Ethanol Plant vs. Local Elevator: What is the Value to Nebraska Corn Producers?

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1. Introduction

Since the millennium, few sectors in the U.S. have seen the substantial growth that is evident in its agricultural sector. And within that, there may not be an agricultural industry that has grown as quickly and robustly as the ethanol industry. Driven by aspirations of becoming less dependent on foreign oil while also limiting transportation-based emissions, Congress authorized the creation of the Renewable Fuels Standard (RFS) through the passing of the Energy Policy Act of 2005. Since that time, ethanol has served as the primary biofuel accomplishing their vision, becoming a staple in the nation's gasoline supply. Since the authorization of RFS, ethanol production has grown from less than 4 billion gallons per year to 15.8 billion gallons in 2019 (U.S. Energy Information Administration).

With corn being the primary feedstock in ethanol production, America's corn growers stood to substantially benefit from the new policy. Prior to the Energy Policy Act of 2005, corn producers selling their grain faced a choice of deciding which nearby grain elevator to deliver to. Then, amid ethanol's rapid expansion, the corn market landscape was altered by the introduction of a new demand center, the ethanol plant. With ethanol plants exhibiting greater demand and having capacity advantages over the typical grain elevator, more competitive prices were offered, and surrounding producers now had a more complex decision environment – sell to the local elevator or the ethanol plant.

The choice is not one to be taken lightly: delivery destination can have a substantial impact on the farmer's net income. The entire revenue stream of the corn grower is dependent on the prices they receive from the grain buyer. With prices varying between buyers, occasionally greatly, the survival of the operation and the ability to pass it on to future generations can very much depend on where the sale is made. Thus, the corn grower must consider the benefits and costs of delivering their grain to each nearby buyer. While case-specific benefits and costs such as relations with buyer, cost of time, and discount schedules should be weighed in individually, producers interested in achieving a higher net price for their crop should focus on two items specific to each grain buyer: posted grain bid and transportation cost.

In terms of the net price received by the corn grower, grain buyer bids serve as the revenue piece. The grain bids seen by the farmer tend to vary from one buyer to the next. Ethanol plants typically offer higher prices than grain elevators, while those grain elevators holding storage capacity and/or rail advantages may hold a price advantage over elevators without the same capabilities. Of course, this doesn't mean grain should always be sold to the ethanol plant. Growers must also consider the cost piece of their net price: transportation cost. Transportation cost is specific to each producer's operation – the more miles it is to deliver to the grain buyer, the higher the transportation cost. As a result, producers located closer to a grain buyer can achieve a net price closer to the posted bid, while those located a greater distance away achieve a lower net price. As it stands, grain elevators are much more densely located throughout the Midwest than ethanol plants, and many producers must travel more miles in order to deliver their grain to an ethanol plant than to a nearby grain elevator.

With the competing advantages – the price advantage of the ethanol plant and the transportation cost advantage of the grain elevator – the extent to which a local producer benefits from ethanol facilities is unclear. Producers close to the plant and those located farther away may both receive the highest price delivering to the ethanol plant, but they will not achieve the same net price. Thus, the benefit that ethanol production provides is not the same for any two operations. It is dependent on the offered prices at local grain elevators and ethanol plant, and the operation's location, affecting its transportation cost to deliver to those locations.

In this study, we seek to observe the value ethanol production brings to the corn grower on a location-by-location basis. By considering sample farm locations in varying proximity to grain elevator and ethanol plant, one can get a better grasp of how the value changes across space, and thus, how producers in different locations derive different values from ethanol production. This will become evident by comparing net price achieved through sale to an ethanol plant against the net price achieved through sale to grain elevators. In addition, we hope to discover how the value attributed by corn growers changes by season and across different production years. Ethanol plants operate continuously and have steady demand for corn, while demand at grain elevators may fluctuate according to their storage availability and terminal market demand. As a result, the prices offered between the two demand centers will diverge and converge across time. As the spread between these bids changes, so too will the amount of benefit corn growers attribute to ethanol production.

The objective of this study is to examine the impact local ethanol production has on net farm price for the diversely-located corn grower. To achieve our objective, we first expand upon the spatial equilibrium model developed in McNew and Griffith (2005), demonstrating how price observed is dependent on location within a spatial system featuring multiple demand centers. We then consider multiple periods of observed buyer basis postings and estimated transportation costs within Nebraska, the nation's second leading ethanol producer. We estimate net price on the farm for both ethanol plant and elevator locations for numerous different farm locations. The difference between the net price received at the ethanol plant and the net price received from a grain elevator is the value derived from ethanol production for any one producer. By comparing this value across multiple periods, one can see how even one producer attributes different values to ethanol across and throughout the years.

2. **Literature Review**

With the rapid of expansion of the ethanol industry in the last two decades being a major source of market disruption, many studies have attempted to measure the size of its impact. Several have focused on ethanol's influence on associated markets and the economy as a whole. Studies such as Brooks et. al (2019) conduct economic impact assessments to measure ethanol's impact on a region's economy in terms of employment, labor income, and total output. Lewis and Tonsor (2011) studied ethanol expansion's impact on spatial corn market relationships, determining the increase in ethanol production and number of ethanol plants to have no significant impact on those existing relationships. For the purpose of this project, the focus will remain on the link between ethanol production and corn price.

Corn price in any location is a function of two aspects: national corn price and local basis. The national corn price reflects U.S. supply and demand conditions, while grain buyers adjust basis postings to reflect local supply and demand conditions. Babcock and Fabiosa (2011) and Fortenbery and Park (2008) each study ethanol's impact on national corn price, with the former separating the per bushel effect by government subsidies and natural expansion, and the latter estimating short run corn price elasticity to be 0.16, indicating a 1% increase in ethanol production leads to a 0.16% increase in corn price.

