The Changing Roles of Urban Influence and Agricultural Productivity in Farmland Price Determination

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ABSTRACT *Between 2000 and 2010, inflation-adjusted U.S. farmland values increased by over 80%. This period of rapid price appreciation coincided with both the agricultural commodity price boom and the broader financial crisis. This paper examines the degree to which the determinants of farmland prices changed over this period, using a panel of farmland transfer declarations from 98 Illinois counties. Hedonic price analysis demonstrates that the relative importance of urban influence decreased over this period, while the relative importance of agricultural productivity increased. The study carries important implications for farmers, farmland owners, and policy makers.* (JEL Q15)

1. Introduction

Between 2000 and 2010, inflation-adjusted U.S. farm real estate values increased by over 80%.[1] Increasing farmland prices were accompanied by growing concern over an imminent downside correction. Farmland accounts for more than 80% of the total value of U.S. farm assets (Nickerson, Morehart, et al. 2012), and a downside correction in farmland values may therefore have pronounced effects on farm financial viability across the nation. Consequently, the causes of farmland price changes and the sustainability of current market conditions are of great concern to farmers, farmland owners, and policy makers.

Farmland values are determined by several factors. Farmland is valued primarily for its ability to generate income through use in agricultural production (Burt 1986; Featherstone and Baker 1987; Just and Mirankowski 1993; Drozd and Johnson 2004). Between 2000 and 2010, aggregate U.S. farm income grew from approximately $57 billion to approximately $98 billion.[2] However, farm income was not the only driver of increasing farmland values. Nickerson, Ifft, et al. (2012) assert that the appreciation in farmland prices over the period was a product of the low interest rate environment brought on by the recent financial crisis. They reason that farm income changes alone would not have supported farmland value growth if interest rates had remained at the long-term average of 6% that existed in 2000. Furthermore, it is argued that the linkage between farm income and farmland prices has weakened for nearly a half century (Nickerson, Morehart, et al. 2012). Recent empirical literature on farmland price determination examines a complex set of factors beyond farm income. These factors include urban proximity (Livanis et al. 2006), ethanol plants (Blo-

[1] Data from the U.S. Department of Agriculture, National Agricultural Statistics Service, "Quick Stats," available at http://quickstats.nass.usda.gov/ (accessed February 20, 2014).

[2] Data from the U.S. Department of Agriculture, Economic Research Service, "Farm Income and Wealth Statistics," available at http://ers.usda.gov/data-products/farm-income-and-wealth-statistics#.UwZ8N_ldV8E/ (accessed February 20, 2014).

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mendahl, Perrin, and Johnson 2011), government farm program payments (Weersink et al. 1999), tax policies (Dillard et al. 2013), and a variety of discount rate and growth expectation variables.

As of 2010, Illinois had the ninth-highest farmland values in the United States.[3] The state's high farmland prices stem from exceptionally productive farmland. As a fraction of total land area, Illinois leads the nation in prime farmland with "the best combination of physical and chemical characteristics for producing food, feed, forage, fiber and oilseed crops" (USDA-NRCS 2009, 18, 2015). Illinois also has an abundance of other factors that the existing literature suggests contribute to farmland values, including a large urban center, making the state an ideal setting for examining farmland markets. Urban proximity boosts farmland prices due to anticipated future income from conversion to nonagricultural use. The impact of urban proximity has been specifically addressed in prior studies of Illinois farmland prices. A parcel-level study by Chicoine (1981) shows that from 1970 to 1974, farmland prices at the rural-urban fringe increased with proximity to Chicago. Similarly, Huang et al. (2006) use county-level transaction data to demonstrate that farmland prices were driven in part by proximity to Chicago and several other population centers from 1979 to 2000.

This study examines the recent appreciation in farmland prices using detailed transactions data from 2000 through 2010. We develop a model of county-level farmland prices using variables representing parcel size, agricultural productivity, and urban influence. The empirical results stemming from this model reveal the relative importance of agricultural and nonagricultural factors during the farmland price appreciation of 2000 to 2010.

