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# The Impact of Ethanol Plants on Cropland Values in the Great Plains

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**By**

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ABSTRACT: Corn ethanol plants consume large amounts of corn and their location has the potential to alter local crop prices and surrounding agricultural land values. The relationship between ethanol plant location and agricultural land prices is examined using data obtained from the Agricultural Credit Survey administered by the Federal Reserve Bank of Kansas City. The findings indicate that the portion of land price changes attributable to location is consistent with previous estimates of basis changes associated with ethanol plant location. As a result, the land markets appear to be rationally adjusting to the location of ethanol plants.

Keywords: farmland, ethanol, land values

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In 2006, ethanol production emerged as a dominating influence on the U.S. farm economy. Changes in U.S. energy policy in 2005 bolstered the demand for ethanol. In 2006, the surge in crude oil and gasoline prices boosted ethanol profits. The result was a perfect storm for the farm community, where ethanol production and bio-fuels fueled sharp gains in corn prices that spilled over into other agricultural commodities. As expectations of higher crop prices over the long-term began to form, farmland values began to rise.

Farmland is by far the largest asset on the farm balance sheet accounting for roughly 86 percent of farm assets in 2007.[1] As a result, understanding changes in farmland values is critical to understanding the behavior of farmers and the financial performance of the agricultural sector. Although a number of studies have examined the economic impacts of ethanol production, few have explicitly examined how ethanol production has impacted land values.

Ethanol production can increase farmland values by increasing the demand for agricultural crops and the expected returns to cropping. In fact, after jumping in the fourth quarter of 2006, both spot and futures prices for corn have remained well above historical levels. Because land is a capital or long-term asset, its value is derived from the discounted value of future earnings that it can be expected to produce. As a result, even small changes in the expectations of these returns can result in large changes in the value of farmland. Alternatively, if one views the recent price changes as transitory, they would have a relatively modest impact on the value of farmland. In order for these expectations to be capitalized into farmland values, the gains must be expected to persist over the long term.

[1] Data obtained from the Economic Research Service, USDA, Farm Income Briefing Room, www.ers.usda.gov

Given the recent increases in farmland values, there is evidence that the rise in corn prices has been capitalized into farmland values across the country. By increasing the returns to corn production, all other commodities must compete for acreage with corn, resulting in higher price levels of other commodities. These higher crop prices should be reflected in higher land prices across the country.

However, ethanol production should also be expected to have a spatial impact on land value gains. Ethanol is produced in relatively large plants that create a relatively large local demand for corn. Economic theory would suggest that the presence of a large local demand such as an ethanol plant should impact local basis patterns (McNew and Griffith). Decreases in the basis would increase the returns to crop production in the area around the plant. As such, ethanol plant locations might have local impacts on farmland values. To the extent that ethanol production alters basis patterns, one would expect that it would lead to stronger land value gains near ethanol plants.

Thus, ethanol production can have at least two impacts on land values. First, it should increase all land values through the impact of overall increased commodity prices. Second, through its impact on local basis patterns ethanol production should increase land values near ethanol plants. While the overall increases in cropland values are readily observed, there remains an important question as to the local impact of ethanol production on farmland values.

The impact on local values is critically dependent upon farmers' expectations regarding the size and lasting impact of basis changes. However, because the industry is still in its infancy, it is difficult to form expectations regarding basis changes. It is important to understand whether ethanol plant location has an impact on local farmland values and whether the changes in land values are consistent with reasonable expectations. It is possible that the large increases in land values in ethanol production regions are not consistent with reasonable expectations over basis changes. If this is the case, then attention should be called to the exuberance in land value gains in order to avert or forestall future contractions in land values. Alternatively, if these spillover impacts in the land market are substantial, this could provide a substantial wealth effect for local communities with ethanol plants.

This paper analyzes the local economic impact of ethanol plant locations on farmland values. Specifically, we examine the relationship between land price changes and the presence of ethanol production. In addition to estimating the economic impact of ethanol plants on farmland values, the paper estimates the impacts across geographic space. In other words, how far do the economic impacts of ethanol plants reach? The paper will examine the magnitude of the influence as well as the distance over which the impact can be observed. Lastly, the size of the impact on land values is examined in relationship to transportation costs and the implied basis changes associated with an ethanol plant. These estimated basis increases are then examined for consistency with some of the actual basis changes observed in the market. The results indicate that the implied basis from the land values are equal to or less than the transportation costs observed from existing literature examining basis changes and ethanol plant locations.

## Literature Review

A farmland value model is needed to analyze the relationship between ethanol plant locations and farmland values. The traditional capitalization model (1) is perhaps the most straight-forward model for calculating the value of farmland.

(1) $$V(t) = \sum_i \frac{E_t r_i}{(1+\delta)^i}, i = 1 \ldots \infty$$

In this formulation, the value of farmland at time *t* is defined by today's expectations ($E_t$) over the future returns to farmland, *r*, and the discount rate $\delta$.

