BASIS EFFECTS OF ETHANOL PLANTS IN THE U.S. CORN BELT

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INTRODUCTION

The price of corn has been volatile in the last seven years, with corn prices ranging from just under $2.00 a bushel in 2005 to around $5.50 a bushel in 2008, and then falling back down to under $4.00 a bushel in 2010 (USDA-NASS 2010). This is illustrated in figure 1, which contains average prices from a monthly survey of about 2,600 grain elevators and buyers in the top producing states in the U.S. (NASS 2009).

According to the USDA Economic Research Service (ERS), ethanol demand in the U.S. has increased by over 400% from 1998 to 2008, and as of 2007 it surpassed exports to become the second highest category in corn usage, behind livestock feed and residuals (figure 2) (USDA-ERS 2011). Ethanol production in the U.S. has increased from about 3.6 billion gallons in January of 2005, to about 13.5 billion gallons as of January, 2011 (RFA 2011).

This volatility in corn prices, in addition to the large increase in ethanol production, makes it logical to question what affect ethanol plants have on the local price of corn in the countryside. In this article, we will determine how changes in ethanol plan capacities affect local corn prices in the corn belt of the United States using a two stage model to account for the endogeneity between ethanol plant location and capacity decisions and local corn basis. Building on previous literature (McNew and Griffeth (2005), O'Brien and Woolverton (2009), and Katchova (2009), among others), this paper determines how the changing ethanol plant industry affects corn prices close to the plant compared with those that are farther away.

Basis is calculated as the difference between the local cash price and the corn futures price of the contract that matures soonest (i.e., the nearby futures price). A weak basis indicates cash corn prices are much lower than the futures price, which encourages storage instead of cash sales. The idea that spatial aspects matter is supported by maps such as the one shown in figure

3, where ethanol plants generally located close to areas with high corn yields (Wade 2009). These high producing areas have been traditionally characterized with a weak basis due to the large supply of corn hitting the market in the fall (harvest time). It is expected that the opening of an ethanol plant, or an increase in existing capacity, will increase demand for cash sales of corn, strengthening local basis.

Ethanol plant owners choose locations based on corn prices, corn production, and natural gas prices among other things, and the maps in figures 3 and 4 show a non-random distribution of plants (Lambert, et al. 2008, Sarmiento and Wilson 2008). Though the data used in this article ranges from December 2009 through September 2010, the maps shown in figure 4 are snapshots of the corn ethanol industry and local corn basis in December of 2005 and 2009 to account for seasonality. As expected, more ethanol plants are located in places where corn production is highest and, generally, where corn basis is relatively weak. This is likely because ethanol plants need to produce at a high capacity in order to break even, and a weak basis means that the price they pay for corn is expected to be lower (compared to the futures price) than if basis was strong.

With a better understanding of how ethanol plants affect local corn prices, ethanol and corn producers, other corn demanders and policy makers will better understand the effect ethanol plants have on the agricultural sector. For example, knowing how an ethanol plant affects the price of corn received, a farmer may choose to alter cropping strategies to maximize profit when they learn new ethanol plant capacity will come online in their area, or livestock producers may choose to change the mix of feed to include dry distillers grains (DDGs), a by-product of ethanol, and reduce corn consumption. Also, if corn producers know that co-op owned plants affect basis differently than privately owned plants, it will be important in making decisions on whether or not to invest in a plant; if the price of corn increases enough when a farmer owned plant opens to cause profits to increase, it may be beneficial to own a plant in their area. Farmers would get profit both from the plant and from increased corn prices. Knowing if ethanol plants do indeed affect corn prices, and what the magnitude of that affect depends on, is crucial to understanding how to proceed with determining how other changes (for example, closing plants or changing plant capacities) affect corn producers, one of the largest agricultural sectors in the United States.

The rest of this paper is set up as follows: Section 2 reviews the previous literature. Section 3 describes the data. Section 4 describes the econometric model, and sections 5 and 6 contain a discussion of the results and conclusions.

LITERATURE REVIEW

McNew and Griffeth estimated a spatial model in 2005 to quantify the impact of introducing an ethanol plant on monthly regional grain basis, as well as to estimate the difference in those effects based on where the elevator is located relative to where the plant and the terminal market for that elevator are located, and to determine how far from the plant the affect traveled (McNew and Griffeth 2005). When spatial autocorrelation is present, an elevator's price may be affected by what is going on in the surrounding regions. McNew-Griffeth (2005) used Anselin's maximum likelihood method to account for spatial autocorrelation (to learn more, see Anselin 1998). They specified that any two markets located within 50 miles of each other are positively correlated.

