The Housing Market Bust and Farmland Prices: Identifying the Changing Influence of Proximity to Urban Centers

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Abstract:

This paper identifies the extent and magnitude of the decline of urban influence on surrounding farmland values due to the recent housing market bust and subsequent economic recessions, using a parcel-level data of agricultural land sales from 2001 to 2010 for a 50-county region of Western Ohio. We quantify urban premium from multiple urban centers by combining the effects of proximity to cities and benefits of surrounding urban population. After controlling for local heterogeneity at census tract level, our estimates from hedonic regressions reveal that urban premium reduced by half, if not completely wiped out, after the housing market bust.

Keywords:

Farmland Values; Housing Market Bust; Structural Change; Urban Premium

JEL Codes:

Q13, Q15, R31

I. Introduction

The recent residential housing market bust and subsequent economic recession have led to a dramatic decline in urban land values and housing values across the U.S. A corresponding dip, however, was not evident in agricultural land prices. Survey data revealed that farm real estate values witnessed a modest increase rather than a decline in many Corn Belt States including Iowa, Indiana, Illinois, and Ohio over 2007 – 2009 (Nickerson et al. 2012; Kuethe et al. 2011). The continued increases in farmland values since then have been attributed to historically low interest rates (Schnitkey and Sherrick 2011), as well as increasing demand for U.S agricultural products due to the growing biofuels market (Wallander et al. 2011) and rising demand for U.S. grain exports (Gloy et al. 2011). Farmland in close proximity to urban areas typically sells for a premium relative to farmland farther away from urban areas - as demand for developable land induces developers to bid above the agricultural production value of land closest to urban areas (Capozza and Helsley 1989) - and recent changes in both farmland and urban land markets raise intriguing questions about the relationships between these competing land markets: what was the magnitude of the drag imposed by the urban residential housing market downturn on surrounding farmland values? Did the pre-housing bust “urban premium” that accrues to nearby farmland remain largely intact, witness a modest dip, or disappear entirely due to the housing market downturn?

Numerous studies have analyzed the determinants of agricultural land values (e.g. Guiling et al. 2009; Livanis et al. 2006; Bastian et al. 2002; Palmquist and Danielson 1989 and Ma and Swinton 2011). Most have employed the standard hedonic pricing method, which treats the agricultural land as a differentiated product whose price is modeled as a function of parcel attributes and locational characteristics, including soil quality measures (i.e. Huang et al. 2006) and environmental amenities (i.e. Bastian et al. 2002). In particular, studies have shown that in areas that are more urbanized or are experiencing rapid population growth, the demand for developable land for residential or commercial uses is the most significant nonfarm factor affecting farmland values (Livanis et al. 2006; Hardie et al. 2001; Nickerson et al. 2012; Blank 2007; Shi, Phipps and Colyer 1997; Plantinga et al. 2002).

The literature of urbanization spillover effects on rural lands is rapidly growing; however, most studies have used aggregate county level data (i.e. Plantinga et al. 2002), which generates a very coarse representation of the spatial extent and magnitude of urban influence, and masks important differences in the influence of spatially disaggregate locational attributes on agricultural land values, such as differences in road networks that contribute to parcel-specific variation in commuting distances to employment centers. In a county-level analysis in West Virginia, Shi, Phipps and Colyer (1997) imbed a gravity model in the hedonic analysis of urban influence on surrounding farmland prices, in which the urban influence potential is measured using a weighted average of the ratio of population of metropolitan city over squared distance to this city for the nearest 3 metropolitan areas. One exception is the study by Guiling et al. (2009). They estimate a multi-level model that incorporate both county-level data and parcel characteristics, and find that the distance where the urban influence on agricultural land values ended fell into a range of 20 to 50 miles, depending on the population and real income of the urban area. While Guiling et al. (2009) demonstrated the spatial heterogeneity of urban influences in farmland markets, the coarse county-level random effects in their model leave the potential for substantial intra-county variations in omitted characteristics (Anderson and West 2006) and thus may not adequately account for the well-known omitted variable bias (Bajari et al. 2012). In particular, two important sources of omitted variable bias (Nickerson and Zhang 2013), spatial dependence among agricultural parcels and the potential sample selection problems, were ignored as in most farmland valuation studies. In addition, the parcel-level urban influence measure is limited to the distance to the nearest city and the population and income of nearest city, without considering the possibility of influences from multiple urban centers.

The recent housing market bust has sparked renewed interest in analyzing the evolution of the land and house prices within and across metropolitan areas (Kuminoff and Pope 2013; Cohen, Coughlin, and Lopez 2011) and the effects of land use regulations (Huang and Tang 2012). Yet these studies on the boom and bust of land and structure values are limited to residential land markets, with no explicit representation of the downturn pressures on surrounding farmland values due to the residential housing bust. In addition, some recent studies have examined how changes in other non-land markets, such as demand for biofuels as an energy source, have affected farmland values (Blomendahl et al. 2011; Henderson and Gloy 2009). However, to date, no study has examined the structural change in the determinants of farmland values precipitated by the bust of the competing urban housing market. The fairly constant or a upward trend in Midwest agricultural land prices over the 2000 decade indicate that the rising demand from biofuels and exports may mask the significant downward pressure of the housing market bust on farmland values, especially those parcels under strong urban influences. As a result, quantifying the structural break in the effects of urban proximity could offer unique insights on the dynamics of the relative importance of different determinants of farmland values and the indispensable linkages between urban and rural land markets.

The aim of this paper is to identify the marginal value of proximity to urban centers and test for a structural change in these effects before and after 2007, the year of the housing market bust. We hypothesize that the urban housing market bust imposed significant downward pressure on urban demands for developable land and hence the urban premium that farmland near urban areas enjoys. This paper uses spatially explicit parcel-level data on arms-length agricultural land sales from 2001 to 2010, a period which encompasses the housing market bust, for a 50-county region of western Ohio - almost all of which is subject to some degree of urban influences (Kuethe et al. 2011). This unique and spatially disaggregate dataset allows us to parse the data into pre (2000-2006) and post (2008-2010) time periods, and investigate the structural change in the effects of urban proximity on surrounding farmland values, yielding new insights into the impacts of changes in competing land markets on farmland values.

We address the potential omitted variable bias embedded in the standard hedonic pricing approach by incorporating local spatial fixed effects at census tract level. In the case of agricultural land under urbanization pressures, access to commuting opportunities, school quality, and air quality could vary significantly within a county (Kuminoff and Pope 2013), which could greatly affect the future development potential of agricultural land parcels. The census tract level spatial fixed effects included in our model are designed to capture the market value of latent attributes of agricultural land. These refined local fixed effects have proved to be effective in removing most of the time-invariant spatial heterogeneity such as spatial autocorrelation in residential housing market studies (Abbort and Klaiber 2011; Kuminoff and Pope 2013). In addition, this paper develops a parcel-specific metric of urban premium to quantify the dollar impact of the structural break of urban influences induced by the residential housing market bust. This metric is unique since we explicitly consider the possibility of influences from urban influences from multiple urban centers by adding three additional measures of urban influences to the traditional metric “distance to nearest city”: the measure of total urban population within 25 miles of each agricultural parcel captures the size of urban demand, while the incremental distance to the second nearest city and a gravity index based on the nearest three cities quantify the effects of multiple urban centers at a parcel level (Shi et al. 1997).

The main result provides evidence that the marginal value of being within close proximity to urban centers on surrounding farmland prices declined by 60 percent or more due to the recent residential housing market bust. On average, the urban premium for parcels under urbanizing influences relative to a parcel at urban fringe[1] fell from $1,586 per acre before 2007 to $633 per acre after the housing market bust. Moreover, the difference in urban premium between parcels in MSA (Metropolitan Statistical Area) counties and those in non-MSA counties shrank from $723 per acre before 2007 to $214/acre after 2007. In other words, the decline of an urban premium due to the housing market bust is more evident in parcels in close proximity to cities and parcels in metropolitan counties. In addition, the results reveal that new parcel level measures such as distance to the second nearest city and surrounding urban population account for at least 30 percent of the total urban premium before 2007, validating the importance of accounting for multiple urban centers. Furthermore, the county fixed effects tend to absorb the effects resulting from surrounding urban population, and thus lead to non-identification of these population measures of urban premium.

