The Impact of Ethanol Production on Local Corn Basis

Kathleen Behnke

and

T. Randall Fortenbery*

*The authors are Instructor and County Agent, University of Wisconsin – Extension, and Washington State University Professor and Endowed Chair, School of Economic Sciences – respectively. This research was supported with funding from the RENK Agribusiness Institute, University of Wisconsin – Madison.

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Abstract

The focus of this study is on the impact local ethanol plants have on corn basis. Basis is the difference between the local cash price and the nearby futures contract price, and accounts for variation in the supply and demand in the local market relative to the national market. It is predicted that the entrance of an ethanol plant into a local cash market will increase corn demand, resulting in an increased cash price relative to futures.

The data employed consists of cash corn prices from 153 grain buyers in eight different Midwestern states from Fall 1999 through Summer 2009. In addition to affects from local ethanol production, it is predicted that basis is influenced to by the ratio of local to national corn production, transportation costs, storage opportunity costs, and seasonal factors. To estimate corn basis performance a spatial error component model is adopted that accounts for both spatial dependencies and panel structures in the data.

Results show that ethanol production within a 50-mile region of a county centroid has a small yet positive impact on local corn prices. The estimated impact of a 50 million gallon per year plant is a 0.425 cent per bushel increase in basis. These findings are smaller than the impacts found in previous work using a more limited time frame, but found to be consistent with earlier work when the time series is truncated to match sample periods from previous work. This suggests that some of the local price impacts dissipate with time.

Key Words: Spatial Econometrics, Ethanol Production, Basis, Corn Prices

Introduction

More than decade ago the United States began an aggressive search to find a practical source of renewable fuel to meet our insatiable energy demand. Alternative fuels such as starch-based ethanol, cellulosic ethanol, and biodiesel are all considered to be potential solutions in a national effort to reduce gasoline usage by 20 percent over the next ten years (Bush, 2007). Corn-based ethanol emerged as an early leader due to the abundance of corn and the popularity of ethanol-gasoline mixes.

The national ethanol industry has expanded dramatically over the last decade. According to the Renewable Fuels Association (RFA), in 2010 there were more than 200 production plants with the capacity to produce almost 13.5 billion gallons of ethanol. This is up from just 54 bio refineries with a production capacity of 1.7 billion gallons in 2000. RFA also reports that the ethanol industry supported 400,000 jobs in 2009 and contributed $53.3 billion to the nation's Gross Domestic Product (GDP) that year. Furthermore, they calculate that despite the tax credit to ethanol producers the industry still contributed a tax surplus of $3.4 billion to the federal treasury.

The rise of ethanol production in the US has been largely driven by government mandates, tax incentives, and the push to lessen America's dependence of foreign oil. The government has supported the use of ethanol as a policy to reduce dependence on foreign oil since the 1970's. In the 1990's it became popular to blend ethanol as an oxygenate in conventional gasoline to reduce smog. More recently, modern ethanol production standards were set in place by the Energy Policy Act of 2005, and then updated as part of the Energy Independence and Security Act of 2007. Currently, the production of transportation bio-fuels is scheduled to reach 36 billion gallons by 2022, with starch based ethanol contributing at least 15 billion gallons. According to the 2010 Ethanol Industry Outlook, production of ethanol in 2009 (10.6 billion gallons) reduced the demand for oil by 364 million barrels.

Government mandates and incentives, coupled with high crude oil prices, have pushed the biofuels sector to center stage in the discussion of future U.S. energy policy. However, this conversation must consider the implications of energy policy on the agricultural sector. Diverting corn and soy to the production of ethanol and biodiesel impacts on their prices, which in turn affects many other sectors of agriculture. Several economic issues are important to stakeholders in the both the ethanol and corn industries. Questions concerning how much corn will be needed to support the growth of the ethanol sector, and how the increased demand for corn will affect prices on both a local and national level have increased in importance as the industry continues to expand.

The ever strengthening relationship between the food and fuel markets clearly raises the question of how the biofuels industry affects the price producers receive for corn. The objective of this study is to examine the magnitude of this impact at the local level, and measure the extent to which the effect is maintained over time.

While this topic has been studied before, the work here is unique because it increases both the scope and the depth of the analysis. By accounting for spatial dependencies and the panel nature of a more complete data set the robustness of earlier results are examined. Thus, this study will provide a greater understanding of the overall impact of ethanol production on local corn prices.

The paper proceeds as follows: First, we discuss previous work related to the connection between ethanol production and corn prices. This is followed by a description of the analytical framework used to describe basis performance. Next, the specific empirical model is presented, followed by a discussion of the data used. We then present the results, including a comparison to earlier work. We finish with a set of conclusions regarding the impact of ethanol production on local corn basis.

Literature Review

Early work measuring the impact of ethanol plants on local grain prices was conducted by McNew and Griffith (2005). They estimated the impacts of 12 ethanol plants that opened between 2000 and 2003. They found, on average, corn prices increased by 5.9 cents in a plant's corn sourcing region, with positive price impacts felt up to 68 miles away. They further found the price impacts ranged from 4.6 to 19.3 cents per bushel, depending on the local corn supply at each location. In theory, one would expect areas with high corn demand or low corn supply to experience price impacts that are relatively greater than in areas with less demand or excess supply. McNew and Griffith's results generally confirmed this expectation.

The findings of McNew and Griffith were supported by a Henderson and Gloy (2009) investigation of ethanol plant impacts on cropland values. Their results indicated that increased crop land prices resulted from local ethanol plant activity. The land price impacts were consistent with an increase in annual corn prices of 2.3 to 6.4 cents per bushel. They concluded the corn price change was a result of the decreased transportation costs to terminal markets since a larger percentage of corn production was now used locally.

