# Determinants of Food Corn Contract Volumes

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**Abstract**

Given the current market for undifferentiated grains, producers are seeking opportunities that add value to their farming operations. One such opportunity is the production of food-grade corn in lieu of a percentage of No 2 feed-grade production, the sale of which is usually based on a contract with a specified premium. When producers and mills come together to execute these transactions, they agree on a certain amount of corn to be delivered within a certain time period. Factors such as premium price, access to drying and storage equipment, and the price of other grain types affect how much food corn is contracted within a growing season. This paper utilizes an unbalanced panel dataset from 2010 – 2016 from a food corn mill in Kentucky to estimate determinants of contract volumes initiated by producers. Over this seven year period, grain market fluctuations in the form of price movements and consumer preference for non-genetically modified ingredients influenced contracting decisions. Results indicate the aforementioned factors and other variables have a substantial impact on the bushel amount producers are willing to contract. Implications of these decisions will be examined from an agribusiness and producer perspective to determine whether aspects of the transaction can be improved.

**Introduction**

Depressed prices for homogenous grains and an uptick in demand for quality attributes such as ingredients that do not contain genetically modified organisms (GMOs) have motivated producers to seek opportunities in the identity-preserved (IP) market. IP grains are differentiated from commodity or feed grains based upon physical or chemical characteristics valuable to the end-user. Essentially, a premium is placed on the bundle of attributes intrinsic to the grain type, as well as the additional management and risk incurred by the farmer. Examples of IP grains include high oleic acid soybeans, white food grade corn, and grains produced according to USDA organic standards.

One motivation for farmers to enter the IP market is that it enables them to diversify and add value to their operations with relatively low investment. This is because most if not all of the assets utilized for producing feed-grade grains are transferable to IP production. The difference arises in the

inputs used and management of grain quality; mainly during harvest, drydown (if necessary), and storage. As one can imagine, there is considerable effort both by farmers and agribusinesses to keep IP grains segregated from commodity grains throughout the supply chain from field to mill.

With all of these factors at play, coordination between buyers and producers is of utmost importance and necessitates the need for contracts. If a broker or end-user business wants to ensure an adequate supply of grain, they must prospect and establish relationships with farmers who can meet their quality standards. Beyond meeting supply quotas for downstream demand, mills and food companies use contracts to establish the desired attributes and grain quality so that unprocessed grain and subsequent products retain their economic value. Of course, the price or pricing mechanism for a farmer's production is established through the contract. From the buyer's perspective, this allows a certain quantity of grain to be procured at a certain price, or within a satisfactory range. If a higher degree of risk management is part of the firm's strategy, cross hedging and offsetting positions in the futures market is possible after the original price for the grain is established. From the producers perspective, alleviating some of the uncertainty regarding what price will be received is valuable and incentivizes the use of contracts. Certainly, other risks prevail in production agriculture, but identifying a price and possibly a premium before or during a growing season enables producers to be more accurate in their forward planning activities.

Another function of contracts in the IP grain market is to specify when, where, and how much of a specialty grain will be delivered by the seller to the buyer. This specification is closely related to the buyer's supply quota mentioned above. Most IP contracts identify whether grain will be delivered during harvest or at a time following harvest, implying the need for storage on the producer's end. If storage is needed, then supply quotas, delivery timing, and a premium become even more related. Constructing storage facilities for most or all of the grain an elevator or mill receives in a given year would be a tremendous upfront expense and unsuitable investment. Instead, buyers provide incentive for producers to utilize existing storage or construct new facilities through premiums. This could be in the form of a fixed premium above a previously agreed upon bushel price, or one that increases with the amount of time the

crop is stored on-farm. If delivery is specified to occur following harvest time, a condition called buyers call is sometimes imposed. Under a buyers call, the producer must deliver grain at the buyers request sometime in the future. Usually, a general timeframe or specific date is established, but the buyer reserves the right to request that the farmer hold the grain longer. While this may cause some inconvenience for the farmer, a higher premium is typically associated with a buyers call caveat.

