Impacts of Urbanization and Bio-fuels Production on The Price of Land in the Corn Belt: A Farm-Level Analysis

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Abstract

This study uses hedonic techniques to estimate the impact of urban influence, increased bio-fuels production, and environmental factors on land prices in the Corn Belt. We hypothesize that urban influence and ethanol production increase land prices on Corn Belt farms. Although not all states in the Corn Belt are entirely subject to urban influence and ethanol production impacts, some states are intensely affected. Despite regional variations in urban influence, Corn Belt states have soil types, climate, and crop patterns/rotations that are relatively homogeneous, helping us to isolate the effects of urbanization and bio-fuels. We find that quality-adjusted land prices in the Corn Belt are significantly increased by the presence of urbanization and bio-fuel plants. During 2006, hedonic procedures indicate that in the entire Corn Belt a 10-percent increase in urban influence leads to a close to 2-percent increase in the quality-adjusted land price. Similarly, hedonic procedures indicate that a 10-percent increase in ethanol capacity leads to a greater than 0.3-percent increase in the quality-adjusted land price. We also find that government payments, conservation payments, off-farm income, and corn revenue per acre significantly boost land prices, though to a lesser extent than urbanization and ethanol production. Clearly ethanol production in the Corn Belt is a new and not unimportant phenomenon influencing land prices. The ARMS data set used in this study incorporates the full price impact of ethanol on corn and land prices that occurred in 2006. Hence it captures, preliminarily, the impact of ethanol production as a new and important influence on land prices in the Corn Belt (the average corn price per bushel increased 75 percent in 2006 compared to 2005) along with urban pressure, government payments and other factors. However, this impact appears to be confined to the Western Corn Belt.

Key Words: hedonic methods, urban-influence, bio-fuels, Conservation Reserve Program.

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Impacts of Urbanization and Bio-fuels Production on Costs of Production and Land Use in the Corn Belt: A Farm-Level Analysis

The causes and consequences of current land use trends and dynamics in North America and Europe are the result of complex interactions among economic, environmental, and social factors. In this paper we use farm-level data from the U.S. Department of Agriculture to examine how major "drivers of change" such as urbanization, bio-fuels production, and environmental factors are affecting costs of production and land use decisions in the U.S. Corn Belt.

The expansion of low-density nonfarm development into traditionally rural areas is affecting more and more U.S. farmland (Nehring, Barnard, Banker, and Breneman). The direct effect of such development, the conversion of rural lands to housing and other nonfarm uses is well documented (Cho, Wu, and Boggess, 2003).

However, this direct conversion may be overshadowed by the secondary effects of "urban influence" on the active farmland that remains interspersed among nonfarm development. Recent studies suggest that such interspersion raises the cost of producing agricultural commodities (Gardner; Lopez and Munoz; Abdalla and Kelsey; Lopez, Adelaja, and Andrews). For instance, we estimate urban influence raises total variable costs per acre for traditional farms in the Corn Belt by more than 8 percent, and is consistent with a 67 percent higher price of land per acre on urban than on rural land. Policies such as government payments, farmland preservation, and environmental impacts that affect land use cannot be properly evaluated without including the urbanization component.

In addition, interspersion may be widespread. The 6.6 percent of non-Federal land categorized as developed by NRCS (Natural Resource Conservation Service) is estimated to "influence" a much larger proportion of U.S. farmland acres, perhaps as much as 17 percent (Barnard). Close to two-thirds of the 3,141 U.S. counties are classified as metropolitan or metro-adjacent (USDA/ERS 2004). The number of urban-influenced acres is so large (relative to acres directly required for urban use) that vast amounts of U.S. agricultural land will operate subject to urban influence indefinitely. Nelson, in a report for the Brookings Institution, estimates that an additional 35 million acres might need to be developed by 2030. More striking, the 17 percent of U.S. farmland that Barnard estimates is urban influenced represents 159 million acres. Even allowing for necessary commercial/industrial land, many times more acres are currently urban influenced than will be required for additional urban use within the next 30 years. Increasingly, ethanol production competes for corn production and has created a long term boost in corn prices (See Tokgoz et al.). Clearly, such a long term boost creates upward pressure on land prices.

Objective

We use hedonic procedures to estimate the impact of urban influence, increased bio-fuels production, and environmental factors on land prices in the Corn Belt. We hypothesize that urban influence strongly increases land prices. For example, the entire Corn Belt is not subject to widespread urban-influence, but some of its areas are. Ohio, for example, has some of the most ubiquitous, low-density urban influence in the United States (U.S. Census 2005).[1] Despite regional variations in urban influence, the Corn Belt has soil types, climate, and crop patterns/rotations that are relatively homogeneous, helping us isolate the effect of urbanization.

Background

Urban influence changes the cost, revenue, and operating structure of remaining active farms (Heimlich and Barnard 1992, 1997). Most studies find that urban influence creates opportunities for farms that adapt to the urbanizing environment, raises land prices and imposes costs upon traditional farms (Berry; Lopez, Adelaja, and Andrews; Larson, Findeis, and Smith). Many farms can adjust their operations to tap into growing, nearby markets. The availability of seasonal labor may also benefit fringe-area farming. Some operations produce for niche markets, selling directly to consumers or providing "agri-tainment." Increased farmland values often provide collateral to finance farm operating and capital expenses.

Several studies have found that crop and livestock producers are likely to bear added costs from (environmental) constraints on agricultural practices and the disappearance of input suppliers and output markets (Adelaja, Miller, and Taslim; Herriges, Secchi, and Babcock). Over time, traditional, land-extensive enterprises generally yield to enterprises that are more land intensive and more urban compatible. Livestock operations, particularly hog and dairy operations which haul manure daily, are especially incompatible with urban-oriented neighbors due to negative externalities, including odors, insects, and water contaminants. High-value crops such as fruits and vegetables that can be sold directly to consumers often replace field crops (Lopez, Adelaja, and Andrews). Greenhouses, nurseries, and turf farms, which cater to urban markets, proliferate. The net effect of the positive opportunities and constraints is to increase the proportion of crops relative to livestock (Lockeretz 1989; 1986).

Much of our understanding of urban-influenced agriculture, however, is derived from studies like those cited above, that are generally based on county- or state-level analysis; the Heimlich and Barnard studies are exceptions since they are based on farm-level data. Few studies have looked at the costs and benefits of urban influence on traditional enterprises at the farm level, nor isolated the cost-increasing effects of urban nuisances and regulations from the revenue/profit increasing effects of new and larger markets brought about by urban proximity. Recently Nehring et al. (AJAE) found that urban proximity, which is associated with higher levels of off-farm income, appears to have raised the costs and decreased the viability of traditional farms. These trends suggest particularly strong competitive pressures on traditional farms in high urban areas, inducing dramatic reductions in livestock herds.

