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Factors Impacting Crop Acreage Decision: A Case Study of North Dakota Agriculture

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Abstract

This study provides an analysis of producers' crop planting decision behavior in response to econometric factors, the biophysical environment, and biofuel policy mandates. Specifically, we measure the effects due to economic impacts on an area planted with corn from 1990 to 2015. We develop a crop supply response model and estimate that acres planted with corn in the state of North Dakota have increased by 1.2 million over the last twelve years. Also, the value of crop price elasticities indicates a significant impact on corn planted acreage decisions due to change in crop prices. Corn future price and ethanol price elasticities are positively impacted by corn planted acreage whereas corn planted acreage negatively impacts competitive crop price elasticities. We find that impact of climate variables on corn acreage decision is evident. We show that the inclusion of county interaction effect variables significantly improves the model parameters. Key findings also indicate that a 1% increase in soil moisture in month of May led to a 0.1486% increase in corn acreage expansion. Similarly, as maximum temperature increased during the planting season, corn planted acreage expanded significantly. Also, the total rainfall is positively correlated with corn planted acreage as expected. For example, a 1% increase in total rainfall led to a 0.2143% increase in total corn planted acreage.

Keywords: Biofuel policy, Crop choice decision, Supply response model, Price elasticity, Interaction effect, Corn acreage.
JEL Classification: Econometric and statistical methods, Simultaneous equation models, Agricultural and natural resource economics, Agricultural R&D, Renewable resources and conservation: Land, General regional economics.
C 10, C 30, Q 00, Q 16, Q 24, R 10.

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Ethical: This study follows all ethical practices during writing.

Contents

1. Introduction

This article highlights the connection between the decisions of U.S. farmers on local crop selections in response to the demand of ethanol for biofuel production. We measure this response by analyzing the change in corn crop areas due to crop prices, oil and ethanol prices, the biofuels boom, climate, and other economic determinants at the county level in the State of North Dakota (ND) from 1990 to 2015.

There has been steady economic growth in many U.S. rural areas as biofuels emerge as a substitute for petroleum-based energy [1]. Farmers face new challenges as their crop mix is increasingly destined for ethanol plants and less for food and livestock feed consumption. The increased demand for biofuel has led to a corresponding increase in the quantity produced. Biofuel production has had an impact on overall energy price, energy consumption, and Greenhouse Gas (GHGs) emissions [2]. Key findings from life-cycle studies suggest that replacing gasoline with ethanol (biofuel) reduces GHGs when made from corn [3]. This expansion of biofuel crops might also affect habitat characteristics and ultimately lead to a reduction of biocontrol services (i.e., the long-term self-sustaining treatment method for managing invasive plants) [4]. An increase in demand for biofuel feedstock dominates agricultural landscapes and is also responsible for changes in the landscapes' composition. Also, there might be a reduction of biocontrol services due to the expansion of corn land acreage [4].

The increasing demand for corn-based ethanol has led to an increase in price by 40%, 20%, and 17% for corn, soybean, and wheat, respectively [3]. As a response to this, farmers often choose to clear additional forests and grasslands and replace them with food crops. So, these factors of biofuel demand and the resulting swing in crop prices drive crop allocation decisions made by farmers. Also, climate conditions influence the allocation decision of farmland to alternative crops [5].

Due to its high demand, the rate of conversion of forestland and grassland to produce food crop-based biofuels is increasing in the U.S. where corn and soybean account for over 90% of biofuel production [6]. Corn is also known as the major feedstock for biofuel production, and as a result, in recent years, the U.S. has experienced higher corn cropland acreage as compared to any other crop. A total of 37% of the corn crop in 2015 was used to produce ethanol for mixing with gasoline compared to only 14% in 2005 [7]. This rapid growth is primarily due to the Renewable Fuel Standard (RFS) mandated by the U.S. federal government.

There has been a significant expansion of ethanol production (e.g., the introduction of gasoline blended with ethanol) since the beginning of 2005 with the enactment of the Energy Policy Act and again in 2007 with the Energy Independence and Security Act. The U.S. Congress introduced rules to require the mixing of 15 billion gallons of conventional biofuel (i.e., corn-based ethanol) with gasoline by 2015. As a response to these policies, U.S. ethanol production increased from 3.9 billion gallons in 2005 to 15.8 billion gallons in 2017 [8] thereby bringing the share of ethanol to 10% of the total motor gasoline supply.

The total corn planted acres in the state of North Dakota have been concentrated in the south-east counites (Figure 1). The corn planted acreage map by counties of ND represents the concentration of corn land over time. The increased production of corn-based ethanol requires more corn feedstock, and the corresponding shift in demand for corn ultimately put pressure on farmland. The total corn planted acres in the U.S. increased from 81.8 million in 2005 to 90.2 million acres in 2017 (Figure 2). The total corn production from this acreage rose from 11.1 billion bushels in 2005 to 14.6 billion bushels in 2018 [9] (Figure 3).

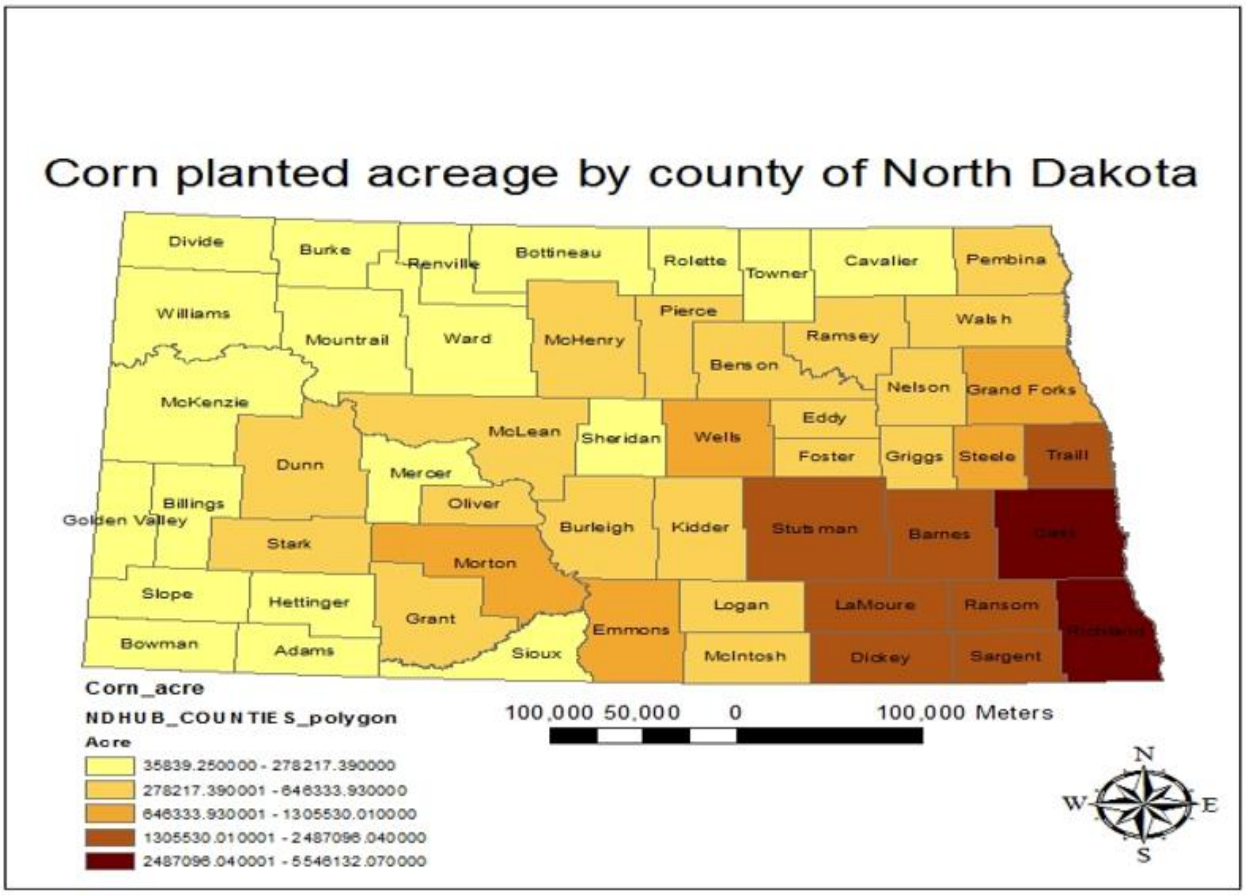

Figure-1. North Dakota Corn planted acreage map by county

Source: Cropland Data Layer
https://www.nass.usda.gov/Research_and_Science/Cropland/SARS1a.php