The quality control aspect of a marketing contract in this instance is of great importance. After all, if there were no distinguishing features between No. 1 and No. 2 corn, there would be no need for hierarchal designation. This also serves to coordinate production flows through a mill or food company's supply chain. Agribusinesses rely on farmers to deliver adequate quantities of grain with the quality attributes they require at the right time. Otherwise, a shortage could occur and a bottleneck would arise. For example, if loads of food grade corn were continually received at a high moisture and the grain had to be artificially dried or refused altogether, a shortage of milled corn could occur for downstream processes. Thus, a contract is used to ensure the producer abides by quality standards outlined in the document; the impetus being discounts to price received, or refusal to purchase the grain.

Given the interdependency between elevators/mills and the farmers that supply them with grain, in addition to various specifications within contracts that connect the two, this paper serves to examine contracting decisions by producers in the form of contract volumes. That is, what factors cause farmers to increase or decrease their contract volumes growing season to growing season? Does an increase in the premium offered induce farmers to contract more bushels with a mill? How much does access to assets like drying and storage equipment increase the amount a producer is willing to contract? These questions and others will be answered in the following analysis to quantify influences on the contracting decisions of producers with elevators and mills. From the buyer's perspective, this information is relevant to demand planning and how characteristics of the contracts they put forward, as well as economic factors larger than the transaction at hand, impact the amount producers intend to grow year to year. Contract and corresponding delivery data from a food corn mill in Kentucky is utilized in the empirical study to

demonstrate local producers' contract decisions. Further, implications of these decisions will be examined to determine what aspects of the transaction can be improved.

**Literature Review**

There are many analyses that can be cited which are relevant to the study at hand. The literature on contractual arrangements is vast and derived from diverse sources, such as academic or law journals, as well as government publications, some of which narrow their focus to contract use in agriculture. Given the concentration of this paper, agricultural contracting will remain the focus as previous works are analyzed, and parallels drawn to the current study.

A paper of little technical applicability, but great conceptual relevance is Cheung's (1969) choice-based analysis to explain contractual behavior in land tenancy. He sought to explain why different contractual arrangements were chosen under a uniform system of property rights. While it may seem commonplace today, he introduces transaction costs and risk to do so. First, if a firm can increase production efficiency by employing the productive resources of more than one owner, a contract to combine both party's resources will prevail. In the case of food corn contracting, the mill employs the productive resources of the farmer, because vertical integration would be capital intensive and less efficient. Cheung also incorporates the postulate of risk aversion into his study. While risk preferences are not the primary focus of this study, the theory underlies part of the motivation for contract-based transactions between farmers and the buyers they sell their products to. Here, in general terms, the farmer reduces risk by establishing a buyer and price which is usually incentivized by a premium. Likewise, the mill reduces their risk by securing their supply of corn prior to harvest at a set price from the farmer. Finally, Cheung states that given transaction costs, risk aversion implies asset values and variance of income are negatively related. In other words, the value of productive assets- land on which the corn is grown, tractors, combines, grain bins- decrease as income variance increases. This would also imply that if a contract can secure a satisfactory price for the farmer's production, it would behoove them to enter the agreement.

Moving ahead to more recent studies, Sykuta and Parcell (2003) performed a survey of 23 different IP soybean contracts sponsored by DuPont Specialty Grains for each cropping year from 1999 to 2002. Their intent was to classify contract structure for IP crops based upon three essential components of economic transactions: the allocation of decision rights, value, and risk. An additional objective was to create a framework by which more methodical analyses of contract structure and performance could be performed. The parsing of the different contracts revealed that producers' management efforts to preserve the identity trait and preventing comingling through harvest, storage, and shipping was the essential source of value underlying each contract. An additional source of value that was variable among contracts was delivery timing. The authors suggest that if the option to choose delivery timing is valuable to the buyer, then the buyer should be able to compensate producers for the transfer of value related to the change in delivery options. While this assertion is fundamental to contract and price theory, the value derived from a delivery timing mechanism is a function of all three economic underpinnings on which the study is based. Sykuta and Parcell's inquiry is characteristic of much of the literature on IP grains in that it is void of statistical analysis. However, the authors pose many questions for future research. Given the focus of the current study, one in particular stands out: What factors affect the rate at which producers buy into a contract programs in a given crop year?

