Are Local Corn Prices Affected by the Location of Ethanol Biorefineries?

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Abstract

This study examines whether the local competition for corn to produce ethanol has lead to significantly higher prices for farmers located close to ethanol biorefineries. If any, such price premiums for spatial closeness would be in addition to the general level of corn price changes experienced by farmers throughout the U.S. The difference-in-differences estimation method is used to account for both time and spatial differences in order to measure the interaction of time and spatial effects. Using the USDA's ARMS data, the results show that while prices in real terms have changed over time, farmers located close to ethanol biorefineries have not received significantly higher prices than farmers living farther away from biorefineries. These findings indicate that there is a lack of evidence for price premiums due to spatial closeness to ethanol plants.

Key words: corn prices, ethanol, ethanol plant location, difference-in-differences.

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U.S. ethanol production has rapidly expanded over the last few years. As of January 2009, there were 170 biorefineries in the U.S. with a total production capacity of 10,569.4 million gallons of ethanol per year (Renewable Fuels Association statistics). This is up from 50 biorefineries with a capacity of 1,701.7 million gallons in January 1999. The increased demand for corn for conversion to ethanol has had significant effects felt throughout the agricultural sector. The upward trending corn prices during the last few years (a trend that has been partially reversed lately) have altered farming practices and profitability of producers.

As of January 2009, 26 states had ethanol biorefineries, however, most biorefineries are spatially concentrated in the states with most intense production of corn. A biorefinery built in a new location will have to compete with previously established marketing channels to secure corn as an input to the ethanol production process. While corn prices have generally increased over time (with partial reversals during recent years), an interesting questions is whether these price changes are affecting all farmers in the U.S. or there are some additional price premiums for farmers located close to ethanol plants.

Several studies have considered various aspects of corn production and ethanol production such as the effect of ethanol-driven demand on crop choices (Klieber, 2009) and ethanol plant location decisions (Sarmiento and Wilson, 2008; and Eathington and Swenson, 2007). Some studies addressed the relationship between ethanol production and national corn prices (Du, Hennessy, and Edwards, 2008 and Fortenbery and Park, 2008). Others considered local corn prices near ethanol plants. McNew and Griffith (2005) studied the impact of ethanol plants on local grain prices with a data set from 2001 to 2002 and found that there were significantly positive responses for corn prices around ethanol plants. Gallagher, Wisner, and

Brubacker (2005) examined the pricing systems for corn in the vicinity of processing plants with data from 2003 and found that the pricing systems differ based on the organization of the ethanol biorefineries. Since the construction of ethanol biorefineries and production of ethanol has intensified during recent years, this study will examine these relationships using more recent data that also covers a greater geographical region.

The main objective of this study is to investigate whether the local competition for corn for ethanol production has lead to significantly higher prices for farmers located close to ethanol biorefineries. If any, these price premiums for spatial closeness would be in addition to the general level of corn price changes experienced by farmers throughout the U.S. The study utilizes the difference-in-differences estimation method to find the interaction of time and location effects after controlling for differences over time and across locations. Specifically, the difference-in-difference model estimates differences in prices at two time points for the treated observations (prices for corn contracts near ethanol biorefineries) and for the control observations (those farther away from biorefineries) and then compares the differences between the two groups. The time differences in corn prices due to common factors or structural changes as well as the spatial differences in corn prices due to different locations are accounted for in order to compare the effect of the treatment which is the interaction of time and location effects.

Difference-in-Differences Models

The difference-in-differences (DID) estimator estimates the difference between outcome measures at two time periods for both the treated observations and controls and then compares the difference between the groups (Cameron and Trivedi, 2005). There are two differences considered: one is the difference in outcomes from one period to the next and the other is the difference between treated and control observations, hence the term difference-in-differences. The difference-in-differences model is defined as

(1) $$y_{it} = \alpha + \beta t_{it} + \gamma d_i + \delta t_{it} d_i + \phi x_{it} + e_{it}$$

where y_{it} is the outcome measure for every unit *i* for the initial or second period, t_{it} is a dummy variable equal to 1 if the observation is in the second period and 0 if it is in the initial period, d_i is a dummy variable equal to 1 if the observation in the treatment group and 0 if it is not, and $t_{it}d_i$ is the interaction term between the time dummy variable and treatment dummy variable, x_{it} are other characteristics that influence the outcome variable, and e_{it} is the error term. The time-treatment interaction term is the difference-in-differences measure for the effect of the treatment on the treated group, controlling for common time differences between the two groups.

Specifically for this study, the outcome of interest y_{it} is local corn prices. The treatment d_i is whether or not a farmer has an ethanol plant nearby with the treated group being famers that have an ethanol plant nearby and the control group being those farmers that do not. Two time periods t_{it} are considered to eliminate the general price changes over time that affect all farmers. The interaction between the dummy variable for the time period and the dummy variable for the presence of an ethanol plant is the difference-in-differences effect that we are interested in. This difference-in-differences effect represents the price premiums (if any) due to spatial closeness to ethanol biorefineries after the general spatial and time effects are accounted for.

