abstract up to date can be substantial, and some portions of the proceeds are often subject to capital gains taxes. Also, the decision to sell land is typically irreversible and investment substitutes are imperfect. As a result, parcels are typically either offered at an estate sale or because the owner needs the money to offset a financial hardship, although some parcels will sell occasionally because someone has offered a favorable price for the land. This desire to sell large parcels immediately could result in a liquidity cost.

Once sellers have committed to selling, they are still faced with a choice of what size parcels to sell. For example, the owner of a 160 acre parcel can choose to either sell the parcel as a whole or divide it into two separate 80 acre parcels. However, the choice to sell as two parcels can create a dilemma. An agricultural buyer might prefer the larger 160 acre parcel and be willing to pay more per acre for the whole parcel than for only half of it. If only one buyer is interested in paying a premium for an 80 acre parcel then the seller could be left with one 80 acre parcel that may be more difficult to sell. This could cause the total value of the two 80 acre parcels to be less than the price a buyer is willing to pay for the single 160 acre parcel. Often at land auctions in rural areas, a 160 acre parcel will be offered as two separate 80 acre tracts and then offered as a single 160 acre tract. The 160 acre parcel will typically receive a higher price than the combined prices of the separate 80 acre parcels. Therefore there may be a liquidity cost to wanting to sell more than one 80 acre parcel at a time. Transaction costs such as the seller's time and legal expenses would also be higher from making two separate sales rather than one.

III. OKLAHOMA HISTORY AND GEOGRAPHY

Settlement patterns may account for some of the differences in parcel sizes across Oklahoma. In Oklahoma, all land is surveyed from the Initial Point in Murray County, with the exception of land located in the Panhandle. Rather than using the Indian Baseline and Meridian, land in the Panhandle is surveyed from the Cimarron Baseline and Meridian. The Initial Point, establishing the Indian Baseline and Meridian, was set in 1870. It is from this point that land was laid out in townships and ranges, with each township and range being 6 miles with a total land area of 36 square miles (Oklahoma Society of Land Surveyors 2010). The sections (640 acres) are further subdivided into quarter sections of 160 acres, which is often found throughout Oklahoma (National Atlas 2011). Oklahoma, or Indian Territory, as it was known at the time, was resurveyed in 1890 to include land belonging to the Choctaw, Chickasaw, Cherokee, Muscogee, and Seminole Indian tribes. The western half of the state was settled between 1889 and 1901 in either a land rush or a land lottery. Prior to a land rush or lottery, a tribe would allot each man, woman, and child 160 acres of land. The surplus land was then sold to the United States to be used in land runs or lotteries (Oklahoma Historical Society 2007b). Quarter sections and town lots were available to settlers (Bohannon and Coelho 1998), with the exception of Osage County. Unlike other Indian tribal lands in Oklahoma, Osage lands, which comprise Osage County, never came under the Homestead Act of 1862. The Osage had previously purchased their land and owned it in fee simple. They allotted their land to tribal members from 1906 to 1907. This Osage allotment provided a headright holder, one who could receive an equal share of the tribe's mineral interests and an allotment of land slightly larger than 640 acres. This division left the Osage with no surplus land (Oklahoma Historical Society 2007a). Tribal land accounts for 2.5% of the land in Oklahoma (Bureau of Indian Affairs 1990).

Geography may explain some of the differences in location of smaller versus larger parcels. The eastern half of the state has more hills and trees, while the western half is a flat or rolling plain with considerably less tree cover. These differences lead to a difference in production practices. The eastern half of the state tends to focus on cattle production, and the western half is typically used for wheat production. The Oklahoma City and Tulsa metropolitan areas are by far the most populated regions of Oklahoma, accounting for almost two-thirds of the state's population.

Every county in Oklahoma has some paved roads as well as some towns. Therefore, every county in Oklahoma is expected to have some land that is more valued in small parcels.

IV. DATA

The data for this research were collected by Farm Credit Service institutions in Oklahoma from 1971 to 2012. Farm sales transaction data include land classification, parcel size, date of sale, legal description specified to the section, and county. The dataset is extensive and it is intended to provide a representation of agricultural land transactions that took place within the state, with the exception that 1995–1996 and 2006 data are clearly lacking in the number of reported land sales. Possible explanations for the lack of data in 1995–1996 include data collection difficulties and the retirement of a faculty member responsible for the dataset. Additionally, since 2000 some Farm Credit Service offices have been subcontracting their land appraisals and therefore their data collection to other parties. There is also some variation across districts in which sales are included.