The estimation of positive price impacts due to a local ethanol plant is not a universal finding, however. For example, Fortenbery, Turnquist, and Foltz (2008) failed to find a positive impact on agricultural land values in communities with an ethanol plant compared to those without a plant.[1] In addition, O'Brien (2009) found Kansas corn prices at elevators located within 60 miles of an ethanol plant were significantly lower than elevators further than 60 miles from a plant. A similar effect was found by Katchova (2009). In his model farmers located in the same zip code as an ethanol plant actually received a price 10.9 cents per bushel lower than other farmers in the sample. This does not mean ethanol plants negatively affect corn prices, but does suggest that spatial differences play an important role in determining prices and close proximity to an ethanol plant does not guarantee higher prices relative to markets without an ethanol plant.

A study of Iowa ethanol plants by Gallagher, Wisner, and Burbacker (2005) found corn price impacts were dependent on the location of the plant. They observed nine market areas in Iowa and found evidence that an ethanol plant does tend to increase the local corn price. However, in locations where there were already many grain buyers, such as the northwest region of the state, the introduction of an ethanol plant had no statistically significant price impact. Thus, the results were mixed and dependent upon pre-existing market conditions.

In order to carefully examine the marginal impacts of ethanol production on local corn prices, it is important to account for other factors that may influence basis. In 2007, Olson, Klein, and Taylor developed a theoretical model for basis analysis. The variables they considered included the futures price, corn production, corn usage in ethanol, a storage measure, and variables dealing with transportation. McNew and Griffith (2005) included state and national corn production, monthly dummy variables, an ethanol dummy variable, diesel price, and a sophisticated distance term. In other basis literature, not specific to ethanol production, the relationship between local and national prices has been modeled by a production ratio, rather than absolute production values

(Fortenbery, 2002). Also, Fortenbery (2002), Kahl & Curtis (1986), and Garcia & Good (1983) stress the importance of including a storage cost or opportunity cost measure in basis analysis. Finally, Kahl & Curtis (1986) also include a price measure.

Analytical Framework

The rise in US ethanol production has many important economic consequences. Diverting corn away from its traditional feed, food, and export markets leads to fundamental shifts in agricultural production decisions. Corn is a commodity, thus corn producers are price takers, meaning they have no direct influence over the prices they receive. Moreover, most producers sell directly to local grain elevators, with the most important price to a producer being the price offered at a specific location and time. The pricing of corn is further complicated by production and use patterns. Corn is produced only once per year, but there is demand throughout the year. Prices vary across time in response to storage costs, and vary across space in response to whether specific regions have a corn surplus or deficit.

Local cash prices are linked to futures prices through the basis. Basis is defined as:

$$\text{Basis} = \text{Local Cash Price} - \text{Nearby Futures Price} \tag{1}$$

The local cash price is defined as the price a corn producer receives for corn on a specific day and at a specific location. The nearby futures price is defined as the price of the nearby futures corn contract traded in Chicago the CME Group exchange.

The basis varies over time in response to changing market conditions. Figure 1 shows the average basis over the past decade for individual states, plus the average of all the states combined. Based on the work described earlier, the factors generally considered to influence basis in this analysis are:

1) Corn Production Ratio: Basis is determined by both the local cash and futures prices, thus the ratio of local to national production is important in determining price relationships. It is

expected that if local stocks make up a relatively greater share of the national stocks, basis will be weaker because corn will need to be transported out of the region.[2]

2) Local Ethanol Production: Local ethanol production accounts for a portion of corn demand in the region.
3) Diesel Fuel Costs: Transportation costs play a major role in determining basis because all surplus grain from the local market must be moved to the national or international market. For excess supply markets the decline in local price occurs with greater distance to the consuming market, matching the increased transport costs. To account for the cost of transport the average Midwest diesel price is used as a proxy for grain rail and trucking costs.
4) Storage Costs: The cost of storage plays a role in determining basis because there is a substantial demand for corn year-round, but the commodity is only produced one time per year. Garcia and Good (1983) note storage costs can include warehouse charges, interest, or insurance. In the model here, storage is accounted for by including the prime interest rate, which mimics opportunity costs. Specifically, if the opportunity cost of holding grain is high, producers are expected to sell. This would amount to an increased supply on the cash market, thus a high opportunity cost is expected to cause a weaker basis.
5) Seasonality: Another important consideration, and one which is closely linked to storage, is seasonality. A higher cash price is expected as time increases from harvest as a method to compensate producers for storing the grain.

A model to explain local corn basis can be developed by combining the factors above. The model used in this study is specified as:

$$\text{Basis} = \beta_0 + \beta_1 * (\text{Production Ratio}) + \beta_2 * (\text{Ethanol Production}) + \beta_3 * (\text{Interest Rate}) + \beta_4 * (\text{Diesel Price}) + \sum_{i=1}^{7} \beta_{i6} * (\text{State}) + \sum_{i=1}^{3} \beta_{i7} * (\text{Season}) \quad (2)$$

As previously noted, Kahl & Curtis (1986) include price in their basis model and find it to be statistically significant in grain surplus markets. Higher prices may induce producers to sell, thus weakening the basis. To allow for this, the model above is also estimated with corn futures prices included.

Empirical Specification

The data used to operationalize the model above varies over time and space. This provides the opportunity to observe changes in basis that occur through time, as well as those that occur across locations. However, such an expansive dataset also presents significant econometric issues. Since OLS is not an appropriate method for panel data, a fixed or random effects approach must be employed (Elhorst, 2003). Additionally, any potential spatial dependency must be accounted for in the model estimation. To account for both issues, we develop and estimate a spatial panel model that is consistent with the hypothesized relation from equation (2).

The Spatial Panel Model

To analyze the effects of time and space, following Anselin, Le Gallo & Jayet (2008), we begin with a basic pooled linear regression model:

$$y_{it}=x_{it}\beta + u_{it} , \qquad (3)$$

In this model *i* represents the cross-sectional index, with *i* = 1….N, and *t* the time index, with *t* = 1….T. The total number of observations is NxT. The dependent variable is y_{it}, where each unique observation is denoted at both *i* and *t*. The observations of the exogenous variables are contained in a 1xK vector x_{it}, β is a Kx1 vector of the regression coefficients, and u_{it} is the error term.