2. Methodology

Hedonic pricing methods offer an attractive empirical approach for modeling agricultural land values (Dillard et al. 2013; Tsoodle, Golden, and Featherstone 2006; Huang et al. 2006). Hedonic pricing methods are very flexible, positing that the value of a parcel of farmland is determined by the value of its characteristics (Rosen 1974). The model takes the following form:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}, \qquad [1]$$

where $\mathbf{y}$ is an $n \times 1$ vector of farmland prices, $\mathbf{X}$ is an $n \times k$ matrix of farmland characteristics, $\boldsymbol{\beta}$ is a $k \times 1$ vector of unknown parameters, and $\boldsymbol{\varepsilon}$ is an $n \times 1$ vector of regression errors. Model 1 is estimated for all n sampled counties for each year from 2000 to 2010. A comparison of results from these 11 yearly regressions reveals temporal changes in the determinants of Illinois farmland prices.

3. Data

Illinois farmland sales data were obtained from the transfer declaration forms that the Illinois Department of Revenue requires for all real property transactions.[4] Farmland sale prices are defined by the department as the total sale price less the value of personal property included in the transfer. The transfer declarations record the total transaction price, total acreage, and legal definition of a parcel's location. We applied a number of filters to the transfer declaration data to limit the impacts of atypical parcel transfers. First, to mitigate the influence of heterogeneous farmland improvements, data were limited to unimproved parcels. Second, to ensure that the sample contained only farmland parcels, the data were limited to parcels with a current status of "farm" or "land/lot only." Third, due to the significant discount typically observed in non-arm's-length transfers (Tsoodle, Golden, and Featherstone 2006; Kostov 2010), transfers between related parties were excluded from the data. Finally, to limit the impact of outliers caused by measurement error or misclassification, additional limits were placed on both total acreage and per-acre price. Per acre prices of less than $500

[3] Data from the U.S. Department of Agriculture, National Agricultural Statistics Service, "Quick Stats," available at http://quickstats.nass.usda.gov/ (accessed February 20, 2014).

[4] Data available at www.revenue.state.il.us.

Table 1
Data Summary

Variable	Units	Mean	St. Dev.	Min.	Max.
Price	Dollars per acre	3,316.57	1,317.42	1,081.57	8,404.85
Parcel size	Acres	69.66	20.02	29.15	344.97
Soil productivity	Units	72.04	14.30	41.61	93.56
Population density	Persons/sq. mile	90.20	118.64	11.75	811.17
Distance to Chicago	Miles	182.01	75.75	28.22	335.04
Distance to St. Louis	Miles	136.33	63.85	11.28	277.52

Note: Variables are annual, county-level measures.

or greater than $10,000 in 2010 dollars were excluded from the sample, as were parcels of less than 10 acres or more than 1,280 acres. All told, the application of these filters from 2000 to 2010 resulted in 56,070 transfer records that are representative of commercially viable farmland intended to remain in agricultural production. Annual county-level averages were then calculated from the valid farmland transfer records, creating a balanced panel. Table 1 indicates that the farmland prices in this panel exhibit a positive skew due to the extremely valuable farmland in a few of the included counties. Average prices are measured in consumer price index–adjusted 2010 dollars.

Our hedonic price model includes several explanatory variables drawn from the existing literature. First, to account for the oft-noted negative relationship between parcel size and per-acre farmland prices (Brorsen, Doye, and Neal 2015; Miller 2006), the model includes average parcel size data gleaned from the Illinois Department of Revenue transfer declarations. Second, differences in agricultural productivity are captured by soil productivity ratings obtained from the Illinois Farm Business Farm Management Association.[5] County average soil productivity ratings were calculated from random soil samples in each county and rated using a standardized scale from 5 to 100 points developed by Grano (1963). County-level soil productivity ratings are held constant throughout the 2000–2010 period. Third, three measures of urban influence are included: midyear population density data obtained from the U.S. Census Bureau[6] and the straight-line distances from the center of each county to Chicago and to St. Louis.[7] The data form a balanced panel of 98 of Illinois's 102 counties. The omitted counties surround Chicago: Cook, Lake, DuPage, and Kane. A summary of the county-level data is provided in Table 1.