Observations with missing price information and duplicated observations were removed from the dataset. Observations lacking a legal description or having other missing data were not used. Outliers of less than $100 and greater than $5,000 per acre were also removed. Parcels that were less than 20 acres or greater than 2,000 acres were removed. Additional observations were lost due to failure to pass error checks such as restricting the sum of pasture and crop acres to be less than the total acres. Of the original 63,064 observations, there were 54,929 usable observations. For graphical purposes, a "crop" parcel consists of at least 50% cropland and "pasture" parcels are at least 50% pasture land. The fair market value of improvements was estimated by the appraiser. The value of the improvements was not included in the calculation of price per acre.

Farm Credit Service appraisers are expected to attempt to write up every arm's-length agricultural transaction.[2] The data, however, do not include the population of all agricultural land transactions. Appraisers at each office choose which sales are included, which may result in variation across offices and across time as appraisers change.

Appraisers use a variety of descriptors to classify land. We reduced the classifications to cropland, pasture, and other uses such as timber, water, and waste/roads. For example, "native pasture" and "improved pasture" classifications are both included under the more general term "pasture." Land in the Conservation Reserve Program (CRP) was classified as "other." The CRP is a voluntary program in which farmers can receive annual rental payments and other benefits in exchange for allowing resource conserving cover on eligible farmland (USDA 2011).

Rural-Urban Continuum Codes were developed by the U.S. Department of Agriculture Economic Research Service to distinguish between rural and urban areas. These codes classify metropolitan and nonmetropol-

[2] An arm's-length transaction is a sale between unrelated parties, and there is no other reason that the sales price might differ from the market price. Sales of land that are expected to be converted to urban use are not considered agricultural and are not included.

TABLE 1
Characteristics of Parcel Size Categories for the First and Last Decade of Collected Data

Time/Size	Number of Observations	Average Number of Acres	Average Price per Acre ($)	% Pasture	Rural-Urban Code	County Population
1971–1980						
20–40 acres	1,225	33	1,152	80	5.04	48,960
41–160 acres	7,033	123	618	55	5.70	31,740
161–320 acres	1,497	251	472	62	5.99	27,000
321–640 acres	596	461	386	75	6.02	26,775
641 + acres	233	1,066	353	85	6.40	21,549
Weighted average	10,584[a]	170	656	60	5.67	32,559
2001–2012						
20–40 acres	1,966	33	2,053	92	4.92	45,802
41–160 acres	10,793	116	1,202	69	5.56	32,702
161–320 acres	2,452	252	968	71	6.07	26,597
321–640 acres	1,007	460	891	79	6.40	22,672
641 + acres	378	1,081	882	86	6.39	23,431
Weighted average	16,596[a]	169	1,242	73%	5.67	32,532

[a] Total.

itan areas of the United States based on factors such as population size, degree of urbanization, and adjacency to metropolitan areas. The codes are available at the county level. A Rural-Urban Continuum Code of 1 indicates the most metropolitan county, with a population of 1 million or more. In contrast, a county classified as a 9 is a completely rural county, not adjacent to a metropolitan area, and has a population less than 2,500 (USDA-ERS 2004).

Table 1 shows the descriptive statistics for a variety of variables used in the study by parcel size category (20–40, 41–160, 161–320, 321–640, and 641 + acres). The upper portion of the table shows the information for 1971–1980, while the lower portion of the table shows information for 2001–2012. Beginning and ending periods of the decades were selected because they make it easier to distinguish structural changes than if the data series were simply split into two pieces. Table 1 shows that price per acre decreased with parcel size in both time periods, as expected. The average parcel size was 170 acres in the early period and 169 acres in the later period. An examination of the distribution of parcels by size category also shows very little difference across time. Thus, these data do not support the hypothesis that parcel size has been decreasing over time. Rural-Urban Continuum Codes indicate that the smaller parcels tend to be in more urban counties. Similarly, small parcel sizes are more common in counties with greater population. Note that the smallest and largest parcel size categories typically have more pasture than medium-sized parcels.

V. METHODS

The procedures focus on three primary hypotheses: (1) the price of a parcel decreases as parcel size increases, (2) small parcel premium increases with proximity to population centers as well as access to quality roads, and (3) parcel size will decrease with proximity to population centers as well as access to quality roads.