Of greater relation to this study, several works look into ethanol production's impact on local corn prices (i.e. local corn basis). Olson et al. (2007) considered the impact of ethanol's expansion, as well as the potential impact from an ethanol plant's entry to a local market in the state of South Dakota. Using an OLS regression model, the authors estimated a positive $0.24 corn basis impact from ethanol production. In addition, the introduction of a 40 MGY ethanol plant would result in a $0.06 – $0.16 improvement in local basis and a $0.03 basis improvement for the state as a whole. Behnke and Fortenbery (2011), on the other hand, consider five primary factors that impact corn basis: local vs. national corn production ratio, transportation cost, storage costs, seasonality, and local ethanol production. Estimating a spatial error components model, coefficients for each of the five factors were estimated, and local ethanol production was found to have a negligent impact on corn basis. McNew and Griffith (2005) study corn price impacts associated with the establishment of a new ethanol plant to a local market using a spatial equilibrium model. Notably, the authors observed an average basis increase of $0.059 in an ethanol plant's region, with prices found to be $0.125 higher at the ethanol plant's location following its introduction.

3. Model

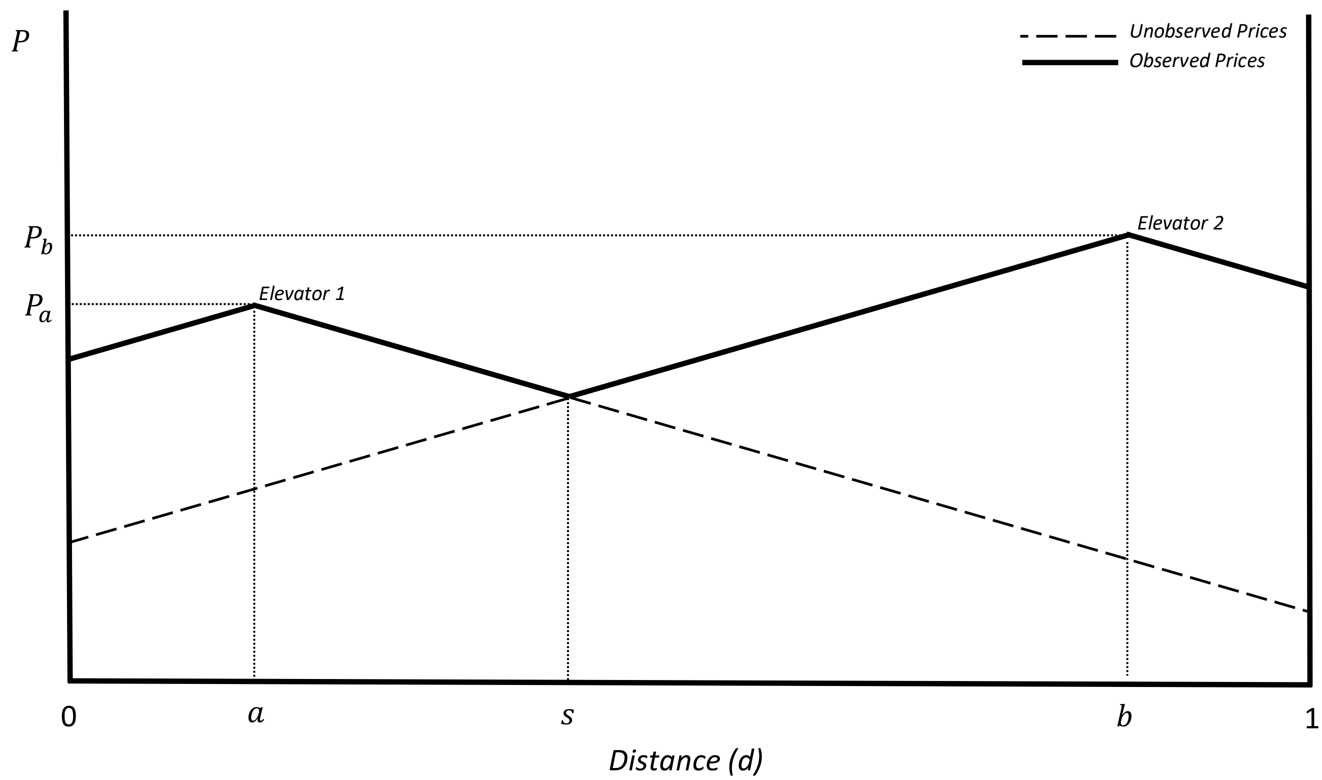
To estimate ethanol's impact on the corn producer differentiated by location, our model first builds upon the spatial equilibrium model developed in McNew and Griffith (2005).[1] The U.S. grain distribution system relies on growers, elevators, and transportation networks to move grain from production regions to domestic and overseas markets (McNew and Griffith 2005). In their introductory model, the authors assume grain producers to be distributed along a line segment $d \in [0,1]$, with all grain in the region being delivered to a terminal market located $d = 1$. The terminal market offers price P_T, and all locations upstream from this terminal market are associated with a lesser price, a price that is inversely proportional to the distance away from the terminal market, due to the role of transportation costs.

In this setup, original grain trade patterns and prices may be impacted by shocks to demand and transportation costs. The introduction of an ethanol plant E represents one possible demand shock to a local market – one that can have a substantial impact on transportation costs observed by producers. Through entry, the ethanol plant can offer a better net price than the terminal market to surrounding producers due to transportation cost savings. The terminal market, now receiving less grain, responds by raising their prices to incentivize delivery among locations now delivering to the ethanol plant. As a result, a new spatial equilibrium is established, and a spatial boundary between the two demand centers is created. At this spatial boundary, net price is equivalent between the two markets. Producers located on the ethanol plant's side receive a higher net price from the plant, while those on the opposing side of the boundary obtain a better net price from the terminal market.