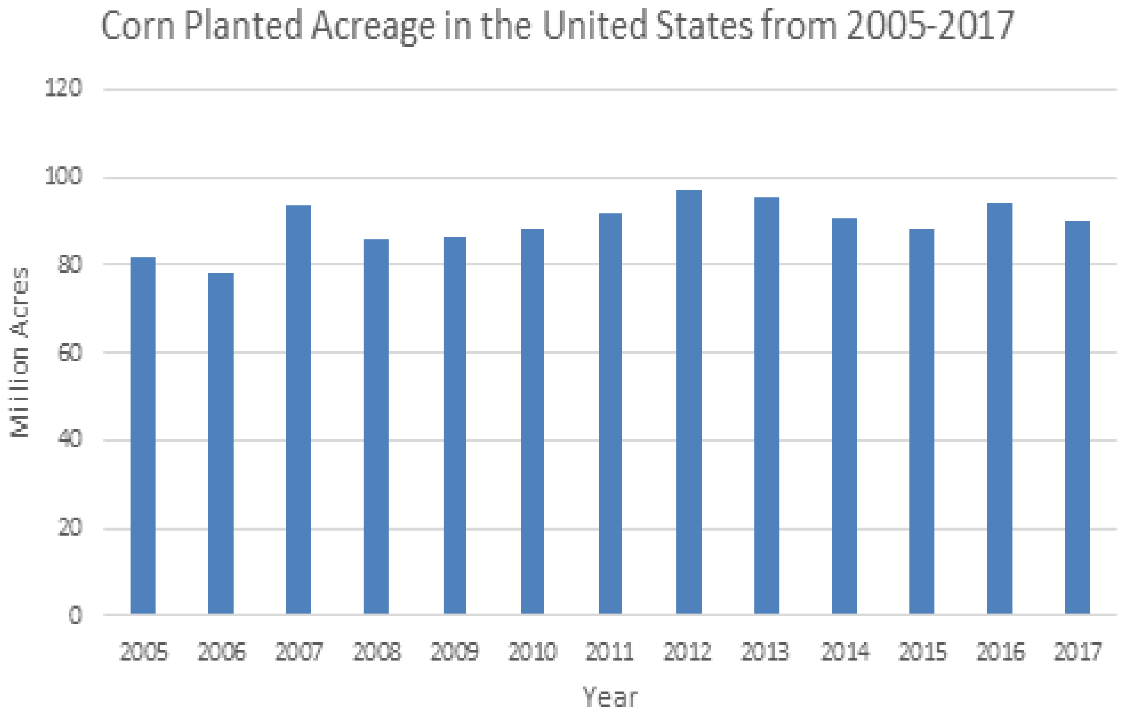

Figure-2. Corn Planted Acreage in the United States from 2005-2017

Source: Feed Grains Database: Custom Query Results
https://www.ers.usda.gov/data-products/feed-grains-database/

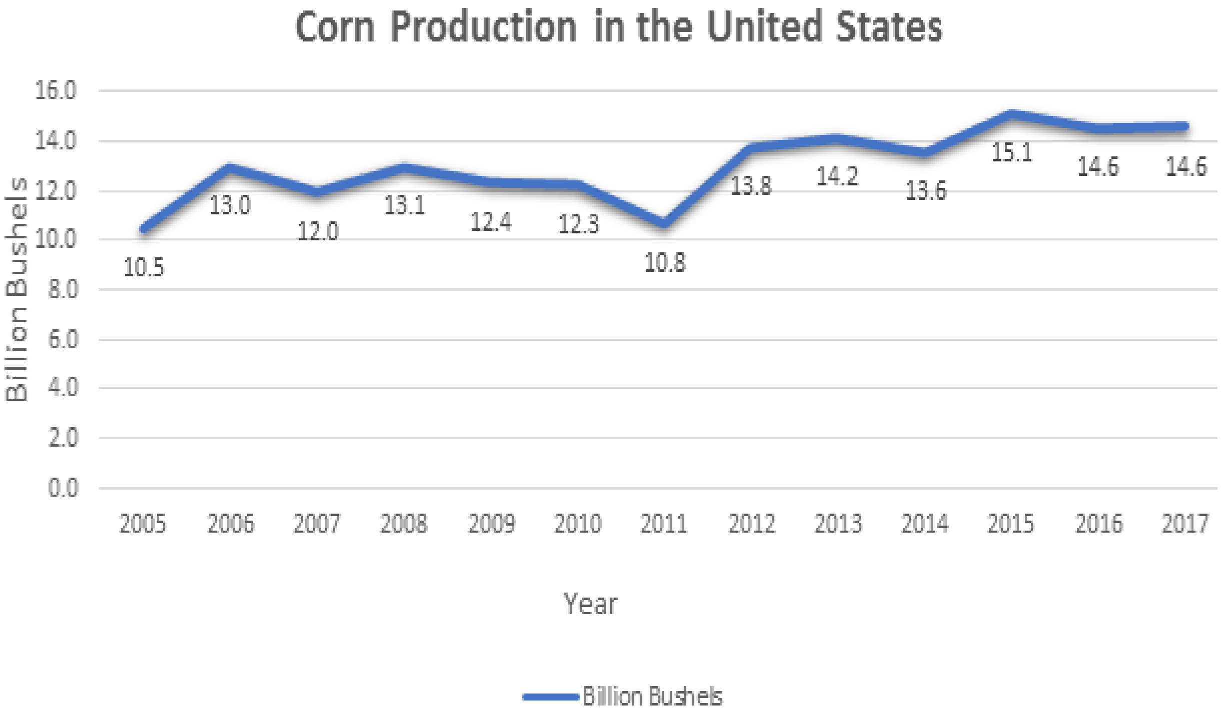

Figure-3. Corn Production in the United States from 2005-2018

The driving factors behind this dramatic growth in corn-based ethanol include the Clean Air Act of 1970 (which requires fuel to include an "oxygenating" agent in high smog areas), the Renewable Fuel Standard Acts of 2005 and 2007 (requiring the ethanol limit to be blended into the fuel supply), and market forces (when price increases in crude oil led to a higher demand for ethanol). Previously published findings indicate that this increase in biofuel production drove growth in corn prices by 22% and soybean prices by 15% between 2007 to 2008 [6]. Therefore, the primary factors causing changes in corn planted acreage are high demand for biofuel and biofuel policy mandates.

This study presents the effects on corn acreage response due to changes in crop prices, oil and biofuel volume, prices, and other exogenous variables. It examines the impact of climate change, market demand for ethanol, and other underlying factors driving local corn planting decisions by North Dakota (ND) farmers. Two concerns motivate this research: first, the increased impact of climate change on crop area, yields, and land values; and second, the expansion of economic growth in U.S. rural economies due to the emergence and success of biofuel technology as a substitute for traditional energy sources. For example, a rural farmer might view ethanol as a value-added strategy and so can achieve financial gain by processing their corn into ethanol instead of selling it on the commodity market [10]. Feedstock producers may also then achieve additional financial success along with an increase in land values located near ethanol plants [11]. In addition to these economic benefits, the increasing volatility in petroleum markets and the demand for renewable energy have further contributed to the growing interest in bioenergy crops.