In the context of this paper, the parameters of interest are those that impact farmers' expectations of the returns to farmland, namely, the impact of higher commodity prices and changes in local basis levels.  To the extent that higher commodity prices are experienced by all farmers, these impacts should be felt equally across the entire farm sector.  However, the impacts of ethanol production on local basis patterns would be expected to vary with the proximity to an ethanol plant.  If farmers believe that price changes associated with tighter local basis levels are permanent, they will cause increases in land values.  This fact allows us to relate the relative magnitude of land price changes associated with ethanol production to the implied rates of basis changes.  These basis changes are then compared to those available in existing literature.

The rise in ethanol production has stimulated a host of economic studies on the ethanol industry.  Among other things, some of these studies examined issues related to the economic feasibility of producing ethanol (Eidman; Gallagher; Gallagher, Shapouri, and Brubaker) and the economic impacts of ethanol production (Parcell and Westhoff; Swenson).  More relevant to the determination of land values is the impact of ethanol production on local commodity prices.  At this point there appear to be two studies that are directly relevant to how ethanol production would impact land values near an ethanol plant.

McNew and Griffith examined how the establishment of an ethanol plant impacts local basis patterns.  In their analysis of basis patterns associated with the opening of 12 ethanol plants over the period of 2000 to 2003, they found that on average basis values increased 5.9 cents per bushel over the 150 square mile region around a plant.  However, they also noted that the price increase tended to be greater at the location of the plant.  In this case, the average impact was a

$0.125 per bushel higher price, with a range of $0.046 to $0.193 per bushel. Given the magnitude of these price changes, one might expect that the local impact on land values would be substantial. For instance, using the valuation model in (1) and assuming a 4 percent discount rate, a national corn yield of 150 bushels per acre, and a permanent $0.125 per bushel price increase, the value of land near an ethanol plant could be expected to increase by $468.75 per acre.[2]

Gallagher, Wisner and Brubaker also examined the impact of ethanol plant on basis levels in Iowa in 2003. Their analysis considered how prices offered by ethanol plants were influenced by local surpluses of grain and the presence of export demand. They found that some Iowa ethanol plants showed increased basis levels that were in relationship to truck transportation costs to the plant. However, in other cases they found no change in basis levels associated with the plants. They attribute these differences to the modes of transport available at the demand center, specifically whether the demand center is near a terminal market.

The findings of these studies would seem to indicate that one should expect some basis changes near ethanol plants. As a result, one would expect to find that ethanol plant locations would have some impact on land values. However, both studies point out that the magnitude of basis changes can be quite variable and dependent upon a variety of factors including proximity to terminal market points. At this point it is an open empirical question as to the extent to which an ethanol plant would impact land values. However, given the importance of land values to the financial health and soundness of the farm sector the question is of great importance. We are

[2] According to NASS, the 2006 national corn yield was 149.1 bushels per acre. According to the Economic Research Service, 2007 cropland values averaged $2700 per acre and cropland cash rents averaged $89 per acre for a capitalization rate of 3.3 percent.

currently unaware of any studies which have explicitly examined the impact of ethanol plant location on land values.

## Empirical Model and Results

Economists have used hedonic models to analyze various market characteristics influencing farmland values. These models relate variation in a number of characteristics to the price of farmland. In general, studies have identified a variety of factors that consistently impact the value of farmland. These factors include the agricultural productivity of farmland, the presence of urban influences, and recreation and amenity factors. In order to estimate the impact of ethanol production on land values it is important to control for these factors. The next section describes some of the characteristics that have frequently been found to impact land values. It should also be noted that farmers are assumed to be price takers so that the overall impact of ethanol production on land values that arises from increased commodity prices is assumed to impact all agricultural lands.

Empirical research confirms that farmland values are based on the productivity and the resulting economic returns from agricultural production. A large number of studies have analyzed the capitalization of agricultural income streams into farmland values (Barnard et al. 1997; Burt 1986; Castle and Hoch 1982; Chavas and Shumway 1982; Featherstone and Baker, 1987; Herriges et al, 1992; Just and Miranowski, 1993; Moss, 1997; Miranowski and Hammes, 1984; Phipps, 1984, Weersink et al 1999). Several of these studies have used hedonic price models to analyze the economic impact of agricultural income streams derived from the market and from government payments.

Various studies have found that urbanization factors influence farmland values (Chicoine, 1981; Clonts, 1970; Dunford et al, 1985; Folland and Hough, 1991; Reynolds and Tower, 1978;

Shi et al, 1997; Shonkwiler and Reynolds, 1986, Livanis et al 2006). These studies also used hedonic price models and cross-sectional data to analyze the spatial variation in farmland values. In general, they found that the potential for urban development was being capitalized into farmland values as regions closer to large and growing urban centers experienced higher land values.