First, we test the hypothesis that average per acre price decreases as parcel size increases. To test for the presence of this increase, a semiparametric regression is used with price per acre as the dependent variable and the size of the parcel as the primary explanatory variable. The purpose of this semiparametric model is to determine the shape of the expected inverse relationship between price per acre and parcel size. The semiparametric approach is more flexible than a parametric approach such as a quadratic, which if used here would incorrectly show prices rising at the largest parcel sizes. The semiparametric regression function imposes no functional form for the relationship between price and parcel size. Other explanatory variables are included parametrically. While the semiparametric estimators are less biased than parametric estimators, they are less efficient than a correctly specified parametric model (Powell 1994). Also, semiparametric estimation routines can become unreliable with large numbers of explanatory variables. The semiparametric estimator uses smoothing with local regressions (LOESS). With a local regression, the regression function is locally estimated, with the local function being parametric. The model is

$$\ln(P_i) = \beta_0 + f(Acres_i) + \beta_1 Year_i + \beta_2 Year_i^2 + \varepsilon_i, \quad [3]$$

where P_i is the price per acre received when the parcel was sold, i represents the individual parcel, $f(Acres_i)$ is the nonparametric functional form used to express the number of $Acres_i$ in the parcel, $Year_i$ is the year the parcel was sold (with the first year set equal to one), and ε_i is an error term with a Gaussian distribution. A quadratic function for year is used here rather than fixed effects for year to reduce the number of explanatory variables. The LOESS estimates a different weighted regression for each data point. The tricube weighting function used still gives weight to every observation, but the weight decreases with the distance from the data point being considered.

The data used in the model were separated into four different categories; the model was then run individually for each. The first division was for two time periods: 1971–1980 and 2001–2012. Parcels with a Rural-Urban Continuum Codes 1–5 were considered metropolitan for the purposes of this model, and the remainder as nonmetropolitan. It is expected that the natural log of price per acre will decrease as parcel size increases but at some point will become relatively flat as land becomes valued mostly for agriculture. The semiparametric model does not impose a specific functional form on this relationship and thus lets the data identify the shape of the relationship.

For the final hypothesis tested in this study, it is expected that parcel size premiums will vary with location. Capozza and Helsley (1989) argue that the closer a parcel is located near an urban boundary, the higher the price it will achieve. This reflects the value of future increases in rent that can be realized after the land has been converted to urban use. A small parcel premium is expected to occur for similar reasons since small parcels are fine for many urban uses.

Two approaches are used to show the effect of location on the parcel size premium. The premiums are first presented graphically based on a simple model with few parameters. The natural logarithm of price per acre is regressed against parcel size and other hedonic variables. The model is regressed individually for each county in Oklahoma. It is expected that parcel size premiums will vary from county to county, with more urban counties having a higher premium than parcels in more rural settings. The model used is

$$\ln P_i = \beta_0 + \beta_1 Y_i + \beta_2 A_i + \beta_3 L_i + \varepsilon_i, \quad [4]$$

where P_i is the price per acre for parcel i, Y_i is the year parcel i was sold, A_i is the number of acres in parcel i, L_i is the percentage of the land use that is in pasture, and ε_i is the error term. For this equation, the primary focus is on the β_2 coefficient, which is presented on a map to give a visual representation of the spatial distribution of small parcel premiums.

The hypothesis that the small parcel premium is affected by location is tested more formally using a hedonic regression. An innovation in our work is including interaction terms of parcel size and distances to urban areas and roads. These interaction terms allow testing the hypothesis that the small parcel premium increases with proximity to urban areas and roads:

$$\ln P_i = \beta_0 + \sum_{j=1}^{4} \beta_j D_{ij} + \sum_{j=1}^{4} \tau_j D_{ij} A_i + \gamma L_i + \sum_{j=1}^{76} \alpha_j C_{ij} + \sum_{j=1}^{41} \delta_j Y_{ij} + \varepsilon_i, \quad [5]$$

where the dependent variable A_i is the number of acres in parcel i, D_{ij} are distance variables (miles to the closest town with at least 10,000 population, closest town with at least 500 population, closest collector[3] road, and closest arterial road), L_i is a variable indicating the percentage of the parcel in pasture, C_{ij} are indicator variables for the county in which the parcel is located, and Y_{ij} are indicator variables for the year the parcel is sold. Spatial autocorrelation is considered by letting the variance of ε_i be a spherical function[4] of distance for parcels sold in the same year. The standard errors reported are adjusted for possible effects of clustering.[5] The results are robust to various specifications such as random instead of fixed effects for county, dropping spatial autocorrelation, and not adjusting standard errors for clustering.