Procedure

Given the inherent heterogeneity of land used in crop agriculture in the Corn Belt (while many agronomic and climatic characteristic are homogeneous, the level of most other characteristics are not), the hedonic procedures developed by Waugh (1929) and Court (1939) appear to be an appropriate method for measuring quality-adjusted land and assessing the impact on land prices in traditional agriculture.

Our data are farm level observations from U.S. Department of Agriculture's annual Agricultural Resource Management Survey (ARMS). We focus on the Corn Belt.

We find strong evidence that land prices are higher on urban-influenced farms compared to more rural farms.

We proceed by first estimating quality-adjusted land for our sample of Corn Belt farms, calculating quality-adjusted land by ASD, conditioned on climatic effects, agronomic effects, and irrigation. In our second stage estimation we regress quality-adjusted land on key drivers, including the level of urbanization, county level ethanol capacity, government payments per acre, the level of conservation payments and corn revenues per acre. We exclude urbanization from our first stage estimation in order to assess the relative strength of key drivers on the level of quality-adjusted land.

Quality-adjusted land

Spatial differences in land characteristics or quality prevent direct comparison of observed prices of land among countries. To account for these differences, indexes of relative prices of land are constructed using hedonic methods where land is viewed as a bundle of characteristics which contribute to the output derived from its use. According to the hedonic approach the price of land represents the valuation of the characteristics "that are bundled in it," and each characteristic is valued by its implicit price (Rosen, 1974). Implicit prices for the characteristics exhibit many of the properties of ordinary prices. But these prices are seldom observed directly and must be estimated from the hedonic price function. Griliches (1964) notes that if we can observe different "quality combinations" selling at different prices, it is possible to estimate, at the margin, the prices of these characteristics.

The hedonic method was pioneered by Waugh (1928) to study the influences of quality factors on vegetable prices at a given point of time, and by Court (1939) to examine if price increases for automobiles were due to quality changes or to monopoly power. Chow (1967) and Griliches (1961), among others, used hedonic methods to obtain quality-adjusted price indexes for automobiles and computers. Hedonic methods have also been used to study markets for agricultural inputs. Griliches (1958) and Rayner and Lingard (1971) studied fertilizer prices. And Palmquist (1989) developed a hedonic model of land values.

A hedonic price function expresses the price of a good or service as a function of the quantities of the characteristics it embodies. Thus, a land hedonic function may be expressed as $w = W(X, D)$, where *w* represents the price of land, *X* is a vector of characteristics or quality variables and *D* is a vector of other variables. In the hedonic framework, we regard different parcels of land as alternative bundles of a smaller number of characteristics. These characteristics reflect measures of land quality.

In areas with moisture stress, agriculture is not possible without irrigation. Hence irrigation (*i.e.*, the percentage of the cropland that is irrigated) is included as a separate variable. Because irrigation mitigates the negative impact of acidity on plant growth, the interaction between irrigation and soil acidity is also included in the vector of characteristics.

In addition to environmental attributes, one may also include a "population accessibility" score for each region in each country. These indexes are constructed using a gravity model of urban development, which provides a measure of accessibility to population concentrations (Shi et al., 1997). A gravity index accounts for both population density and distance from that population. The index increases as population increases and/or as distance from the population center decreases.

Other variables (denoted by *D*) are also included in the hedonic equation, and their selection depends not only on the underlying theory but also on the objectives of the study. If the main objective of the study is to obtain price indexes adjusted for quality, as in our case, the only variables that should be included in *D* are country dummy variables, which will capture all price effects other than quality. After allowing for differences in the levels of the characteristics, the part of the price difference not accounted for by the included characteristics will be reflected in the country dummy coefficients.

Most empirical studies adopt the semilog or double-log form of the hedonic price function. However, the functional form of the hedonic function is entirely an empirical matter. In this study, we present a generalized linear form (our preliminary estimations employ a semi-log specification presented later in this manuscript), where the dependent variable and each of the continuous independent variables is represented by the Box-Cox transformation. This is a mathematical expression that assumes a different functional form depending on the transformation parameter, and which can assume both linear and logarithmic forms, as well as intermediate non-linear functional forms.

Thus the general functional form of our model is given by:

$$w(\lambda_0) = \sum_{n=1}^{N} \alpha_n X_n(\lambda_n) + \sum_{m=1}^{M} \gamma_m D_m + \varepsilon, \tag{20}$$

where $w(\lambda_0)$ is the Box-Cox transformation of the dependent price variable

$$w(\lambda_0) = \begin{cases} \dfrac{w^{\lambda_0} - 1}{\lambda_0}, \lambda_0 \neq 0, \\ \ln w, \lambda_0 = 0. \end{cases}$$

Similarly, $X_n(\lambda_n)$ is the Box-Cox transformation of the continuous quality variable X_n where $X_n(\lambda_n) = (X_n^{\lambda_n} - 1)/\lambda_n$ if $\lambda_n \neq 0$ and $X_n(\lambda_n) = \ln X_n$ if $\lambda_n = 0$. Variables represented by *D* are country dummy variables, not subject to transformation; λ, α, and γ are unknown parameter vectors, and ε is a stochastic disturbance.

Several methods have been used to calculate price indexes adjusted for quality using hedonic functions, including characteristics prices and dummy variable techniques. The latter is used in this study because it is simpler, and Triplett (1989) has provided extensive empirical evidence of the robustness of the hedonic price indexes to the method of calculation. Using the dummy variable technique, quality-adjusted price indexes are calculated directly from the coefficients on the country dummy variables *D* in the hedonic regression.

USDA's Annual Survey and Data Construction

The first and second stage models employed in this study both use U.S. farm-level data from the 2006 ARMS Phase III surveys (USDA/ERS 2006) matched to more aggregated data (See Data

Appendix A). In this section we describe these USDA surveys, which provide us with individual farm data on the value of output and cost of production. Then we build a quality-adjusted land input variable, present the construction of our urban-influence variables. We follow this discussion with a description of the ethanol variable. Finally, we summarize the rural/urban aspects of the ARMS data.

Construction of Variables from ARMS

The rich data available in ARMS make our analysis possible. ARMS is an annual survey covering farms in the 48 contiguous States, conducted each year by USDA, and designed to incorporate information from both a list of farmers producing selected commodities and a random sample of farmers based on area (USDA/ERS 2002).