Recreation and amenity characteristics have been found to influence property values, primarily residential property, with a few studies analyzing the impact of amenities on farmland values. Using a hedonic price model, residential properties in Maryland were found to be higher in areas with more open space (Irwin and Bockstael, Irwin). Using data on Texas and Wyoming land values, other studies have found land values to be higher in areas with scenic views and more plentiful wildlife amenities (Pope, Adams, and Thomas 1984; Pope 1985; Bastian et al. 2002; Henderson and Moore 2006).

The empirical model in the following equation is used to analyze farmland values,

$$LV = f(\boldsymbol{A}, \boldsymbol{U}, \boldsymbol{R}, \boldsymbol{E})$$

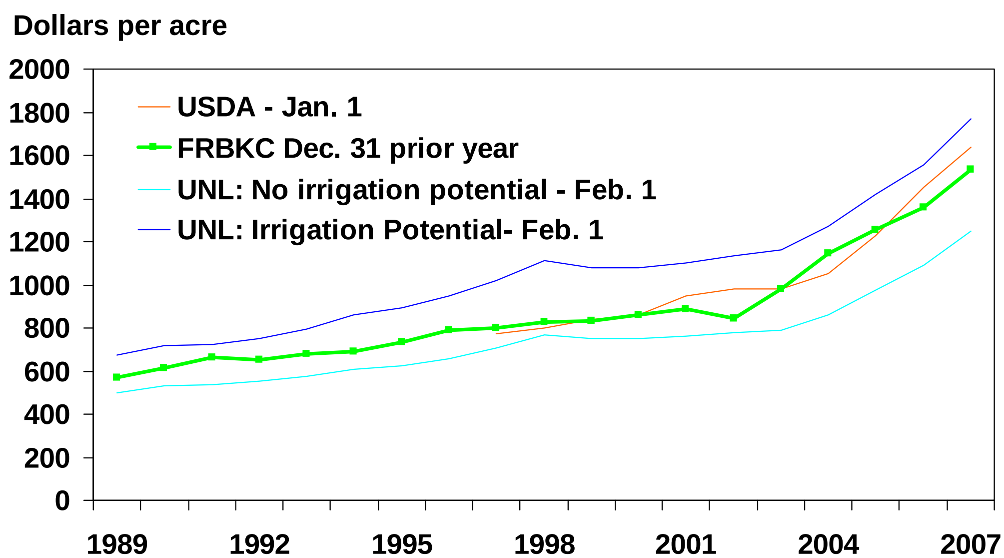
where $LV$ is land value, $\boldsymbol{A}$ is a vector of agricultural characteristics including ethanol plant location, $\boldsymbol{U}$ is a vector of urbanization measures, $\boldsymbol{R}$ is a vector of recreation or amenity characteristics, and $\boldsymbol{E}$ is a vector of characteristics associated with ethanol plant location.

*Farmland Values*

Farmland values were measured by non-irrigated cropland values obtained from the quarterly Agricultural Credit Survey from the Federal Reserve Bank of Kansas City. The Federal Reserve Bank of Kansas City covers the states of Nebraska, Kansas, Oklahoma, Colorado, Wyoming, western Missouri, and northern New Mexico. On average, roughly 360 agricultural bankers are surveyed with over 250 responses received each quarter. Bankers are asked for the average price for non-irrigated land in their market area. For this analysis, the data set is limited to respondents that reported in every quarter from the third quarter of 2006 to the second quarter of 2007, leaving 219 respondents.

One drawback of the agricultural credit data is that it is obtained from an opinion survey. However, the prominent role bankers have in financing agricultural land sales in their region and the use of farmland as collateral in agricultural operating loans makes provides them with a unique and highly knowledgeable perspective on farmland values and is expected to mitigate some of the challenges to using an opinion survey. In fact, survey results are quite consistent with results found in other farmland value surveys. For example, non-irrigated cropland values for the state of Nebraska are quite consistent with USDA estimates and estimates reported by the University of Nebraska-Lincoln (Chart 1).

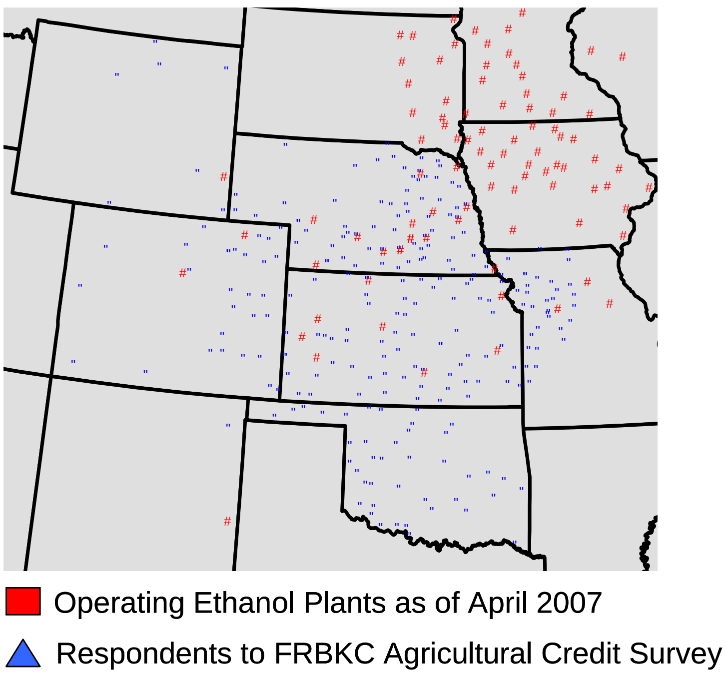
**Chart 1: Nebraska Non-irrigated Cropland Values**