To properly analyze spatial effects the observations are stacked first by the time period $t = 1 \ldots T$ and then by the cross-section $i = 1 \ldots N$ which leads to $y' = (y_{11}, \ldots y_{1N}, \ldots y_{T1}, \ldots y_{TN})$. The error term consists of spatially autocorrelated residuals, as well as random disturbances. Following Baltagi et al. (2003), the error vector for time t is represented as

$$u_t = \mu + \varepsilon_t \tag{4}$$

with

$$\varepsilon_t = \lambda W \varepsilon_t + v_t. \tag{5}$$

where $u_t' = (u_{t1}, \ldots, u_{tN})$, $\varepsilon_t' = (\varepsilon_{t1}, \ldots, \varepsilon_{tN})$ and $\mu' = (\mu_1, \ldots, \mu_N)$ denote the vector of random region effects which are assumed to be $IIN(0, \sigma^2_\mu)$. An important feature of spatial models, and one that is frequently ignored in the literature, is the construction of the NxN spatial weights matrix. There are numerous ways to build a weights matrix and for this particular model McNew and Griffith (2005) suggest that any locations within 50 miles will be correlated.

However, the field of spatial econometrics provides no set rules for picking a W-matrix structure so it is best to try a variety of specifications to test the robustness of the results. Thus, this study creates and tests several different weights matrices in addition to the base assumption. Using the latitude and longitude of the county centroid for all counties with a dependent variable observation (N=153), the following spatial weight matrices are constructed:

-50-mile Buffer – For county i, the neighborhood set includes all counties with centroids within 50 miles of the centroid of county i. In this specification, counties have between one and ten neighbors (consistent with McNew and Griffith).

-Contiguous Counties – For county i, the neighborhood set includes all counties contiguous to county i.

-Nearest Neighbors (NN) - For county i, the neighborhood set includes the m counties nearest to county i. The specifications examined are m = 5, 7, and 10.

The spatial weights matrix, W, is an N x N positive matrix that specifies the neighborhood set for each observation. If location i and location j are considered to be neighbors wij will have a non-zero value, and if the locations are not neighbors $w_{ij} = 0$. Also, by convention a location is not considered to be its own neighbor thus the diagonal elements $w_{ii} = 0$. The weights are standardized so that the elements of each row sum to one, or $w_{ij}^{s} = w_{ij} / \sum_{j} w_{ij}$. Using the W-matrix we are able to find λ, the spatial autoregressive coefficient, which will have a positive value less than one. In a panel setting the spatial weights matrix and the spatial autoregressive coefficient are assumed to remain constant over time (Anselin, 1988). Finally, $v_t' = (v_{t1}, \ldots, v_{tN})$ where v_{ti} is i.i.d. over *i* and *t* and is assumed to be $N(0, \sigma^2 v)$. ε_t can be rewritten as

$$\varepsilon_t = (I_N - \lambda W)^{-1} v_t = B^{-1} v_t, \tag{6}$$

where $B = I_N - \lambda W$ with I_N an identity matrix of dimension N.

Once the data is stacked the pooled regression can be written as:

$$y = X\beta + u,$$

(7)

where y is a NT x 1 vector, X is a NT x K matrix, and ε is a NT x 1 vector. The error vector takes the form:

$$u = (i_T \otimes I_N)\mu + (I_T \otimes B^{-1})v, \tag{8}$$

where i_T is a vector of ones with dimension T and I_T is an identity matrix of dimension T. From this the covariance matrix for u can be written:

$$\Omega_u = \sigma^2_\mu (J_T \otimes I_N) + \sigma^2_v (I_T \otimes (B'B)^{-1}), \tag{9}$$

where J_T is a matrix of ones with dimension T. From this we can rewrite the matrix as:

$$\Omega_u = \sigma^2_v [K_T \otimes (T \varphi I_N + (B'B)^{-1}) + E_T \otimes (B'B)^{-1}] = \sigma^2_v \Sigma_u, \tag{10}$$

Where $\varphi = \sigma^2_\mu / \sigma^2_v$, $K_T = J_T/T$, $E_T = I_T - K_T$, and $\Sigma_u = [K_T \otimes (T \varphi I_N + (B'B)^{-1}) + E_T \otimes (B'B)^{-1}]$ thus:

$$\Sigma_u^{-1} = K_T \otimes (T \varphi I_N + (B'B)^{-1})^{-1} + E_T \otimes (B'B) \tag{11}$$

and:

$$|\Sigma_u| = |T \varphi I_N + (B'B)^{-1}| * |(B'B)^{-1}|^{T-1}. \tag{12}$$

Using these results, Anselin derived the following log-likelihood function for the model:

$$L - \frac{NT}{2} \ln 2\pi\sigma_v^2 - \frac{1}{2} \ln [\, |T\phi I_N + (B'B)^{-1}|] + \frac{T-1}{2} \ln |B'B| - \frac{1}{2\sigma_v^2} u'\Sigma_u^{-1} u \tag{13}$$

Data

In order to estimate the impact of ethanol plants on local corn basis the study includes data from Illinois, Indiana, Iowa, Kansas, Minnesota, Nebraska, South Dakota, and Wisconsin. To estimate basis changes over time the sample period ranges from October 1999 through September 2009. This allows for estimation from the beginning of the period of rapid ethanol plant expansion. The data is aggregated by season to account for the variation throughout the year. Overall, there are observations from 153 different locations and 40 time periods included in the sample. The data includes information on monthly cash corn prices, nearby futures prices, diesel prices, interest rates, and ethanol production. Additionally, there is annual information on local and national corn production and quarterly information concerning national and state stock levels.

The primary variable of interest is the corn basis. Thus, the dependent variable is specified as the monthly cash corn price minus the monthly average nearby futures price. Local prices are a collection of corn prices compiled by CashGrainBids.com from 153 grain elevators over 129 months. All monthly data are aggregated to quarterly data. Missing price observations, which represents approximately two percent of the data points, are interpolated from neighboring counties. All counties with observed corn prices are shown in Figure 1.