Hudson and Lusk (2004) use a choice-based experiment to observe contract choices by two groups of producers in Texas and Mississippi to estimate marginal utilities of contract attributes. Variables from both principal-agent and transaction cost models considered theoretically important are incorporated. Although the authors did not specifically study IP grains as the product being contracted, many of their observations are relevant. They found that increases in expected income from a given contract were significantly related to increases in the probability of that contract being chosen, i.e. income has a positive marginal utility. Further, they observed that the producers derived significant disutility from investment in relationship-specific assets, which suggests producers would prefer to invest in assets with multiple uses to avoid rent appropriation by the buyer. Both findings are intuitive and of great importance for the motivation of this study. In particular, premium levels for different corn types, as well

as the use of more efficient grain dryers, had a significant effect on the volume of corn producers were willing to contract in the current study.

In addition to journal articles, there are well-developed government publications from USDA/ERS worth citing not only for their analyses of trends, but also application of economic theory and examination of diverse markets. McDonald, et al. (2004) begin their report on contract use in agriculture by quantifying the prevalence of certain characteristics of marketing contracts for field crops using data from the 2001 ARMS and NASS data for average prices. They first note that variation in contract prices likely reflect differences in contract terms, such as delivery, storage, or differences in product characteristics. On the buyers end, the contract is considered a bundle of attributes, and more utility is derived as more value-added processes are added. This information is captured in variables such a corn color, non-GMO (GMO), and premium level in the current study. Next, the authors point out that farmers who contract corn usually contract just part of their production, but the range in contract volumes is quite surprising. Twenty five percent of corn contracts were 5000 bushels or less, while contract volumes at the 75$^{th}$ percentile were for 21000 bushels or more. While this data comes from 2001 and is for feed grade corn, a similar pattern is observed in the firm-level data constituting the dependent variable in the current analysis.

McDonald, et al. also discuss asset specificity and its relationship to the use of contracts in agriculture. They cite Williamson's (1985) definition of asset specificity as durable investments undertaken in support of particular transactions. Physical asset specificity could include devoting the current use of, or purchasing new, drying and storage equipment for food corn production. While this is not as obvious as other examples, if food corn production is of higher value than other undifferentiated grains, the redeployment of those assets solely for feed grains would cause a decrease in their value. The authors further describe the tendency of food processors to be located in high production areas, introducing the concept of site specificity for both the farmer and mill, since compensating producers to haul long distances would be costly and inefficient. Reflecting on both forms of asset specificity, a much deeper relationship between buyer and seller is recognized. It is also quantified by their observation that

74.4 percent of IP corn was produced under contract in 2001. They note that contracts are utilized because few nearby buyers exist, and because higher costs of production expose them to risks of holdup in the spot market. A final and germane observation put forth in the McDonald, et al. ERS report is the amount of turnover among producers selling IP corn to processors. Thirty percent of producers in 2000 did not return in 2001, and 27 percent of producers in 2001 did not return in 2002. Again, while this data is not current, a similar pattern of turnover among producers was seen year-to-year in the data used for the current study.

**Materials and Methods**

Principal-agent theory is the framework which underlies this analysis. In this instance, the mill (principal) employs the farmer (agent) to take actions which ultimately affect the well-being of the milling enterprise. Naturally, these actions include the production of food grade corn subject to quality standards and the successful segregation of that production to preserve its economic value. Difficulties in principal-agent relationships arise when two situations occur: 1) the objectives of principal and agent are unaligned, and 2) actions taken by the agent or information possessed by the agent are hard to observe (Besanko, 2010). In this case, the bushel amount of food corn producers are willing to contract year-to-year, if any, is difficult for the mill to determine. The statistical analysis in this paper was performed to shed light on this issue.