Sources: USDA, Federal Reserve Bank of Kansas City, University of Nebraska-Lincoln

The survey covers a region with a large ethanol industry. According to the Renewable Fuels Association (RFA) and the American Coalition for Ethanol (ACE), in April 2007, the Kansas City Federal Reserve District contained 30 ethanol plant locations with a capacity of roughly 1.1 million gallons per year, or approximately 18 percent of the national production capacity (Map 1).

**Map 1: Ethanol Plants and Agricultural Bank Respondents**




The District, however, has substantial spatial variation in ethanol plant locations. For example, 13 ethanol plants were in operation in Nebraska with an annual production capacity of approximately 583 million gallons of ethanol per year with 976 million gallons of ethanol production capacity under construction at and additional 13 sites. In contrast, Oklahoma had no ethanol plants in operation or under construction. Visual inspection of land value gains and ethanol plant locations suggests that land value gains were stronger in locations closer to ethanol plants. For example, non-irrigated cropland values in Nebraska rose 17.4 percent annually in the first quarter of 2007, while non-irrigated cropland values in Oklahoma rose a more modest 5.7 percent annually.

*Agricultural Production Factors*

Various county level measures are used to describe the characteristics of local cropland markets that are expected to influence non-irrigated cropland values. Land values are expected to be higher in locations with higher farm income levels. The average gross farm income per acre from crop revenues (*CROPS*), livestock revenues (*LIVESTOCK*), and government payments (*GOV*) from 2002 to 2005 were used to measure agricultural revenues and productivity.[3] Agricultural measures were limited to the 2002 to 2005 time frame to coincide with the policy environment associated with the 2002 Farm Bill.

*Urbanization Factors*

Urbanization influences include the size of the rural communities but also distance to metropolitan areas. For example, the USDA measures rurality with Rural-Urban Continuum Codes based on local urbanization and distance to metropolitan areas. The county population density in 2005 ($POP_{DEN}$) and county population growth from 2001 to 2005 ($POP_{GROW}$) were used to measure urbanization pressures emerging from the size and growth of local communities.[4] The proximity to urban areas was measured by identifying metropolitan counties

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[3] Data was obtained from the Regional Economic Information System at the Bureau of Economic Analysis, www.bea.gov.

[4] Population data was obtained from the Bureau of Economic Analysis, www.bea.gov, and land area was obtained from the US Counties data provided by the Census Bureau, www.census.gov. The data are only available through 2005.

and non-metropolitan counties adjacent to metropolitan areas with dummy variables, (*METRO*) and (*ADJACENT*), respectively.[5]

*Amenity Factors*

USDA natural amenity data were used to derive a variable to measure recreation and amenity characteristics in local markets. The standardized z-scores of topography and surface water area were summed to create an overall measure of natural amenities (*AMENITY*).[6] Places with more abundant natural amenities are assumed to have higher probability of recreational activity. In the Kansas City Federal Reserve District, counties with higher levels of amenity values had more farms earning recreation service income in 2002.

*Ethanol Plant Location*

Proximity to ethanol plants was measured as the Euclidian distance between ethanol plant locations and the bank location of survey respondents ($E_{DIST}$). Plant locations were those identified by the Renewable Fuels Association (RFA) and the American Coalition on Ethanol (ACE) as plants in operation as of April 3, 2007. Given the surge in ethanol production in 2006 and 2007, these ethanol plant information may not be fully inclusive of all ethanol plants, but this is the most consistent and comprehensive data available to the authors. The minimum distance between an ethanol plant location and survey respondent averaged 65 miles for a single plant, 93 miles for two ethanol plants, and 112 miles for three plants. For example, on average a circle

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[5] Metro and adjacent dummy variables were created from USDA's rural-urban continuum codes based on the 2000 Census of Population available at www.ers.usda.gov.

[6] County level data on water surface area and topography were obtained from the USDA's natural amenity index available at www.ers.usda.gov.

with a radius of 93 miles would include two plants. $E_{DIST}$ is expected to be negatively related to cropland values because farmland locations with greater distance from an ethanol plant are expected to have lower land values, ceteris paribus. We also estimate a model that examines the impact of an ethanol plant by considering the number of ethanol plants located within a 50 mile radius of the bank respondent. Table 1 provides descriptive statistics for the data used in the empirical model.