Information concerning ethanol production, such as plant location and nameplate capacity, comes from the Renewable Fuels Association (RFA). To determine the date production began at the plant, data was used from Ethanol Producer Magazine. If the date was unavailable, the plant's website was used or the plant was called for the information. Figure 2 is a map displaying all counties with at least one ethanol plant.

Data for national and county level corn production, as well as state and national stocks, comes from the USDA National Agricultural Statistics Service (NASS). Any missing data points in an individual county's corn production is estimated by using the existing data from the county, and the average percentage change in production from around the state relative to the previous year.

Data on corn production is only available on a county level, while ethanol production is for a specific plant location. However, to truly understand the local supply and demand conditions that determine the price at a given location a broader measure is needed. In an effort to get a more complete understanding of price dynamics, a 50 mile buffer ring was drawn around the centroid of each county. Based on this, data from each county was summed with data from any other counties whose centroid fell within the 50 mile buffer.[3]

In the model, diesel prices are used as a proxy for transportation costs. The price used is the average monthly Midwest retail price as provided by the U.S. Energy Information Administration. The prime interest rate acts as a proxy for storage opportunity costs in the model. This information comes from the Federal Reserve Bank Statistical Release. Table 1 provides summary statistics of the data.

Empirical Results

A spatial error components model is used to obtain efficient and unbiased coefficient estimates. The data is entered into the maximum likelihood function developed by Anselin (1988) and the W-matrix specifies that any observations within 50-miles of one another may have correlated errors (McNew & Griffith, 2005).

The literature has employed a variety of model specifications to estimate basis. The theoretical model discussed above included a production ratio, transportation costs, storage costs, ethanol production, and state and seasonal dummy variables. The results of estimating this model, along with several alternative specifications, are displayed in Table 2. Results from the theoretical model described above are labeled Model A. Model B uses the ratio of local stocks to national stocks, rather than the local to national corn production ratio. Model C omits the measure of storage opportunity cost, Model D omits the transportation proxy variable, and Model E omits the seasonal dummy variables. Model F includes the nearby futures price as an additional variable, following the specification of Kahl and Curtis.

In order to pick the most appropriate model in a panel setting, Frees (2004) recommends using the Akaike's Information Criterion (AIC) and the Bayesian Information Criterion (BIC) to choose between alternatives. Both statistics allow for comparison between nested and non-nested models, making them appropriate for this application. The preferred model is indicated by the smallest AIC or BIC statistic.

Model F returns the lowest AIC and BIC, followed closely by Model A. Thus, the more complete models are superior. The difference between models A and F is the inclusion of the futures price in F, which is found to be statistically insignificant. As a result we will focus our discussion on Model A. However, note all models indicate that ethanol production is statistically significant with estimated coefficient values similar across models. The model parameters, β, can be interpreted as partial derivatives, similar to least-squares interpretation (Lesage & Pace, 2009). Thus, $\delta y_i/\delta x_{ir} = \beta_r$ for all i, r and $\delta y_i/\delta x_{jr} = 0$, for all $j \neq i$ and for all variables r.

The production ratio measures local corn production as a percentage of national corn production. As expected, the coefficient has a negative sign. This implies an increase in local supply, relative to national supply, will cause the basis to weaken. The coefficient implies a one percent increase in local corn production relative to national production results in a weakened basis of 1.29 cents.

The diesel price coefficient is also negative. Transportation costs greatly influence basis and the results indicate that as transport costs rise, the basis weakens. The coefficient of -0.1 implies that if the price of diesel rises by 10 cents will weaken by one cent.

The interest rate coefficient is also negative as expected. It is a proxy for the opportunity cost of storage, and as the opportunity cost of holding grain increases it is expected that more will be sold on the cash market, causing the basis to weaken. A one percent increase in the interest rate will cause the basis to weaken by 2.12 cents.

All of the states had statistically significant coefficients when compared to the base state of Indiana. The basis in Indiana is fairly strong relative to the other states in the sample so it is not surprising that the dummy coefficients for the other states are negative. Also note that none of the seasonal dummy variables are statistically significant.

The variable of most interest, ethanol production, is both positive and statistically significant. This indicates that local ethanol production positively affects basis, as expected. An ethanol plant is predicted to strengthen basis by .0085 cents per million gallons of ethanol production. This means a

50 MGY plant will increase basis by 0.425 cents. The model also estimates λ, σ^2_v and σ^2_μ to be statistically significant. The spatial autocorrelation coefficient is denoted as λ, σ^2_μ is the variance of the random-effects vector and σ^2_v is the variance of the error vector. Their significance implies they are needed in the model, further verifying the model's validity.

Model A was also estimated with the alternate W matrices defined earlier, and results are presented in Table 3. Lasage and Pace (2009) note there is not a formal measure to compare models with different spatial weight matrices because they are not nested models. Still, they recommend comparing the log-likelihood function values. This measure indicates the best model is when the W-matrix is specified with seven neighbors.

When comparing different W-matrix specifications the main variable of interest, ethanol production, is always statistically significant. Interestingly, the 50-mile neighbor relationship specified by McNew and Griffith returns the lowest estimate for ethanol production's impact on basis. The seven-neighbor model estimates the impact of ethanol production to be 0.0113 cents per million gallons, which equates to a 0.565 cent increase in basis for a 50 MGY plant. The five-neighbor matrix returns the largest ethanol production impact and predicts a .675 cent increase for a 50 MGY plant.

Comparison to Previous Estimates

The impact of ethanol on corn basis estimated in this study is somewhat surprising when compared to previous work. Here it is estimated a 50 MGY ethanol plant within 50 miles of a county centroid has a 0.425 cent impact on local basis, whereas others suggest the impact may be greater. In this section we validate this study's results, and provide insight into the differences between this and earlier work. This is done by comparing the model employed here with the work of McNew and Griffith (2005).