Overall, this study makes at least three contributions to the literature on agricultural land valuation. First, to our knowledge, this paper offers the first analysis of the structural break in the effect of urban influence on surrounding farmland values due to the recent housing market bust. Second, this paper develops a parcel-level measure of urban premium that explicitly accounts for the influences of multiple urban centers and shows that failure to account for the effects of

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[1] The hypothetical reference parcel with no urban influence at urban fringe that is assumed to have no urban influences are defined as a parcel 60 miles away from nearest city center, at least 100 miles away from the second nearest city center, and with no surrounding urban population.

multiple urban centers will result in a 30 percent undervaluation of the urban premium. Finally, this study re-highlights the superiority of spatially disaggregate analysis of agricultural land prices, and demonstrates the effectiveness of local spatial fixed effects in removing most of the spatially correlated omitted variables bias.

II. Conceptual Framework

Among the most influential theories that help explain the value of land is Ricardo's economic theory of rent. Ricardo's key insight was that land which differs in quality and which is limited in supply generates rents that arise from the productive differences in land quality or in differences in location. The valuation of farmland subject to urban influence dates back to a model developed by Von Thünen in 1826, which posits that rent differentials for farmland also arise both from the value of commodities produced and the distance from central markets. In this model the Ricardian rent is a decreasing function of the distance to the urban center, and land closer to the urban center earns higher rents because of reduced transportation costs. Farmland value is comprised of the net present value of economic returns to land. The model is written as

$$V_{it} = E_t \sum_s \frac{R_{is}}{(1+\delta_t)^{s-t}}, where\ s = t, t+1, \ldots \text{(1)}$$

In this formulation, the value of agricultural land parcel *i* at time *t* V_{it} is defined as the expected annual returns to farmland *R* discounted at rate δ_t. The term *R* includes any factor affecting farmland returns, such as returns to agricultural production, returns to using land for recreational purposes, or potential profitability of future development for urban uses.

The study region - Western Ohio - is fairly homogenous in soil type, slope of the land, climatic conditions and surrounding land uses for fishing or hunting opportunities, and hence little variation in generating recreational income is expected among all the parcels. As a result, returns to recreational land uses are ignored in this model. Instead, following Capozza and Helsley (1989), we are in particular interested in modeling the option value of future land conversion from agricultural use to urban uses – the most significant non-farm factor affecting values of farmland under urbanization pressures (i.e. Hardie et al. 2001). Specifically the value of an agricultural parcel *i* at time *t* under urban influence can be defined as

$$V_i(t) = \sum_{t=0}^{t^*} R_A(A_i, t)\delta_t + \sum_{t=t^*}^{\infty} R_U(U_i, t)\delta_t, (2)$$

where t^* is the optimal timing of land use conversion from agricultural use to residential or commercial uses, R_A is the agricultural land rent, and R_U is the urban land rent net of the conversion costs. The first term represents the present value of agricultural rents up to t^*, which depends on the parcel-specific variables affecting agricultural productivity $\boldsymbol{A_{it}}$ such as soil quality, slope of the parcel, and proximity to agricultural market channels such as ethanol plants and grain elevators. The second term captures the present value of returns to urban development from optimal conversion time onward, which depends on the location-specific urban influences variables $\boldsymbol{U_{it}}$ such as proximity to nearest and second nearest city, surrounding urban population, and access to highway ramps and railway stations. In this formulation, the vector of parcel attributes and location characteristics $\boldsymbol{X_{it}}$ is decomposed into two distinct groups: the agricultural productivity influences variables $\boldsymbol{A_{it}}$ and the urban influences variables, so that

$$\boldsymbol{X_{it}} = \boldsymbol{A_{it}} + \boldsymbol{U_{it}}. \quad (3)$$

This yields the following model specification:

$$V_{it} = E_t \sum_s f(\boldsymbol{A_{is}}, \boldsymbol{U_{is}};\ \delta_t), where\ s = t, t+1, \dots (4)$$

The urban influence variables $\boldsymbol{U_{it}}$ work through two channels. First, that proximity to population centers and increased access to customers could influence farmland values by increasing expected agricultural returns (Nickerson et al., 2012), and second, that agricultural land closer to urban fringe could sell for a premium, an option value that equals to the expected returns from the conversion into urban development at a future date (Capozza and Helsley, 1989; Guiling et al., 2009). The classical urban economic theory suggests that the latter effect is more important, and thus contends that the value of land declines as one move away from the urban center (Capozza and Helsley, 1989). This urban housing market downturn may greatly diminish the urban option conversion value of the agricultural land, and as a result, a declining relative significance of the urban influence variables $\boldsymbol{U_{it}}$ in shaping surrounding farmland values is expected.

III. Econometric Procedures

a. The hedonic price method

Hedonic models are a revealed preference method based on the notion that the price of a good or parcel in the marketplace is a function of its attributes and characteristics. With Rosen's (1974) seminal work as a backdrop, the hedonic price method has quickly become the workhorse model in the studies of real estate or land values (i.e. Palmquist 1989), and the determinants of farmland values. Numerous applications of hedonic models applied to farmland markets have examined the marginal value of both farm and non-farm characteristics of farmland, including soil erodibility (Palmquist and Danielson 1989), urban proximity (i.e. Shi et al. 1997), wildlife recreational opportunities (i.e. Henderson and Moore 2006), zoning (i.e. Chicoine 1981), and farmland protection easements (i.e. Nickerson and Lynch 2001). Almost all of the aforementioned literature on agricultural land values has employed the hedonic model. The farmland returns R_{it} in equation (1) can be approximated by a linear combination of parcel attributes and location characteristics $\boldsymbol{X_{it}}$ using Taylor expansion. This yields the most common specification of hedonic model, which is the log-linear form defined as

$$\log(V_{it}) = \beta_0 + {\beta_A}'\boldsymbol{A_{it}} + {\beta_U}'\boldsymbol{U_{it}} + \tau_t + \varepsilon_{it}, \qquad (5)$$

where τ_t is time fixed effects and ε_{it} is the remaining normally distributed error term, and the agricultural land values $V_{it}$are approximated by the real sale prices of the agricultural land without structures.

In this hedonic setting, agricultural land is regarded as a differentiated product with a bundle of agricultural quality and location characteristics, and each characteristic is valued by its implicit price.

b. Incorporating the hedonic model with localized spatial fixed effects

Despite its popularity, the hedonic pricing method suffers from a number of well-known econometric problems. Foremost among them, the researcher can not directly observe all land characteristics that are relevant to farmers and developers, and omitted variables may lead to biased estimates of the implicit prices of the observed attributes (Bajari et al. 2012). We address the omitted variable bias problem by incorporating local-level spatial fixed effects, which are denoted as θ_j:

$$\log(V_{it}) = \beta_0 + \beta_A{}'\boldsymbol{A_{it}} + \beta_U{}'\boldsymbol{U_{it}} + \tau_t + \theta_j + \varepsilon_{it}, \qquad (6)$$

In the case of agricultural land under urbanization pressures, the access commuting opportunities, school quality, and air quality could vary significantly within a county (Kuminoff and Pope 2013), which could greatly affect the future development potential of agricultural land parcels. For agricultural land parcels under no immediate urban conversion pressures, some other significant unobserved characteristics may also exist, such as access to agricultural technical support, public services, existence and effects of drainage system, and local climatic conditions. The localized spatial fixed effects at census tract level are used in this paper to capture the market value of these aforementioned and other unobserved characteristics determining prices of agricultural land, which are relatively homogenous within a census tract. Previous studies have shown that coarser fixed effects beyond county level may leave too large intra-county variations and thus perform poorly in controlling the unobserved spatial heterogeneity (Anderson and West 2006), and these refined localized spatial fixed effects have been shown to effectively remove most of time-invariant omitted variable bias, such as spatial autocorrelation (Abbort and Klaiber 2012). In addition, regression diagnosis techniques such as *Moran's I* are used to test for spatial autocorrelation.