The time period of this study was from 2001 through 2003, and included 12 ethanol plants. Basis was used in place of the local cash corn price in order to incorporate transportation, storage, national supply and demand, and local supply and demand conditions. They specified an arbitrary draw area as 150 square miles around the plant. Spatial autocorrelation was statistically significant, a plant opening had a significant positive affect on local basis, and that the effect was concentrated around the plant. They also found that average basis effects were non-uniform over space, and each plant's effect on market prices persisted for between 31 and 104 miles from the plant.

In a separate study, O'Brien found that ethanol plant proximity did not affect corn prices in Kansas in 2008 using a method similar to that of McNew-Griffeth (2005) (O'Brien 2009). This difference in findings was revisited by O'Brien and Woolverton (O'Brien and Woolverton, 2009). They posited that the plants may not be exogenously located, as was assumed by O'Brien (2009). Also, the data did not include any pre-ethanol plant information. With no pre-plant information, it was not possible to compare results from before the plants opened to after the plants opened.

A more recent study looked at four states (Michigan, Kansas, Iowa and Indiana) over 10 years (September 1998 through June 2008), and included information on 35 ethanol plants opening over that time span (Lewis, 2010). The study determined if the opening of an ethanol plant affected the corn price relationship of other grain markets, and then focused on whether a new ethanol plant affected local corn basis. Lewis (2010) found no effect of the opening of an ethanol plant on other grain markets. The second part of the research followed the same process as McNew-Griffeth (2009), finding similar results. Three of the four states (Michigan, Kansas and Iowa) had positive and significant effects in most of the new plant areas, however Indiana had mostly negative and significant impacts around the area of a new plant. Lewis also introduced a third model which allowed the basis effect to change as the number of months the plant had been open increased. The number of months the plant was open was significant and positive for 16 of the 35 plants, with the price impact decreasing the longer a plant was open.

Katchova used a Differences-in-Differences (DD) technique in an attempt to distinguish price effects over time and space from the opening of ethanol plants (Katchova 2009). She focused on corn prices in eight states; Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska and Wisconsin. The difference in prices close to the ethanol plant from before and after an ethanol plant opens were compared to the difference in prices farther away from the plant from before and after the ethanol plant opens. The data, contract prices received by farmers for marketing contracts from USDA-ARMS, included an initial time period of 2005 and a final time period of 2007. Marketing contracts include any contract that specifies a price, or a mechanism to determine price, a time and place for delivery, and the quantity to be delivered, with the terms determined before harvest and where control of the crop and production practices remain with the farmer until delivery (MacDonald and Korb 2008). An example of this would be forward contracts. The initial time period of the study was arbitrary, however results were similar when using other initial time periods. Katchova (2009) indexed the corn price for 2007 using the producer price index for farm products in order to discuss the results in real terms. The results found in the study were also different from those in the McNew-Griffeth (2005) study: farmers located within the same zip code or county as an ethanol plants did not receive significant higher prices than those located in another zip code or county.

This article advances the literature in some important ways. The data we use is rich in that it contains a large number of ethanol plants and elevators over a significant time horizon. Our data is from December 2005 through September 2010 and it contains 19 Corn Belt states, with ethanol plants opening in all but three of them. This is the first of the basis studies to include a significant portion of the sample in a mature ethanol market; previous studies may have been measuring effects in market disequilibrium. According to the Renewable Fuel Association, total corn ethanol capacity hit about 13.5 billion gallons per year as of January 2011 which is close to the 15 billion gallons by 2022 mandate set by the Energy Independence and Security Act of 2007 (RFA, 2011). Because of this, it is expected that growth in existing plant capacity and new plant openings will decline, this is supported by RFA statistics as seen in table 1. However, knowing how different ethanol plants affect basis in this mature market can lead to better understanding of how future changes in the corn ethanol industry will affect corn producers.

Also, we include plant ownership regime, public (or co-op/farmer owned plants) versus private. Ownership is expected to have an effect on prices because farmer owned plants (or co-ops) are likely to have contracts with the farmer-owners to supply at least a percentage of their corn to the plant, regardless of opportunities available elsewhere. This might deflate the price effect compared to privately owned plants, which may have to offer incentives to get the corn needed to reach capacity.

It is feasible to assume that ethanol plant location and capacity decisions are not just non-random, but also endogenous. Corn price and production levels are inputs into the decision of where to locate an ethanol plant, and they likely affect the decision on what size to build the plant (Bertrand, Duflo and Mullainathan 2004, Sarmiento and Wilson 2008). Therefore, in order to determine the effect changing ethanol plant capacity has on local corn basis while accounting for this endogeneity, we will use a two stage approach, with the first stage predicting the total ethanol capacity in each county based on a Poisson distributed regression using instrumental variables correlated with plant location and capacity decisions and uncorrelated with corn basis. State fixed effects are used to account for time invariant characteristics each state is likely to have and year fixed effects are used to account for changes that take place across all states over time, for example changes in national energy policies.