Since the data is an unbalanced panel containing six years of transactions, a fixed-effects model is chosen to quantify variables affecting producers' annual buy-in to the mill's contract program. Further, the fixed-effects model controls for the unobserved factors that are constant, and those which vary over the six-year period. The theoretical fixed-effects model is as follows:

$$y_{it} = \beta_0 + \delta_0 D_t + \beta_1 x_{it} + a_i + u_{it}, \quad t = 1, 2, \ldots, \mathrm{n}$$

Following the notation, $i$ signifies the individual farmer who contracts with the mill. $D_t$ is a vector of dummy variables that equal zero when the period of the dependent variable is not congruent with that of the dummy, and one when it is. This allows for different intercepts over time, given unobserved

changes that take place over time. While unrealistic, if every producer increased their acreage of IP corn to increase contract volumes from one year to the next, and that change went unmeasured, the unique intercept generated by the period dummy would help account for that alteration in the producers' decision making. The variable $a_i$ captures all of the unobserved factors that do not vary over time. Hence, it is not indexed by subscript $t$, and is the fixed effect(s) affecting the value of $y_{it}$. For instance, if on farm storage capacity of each producer went unchanged over the six period, but was unobserved, the fixed-effects variable would account for that. Finally, $u_{it}$ is the idiosyncratic error that represents unobserved factors that do change over time. Usually, the unobserved effect and the idiosyncratic error are combined to create a composite error, $v_{it}$, where $v_{it} = a_i + u_{it}$.

Since the focus is observing factors that influence farmers' contracting decisions over time, the empirical model follows the fixed-effects framework. This allows for changes that went unobserved within individual years, but still influenced bushel amount per contract, to be considered when generating results. The following is the empirical model and variable definition used in the analysis of contract transactions between producers and the mill from 2011 – 2016:

$$\begin{aligned} volume_{it} = {} & \beta_0 + \delta_0 D_t + \beta_1 color_{it} + \beta_2 gmo_{it} + \beta_3 deliver_{it} + \beta_4 premium_{it} + \beta_5 corn_{it} \\ & + \beta_6 beans_{it} + \beta_7 market_{it} + \beta_8 con_{it-1} + \beta_9 disc_{it-1} + \beta_{10} nonyear_{it} + \beta_{11} tower_{it} \\ & + \beta_{12} stack_{it} + \beta_{13} inbin_{it} + \beta_{14} quart2_{it} + \beta_{15} quart3_{it} + \beta_{16} quart4_{it} + v_{it} \\ & i = 1, 2, 3, \ldots, n \\ & t = 1, 2, 3, 4, 5, 6 \end{aligned}$$

Where:

Color = corn color
GMO = GMO designation
Deliver = timing of delivery
Premium = premium above CBOT price
Corn = CBOT December corn futures price on contract date
Beans = CBOT November soybean futures price on contract date

Market = whether the transaction took place from 2010 – 2013, or 2014 – 2016

Con = previous year contract volume of specific corn type

Disc = previous year discounts of specific corn type

Nonyear = year when GMO corn was not contracted

In Bin = in bin dryer

Stack = stack dryer used for drydown

Tower = tower dryer used for drydown

Quart2 = corn contracted during the second quarter

Quart3 = corn contracted during the third quarter

Quart4 = corn contracted during the fourth quarter

The firm-level data used in this study comes directly from a milling enterprise in which 346 producers contracted IP corn production over a six year period, generating 1135 observations on contract volumes. Descriptive statistics for the variables utilized in this study may be seen in Table 1. As previously mentioned, the data is an unbalanced panel because many producers do not return to contract with the mill every year from 2010 to 2016. While the original data set obtained from the mill contained observations for color, GMO, delivery, premium, corn, and previous contract variables, daily soybean prices were gathered from (Commodity Research Bureau, 2016). Specific contract dates contained in the data mentioned above allowed for classification of contracts by fiscal year quarters. Additional data related to the delivery and quality analysis of the contracted corn enabled the calculation of previous year discounts as well as the type of dyer used by the farmer to dry the corn to a suitable moisture for storage. Finally, the standard contract used to complete these transactions was also provided by the mill and used to gain further insight into the transactions being studied.