**Table 1: Descriptive Statistics**

| Variable | Mean | St. Dev. | Min. | Max |
|---|---|---|---|---|
| Dependent Variables: Non-irrigated farmland values | | | | |
| 2006:Q3 | 1148 | 723 | 185 | 3750 |
| 2006:Q4 | 1198 | 748 | 200 | 3500 |
| 2007:Q1 | 1285 | 846 | 200 | 4000 |
| 2007:Q2 | 1298 | 827 | 300 | 3800 |
| | | | | |
| Independent Variables | | | | |
| *AMENITY* | -0.81 | 1.25 | -3.39 | 1.84 |
| $POP_{DEN}$ | 20.50 | 39.99 | 1.00 | 466.40 |
| $POP_{GROW}$ | -2.53 | 5.08 | -12.80 | 24.52 |
| *LIVESTOCK* | 174.39 | 245.57 | 13.04 | 1807.18 |
| *CROP* | 75.73 | 58.58 | 0.56 | 274.67 |
| *GOV* | 18.74 | 10.84 | 0.50 | 51.33 |
| *ADJACENT* | 0.24 | 0.43 | 0.0 | 1.0 |
| *METRO* | 0.14 | 0.34 | 0.0 | 1.0 |
| $E_{DIST}$ | 65.41 | 53.68 | 0.00 | 279.94 |
| $E_{MILE50}$ | 1.00 | 1.37 | 0.0 | 7.0 |

*Empirical Results*

The empirical model was applied to 219 survey responses from agricultural bankers that reported non-irrigated cropland values in every quarter from the third quarter of 2006 to the second quarter of 2007. Individual linear regressions were estimated for non-irrigated cropland values from the third and fourth quarters of 2006 and the first and second quarters of 2007.[7]

[7] The models were also estimated with a log-linear formulation. The linear model is of most interest because it allows one to directly examine the relationship between implied basis changes and land values.

Empirical results indicate that the empirical model has relatively good fit (Table 2). The models were found to be statistically significant with adjusted R-square measures ranging from 53 percent to 58 percent. Multicollinearity does not appear to be a problem as most of the variance inflation factors were below two. The exception was crop and government revenues per acres where variance inflation factors where above seven.

**Table 2: Empirical Results: Land Values and Distance to Ethanol Plants**

| Dependent Variable: Non-irrigated Cropland Values (dollars per acre) | | | | |
|---|---|---|---|---|
| | 2006:Q3 | 2006:Q4 | 2007:Q1 | 2007:Q2 |
| | (Model 1) | (Model 2) | (Model 3) | (Model 4) |
| $E_{DIST}$ | **-1.43** | **-1.48** | **-1.69** | **-2.14** |
| | **(0.72)** | **(0.74)** | **(0.86)** | **(0.86)** |
| *CROP* | **4.61** | **4.54** | **4.69** | **4.89** |
| | **(1.56)** | **(1.6)** | **(1.86)** | **(1.86)** |
| *GOV* | **19.22** | **19.47** | **25.53** | **18.72** |
| | **(8.65)** | **(8.87)** | **(10.3)** | **(10.3)** |
| *LIVESTOCK* | **-0.97** | **-0.97** | **-1.06** | **-0.95** |
| | **(0.21)** | **(0.22)** | **(0.25)** | **(0.25)** |
| *POPDEN* | 1.45 | 1.53 | 1.24 | 1.71 |
| | (0.92) | (0.94) | (1.09) | (1.09) |
| *POPGROW* | 13.04 | 9.49 | 6.01 | 4.73 |
| | (9.05) | (9.28) | (10.78) | (10.78) |
| *METRO* | **316.99** | **374.92** | **489.76** | **385.90** |
| | **(133.75)** | **(137.15)** | **(159.25)** | **(159.3)** |
| *ADJACENT* | **236.30** | **292.56** | **228.39** | **296.20** |
| | **(88.9)** | **(91.16)** | **(105.85)** | **(105.88)** |
| *AMENITY* | **177.40** | **186.83** | **203.12** | **208.01** |
| | **(30.84)** | **(31.63)** | **(36.73)** | **(36.74)** |
| Intercept | **750.77** | **766.49** | **767.15** | **892.02** |
| | **(120.39)** | **(123.46)** | **(143.35)** | **(143.39)** |
| F-value | 29.34 | 28.79 | 26.39 | 23.79 |
| Adj. R-square | 0.5836 | 0.5788 | 0.5567 | 0.5299 |
| Obs | 219 | 219 | 219 | 219 |

Number in bold are significant at the 0.10 level

Most of the independent variables were found to be statistically related to non-irrigated cropland values with the expected sign and robust to the quarterly land value. Agricultural characteristics, *CROP* and *GOV*, were positive and significantly related to cropland values in all models. Urbanization characteristics were also positive and significantly related to cropland values. Distance to metropolitan areas, *METRO* and *ADJACENT*, was found to be significant factor related to farmland values in all models. *POPDEN* and *POPGROW* were less robust in terms of statistical significance.