c. Construction of urban premium

To better quantify the structural break in the effect of urban influences on surrounding farmland values induced by the housing market bust, we develop a parcel level measure of an "urban premium". This metric quantifies for each parcel, relative to a hypothetical agricultural land parcel with no urban influence, the total dollar value resulting from being located closer to urban areas. This urban premium measure consists of four distinct parts: value derived from being closer to the nearest city than the reference parcel, additional value derived from being within proximity to a second nearest city, the positive effects resulting from both surrounding urban population, and benefits derived from total weighted population among three nearest cities captured in the gravity population index. With these measures, we are able to identify the parcel-level structural change in the influence of urban premium before and after the housing market bust. To construct this metric, the coefficients from the hedonic model with spatial fixed effects are used:

$$\log(V_{\iota t}) = \beta_0 + \beta_A{}' \boldsymbol{A_{it}} + \beta_N{}' \boldsymbol{N_{it}} + \beta_{U\_boom}{}' \boldsymbol{U_{it}} * D_{t\_boom} + \beta_{U\_bust}{}' \boldsymbol{U_{it}} * D_{t\_bust} + \tau_t + \theta_j + \varepsilon_{it}, (7)$$

where D_{t_boom} and $D_{t_bust}$are the time dummies indicating the timing of the recent housing market bust.

In essence, the parcel level urban premium is calculated as the difference between the predicted prices $\exp(\widehat{\log(P_{\iota t}}))$ using actual distance and population variables $\boldsymbol{U_{it}}$ for one parcel and the predicted prices $\exp(\dddot{\log}(P_{\iota t}))$ using distance and population variables $\overline{\boldsymbol{U}}$ of the reference parcel with no urban influence.

$$\widehat{\log(P_{\iota t})} = \widehat{\beta_0} + \widehat{\beta_0}\, t + \widehat{\beta_A}{}' \boldsymbol{A_{it}} + \widehat{\beta_N}{}' \boldsymbol{N_{it}} + \widehat{\beta_{U\_boom}}{}' \boldsymbol{U_{it}} * D_{t\_boom} + \widehat{\beta_{U\_bust}}{}' \boldsymbol{U_{it}} * D_{t\_bust} + \widehat{\theta_J} + \varepsilon_{it}, (8)$$

$$\dddot{\log(P_{\iota t})} = \widehat{\beta_0} + \widehat{\beta_0}\, t + \widehat{\beta_A}{}' \boldsymbol{A_{it}} + \widehat{\beta_N}{}' \boldsymbol{N_{it}} + \widehat{\beta_{U\_boom}}{}' \overline{\boldsymbol{U}} * D_{t\_boom} + \widehat{\beta_{U\_bust}}{}' \overline{\boldsymbol{U}} * D_{t\_bust} + \widehat{\theta_J} + \varepsilon_{it}, (9)$$

$$urban\ premium = \exp\left(\widehat{log(P_{\iota t})}\right) - \exp\left(\dddot{\log(P_{\iota t})}\right). (10)$$

Guiling et al. (2009) has estimated the extent of urban influence using parcel level data in Oklahoma, and found that for a city with around 50,000 residents, the urban influence on farmland prices extends 45 miles from the city center. Semiparametric regressions using our data in Ohio reveal that the effects of urban influence become negligible around 60 miles away from the nearest city center, and the effects of incremental distance to the 2nd nearest city are no longer evident 40 miles[2]. As a result, the distance and population variables for the reference parcel in this study are 60 miles for distance to nearest city, 40 miles for incremental distance to 2nd nearest city, and zero for surrounding urban population and gravity index. Using this definition, the urban premium is a relative concept with the hypothetical parcel $\overline{\boldsymbol{U}}$ as the reference; and in

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[2] The incremental distance to second nearest city is defined as the difference between the distance from the second nearest city center and the distance from the nearest city center. For example, a parcel located 10 miles away from the nearest city and 30 miles away from the second nearest city will have an incremental distance to the 2nd nearest city of 20 miles.

our study region of Ohio, this metric is always positive for all the agricultural parcels. The construction of urban premium metric is to uncover the structural change in the value of urban influences, and urban influence variables such as *access to highway ramps and railway points, percentage of developed area within the agricultural parcels* that are relatively homogenous across the landscape and stayed constant over time are not included, such as distance to interstate highway on-ramps and railway stations.

d. Testing for potential sample selection bias

Another problem worth consideration is the potential for sample selection bias. The standard hedonic price method assumes linear parameterization and distributional equality of the covariates across the treatment and control subsamples, which may result in sample selection bias due to unbalanced observables (Heckman and Robb 1985). Intuitively, agricultural parcels closer to the urban centers could have easier access to the transportation network and agricultural output markets, such as ports and rail terminals, than that of those parcels further away. These systematic differences, if not corrected, may result in erroneous estimates of the impact of proximity to urban centers on farmland values. As a result, we use difference-in-difference (DID) matching estimators as robustness check. Intuitively, matching solves the sample selection on the observables by selecting treated observations and comparison observables with similar covariates, by covariates (e.g., Rubin 1980) or by propensity score (e.g., Rosenbaum and Rubin 1983). Matching presents several key advantages over the standard hedonic approach: it is nonparametric (Smith and Todd 2005) and ensures that observations in treatment and control groups share the common support (Ravallion 2008). The spatial dependence and sample selection problems were largely ignored until very recently in previously studies of farmland valuation (Nickerson and Zhang 2013). In this paper, we not only control and test for spatial dependence using local spatial fixed effects, but also attempt to address the potential for sample selection bias using a robustness check involving matching. Specifically, we use propensity score matching (PSM) to construct treatment and control groups based on distances to nearest urban center, and use DID regression to examine whether the relative influence of urban proximity on agricultural land values changed following the housing market bust. To assess the potential for sample section bias, the results from this quasi-experimental design are compared to the main results from the hedonic regressions with spatial fixed effects.

IV. Data

Western Ohio hosts a vast majority of the state's agricultural land and provides an excellent laboratory to study the structural change in determinants of farmland values that was precipitated by the residential housing bust. Ohio became one of hardest hit states in the housing market bust and accompanying recession, as evidenced by the sharp decline of residential housing prices (see Fig. 1). Using Metropolitan Statistical Area (MSA) level data on residential land prices and structure costs (Lincoln Institute of Land Policy, 2012); Fig. 1 reveals that Ohio residential home values declined significantly after the housing market bust in 2007. To analyze the impact of the housing market bust, we have assembled a detailed database of 21,342 armslength agricultural land sale records for 50 western Ohio counties obtained from county assessors' offices, and purchased sales data from CoreLogic, a private firm.