The first stage prediction of county capacity uses instrumental variables ($\boldsymbol{Z_{jt}}$) like population density, median income, and natural gas prices. The choice of these variables comes from two particular studies of ethanol plant location decisions: Lamber, et al. (2008) and Samiento, et al. (2008). Included in the second stage model are ($\boldsymbol{X_{it}}$) estimates of transportation costs, plant ownership regime, and month dummies. The monthly time dummies are to account for changes that may happen over time (for example changes in laws), as well as to account for the seasonality in corn prices.

DATA

In order to expand upon the current literature in the ways mentioned above, similar data is needed, and it is obtained from six main sources. Basis is determined from a data set from DTN, "My DTN Cash Bids", including daily prices reported by elevators across the corn belt from mid-2005 through late-2010, and nearby corn futures prices from the Chicago Board of Trade. Ethanol plant information comes from the Renewable Fuels Association, Ethanol Producer Magazine, the American Coalition for Ethanol, and press releases about plant openings. Corn production for each state comes from USDA-NASS.

There are 3,341 locations over 19 states from which cash bids are collected and 84 of these locations are ethanol plants. The observations span early July, 2005 and late September, 2010, though we dropped the observations from before December, 2005 because many of them are missing. The daily observations were aggregated to monthly observations for the analysis. The second Tuesday of every month was used, if the second Tuesday was missing, the data was supplemented, first, with the following Wednesday and then the following Thursday. After the daily data was aggregated to monthly, 82,014 basis observations remain. The data includes nineteen states: Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, Wisconsin and Wyoming. Seventeen of these contain ethanol plants. The two that do not are Arkansas and Oklahoma. Of the remaining states, 79 counties contained ethanol plants in December 2005 and 163 contained plants in September 2010. The state with the largest increase in number of ethanol plants and ethanol capacity is Iowa. The ethanol plant statistics can be seen in table 2. Basis weakened in every state, with Iowa experiencing the smallest change in average basis and the Dakotas experiencing the largest changes. Basis statistics over time and by state can be seen in table 3.

We control for plant ownership regime, corn production, a measure of transportation costs, and state specific fixed effects through state dummy variables. In the first stage, annual changes are accounted for through year dummies and in the second stage, seasonality is controlled for through month dummies. The plant's ownership regime is included because it is expected that the effect of plant ownership on basis will be different for farmer/co-op owned plants than for privately owned plants. A co-op is likely to have contracts with farmer/owners to supply a certain amount of corn, causing them to feel less pressure to offer incentives to fill capacity than a privately owned plant may. Corn production by county is included because it is an economic factor in determining corn prices, which is part of basis.

METHOD

Due to the issue of endogeneity of ethanol plant location and capacity decisions on local basis levels, we chose a two stage model. The first stage uses instrumental variables to determine an exogenous predicted level of capacity in each county. We use the predicted level of capacity per county in the second stage to determine how ethanol plant capacity in a county affects the corn basis in surrounding areas.

First, we aggregated the ethanol plant data to the county level. In order to fully capture differences in counties with and without ethanol plants, we ensure that the data set contained all of the counties from the 19 states; as such, there are many counties where the total capacity is zero. We then assigned a dummy variable to each county based on whether or not there is a privately owned plant in the county.

From there, we added the instrumental and exogenous variables. The instrumental variables used are county population ($population_{it}$), local tax burden (tax_{it}), natural gas price ($natgas_{it}$), median income ($income_{it}$), and unemployment rate ($unemp_{it}$). These variables come from previously published research on ethanol plant location decisions, as well demand side inputs in the ethanol plant industry (Sarmiento, et al., 2008 and Lambert, et al., 2008). The included exogenous variables are corn production ($production_{it}$), diesel price as a proxy for transportation cost ($transport_{it}$), level of cattle in the county as a proxy for demand for corn and DDGs from the livestock industry ($livestock_{it}$), plant ownership regime (own_{it}), year dummies ($year_t$), and state dummies ($state_i$). We include the dummy variables to account for changes that happen over time and differences between states that do not change and are not included in the model.

We also include a one period lagged sum of capacity in the county ($totcap_{i,t-1}$). Existing capacities are independent and exogenous factors in the capacity and location decision of each ethanol plant. The lagged sum of capacity accounts for changes that have happened in the ethanol plant sector of that county as well as includes information that may affect the addition of new capacity either in the form of increasing capacity at a current plant or building a new plant.