The ordinary least squares estimator of the difference-in-differences model assumes that each observation is independent of all other observations in the data set. When observations are correlated within a cluster (intraclass correlation), each observation contains less unique information. In this study, data from farmers residing close to each other (say within the same county or zip code location) may be correlated. Therefore, the standard errors need to be corrected for the intraclass correlation within clusters. We use the robust cluster variance estimator:

(2) $V_{cluster} = (X'X)^{-1} \sum_{j=1}^{n_c} u_j' u_j \, (X'X)^{-1}$,

where X include all variables including the constant, $u_j = \sum_{j \, cluster} e_i \, X_i$, and n_c is the total number of clusters. Here, the observations are farmers and the clusters are the county or zip code locations where farmers reside.

Data and Descriptive Statistics

The data for this study are from three sources. The ethanol biorefineries locations are obtained from the Renewable Fuels Association. The location of each ethanol plant is associated with the county or zip code. Corn prices received by farmers for their marketing contracts are obtained from the USDA's Agricultural and Resource Management Survey (ARMS). Prices are indexed in 2007 dollars using the producer price index for farm products. Two matching criteria are used to merge the two data sets: county and zip code for the location of the ethanol biorefineries and farms. The analysis is conducted with data for 12 states with most intense ethanol production: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. The latest year that commodity price data are available is 2007. Because the estimation method requires two periods to isolate general price changes over time, the initial period is considered to be 2006. Several other initial years were considered (starting with 2003) and the results remain similar. Farm characteristics such as diversification entropy index, land tenure, farm size, corn quantity contracted, operator age and education are also from the ARMS data and are hypothesized to affect corn prices (Katchova and Miranda, 2004). County characteristics such as indicators for a farming dependent county, low employment county, and a rural county index are from the U.S. Census and are considered to account for the general economy effects on corn prices.

Descriptive statistics of the data are presented in table 1. The average corn contract price for the two periods was about $3/bushel, indexed in 2007 dollars. When using county clusters to match the two data sets, 21.5% of the counties that had data on corn prices had an ethanol plant in the same county and the rest did not. When using zip code clusters, 4.2% of zip code locations with corn growers had an ethanol plant in the same location. Forty four percent of the data are from 2007 (the second period) and the rest of the data are from 2006 (the initial period). The interaction term shows that 9% of the data on corn growers that have an ethanol plant in their county are recorded in the second period and 2.1% of the corn growers have an ethanol plant in their zip code location and are recorded in the second period. For 3.6% of the corn growers, a new ethanol plant was built during the study period of 2006-2007 and for 0.05% of the corn growers, a new ethanol plant was build in the same zip code location.

Depending on whether county or zip code clusters are used, the average quantity of corn contracted is 22 to 23 thousand bushels, the average farm size measured in total assets is about $1.7 million dollars, the average operator age is about 51-52 years, and the average education is 2.8, which is measured as a categorical variable. There are 3,475 corn contract observations in the data, which are from 663 distinct counties. Likewise, there are 1,817 corn contracts in the data, which are from 1,817 distinct zip codes. The number of observations is not the same in the two analyses because either the county or zip code location was missing for some ethanol biorefineries.

Difference-in-Differences Model Results

Difference-in-differences models are estimated to examine whether there are any price premiums for farmers located close to ethanol biorefineries in addition to the general price changes over time for all farmers. Two difference-in-differences models are estimated based on whether clusters for the analysis are counties or zip codes. When farms are located in the same county or zip code, it is expected that the corn prices that the farmers received on their contracts will be more similar than if living farther apart, i.e. the observations will be correlated. To account for the clustering effects of farmers that are located in the same areas, the standard errors are corrected using the county or zip code locations as clusters.

The results shown in table 2 indicate that the time dummy variable is significant, indicating an upward trend in prices between 2006 and 2007. Since prices are indexed in 2007 dollars, the increase in prices between the two periods shows increase in real terms. The ethanol plant dummy is not significant in either of the models. This effect reflects spatial differences in prices (some locations have higher and other locations have lower prices than the national average price) and is not necessarily an indication that ethanol biorefineries have a positive or negative influence on local corn prices.

The interaction term of the ethanol plant dummy and time dummy is not significant in the two models. The term measures the difference-in-differences effect of ethanol biorefineries on local corn prices while controlling for changes in prices from one period to the next that may be common for all farmers regardless of whether an ethanol plant is located nearby. These results provide an indication that while prices in real terms have risen over the last few years across the U.S., farmers located close to ethanol biorefineries have not been able to secure even higher prices due to their proximity to ethanol plants.

Other variables are also included in the models as control variables. The coefficient on the entropy diversification index is negative and significant indicating that more diversified farmers obtain lower prices on their corn contracts. Also, older farmers are able to secure higher corn prices possibly due to their experience. Farmers located in farming dependent counties tend to receive lower corn prices using the county clusters model and similar price using the zip code clusters model than farmers who are located in counties than are not farming dependent. Also, farmers in low employment counties tend to receive lower prices than their counterparts in high employment counties. These results indicate that when alternative opportunities are limited in terms of farming dependency and low employment, farmers are accepting lower prices for their corn production. Finally the urban-rural designation of the county has no effect on local corn prices.