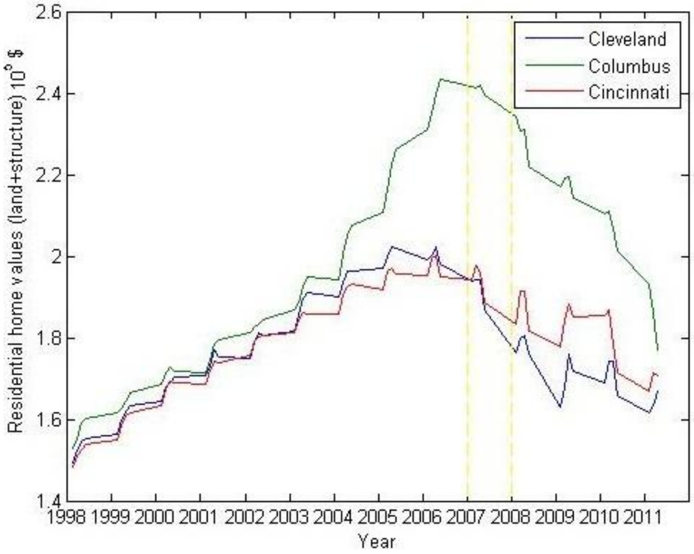

Figure.1: Ohio residential home values 1998-2011

The sample is further screened to eliminate rural parcels under no or little urban influences: parcels that are located outside the Core Based Statistical Area counties and beyond 10 miles away from the edge of nearest city are dropped. In addition, only those agricultural parcels sold between 2001 and 2010 and with a valid arms length indicator are retained. These valid agricultural sale records were merged with georeferenced parcel boundaries or geocoded based on property addresses using ArcGIS. The per-acre sale price was adjusted for inflation using the consumer price index of the metropolitan area where the parcel is located at, with year 2000 being the base year. Construction of the dependent variable is a common problem in farmland value studies, given that sale prices reflect the value of both land and structures in presence of farm structures, residential dwellings, or both (Nickerson and Zhang 2013). Without data quantity and quality of buildings on farmland, we instead construct a sales price for land only as the dependent variable: the new sales price was calculated as a fraction of the original price, with the ratio being the percentage of *assessed values of land only* over *assessed values of land and buildings altogether*. This assumes the portion of sales price attributable to land only could be approximated based on the contribution of assessed value of land to the total assessed value of land plus buildings. Similarly, Guiling et al. (2009) also subtracted the value of improvements from the sale prices. Parcels with the new sales prices above $20,000/acre or below $1,000/acre are dropped along with parcels sold in the year 2007. Figure 1 shows a plot of the filtered sample consisting of 13,012 valid parcel transactions. As is evident from the figure, these data are widely distributed over the entire region. The locations of Ohio urbanized areas and interstate

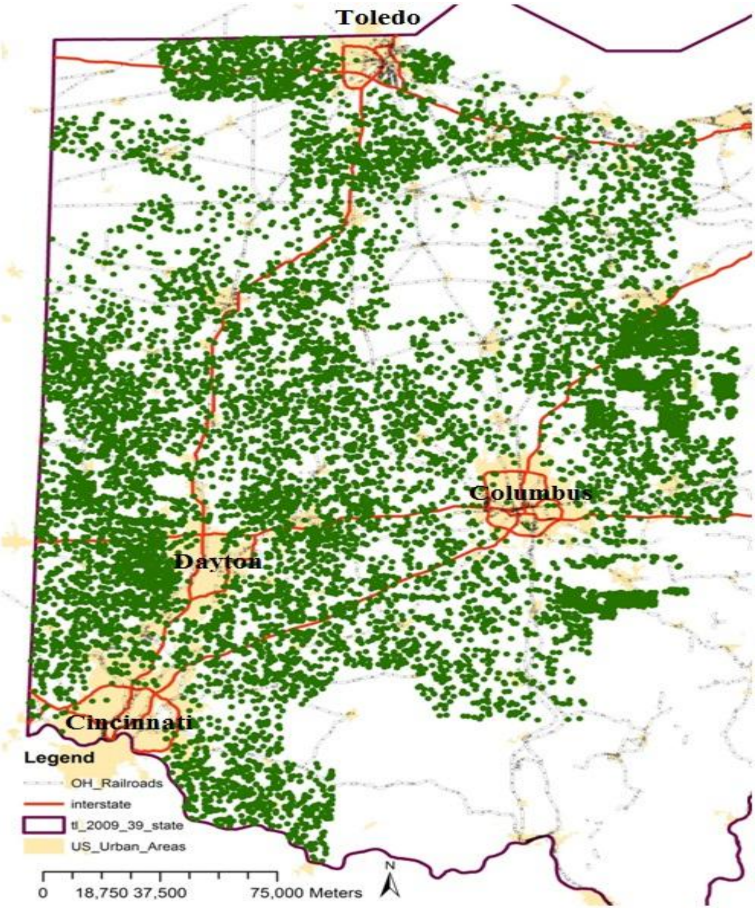

Figure 2: Agricultural land transactions from 2001 to 2010 under urban influence in western Ohio

highways are also shown in Fig.2. The temporal trends of real agricultural land prices for these filtered parcels are plotted in Fig.3, from which the drastic decline seen in the residential housing markets is not evident. The average real agricultural land sale prices stayed fairly constant around $5,000 per acre over the 2000 decade, yet the dip in average sale prices from 2008 to 2009 is still noticeable.

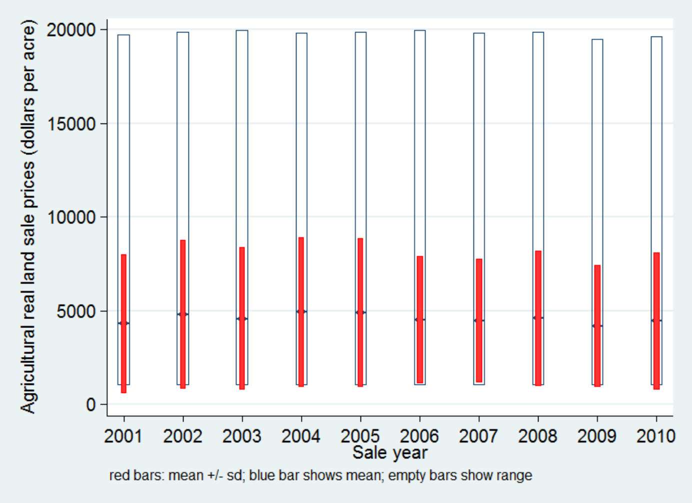

Figure 3. Western Ohio real agricultural land prices 2001-2010

Data on parcel attributes and location characteristics were obtained largely from the U.S. Department of Agriculture Natural Resources Conservation Services GeoSpatial Data Gateway (USDA GeoSpatial Data Gateway, 2012), including the Census TIGER/Line Streets, National Elevation Dataset, National Land Cover Dataset (NLCD), Soil Survey Spatial Data (SSURGO). Additional data on locations of cities and towns in Ohio were obtained from the Ohio Department of Transportation (2012). We also used Census Block Shapefiles with 2010 Census Population and Housing Unit Counts (U.S. Census TIGER/Line, 2012) to calculate the surrounding urban population. Data on ethanol plants, grain elevators and agricultural terminal ports were obtained from the Ohio Ethanol Council (2012), the Farm Net Services (2012) and the Ohio Licensed Grain Handlers List (2012). Using these data and ArcGIS software, we were able to create the parcel attributes and location characteristics vector $\boldsymbol{X_i}$. Table 1 reports summary statistics for these variables.

Most of variables in table 1 are self-explanatory; however, several explanations are in order. First, the variable *National Commodity Crops Productivity Index (NCCPI)* is an

	Unit	Mean	Std. Dev.	Min.	Max.
General Parcel Attributes					
Sales price per acre (without structures)	Dollars	4098.04	3666.46	1000.16	19956.21
Log of sales price per acre (without structures)	Dollars	7.99	0.82	6.2152	9.901296
Assessed land value	Dollars	83616.02	180875	0	7394300
Assessed improvement value	Dollars	37068.38	65850.29	0	1428250
Assessed land value % of total assessed	%	68.87%	31.95%	0.35%	100.00%
Total acres	Acres	47.17	74.11	0.14	2381
Sale year	Year	2004.90	2.67	2001	2010
Agricultural Profitability Influence Variables					
National Commodity Crops Productivity Index	Number	5740.04	1567.05	0	8800.8
Cropland % of parcel	%	54.49%	37.80%	0.00%	100.00%
Soil class 1 area % of parcel	%	37.26%	36.22%	0.00%	100.00%
Soil class 2 area % of parcel	%	42.80%	41.14%	0.00%	100.00%
Soil class 3 area % of parcel	%	19.94%	29.22%	0.00%	100.00%
Steep slope (< 15 degrees, 15-25, 25-40, >40)	Binary	0.42	0.71	0	3
Distance to nearest ethanol plant	Miles	29.65	13.89	0.55	69.84
Distance to nearest grain elevator	Miles	8.24	6.99	0.03	55.27
Distance to nearest agricultural terminal	Miles	31.41	14.74	0.13	74.62
Forest area % of parcel	%	16.38%	26.84%	0.00%	100.00%
Wetland area % of parcel	%	0.34%	2.92%	0.00%	100.00%
Urban Influence Variables					
Building area % of parcel	%	3.32%	12.45%	0.00%	100.00%
Distance to nearest city center with over 40,000 people	Miles	22.77	10.67	0.12	57.39
Distance to railway station	Miles	3.09	1.82	0.01	11.25
Total urban population within 25 miles	Thousands	312.15	236.28	647.72	1187.38
Gravity index of 3 nearest cities		1291.45	38158.82	62.14	4255332
Distance to highway ramp	Miles	3.21	2.05	0	11.94
Observations			13012		