To account for the plants in surrounding areas that may affect capacity in each county at each time, we include two levels of spatially weighted sums of capacities in the surrounding counties ($\sum_{j=1}^{n} W_i\, totcap_{jt}$ and $\sum_{j=1}^{n} W_i^2\, totcap_{jt}$). W_i is a queen's contiguity weights matrix with a positive weight given to all counties directly surrounding county *i*, and a weight of zero given to all other counties and W_i^2 is a second order queen's contiguity matrix with a positive weight given to all counties in the second order of contiguity from county *i* and a weight of zero given to all other counties.

We use a Poisson distribution in order to estimate the probability of positive capacity in each county, accounting for the variables mentioned above. We estimate the first stage capacity decision with the equation

$$\begin{aligned} TotCap_{i,t} = {} & \alpha_0 + \alpha_1 population_{it} + \alpha_2 production_{it} + \alpha_3 tax_{it} + \alpha_4 transport_{it} \\ & + \alpha_5 natgas_{it} + \alpha_6 income_{it} + \alpha_7 unemp_{it} + \alpha_8 livestock_{it} + \alpha_9 own_{it} \\ & + \alpha_{10} year_t + \alpha_{11} state_i + \alpha_{12} totcap_{i,t-1} + \sum_{j=1}^{n} \gamma_j W_i\, totcap_{jt} \\ & + \sum_{j=1}^{n} \delta_j W_i^2\, totcap_{jt} + u_{it} \end{aligned}$$

The second stage determines the effect ethanol plant capacity has on local basis. The predicted capacity of each county, $\widehat{TotCap}_{i,t}$ calculated from the first stage results, is used in the place of actual capacity. This should eliminate the problem of endogeneity between basis levels and ethanol plant capacity and location decisions. This stage also includes the spatially weighted sum of predicted capacities in the surrounding counties ($\sum_{j=1}^{n} W_i\, \widehat{totcap}_{jt}$ and $\sum_{j=1}^{n} W_i^2\, \widehat{totcap}_{jt}$), plant ownership regime in the county (own_{it}), corn production ($production_{it}$), livestock ($livestock_{it}$), transportation cost ($transport_{it}$), and state and month dummies ($state_i$ and $month_t$). The spatially weighted sum of predicted capacities in the surrounding regions is used because basis is not only determined by what happens at the location it is measured, but by what is going on around it. An ethanol plant will affect the price of corn within its entire draw area, which is larger than just the county in which it is located.

Plant ownership regime in the county is included because a co-op may feel less pressure to offer incentives to fill capacity than a privately owned plant, which could affect the price differently. Livestock, corn production and transportation cost are all factors in determining corn price. Following the economic theory of supply and demand, as demand for corn increases or supply of corn falls, the price of corn is expected to increase. We include a measure of livestock because the livestock industry is a major player in the demand for corn, and corn production is included because it is a measure of the supply of corn on the market. Transportation cost is important because corn price at each location takes into account the cost of transporting the grain to its final destination. State dummies are included here for the same reason as they are used in the first stage, and month dummies are used to account for the seasonality in corn production and prices.

The second stage model is

$$Basis_{it} = \beta_0 + \beta_1\, \widehat{TotCap}_{i,t} + \sum_{j=1}^{n} \rho_j W_i\, \widehat{totcap}_{jt} + \sum_{j=1}^{n} \varphi_j W_i^2\, \widehat{totcap}_{jt} + \beta_2 own_{it} + \beta_3 production_{it} + \beta_4 livestock_{it} + \beta_5 transport_{it} + \beta_6 month_t + \beta_7 state_i + e_{it}$$

Where the W_i and W_i^2 weights matrices are the same as described above.

RESULTS

The final results of this research are preliminary, with only the first stage presented here. The second stage results will be available soon. The first stage results are in table 4. Population, local tax burden, natural gas prices, and income all varied negatively with the total capacity in a county, though population is not significant. These signs are all as expected since a high tax burden, high natural gas prices, and a high median income (and therefore presumably a high wage required to staff the plant) of the population in the county all would negatively impact the profitability of a potential ethanol plant.

Corn production, transportation costs, unemployment rates, and livestock levels within a county all vary positively with total capacity in the county, though livestock levels are not significant. A positive sign on corn production is as expected because ethanol plants logically prefer to locate in locations which produce a lot of corn. The positive sign on transportation costs is not as expected. We could be picking up a demand side effect here since the ethanol produced in a local plant helps to substitute for high priced petroleum fuel. High unemployment rates indicate ready access to labor, and the presence of livestock indicates a close outlet for sale of the plant's co-product, DDGs. The insignificant result on livestock could be due to demand and supply side effects offsetting one another; the livestock industry affects ethanol capacity through demanding DDGs, however it also demands corn, reducing the available supply to the ethanol plant.