The McNew and Griffith study examined the regions surrounding 12 different ethanol plants from March 2000 to March 2003. They find that in the 150 square mile region surrounding a plant the average impact is a 5.9 cent per bushel strengthening of basis. This is several magnitudes greater than the results presented here. However, this study differs from McNew and Griffith in three important ways:

1) The time period used in the McNew and Griffith study is a sub-sample of the time period studied here. It should be noted the Midwestern average annual corn basis was continually strengthening in all markets between 2000 and 2003 (the period covered by McNew and Griffith). However, over the full sample period of this study (1999 to 2009), the average annual basis has been weakening.
2) To estimate their model, McNew and Griffith use state-level corn production, national-level corn production, monthly dummy variables, a dummy variable for ethanol production, and a sophisticated transportation variable. Differences in this analysis are the use of a corn production ratio, a different transportation cost measure, and interest rates as a proxy for storage costs.
3) The McNew and Griffith study uses locations that are within approximately 75 miles of a new ethanol plant. They specifically look at regions with new ethanol plants whereas the data set in this study contains counties with pre-existing plants, counties which gain plants during the 10 year period, and some counties that never had a plant.

To directly compare the model used in this study with that of McNew and Griffith, a sub-sample of the data was extracted. The sub-sample only includes counties from Illinois, Iowa, South Dakota, and Wisconsin because these are the states used by McNew and Griffith (they also have one observation in Missouri). Also, in keeping with McNew and Griffith's selection criteria, the sub-sample only includes counties where an ethanol plant opened between Spring 2000 and Spring 2003.

Table 4 contains the estimates of four different models used to compare the results of this study to the results of McNew and Griffith. The models run are:

- Sub-sample in Time 1 - This model is the direct comparison to McNew and Griffith.
- Sub-sample cross-section (consistent with McNew and Griffith) estimated from 1999-2009
- -Full sample in Time 1 (all 153 locations from this study estimated from 2000-2003) – This model examines whether the impacts found by McNew and Griffith hold when the model includes counties with and without an ethanol plant.
- -Full cross-section over the full time period (1999-2009).

Near the end of their paper, McNew and Griffith state they were unable to identify whether the price impacts they discovered would persist over time due to data constraints. Over half of the plants in their sample had been open for less than six months. They predicted over time the price impact of a plant might diminish as market conditions adjust to the new demand center (p. 176). Thus, they conclude their estimates are likely measures of short-term impacts and not indicative of an ethanol plant's long-term price impact. This is one of the hypotheses that can be tested by comparing the results of the models described above.

In all four models the impact of ethanol production, the main variable of interest, come back statistically significant. It should be noted that McNew and Griffith did not use a measure of storage or storage costs so it was not included here. Table 5 shows the impacts a 50 MGY ethanol production plant would have on corn basis, as estimated by each of the models.

When looking at the sub-sample in Time 1, which is designed to mimic the sample of McNew and Griffith, a basis improvement of 6.67 cents per bushel is found. This is in the range found by McNew and Griffith. They cite basis improvements ranging between 1.5 cents and 12 cents per bushelfor individual plants, with the average across the sample of 5.9 cents per bushel. The 50 MGY size used in the analysis here is larger than the average plant size used in the McNew and Griffith sample, but they indicate plant size is relatively unimportant.

It is found that when all locations are examined in Time 1, the price impact of an ethanol plant is considerably less. This could be for a variety of reasons. First, McNew and Griffith may attribute some of the strengthening of basis across all markets to ethanol production by not examining basis changes in markets with and without ethanol production. Over their sample period, ethanol production was increasing while basis was strengthening in markets both with and without ethanol plants. Perhaps not including locations without ethanol plants leads to over estimating ethanol plant impacts.

A second and more probable explanation is that the lack of price impact from local ethanol production in the full sample does not mean there is no impact; rather it may mean the price impacts from ethanol production are being spread well beyond the 50-mile region defined by the model. This means even counties without an ethanol plant within 50 miles are still receiving positive price impacts from ethanol production. Thus, when including counties in the sample without plants, the direct impact of local ethanol production is diluted as impacts are still being felt by counties further away.

Another interesting finding in Table 5 is that over time the price impact of ethanol plants seems to decrease. Examining the sub-sample, in Time 1 the impact is 6.67 cents, but over the full time period the impact of ethanol production is 0.38 cents. As suggested by McNew and Griffith (2005), it appears that the price impacts do diminish over time as market conditions evolve to meet new centers of demand. The extended sample period allows for the examination of more long-term price impacts, rather than capturing the short-term price adjustments found by McNew and Griffith. These long-term impacts are expected to be smaller, accounting for at least part of the differences between this study and previous work.

As previously noted, McNew and Griffith do not account for storage opportunity costs whereas this study takes them into account. The four models were re-run, this time including the interest rate and the results are in Table 6.

Again the price impacts of a 50 MGY ethanol plant are calculated and can be found in Table 7. When accounting for storage opportunity costs the impact of ethanol production in the sub-sample during Time 1 decreases from 6.67 cents to 1.94 cents. This may indicate that an unaccounted for factor played an important role in predicting basis, and its absence resulted in an over-estimation of the price impacts in earlier work. The difference between estimations in the sub-sample and the full sample remains and it is believed that this variation is still a result of the factors described above.

Conclusions

The impact on local corn prices associated with having an ethanol production plant within 50 miles was estimated to be a 0.40 cent per bushel basis improvement. It was determined that the long-term price impact of ethanol production is considerably less than the impact found in the short-run. The data was able to closely replicate short-term findings of previous work, but over time the impacts were found to decrease.

Transportation costs are one of the driving forces in determining basis and in this study they were modeled using the proxy of Midwest monthly average diesel price to capture the variation in cost over time. However, transportation costs also vary over space so some measure of distance to a terminal grain market may be useful. The depth of the McNew and Griffith (2005) data set allowed them to account for the specific distance grain travels, but this analysis only partially accounts for differences over space by using state-level dummy variables. Including a specific transportation distance to terminal market variables may allow for a more complete analysis of specific price impacts.