The final question addressed is, "Where does land ownership fragmentation occur?" Maps were used to provide a visual answer to this question. Since we have only the section rather than the full legal description of the parcels, the latitude and longitude for each parcel is taken as the center point of the section. Also included on the map is the location of the 14 cities in Oklahoma as defined by the 2010 Census (U.S. Census Bureau 2010). Census information defines a place with a population of 25,000 or larger as a city (U.S. Census Bureau 2010). Cities were added to provide relevant landmarks and identify the location of urban areas. Similar maps and tables were made to illustrate both pasture sales and crop sales using 1971–1980 and 2001–2012 time frames. The maps are used to show where small parcels occur as well as to provide additional evidence that parcel size has changed little over time.

Next, we formally test the hypothesis that parcel size decreases with proximity to an urban area. Parcel size is regressed against variables to take into account the parcel's closeness to an urban area, land usage indicator variables, county indicator variables, and year indicator variables. The model used to test this hypothesis is

$$A_i = \beta_0 + \sum_{j=1}^{4} \beta_j D_{ij} + \gamma L_i + \sum_{j=1}^{76} \alpha_j C_{ij} + \sum_{j=1}^{41} \delta_j Y_{ij} + \varepsilon_i, \qquad [6]$$

where the specification and estimation method are the same as in [5]. The parameters are estimated by restricted maximum likelihood, spatial autocorrelation is considered, and standard errors are adjusted for clustering.

VI. RESULTS

For the hypothesis that average price per acre will decrease as parcel size decreases, the semiparametric regression function for equation [3] yielded the expected results (Figure 1). For all four categories, parcel size has an inverse relationship with price per acre. The bulk of this inverse relationship is expected to be explained by nonagricultural uses that do not increase with parcel size. Less competition for large parcels may be a partial explanation, since the graphs in Figure 1 indicate price per acre does not completely flatten out as parcel size increases for the nonmetropolitan parcels in the early time period. For the other three graphs, the price per acre does flatten out at around 320–400 acres. The kinks that can be seen in some of the line graphs may be attributed to a large number of observations clustered around a certain parcel size, for example, a large number of observations around 160 acres. The small parcel size premium is much larger for parcels with fewer than 160 acres than for parcel sizes with more than 160 acres.

For the model testing variability in parcel premiums by county, the log of price per acre was regressed against parcel size, year sold, and other variables describing land use (equation [4]). The regression was run separately for all 77 counties in Oklahoma. The sign for the *Acres* coefficient is negative and statistically significant for all 77 counties. Due to the large volume of results, the results are presented graphically in Figure 2. A more negative coefficient for the variable *Acres* indicates a larger price per acre premium for smaller parcels, while a less negative number means

[3] See the Federal Highway Administration (2013) for formal definitions of arterial and collector roads.

[4] The spherical function is $\sigma^2[1-(3d_{ij}/2\rho)+(d_{ij}^3/2\rho^3)]I(d_{ij} \le \rho)$, where d_{ij} is the Euclidean distance between two parcels and ρ is a parameter to be estimated.

[5] The standard errors are calculated using the Empirical option of SAS/STAT procedure MIXED (SAS Institute 2014). Greene (2012, 545–46) argues that there is little theoretical gain to using such a sandwich estimator, but we use it here since it has become the convention to do so.