A USDA-defined region encompassing most of the Corn Belt---was selected as the study area (see figure 1). The Corn Belt region analyzed contains ten States: IL, IN, IA, MI, MN, MO, NE, SD, OH, and WI. Despite regional variations in urban influence, these regions have soil types, climate, and crop patterns/rotations that are relatively homogeneous, helping us to isolate the effects of urbanization.

Quality-adjusted drivers like government payment are measured as annual per-farm benefits: off-farm income is measured as total off-farm income per acre, corn revenue is measured per harvested acre, conservation reserve payments measured per acre operated. The land variable is described in detail below.

Quality-Adjusted Land Variable

Our construction of a variable to represent the land input is unique. Land in agricultural production typically varies widely by soil type, soil characteristics, urban influence, and other productivity-related factors. The land market's capitalization of spatial differences in land quality and urban influence means that the observed value of land on farms in urban areas represents not only the value of land in agricultural use, but its use in alternative urban uses, thus preventing the direct comparison of observed land prices from rural and urban areas for use in economic analysis. Failing to account for capitalization and these spatial differences leads to a biased or distorted measures of the land input, and e.g. to biased technical efficiency scores (see Alvarez and Gonzalez). Hence, we constructed a land input variable based on the quality-adjusted price of land.

The rapid decline in farmland combined with strong increases in population accessibility scores in the Corn Belt states suggests that urban influences there are strong. Hence, the model used in this study includes variables that affect the quality of land; distance from market, pedo-climatic factors, and agronomic factors. Distance from market represents both a development "entitlement" and a cost of marketing impact and is captured by variables measuring distance from market and size of market. Land quality differences are captured by pedo-climatic and agronomic factors. Clearly, differences in distance from market and land quality characteristics must be taken into account in order to compare the efficiency of large versus small farms.

The characteristics of land were derived from climatic and geographic data bases (USDA soils data in STATSGO), supplemented by land resource data made available by the World Soils Research Program of the Natural Resources Conservation Service. In addition, we included a variable that reflects the size of nearby population centers and the distance from the population center (the combined urbanization and Von Thunen effects—the latter effect named after Johann Heinrich von Thunen, a 19th century German economist, who noted that differences in land use could be attributed to such factors as distance to market, ease of transportation, bulk weight, and perishability of the commodities sent to market—see Barlowe). These data were compiled for each of the counties in the Corn Belt. Thus, there were 2,265 observations in the hedonic regression equation for the Corn Belt states analyzed. The variables included in the price equation reflect the physical characteristics of land. It follows that the coefficient of an ASD constructed dummy variable can be interpreted as the price of an acre of land of constant quality.

To account properly for the effect of differences in land characteristics on land prices, a quality-adjusted land input was constructed using hedonic regression techniques following Ball et al. and Ball, Butault, and Nehring (2000; 2001). To compute quality-adjusted land prices by farm, observations by Agricultural Statistics Districts (ASDs) in the Corn Belt were related to their physical characteristics using hedonic techniques. Such an approach presumes that land price differences across space (or time) are due mainly to quality differences that can be measured in terms of common attributes. Hence, using a semi-log model, the price of land in 2005 was regressed on 31 ASD based dummies (representing 2,265 individual observations), level of urban influence (see next section), 10 climatic characteristics (including, for example, the moisture/temperature regime favorable for corn production), 9 physical characteristics (texture, water holding capacity, a t-factor showing erosion tolerance, a k-factor showing erodibility, percent organic matter, shrink/swell potential, small pebbling, large pebbling, and an acidity/irrigation interaction effect), and the percent of cropland irrigated (USDA/NRCS 1994). Because irrigation mitigates the negative impact of acidity on plant growth, the interaction between irrigation and soil acidity is also included in the vector of characteristics.

Appendix figure 1 presents population accessibility scores by region and another important characteristic, soil texture, is presented in Appendix figure 2.

Urban-Influence Variables

Our two urban-influence variables, described in Barnard, Wiebe, and Breneman, are a continuous index and a categorical variable created from the continuous index. The index was created from an analysis of block-level group population data from the 1990 Census of Population (USDC/BL). Using statistical smoothing techniques within a Geographic Information System (GIS) framework, population was estimated for each cell in a 5-km grid laid out across the total U.S. land area. An index number was calculated for each cell using a GIS function based on the concept of a "gravity" model of urban development. In our study, urban influence at a single grid cell location is defined as follows: $U_{ij} = \{P_j / D_{ij}\}$ where U_{ij} is the computed index number representing the influence on cell i of the population located in cell j, P_j is the population of cell j, and D_{ij} is the distance from cell i to cell j.[4] In order to assess the effect on cell *i* of proximity to population in multiple nearby cells, the index is aggregated across n possible locations (cells). In an aggregate form, the index used in this study for each cell is given by: $UI_i = \sum_{j=1}^{n} \{P_j / D_{ij}\}$ where the index j represents grid cells within a 50 mile radius of cell i.

The continuous index increases as population increases, (since population is in the numerator) and/or as distance to the population decreases (since distance is in the denominator). The index number assigned for each county is the value of the index as measured at the geographic center of the county (centroid). Computed values of UI_i used in this analysis range from less that 10 to greater than 6,000, with the majority ranging from 20 to 700. The urban-influence index is modeled as an inefficiency effect in equation (2), and is used as a characteristic in the hedonic specification from which the quality-adjusted price of land is estimated.

The continuous urban-influence index, however, does not identify which counties are rural and which are urban influenced. To do that and to create the categorical variable, we set thresholds for the continuous variable based on the level of the urban-influence index in "totally rural" census tracts (which were previously defined by Cromartie). "Totally rural" means that the census tract does not contain any part of a town of 2,500 or more residents and that the primary commuting pattern was to sites within the census tract. Any parcel not satisfying these conditions was considered urban-influenced. Those cells classified as urban influenced were subdivided into three categories labeled near rural, near urban, and urban, each representing an increasing level of urban influence. More specifically, we defined counties as rural if UI_i <=115, near rural if 115< UI_i <=155, near urban if 155< UI_i <=236, and urban if UI_i >236.

Figure 1 presents the spatial distribution of the rural and three urban-influenced categories. Regional variations in the level of urban-influence are important. We find that 30 percent of the farms in the region analyzed are urban influenced, with pronounced urban influence in the eastern Corn Belt. Smaller, but not insubstantial, urban influence occurs even in the heavily agricultural areas of the western Corn Belt. Close to 100 percent of farms in Ohio are urban influenced, 82 percent in Indiana, 32 percent in Illinois, and 17 percent in Iowa.