A co-op or farmer owned plant in the county of interest is associated with higher total capacity in the county by just over 1 million gallons per year. The preliminary results indicate that being in a particular state is not a significant predictor of total plant capacity in a county, however the year does matter, with later years being more positively associated with higher levels of capacity. This is as expected because as the industry matured we saw a general trend upward in the nameplate capacity of newly constructed plants.

Lagged capacity in a county is positive and significant, increasing total capacity in a county by just over 0.006 million gallons per year (mgy) for every mgy increase in lagged capacity. This indicates that the higher the capacity in time *t-1*, the higher the capacity will be in time *t*, which is intuitive. It is unlikely that a plant is built, or an existing plant increases capacity, in the span of one month. Future work will include longer lags. The spatial lags are of opposite signs. The first order spatial lag, the sum of capacity in the counties directly adjacent to the county of interest, negatively affects total capacity in the county of interest; the higher the amount of capacity in the surrounding counties, the lower the total capacity in the county of interest. The second order spatial lag, the sum of capacity in the counties one county away from the county of interest, positively affects total capacity in the county of interest. This result is as expected since the presence of ethanol plants near a potential plant location indicates competition for access to the corn locally produced. This result suggests that ethanol plants optimally locate at least one county away from an existing ethanol plant.

CONCLUSION

There are strong indications from previous studies that new ethanol plants cause corn prices to increase, and that co-op ownership lessens that effect. Our final results will focus on ethanol plant capacity, not just new ethanol plants, as well as include ownership regime and account for endogeneity of ethanol plant location and capacity decisions. Also, our data includes information from a more mature ethanol market, which has not been discussed in previous literature.

This article presents evidence that there is non-randomness in plant locations and that there is endogeneity between ethanol plant capacity and local corn basis. In the first stage results, we show that two variables historically used in determining corn price, corn production and transportation cost, are also significant factors in determining ethanol plant capacity in a county. We attempt to control for this endogeneity through a two stage, instrumental variables approach by predicting the total ethanol capacity in each county in a first stage equation to use as the variable of interest in our final model.

Though the corn ethanol industry is predicted to slow down, knowing how changes in an industry affect prices of its major input may translate into understanding how future generations of similar agricultural industries affect their major input prices. Also, this may be helpful in understanding how future changes in the corn ethanol industry (closing plants, increasing production prices, etc.) affect the corn industry-the largest agricultural market in the United States.

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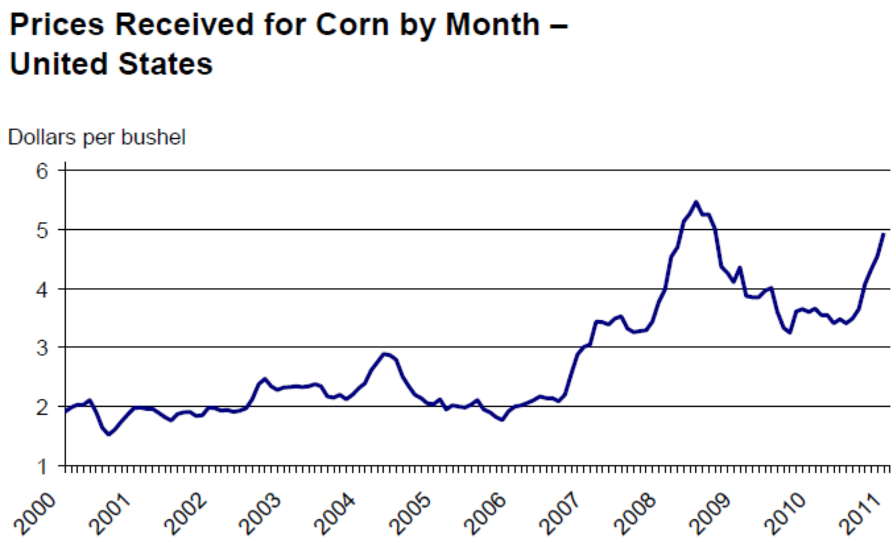
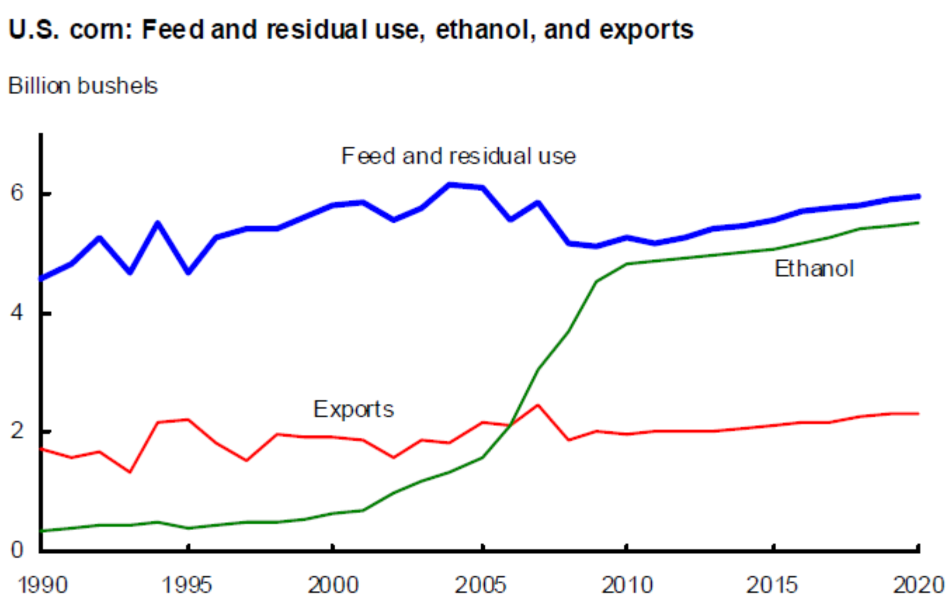
Figure 1. Monthly U.S. Corn Price