Another interesting extension of the current research would be to narrow the scope of the research to investigate the impacts of ethanol in particular regions. McNew and Griffith were able to show a wide range of impacts depending on the plant, so it would be useful to see if that is also true longer-term. It is likely that the impacts of ethanol production on corn basis are greater in corn deficit areas.

It cannot be denied that the use of corn in ethanol production has drastically impacted grain markets. Today almost 40 percent of the nation's corn goes into ethanol production and increased demand has been shown to be partially responsible for the price run-up in 2007-08. However this study finds that at the most local level, between Fall 1999 and Summer 2009, the mere presence of ethanol production within 50 miles is not likely to induce a large long-term shift in corn basis.

Figure 1. Counties with Corn Price Observations

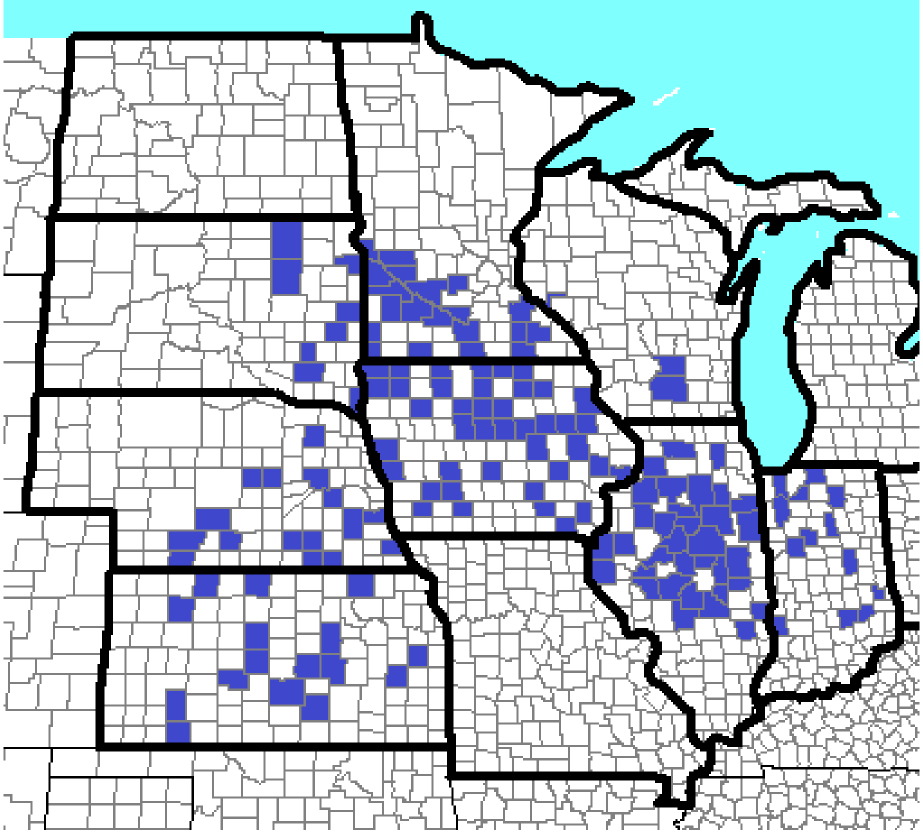

Figure 2. Counties with Ethanol Plants

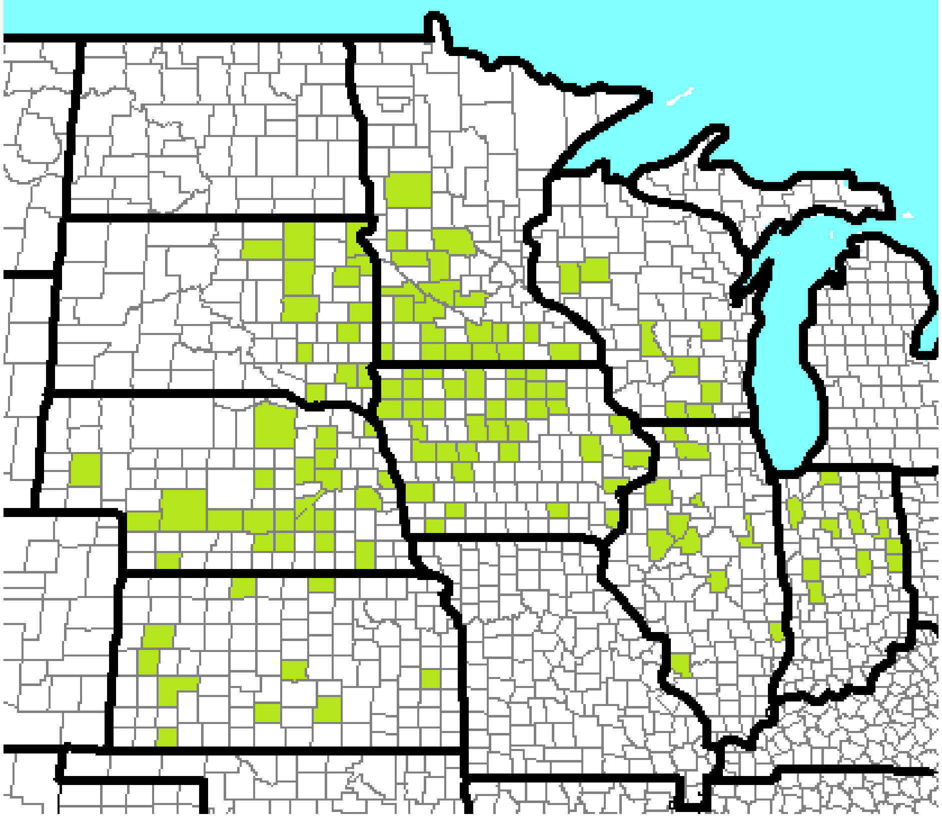

Table 1. Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
Basis (cents)	-28.14	14.52	-92	16
Local Corn Production (million bushels)	227.28	109.11	7	544
Ethanol (MGY)	136.32	155.49	0	1026
Midwest Diesel Price (cents)	211.46	80.86	115.40	434.20
National Corn Production (billion bushels)	10.65	1.26	8.97	13.04
Production Ratio	2.14	0.99	0.07	4.34
Local Stocks (million bushels)	155.03	92.38	2.51	543.99
National Stocks (billion bushels)	5.10	2.79	0.96	10.28
Stocks Ratio	3.71	2.35	0.08	13.70
Interest Rate	6.12	1.95	3.25	9.50