Now, in this McNew and Griffith (2005) spatial model, the impact of the ethanol plant is felt to a varying degree among different farm locations around the plant. Those locations on the wayside of the ethanol plant ($d < E < 1$) all experience the highest transportation cost savings from no longer having to deliver all the way to the terminal market. As a result, producers in this area will obtain the most benefit from the ethanol plant's existence. For those producers located between the ethanol plant and terminal market ($E < d < 1$), benefit decreases as the distance from the plant increases, as the transportation cost savings become comparably lesser. Ethanol's benefit to the producer eventually reaches zero at the spatial boundary. However, those producers receiving a better net price from the terminal market still attribute a positive value to ethanol production, as the terminal market's price increase allows these producers to obtain a higher price than prior to the ethanol plant's entry. Thus, all producers within an ethanol plant's scope of influence derive a positive, unique value from ethanol production.

To investigate the degree to which ethanol production provides value to individual corn growers, we expand on the McNew and Griffith (2005) model, increasing relevancy by considering *two* initial demand sources prior to the ethanol plant's entry. Thus, our model starts with two demand centers: Grain Elevator a and Grain Elevator b. In a closed system, each elevator is situated along a line segment d, with their reach of acquiring grain extending to the end points $d \in [0,1]$. Corn producers supplying the grain to elevators are assumed to be uniformly distributed along this line segment, situated at location d. Figure 3 portrays this two-elevator demand system graphically.

Figure 1, Two-Elevator Spatial Demand System

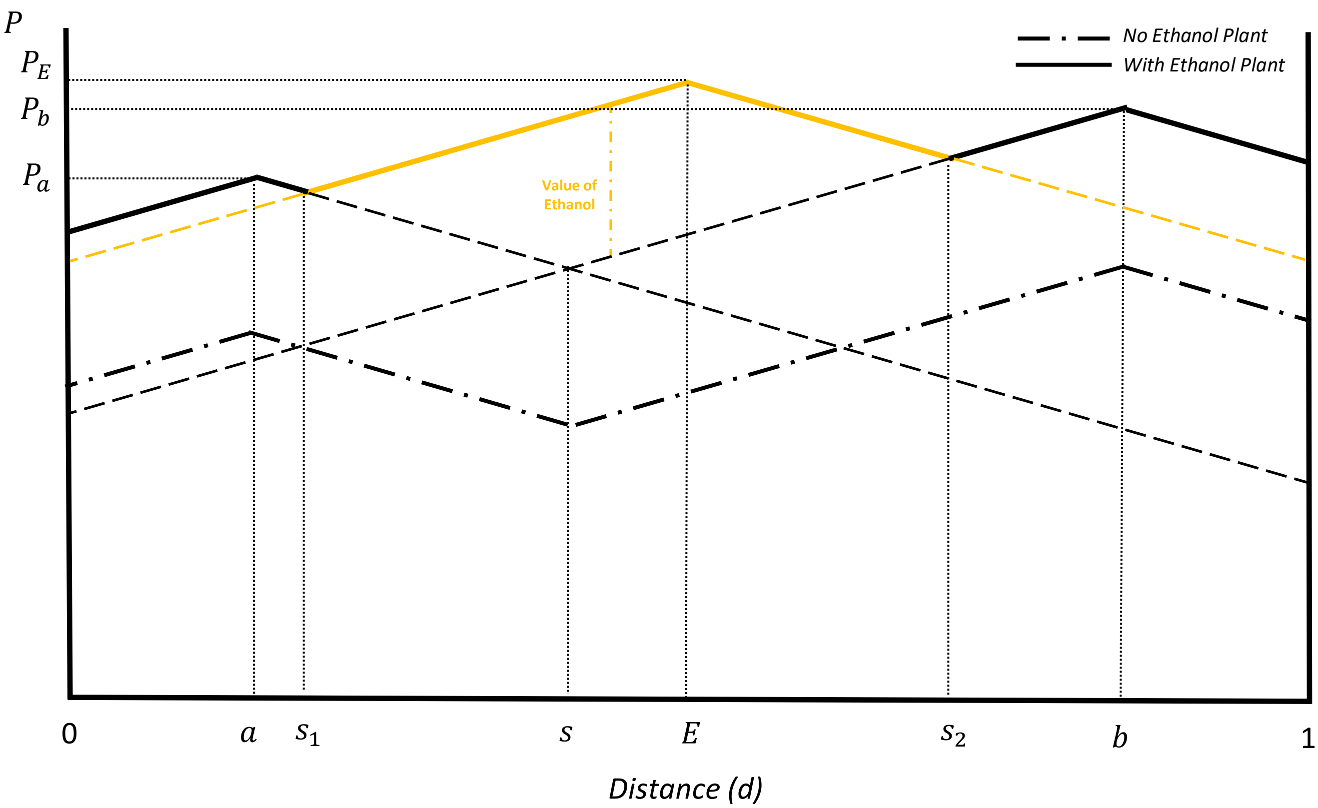


Each grain elevator has their respective location along the line segment, a and b, and offer price P_i, which is equal to their posted bid at the location of the facility.[2] As one moves along the line segment away from the elevators in either direction, this price slopes downward, as transportation costs create lower net prices in more remote locations. Thus, two unique prices P_{d_a} and P_{d_b} are available at each unique location d, with the difference between the posted bid

P_i and the price specific to that location P_{d_i} being equal to the cost of transportation. The price that is observed at any farm location, P_d, is the highest net price from the two grain buyers. All producers along the line segment receive a better net price by delivering to one of the two elevators, with the exception of those located at spatial boundary s, who receive equivalent net prices at each elevator and are indifferent in where delivery is made. With producers interested in selling and delivering to the location where they achieve the best net price, those growers located $[0, s]$ deliver their grain to Elevator a and travel $|d - a|$, while those located $(s, 1]$ deliver to Elevator b and travel $|d - b|$. As location 0 and location 1 represent the grain sourcing boundaries for each elevator, it is assumed any producer located to the left of location 0 and to the right of location 1 would achieve a higher net price from a grain buyer outside this two-elevator demand system.