Corn color is a key factor in the premium over the Chicago Board of Trade (CBOT) December futures price that will be received by the farmer once the corn is delivered. Only yellow and white food grade corn are purchased by the mill over the six-year period, with white corn commanding a higher premium. Of course, this is constructed as a dummy variable where white corn equals one and yellow equals zero. Since white corn has higher production cost (Pritchett, 2000), it is hypothesized that producers allot smaller bushel amounts to these contracts. Related to the color attribute is whether the production under

contract is a genetically modified organism (GMO) or not. Once again, this designation contributes to the premium. Since the majority of corn produced in the United States is GMO, non-GMO corn is given a higher premium because of its higher production cost, differentiated nature, and lower yield potential (Greene, 2016). From a producer's standpoint, the higher production cost associated with non-GMO corn could deter them from growing more of it compared to GMO corn, resulting in a higher per contract bushel amount of GMO corn. Because the choice to grow GMO or non-GMO corn is binary, a dummy variable is employed where non-GMO corn equals one and GMO corn equals zero.

Whether corn is delivered to the mill during harvest, or if it is stored on the farm and delivered at a later date, contributes to the premium and varies among contracts. If the mill can avoid having to store all the corn themselves, as well as the fixed cost and risk associated with the amount of storage required to do so, it makes sense that the mill would pay a higher premium to have the farmer utilize their assets to store grain. To quantify the effect this decision has on individual contract volumes, the Deliver variable is used. One could expect that a farmer with limited on-farm storage might allocate a large amount of bushels to a contract(s) with harvest delivery, and a much smaller amount requiring storage. While this should not be construed as a proxy for storage resources of the individual farmers, it serves to measure why farmers elect to grow more corn for a contract with certain stipulations. Yet again, the decision to deliver during harvest or sometime after is binary when completing a contract. Therefore, it is included as a dummy in the model where harvest time delivery equals one and a later delivery date associated with on-farm storage equals zero.

Certainly, the premium above the CBOT December futures quote is what motivates producers to grow IP corn in the first place. In other words, it is the price signal the mill uses to attract local farmers to produce food grade corn. As has been discussed, what color the corn is, whether it is GMO or not, and when it will be delivered all factor into the value of the premium. For example, in 2012 the mill paid a $0.25 premium for GMO yellow corn delivered at harvest. During the same year, a $0.70 premium was paid for non-GMO white corn stored on the farm and delivered after harvest. Further, premiums for all corn types increase over the six year period. The same white corn contract that fetched $0.70 in 2012 had a premium

of $0.90 in 2016. Given the premium is a price signal, the expectation is formed that an increase in premium will result in an increase in the per contract bushel amount.

The Corn variable is the CBOT December futures quote on the day the contract was made. This information is included because it is the price a premium is added to that determines the overall price received by the farmer. Additionally, the December price of No. 2 corn on the day the contract is completed is the broader economic point of reference the producer has for the corn market. If prices are low, it is easy to imagine a producer would reduce their corn acreage (food grade or not) and substitute it with a crop that has the potential to be more profitable, say, soybeans. This action could decrease the bushel amount a farmer would contract. Therefore, the price of soybeans is also included in the model. This is accomplished by using the November soybean futures price from the same day the food corn contract was made.

Market is a dummy variable used to indicate whether the transaction took place during 2010 – 2013 or from 2014 – 2016. This variable is utilized to reflect distinctly different grain market conditions during the six year period. It is well known that grain prices increased rapidly from 2010 to 2013 and decreased rapidly thereafter. Thus, a mechanism is implemented to account for altered decision-making during market upswings and downturns; the expectation being larger contract volumes during times of high commodity prices. In the data, transactions occurring between 2010 and 2013 equal zero, and those executed from 2014 to 2016 equal one.

The previous year's contract volume(s) and quality discounts have the potential to influence a producer's decision making in the current year, so the Con and Disc variables are included in the model. While the producers were able to enact many contracts in a single year- meaning the entirety of their white or yellow corn production could be spread across multiple contracts with varying stipulations- the previous year's contract volumes were aggregated by corn color, GMO/non-GMO, and delivery time. Previous year discounts are derived from the second data set of delivery information and quality analysis. Following the methodology for aggregating contract volumes in period $t-1$, previous discounts are calculated by summing the amount of bushels rejected per delivery of corn contracted by color, GMO/non-GMO, and delivery time. Although it is difficult to determine an expected relationship between a prior year's contracting

decisions and the current one, one can assume an increase in a previous year's discounts will result in a decrease in contract volume in the current period.