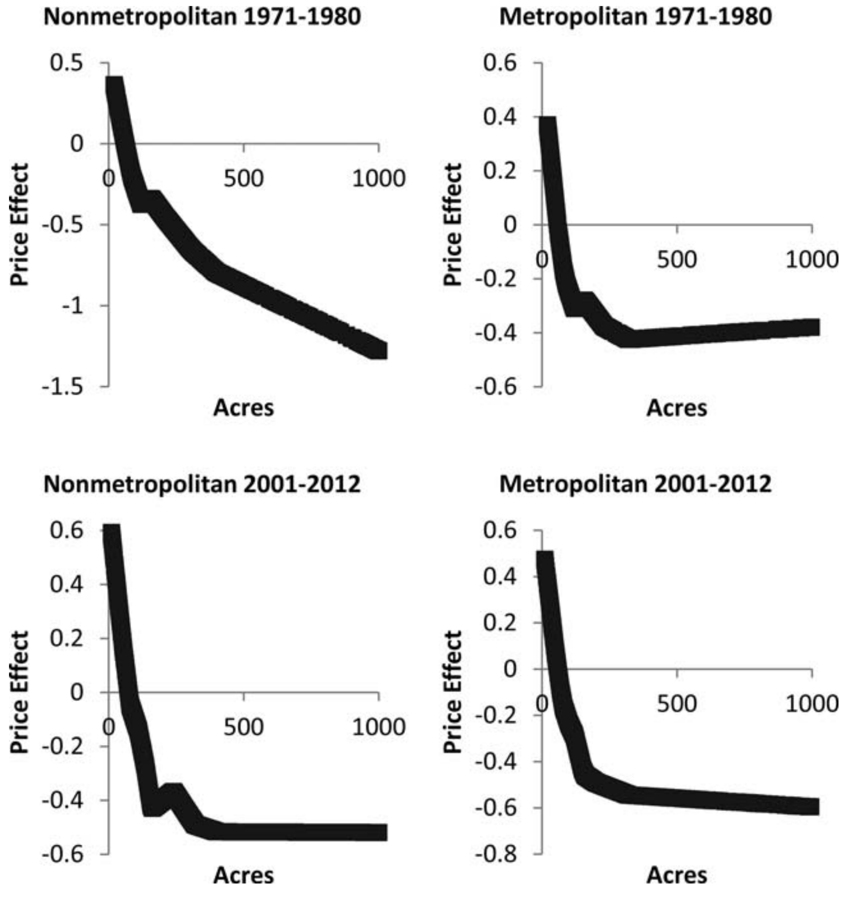

FIGURE 1
Semiparametric Estimates of the Effect of Parcel Size on Land Price

little or no premiums exists in that county. Counties with darker shading receive larger per acre price premiums for smaller parcels. Of the 10 counties with the greatest small parcel premiums, 9 of those either are metro areas or are adjacent to metro areas (Rural-Urban Continuum Codes 1–3). To test whether there were statistically significant differences between Rural-Urban Continuum Codes, the coefficient for *Acres* was regressed against them. An examination of the test for fixed effects shows the differences between the codes are statistically significant with a calculated F-value of 22.53 and a critical F-value of 3.965, allowing the null hypothesis of no differences to be rejected. At some distance from an urban area a parcel may be valued solely for its agricultural use.

Finally, the natural logarithm of price is regressed against parcel size and the interaction of parcel size and distance (Table 2). As Ma and Swinton (2012) also found, even with the distance variables included, a substantial small parcel premium exists. The small parcel premium is reduced with distance from residential areas or roads, as all of the interaction variables with roads are significant and positive. All four distance variables would need to be 2.17 standard deviations above their mean for the parcel size premium to go to zero. Thus, only the most remote parcels would have no parcel size premium.

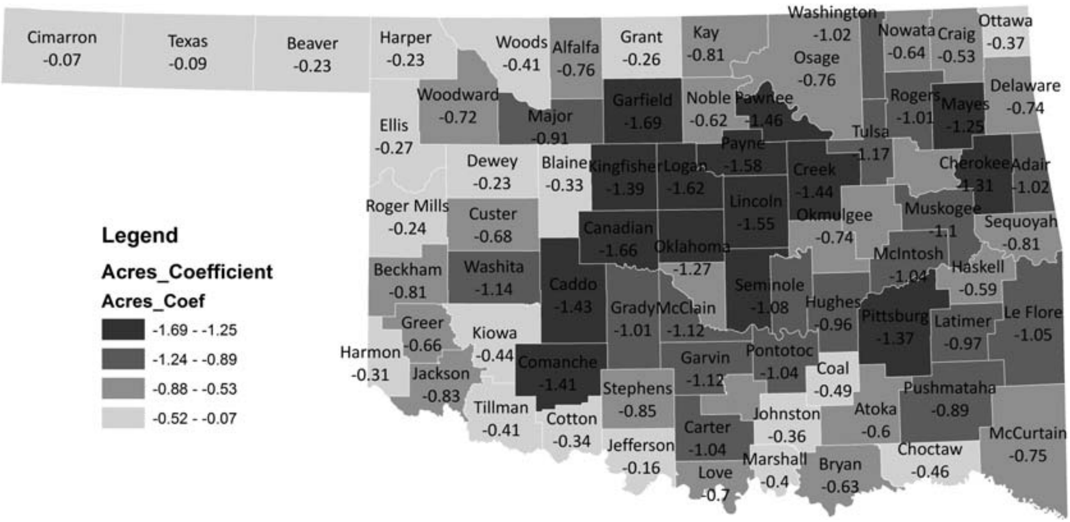

FIGURE 2
Parameter Estimates for Effect of *Acres* on Per Acre Prices

TABLE 2
Regression Models for the Natural Logarithm of Price ($/acre) and for Parcel Size (acres)