Table 2. Alternative Specifications

	Model A	Model B	Model C	Model D	Model E	Model F
Intercept	20.32 **	4.18	5.99	0.93	20.78 **	21.64 **
Prod Ratio	-1.29 *		-1.11	-1.18 *	-1.22 *	-1.29 *
Stocks Ratio		-2.20 *				
Diesel	-0.10 **	-0.11 **	-0.12 **		-0.11 **	-0.09 **
Ethanol	0.0085 **	0.0084 **	0.0083 **	0.0083 **	0.0084 **	0.0085 **
Interest	-2.16 **	-2.19 **		-2.40 **	-2.23 **	-2.27 **
Futures						-0.01
Illinois	-6.46 **	6.20 **	-6.88 **	-6.60 **	-6.65 **	-6.46 **
Iowa	-13.12 **	12.89 **	-11.03 **	-13.02 **	-12.45 **	-13.12 **
Kansas	-7.48 *	3.98	-6.88	-7.39 *	-7.36 *	-7.49 *
Minnesota	-19.72 **	-6.42 **	-17.21 **	-19.55 **	-18.90 **	-19.73 **
Nebraska	-8.36 *	4.53	-6.20	-8.16 **	-7.60 *	-8.37 **
South Dakota	-22.10 **	-8.83 **	-19.55 **	-21.85 **	-21.27 **	-22.11 **
Wisconsin	-24.35 **	-11.00 **	-22.98 **	-24.24 **	-24.04 **	-24.35 **
Fall	-2.39	2.39	3.13	-3.24		-2.68
Spring	2.25	5.52	6.37	-0.11		2.18
Summer	-1.38	2.97	2.17	-4.61 *		-1.74
σ_v^2	11.66 **	11.65 **	11.64 **	11.84 **	11.65 **	11.66 **
σ_μ^2	17.91 **	17.83 **	16.76 **	17.71 **	17.43 **	17.92 **
λ	0.95 **	0.95 **	0.96 **	0.95 **	0.95 **	0.98 **
Likelihood	-18447.8	-18464.7	-18682.2	-18511.2	-18533.4	-18446.5
Parameters	15	15	14	14	12	16
AIC	36926	36959	37392	37050	37091	36925
BIC	36898	36932	37367	37025	37069	36896
	***Notes significance at the five percent level** ****Notes significance at the one percent level**					

Table 3. Spatial Weight Variations

	50-Miles		Contiguous		N=5		N=7		N=10	
Intercept	20.32	**	11.15	**	20.28	**	13.74	*	24.83	
Prod Ratio	-1.29	*	-2.20	**	-3.18	**	-3.30	**	-2.96	**
Diesel	-0.10	**	-0.08	**	-0.10	**	-0.08	**	-0.07	
Ethanol	0.0085	**	0.0110	**	0.0135	**	0.0113	**	0.0120	**
Interest	-2.16	**	-1.86	**	-2.69	**	-3.17	**	-5.90	**
Illinois	-6.46	**	-3.75		-4.48	*	-0.0004		-4.07	*
Iowa	-13.12	**	-11.02	**	-9.44	**	-4.70	**	-2.51	
Kansas	-7.48	*	-5.87		-6.56	**	-0.02	**	3.02	
Minnesota	-19.72	**	-17.81	**	-17.00	**	-12.17	**	-8.59	**
Nebraska	-8.36	*	-10.27	**	-10.37	**	-4.15	*	-1.61	
South Dakota	-22.10	**	-22.07	**	-21.65	**	-16.76	**	-12.61	**
Wisconsin	-24.35	**	-18.42	**	-19.27	**	-15.99	**	-15.86	**
Fall	-2.39		1.58		2.01		3.07		0.03	
Spring	2.25		2.12		6.16	**	6.85	*	10.45	
Summer	-1.38		-0.52		3.95		5.59		16.51	
σ_v^2	11.66	**	13.51	**	12.88	**	12.82	**	13.36	**
σ_μ^2	17.91	**	26.43	**	26.11	**	27.36	**	25.92	**
λ	0.95	**	0.97	**	0.96	**	0.96	**	0.99	**
Likelihood Value	-18447		-17902		-17808		-17579		-17627	

***Notes significance at the five percent level**
****Notes significance at the one percent level**
T-values have been omitted from this table

Table 4. Compare Full Sample and Sub-Sample Estimates

		Fall 1999 - Summer 2003 (Time 1)	**Fall 1999 - Summer 2009 (Full Time)**
Sub-sample (N=22)	Intercept	-38.1568 ** (-6.10)	-13.6663 ** (-2.64)
	Production Ratio	0.21435 (0.20)	-3.97666 ** (-2.59)
	Diesel	-0.01474 (-0.38)	-0.06996 ** (-10.31)
	Ethanol	0.13347 ** (11.51)	0.00751 * (2.47)
	Illinois	15.36167 ** (4.32)	11.66646 * (2.38)
	South Dakota	-5.22206 (-1.75)	-7.41843 * (-2.10)
	Wisconsin	9.37036 * (2.00)	1.43494 (0.28)
	Winter	4.08061 ** (3.36)	2.22307 (1.58)
	Spring	4.42004 ** (3.62)	4.46042 ** (3.16)
	Summer	-0.99808 (-0.81)	3.37015* * (2.39)
	σ_v^2	17.24287 ** (12.85)	23.62253 ** (20.89)
	σ_μ^2	16.57584 ** (3.00)	11.30683 ** (2.90)
	λ	0.56 * (2.30)	0.86 ** (5.48)