County level ethanol capacity

On August 8, 2005, President Bush signed the Energy Policy Act of 2005 (H.R. 6) into law. The comprehensive energy legislation includes a nationwide renewable fuels standard (RFS) that will double the use of ethanol and bio-diesel by 2012. County level ethanol capacity was reported as millions of gallons per year of production. Our data set reported in Breneman and Nulph indicates that ethanol production is centered in North Central Iowa and Western Illinois. Production is well connected to rail links. (see Ethanol Figures). Close to 1 billion bushels of corn were processed into ethanol in the Corn Belt in 2005.

Specification of the First Stage: Estimating Quality-adjusted Land

Our basic theoretical model is as defined in

(1) $w(\lambda_0) = \sum_{n=1}^{N} \alpha_n X_n(\lambda_n) + \sum_{m=1}^{M} \gamma_m D_m + \varepsilon,$. For our estimating model using ARMS data and matched aggregated data (see Data Appendix A) we set λ_0 =0, and λ_0 =1. That is we specify a semi-log model. Our specific characteristics are defined as 6 climatic characteristics (including, for example, the moisture/temperature regime favorable for corn production), 7 physical characteristics (texture, a t-factor showing erosion tolerance, a k-factor showing erodibility, small pebbling, and an acidity/irrigation interaction effect), and the percent of cropland irrigated (USDA/NRCS 1994).

Specification of the Second Stage: Assessing the impact of Key Drivers on Quality-adjusted Land

The second stage elasticity analysis using 2006 cross-section data was specified as,

(8) $\ln Y_{LD,i} = \beta_0 + \beta_E \ln (X_{E,,t}) + \beta_G \ln (X_{G,,i}) + \beta_{CRP} \ln (X_{CRP,,i}) + \beta_{CR} \ln (X_{CR,,i}) + \beta_{Off} \ln (X_{PA,,i}) + \beta_{PA} \ln (X_{CR,,i}) + \beta_{EAST} (D_{EAST,,i}) + \beta_{\mathrm{CENTRAL}} (D_{CENTRAL,,it}) + v_{it},$

where subscripts *i* refer to the *i*-th farmer. Quality-adjusted land (Y_{LD}), ethanol (X_{E}), government payments per acre operated (X_{G}), conservation payments per acre operated, (X_{CRP}), corn revenue per acre harvested (X_{CR}), off-farm income per acre harvested (X_{Off}), and population accessibility (X_{PA}), and the quality-adjusted price of land (Y_{LD}) are all measured as logs of monetary terms. Population accessibility (X_{PA}) is measured as the log of the urbanization index discussed above. A regional dummy is constructed for central corn states by setting ($\mathrm{D}_{\mathrm{CENTRAL}}$)=1 if observations occur in Iowa, Minnesota, and Missouri and zero otherwise. Similarly, a regional dummy is constructed for Eastern Corn Belt states by setting ($\mathrm{D}_{\mathrm{EAST}}$)=1 if observations occur in Illinois, Indiana, Michigan, Ohio, and Wisconsin, and zero otherwise. The Western Corn Belt states, Nebraska and South Dakota are the reference region.

Comparison of Key characteristics by Ethanol production region

Below we compare key economic indicators in major ethanol production regions—Western Illinois, Northern Iowa and Southern Minnesota, the Rest of the Eastern Corn Belt, and the Rest of the Western Corn Belt. We can learn more about the specific impact due to urban influence and the other key drivers by linking such factors to region and identifying level of economic performance. First note ethanol production is centered in Eastern Illinois and Northern Iowa as shown in the attached ethanol charts and in Table 2.

As shown in table 2 land prices, as one would expect, follow a clear pattern as our index of urbanization increases, jumping from $3,584 per acre on rural farms in Northern Iowa and Southern Minnesota to $4,363 on highly urban influenced farms in North and Central Illinois as evidenced by the relatively high population accessibility score. Land prices fall off somewhat in the rest of the Eastern Corn Belt States of Michigan, Indiana, Michigan, and Ohio to $3,084 per acre. Rural and somewhat less productive areas in the Western Corn Belt—Northern Minnesota, Missouri, Southern Iowa, South Dakota and Nebraska—exhibit by far the lowest land prices--$1,632 per acre.

Table 2 also shows that higher land prices tend to be consistent with operations exhibiting higher off-farm income per acre and higher labor costs per acre—comparing the data for other Eastern Corn Belt in column three to labor costs per acre in the Central Corn Belt (column 2) and in the Western Corn Belt (column 4). The Illinois sample used in column 1 (Northern and Central Illinois) is an interesting exception—characterized by highly productive land (valued at high prices in agricultural use) with major pocket of rural counties with declining populations—but with strong urban influence based on our index of urbanization.

Empirical Results

The first stage results are presented in Table 2. More than half of the coefficients for the semi-log hedonic specification are significant, indicating a good fit. The significant and positive signs on wet tempustic, texture, and irrigation percentage and the significant and negative signs on frigid wet tempustic, frigid typic udic xeric, and the K factor are as we would expect. The resulting quality-adjusted land prices (preliminary results computed by evaluating the exponents of the coefficients of the ASD dummies only are shown in Appendix figure 3-quality-adjusted land prices used in equation (2) are based on ASD groupings—e.g. the bottom tier of three ASDs in Minnesota are modeled as one dummy and each of the top, middle and bottom three ASD groupings are modeled as one dummy). Quality-adjusted land prices tend to be highest in Ohio ASDs near urban centers and in Illinois and Iowa, ASDs traditionally characterized as having high-quality land.

The second stage results are presented in Table 3. We present four alternative cuts on the data, 1) the whole Corn Belt sample, 2) only farms receiving government payments, 3) only farms located in the Western Corn Belt (Iowa, Minnesota, Missouri, Nebraska, and South Dakota), and 4) only farms located in the Eastern Corn Belt. We find that for the whole Corn Belt sample that the quality-adjusted land price conditioned on climatic, agronomic, and irrigation characteristics (but not population accessibility) is positively and significantly affected by greater ethanol capacity per county, and by higher levels of government payments per acre, conservation payments per acre, corn revenues per acre, off-farm income per acre, and by higher county level population accessibility score. Population accessibility is the strongest driver followed by ethanol capacity, corn revenues per acres, conservation payments per acre, off-farm income and government payments. More precisely, we find that a 10 percent increase in population accessibility is consistent with a 2 percent increase in the quality-adjusted land price. Similarly a 10 percent increase in ethanol capacity is consistent with a .33 percent increase in the quality-adjusted land price. And a 10 percent increase in conservation payments, corn revenue per acre, and off-farm income are consistent with 0.15, 0.3, and 0.10 percent increases in the quality-adjusted land price, respectively. The regional cuts indicate no influence of ethanol capacity on quality-adjusted land prices in the Eastern Corn Belt, but population accessibility remains important. In contrast, the ethanol capacity is a highly significant driver in the Western Corn Belt, along with conservation reserve payments and population accessibility. Finally note that in the government payments cut a 10 percent increase in government payments is consistent with a .3 percent increase in the quality-adjusted land price.