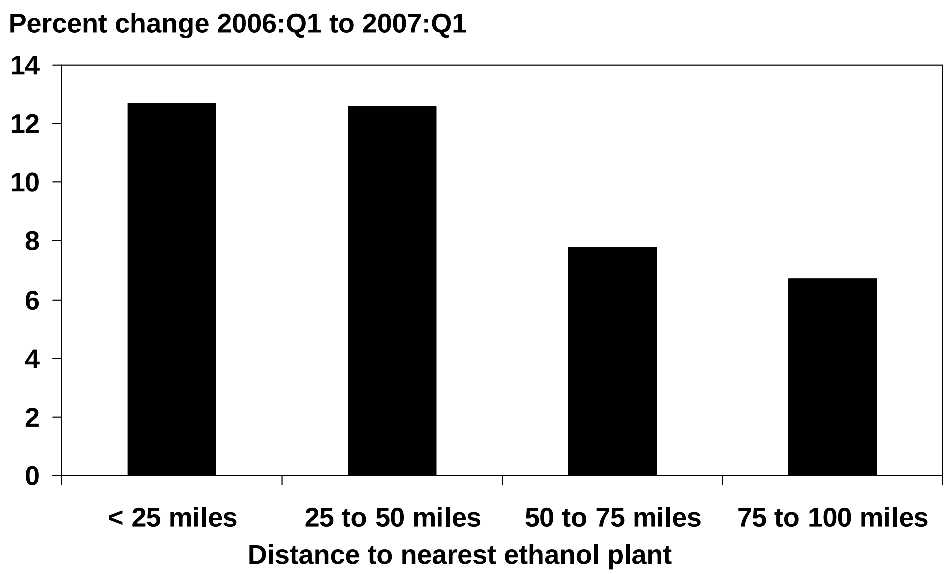
Empirical results indicate that cropland values were higher in places in closer proximity to an operating ethanol plant and that the impact of ethanol plants strengthened in 2007. Distance to ethanol plants ($E_{DIST}$) was negative and significant at the 0.01 level. The results indicate that for every mile of increased distance, non-irrigated cropland values were $1.44 per acre lower in the third quarter of 2006. By the second quarter of 2007, the marginal impact was $2.14 per acre. In percentage terms, cropland values in the third quarter of 2006 were 0.13 percent lower for every mile of increased distance to an ethanol plant and 0.16 percent lower in the second quarter of 2007.[8]

Although the distance to an ethanol plant appears to be related to farmland values, the level of competition could also play an important role in farmland value gains. For example, the impact of ethanol plant locations on cropland values could be higher in areas that have multiple ethanol plants bidding for local crop production. Another analysis was also conducted to examine farmland price changes in 25 mile increments from ethanol plants. Chart 2 shows the annual percentage change (first quarter 2006 to first quarter 2007) for non-irrigated cropland

[8] Empirical results from a model specified in log-linear form found that land values were 0.09 percent lower for every mile of increased distance from an ethanol plant in the third quarter of 2006 and 0.12 percent lower in the second quarter of 2007.

within 25 mile increments of the nearest ethanol plant.  The biggest farmland value impacts emerge for land located within 25 and 50 miles of an ethanol plant.  Bankers within 50 miles of an ethanol plant reported non-irrigated cropland gains of 12.6 percent, with virtually no difference between 25 and 50 miles, but significant differences between the 50 and 75 mile radius (Chart 2).  This is consistent with McNew and Griffith who found that ethanol plant locations impacted grain prices up to 68 miles away from the plant.

**Chart 2: Non-Irrigated Cropland Value Gains and Distance to Ethanol Plants**




A second series of regression models were estimated using the same formulation as in Table 2 but replacing the variable for distance to the nearest ethanol plant with the number of ethanol plants within 50 miles of the bank respondent. The number of ethanol plants operating within 50 miles of the banker respondent ($E_{MILE50}$) was positive and significantly related to cropland values in all models (Table 3). Again, the marginal relationship appears to have strengthened over time, rising from $119 per acre when a plant is within 50 miles in the third quarter of 2006 to $158 per acre when a plant is within 50 miles in the first quarter of 2007.