The literature covering the estimation of supply in response to prices in agricultural economics has a long history [12, 13] and there is now a renewed interest in supply response research. Much of the existing econometric analyses focus on domestic price shocks to national supply responses [14] along with a concentration on country-level supply responses to prices [15]. This article instead addresses the supply response function of crop corn at the county-level due to factors like crop prices, biofuel policies, rainfall, temperature, crop yields, and other crop stock variables. For our empirical study, we use acreage as a representation of the desired output supply.

Corn planted acres is selected for modeling the output supply response because (a) it is not influenced by external shocks that occur after planting and (b) acreage response is also an environmental issue, which this analysis includes. Following Nerlove [16] several previous studies alternatively selected yield and production along with acreage as proxy for the desired output supply [17, 18]. In addition, the majority of previous empirical literature at the farm- and micro-level ignore the climate affect in their supply response model [19, 20]. However, external "climate variables" are also important to include in supply response model because as farmers become aware of the climate for a certain location (the maximum and minimum air temperature, and precipitation over the long run), their production decision-making would be more informed. Therefore, a climate variable is included here to see how it might affect farmers' planting decisions. The impact of weather on yields can be estimated by using a simulation approach and field experiments [21]. A Ricardian economic approach has also been used to assess the impact of climate change using cross-sectional data, which assumes constant input and output prices over time [22].

Several empirical studies in the literature conclude the possibility that producers would switch crops as a result of changing prices and other factors. This choice then leads to acreage expansion of "high demand" crops, such as corn, by shifting out "low demand" cropland [23]. Another study supports the idea that selecting planted acreage as a dependent variable can reduce endogeneity bias in a supply elasticity estimation [24]. Our research subtly differs from these previous studies regarding the selection of the dependent variable (corn planted acreage), the proxy used for expected prices, and the inclusion of prices and yields from North Dakota producers' own and competing crops. Instead, we use corn, wheat, and soybean future prices to proxy for farmers' anticipated prices.

We also contribute to the literature by identifying how information about temperature and precipitation affect corn acre planting decisions. Farmers are facing the challenge of increasing food production to address the issue of a growing per-capita consumption and the use of agricultural products as biofuels. The problem of planting time is key to maintaining crop yields in the face of a changing climate [25, 26]. The information on relative wetness and dryness of a local area is also affecting planting decisions as farmers can rotate their crop choices based on these levels in the atmosphere.

The hypothesis of this paper is the corn acreage response function correlates crops selections by individual farmers and their competitors with the expected prices, yields, ethanol prices and volume, crop stocks, air temperature and precipitation in the long run. The central question explored here is how corn planting decisions by local farmers and producers are affected by changes in expected prices and yields of their crops and those of their competitors, along with energy prices and weather variables. Also, we provide relevant information on the potential exogenous factors that drive corn acreage expansion in North Dakota. Our article highlights the connection between the growing energy sector and the weather, and the consequences for these local crop areas. Finally, we analyze the supply responsiveness of corn crops to changes in output prices for major crops, ethanol production, biofuel policies, and weather at the county-level of North Dakota.

Understanding the connection between biofuel policy mandates, crop prices, climate, and crop area response are useful when designing agricultural, environmental, and natural resource management policies. Researchers and policy-makers are very interested in better understanding the effects of the biofuel industry on the agricultural landscape of the United States (U.S.). The findings presented here will help forecast future land use trends and crop area responses. Further, this research will help policy-makers and producers make better-informed crop production decisions.

2. Conceptual Framework

A crop production function can model the relationship between crop yield per acre or acreage expansion and the factors affecting it, such as farm management practices, climate, and input and expected output prices. Crop yield per acre or acreage expansion at the county-level represents the decision of farmers both as an intensive and extensive margin. Farming decisions are likely to be affected by prices of crops as well as agricultural policies. In other words, both price and non-price factors play a vital role when examining farmers' production behavior and supply response. Price factors include output prices (both spot and future prices of crops) and input costs, and non-price factors including biophysical conditions, such as rainfall, temperature, and irrigation [14, 27]. Due to a lack of resources, there is a delay of output adjustments (including area and yield) for one to two agricultural production cycles. So, it is important to adopt a dynamic approach that incorporates time lags in the agricultural supply response.

Two key frameworks have been developed to estimate supply responses after applying adjustments from both theoretical and empirical considerations [14, 28]. The first is the Nerlovian Partial adjustment Model (NPM) and the second is the Supply Function Approach (SFA). NPM allows for the estimation of adjustments from the actual output to the desired output. A profit-maximizing framework is the basis for SFA [29].

Our main focus in this research is to estimate the output supply function. In other words, our goal is to estimate farmers' output reaction to policy instruments and other price variables. As a result, we choose NPM to frame the econometric approach based on price expectations and partial area adjustments. We also expect that factors such as rainfall and the maximum and minimum temperature measured during the previous and current seasons play a fundamental role in farmers' corn acreage decisions. Thus, we also add alternative price expectation assumptions and other key explanatory variables, including weather, biofuel, energy policy, and crop future price into our econometric model.

3. Theoretical Framework

We assume that land tract "j" has two alternative uses of land known as crop and grass. The utility function of the producer can be given as $\pi_j^a + \gamma_j^a$ where π_j^a refers to profit from cropping and γ_j^a reflects profit idiosyncrasies particular to cropping operation. Profit form cropping can be viewed as $\pi_j^a\ (p^a, r^a, \alpha^a, w) \ = \max p^a q^a (x^a, \alpha^a, w)$

- $r^a\, x_j^a$ where p^a refers to output price, x^a vector of cropping inputs with price vector r^a, α^a stands for energy variables. Variable w stands for weather/climate variables. Similarly, producer utility from grass-based production can be viewed as
$\pi_j^g\ (p^g, r^g, \alpha^g, w)\ = \max\ p^g q^g(x^g, \alpha^g, w)$ - $r^g\, x_j^g$ where variables have meanings that correspond to those for cropping. The profit maximizing producer seeks to maximize over crop choice alternatives. We can model this as

$$\text{Max}\ [\gamma_j^a + \pi_j^a\ (p^a, r^a, \alpha^a, w).\, \gamma_j^g + \pi_j^g\ (p^g, r^g, \alpha^g, w)] \qquad (1)$$

From Equation (1) we can calculate the probability of land under crops as

$$\Pr\ (\text{cr}) = \frac{e^{\beta\pi_j^a\,(p^a, r^a, \alpha^a, w)}}{e^{\beta\pi_j^a\,(p^a, r^a, \alpha^a, w)} + e^{\beta\,\pi_j^g\,(p^g, r^g, \alpha^g, w)}} \qquad (2)$$

Here, β is a positive constant. The crop price responsiveness impact on land use decisions can be modeled as

$$\frac{d\,\Pr(cr)}{dp^a} = \beta q^a\ (p^a, r^a, \alpha^a, w)\Pr(cr)\Pr(gr) \qquad (3)$$

4. Conceptual Model

Crop supply response model can be formulated in terms of area, yield or total output response. Here, we model our corn supply response (dependent variable) in terms of planted acres. The desired crop area in time period *"t"* can be expressed as a function of expected prices of output and several other exogenous factors [30].

$$Y_t^a = \beta_1 + \overrightarrow{\beta_2}\overrightarrow{EP_t^e} + \overrightarrow{\beta_3}\overrightarrow{X_t} + \varepsilon_t \qquad (1)$$

here Y_t^a refers to planted acres of crop "a" in t time period; $\overrightarrow{EP}$ is the vector of expected prices; $\overrightarrow{X_t}$ denotes vector of set of exogenous variables including biofuel, energy policy variables, the wetness and dryness of weather, climate variables etc; ε_t accounts for unobserved factors affecting planting decision with zero expected mean; and β_t are the parameters to be estimated.