Now, assume an ethanol plant also exists along the line segment at a location between the original two elevators ($a < E < b$). Due to its capacity advantages and greater demand, the ethanol plant offers a higher price than the elevators, P_E, and captures a portion of the bushels previously delivered to Elevator a and b under the two-elevator demand system. As in McNew and Griffith's (2005) model, increased competition for bushels translates into higher prices offered by competing grain buyers. In this case, the grain elevators offer higher prices with the presence of the ethanol plant than in the original two-elevator demand system, to attract a portion of the bushels that would otherwise be delivered to the ethanol plant. Figure 4 illustrates the existence of an ethanol plant within the original two-elevator demand system, where $P_a < P_b < P_E$ and E is located equidistantly between the two grain elevators[3].

Figure 2, Two Elevator, One Ethanol Plant Spatial Demand System



Under this new demand system, a new spatial equilibrium is established. With the ethanol plant now included, new unique net prices P_d are available along line segment d. In addition, two spatial boundaries, s_1 and s_2, are created, and producers located between these boundaries now achieve the highest net price by delivering to the ethanol plant. Those producers located outside (s_1, s_2) receive higher net prices from their respective elevators but still benefit indirectly from the overall higher prices within the demand system. As was the case for those located at spatial boundary s in the original demand system, producers located at s_1 and s_2 receive equivalent net prices at their respective elevator and the ethanol plant and are indifferent between which delivery is made. In short, Elevator a will source all grain along $[0, s_1]$, ethanol plant E sources all grain along (s_1, s_2), and Elevator b sources all grain along $[s_2, 1]$. In terms of grain transportation, producers located $(0 \leq d \leq s_1)$ will travel $|d - a|$ to deliver their grain. Producers located $(s_1 < d < s_2)$ will travel $|d - E|$, and those located $(s_2 \leq d \leq 1)$ will travel $|d - b|$.

All producers are better off in this scenario, achieving higher net prices from the increased competition in the region. However, producers attaining the highest net price at the ethanol plant achieve an additional value because of the higher offered prices and/or reduced transportation costs. This value is evident in the difference between net price received at the ethanol plant versus net price received at grain elevator. The difference between these net prices can be attributed as the value of ethanol production to the grain producer.

For those farms located outside the spatial boundaries, the value provided by ethanol is inherently zero in this model. The true value is greater than zero, as the heightened price competition in the region from the sheer existence of the ethanol plant provides an unobserved value to farms located outside of spatial boundaries s_1 and s_2. However, for those farms located between spatial boundaries s_1 and s_2, the value provided by ethanol is positive. As one can see in Figure 4, that value is unique to each operation. It is dependent on the farm's proximity to the elevators and the ethanol plant, as well as the strength of each grain buyer's bid.

In the case of Figure 4, the value derived from ethanol between s_1 and s_2 is different for locations on each side of the plant. The ethanol plant's value is comparably greater for farms located to the left of E than those located the same distance from the plant to the right. In addition, the value from the ethanol plant extends over a greater distance towards Elevator a than to Elevator b. This has to do with the positioning of the ethanol plant in accordance with the original spatial boundary s, which is created according to the price offerings of the two elevators.

Let's consider individual scenarios for each producer location. Producers located $[s, E]$ all derive the exact same value from ethanol production. These locations are better off delivering to the Elevator b than Elevator a. In addition, the ethanol plant is located enroute to Elevator b. As a result, all producers in this range enjoy the exact same transportation cost reduction by making delivery to the ethanol plant over the elevator. So, although locations closer to s receive a comparatively lower net price, the value that ethanol production adds to these farms is the same for each.

For producers receiving a positive value from ethanol production, those located $[s_1, s]$ and $[E, s_2]$, the value derived decreases as one moves away from the ethanol plant E. In both cases, farms haul their grain back to the ethanol plant, against the natural flow of grain that would occur if the ethanol plant ceased to exist. These producers do not receive the full transportation cost savings of those farms located $[s, E]$, and thus, derive less value from ethanol production.

Those farms located directly at and outside of spatial boundaries s_1 and s_2 do not receive value from delivering to the ethanol plant. Those located at the spatial boundaries receive equivalent prices between elevator and ethanol plant, and those outside the boundaries receive a better net price by delivering to their nearby elevators. As a result, these locations do not derive a direct benefit from ethanol production. However, the increased price competition resulting from the ethanol plant's existence allows these producers to achieve a higher net price than if the ethanol plant ceased to exist, creating an indirect benefit that is enjoyed equally by all locations along the line segment. However, for the case where an ethanol plant is assumed to already exist within a region, as it is within the scope of this project, this indirect benefit is unobservable. Instead, the focus will remain on observing the net price difference between ethanol plant and elevator as it stands in present time, thereby discerning the heterogeneous producer's current attributed value to ethanol production.

4. Approach

The price producers receive for their grain is a function of the grain buyer's price offering and the cost of shipping grain to the buyer (McNew and Griffith 2005). Assuming all grain is shipped to a single terminal market located at $d = 1$ (Figure 1), the price at any location d can be represented by:

(1) $$P(d) = P_T - r(1 - d)$$

where P_T is the offered price at the terminal market and r is the per unit cost of shipping. In full, $r(1 - d)$ represents the cost of shipping grain from any location d to the terminal market, located at $d = 1$.

Modifying this by considering n demand centers located at unique locations along the line segment, the price at any location d can be represented by:

(2) $$P(d)_n = P_i - r|i - d|$$

where i represents the location of the specified grain buyer along the line segment. As locations on either side of a grain buyer may make delivery in this scenario, d may be greater than i. Thus, cost of shipping grain from any location d to market i is represented by $r|i - d|$.

Consider a scenario similar to the spatial demand system laid out in Figure 4, in which corn growers have the option of delivering to two grain elevators (a and b) and an ethanol plant (E), but now also have an additional third grain elevator c to consider[4]. Under this scenario, four different prices are available at any location d, one for each combination of price received and cost of shipping associated with each grain buyer.