Table 1. Summary statistics of agricultural land sales under urban influences in western Ohio

interpretation in the National Soil Information System (NASIS). Specifically, the interpretation uses natural relationships of soil, landscape, and climate factors assign productivity ratings for dry-land commodity crops, where the most desirable properties, landscape features and climatic conditions lead to larger values of *NCCPI* (see Dobos et al. (2008) for details). The soil classes are defined based on the land capability classification or suitability of soils for most kinds of field crops: soil class 1 or prime soil is defined as “Prime farmland”, class 2 as “Farmland of local importance” and class 3 as “not prime farmland”. For each parcel, the percentage measures of land area in three soil classes are calculated. Most grain elevators and agricultural terminals are already there before the start date of this study, and thus the distances to these two types of agricultural delivery points are constant over the study period. However, all of the six ethanol plants in Western Ohio did not start operations until 2008, as a result, in the model we assume the positive value of proximity to ethanol plants did not get capitalized before 2007 and thus the variable *distance to nearest ethanol plant* is interacted with a post 2007 time dummy.

Finally, this study highlights the set of the urban influence variables $\boldsymbol{U_i}$ in particular. Several aspects of urban influences are considered: *distance to nearest city* captures the importance of urbanized areas as a commuting hub or sources of non-farm income, proximity to interstate network (as measured of the distance to the nearest highway on-ramp) and railway system and *surrounding urban population within 25 mile-radius for each parcel* represent the option value of future land conversion to urban uses. Surrounding urban population also captures the consumer demand for agricultural products, which will drive up the agricultural returns (Nickerson et al. 2012). *The percentage of building area within a parcel* is designed to capture the remaining unobserved and often beneficial factors prices that contribute to the decision of building residential or farm structures after subtracting value of buildings from the sales. The *incremental distance to second nearest city* is defined as the additional distance from one parcel to reach the second city net of the distance to nearest city. This measure is commonly used in the literature of studies on Central Place Theory and urban hierarchy to capture the additional value of influences from multiple urban centers (i.e. Partridge et al. 2008). The *incremental distance to second nearest city* and the *gravity index* accounts for the aggregate urban influences resulting from multiple urban centers. The *gravity index* is calculated as the weighted average of population divided by distance squared for the nearest three cities following Shi, Phipps and Colyer (1997). As made clear in section III.c, we focus more on four specific variables in constructing the urban premium: *distance to nearest city*, *incremental distance to 2nd nearest city, surrounding urban population within 25 miles*, and *the gravity index.*

V. Results and Discussion

As shown in Fig. 3, the housing market bust did not lead a drastic drop in Ohio agricultural land values; however, Fig. 4 reveals that the number of agricultural land sales dropped precipitously after the housing market bust. This again offers additional evidence to our contention that there was a significant decline in the effects of urban influence after the housing market bust.

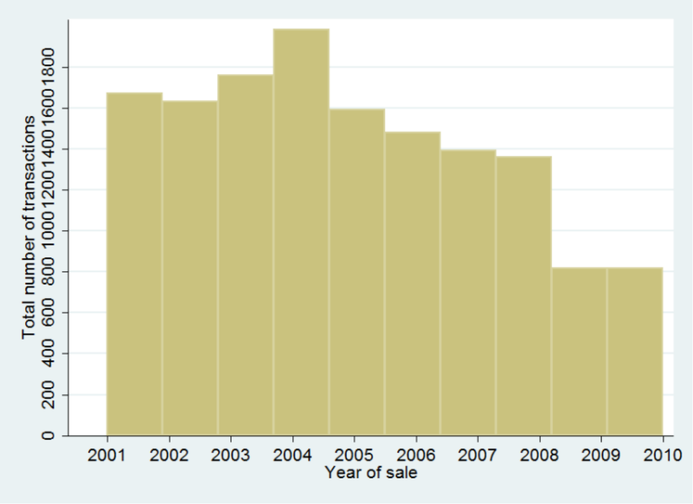

Figure 4. The number of armslength agricultural land sales in Western Ohio 2001 – 2010

Before we analyzed whether a structural break occurred in 2007 due to the housing bust, we considered the spatial scales at which changes in urban influences could be best identified. Table 2 shows results for models with county fixed effects and census tract fixed effects, with parcels sold in 2007 dropped and no interaction terms to capture structural changes induced by the housing bust. These two models yield qualitatively similar results and most of the coefficients are intuitive and as expected: for example, the farther away a parcel was from ethanol plants, the lower the per acre sales prices. However, some important differences between the results of the two models do emerge: the productivity variables *NCCPI* and *percentage of prime soil* in the parcel are only significant in the hedonic model with census tract fixed effects. More importantly, in the regression with county fixed effects, the urban influence variables *distance to highway ramps* and *surrounding urban population* show no significance in determining farmland values; while the model with census tract fixed effects reveal a different pattern. To sum up, several variables that determine agricultural land prices such as *percentage* *of prime soil* and *surrounding urban population* vary significantly across census tracts, but not across counties. This implies that county fixed effects are too coarse to pick up the important spatial variations of agricultural and urban influence variables, and models including localized spatial fixed effects measured at the census tract level are superior to models with only county fixed effects.

Model	Model I: County FE		Model II: Census Tract FE	
	Coef.	Std. Err.	Coef.	Std. Err.
Intercept	9.2137***	0.1432	8.3404***	0.1493
Assessed land value % of total assessed	0.3758***	0.0227	0.3861***	0.0215
Total acres	-0.0052***	0.0001	-0.0054***	0.0001
Total acres squared	2.89E-06***	1.20E-07	3.01E-06***	1.22E-07
National Commodity Crops Productivity Index	6.20E-06	5.25E-06	1.20E-05**	4.86E-06
Prime Soil area % of parcel	0.0229	0.0206	0.0357*	0.0195
Steep slope (>15 degrees)	-0.0125	0.0109	-0.0043	0.0108
Distance to nearest ethanol plant * Post 2007 dummy	-0.0047***	0.0010	-0.0029***	0.0010
Distance to grain elevator	-0.0015	0.0021	-0.0006	0.0016
Distance to nearest agricultural terminal	-0.0086***	0.0011	-0.0044***	0.0006
Building area % of parcel	0.0813*	0.0475	0.0902*	0.0487
Distance to highway ramp	-0.0050	0.0030	-0.0058*	0.0030
Distance to nearest city center	-0.0134***	0.0016	-0.0098***	0.0010
Incremental distance to 2nd nearest city center	-0.0073***	0.0011	-0.0032***	0.0007
Total surrounding population within 25 miles	6.87E-06	4.92E-05	2.32E-04***	4.08E-05
Distance to railway station	-0.0018	0.0033	-0.0002	0.0034
Forest area % of parcel	-0.0343	0.0285	-0.0088	0.0288
Wetland area % of parcel	-0.3296	0.2055	-0.1914	0.2103
Year 2001	-0.3043***	0.0340	-0.2496***	0.0437
Year 2002	-0.2072***	0.0398	-0.1656***	0.0402
Year 2003	-0.2170***	0.0397	-0.1818***	0.0401
Year 2004	-0.1784***	0.0398	-0.1282***	0.0398
Year 2005	-0.1367***	0.0398	-0.0943***	0.0402
Year 2006	-0.1463***	0.0401	-0.1043**	0.0405
Year 2008	0.0102	0.0293	-0.1333	0.0301
Year 2009	-0.0099	0.0322	-0.0305	0.0332
County fixed effects	yes			
Census tract fixed effects			yes	
Adjusted R-squared	0.2404		0.2217	
Number of Observations	11726		11726	

Table 2. Hedonic regressions without structural change

Note: the dependent variable in this model is the log of per-acre, real agricultural land prices without structures. *, **, and *** indicates the coefficient is significant at 10%, 5% and 1% level, respectively. Model I includes 49 county fixed effects, while model II include 511 census tract fixed effects.