Here, we model the desired planted area of corn as a function of prices of corn and other competing crops of last year, expected yield and revenue to competing crops, and all other exogenous factors. We have N counties observed over T periods, the area of crop *"c"* in county i in t time period. We can rewrite Equation (1) as

$$Y_{cit} = \alpha_{c0} + \textstyle\sum_{e=1}^{l1} \alpha_{ce} Y_{ci,t-1} + \sum_{k=1}^{l2} \Sigma_j\, \beta_{c,j,k}\ \left(X_{cij,t-k}\right) + \varphi_{ct} + \theta_{ci} + u_{cit} \quad (2)$$

$E\,(\theta_{ci}) = E\,(u_{cit}) = E\,(\theta_{ci}u_{cit}) = 0$
$i = 1, \ldots N;\ t = m{+}2, \ldots, \text{T}.$

Where Y_{cit} denotes corn planted area in county i in time period t; α_{c0} is the intercept; α's and β's are the parameters to be estimated; X_j's are independent variables, the prices include future prices of own and competing crops that prevails in period t - k., and all other exogenous variables; φ_{ct} denotes dummy to capture the effect of biofuel policies and regulations; u_{cit} (idiosyncratic shock) refers to two orthogonal components of the disturbance term. Also, we assume the lag lengths $l1$ and $l2$ are sufficient to enusure that u_{cit} is a stochastic error, usually $l1$ equals $l2$.

5. Data and Variable Selection

For our model, we utilize a comprehensive database covering a period from 1990 to 2015 compiled from county-level planted acreage data for corn provided by the National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture (USDA). This data (Table 1) is used to estimate an acreage response function for corn where the corn planted area is the dependent variable. All other explanatory variables are incorporated in our estimation model. The inclusion of more variables with significate reduces omitted variables bias. The corn acreage response function includes data from all 53 ND counties. Also, corn and wheat spot price variables (excluding future prices) represent a one-year lag from state-level prices. However, the ethanol price variable is obtained from the national-level price. Finally, we apply a logarithmic transformation to all variables except the dependent variable.

We model farmers' price expectations using relevant crop spot and future prices since actual prices are not yet available during planting time. We used Quandl, an MS Excel extension, to compile the future price data for corn, soybean, and wheat between 1999 and 2015. From this source, we select February's price of corn, wheat, and soybean for December future contracts so that we can get price for the next crop year rather than current crop year. Further, the corn and wheat future prices data are collected from the Chicago Mercantile Exchange futures data and Stevens Continuous Futures data, respectively. All model variables are listed and explained in detail in Table 1.

The decision of timing of corn planting varies depending on the relative wetness and dryness of the weather. Also, farmers make planting decisions before planting start dates. Thus, we also include the Palmer Drought Severity Index (PDSI) to capture the soil moisture effect on corn planting decisions. The data on PDSI are compiled from North Dakota State University's (NDSU) climate station. PDSI values range from (-10) to (+10) and denotes relative wetness and dryness. We collect PDSI values for the planting month of March.

Table-1. Explanation of Model Variables

Variables	Definition	Units	Source
Corn_acre_sp	Total Corn planted acres by county	Acres	USDA, National Agricultural Statistics Service, Quick Stats (survey data);
			Farm service agency Report on corn planted acre (2009-2015)
Corn_fpy	Interaction of corn future price and corn yield	$ / BU	USDA, National Agricultural Statistics Service, Quick Stats (survey data)
Corn_stocks	National level Total corn, grain – stocks (month of December)	Bushel (BU)	USDA, National Agricultural Statistics Service, Quick Stats (survey data)
Corn_fp	December future contract price for corn*	$ / BU	Chicago mercantile exchange futures data on "Quandl"
Wheat_fp	State level annual spot price for wheat	$ / BU	USDA, National Agricultural Statistics Service, Quick Stats (survey data)
Hay_sp	State level annual spot price for hay	$ / BU	USDA, National Agricultural Statistics Service, Quick Stats (survey data)
Soybean_fp	December future contract price for soybean*	$ / BU	Chicago mercantile exchange futures data on "Quandl"
Eth_price	Ethanol price	$ / gal	Nebraska Energy Office, http://www.neo.ne.gov/statshtml/66.html
Eth_vol	Annual U.S. Fuel Ethanol Production (volume)	millions of gallons	http://www.ethanolrfa.org/resources/industry/statistics
Renfuel_vol	Renewable fuel mandate volume	millions of gallons	Renewable fuels association;
			http://www.ethanolrfa.org/policy/
			regulations/renewable-fuel-standard/
Logtrans_pdsi	Palmer drought severity index		https://www.ndsu.edu/climate
Max_temp	Maximum air temperature in the month of June & July	in degree Fahrenheit	https://www.ndsu.edu/climate
t_rainfall	total precipitation (month of April, May, June and July)	in inch	https://www.ndsu.edu/climate
Min_temp	Minimum air temperature in the month of May	in degree Fahrenheit	https://www.ndsu.edu/climate
Corn_yield	County level corn, grain - yield	BU / ACRE	USDA, National Agricultural Statistics Service, Quick Stats (survey data)
County Dummy	County dummy variables		
Eth_plant_d	Dummy variables for ethanol plants		County with ethanol plants = 1; otherwise = 0

For ND, we first identify the most active planting dates based on the NASS report and then select prices for corn, soybeans, and wheat during these times. We next add the future prices into our regression model. We collect county-level corn planted acres data from the USDA (from 1990 to 2006) and also from the Farm Service Agency Report (from 2007 to 2015). Also, we obtain the national-level data on corn stocks for December and the state-level annual data on spot prices for corn, wheat, and soybean from the NASS quick stats. We compiled ethanol price data from the Nebraska Energy Office (from 1990 to 2015). Finally, all price variables for corn, soybean, wheat future price, hay spot price, and ethanol price are converted to 2015 dollars using the U.S. Gross Domestic Product (GDP) implicit price deflator. In other words, we adjust all price variables for inflation with the base year of 2015.

Data is included in our analysis on ND weather variables such as maximum air temperature, minimum air temperature, and total precipitation, and these climate variables come from the NDSU official website (www.ndsu.edu/climate). A representative weather station located within ND county boundaries provides the basis for the county weather variables. Trends in these measured temperatures and precipitations over an extended time frame is a key component of our corn acreage response function as the variation of climatic variables across counties is quite significant over time. Other factors believed to have contributed to crop acreage response include weather/climate. The factors like maximum temperature (month of June and July), rainfall (month of April, May, June and July), and minimum temperature (month of May) of previous year are believed to be contributed to farmers' crop choices decision for the upcoming year.

The Renewable Fuels Association is the primary data source for renewable fuel volume (in millions of gallons), which we obtained from their database. There are five ethanol plants in North Dakota producing millions of gallons of ethanol each year. So, an "ethanol plant dummy" variable is also added into the model to examine the effect of those plants in farmers' corn planting decisions. This variable will also help capture ethanol plant effect on price in a particular county.

6. Empirical Framework

The predictions are tested by estimating relationships in the data in regression equation. Here, multiple linear regression framework is used to estimate our parameters. Our hypothesis "Demand for ethanol posed by market significantly affect local crop selection decision of U.S. farmers over a certain period" is typically examined using corn acreage supply function model. Given the abovementioned theoretical model (1) & (2), and assuming we have *N* counties observed over *T* periods, the crop acreage response function can be expressed as

$$A_{cit} = \alpha_{c0} + \sum_{j=1}^{J} \beta_{i,j}^{RFS}\, RFS_{j,i,t} + \sum_{j=1}^{J} \beta_{i,j}^{Y}\, Y_{j,i,t} + \sum_{f=1}^{f} \beta_{i,f}^{P}\, P_{f,t} + \sum_{m=1}^{m} \beta_{m}^{L}\, L_{i,m} + u_{i,t}$$

$$i = 1, \dots N;$$

Where A_{cit} denotes corn planted area in county *i* in time period *t*; α_{c0} is the intercept for crop *c*, β's are the parameters to be estimated. $RFS_{j,i,t}$ accounts for renewable fuel mandate at county *i* in year *t*; $Y_{j,i,t}$ is the yield of crop *j* in county *i* in year *t*; $Y_{j,i,t}$ denotes yield of crop *j* in county *i* in year *t*; $P_{f,t}$ refers to expected price of good *f* (which could either be another crop or a factor of production) in year ; $L_{i,m}$ is the value of time-invariant factor *m* (which could be latitude, and longitude) in county *i*; $\beta_{i,j}^{RFS}$ is the effect of rfs ; $\beta_{i,j}^{Y}$ is the effect of expected yield of crop *j*; $\beta_{i,l}^{P}$ is the effect of the price of good *f* on county *i*; β_{m}^{L} is the impact of time-invariant factor *m and* $u_{i,t}$ is an error term for corn in county *i* in year *t*, having a mean of zero, and a variance σ_i^2.