4. Results

Ordinary least squares regression results based on the data in Table 1 and hedonic Model 1 are reported in Table 2. The dependent variable and explanatory variables are expressed in natural logarithms. To combat heteroskedasticity, robust standard errors were estimated. The results of the yearly regressions are relatively unsurprising. For example, the coefficient for soil productivity rating is positive and significant at the 1% level in all years from 2000 to 2010. This finding suggests that farmland in more productive regions is associated with higher market values. Likewise, proximity to urban areas increases farmland prices.[8] Specifically, the coefficient for population density is positive and significant at the 1% level in all

[5] Data from *Summary of Illinois Farm Business Records 2010,* available at www.fbfm.org/pdfs/Summary%20of%20FBR%20for%202010.pdf.

[6] Data from www.census.gov/programs-surveys/popest.html.

[7] Data from https://catalog.data.gov/dataset/place-national.

[8] It is important to note that, following the suggestions of an anonymous reviewer, alternative measures of population influence were considered to examine the robustness of the urban influence results. Augmenting Model 1 by adding annual interpolations of the Economic Research Service's Urban Influence Codes, commonly labeled "Beale codes," does not qualitatively change the results presented in Table 2 (see Ghelfi and Parker 1997). These results are available from the authors upon request.

but two years. In addition, the coefficient for distance to Chicago is negative and significant at the 1% level in all years from 2000 to 2010, while the coefficient for distance to St. Louis is negative and significant at the 1% level for all years but 2000. These negative coefficients mean that farmland prices decrease as farmland is located further from urban centers. Moreover, the relative differences in coefficient magnitudes indicate that Chicago conveys a greater price premium than proximity to St. Louis. This result makes sense given the relative populations of the two metropolitan areas.

Table 2 allows for comparisons between regressions describing different years. These comparisons suggest several temporal trends during the 2000–2010 period. The influence of soil productivity rating seems to be greater during the latter part of the period. Indeed, four of the five largest soil productivity coefficients displayed in Table 2 occur from 2007 to 2010. These results indicate that agricultural production potential increased in relative importance during the 2000–2010 period. The increased importance of soil productivity is consistent with the commodity price and income trends for Illinois's primary crops. Inflation-adjusted corn prices were 126% higher in 2010 than in 2005, while inflation-adjusted soybean prices increased 83% over the same period.[9] Although strong crop prices increase returns to farmland of all productivity levels, they are especially advantageous for high-productivity farmland.[10]

The increasing importance of agricultural productivity is contrasted by the declining price premium associated with urban influence. The four smallest population density coefficients occur in the four years from 2007 to

Table 2
Ordinary Least Squares Regression Results

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Constant	6.025***	7.334***	8.322***	8.775***	6.746***	6.924***	6.703***	7.450***	6.923***	7.130***	6.012***
	(1.059)	(0.905)	(0.756)	(0.930)	(0.994)	(0.923)	(1.065)	(0.781)	(0.818)	(0.724)	(0.803)
Parcel size	−0.010	−0.082	0.007	−0.048	−0.099	−0.025	0.133*	−0.150	−0.058	−0.200***	−0.086
	(0.096)	(0.084)	(0.096)	(0.091)	(0.093)	(0.066)	(0.077)	(0.091)	(0.103)	(0.065)	(0.063)
Soil productivity	0.707***	0.725***	0.513***	0.570***	0.903***	0.828***	0.679***	0.881***	0.861***	0.933***	0.977***
	(0.138)	(0.127)	(0.110)	(0.114)	(0.117)	(0.115)	(0.129)	(0.115)	(0.107)	(0.094)	(0.093)
Population density	0.137***	0.105***	0.113***	0.069***	0.101***	0.103***	0.087***	0.016	0.053***	0.017	0.066***
	(0.034)	(0.027)	(0.022)	(0.023)	(0.025)	(0.020)	(0.022)	(0.018)	(0.018)	(0.019)	(0.024)
Distance to Chicago	−0.288***	−0.402***	−0.464***	−0.485***	−0.377***	−0.378***	−0.325***	−0.340***	−0.318***	−0.310***	−0.215***
	(0.082)	(0.081)	(0.057)	(0.077)	(0.078)	(0.073)	(0.092)	(0.068)	(0.058)	(0.059)	(0.060)
Distance to St. Louis	−0.061	−0.148***	−0.170***	−0.200***	−0.153***	−0.165***	−0.155***	−0.157***	−0.138***	−0.101***	−0.139***
	(0.055)	(0.042)	(0.034)	(0.047)	(0.043)	(0.042)	(0.045)	(0.043)	(0.040)	(0.030)	(0.039)
Observations	98	98	98	98	98	98	98	98	98	98	98
R^2	0.735	0.769	0.818	0.771	0.793	0.836	0.731	0.774	0.815	0.789	0.757