(3) $$P(d)_a = P_a - r|a - d|$$

(4) $$P(d)_b = P_b - r|b - d|$$

(5) $$P(d)_c = P_c - r|c - d|$$

(6) $$P(d)_E = P_E - r|E - d|$$

With corn growers interested in achieving the best price for their grain, only the highest price among these is observed at any location along the line segment. Thus, each location along the line segment is associated with a price from exactly one grain buyer, with the only exceptions occurring at $n - 1$ spatial boundaries, where the price available between two buyers converge. At these locations, offered price less shipping cost is equivalent between two grain buyers, and grain sellers are indifferent between shipping to one buyer over the other (s_1 and s_2 in Figure 4).

We derive an estimate for the value of ethanol production at any farm location d by finding the difference between $P(d)_E$ and max $[P(d)_a, P(d)_b, P(d)_c]$. This is the difference between the price farm location d receives at the ethanol plant and that of the best-priced elevator. It is this difference that we are interested in calculating – the value of ethanol production at any farm location d.

To understand the value of ethanol across time and space, we consider multiple ethanol plant regions under different time frames. We seek to observe this value based on actual grain buyer bids and transportation cost estimates using sample farm locations. Based on the layout of ethanol and grain elevator sites, farm locations derive a unique value from ethanol production specific to the grain bids and transportation cost faced in that location. The following paragraphs detail the process by which these values, the premiums farm locations receive from an ethanol plant over a grain elevator, are observed.

In total, this study focuses on six "regions" across the state of Nebraska where ethanol plants exist. The ethanol plants vary in production capacity and location within the state. The sites include: Columbus, Fairmont, Plainview, Ravenna, Cambridge, and Madrid. Due to the differences in location and capacity among the plants, they vary in price competitiveness in relation to competing grain buyers. An ethanol plant offering more competitive prices will provide more value to local corn growers over a greater distance. Thus, the level of value farm locations derive from ethanol production will vary from one region to the next.

Within each region, three accompanying grain elevators are chosen to represent competing grain buyers within range of the ethanol plant. The three grain elevators vary in location relative to the plant, as well as in terms of rail access and loading capacity. Grain elevators with superior rail access and loading capacities are more efficient and characteristically offer more competitive grain bids. In total, with the six ethanol regions, eighteen grain elevators are considered in this study.

For each of the three grain elevators within a region, four sample GPS coordinates were chosen to serve as farm locations. The farm locations allow us to estimate ethanol's value to those specific locations. The method for choosing the four sample farm locations is the same for each grain elevator location. In that, each sample farm location chosen is in proportional distance to the ethanol plant and its associated grain elevator. The four farm location conditions are as follows: 1) near the ethanol plant, 2) in between ethanol plant and grain elevator, 3) near the grain elevator, and 4) located beyond the grain elevator. Additional details regarding these conditions can be found in the data section. With four farm locations associated with each grain elevator, a total of seventy-two farm locations are under scope in this study.

For each farm location, four unique prices are available, one associated with each grain buyer in the region. Actual grain bids and projected transportation costs for each grain buyer can be used to estimate these farm prices. To understand how ethanol value changes across time, the four prices available to any one farm location were estimated at the three distinct times of the year: mid-fall, late-spring, and mid-summer. Grain bids among the four buyers were observed and transportation costs estimated for each time frame to arrive at a farm price associated with each grain buyer. This was repeated for the years of 2009 to 2021 to obtain a larger sample size and further understand how the value of ethanol production changes across time.

Ethanol's value for each farm location was observed by finding the difference between the farm's price at the ethanol plant and the farm's price at the highest-priced grain elevator for each time frame over the years considered. Each farm location receiving the best price at the ethanol plant derives a positive value from ethanol production, with the difference between this price and the price received at the "next-best" grain buyer being the quantifiable value derived. Across thirteen years and three time frames within each year, thirty-nine ethanol value observations were obtained for each farm location.

5. **Data**

This section examines the origins of the various data used throughout this work. The scope of this study takes place in Nebraska, the nation's second-leading ethanol producer, third-leading corn producer, and a relevant site for this study focusing on the link between ethanol production and corn price on the farm. Net farm price is comprised of the grain bid and the transportation cost, with all figures expressed on a dollars per bushel basis. Bid postings from grain elevators and ethanol plants within Nebraska are used, while transportation costs are based on rental truck rates. Based on data limitations, the range of this study takes course over thirteen years, from 2009-2021.

The corn price data was obtained from DTN, an agricultural company specializing in data delivery and analysis. The data contains daily price postings for 325 grain merchants located across the state of Nebraska. Specifically, cash price and basis postings were collected for both the spot and new crop markets, with spot bids representing present-day delivery and new crop bids indicative of harvest delivery. Corn bids from each of the six selected ethanol plants, as well as a total of eighteen elevator locations (three locations for each ethanol region), were used for analysis. Ethanol plants were chosen based on variation in capacity and location. Elevators were chosen based on corn basis bid competitiveness, location relative to the ethanol plant, location relative to other grain elevators, company ownership, rail access (or lack thereof), and train-car capacity. This price data provides four net price figures for each farm: one associated with delivery to the ethanol plant and the others associated with delivery to each of the three grain elevators in the region.

Rather than using corn price from any one day, corn price averages were calculated based on two-week windows to provide a less biased figure. For our analysis, two-week corn price averages were observed at three distinct time frames during the year. The three time frames are: mid-summer, mid-fall, and late-spring. Observing corn prices at different times of the year allows for the ability to understand how ethanol's value to corn growers shifts across the growing season.

The mid-fall time frame is included to consider harvest-time price conditions. Nearly all corn growers deliver and sell at least a portion of their grain directly from the field. Thus, the mid-fall time frame is one of interest to the farmer. The two-week time window for mid-fall is chosen based on estimates in the USDA's Crop Progress Report. Based on weekly harvest progress percentages, the point in time in which Nebraska achieved 50% harvest progress is estimated to the closest day possible. From this selected day, prices ranging from one week before to one week after are averaged, and this price is used as the average harvest price for each location. This was repeated each year of the study.