7. Estimation Methods

All explanatory variables, including prices of farmer crops, their competitors, and the ethanol price, are specified as logarithms in our econometric model. Thus, the estimated coefficients are defined as short-run elasticities, and we use multiple linear regression models to estimate these parameters. A "Least Squares" method predicted the model parameters and the interaction effect of county dummies on repressors are also added into our regression model.

7.1. Tests for Multicollinearity

We test for collinearity among corn yield, corn expected revenue, and corn spot price variables. According to the rank correlation test, there is collinearity among corn yield and corn expected revenue (r = 0.82). Thus, we drop the corn yield variable and re-run the multiple regression models, which improves the model by generating more efficient parameters.

7.2. Tests for Heteroscedasticity

We run white test to check for potential heteroscedasticity. We account for heteroscedasticity by using county interaction effect of majority variables. The inclusion of county interaction variables improves the model by estimating heteroscedasticity consistent parameters.

8. Results and Discussion

This paper presents an empirical analysis of producers' corn planting decision behavior due to econometric conditions, biophysical factors, energy, and biofuel policy variables at the county-level in ND from 1990 to 2015. We compiled a database built on a USDA-NASS source including variables of corn planted acre, corn stocks, and major crop (corn, wheat, soybean, and hay) prices. We also used interaction term of corn future price and yield in our model to capture the marginal effect of corn future price. The marginal effect is also known as elasticity and an important component of our corn acreage model. The climate variables (maximum and minimum air temperature, PDSI, and rainfall) are obtained from the NDSU climate station. In addition, variables such as ethanol prices and renewable fuel mandate volumes are also included. We also add biophysical environment variables like monthly temperature (max & min), total precipitation, and palmer drought severity index (PDSI) data from NDSU climate station. Further, our analysis includes dummy variables like county dummy and ethanol plants. All our model variables are explained in Table 1.

Our regression results include both significant and insignificant variables. Even though the sign of the estimated coefficients for some of these variables matches our expectation, parameters were not significant ($\rho > 0.10$) (Table 2). Thus, we exclude further discussion of these insignificant variables from our analysis. Our multiple linear regression model variables are explained and reported in Table 3. Parameters are estimated using the least-square method. The statistical significance of regression coefficients is tested using the t-statistic table probability. The reported test statistics are R-squared = 0.96, Adj R-sq = 0.93, F-statistics= 36.80, Probability > F = <0.0001, and number of observation = 1,378 (Table 2). The coefficients presented in Table 3 are LS estimators, which indicate the greatest probability of giving the observed value. The model includes an F-test to test the significance of coefficients (in the case of LS estimators). All model variables lag by one year except for the future price variables. Finally, we take the natural logarithm of all model variables. From a purely statistical viewpoint, the estimated regression line fits the data well. The R^2 value of 0.96 means that 96% of the variation in the corn planted acreage (the scaled proportion) is explained by the logs of all the explanatory variables.

The key results here indicate variables such as interaction term of corn future price and yield, corn stocks, the future prices for corn and soybean, the and spot prices for wheat and hay crops are statistically significant (ρ values < 0.10). However, variables like ethanol price, ethanol volume, renewable fuel mandate volume, and minimum temperature are insignificant (ρ values > 0.10).

Table-2. Multiple Linear Regression Model Analysis of Variance (ANOVA)

Number of observation = 1,378

R-squared = 0.95

Adj R-squared = 0.93

Root MSE = 1.42

Coeff var = 38.63

Source	**Sum of Squares**	**DF**	**Mean Square**	**F Value**	**Pr > F**
Model	39970	533	74.99	37.1	<.0001
Error	1706.04	844	2.02		
Corrected Total	41676	1377			

Table-3. Multiple Linear Regression Parameter Estimates

Dependent variable: corn_acre_sp						**Heteroscedasticity consistent**		
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	-16.84	16.61	-1.01	0.31	11.47	-1.47	0.14
eth_plant_d	1	0.06	1.13	0.05	0.96	0.6	0.1	0.92
t_rainfall	1	0.27	0.18	1.51	0.13	0.13	2.08	0.04
soybean_fp	1	1.16	0.65	1.77	0.08	0.45	2.59	0.01
logtrans_pdsi	1	-0.04	0.8	-0.04	0.96	0.24	-0.15	0.88
Barnes_D_logtrans_pdsi	1	0.51	1.38	0.37	0.71	1.34	0.38	0.7
Benson_D_logtrans_pdsi	1	0.45	1.31	0.34	0.73	0.57	0.78	0.43
Billings_D_logtrans_pdsi	1	-0.11	1.34	-0.08	0.93	0.26	-0.43	0.67
Bottineau_D_logtrans_pdsi	1	0.93	1.39	0.66	0.51	0.34	2.7	0.01
Bowman_D_logtrans_pdsi	1	-0.22	1.25	-0.17	0.86	0.32	-0.68	0.5
Burke_D_logtrans_pdsi	1	-0.1	1.23	-0.08	0.93	0.26	-0.4	0.69
Burleigh_D_logtrans_pdsi	1	0.02	1.38	0.01	0.99	0.41	0.05	0.96
Cass_D_logtrans_pdsi	1	-0.44	1.36	-0.33	0.74	1.96	-0.23	0.82
Cavalier_D_logtrans_pdsi	1	0.28	1.6	0.17	0.86	0.35	0.78	0.43
Dickey_D_logtrans_pdsi	1	-3.3	1.39	-2.38	0.02	2.15	-1.53	0.13
Divide_D_logtrans_pdsi	1	0.19	1.37	0.14	0.89	0.26	0.71	0.48
Dunn_D_logtrans_pdsi	1	-0.09	1.3	-0.07	0.95	0.29	-0.3	0.77
Eddy_D_logtrans_pdsi	1	0.84	1.35	0.62	0.53	0.63	1.33	0.18
Emmons_D_logtrans_pdsi	1	-0.23	1.28	-0.18	0.86	0.93	-0.25	0.81
Foster_D_logtrans_pdsi	1	1.18	1.34	0.88	0.38	1.17	1.01	0.32
Goldenvalley_D_logtrans_pdsi	1	-0.01	1.36	0	1	0.28	-0.02	0.98
GrandForks_D_logtrans_pdsi	1	1	1.36	0.73	0.46	0.79	1.26	0.21
Grant_D_logtrans_pdsi	1	-0.08	1.2	-0.07	0.94	0.42	-0.2	0.84
Griggs_D_logtrans_pdsi	1	0.32	1.3	0.24	0.81	0.68	0.46	0.64
Hettinger_D_logtrans_pdsi	1	-0.01	1.26	0	1	0.48	-0.01	0.99
Kidder_D_logtrans_pdsi	1	-0.13	1.4	-0.09	0.93	0.4	-0.32	0.75
LaMoure_D_logtrans_pdsi	1	-2.79	1.38	-2.02	0.04	2.11	-1.32	0.19
Logan_D_logtrans_pdsi	1	-0.92	1.45	-0.63	0.53	0.85	-1.08	0.28
McHenry_D_logtrans_pdsi	1	0.46	1.26	0.36	0.72	0.4	1.13	0.26
McIntosh_D_logtrans_pdsi	1	-0.85	1.42	-0.6	0.55	0.71	-1.2	0.23
McKenzie_D_logtrans_pdsi	1	0.01	1.3	0.01	0.99	0.25	0.06	0.95
McLean_D_logtrans_pdsi	1	0.33	1.36	0.25	0.81	0.34	0.97	0.33
Mercer_D_logtrans_pdsi	1	1	1.57	0.64	0.52	0.58	1.73	0.08
Morton_D_logtrans_pdsi	1	0.13	1.33	0.1	0.92	0.44	0.29	0.77
Mountrail_D_logtrans_pdsi	1	-0.02	1.42	-0.01	0.99	0.26	-0.08	0.94
Nelson_D_logtrans_pdsi	1	-0.62	1.43	-0.43	0.66	0.52	-1.19	0.23
Oliver_D_logtrans_pdsi	1	0.19	1.22	0.15	0.88	0.39	0.48	0.63
Pembina_D_logtrans_pdsi	1	0.26	1.4	0.19	0.85	0.44	0.6	0.55