Summary and Conclusions

This study uses hedonic techniques to estimate the impact of urban influence, increased bio-fuels production, and environmental factors on the land prices in the Corn Belt. We hypothesize that growing urban influence and ethanol production increase land prices on Corn Belt farms. Although not all states in the Corn Belt are entirely subject to urban influence and ethanol production impacts, some states are intensely affected. Despite regional variations in urban influence, Corn Belt states have soil types, climate, and crop patterns/rotations that are relatively homogeneous, helping us to isolate the effects of urbanization and bio-fuels. We find that land prices in the Corn Belt are significantly increased by the presence of urbanization and bio-fuel plants. During 2006, hedonic procedures indicate that a 10-percent increase in urban influence leads to a close to 2-percent increase in the quality-adjusted land price. Similarly, hedonic procedures indicate that a 10-percent increase in ethanol capacity leads to a greater than .3-percent increase in the quality-adjusted land price. We also find that government payments, conservation payments, off-farm income, and corn revenue per acre significantly boost land prices, though to a lesser extent than urbanization and ethanol production. Clearly ethanol production in the Corn Belt is a new and not unimportant phenomenon influencing land prices. The ARMS data set used in this study incorporates the full price impact of ethanol on corn and land prices that occurred in 2006. Hence it captures, preliminarily, the impact of ethanol production as a new and important influence on land prices in the Corn Belt (the average corn price per bushel increased 75 percent in 2006 compared to 2005) along with urban pressure, government payments and other factors. However, this impact appears to be confined to the Western Corn Belt.

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Table 1. USDA Agricultural Resource Management Survey estimates, by group, 2006

Item	No.and Central IL	So. MN and No. IA	Other Eastern Corn Belt	Other Western Corn Belt
Million gallons of ethanol capacity	745	1,691	663	1,339
Million gallons of ethanol capacity per county	56.5	62.6	1.83	5.56
Number of observations	501	930	2,114	2,516
Number of farms	35,484 BCD	67,495 ACD	177,486 ABD	204,629 ABC
Percent of farms	7.3	13.9	36.6	42.2
Percent of value of production	10.2	24.1	28.4	37.2
Government payments per acre operated ($/acre)	15 D	14 D	10 D	3 ABC
Conservation payments per acre operated ($/acre)	2 D	2 D	4	6 AB
Corn revenue per acre operated	172.782 BCD	142.217 ACD	77.060 ABD	40.503 ABC
Total off-farm income relative to total income (percent)	33.30 CD	29.99 D	51.40 AB	55.50 AB
Net return on assets (percent)	0.055 CD	0.063 CD	0.034 AB	0.032 AB
Net return on household assets (percent)	0.051 CD	0.053 CD	0.028 AB	0.027 AB
Water holding capacity	8.3 B	11.7 ACD	7.9 B	8.6 B
Soil texture	7.1 BCD	6.4 ACD	5.5 ABD	6.1 ABC
Population accessibility score	144.1 BD	71.7 AC	161.2 BD	68.4 AC
Variable costs per acre ($)	160.8 BCD	211.5 AD	206.0 AD	103.9 ABC
Labor costs per acre ($)	67.1 CD	80.5 CD	104.8 ABD	49.8 ABC
Fuel costs per acre ($)	19.4 D	21.2 D	19.6 D	12.1 ABC
Fertilizer costs per acre ($)	74 BCD	65 AD	64 AD	51 ABC
Miscellaneous costs per acre ($)	28.7 BCD	43.2 AD	37.4 AD	18.4 ABC
Machinery costs per acre ($)	45.1 BCD	58.2 AD	58.1 AD	29.2 ABC
Corn yield in bushels per acre	169.19 CD	171.46 CD	147.42 ABD	143.25 ABC
Soybean yield in bushels per acre	50.83 CD	51.20 CD	46.22 ABD	42.05 ABC
Corrected average price of land per acre ($/acre)	4,363 BCD	3,584 ACD	3,084 ABD	1,632 ABC
manurenp per harvested acre ($/acre)	1 BCD	7 AD	8 AD	4 ABC
manurepp per harvested acre ($/acre)	*1 BCD	5 ACD	4 ABD	3 ABC
Government payments per acre with landlord($/acre)	30 BCD	34 ACD	25 ABD	15 ABC

Notes: Three asterisks indicate significance at the 1% level (t=2.576), and two asterisks indicates significance at the 5% level (t=1.96).
Source: USDA Agricultural Resource Management Survey. USDA (2006).
The t-statistics are based on 6,091 observations using weighting techniques described in Dubman, p. 24, and correspond to the test of the null hypotheses of equal means.
A = Northern and Central IL, B = Southern MN and Northern Iowa, C = other Eastern Corn Belt States, and D = other Western Corn Belt States.

Table 2. Inter-spatial Regression Results for the Corn belt; see Data Appendix A					
Pedo-climatic Variables	Parmeter	t-stat	Agronomic Variables and irrigantion	Parmeter	t-stat
Mesic typic xeric	-0.002	(-0.65)	Texture index	0.072	(1.69)
Thermic typic udic	0.001	(3.79)	Kfactor erodibility	-0.243	(-0.36)
udic					
Mesic weak	-0.448	(-0.93)	Tfactor erosion Tolerance	-0.014	(-2.72)
aridic					
Mesic typic	0.017	(2.39)	Bulk Density	-0.548	(-2.63)
Udic			Index		
Frigid wet	-0.002	(-1.72)	Permeability	0.019	(1.34)
tempustic			Index		
Frigid typic	0.023	(0.10)	Pebblling	0.029	(2.66)
Udic xeric			Score		
			Acid/Irrigation	-0.001	(-0.53)
			Interaction		
			PHDummy	1.608	(2.17)
			Irrigation	0.004	(2.57)
			Percent		

Semi-Log model, 3,947 observations, R-Squared=0.99, t-statistics in parentheses.
We ignore weighting procedures because the right hand side variables are county-weighted data. Given the large sample size we assume that estimation biases introduced by treating the left hand side variable, land price, as a simple random variable are minimal.