Source: http://usda.mannlib.cornell.edu/usda/nass/AgriPric//2010s/2010/AgriPric-12-30-2010.pdf

Figure 2. U.S. Corn Use



Source: http://www.ers.usda.gov/Publications/OCE111/OCE111d.pdf

Figure 3. 2007 Corn Yields and Ethanol Plant Locations

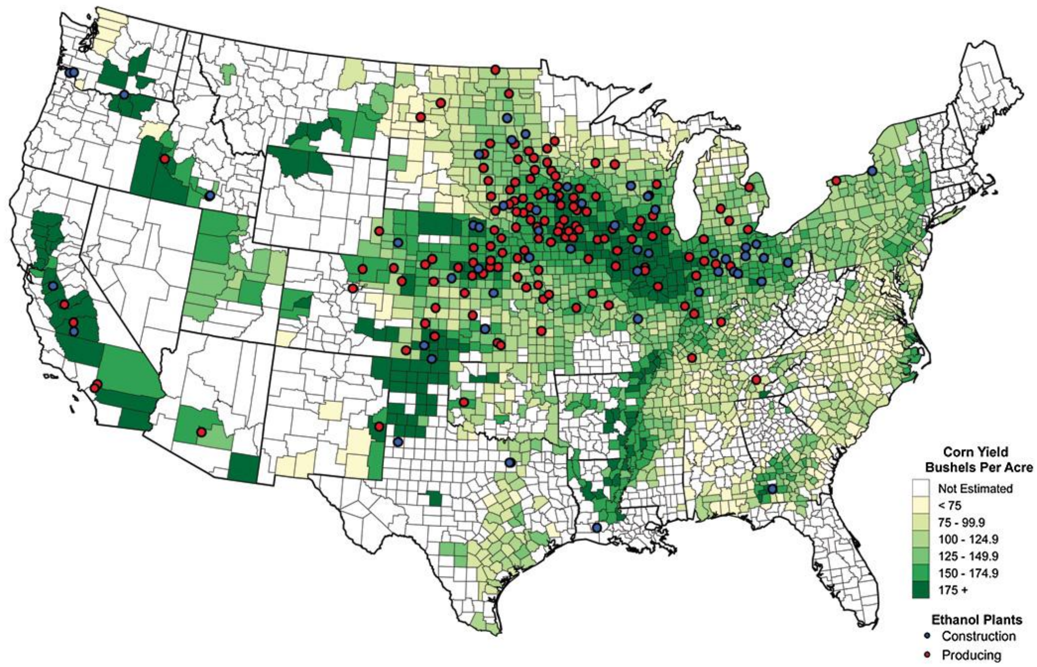


Figure 4. Ethanol Plants and Predicted Basis, December 2005 and December 2010

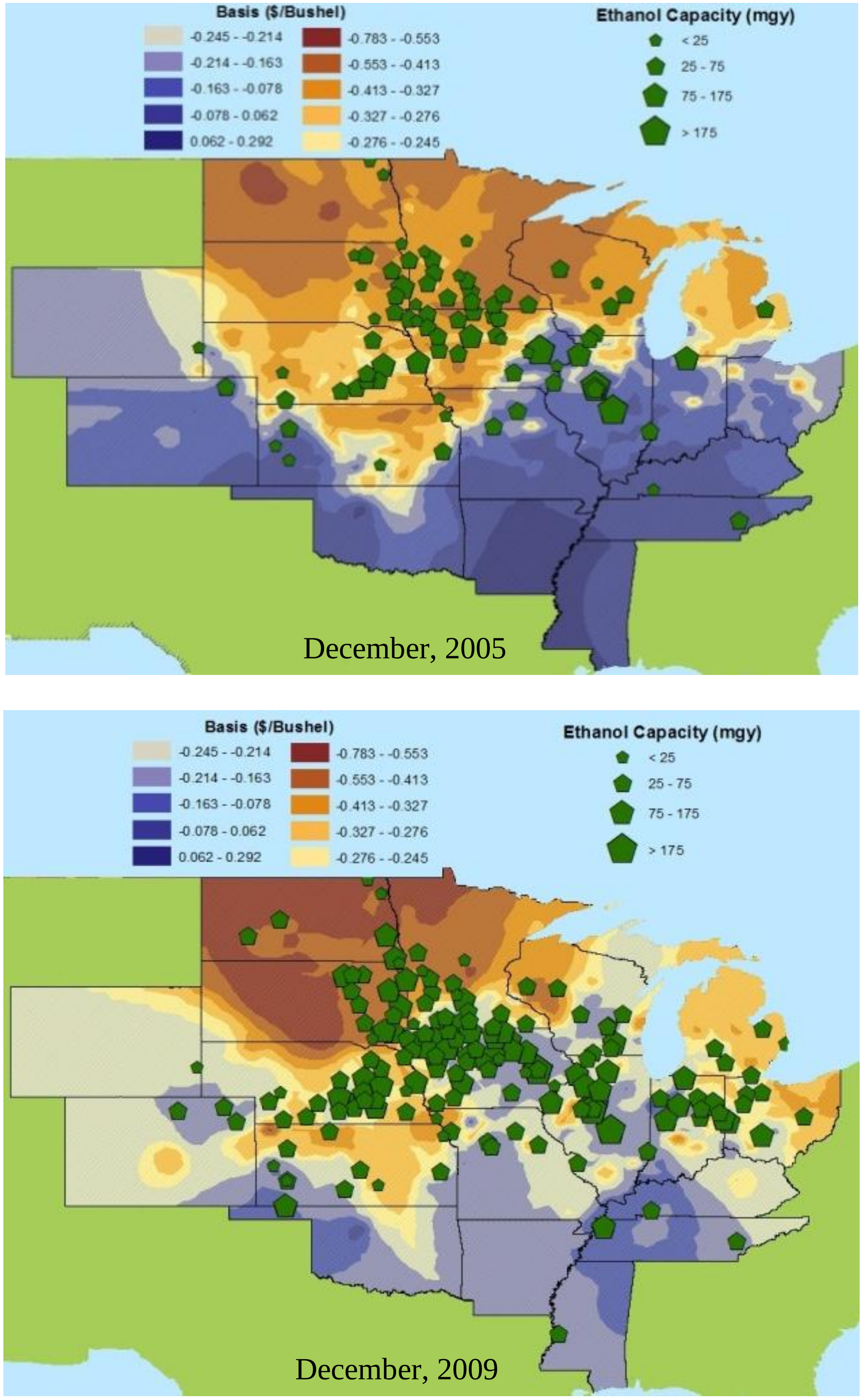


Table 1. U.S. Ethanol Plants and Production Capacity Over Time

	Total Ethanol Plants	Capacity (mgy)	Plants Under Construction/Expanding	Cap. Under Construction/Expanding
January 2005	81	3,643.7	16	754
January 2006	95	4,336.4	31	1,778
January 2007	110	5,493.4	76	5,635.5
January 2008	139	7,888.4	61	5,536
January 2009	170	10,569.4	24	2,066
January 2010	189	11,877.4	15	1,432
January 2011	204	13,507.9	10	522