Pierce_D_logtrans_pdsi	1	0.59	1.47	0.4	0.69	0.6	0.98	0.33
Ramsey_D_logtrans_pdsi	1	-0.32	1.35	-0.24	0.81	1.29	-0.25	0.8
Ransom_D_logtrans_pdsi	1	0.1	1.27	0.08	0.93	1.14	0.09	0.93
Renville_D_logtrans_pdsi	1	0.26	1.21	0.21	0.83	0.3	0.86	0.39
Richland_D_logtrans_pdsi	1	-1.43	1.28	-1.12	0.26	1.36	-1.05	0.29
Rolette_D_logtrans_pdsi	1	-0.23	1.24	-0.19	0.85	0.32	-0.73	0.47
Sargent_D_logtrans_pdsi	1	-0.95	1.29	-0.74	0.46	1.59	-0.6	0.55
Sheridan_D_logtrans_pdsi	1	-0.16	1.27	-0.12	0.9	0.52	-0.3	0.76
Sioux_D_logtrans_pdsi	1	-0.89	1.21	-0.73	0.46	0.46	-1.93	0.05
Slope_D_logtrans_pdsi	1	-0.03	1.29	-0.02	0.98	0.28	-0.11	0.91
Stark_D_logtrans_pdsi	1	-0.05	1.28	-0.04	0.97	0.35	-0.14	0.89
Steele_D_logtrans_pdsi	1	1.15	1.29	0.9	0.37	1.88	0.61	0.54
Stutsman_D_logtrans_pdsi	1	-1.36	1.51	-0.9	0.37	1.23	-1.11	0.27
Towner_D_logtrans_pdsi	1	0.51	1.41	0.36	0.72	0.4	1.27	0.2
Trail_D_logtrans_pdsi	1	4.82	1.36	3.55	0	2.54	1.9	0.06
Walsh_D_logtrans_pdsi	1	0.29	1.51	0.19	0.85	0.51	0.57	0.57
Ward_D_logtrans_pdsi	1	0.01	1.25	0.01	1	0.27	0.03	0.98
Wells_D_logtrans_pdsi	1	0.16	1.28	0.13	0.9	0.7	0.23	0.81
Williams_D_logtrans_pdsi	1	0.08	1.31	0.06	0.95	0.25	0.31	0.76
corn_fpy	1	0.08	0.2	0.41	0.68	0.06	1.36	0.17
Barnes_D_corn_fpy	1	2.71	1.19	2.27	0.02	1.42	1.91	0.06
Benson_D_corn_fpy	1	0.65	1	0.66	0.51	0.5	1.3	0.19
Billings_D_corn_fpy	1	-0.13	0.27	-0.48	0.63	0.06	-2.04	0.04
Bottineau_D_corn_fpy	1	-0.51	1.12	-0.46	0.65	0.28	-1.85	0.06
Bowman_D_corn_fpy	1	0	0.31	0	1	0.07	0.01	0.99
Burke_D_corn_fpy	1	-0.1	0.25	-0.4	0.69	0.06	-1.65	0.1
Burleigh_D_corn_fpy	1	-0.94	1.26	-0.75	0.45	0.3	-3.11	0
Cass_D_corn_fpy	1	5.34	1.14	4.7	0	1.81	2.95	0
Cavalier_D_corn_fpy	1	-0.09	0.44	-0.21	0.84	0.08	-1.1	0.27
Dickey_D_corn_fpy	1	3.19	1.57	2.03	0.04	2.67	1.2	0.23
Divide_D_corn_fpy	1	-0.06	0.24	-0.26	0.79	0.06	-1.05	0.3
Dunn_D_corn_fpy	1	-0.15	0.85	-0.17	0.86	0.13	-1.12	0.26
Eddy_D_corn_fpy	1	-0.32	0.92	-0.35	0.73	0.44	-0.74	0.46
Emmons_D_corn_fpy	1	-1.64	0.85	-1.94	0.05	0.63	-2.61	0.01
Foster_D_corn_fpy	1	-1.06	1.02	-1.03	0.3	1.18	-0.89	0.37
Goldenvalley_D_corn_fpy	1	-0.06	0.27	-0.24	0.81	0.06	-1.01	0.31
GrandForks_D_corn_fpy	1	2.64	1.42	1.86	0.06	1.16	2.28	0.02
Grant_D_corn_fpy	1	0.45	1.24	0.36	0.72	0.66	0.68	0.5
Griggs_D_corn_fpy	1	0.26	1.22	0.21	0.83	0.69	0.37	0.71
Hettinger_D_corn_fpy	1	0.12	0.31	0.4	0.69	0.1	1.19	0.23
Kidder_D_corn_fpy	1	-0.35	1.09	-0.32	0.75	0.26	-1.34	0.18
LaMoure_D_corn_fpy	1	3.93	1.52	2.59	0.01	2.75	1.43	0.15
Logan_D_corn_fpy	1	-1.28	1.39	-0.91	0.36	0.93	-1.38	0.17
McHenry_D_corn_fpy	1	-0.15	0.99	-0.15	0.88	0.26	-0.58	0.56
McIntosh_D_corn_fpy	1	-2.6	1.57	-1.66	0.1	0.96	-2.72	0.01
McKenzie_D_corn_fpy	1	-0.09	0.36	-0.25	0.81	0.06	-1.46	0.15
McLean_D_corn_fpy	1	-0.29	1.39	-0.21	0.83	0.41	-0.72	0.47
Mercer_D_corn_fpy	1	-0.42	1.39	-0.3	0.76	0.48	-0.88	0.38
Morton_D_corn_fpy	1	0.13	1.28	0.1	0.92	0.53	0.24	0.81
Mountrail_D_corn_fpy	1	-0.09	0.29	-0.3	0.77	0.06	-1.43	0.15
Nelson_D_corn_fpy	1	1.67	1.53	1.09	0.28	0.62	2.69	0.01
Oliver_D_corn_fpy	1	0.28	0.89	0.32	0.75	0.34	0.83	0.41