	ln(*Price*)		Parcel Size (acres)	
Variable	Coefficient	*t*-Value[b]	Coefficient	*t*-Value[b]
Intercept	7.48	262.71	200.28	18.72
Acres[a]	− 0.0011	− 21.13		
10,000 population	− 0.0072	− 11.18	0.40	2.20
500 population	− 0.0174	− 5.70	2.34	6.02
Collector	− 0.0289	− 8.36	13.27	12.53
Arterial	− 0.0478	− 20.80	10.59	15.32
*Acres*10,000 population*	4.5E–06	4.02		
*Acres*500 population*	0.000027	5.80		
*Acres*Collector*	0.000042	3.04		
*Acres*Arterial*	0.000064	9.13		
Pasture	0.0028	11.73	− 0.35	− 8.67
County fixed effects		<0.0001		<0.0001
Year fixed effects		<0.0001		<0.0001
Spatial autocorrelation		<0.00001		0.036

[a] The means with the standard deviations in parentheses of the four distance variables are 10,000 population: 17.3 (13.6), 500 population: 5.92 (4.52), collector road: 1.09 (0.83), and arterial road: 1.94 (1.6). At the mean of these four variables, the derivative of *Acres* is − 0.00069. All four distance variables would need to be 2.17 standard deviations above their means for the derivative of *Acres* to be zero.
[b] The last three values in the column are *p*-values rather than *t*-values.

Figure 3 shows the location of pasture sales by parcel size from 1971 to 1980, while Figure 4 shows the same information from 2001 to 2012. Large areas of white space indicate no sales took place in the area. Large ranches are typical in Osage county northwest of Tulsa, which accounts for a lack of markers there. Similarly, large tracts of land are owned by timber companies in southeastern Oklahoma and the land changes hands infrequently. Areas with few sales can represent public land, urban areas, land held by Indian