Table 3 presents the results of our tests for structural change in the effect of urban influence using a hedonic model with 511 census tract fixed effects, denoted as the default model – model 0. The key variables are the interactions of pre- or post- 2007 dummies with urban influence variables such as *distance to nearest city*. The pre- (post-) 2007 dummy is defined to be 1 (0) if the parcel is sold before 2007, and 0 (1) otherwise. The interaction terms include the four urban influence variables mentioned in section III.c, with distance to nearest city center further decomposed into whether the parcel is within 10 miles from the boundary of an urbanized area with at least 25,000 people. The cutoff distance 10 miles have been previously shown as important cutoff beyond which the urban influences are not as evident (Nickerson et al. 2012). Several things could be noted regarding the urban influence variables and their effects. The biggest contributor to the urban influence is *the distance to nearest city*, whose effect is twice as big as that of *incremental distance to 2*nd *nearest city*. All else being equal, the positive benefit per acre resulting from being close to nearest city declined from $26.44 per mile before 2007 to $15.01 per mile after the housing market bust, an almost 50 percent reduction. The decline is universal across parcels located 10 miles or more from the boundary of urbanized areas. In addition, the structural change in the effect of urban influence resulting from the housing market bust is so large that *surrounding urban population* and the effects of multiple urban centers are no longer significant after 2007. As illustrated in section III.c, Other urban influence variables such as *access to highway ramps and railway points*, *percentage of developed area within the agricultural parcels* are relatively homogenous across parcels and across time, and thus not included in the interaction terms in the model.

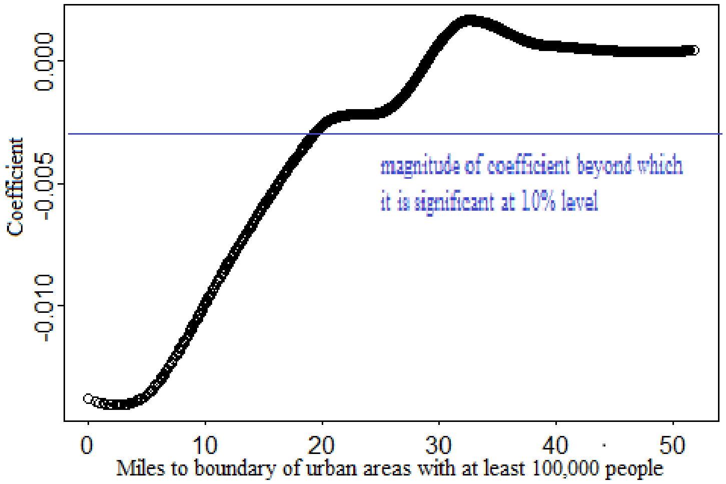

Figure 5. Semiparametric analysis – miles to the boundary of urbanized areas with at least 100,000 people

Model	Model 0	
	Coef.	Std. Err.
Intercept	8.1094***	0.1611
Assessed land value % of total assessed	0.3939***	0.0215
Total acres	-0.0054***	0.0001
Total acres squared	2.99E-06***	1.22E-07
National Commodity Crops Productivity Index	1.24E-05**	4.87E-06
Prime Soil area % of parcel	0.0300	0.0196
Steep slope (>15 degrees)	-0.0144	0.0109
Distance to nearest ethanol plant * Post 2007 dummy	-0.0037***	0.0007
Distance to grain elevator	-0.0043***	0.0014
Distance to nearest agricultural terminal	-0.0046***	0.0006
Building area % of parcel	0.0645	0.0529
Distance to highway ramp	-0.0061**	0.0031
Distance to city center*within 10 miles from urban boundary*Pre 2007 dummy	-0.0090***	0.0013
Distance to city center*within 10 miles from urban boundary*Post 2007 dummy	-0.0051***	0.0019
Distance to city center*beyond 10 miles from urban boundary*Pre 2007 dummy	-0.0090***	0.0012
Distance to city center*beyond 10 miles from urban boundary*Post 2007 dummy	-0.0054***	0.0018
Incremental distance to 2nd nearest city center*Pre 2007 dummy	-0.0046***	0.0008
Incremental distance to 2nd nearest city center*Post 2007 dummy	-0.0017	0.0012
Total surrounding population within 25 miles*Pre 2007 dummy	1.78E-04***	4.66E-05
Total surrounding population within 25 miles*Post 2007 dummy	7.88E-05	8.36E-05
Gravity index of 3 nearest cities*Pre 2007 dummy	2.29E-05***	4.47E-05
Gravity index of 3 nearest cities*Post 2007 dummy	4.05E-08	1.46E-07
Distance to railway station	-0.0007	0.0034
Forest area % of parcel	-0.0033	0.0289
Wetland area % of parcel	-0.2188	0.2101
Year 2001	-0.0886	0.0802
Year 2002	-0.0036	0.0802
Year 2003	-0.0206	0.0801
Year 2004	0.0325	0.0798
Year 2005	0.0692	0.0802
Year 2006	0.0607	0.0800
Year 2008	-0.0094	0.0301
Year 2009	-0.0252	0.0333
Census tract fixed effects	yes	
Adjusted R-squared	0.2250	
Number of Observations	11726	

Table 3. Hedonic regression with structural changes of urban influence variables

Note: the dependent variable in this model is the log of per-acre, real agricultural land prices without structures. *, **, and *** indicates the coefficient is significant at 10%, 5% and 1% level, respectively. 511 census tract fixed effects are included in the model.

The validity of the results is tested using multiple robustness checks shown in table 4. Different specifications and different samples are used to construct these robustness checks. Model I changes “within 10 miles from the boundary of urbanized areas with at least 25,000 people” to “within 20 miles from the boundary of urbanized areas with at least 100,000 people”, because semiparametric analysis reveals that the effects of large urban centers (with at least 100,000 people) will not disappear until 20 miles away from its boundary (see Fig.5). Model II drops surrounding urban population to avoid potential multicollinearity problems; model III does not distinguish parcels within 10 or 20 miles from boundary of urbanized areas from those beyond the cutoff; models VI and V use county fixed effects rather than census tract fixed effects; model VI adds back the parcels sold in the year of 2007; and model VII only includes observations located within MSA counties. The results across different specifications are fairly robust: *the distance to nearest urban center* is significant throughout the decade, with the effects almost cut in half after 2007; the coefficient of *incremental distance to 2nd nearest city* is either insignificant, or greatly reduced after the housing market bust; the impact of surrounding urban population and the gravity index switched from significant before 2007 to negligible subsequently. Comparisons of model IV, V and others show that county fixed effects obscured the benefits of *surrounding urban population* and *proximity to highway ramps* even before the housing market bust. And when only including parcels in MSA counties, the magnitude of the effects of *distance to nearest city and 2nd nearest city* is higher than the whole sample.

To better understand the magnitude of the structural change, we convert the regression results in table 3 and 4 to urban premiums in table 5 and 6 following the methods illustrated in section III.c. From table 5, we observe that, relative to the reference parcel 60 miles away from city center, the agricultural parcels on average enjoy a $1,586 per acre urban premium, or roughly 40% of the total sales prices before 2007. However, after the housing market bust, this urban premium witnessed a sizeable reduction: declined from $1,586 per acre to only $633 per acre, less than 20% of the total sales prices. Previous studies have typically only considered the distance to nearest city when measuring the urban influence (e.g. Guiling et al. 2009), however, table 5 reveals that failure to account for the joint effects of multiple urban centers may underestimate the size of the urban premium by as much as 30%. When we further break down the sample by proximity to urban centers, we find that, as expected, the urban premium is on