Pembina_D_corn_fpy	1	-0.34	1.17	-0.29	0.77	0.48	-0.71	0.48
Pierce_D_corn_fpy	1	0.12	1.23	0.1	0.92	0.5	0.25	0.8
Ramsey_D_corn_fpy	1	1.8	1	1.8	0.07	0.98	1.84	0.07
Ransom_D_corn_fpy	1	1.01	1.16	0.87	0.39	0.87	1.16	0.25
Renville_D_corn_fpy	1	-0.06	0.26	-0.23	0.82	0.07	-0.88	0.38
Richland_D_corn_fpy	1	3.17	1.11	2.86	0	1.34	2.37	0.02
Rolette_D_corn_fpy	1	-0.05	0.32	-0.17	0.87	0.07	-0.71	0.48
Sargent_D_corn_fpy	1	2.59	1.13	2.29	0.02	1.1	2.35	0.02
Sheridan_D_corn_fpy	1	0.35	1	0.35	0.72	0.39	0.9	0.37
Sioux_D_corn_fpy	1	-0.2	0.27	-0.72	0.47	0.08	-2.41	0.02
Slope_D_corn_fpy	1	-0.03	0.3	-0.09	0.93	0.06	-0.42	0.67
Stark_D_corn_fpy	1	0.05	0.31	0.18	0.86	0.08	0.72	0.47
Steele_D_corn_fpy	1	3.67	1.09	3.37	0	1.86	1.97	0.05
Stutsman_D_corn_fpy	1	2.22	1.35	1.64	0.1	1.44	1.55	0.12
Towner_D_corn_fpy	1	-0.14	0.4	-0.34	0.73	0.1	-1.32	0.19
Trail_D_corn_fpy	1	8.79	1.15	7.65	0	2.65	3.32	0
Walsh_D_corn_fpy	1	0.7	1.4	0.5	0.62	0.71	0.98	0.33
Ward_D_corn_fpy	1	-0.08	0.31	-0.25	0.8	0.06	-1.22	0.22
Wells_D_corn_fpy	1	0.9	1.02	0.89	0.38	0.77	1.18	0.24
Williams_D_corn_fpy	1	-0.08	0.28	-0.29	0.77	0.06	-1.33	0.19
corn_stocks	1	-0.08	1.31	-0.06	0.95	0.62	-0.13	0.89
Barnes_D_corn_stocks	1	0.9	2.71	0.33	0.74	2.5	0.36	0.72
Benson_D_corn_stocks	1	0.49	2.58	0.19	0.85	1.44	0.34	0.73
Billings_D_corn_stocks	1	0.48	1.89	0.25	0.8	0.46	1.04	0.3
Bottineau_D_corn_stocks	1	-0.56	2	-0.28	0.78	0.62	-0.9	0.37
Bowman_D_corn_stocks	1	0.39	1.77	0.22	0.83	0.45	0.88	0.38
Burke_D_corn_stocks	1	0.57	1.75	0.32	0.75	0.42	1.36	0.17
Burleigh_D_corn_stocks	1	-0.67	2.13	-0.32	0.75	0.65	-1.04	0.3
Cass_D_corn_stocks	1	1.19	2.34	0.51	0.61	3.16	0.38	0.71
Cavalier_D_corn_stocks	1	0.41	1.84	0.23	0.82	0.48	0.86	0.39
Dickey_D_corn_stocks	1	-1.42	2.14	-0.66	0.51	2.56	-0.56	0.58
Divide_D_corn_stocks	1	0.73	1.74	0.42	0.67	0.42	1.73	0.08
Dunn_D_corn_stocks	1	0.71	2.06	0.35	0.73	0.47	1.5	0.13
Eddy_D_corn_stocks	1	-0.88	2.51	-0.35	0.73	0.96	-0.92	0.36
Emmons_D_corn_stocks	1	-1.57	1.7	-0.93	0.35	1.08	-1.45	0.15
Foster_D_corn_stocks	1	-3.44	2.9	-1.19	0.23	2.97	-1.16	0.25
Goldenvalley_D_corn_stocks	1	0.3	1.97	0.15	0.88	0.44	0.67	0.51
GrandForks_D_corn_stocks	1	1.28	2.26	0.57	0.57	1.38	0.93	0.35
Grant_D_corn_stocks	1	-0.81	1.77	-0.46	0.65	0.61	-1.31	0.19
Griggs_D_corn_stocks	1	-1.16	2.57	-0.45	0.65	1.18	-0.99	0.32
Hettinger_D_corn_stocks	1	0.1	1.85	0.05	0.96	0.61	0.17	0.87
Kidder_D_corn_stocks	1	-0.53	2.52	-0.21	0.83	0.65	-0.81	0.42
LaMoure_D_corn_stocks	1	-0.74	2.39	-0.31	0.76	2.67	-0.28	0.78
Logan_D_corn_stocks	1	-2.01	1.97	-1.02	0.31	1.28	-1.57	0.12
McHenry_D_corn_stocks	1	0.63	2.41	0.26	0.79	0.72	0.88	0.38
McIntosh_D_corn_stocks	1	-3.73	2.05	-1.81	0.07	1.02	-3.64	0
McKenzie_D_corn_stocks	1	0.58	2.04	0.29	0.78	0.41	1.42	0.16
McLean_D_corn_stocks	1	-0.25	2.86	-0.09	0.93	0.86	-0.29	0.77
Mercer_D_corn_stocks	1	0.7	2.07	0.34	0.74	0.81	0.86	0.39
Morton_D_corn_stocks	1	0.35	1.96	0.18	0.86	0.72	0.49	0.63
Mountrail_D_corn_stocks	1	0.59	1.88	0.31	0.76	0.41	1.42	0.16
Nelson_D_corn_stocks	1	1.43	2.78	0.51	0.61	1.05	1.36	0.18