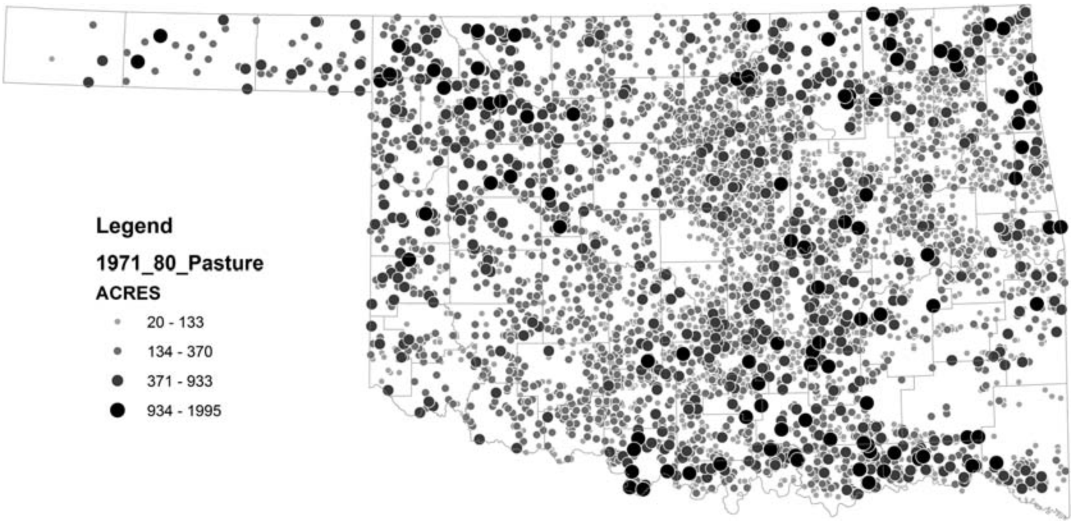

FIGURE 3
Pasture Sales, 1971–1980

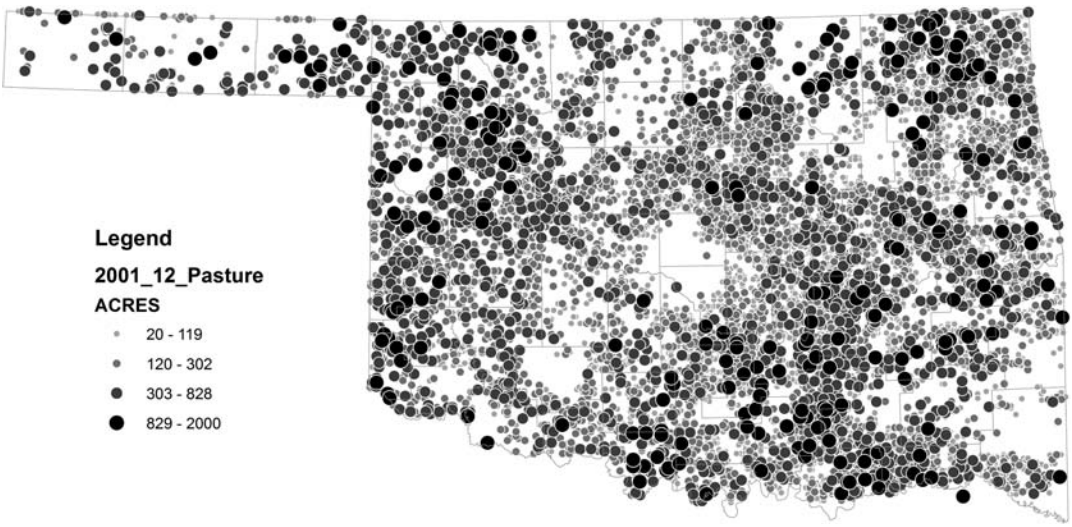

FIGURE 4
Pasture Sales, 2001–2012

tribes, or an area of little interest to the Farm Credit Services appraiser. For example, a large military base near Lawton, Oklahoma, and the Wichita Mountains Wildlife Refuge account for the relatively few sales in Comanche County. Other possible explanations include an appraiser who chose not to report sales in an area or simply an area where land changes hands infrequently.

Figure 3 shows mostly small to medium parcels located along the Interstate 35 corridor (which bisects Oklahoma and passes through Oklahoma City) and Tulsa metropolitan area (also Bentonville, Arkansas, which is due east

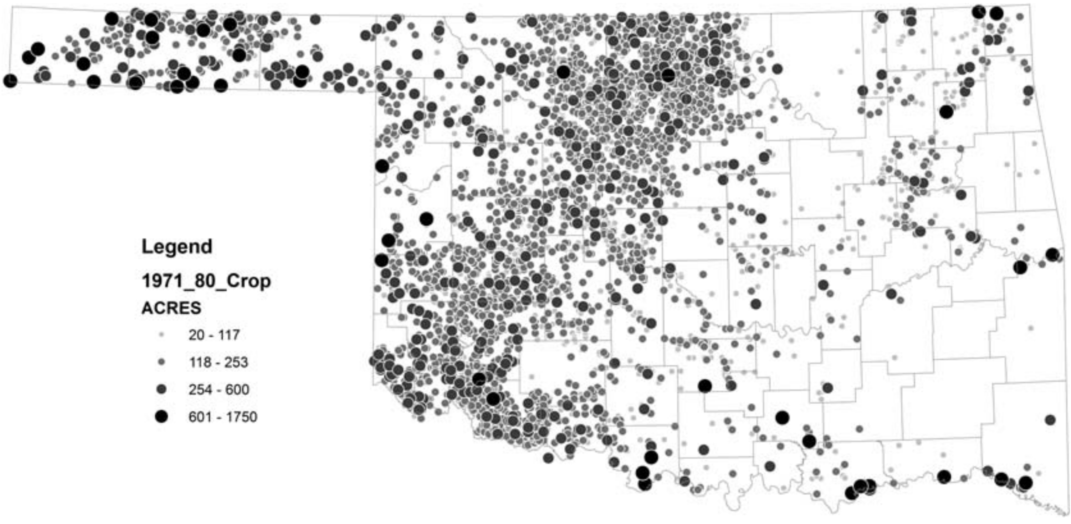

FIGURE 5
Cropland Sales, 1971–1980

of Tulsa), as well as to the east and north of the Oklahoma City metropolitan area. Largest parcels are slightly more common in southern Oklahoma. Figure 4 also shows small parcels are more common in the more populous central and eastern parts of the state.

Many of the crop parcels are located in the less populous western half of the state (Figure 5). Larger parcels tend to be located either along the southern border of the state or in the Panhandle.