**Table 3: Empirical Results: Non-Irrigated Cropland Values and Ethanol Plants within 50 miles**

| Dependent Variable: Non-irrigated Cropland Values (dollars per acre) | 2006:Q3 (Model 5) | 2006:Q4 (Model 6) | 2007:Q1 (Model 7) | 2007:Q2 (Model 8) |
|---|---|---|---|---|
| *$E_{MILES50}$* | **119.00** | **115.81** | **165.57** | **157.58** |
| | **(36.22)** | **(37.27)** | **(42.62)** | **(43.12)** |
| *CROP* | **3.48** | **3.46** | 3.03 | **3.45** |
| | **(1.59)** | **(1.63)** | (1.87) | **(1.89)** |
| *GOV* | **18.76** | **19.11** | **24.57** | **18.36** |
| | **(8.47)** | **(8.72)** | **(9.97)** | **(10.09)** |
| *LIVESTOCK* | **-0.98** | **-0.98** | **-1.07** | **-0.97** |
| | **(0.21)** | **(0.21)** | **(0.24)** | **(0.24)** |
| *POPDEN* | **1.62** | **1.70** | **1.44** | **1.97** |
| | **(0.89)** | **(0.92)** | **(1.05)** | **(1.06)** |
| *POPGROW* | 14.95 | 11.27 | 8.91 | 7.05 |
| | (8.91) | (9.17) | (10.48) | (10.61) |
| *METRO* | **337.23** | **395.59** | **514.43** | **415.46** |
| | **(131.01)** | **(134.78)** | **(154.14)** | **(155.94)** |
| *ADJACENT* | **260.00** | **315.33** | **262.41** | **326.75** |
| | **(87.63)** | **(90.15)** | **(103.11)** | **(104.31)** |
| *AMENITY* | **171.27** | **180.60** | **195.55** | **199.14** |
| | **(30.19)** | **(31.06)** | **(35.52)** | **(35.94)** |
| Intercept | **625.99** | **635.37** | **628.48** | **699.18** |
| | **(88.01)** | **(90.54)** | **(103.55)** | **(104.76)** |
| F-value | 31.22 | 30.32 | 29.29 | 25.5 |
| Adj. R-square | 0.5991 | 0.5918 | 0.5832 | 0.5478 |
| Obs | 219 | 219 | 219 | 219 |

Number in bold are significant at the 0.10 level

The previous results all consider the case of non-irrigated farm land values. Because there are significant amounts of irrigation in this region, another analysis was conducted to examine the impact for irrigated farmland values. Here, the empirical model was also applied to irrigated cropland values reported by 132 agricultural bankers in every quarter from the third quarter of 2006 to the second quarter of 2007. The estimates suggest that irrigated cropland values are driven by agricultural characteristics and significantly related to distance to ethanol plants only in 2007.[9] As in the non-irrigated case, crop revenues per acres were significantly related to land values. Table 4 shows the marginal impacts of the ethanol related variables for the irrigated and non-irrigated cropland. The distance to the nearest ethanol plant, ($E_{DIST}$), was only significantly related to irrigated cropland values during the first and second quarters of 2007. In the second quarter of 2007, the irrigated regression results indicate that for every mile of increased distance, irrigated cropland values would fall by $2.62 per acre, a significantly larger decline than the results for non-irrigated cropland (Table 4). In percentage terms, cropland values were 0.13 percent lower in the second quarter of 2007.[10]

**Table 4: Marginal Impact of Ethanol Plants on Irrigated and Non-Irrigated Cropland Values**

| | Ethanol Variable | |
|---|---|---|
| | Minimum distance to an ethanol plant, ($E_{DIST}$) | Number of ethanol plants within 50 miles ($E_{MILES50}$) |
| Non-irrigated Cropland | | |
| 2006:Q3 | -1.44** | 119.00*** |
| 2006:Q4 | -1.48** | 115.81*** |
| 2007:Q1 | -1.69** | 165.57*** |
| 2007:Q2 | -2.14*** | 157.58*** |
| Irrigated Cropland | | |
| 2006:Q3 | -1.60 | 86.44* |
| 2006:Q4 | -1.58 | 92.20* |
| 2007:Q1 | -2.21* | 119.53** |
| 2007:Q2 | -2.62** | 121.85** |

Significant at the 0.10 level*
Significant at the 0.05 level**
Significant at the 0.01 level***

[9] The urbanization variables, *METRO, ADJACENT*, *POPDEN,* and *POPGROW* were insignificant, which is not surprising given that irrigated land is concentrated in the sparsely populated areas of the Tenth District. As expected, the amenity variable was positive and significantly related to irrigated cropland values. *AMENITY* is composed of surface water variable and may be identifying some regions that use surface water for irrigation.

[10] Empirical results from a model specified in log-linear form found that land values were 0.10 percent lower for every mile of increased distance from an ethanol plant in the third quarter of 2006 and 0.15 percent lower in the second quarter of 2007.

However, the number of ethanol plants within 50 miles was found to be significant in all time periods, indicating that irrigated cropland values are higher in locations with a closer proximity to multiple ethanol plant locations (Table 4). In the third quarter of 2006, irrigated cropland values were $86 per acre higher when an ethanol plants was located within 50 miles. By the second quarter of 2007, the marginal impact has expanded to $121 per acre. In percentage terms, a log-linear specification indicates that irrigated cropland values with an ethanol plant within 50 miles were 4.3 percent higher than other irrigated cropland in the third quarter of 2006 and 6.0 percent higher in the second quarter of 2007.