Model	Model I[#]	Model II	Model III	Model IV	Model V	Model VI	Model VII
Dist_City*within 10 miles*Pre 2007 dummy	-0.0098***	-0.0106***			-0.0130***	-0.0092***	-0.0138***
	(0.0012)	(0.0012)			(0.0018)	(0.0012)	(0.0018)
Dist_City*within 10 miles*Post 2007 dummy	-0.0062***	-0.0060***			-0.0088***	-0.0059***	-0.0078***
	(0.0019)	(0.0017)			(0.0022)	(0.0016)	(0.0028)
Dist_City*beyond 10 miles*Pre 2007 dummy	-0.0087***	-0.0113***			-0.0132***	-0.0091***	-0.0117***
	(0.0012)	(0.0010)			(0.0017)	(0.0011)	(0.0016)
Dist_City*beyond 10 miles*Post 2007 dummy	-0.0049***	-0.0065***			-0.0102***	-0.0059***	-0.0064**
	(0.0018)	(0.0014)			(0.0022)	(0.0015)	(0.0026)
Dist_City*Pre 2007 dummy			-0.0090***	-0.0130***			
			(0.0011)	(0.0017)			
Dist_City*Post 2007 dummy			-0.0053***	-0.0096***			
			(0.0017)	(0.0021)			
Incre Dist_2nd City*Pre 2007 dummy	-0.0047***	-0.0059***	-0.0046***	-0.0080***	-0.0080***	-0.0044***	-0.0061***
	(0.0008)	(0.0007)	(0.0008)	(0.0012)	(0.0012)	(0.0007)	(0.0010)
Incre Dist_2nd City*Post 2007 dummy	-0.0018	-0.0023**	-0.0016	-0.0053***	-0.0054***	-0.0018*	-0.0042**
	(0.0012)	(0.0010)	(0.0012)	(0.0015)	(0.0015)	(0.0010)	(0.0016)
Urban popu within 25 miles*Pre 2007 dummy	0.0002***		0.0002***	9.05E-06	4.80E-06	0.0002***	0.0001**
	(4.69E-05)		(4.51E-05)	(0.0001)	(5.33E-05)	(4.53E-05)	(0.0001)
Urban popu within 25 miles*Post 2007 dummy	0.0001		8.56E-05	-7.36E-06	-3.90E-05	5.16E-05	9.14E-05
	(0.0001)		(0.0001)	(0.0001)	(8.78E-05)	(0.0001)	(0.0001)
Gravity index*Pre 2007 dummy	2.07E-05***	2.44E-05***	2.14E-05***	1.83E-05***	1.84E-05***	2.18E-05***	1.22E-05**
	(5.63E-06)	(5.57E-07)	(5.62E-06)	(5.67E-06)	(5.69E-06)	(5.57E-06)	(6E-06)
Gravity index*Post 2007 dummy	3.68E-08	3.61E-08	4.01E-08	2.41E-08	2.58E-08	3.65E-08	5.15E-08
	(1.46E-07)	(1.46E-07)	(1.46E-07)	(1.42E-07)	(1.42E-07)	(1.45E-07)	(1.47E-07)
Building area % of parcel	0.0610	0.0798*	0.0646	0.0661	0.0656	0.0743	-0.0069
	(0.0487)	(0.0485)	(0.0487)	(0.0476)	(0.0476)	(0.0458)	(0.0623)
Distance to highway ramp	-0.0068**	-0.0067**	-0.0061**	-0.0050	-0.0049	-0.0043	-0.0094**
	(0.0031)	(0.0031)	(0.0031)	(0.0030)	(0.0030)	(0.0029)	(0.0042)
Distance to railway station	0.0006	0.0012	0.0007	0.0014	0.0015	0.0003	0.0045
	(0.0034)	(0.0034)	(0.0034)	(0.0033)	(0.0033)	(0.0032)	(0.0044)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County Fixed Effects				Yes	Yes		
Census tract fixed effects	Yes	Yes	Yes			Yes	Yes
Include parcels sold in 2007						Yes	
Parcels in MSA counties only							Yes
Adjusted R-squared	0.2253	0.2600	0.2251	0.2404	0.2404	0.2217	0.2506
Number of Observations	11726	11726	11726	11726	11726	13202	7639

Table 4. Robustness checks

[#]: Model I distinguishes parcels not by within 10 miles of the boundaries of urban centers with at least 25,000 people, but by within 20 miles of the boundaries of urban centers with at least 100,000 people. Standard Errors are in parentheses. The dependent variable in this model is the log of per-acre, real agricultural land prices without structures. *, **, and *** indicates the coefficient is significant at 10%, 5% and 1% level, respectively.

average higher for parcels within close proximity to urban centers. The size of urban premium for parcels within 10 miles from urban centers is almost three times of that for parcels that are 30 miles or more away from urban centers. Similar trends emerge when we compare parcels in MSA counties and non-metropolitan counties. Another interesting finding is that before 2007, the difference of urban premium between parcels in MSA counties and non-metropolitan counties is on average $700; however, this difference shrank to $200 after the housing market bust. This is also true when we compare parcels within 10 miles from urban centers and those between 10 and 20 miles away from urban centers. In other words, the housing market bust has a greater impact on parcels closer to urban centers than those farther away, resulting in a convergence pattern of urban premium for these two groups.

	Whole sample		**<10 miles**		**10-20 miles**		**30-60 miles**		**MSA Counties**		**Non-MSA Counties**	
	Boom	**Bust**	**Boom**	**Bust**	**Boom**	**Bust**	**Boom**	**Bust**	**Boom**	**Bust**	**Boom**	**Bust**
Total Urban Premium	**$1586**	**$633**	**$2412**	**$982**	**$1800**	**$799**	**$961**	**$382**	**$1814**	**$731**	**$1091**	**$517**
	($1730)	($302)	($1287)	($397)	($797)	($262)	($366)	($291)	($2030)	($327)	($438)	($219)
1) miles to nearest city	$1105	$633	$1770	$982	$1300	$799	$568	$382	$1270	$731	$751	$517
	($1090)	($302)	($727)	($397)	($476)	($262)	($249)	($149)	($1264)	($327)	($340)	($219)
2) incremental dist to 2nd city	$291	*$122*	$264	*$95*	$271	*$108*	$313	*$145*	$302	*$125*	$266	*$118*
	($396)	*($78)*	($303)	*($102)*	($219)	*($88)*	($120)	*($68)*	($466)	*($81)*	($160)	*($73)*
3) surrounding urban population	$142	*$66*	$239	*$111*	$177	*$94*	$67	*$38*	$179	*$88*	$62	*$39*
	($227)	*($62)*	($204)	*($98)*	($149)	*($73)*	($57)	*($28)*	($266)	*($74)*	($35)	*($23)*
4) gravity index	$48	*$0.37*	$140	*$3.3*	$52	*$0.12*	$13	*$0.03*	$65	*$0.65*	$13	*$0.03*
	($116)	*($12.35)*	($231)	*($40.5)*	($52)	*($0.12)*	($10)	*($0.02)*	($137)	*($17)*	($11)	*($0.03)*
Observation	9013	2713	1306	251	2844	763	2010	775	6168	1471	2845	1242

Table 5. Comparison of urban premiums before and after the housing market bust – Model 0

Note: The values of incremental *distance to 2nd nearest city, surrounding urban population and gravity index* after 2007 are not included in the construction of urban premium if their corresponding coefficients are not significant at 10% level. Standard deviations are in parentheses.

Measures of urban premiums across different specifications shown in table 6 are fairly robust: all experienced an on average significant decline in urban premium after the housing market bust, more or less by half. The size of urban premium is much larger in model VII because it only includes parcels in MSA counties, but it is still comparable to table 5 columns 5. County fixed effects fail to control for many within county inherent spatial heterogeneity and thus overestimating the effects of urban influences in column 4 and 5. The drastic different results from the breakdown in table 5 and the large standard deviation of urban premium in tables 5 and 6 reveal that there is rich spatial heterogeneity of urban premium from parcel to parcel. This rich spatial heterogeneity supports our contention that spatially disaggregated analysis of the determinants of farmland prices is better than the traditional county level aggregate analysis.