Late-spring is included in this analysis to consider a relevant non-harvest time frame where corn producers may have incentive to sell their grain. As it stands, seasonal highs in corn price often occur during the months of May and June, and higher corn prices may induce additional corn movement. Thus, the late-spring two-week window is chosen to occur exactly 7 months after each mid-fall two-week window. With achievement of 50% harvest progress ranging anywhere from September all the way to late-November in recent years, choosing a 2-week window specific to the previous year's harvest provides a bit of consistency from year to year in terms of grain flow. In the average production year, May and June falls approximately 7 months after harvest.

The mid-summer time frame is relevant to consider, as it is common for corn growers to sell bushels in advance to harvest, avoiding seasonal lows often occurring at harvest-time. As a result, the conditions of this time frame model after that of a forward contract, where corn price is set at the time of sale and with the bushels to be delivered at a later time. As a result, new crop prices and harvest-time transportation rates are used for this time frame. As with the mid-fall time frame, the mid-summer two-week pricing window is based on data from USDA's Crop Progress Report. Using a similar method, the day Nebraska reaches 75% in terms of corn silking is estimated each year. From this date, usually occurring in late July, the day exactly 3 weeks afterward is chosen, with prices ranging from one week before to one week after this day being averaged to be used as the mid-summer price for that year. This time period is chosen specifically to account for the point in the growing season where growers are able to begin accurately predicting yield. The yield component method, a popular yield prediction method used by growers, can be done as early as the R3 stage in corn, which typically occurs 18-22 days after silking.

Transportation cost is the centerpiece in this work. Difference in location, as captured by transportation cost, is what causes the value provided by an ethanol plant to vary from one farm to the next. Farms located closer to an ethanol plant will have the lowest transportation cost associated with making delivery, and thus, will derive the most value from the ethanol plant. Farms located farther away will have a steeper transportation cost and may derive no value from an ethanol plant if they are able to achieve a higher net price by delivering their grain elsewhere.

Transportation cost data was sourced through Grain Truck and Ocean Rate Advisory (GTOR) compiled by USDA–AMS. GTOR provides an quarterly overview of the transportation market for grain trucks and ocean freight. Important for our research, GTOR compiles estimated truck availability, current truck use, and future truck use to report rate per mile figures for grain trucks. Rates are estimated for each of the 5 geographic regions, with separate rates for 25-mile, 100-mile, and 200-mile travelling distances. The rates are on a per loaded mile basis and serve to capture the rental rate of grain trucks, accounting for all cash and non-cash costs of operation. As we are considering grain buyers in close proximity to farms, we use the 25-mile rate for this study. Although Nebraska lies within the Midwest Region in the GTOR report, we use the reported national rate due to limited regional data availability prior to 2015. As GTOR is compiled quarterly, the transportation rate used for each time frame will be the one as reported in the corresponding GTOR report for that quarter. Using a standard truckload capacity of 1000 bushels, the per loaded mile rate is converted into a per bushel transportation cost, making it possible to arrive at a net farm price expressed in dollars per bushel.

Transportation cost is specific to each farm location, as distance to ethanol plant and elevator changes spatially. To provide some consistency among chosen farm locations for this study, the number of miles to elevator and to ethanol plant for each farm will remain proportional across all four ethanol plant regions. For each of the three elevator locations within a region, four farm locations are developed, amounting to a total of 12 farm locations within each region. Each of the four farm locations are located a different proportional distance away from their associated elevator and the ethanol plant. The four conditions are 1) near the ethanol plant, 2) in between ethanol plant and grain elevator, 3) near the grain elevator, and 4) located beyond the grain elevator.

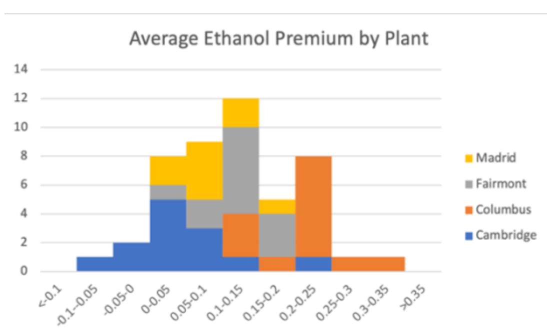
Farm conditions 1, 2, and 3 are all located between the elevator and ethanol plant. The “near the ethanol plant” farm is located at a point 10% of the total distance from the ethanol plant to the elevator. Similarly, the “near the grain elevator” farm is located at a point approximately 10% of the total distance from the grain elevator to the ethanol plant. The “between” farm location is located at the midpoint between the ethanol plant and elevator. Farm condition 4, the “beyond” farms, are located on the other side of the grain elevator, where making delivery to the ethanol plant would theoretically require driving by the grain elevator. These farms are situated so that they are the “between” number of miles away from the grain elevator. However, as they are located on the opposite side, they are three times the “between” distance away from the ethanol plant.

Using these criteria and Google Maps technology, sample GPS coordinates are chosen to represent the farm locations under scope in this study. With four farms for each elevator, three elevators in each region, and six ethanol plant regions, a total of 72 farm coordinates across Nebraska are chosen for estimating the net price difference between delivering to a grain elevator as compared to delivering to the regional ethanol plant. This price difference will vary for each farm location, and all will derive a unique value from ethanol production specific to the grain bids and transportation cost faced in that location. Refer to Appendix A for a more extensive view of an ethanol plant region

6. **Results**

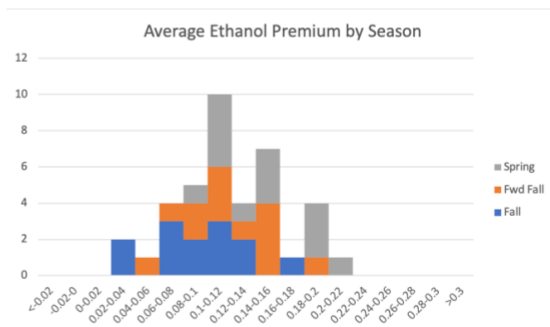
Initial results suggest ethanol's value to corn growers to be exceedingly positive on average for the farm locations considered in this study. This was consistent across the four ethanol plant regions, although to varying degrees. Figure 3 shows how average ethanol premium to growers varies by ethanol plant, where ethanol premium represents the higher net price a grower achieves by delivering to the ethanol plant over a grain elevator. Each data point represents a one-year average premium corresponding to each ethanol plant. In 49 of 52 yearly observations, the sample farm locations achieved a greater price by delivering to the ethanol plant. The most positive premiums are associated with the Columbus ethanol plant, followed by Fairmont, Madrid, and Cambridge. This order follows that of the plant's operating capacity, as ethanol plants with larger capacities characteristically offer higher prices.