Table 3. Second Stage estimates

	Whole Sample		Receive Govt Payments		Western Corn Belt Farms		Eastern Corn Belt Farms	
	Parameter	t-statistic[a]	Parameter	t-statistic[a]	Parameter	t-statistic[a]	Parameter	t-statistic[a]
β_0	4.719	(94.62)	4.936	(98.63)	5.640	(89.61)	6.347	(76.68)
β_{XETH}	0.033	(9.56)	0.015	(2.29)	0.024	(5.13)	-0.003	(-0.54)
β_{XGOVTH}	0.002	(0.84)	0.027	(3.18)	0.005	(1.27)	0.003	(0.73)
β_{XCRP}	0.015	(3.35)	-0.002	(-0.19)	0.019	(2.71)	0.001	(0.15)
$\beta_{XCORNREV}$	0.031	(15.84)	0.022	(5.04)	0.007	(2.09)	0.008	(2.80)
$\beta_{XOFF\text{-}FARM}$	0.010	(5.90)	0.001	(0.06)	0.002	(0.85)	-0.003	(-1.12)
β_{XURBAN}	0.202	(38.58)	0.172	(14.60)	0.245	(33.08)	0.183	(21.28)
β_{XEAST}	-0.172	(-16.42)	-0.121	(-5.47)	-0.438	(-30.52)		
β_{XWEST}	-0.587	(-35.56)	-0.586	(-15.79)				
Observations	3,947		892		2,063		1,881	
RSquared	0.685		0.628		0.643		0.409	

Note: Significance at the 1% level (t=2.576), at the 5% level (t=1.96), and at the 10% level (t=1.645).
Source: Authors' analysis of USDA Agricultural Resource Management Survey data.
a. Dummy base Iowa in Western Corn Belt run; dummy base Illinois in Eastern Corn Belt run.