Figure 6 also shows data for 2001–2012. The largest concentration of large parcels is in the lightly populated Panhandle, with some large parcels scattered throughout the state, particularly in the western half. The eastern half of the state is mostly given over to smaller parcels, while small parcels are less common in the western half. Land settlement patterns may explain some of these differences. Also, the western half of the state contains more cropland.

These figures show little evidence of parcel size changing over time. We cannot, however, rule out the Farm Credit Services using parcel size in defining whether land is agricultural. The results are insufficient to assess whether urban areas are expanding.

In the final model (equation [6]), which sought to test the hypothesis that parcel size decreases as urban proximity increases, parcel size is regressed against a variety of variables. All four of the distance variables (collector, arterial, and interaction terms) are significant and have the expected positive sign (Table 2). Thus small tracts are more common near residential areas and near quality roads. This may reflect small tracts being used for exurban development. County and year fixed effects were significant, as expected. There was also significant spatial autocorrelation, but the spatial autocorrelation was not large. The coefficient on pasture was negative. Pasture is more appealing for exurban uses, and small cropland parcels may not be economical.

VII. SUMMARY AND CONCLUSIONS

This study provides a better understanding of the small parcel size premium for agricultural land. As expected, parcel size and price per acre have an inverse relationship. A semiparametric regression was used to avoid the restrictions imposed by a parametric model. The resulting graphs show price per acre decreases sharply as parcel size increases. The discount for large parcels slows at about 160 acres and then flattens out around 320 acres (except for rural counties in the earliest decade).

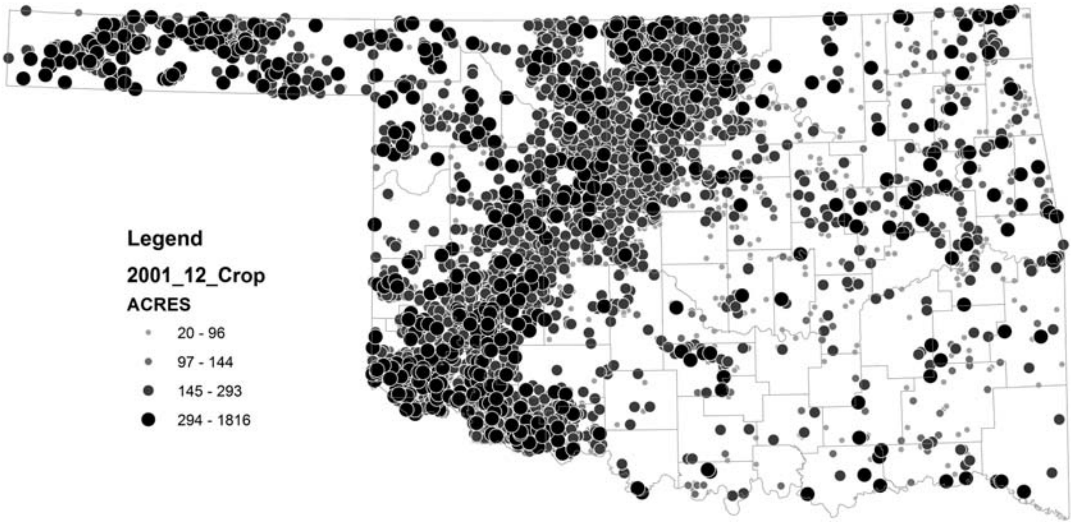

FIGURE 6
Cropland Sales, 2001–2012

Parcels tend to be smaller when nearer residential areas and nearer quality roads. This supports the hypothesis that small parcels are more likely to be used for nonagricultural or noncommercial purposes. The theory provided argues that values for some uses such as exurban development or hobby farming may increase little beyond some minimal parcel size.

The small parcel premium was greater in or near urban areas. The distance from roads and population centers can explain part, but not the entire, small parcel premium. A small parcel premium was found in all 77 Oklahoma counties. A location premium exists for smaller parcels, with parcels in urban counties receiving a larger premium than those located in more rural counties.

A regression showed that the small parcel premium decreased sharply as the distance from urban areas and the distance from quality roads increased. A partial explanation of all land not being sold in small parcels could be because the small parcel premium is less in the most remote areas.

At least part of the small parcel premium in past studies is due to not including variables for distance to roads and population centers. Such data have only recently become feasible to obtain with improvements in geographic information systems. The paper has explained a large portion, but not all, of the small parcel premium puzzle.

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