Nonyear is a dummy variable employed to determine whether the mill was accepting both GMO and non-GMO corn during a certain year, or only non-GMO corn. In the data, there are years where the mill purchased only non-GMO corn. The years in which this selective buying took place were 2010 and 2011, as well as 2015 and 2016, and equal 1. Being limited to only planting non-GMO seed could have prevented certain producers from expanding or maintaining the same contract volumes as in prior years, because of the higher production cost associated with non-GMO corn. Instead, they could opt to grow more of another crop, like GMO feed grade corn or soybeans, ultimately decreasing the amount of bushels they contract with the mill.

In Bin, Stack, and Tower represent the method in which the corn was dried to fifteen percent moisture, making it suitable for storage. Because asset specificity is a concept inherent of principal-agent theory, as well as having access to this unique data, the question was posed whether the use of grain dryers would cause the producers to allot more bushels per contract. In Bin, Stack, and Tower indicate whether the dryer was a tower, stack, or in bin configuration. The alternative to mechanical drying is to let the grain dry naturally in the field over time, which is a reference for the three dryer variables where Field = 1, In Bin = 2, Stack = 3, and Tower = 4. Under the hypothesis that the use of dryers has less value when deployed for drying less valuable, non-IP grains, an expectation is formed that, on average, contract volumes will be higher when the farmer intends to utilize a mechanical drying during the production process. Yet, it should be recognized that having a mechanical dryer on the farm could be indicative larger farms with more resources (land, labor, and capital), enabling those farmers to grow more IP corn. Unfortunately, data on farm size to control for this effect was unavailable and is recognized as a limitation.

Finally, what quarter the producer chose put the bushel amount he grew for the mill under contract is modeled through Quart2, Quart3, and Quart4. The parameters of these variables are compared to the first quarter where Quart1 = 1, Quart 2 = 2, Quart3 = 3, and Quart4 = 4. Timing of contract agreements affects what price per bushel is received since the mill uses daily December corn futures to price grain. Thus, the

usual temporal transmission of grain prices could cause producers to price more of their IP corn away from harvest time, when stocks have decreased and prices are generally higher. Conversely, producers could wait to see how strong their yield is before pricing a crop, causing them to price the corn closer to harvest when prices are lower, but nevertheless avoiding any obligation to the mill for production shortfalls. Thus, variables to measure the timing of the agreement's effect on bushel amount are included and derived from the specific date each contract was made.

Table 1. Descriptive statistics

| **Variable** | **Mean** | **Std. Dev.** | **Min** | **Max** | **Expected Sign** |
|---|---|---|---|---|---|
| Volume | 12674.49 | 14052.95 | 332 | 150000 | |
| Color | 0.460793 | 0.49868 | 0 | 1 | - |
| GMO | 0.681938 | 0.465929 | 0 | 1 | - |
| Premium | 0.608546 | 0.211762 | 0.25 | 1.2 | + |
| Deliver | 0.352423 | 0.477935 | 0 | 1 | +/- |
| Corn | 4.970152 | 1.183247 | 3.2275 | 8.3525 | + |
| Beans | 11.64391 | 1.804131 | 8.7275 | 17.4575 | - |
| Market | 0.399119 | 0.489933 | 0 | 1 | - |
| Con | 22663.35 | 26118.85 | 0 | 190000 | + |
| Disc | -378.714 | 722.2195 | -6824 | 0 | - |
| Nonyear | 0.536564 | 0.498881 | 0 | 1 | - |
| Tower | 0.081057 | 0.273043 | 0 | 1 | + |
| In Bin | 0.555066 | 0.497178 | 0 | 1 | + |
| Stack | 0.120705 | 0.325928 | 0 | 1 | + |
| Quart2 | 0.225551 | 0.418129 | 0 | 1 | +/- |
| Quart3 | 0.206167 | 0.40473 | 0 | 1 | +/- |
| Quart4 | 0.295154 | 0.456313 | 0 | 1 | +/- |
| N = 1135 | | | | | |

**Results**

Results of the fixed-effects model to estimate influences on contract volumes in an IP corn contracting program were generated using the XTREG command in STATA (StataCorp, 2013). Results may be viewed in Table 2. Overall, the model is significant with an *F*-statistic of 0.0000. Of the 16 variables measured, three were significant at ten percent significance level, and five were significant at 5

percent significance level. With one exception, relationships between variables and the per contract bushel amount the farmers contracted are as expected. A Hausman test was conducted for specification between fixed-effects and random-effects models. Based on the results of the test, the null hypothesis that the covariates and unique errors were not correlated was rejected with a *p*-value of 0.0000.