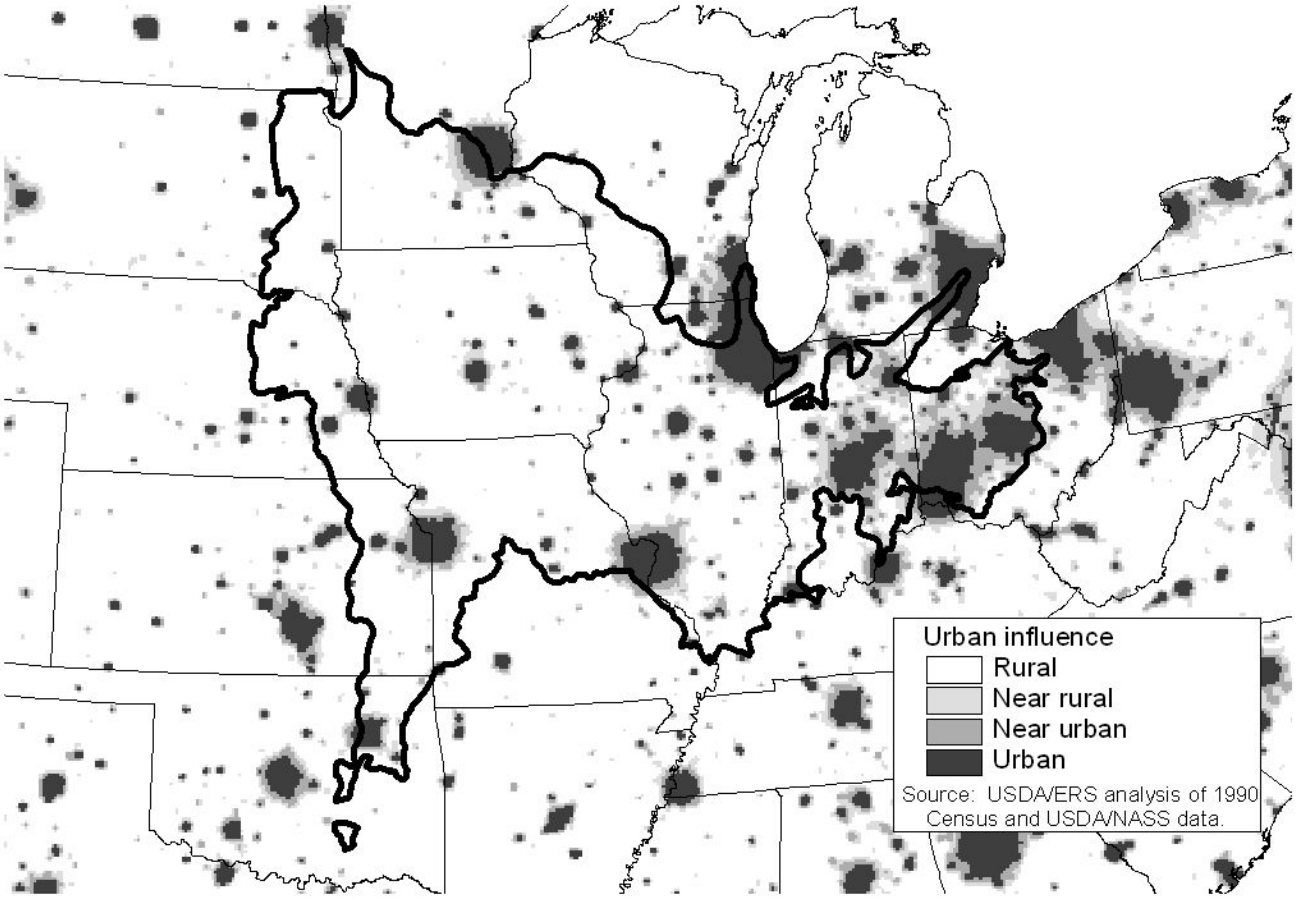
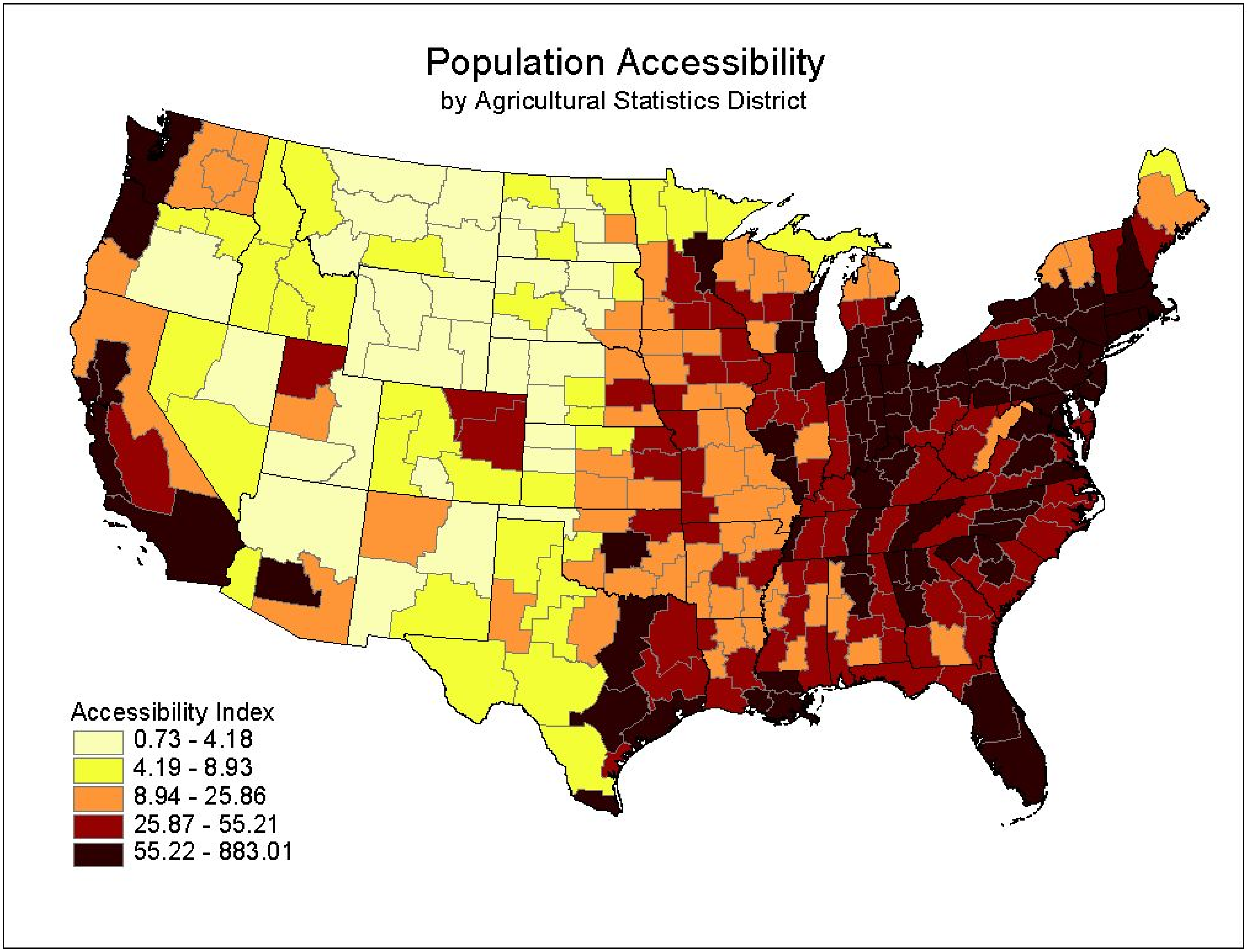
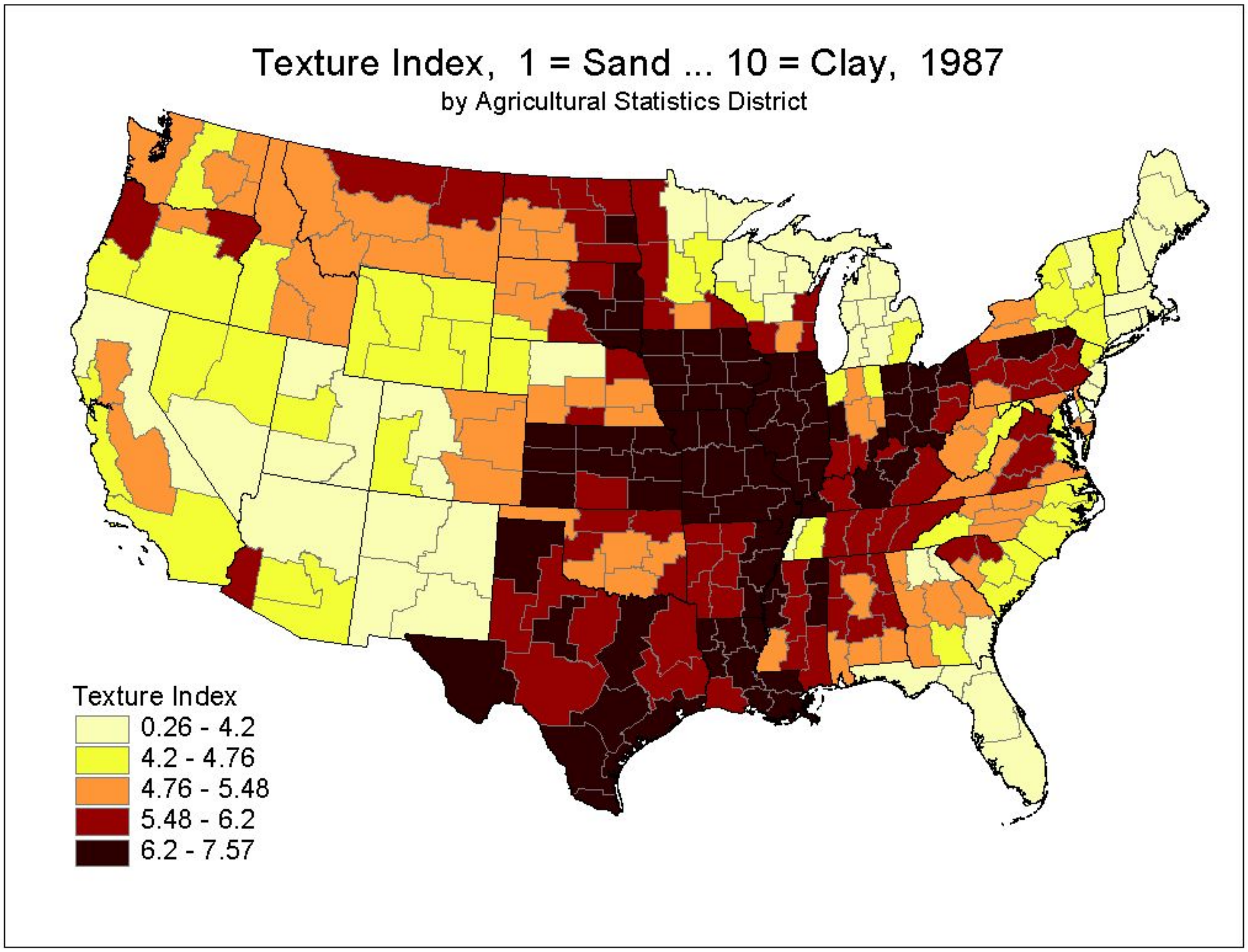