Note: Heteroskedasticity-consistent standard errors in parentheses.
* $\alpha \leq 0.10$; *** $\alpha \leq 0.01$.

[9] Data from the U.S. Department of Agriculture, National Agricultural Statistics Service, "Quick Stats," available at http://quickstats.nass.usda.gov/ (accessed February 20, 2014).

[10] One anonymous reviewer suggested that this may be a result of increased bioenergy production, following Blomendahl, Perrin, and Johnson (2011) and Towe and Tra (2013). We test this hypothesis by adding explanatory variables representing ethanol and biodiesel facility capacities to the original yearly models. Adding these bioenergy facility capacity variables does not qualitatively change the results presented in Table 2. These results are available from the authors upon request.

2010. Likewise, for both distance to Chicago and distance to St. Louis, three of the four coefficients with the smallest magnitudes occur from 2007 to 2010. The aforementioned patterns warrant closer consideration.

Although the simplicity of annual regressions is appealing, information can be gained by combining observations from all counties and years into a balanced panel. A random effects model decomposes the error term ($\boldsymbol{\varepsilon}$) from Model 1 into two components.[11] Specifically,

$$\dot{\mathbf{y}} = \dot{\mathbf{X}}\dot{\boldsymbol{\beta}} + \mathbf{u} + \mathbf{w}, \qquad [2]$$

where $\dot{\mathbf{y}}$ is an $(n \times t) \times 1$ vector of farmland prices from all sampled counties (n) and years (t), $\dot{\mathbf{X}}$ is an $(n \times t) \times k$ matrix of farmland characteristics, $\dot{\boldsymbol{\beta}}$ is a $k \times 1$ vector of unknown parameters, $\mathbf{u}$ is an $(n \times t) \times 1$ vector of random county effects, and $\mathbf{w}$ is an $(n \times t) \times 1$ vector of individual error terms. This specification is advantageous because many important farmland characteristics in our model do not vary through time, including location and soil quality, and fixed effects estimation would not allow these characteristics to be analyzed.

Random effects generalized least squares (GLS) estimates of Model 2 are displayed in Table 3. Like the yearly regression summarized in Table 2, Table 3 shows that soil productivity and urban pressures are positively associated with farmland prices. The coefficient values listed in Table 3 are often similar to coefficient values from the yearly regressions. For example, distance to Chicago once again has a stronger relationship with farmland prices than distance to St. Louis. However, Model 2 forces all coefficients to remain constant from 2000 to 2010, implying that the influence of each variable remained constant throughout that period. This restriction reduces the model's explanatory power relative to a flexible random effects model where coefficients are allowed to vary by year. Indeed,

[11] A random effects approach is recommended by a Hausman test of the null hypothesis that the random effects estimator is consistent in this case. The Hausman test yields a test statistic of 0.07, which has a p-value of 0.967 based on a χ^2 distribution with 2 degrees of freedom.

Table 3
Random Effects Generalized Least Squares Regression Results, 2000–2010

	Estimates of Model 2
Constant	6.959 (0.598)***
Parcel size	0.004 (0.042)
Soil productivity	0.751*** (0.078)
Population density	0.082*** (0.015)
Distance to Chicago	–0.349*** (0.046)
Distance to St. Louis	–0.146*** (0.028)
Observations	1,078
R^2	0.573

Note: Heteroskedasticity-consistent standard errors in parentheses.
*** $\alpha \le 0.01$.

a Wald test strongly rejects the hypothesis that the coefficients do not vary from year to year.