Figure 3, Average Ethanol Premium to Farm Locations by Ethanol Plant



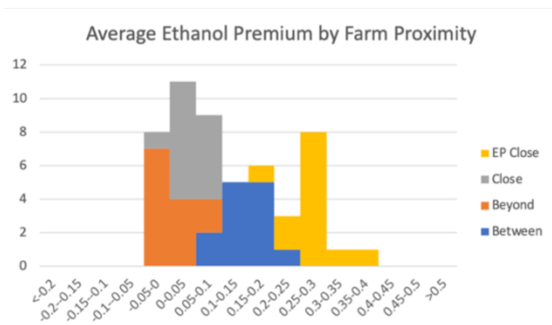
Average ethanol premiums also vary by season. Figure 4 depicts average premiums across all four ethanol plant regions by time frame considered. The "fall" period, occurring at 50% harvest progress in Nebraska, shows notably lower ethanol premiums than the "spring" period occurring 7 months after. This can perhaps be explained by demand differences between grain elevator and ethanol plant. Contrary to grain elevators, ethanol plants need consistent corn flow to remain in operation year round. Grain elevators, on the other hand, may acquire most of their grain at harvest time and not exhibit as strong of demand the rest of the year. Thus, ethanol plants may offer comparably higher prices at non-harvest time frames in order to incentivize delivery, resulting in higher ethanol premiums to corn growers.

Figure 4, Average Ethanol Premium to Farm Locations by Season



As has been discussed, corn producers located close to the ethanol plant will derive the most value from its existence due to transportation cost savings. In this study, four different proximities between grain elevator and ethanol plant were considered for farm locations: near the ethanol plant (EP Close), equidistant between elevator and ethanol plant (Between), near the grain elevator (Close), and beyond the grain elevator from the ethanol plant (Beyond). Figure 5 shows how average ethanol premium varies by farm location. Those corn producers located close to an ethanol plant achieve as much as $0.35 per bushel greater by delivering to the ethanol plant over grain elevator, on average. Farm locations situated an equal distance from ethanol plant and grain elevator also obtain a much greater price from the ethanol plant on average. Even for those producers located close to the grain elevator, a higher price could be achieved by delivering to the ethanol plant in 12 of the 13 years considered in this study. Finally, considering those growers located on the other side of the grain elevator from the ethanol plant, price was higher delivering to the ethanol plant in 6 of the 13 years. In other words, growers in these locations are occasionally better off driving directly past their local grain elevator to sell their grain at the ethanol plant farther down the road.

Figure 5, Average Ethanol Premium to Farm Locations by Proximity



7. Conclusion

Ethanol's great expansion over the last two decades has enabled many growers in the Midwest to enjoy higher offered prices for their grain. However, due to the role of transportation costs, those operations located closer to the ethanol plant see the greatest price differential between the plant and the next-best buyer, and operations located farther away may be able to achieve a greater price elsewhere. In order to determine which operations benefit from ethanol production and to what extent, this study examines the dollar value corn growers located in varying locations attribute to ethanol production in their region.

The study is guided by an expanded upon model of McNew and Griffith (2005). By considering a spatial demand model considering two grain elevators and an ethanol plant, one is able to depict the value any location attributes to ethanol production, as it is dependent upon grain bids and transportation cost. We consider ethanol plants, grain elevators, and sample farm locations in Nebraska for this study. We examine how the price difference between delivery to the ethanol plant and delivery to a grain elevator varies by the ethanol plant, the season, and the farm proximity considered. Our findings suggest that ethanol plants with larger capacities provide greater value over a wider scope, and ethanol premiums are greatest in late-spring time frame. A large majority of farm locations in this study derived a positive value from ethanol production on average, with some being able to bypass their local elevator and achieving a higher price at the ethanol plant, and others achieving as much as $0.35/bu. greater at the ethanol plant.

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[1] Their spatial equilibrium model stems from the agents-on-links model. In the agents-on-links model, production is assumed to occur along a line segments or links. The links contain demand centers.

[2] Grain bids between elevators vary, even for those in close proximity. In our model, it is assumed Elevator b is positioned on a main rail line and has unit loading capacity. As such, Elevator b has a transportation cost advantage over Elevator a, and as a result, $P_b > P_a$.

[3] The two elevator, one ethanol plant spatial demand system creates a simple, two-dimensional figure. This model behaves in a way so that an x-dimensional figure is created based on x number of grain elevators in the demand system. For simplicity, our model does not extend beyond this simple two elevator system, although our approach utilizes a three elevator demand system.

[4] See footnote 3. This three elevator, one ethanol plant spatial demand system creates a three-dimensional figure. For simplicity, we only discuss a two elevator system in our model.

Appendix A

Four ethanol plant regions were chosen for analysis in this study, with each located in unique corn-producing regions across the state. The Cambridge, Nebraska ethanol plant serves southcentral and southwestern Nebraska corn growers. Figure A1 specifies the portion of Nebraska under scope for the Cambridge ethanol region, as shown in Figure A2.