The main finding here that there are no significant price responses for farms located close to ethanol biorefineries is different than the previously obtained result in McNew and Griffith (2005). They found that there are positive corn price responses around the biorefineries but noted that price impacts would likely diminish as local producers increase corn supplies over time. However, they used data from 2001-2002 and since then ethanol production and biorefinery construction have intensified. This study finds no such price premiums using more recent data and a different methodological approach. In other words, while the initial supply of corn was inelastic over the 2001-2002 production year, the long-term adjustments of corn production has likely eliminated the price premiums for proximity to ethanol plants.

Conclusions and Policy Implications

This study analyzes the spatial effect of ethanol biorefinery locations on local corn prices. Difference-in-differences models are estimated to show that farmers located spatially close to ethanol biorefineries have not received significantly different prices from farmers who are located at least one county or zip code location away from an ethanol plant. These results are obtained after accounting for changes over time in corn prices and only comparing the effect of the ethanol plant presence in the farmer's county or zip code location on corn prices.   In other words, this study does not show any evidence that ethanol biorefineries have had a significant effect by raising local corn prices beyond the price changes experienced by farmers across the nation. The results remain robust if changes over one or five years are considered as well as considering clustering based on county or zip code locations.

These findings have several implications. The profitability and long-term survival of the biorefineries critically depend on input prices paid for corn. As corn production nears its capacity to provide for local production of ethanol, the competition may drive local corn prices higher. Therefore, it is important to consider future plant construction sites as to not reach the capacity point in a local area and thus bid up local prices. In addition, because of transportation costs, farmers located close to biorefineries may not be able to transport their production to farther processors to obtain higher prices after accounting for transportation costs. and make ethanol production less profitable, especially when coupled with lower gasoline prices as experienced recently

Finally, alternative sources of biofuels and conversion technologies are being developed that will utilize new feedstocks in addition to corn and other grains. These cellulosic feedstocks – woodchips, native grasses, corn stover, dedicated energy crops, and municipal waste – offer the opportunity to dramatically increase the production of ethanol while potentially decrease the demand for corn for ethanol production. These alternative sources of biofuels will likely change the local price effects for corn.

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Table 1. Descriptive Statistics

Variable	Definition	County Clusters	Zip Code Clusters
Corn contract price	Price received for corn contracts, expressed as 2007 dollars/bushel	2.995	2.992
Ethanol plant dummy	1 if the county or zip code location of farmer has an ethanol plant	0.215	0.042
Time dummy	1 if observation is in the second period	0.441	0.436
Ethanol plant dummy * time dummy	Interaction term measuring the difference-in-differences effect	0.090	0.021
New ethanol plant dummy	1 if new ethanol plant was built during the study period 2006-2007	0.036	0.005
Corn quantity contracted	Quantity contracted of corn in bushels	22,394	23,298
Entropy diversification index	An ERS_USDA defined diversification index between 0 and 1, with higher values representing higher diversification	0.266	0.277
Land tenure	Proportion of owned to total land	0.389	0.406
Farm size	Total assets in dollars	1,672,815	1,732,490
Operator age	Years	50.710	52.035
Operator education	Category from 1 to 4	2.844	2.823
Farming dependent county	U.S. Census defined index equals 1 if county is farming dependent	0.172	0.172
Low employment county	U.S. Census defined index equals 1 if county is low employment county	0.002	0.002
Urban-rural county index	U.S. Census defined category from 1 to 7, with higher numbers representing more rural locations	5.377	5.328
Number of observations	Number of corn contracts	3,475	3,388
Number of clusters	Number of distinct counties or zip code locations	663	1,817

Table 2. Difference-in-Differences Models

	Corn Contract Price	
	County Clusters	Zip Code Clusters
Intercept	2.4912**	2.4011**
	(0.1417)	(0.1617)
Ethanol plant dummy	-0.0770	-0.0141
	(0.0472)	(0.0837)
Time dummy	0.8977**	0.8851**
	(0.0520)	(0.0472)
Ethanol plant dummy * time dummy	-0.0551	-0.0637
	(0.0936)	(0.1868)
New ethanol plant dummy	-0.1927	-0.0389
	(0.1276)	(0.1438)
Corn quantity contracted	-3.e-07	-3.e-07
	(2.e-07)	(2.e-07)
Entropy diversification index	-0.2875*	-0.3541**
	(0.1506)	(0.1507)
Land tenure	0.0704	0.0684
	(0.0574)	(0.0571)
Farm size	9.e-09	9.e-09
	(6.e-09)	(6.e-09)
Operator age	0.0045*	0.0059**
	(0.0023)	(0.0025)
Operator education	-0.0017	0.0051
	(0.0211)	(0.0225)
Farming dependent county	-0.0904*	-0.0599
	(0.0466)	(0.0465)
Low employment county	-0.2761**	-0.2438**
	(0.1190)	(0.0966)
Urban-rural county index	-0.0054	-0.0086
	(0.0078)	(0.0074)
Number of observations	3,475	3,388
Number of clusters	663	1,817
R squared	0.384	0.372

Note: * and ** denote significance at the 10% and 5% significance level, respectively.