## Implications

The empirical results indicate substantial variation in farmland values based on the proximity to ethanol plant locations. Ethanol plant locations can have considerable impacts on farmland values. For example, based on the marginal impacts derived from Model 4 for the second quarter of 2007, a farm parcel more than 50 miles from an ethanol plant would have a price $107 less per acre than an equivalent parcel of land next to an ethanol plant, or 8.2 percent of the average non-irrigated farmland value of $1,298 per acre. Similarly, for an irrigated parcel, the marginal impacts for the second quarter of 2007 would suggest that the land price for a parcel over 50 miles from an ethanol plant would be $131 per acre less than a parcel next to an ethanol plant or a 6.6 percent of average irrigated farmland values of $1,966 per acre.

The empirical results also suggest that proximity to multiple ethanol plants may further boost farmland values. Based on the results for Model 8 (Table 3), farmland values were $157 per acre higher for every additional ethanol plant located within 50 miles, an impact substantially larger than the impact derived by only calculating the distance to the nearest ethanol plant (model 4). Using the estimates in for the second quarter of 2007 (model 4), a tract located 50 miles from a plant would be worth $107 less than a tract next to the plant.[11] As a result, it would appear that the presence of competition due to multiple plants in a given area can have a strong impact on land value changes.

The spatial relationship between farmland values and ethanol plant locations is expected to be driven by changes in local crop basis patterns. In efficient markets, the basis is expected to be based on transportation costs. As a result, transportation costs or the avoidance of grain shipping costs are expected to explain the most of the relationship between cropland values and the distance to ethanol plants. Gallagher, Wisner and Brubaker indicate the cost of transporting a bushel of corn to an ethanol plant by truck is $0.002316 per bushel per mile. This value was compared with the estimated impact of ethanol plant locations on farmland values in the Kansas City Federal Reserve District.

The estimated marginal impacts on farmland values were converted from per acre to per bushels for comparison. In the Kansas City Federal Reserve District, corn yields on non-irrigated cropland averaged 90 bushels per acre in 2006. Using the marginal impact of $2.14 per acre in the second quarter of 2007 (model 4) and a capitalization rate of 4%, would result in implied transportation costs of $0.000951 per bushel per mile ($2.14 / 90 * .04 = $0.000951). Thus, the estimated marginal impact derived from the land values was less than half the cost of transportation found by Gallagher, Wisner, and Brubaker. Alternatively, the capitalization rate would need to be roughly 10 percent for the estimated marginal impacts derived from land values to equal the costs of transportation impacts found by Gallagher, Wisner, and Brubaker.

[11] Calculated using the marginal impact for the second quarter of 2007 (2.14) multiplied by 50 miles.

Using the estimated impacts of ethanol plants within 50 miles on farmland values produces results closer to those found in past literature. McNew and Griffith found that ethanol plants within 150 square miles raised corn prices by 12.5 cents per bushel on average, ranging from 4.6 cents to 19.3 cents per bushel. In our analysis, farmland values were estimated to be $157 higher when an ethanol plant was within 50 miles. Using a capitalization rate of 4 percent and a 90 bushel per acre average, annual impact of an ethanol plant would be 7.0 cents per bushel, well within the range of McNew and Griffith's findings. On average, when a plant was located within 50 miles, the average distance was 29 miles resulting in a $0.002791 per bushel per mile impact, slightly larger than the $0.002361 per bushel per mile impact found in Gallagher, Wisner, and Brubaker.

## Conclusion

The recent surge in ethanol production has fueled higher corn prices and led to higher crop prices as the market bid for production acres. Higher crop prices quickly translated into higher farmland values across the country, but the magnitude of these gains were highly variable. Based on land values derived from a survey of agricultural bankers in the Kansas City Federal Reserve District, farmland values are higher in locations in close proximity to ethanol plant locations.

Economic theory suggests that spatial variations in farmland values would be derived from the difference in local crop basis and transportation costs. The estimated impact of ethanol plants on farmland values appears to be equal or less than the impact of ethanol plants on local basis prices found in existing literature. These results indicate that the recent run-up in farmland values is consistent with expected revenue gains from higher basis levels. While agricultural bankers expressed concern about the sustainability of farmland value gains, these results suggest that the component of land value price increases due to changes in transportation costs appear reasonable.

Future research is needed to clarify the relationship between farmland value gains and basis level changes. One drawback of this study is the use of farmland values derived from an opinion survey of agricultural bankers. Opinions may differ from actual values, although agricultural bankers frequently finance farmland sales, which should improve their knowledge of farmland values. Future research using actual sales data would provide additional insight into the impact of ethanol plant locations on farmland values.  Moreover, sales transactions often have information on parcel characteristics, land productivity and tillable acres, which could improve the estimation of farmland values in a hedonic price model.

Additional research is needed to determine what is driving the change in farmland values and the basis. The basis could be driven by two factors. First, reduced transportation costs associated with a new terminal market could alter the basis and increase land values. For example, an ethanol plant 5 miles away would reduce transportation costs for a farm operation where the previous market terminal was 50 miles away. Second, given no change in terminal market locations, basis changes could be driven not by changes in distance, but by changes in local demand. In this case, the ethanol plant may have been located next to the existing market terminal, which would lead to no change in transportation costs, but would change local demand for grain.

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