Table 2. Fixed-effects estimates of factors affecting food corn contract volumes

| **Variable** | **Parameter** | **Standard Error** |
|---|---|---|
| Constant | 7740.819 | 5214.018 |
| Color | -2496.096* | 1433.245 |
| GMO | -7001.134*** | 1688.937 |
| Premium | 19563.33*** | 4702.485 |
| Deliver | -2203.357 | 1395.865 |
| Corn | 1203.409 | 893.975 |
| Beans | -915.320 | 618.515 |
| Market | -4404.617*** | 1473.577 |
| Contract | .0248 | 0.020 |
| Discount | -1.048 | 0.689 |
| Nonyear | 4220.931*** | 1657.432 |
| Tower | 3741.9 | 3107.667 |
| Stack | 8675.599*** | 2619.216 |
| In Bin | 769.962 | 1525.38 |
| Quart2 | -1278.34 | 1409.348 |
| Quart3 | 2797.041* | 1653.287 |
| Quart4 | 2965.572* | 1538.322 |
| $F$ = 0.0000 | | |

*Significant ($P < 0.1$); **significant ($P < 0.05$); ***highly significant ($P < 0.01$)

Whether the contract was for yellow or white corn had an impact on the amount of bushels specified in the contract. The Color regressor exhibits a negative relationship with contract volume with a *p*-value of 0.082. The negative association between Color and contract volume is consistent with the hypothesis that higher production decreases the bushel amount producers are willing to contract. If a producer chose to initiate a white corn contract, that contract would contain 2496 less bushels than the

same contract for yellow corn. The qualitative variable GMO also reveals a negative relationship with contract volume. With an associated *p*-value of 0.000, the parameter indicates that contracts for non-GMO corn will be 7001 bushels less than the same contract for GMO corn. This confirms the expectation that the higher production cost associated non-GMO corn limits the amount of bushels contracted compared to GMO corn. Indeed, the premium received for producing IP corn has an influence on the bushel amount contracted. A *p*-value of 0.000 supports the hypothesis that this price signal gets producers in the door and has a positive effect on their buy-in to the contracting program. On average, if a premium for a particular contract increases by $0.10, the volume obligated to that contract is expected to increase by 1956 bushels, *ceteris paribus*.

The overall condition of the grain market from 2010 – 2016 had a significant effect on contract volumes. The downturn in the corn market from 2014 – 2016 and its effect on contracting decisions is evident in the coefficient for the Market variable. 4404 less bushels per contract are associated with this period of low prices relative to 2010 – 2013. This result is consistent with the idea that a depressed grain market will negatively affect the amount of bushels producers allot to individual contracts. Another variable related to market condition and demand is whether the mill was accepting both non-GMO and GMO corn during a particular year, or only non-GMO corn. Yet, the relationship between the Nonyear variable and dependent variable is not as expected. A decrease in contract volumes for years when more selective buying took place did not occur. Rather, an increase of 4220 bushels per contract occurred during years when only non-GMO corn was accepted at the mill. This result contradicts the notion that limiting producers to only one kind of seed technology would induce an increase in their buy-in to those contracts.

Only one type of mechanical dryer returned a statistically significant result. However, this result had the largest impact on contract volumes. Compared to natural field drydown, the use of a stack dryer in the production process is associated with an 8675 bushel increase in contract volume. This outcome is consistent with the expectation that prior investment in a mechanical dryer would result in larger contract volumes of IP corn. Stack dryers fall into the category of high temperature grain dryers, making them

more efficient than an in bin, low temperature method of drying. If a farmer is able to efficiently dry and store value-added grain ahead of other undifferentiated grains during harvest, they may be inclined to initiate larger contracts to generate more income from their enterprise mix. Regardless of motivation, an association is observed between dryers and larger contract volumes, pointing towards some degree of asset specificity.