Table 4 Continued

		Fall 1999 - Summer 2003 (Time 1)		**Fall 1999 - Summer 2009 (Full Time)**	
Full Sample (N =153)	Intercept	-15.8176 (-2.02)	*	5.994 (1.08)	
	Production Ratio	-1.59076 (-2.74)	**	-1.10714 (-1.92)	
	Diesel	0.02141 (0.43)		-0.12284 (-7.95)	**
	Ethanol	0.00779 (2.38)	*	0.00833 (7.43)	**
	Illinois	-5.61763 (-2.56)	*	-6.87933 (-2.77)	**
	Iowa	-14.2573 (-5.94)	**	-11.0317 (-3.49)	**
	Kansas	-7.04125 (-2.31)	*	-6.87786 (-1.42)	
	Minnesota	-21.7964 (-8.49)	**	-17.2101 (-5.07)	**
	Nebraska	-8.54345 (-2.87)	**	-6.19979 (-1.29)	
	South Dakota	-25.5823 (-8.50)	**	-19.5501 (-5.20)	**
	Wisconsin	-21.5224 (-4.94)	**	-22.9762 (-4.62)	**
	Fall	3.626 (2.17)	*	3.12733 (0.95)	
	Spring	5.30165 (5.30)	**	6.36547 (1.78)	
	Summer	0.00749 (0.25)		2.16525 (0.85)	
	σ_v^2	5.4353 (33.80)	**	11.64203 (54.61)	**
	σ_μ^2	18.24325 (7.45)	**	16.75687 (7.51)	**
	λ	0.93 (21.05)	**	0.96 (29.23)	**
	* Notes significance at the five percent level **Notes significance at the one percent level T-values reported in parentheses				

Table 5. Ethanol Impacts

Ethanol Impact on Basis	**Time 1**	**Full Time**
Sub-Sample	6.67	0.38
Full Sample	0.39	0.42

Table 6. Compare Full Sample and Sub-Sample Estimates with Interest

		Fall 1999 - Summer 2003	**Fall 1999 - Summer 2009 (Full)**
Sub-sample (N=22)	Intercept	-37.01 ** (-9.56)	-1.45 (-0.37)
	Production Ratio	-1.77 (-1.86)	-2.95 ** (-2.56)
	Diesel	0.21 ** (8.11)	-0.061 ** (-10.99)
	Ethanol	0.0388 ** (4.16)	0.0064 ** (2.40)
	Interest	-3.48 ** (-21.04)	-2.64 ** (-13.88)
	Illinois	15.26 ** (5.27)	11.33 ** (3.97)
	South Dakota	-7.43 ** (-2.91)	-7.11 ** (-2.69)
	Wisconsin	5.56 (1.33)	3.00 (0.76)
	Winter	2.95 ** (4.27)	2.72 ** (2.75)
	Spring	2.82 ** (4.05)	3.53 ** (3.55)
	Summer	-3.67 ** (-5.19)	0.68 (0.67)
	σ_v^2	9.02 ** (12.85)	24.53 ** (20.73)
	σ_μ^2	13.28 ** (3.19)	10.01 ** (3.08)
	λ	0.38 ** (1.31)	0.61 ** (2.42)

Table 6 Continued

		Fall 1999 - Summer 2003	Fall 1999 - Summer 2009 (Full)
Full Sample (N =153)	Intercept	-16.15 * (-2.58)	20.32 ** (4.67)
	Production Ratio	-1.88 ** (-3.26)	-1.29 * (-2.30)
	Diesel	0.240 ** (5.43)	-0.105 ** (-9.80)
	Ethanol	0.0075 * (2.29)	0.0085 ** (7.65)
	Interest	-4.19 ** (-17.53)	-2.16 ** (-4.85)
	Illinois	-4.74 * (-2.37)	-6.46 ** (-2.87)
	Iowa	-14.67 ** (-7.10)	-13.12 ** (-5.06)
	Kansas	-6.96 ** (-2.64)	-7.48 * (-2.24)
	Minnesota	-23.06 ** (-10.27)	-19.72 ** (-7.12)
	Nebraska	-9.83 ** (-3.93)	-8.36 * (-2.53)
	South Dakota	-27.33 ** (-10.10)	-22.10 ** (-6.97)
	Wisconsin	-21.34 ** (-5.38)	-24.35 ** (-5.33)
	Fall	1.95 (1.36)	-2.39 (-1.05)
	Spring	2.52 (1.83)	2.25 (1.05)
	Summer	-3.30 * (-2.40)	-1.38 (-0.93)
	σ_v^2	5.11 ** (33.75)	11.66 ** (54.59)
	σ_μ^2	20.45 ** (7.60)	17.91 ** (7.43)
	λ	0.90 ** (7.60)	0.95 ** (22.18)
	* Notes significance at the five percent level **Notes significance at the one percent level T-values reported in parentheses		

Table 7. Ethanol Impacts with Interest

Ethanol Impact (with Interest)	Time 1	Full Time
Sub-Sample	1.94	0.32
Full Sample	0.38	0.43

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Foot Notes

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[1] Fortenbery et al. did not look directly at land values due to data limitations. Instead, as a proxy for land values, they examined the rate at which agricultural land was converted to other uses. They found that communities with ethanol plants did not experience a reduced rate of land leaving agriculture relative to communities without an ethanol plant. They thus concluded that the existence of an ethanol plant was not sufficient to increase the opportunity cost of land leaving agriculture to the point that exit rates were reduced.

[2] A weaker basis implies cash corn price is reduced relative to the futures price. Conversely, a stronger basis implies cash price has increased relative to futures.

[3] This is assumed to be the approximate drawing range for a 50 million gallon a year ethanol plant in a corn producing area.