	Model I		**Model II**		**Model III**		**Model IV**		**Model V**		**Model VI**		**Model VII**	
	Boom	**Bust**	**Boom**	**Bust**	**Boom**	**Bust**	**Boom**	**Bust**	**Boom**	**Bust**	**Boom**	**Bust**	**Boom**	**Bust**
Total Urban Premium	**$1631**	**$672**	**$1681**	**$734**	**$1588**	**$638**	**$1899**	**$1468**	**$1923**	**$1364**	**$1577**	**$797**	**$2182**	**$1274**
	($1801)	($262)	($1804)	($346)	($1732)	($311)	($1579)	($528)	($1601)	($514)	($2007)	($372)	($1602)	($618)
1) miles to nearest city	$1143	$672	$1288	$734	$1106	$638	$1454	$1151	$1475	$1052	$1092	$667	$1723	$989
	($1161)	($262)	($1308)	($346)	($1090)	($311)	($1163)	($479)	($1181)	($456)	($1246)	($311)	($1185)	($474)
2) incremental distance to 2nd city	$290	*$133*	$340	*$158*	$291	*$120*	$409	$317	$408	$312	$282	$130	$330	$285
	($388)	*($84)*	($461)	*($101)*	($397)	*($77)*	($445)	($182)	($446)	($194)	($446)	($85)	($362)	($187)
3) surrounding urban population	$153	*$92*			$142	*$71*	*$2*	*$-19*	*$6*	*$-5*	$153	*$46*	$99	*$88*
	($241)	*($84)*			($228)	*($67)*	*($2)*	*($16)*	*($8)*	*($4)*	($278)	*($41)*	($112)	*($71)*
4) gravity index	$45	*$0.31*	$54	*$0.32*	$48	*$0.36*	$35	*$0.17*	$34	*$0.17*	$50	*$0.26*	$30	*$0.67*
	($105)	*($10.4)*	($135)	*($11)*	($115)	*($12)*	($84)	*($6)*	($82)	*($6)*	($126)	*($9)*	($52)	*($17)*
Observation	9013	2713	9013	2713	9013	2713	9013	2713	9013	2713	9013	3999	6168	1471

Table 6. Robustness checks across different hedonic models

Note: The values of incremental *distance to 2nd nearest city, surrounding urban population and gravity index* are not included in the construction of urban premium when their corresponding coefficients are not significant at 10% level. Standard deviations are in parentheses.

We previously described the potential for omitted variable bias arising from spatial dependence, as the land parcels in our data are spatially ordered. We test for spatial autocorrelation using *Moran's I* test, where a positively significant *I* indicates that the variable value at each parcel tends to be similar to nearby neighbor parcels (Anselin and Hudak 1992). The global spatial autocorrelation by *Moran's I* test indicates that although some explanatory variables are spatially correlated, the residuals from the hedonic regressions exhibit no patterns of spatial autocorrelation, even without including census tract fixed effects. It must be that the various measures of urban influences and agricultural productivity adequately controlled for the inherent spatial correlation. The localized spatial fixed effects at census tract level also significantly alleviate the problem of omitted variable bias, if any.

Our final robustness check is a test for sample selection bias. Table 7 shows the results of difference-in-difference regressions on the matched sample. Matching through propensity scores or covariates effectively ensure that the only difference between the control and treatment group is whether the parcel is close to (i.e. within 8 miles) the city center, and DID regression controls for time-invariant spatial heterogeneity. The interaction term “dummy_proximity * dummy_time” serves as the DID estimator and captures the reduction of the marginal value of being located close to a city center after 2007. Results across different matching algorithms and different definitions of proximity to urban centers suggest that being located within close proximity to urban centers, say 8 miles, could translate into a $450 per acre premium compared to other similar parcels farther away. However, this urban premium is completely wiped out by the housing market bust. On average, the pre-2007 premium is $300 to $700 per acre, while the structural decline of the urban influence spans from $500 to $1500 per acre. For example, parcels within 6 miles from urban centers used to enjoy an urban premium compared to those similar parcels beyond 6 miles away from urban centers before 2007, however, may become less valuable after the housing market bust.

	Model I	Model II	Model III	Model IV	Model V	Model VI
Dummy_close to urban areas	0.0929**	0.1158***	0.1419*	0.0402	0.0932*	0.0624*
	(0.0390)	(0.0390)	(0.0797)	(0.0505)	(0.0521)	(0.0373)
Dummy_sold after 2007	0.0122	0.1936	0.1100	0.1667	0.2375	0.0720
	(0.1272)	(0.1277)	(0.3013)	(0.1804)	(0.1861)	(0.1193)
Dummy_proximity*Dummy_2007	-0.1187*	-0.1170*	-0.3415**	-0.2243**	-0.2095**	-0.1847***
	(0.0712)	(0.0699)	(0.1522)	(0.0914)	(0.0953)	(0.0691)
Adjusted R-square	0.2793	0.3437	0.3333	0.3582	0.2647	0.3415
Number of Observations	1616	1608	384	895	895	1682
Matching method	1-4 nn	1-1 nn	1-1 nn	1-1 nn	1-4 nn	CVM
Definition of close to urban areas: miles to nearest city	<10	<10	<6	<8	<8	<10
Regional Dummies in the matching	County FE					
Regional Dummies in DID regression	Census tract FE					

Table 7. Propensity score matching and difference-in-difference regressions

Note: the dependent variable in this model is the log of per-acre, real agricultural land prices without structures. *, **, and *** indicates the coefficient is significant at 10%, 5% and 1% level, respectively.

The magnitude of the structural change in the DID matching estimator is greater than our main results from hedonic models; this is because after stringent matching, the matched sample only consists of 10% of total observations. To ensure the overall balancing property for treatment and control subsamples, at most a distance cutoff of 10 miles away from the nearest city center could be used. Notice in the hedonic model the maximum distance away from the nearest city center is more than 50 miles. Despite the substantial reduction in sample size, the key message is still the same: there is a significant structural decline in the urban influences. Matching could address sample selection problem, however, with access to road network not significant and qualitatively similar results with the hedonic regressions, there is no evidence of serious sample selection bias. In contrast, hedonic regressions present key advantages in measures of urban premium compared to the matching estimator. To make the matching work, detailed continuous distance variables have to be converted to binary variable using arbitrary cutoff distance for closeness, and other measures such as *incremental distance to 2nd city* and *surrounding urban population* are also discarded to avoid collinearity. With no serious sample selection problems, it makes no sense to discard the refined measures of urban influences used in the hedonic regressions and switch to the matching estimation.

VI. Conclusion

Farm real estate values represent over 80 percent of the value of the farm sector assets, and typically are the single largest item in farm household investment portfolios (Nickerson et al. 2012). This means that understanding the key determinants of changes in farmland prices are of perennial interest to policymakers. Yet, little is known about how significant changes in competing land markets affect farmland values. With more than one-third of farmland estimated to be subject to urban influences, the effects of the 'bust' that occurred in the housing market in 2007 are of particular interest. Understanding and quantifying the structural break in the effects of urban influence precipitated by this bust could offer unique insights into the dynamics of the relative importance of different determinants of farmland values, and help inform on the linkages between urban and rural land markets. By controlling for spatial heterogeneity using localized fixed effects and developing a parcel level measure of urban premium, this study provides the first concrete evidence on the decline in the effect of urban influences on surrounding farmland prices after the housing market bust.

Using a hedonic modeling approach, this paper demonstrates that models with census tract fixed effects are preferable to the county fixed effects since many key variables such soil quality, access to highway ramps, and surrounding urban population vary significantly across census tracts, but not across counties. This variation is obscured in hedonic models that control for these differences with county fixed effects. Our main results also demonstrated that failure to account for multiple urban centers using variables such as incremental distances to 2^{nd} city would underestimate the urban influence premium by as much as 30 percent. In addition, the regional differences of parcel-level urban premium in different distance bands illustrate the rich spatial heterogeneity of urban influences and thus validates the superiority of spatially disaggregate parcel-level analysis over traditional county-level aggregate study. Furthermore, the regression diagnosis reveals that the over 500 census tract fixed effects are effective in removing most of the omitted variable bias.

With the urban premium declining from $1,586 per acre on average before 2007 to $633 per acre on average after the housing market bust, the proportion of urban influences reduced from almost 40 percent of the total sales prices to less than 20 percent. In the context of current heated debate about potential bubbles in farmland markets, this study of dynamics of competing determinants of agricultural land prices provides a timely contribution in evaluating the economic fundamentals of the farmland values.

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