Source: http://www.ethanolrfa.org/pages/statistics#A

Table 2. Ethanol Plant Capacity December 2005 and September 2010

	Counties With Ethanol Plants		Mean Capacity		Minimum Capacity		Maximum Capacity	
	2005	**2010**	**2005**	**2010**	**2005**	**2010**	**2005**	**2010**
Total	79	163	52.7	75.8	1.5	1.5	274	465
Arkansas	0	0	-	-	-	-	-	-
Colorado	1	3	42	40.7	42	40	42	42
Illinois	5	11	154.8	111.5	40	37	274	290
Indiana	1	11	102	83	102	40	102	115
Iowa	18	35	62.9	101.3	5	20	260	465
Kansas	6	10	20.75	44.4	1.5	1.5	45	110
Kentucky	1	1	24	33	24	33	24	33
Michigan	1	5	50	53	50	50	50	57
Minnesota	14	20	35.2	56.7	18	18	52	225
Mississippi	0	1	-	54	-	54	-	54
Missouri	3	6	36.6	43.5	20	20	45	55
Nebraska	10	23	54.3	76.7	17.5	25	114	300
North Dakota	2	6	16.8	59.7	10.5	10	23	110
Ohio	0	7	-	76.9	-	54	-	110
Oklahoma	0	0	-	-	-	-	-	-
South Dakota	10	13	47.5	78.2	9	11	120	220
Tennessee	1	2	67	91	67	67	67	115
Wisconsin	5	8	37.6	62.3	4	40	49	130
Wyoming	1	1	5	5	5	5	5	5

Table 3. Corn Basis December 2005 and September 2010

	Counties With Basis Reported		Mean Basis		Minimum Basis		Maximum Basis	
	2005	**2010**	**2005**	**2010**	**2005**	**2010**	**2005**	**2010**
Total	1827	1827	-0.20	-0.62	-0.78	-1.60	0.35	0.01
Arkansas	7	7	0.19	-0.41	0.10	-0.45	0.26	-0.37
Colorado	30	24	-0.06	-0.54	-0.16	-0.74	0.11	-0.22
Illinois	136	239	-0.08	-0.43	-0.34	-0.90	0.23	-0.13
Indiana	103	87	-0.09	-0.40	-0.47	-0.60	0.19	0
Iowa	371	407	-0.26	-0.60	-0.46	-0.81	0.09	-0.29
Kansas	206	209	-0.18	-0.57	-0.56	-0.87	0.31	-0.07
Kentucky	25	23	0.08	-0.36	-0.13	-0.52	0.20	-0.20
Michigan	26	25	-0.27	-0.59	-0.39	-0.70	-0.01	-0.40
Minnesota	182	199	-0.33	-0.85	-0.67	-1.3	-0.19	-0.50
Mississippi	1	1	-0.19	-0.17	-0.19	-0.17	-0.19	-0.17
Missouri	82	80	-0.09	-0.60	-0.49	-0.89	0.25	-0.25
Nebraska	219	230	-0.24	-0.64	-0.42	-0.90	-0.04	-0.23
North Dakota	60	52	-0.37	-1.06	-0.78	-1.6	-0.17	-0.85
Ohio	118	90	-0.12	-0.43	-0.65	-0.71	0.074	-0.25
Oklahoma	4	15	0.16	-0.40	-0.02	-0.55	0.35	0.01
South Dakota	84	90	-0.32	-0.97	-0.55	-1.3	-0.16	-0.63
Tennessee	10	13	0.16	-0.32	-0.04	-0.47	0.30	-0.15
Wisconsin	34	34	-0.36	-0.88	-0.52	-1.32	-0.16	-0.60
Wyoming	2	2	-0.22	-0.53	-0.22	-0.60	-0.22	-0.45

Table 4. 1st stage results

Variable	Coefficient	Std. Dev.
Population	-1.45e-6***	1.3e-6
Production	3.96e-9***	7.6e-10
Local Tax Burden	-17.46***	1.39
Transportation	0.03***	0.005
Natural Gas	-0.004***	0.001
Income	-1.92e-6*	1.14e-6
Unemployment	0.012***	0.002
Livestock	0.00	0.00
Ownership	1.17***	0.02
Lagged Capacity	0.007***	0.00
1st Order Spatial Lag	-0.015***	0.00
2nd Order Spatial Lag	0.047***	0.00
Constant	2.78	5.32
Arkansas	-36.8	3.55e6
Colorado	-0.20	5.53
Illinois	-1.04	5.36
Indiana	Omitted	
Iowa	-0.06	5.36
Kansas	-0.69	5.35
Kentucky	-36.61	1.56e6
Michigan	-0.14	5.55
Minnesota	-0.17	5.38
Mississippi	Omitted	
Missouri	-1.1	5.38
Nebraska	0.34	5.36
North Dakota	-0.07	5.41
Ohio	-0.84	5.41
Oklahoma	-36.85	2.52e6
South Dakota	-0.54	5.39
Tennessee	0.57	6.14
Wisconsin	0.27	5.48
2005	Omitted	
2006	-0.12***	0.01
2007	-0.06***	0.01
2008	0.01	0.01
2009	0.05***	0.01

***significant at the 1% level
**significant at the 5% level
*significant at the 10% level