The last of the statistically significant variables are the quarters in which the corn was contracted and ultimately priced. The third quarter resulted in 2797 more bushels contracted compared to the first quarter, and the fourth 2965 more bushels. An expected relationship between when corn is contracted and the bushel amount per contract was not defined due to the many factors affecting pricing decisions. However, it is possible to observe that contract volumes increase once better yield potential information is available during the summer months of the third quarter, and once yields are realized during the fourth quarter.

**Conclusions**

Through the firm-level analysis of contracting decisions between producers and a mill, insight has been gained into factors that affect how much IP corn is put under contract in a single transaction, but what are the implications? Many questions regarding the farmers in this relationship have been discussed and answered. From the mill's perspective, having an understanding of these factors can lead to better decisions in demand planning. If the agribusiness decides in subsequent years to accept GMO corn again, what premium should be set to attract buy-in from producers and ensure adequate bushels for the markets they are supplying? The results indicate that farmers will produce more corn per contract relative to non-GMO corn and that small premium increases have a large effect on the amount of bushels per contract. Too low of a premium could result in low buy-in, not only because it is an unattractive price signal, but because of switching costs incurred by the farmer from year to year when certain grain types are accepted and others are not. If this were to materialize, the mill could experience a shortage, and potentially have to make up for that shortage by buying grain from brokers at a higher cost.

The condition of the commodity markets should also play a role in decision making. It was observed that a depressed market decreases producers' willingness to contract larger volumes of IP corn. Although it was seen in the data that as corn prices fell, premiums increased, but what is the strategy when the market strengthens and prices increase? Should a premium be lowered to improve the bottom line of the milling enterprise and risk losing buy-in from producers, or should it remain the same to reduce turnover among producers and ensure adequate supply? Of course, these questions can be partially answered by analyzing the result of the Premium variable, but observing other factors like market volatility compounds information and allows for better decision making.

If the mill continues to buy only non-GMO corn into the future, steps should be taken to ensure producers are satisfied with their business relationship. While the results indicate that larger contract volumes occur during years when only non-GMO corn is purchased, the overall number of contracts in these years is markedly lower. If a producer discontinued their business with the mill from one year to the next, they could experience a substantial loss of corn. Either a new producer who could produce the same amount of corn would have to be identified, or the remaining producers would need to grow more corn. Each situation could result in search cost or an increase in coordination effort, respectively. Given previous ERS studies and the pattern seen in the data used for this study, turnover among producers in the IP corn market is most relevant. Just as businesses experience costs with high employee turnover, so would a mill that uses contractual arrangements with farmers to supply them corn. If year after year the mill loses producers and has to search for others to meet supply quotas, in addition to on-boarding those producers and educating them about quality standards, etc., transaction cost significantly increases. In this sense, it would behoove to the mill to engage producers and receive feedback before one or a handful of farmers stop contracting altogether, recognizing there are costs associated with this too.

Finally, drying equipment should be a consideration if the mill needs to prospect new producers to meet demand or expand the enterprise. Higher efficiency, higher temperature dryers allow producers to increase throughput during harvest. When considering the result of the Stack dryer variable, producers with this type of dryer choose to contract more grain per contract. Attracting producers with these assets

may ensure an adequate supply of grain stored past harvest and delivered by buyer's call, not subject to the yield loss and quality issues associated with natural drydown in the field. However, the use of high temperature drying puts the grain at risk for stress cracks, which could cause discounts when the corn is delivered. However, if the mill decided to prospect for new producers with high temperature dryers, they may have to provide education on drying IP corn to maintain quality, which would come at a cost and increase coordination effort.

This study serves to quantify variables surrounding contracting decisions among farmers producing IP corn. Using a fixed-effects model, statistical analysis was performed on six years of contract and pricing data to generate results and provide insight to the principal-agent relationship taking place between the mill and numerous producers. Further, this inquiry fills a void in the economic literature on IP grains that lacks quantitative methods and is focused on industrial organization. Utilizing the results, aspects of the contractual arrangements that have the potential to impede the course of business are analyzed. With this understanding, a better principal-agent relationship may be forged, and better business decisions can be made.

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