The rapid appreciation in farmland values between 2000 and 2010 was likely the result of a combination of factors, and the results in Table 2 suggest that the relative values placed on individual characteristics may have changed during the observation period. This possibility can be tested within the hedonic framework by estimating a multilevel model with different slope coefficients (or slope-shift coefficients) for defined subperiods. We divide the sample period into an early (or base) subperiod and a later subperiod. The shift is captured by interaction terms calculated by interacting all explanatory variables with a dummy variable that is equal to one for observations during the later subperiod. Augmenting Model 2 in this fashion results in the specification

$$\dot{\mathbf{y}} = \dot{\mathbf{X}}\dot{\boldsymbol{\beta}} + \dot{\mathbf{Z}}\dot{\boldsymbol{\gamma}} + \mathbf{u} + \mathbf{w}, \qquad [3]$$

where $\dot{\mathbf{Z}}$ is an $(n \times t) \times k$ matrix of farmland characteristics that contains zeroes for all entries from the early subperiod and is otherwise identical to $\dot{\mathbf{X}}$. The $k \times 1$ vector of unknown slope-shift parameters, $\dot{\boldsymbol{\gamma}}$, captures changes in the relative value of characteristics in the later subperiod. If a slope-shift coefficient in $\dot{\boldsymbol{\gamma}}$ is statistically significant, it implies that the contribution of that characteristic to observed market prices changed between the early and later subperiods. The summation of $\dot{\boldsymbol{\beta}}$ and $\dot{\boldsymbol{\gamma}}$ therefore yields the full impact of a variable during the later subperiod.

Random effects GLS estimates of Model 3 were estimated using a variety of subperiod divisions. Specifically, 2004, 2005, 2006, and 2007 were each used as the final year of the early subperiod in different iterations. In each case, the $\dot{\boldsymbol{\beta}}$ coefficients assume their predicted signs at the 1% significance level. Furthermore, in each case, the $\dot{\boldsymbol{\gamma}}$ coefficient for soil productivity is positive and significant at the 1% level while the $\dot{\boldsymbol{\gamma}}$ coefficients for population density and distance to Chicago have the opposite sign as in $\dot{\boldsymbol{\beta}}$. The latter results hold at the 5% significance level or better. In other words, regardless of where the sample was divided, the magnitude of the relationship between soil productivity and farmland prices increased later in the 2000 to 2010 period. In contrast, across all specifications, the deterministic influence of urban pressures waned later in the period. Although these results agree with anecdotal evidence and the results presented in Table 2, they are imperfect. Specifically, tests of coefficient equality within subperiods are rejected for each division at the 1% significance level.[12] All told, although the determinants of farmland prices change through time, these temporal trends are not clear cut.

5. Conclusions

The rapid increase in farmland values from 2000 to 2010 raised a number of important questions related to the causes and sustainability of current farmland prices. The future of farmland values across the United States is of key interest to policy makers, farmers, and farmland owners. This study examines the relative importance of a number of factors linked to farmland price appreciation in Illinois. The results suggest that from 2000 through 2010, the price premium associated with urban influence exhibited a decline, while the price premium associated with agricultural productivity generally increased. Although the study area was restricted to Illinois, we would expect the findings to apply to other Midwestern states and perhaps in other states with similar population densities and a similar mix of agricultural commodities.

The shift in the relative contributions of urban influence and agricultural productivity is likely the result of two coincidental phenomena. First, as a result of increasing commodity prices and farm incomes, farmland values increased most markedly for highly productive farmland. Low interest rates also allowed for accelerated capitalization of booming farm incomes. The end result was a rapid appreciation in farmland prices. Second, as a result of the housing and financial crisis in the latter portion of the observation period, new construction slowed, easing demand for transitional farmland sales. The decreased demand for transitional farmland sales was insufficient to adversely affect aggregate market prices, but it did lead to a shift in the relative importance of urban influence in the determination of agricultural land values.

[12] Wald tests assuming equality of coefficients within each subperiod are rejected at the 1% level for all regressions.

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