Figure 1. Corn Belt Area Comprising Land Resource Region 13



Appendix Figure 1. Population Accessibility Scores by ASD



Appendix Figure 2. Texture Index By ASD

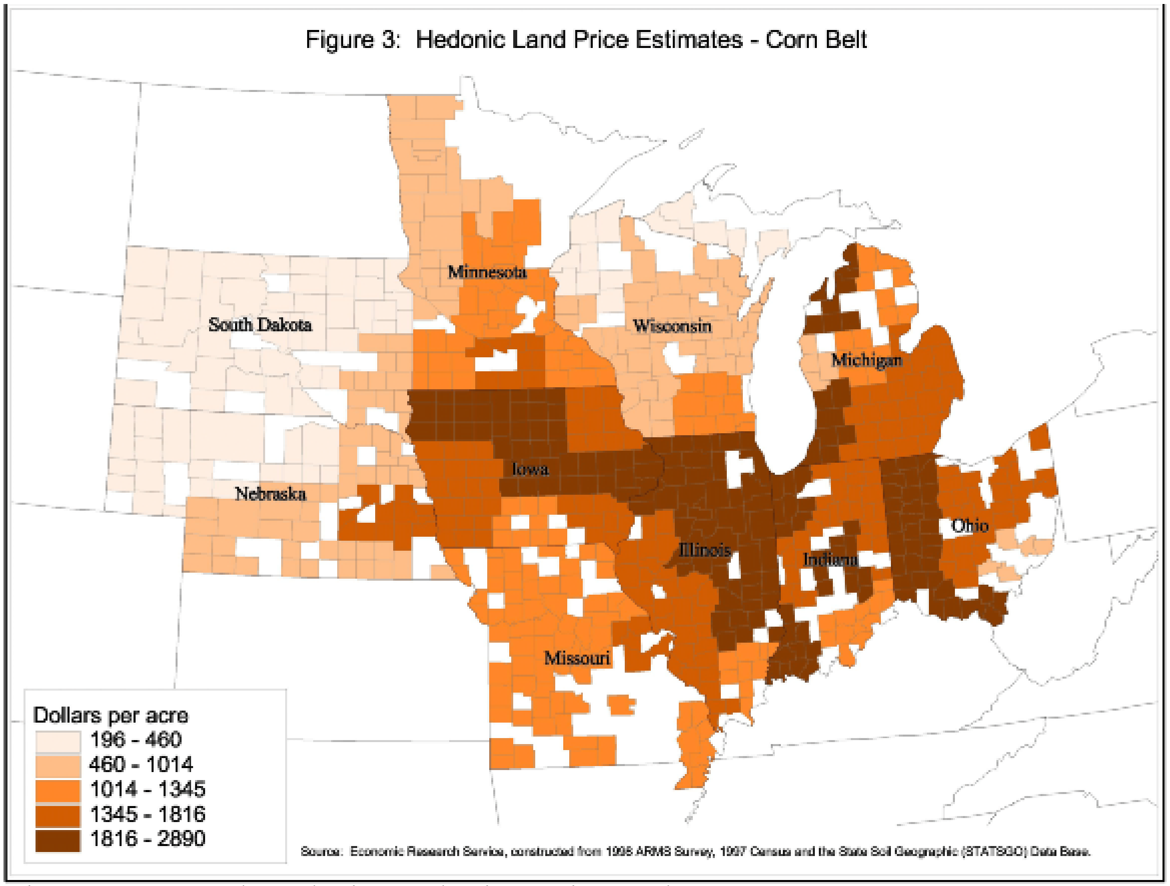


Figure 3. Corn Belt Hedonic Land Price Estimates *

- Blank counties indicate no ARMS observation.

[1]Continuing population growth in more than 10 percent of the rural Corn Belt counties since 2000 and projections of strong long term population growth in the northern Corn Belt suggests that urban influence on agriculture will increase in the future.

[2] In Shi, Phipps, and Colyer and in Hardie, Narayan, and Gardner, distance is accounted for using D^2. In our analysis we used D, rather than D^2, based on information in Song that the reciprocal of distance, the most commonly used weight in gravity-type measures, is statistically equivalent to any of eight other measures.

Appendix Table A. Description of Variables				
Variable	Equation	Description	Calculated as:	Source
W_t	1	Nominal price of land per acre	Value of owned and rented land divided by acres operated by farm	ARMS
Mesic typic xeric	1	Mild Mediterranean climate regime	Proportion of ASD climate	NRCS and ERS estimates
Thermic typic udic	1	Warm avg humidity climate regime	Proportion of ASD climate	NRCS and ERS estimates
Mesic weak aridic	1	Mild somewhat dry climate regime	Proportion of ASD climate	NRCS and ERS estimates
Mesic typic udic	1	Mild avg humidity climate regime	Proportion of ASD climate	NRCS and ERS estimates
Frigid wet tempustic	1	Cool very rainy climate regime	Proportion of ASD climate	NRCS and ERS estimates
Frigid typic udic	1	Cool rainy climate regime	Proportion of ASD climate	NRCS and ERS estimates
texture	1	Index of relative levels of sand, silt, and loam	1=sand…..10=clay avg by county	STATSCO and ERS estimates
k-factor	1	An erodibility factor	Expressed as an index avg by county	STATSCO
t-factor	1	Soil loss tolerance	The maximum rate of soil erosion that will permit high crop prod avg by county	STATSCO
Bulk density	1	Maximum value for the range in moist bulk density of the soil horizon	Expressed in grams per cubic centimeter, county avg	STATSCO
Permeability	1	Maximum value for the range in permeability of the soil horizon	Expressed in inches per hour, county avg	STATSCO
Pebbling	1	Small rocks 3 to 10 inches in size	The minimum value of the range in % of weight of rock fragments, county avg	STATSCO
Acid/irrigation interaction	1	The interaction between irrigation and soil acidity	pH times % acres irrigated, county avg	STATSCO
Ph dummy	1	Soil reaction (pH)	1 if pH >4.5 suitable for grass production; 0 otherwise, county avg	STATSCO

Appendix Table A. Description of Variables-continued				
Variable	Equation	Description	Calculated as:	Source
Y	2	Quality-adjusted price of land per acre	Calculated from dummy Values in equation 2, based 31 on ASD groupings	ERS estimate
X_E	2	Millions of gallons of ethanol produced	County averages	Nulph and Breneman
X_G	2	Dollars of government payments per acre	Farm observation	ARMS
X_{CRP}	2	Dollars of conservation reserve payments per acre	Farm observation	ARMS
X_{CR}	2	Dollars of corn revenues per acre	Farm observation	ARMS
X_{OFF}	2	Dollars of all off-farm income per acre	Farm observation	ARMS
X_{PA}	2	Urbanization index	Constructed by County	ERS estimate