Figure A1: Nebraska Rail Map, Cambridge Region Specified

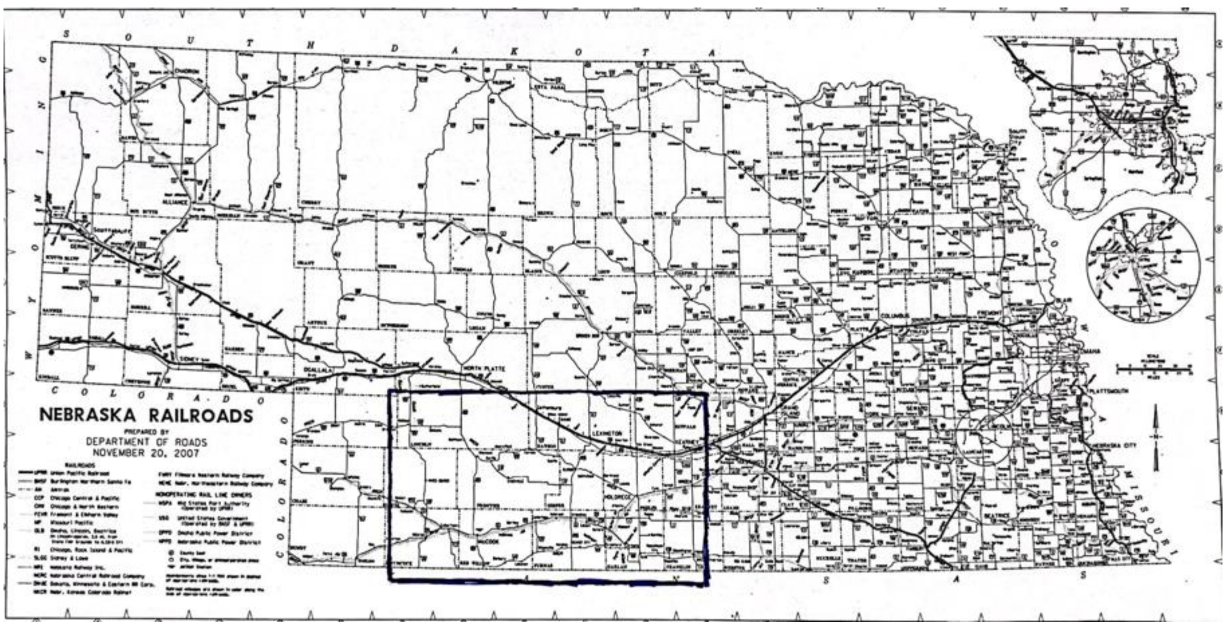
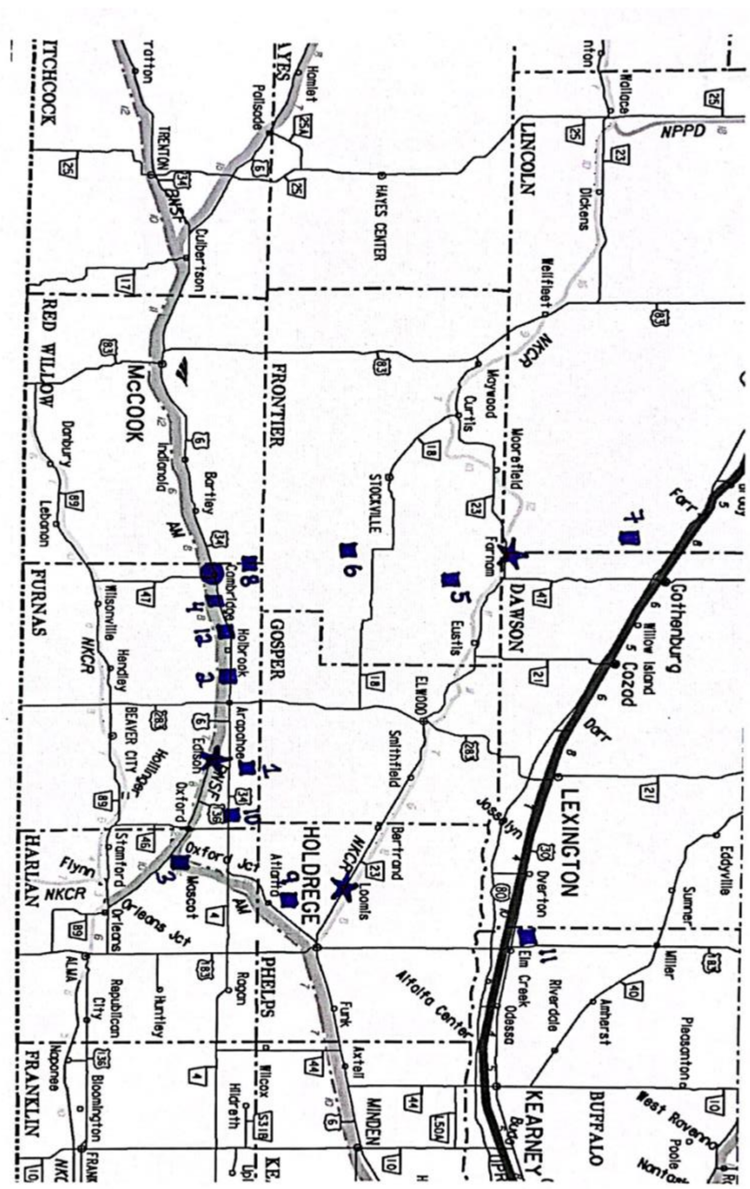


Figure A2 illustrates the relative locations of the ethanol plant, grain elevator, and farm locations sites used to determine ethanol's value to corn growers in the Cambridge region. The ethanol plant location is represented by the filled circle. The grain elevator locations are represented by stars, and each farm location is numbered and represented by a filled square. Farm locations 1-4 are associated with the Edison elevator, while farm locations 5-8 and 9-12 are associated with the Farnam and Loomis elevators, respectively. The first farm location associated with each elevator (1, 5, and 9) represent the "close to elevator" proximity ("Close"). The second associated farm location (2, 6, and 10) represent the "between" proximity, while the third and fourth associated farm locations represent the "beyond" and "close to ethanol plant" proximities, respectively. Profit is estimated for each farm location to each of the grain elevators. The difference between profit achieved at the ethanol plant and highest profit achieved at the grain elevators represents the value the individual farm location derives from ethanol production.

Figure A2: Cambridge Region: Ethanol Plant, Grain Elevators, Farm Locations



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