Oliver_D_corn_stocks	1	1.39	2.08	0.67	0.5	0.75	1.86	0.06
Pembina_D_corn_stocks	1	0.55	2.51	0.22	0.83	1.12	0.49	0.62
Pierce_D_corn_stocks	1	0.39	2.62	0.15	0.88	0.94	0.42	0.67
Ramsey_D_corn_stocks	1	0.98	2.55	0.39	0.7	1.83	0.54	0.59
Ransom_D_corn_stocks	1	-0.37	2.31	-0.16	0.87	2.03	-0.18	0.86
Renville_D_corn_stocks	1	0.48	1.91	0.25	0.8	0.48	0.99	0.32
Richland_D_corn_stocks	1	-1.69	2.32	-0.73	0.47	2.47	-0.68	0.5
Rolette_D_corn_stocks	1	0.51	1.78	0.29	0.77	0.53	0.97	0.33
Sargent_D_corn_stocks	1	0.64	2.32	0.27	0.78	2.64	0.24	0.81
Sheridan_D_corn_stocks	1	-0.46	1.84	-0.25	0.8	0.61	-0.75	0.45
Sioux_D_corn_stocks	1	0.24	1.86	0.13	0.9	0.72	0.34	0.74
Slope_D_corn_stocks	1	0.39	1.81	0.21	0.83	0.44	0.88	0.38
Stark_D_corn_stocks	1	0.62	1.9	0.33	0.74	0.52	1.2	0.23
Steele_D_corn_stocks	1	0.22	2.48	0.09	0.93	3.3	0.07	0.95
Stutsman_D_corn_stocks	1	-1.19	2.49	-0.48	0.63	1.76	-0.67	0.5
Towner_D_corn_stocks	1	-0.26	1.94	-0.14	0.89	0.67	-0.39	0.7
Trail_D_corn_stocks	1	6.03	2.33	2.59	0.01	4.85	1.24	0.21
Walsh_D_corn_stocks	1	0.01	2.63	0	1	0.95	0.01	0.99
Ward_D_corn_stocks	1	0.42	2.11	0.2	0.84	0.46	0.91	0.36
Wells_D_corn_stocks	1	-0.75	2.33	-0.32	0.75	1.27	-0.59	0.56
Williams_D_corn_stocks	1	0.61	2.27	0.27	0.79	0.42	1.47	0.14
corn_fp	1	-1.67	3.53	-0.47	0.64	1.21	-1.38	0.17
Barnes_D_corn_fp	1	-21.08	6.01	-3.5	0	7.4	-2.85	0
Benson_D_corn_fp	1	-6.87	5.89	-1.17	0.24	2.7	-2.55	0.01
Billings_D_corn_fp	1	0.9	5.56	0.16	0.87	1.26	0.72	0.47
Bottineau_D_corn_fp	1	-1.37	5.98	-0.23	0.82	2.01	-0.68	0.5
Bowman_D_corn_fp	1	0.68	5.45	0.13	0.9	1.42	0.48	0.63
Burke_D_corn_fp	1	0.21	5.16	0.04	0.97	1.28	0.16	0.87
Burleigh_D_corn_fp	1	2.63	6.93	0.38	0.7	1.95	1.35	0.18
Cass_D_corn_fp	1	-30.55	6.33	-4.82	0	7.46	-4.09	0
Cavalier_D_corn_fp	1	-0.86	5.25	-0.16	0.87	1.45	-0.6	0.55
Dickey_D_corn_fp	1	-18.3	7.17	-2.55	0.01	9.66	-1.9	0.06
Divide_D_corn_fp	1	-0.11	5.2	-0.02	0.98	1.28	-0.09	0.93
Dunn_D_corn_fp	1	0.76	6.7	0.11	0.91	1.43	0.53	0.6
Eddy_D_corn_fp	1	-1.63	5.69	-0.29	0.77	2.77	-0.59	0.56
Emmons_D_corn_fp	1	6.09	6.21	0.98	0.33	4.97	1.23	0.22
Foster_D_corn_fp	1	-4.59	5.95	-0.77	0.44	4.27	-1.07	0.28
Goldenvalley_D_corn_fp	1	-0.24	5.45	-0.04	0.97	1.4	-0.17	0.86
GrandForks_D_corn_fp	1	-13.18	7.05	-1.87	0.06	4.15	-3.18	0
Grant_D_corn_fp	1	-1.36	7.44	-0.18	0.86	2.89	-0.47	0.64
Griggs_D_corn_fp	1	-7.32	6.47	-1.13	0.26	3.82	-1.91	0.06
Hettinger_D_corn_fp	1	-1.12	5.53	-0.2	0.84	2.24	-0.5	0.62
Kidder_D_corn_fp	1	0.63	6.58	0.1	0.92	1.59	0.4	0.69
LaMoure_D_corn_fp	1	-23.99	6.93	-3.46	0	11.59	-2.07	0.04
Logan_D_corn_fp	1	6.03	7.58	0.8	0.43	4.07	1.48	0.14
McHenry_D_corn_fp	1	-1.95	5.84	-0.33	0.74	1.87	-1.05	0.3
McIntosh_D_corn_fp	1	8.19	6.91	1.19	0.24	3.87	2.11	0.03
McKenzie_D_corn_fp	1	0.77	5.39	0.14	0.89	1.21	0.64	0.52
McLean_D_corn_fp	1	-0.24	6.42	-0.04	0.97	2.12	-0.11	0.91
Mercer_D_corn_fp	1	-1.72	6.56	-0.26	0.79	2.17	-0.79	0.43
Morton_D_corn_fp	1	-0.75	7.05	-0.11	0.92	2.15	-0.35	0.73
Mountrail_D_corn_fp	1	0.54	5.38	0.1	0.92	1.24	0.44	0.66

Nelson_D_corn_fp	1	-10.08	6.99	-1.44	0.15	3.07	-3.28	0
Oliver_D_corn_fp	1	-3.35	6.85	-0.49	0.62	2.7	-1.24	0.21
Pembina_D_corn_fp	1	5.51	6.12	0.9	0.37	2.72	2.03	0.04
Pierce_D_corn_fp	1	-3	6.24	-0.48	0.63	2.46	-1.22	0.22
Ramsey_D_corn_fp	1	-16.9	6.25	-2.7	0.01	4.17	-4.05	0
Ransom_D_corn_fp	1	-11.88	6.4	-1.86	0.06	4.58	-2.6	0.01
Renville_D_corn_fp	1	-0.95	5.28	-0.18	0.86	1.55	-0.61	0.54
Richland_D_corn_fp	1	-21.39	6.06	-3.53	0	5.34	-4	0
Rolette_D_corn_fp	1	-0.72	5.31	-0.13	0.89	1.43	-0.5	0.62
Sargent_D_corn_fp	1	-19.32	5.81	-3.33	0	5.23	-3.69	0
Sheridan_D_corn_fp	1	-3.22	5.8	-0.55	0.58	3	-1.07	0.28
Sioux_D_corn_fp	1	0.45	5.34	0.08	0.93	2.29	0.2	0.84
Slope_D_corn_fp	1	0.2	5.58	0.04	0.97	1.33	0.15	0.88
Stark_D_corn_fp	1	-0.82	5.66	-0.15	0.88	1.57	-0.52	0.6
Steele_D_corn_fp	1	-31.91	6.57	-4.85	0	10.11	-3.16	0
Stutsman_D_corn_fp	1	-17.32	6.92	-2.5	0.01	6.29	-2.75	0.01
Towner_D_corn_fp	1	-1.72	5.24	-0.33	0.74	1.79	-0.96	0.34
Trail_D_corn_fp	1	-58.85	6.53	-9.02	0	11.24	-5.23	0
Walsh_D_corn_fp	1	-3.76	6.27	-0.6	0.55	2.33	-1.61	0.11
Ward_D_corn_fp	1	-0.22	5.23	-0.04	0.97	1.35	-0.16	0.87
Wells_D_corn_fp	1	-10.2	6.14	-1.66	0.1	3.87	-2.63	0.01
Williams_D_corn_fp	1	0.52	5.21	0.1	0.92	1.22	0.42	0.67
wheat_fp	1	-0.58	3.17	-0.18	0.86	0.93	-0.62	0.54
Barnes_D_wheat_fp	1	7.39	4.74	1.56	0.12	5.2	1.42	0.16
Benson_D_wheat_fp	1	4.14	4.77	0.87	0.39	2.09	1.99	0.05
Billings_D_wheat_fp	1	0.09	4.79	0.02	0.99	1	0.09	0.93
Bottineau_D_wheat_fp	1	2.03	4.64	0.44	0.66	1.37	1.49	0.14
Bowman_D_wheat_fp	1	-1.02	4.86	-0.21	0.83	1.1	-0.92	0.36
Burke_D_wheat_fp	1	0.67	4.71	0.14	0.89	1.04	0.64	0.52
Burleigh_D_wheat_fp	1	-0.43	5.1	-0.08	0.93	1.33	-0.32	0.75
Cass_D_wheat_fp	1	8.73	4.77	1.83	0.07	5.81	1.5	0.13
Cavalier_D_wheat_fp	1	1.43	5.21	0.27	0.78	1.22	1.17	0.24
Dickey_D_wheat_fp	1	-3.44	4.92	-0.7	0.48	7.07	-0.49	0.63
Divide_D_wheat_fp	1	0.97	4.73	0.21	0.84	1.04	0.94	0.35
Dunn_D_wheat_fp	1	0.8	5.19	0.15	0.88	1.08	0.74	0.46
Eddy_D_wheat_fp	1	1.83	4.83	0.38	0.71	2.45	0.75	0.46
Emmons_D_wheat_fp	1	-2.73	5.08	-0.54	0.59	3.9	-0.7	0.48
Foster_D_wheat_fp	1	3.07	4.81	0.64	0.52	3.36	0.91	0.36
Goldenvalley_D_wheat_fp	1	0.5	4.64	0.11	0.92	1.1	0.45	0.65
GrandForks_D_wheat_fp	1	3.09	4.81	0.64	0.52	3.18	0.97	0.33
Grant_D_wheat_fp	1	-1.08	4.79	-0.23	0.82	1.62	-0.67	0.51
Griggs_D_wheat_fp	1	3.34	4.8	0.7	0.49	2.99	1.12	0.26
Hettinger_D_wheat_fp	1	-0.62	4.92	-0.13	0.9	1.81	-0.34	0.73
Kidder_D_wheat_fp	1	-0.04	4.89	-0.01	0.99	1.42	-0.03	0.98
LaMoure_D_wheat_fp	1	-0.34	4.75	-0.07	0.94	6.96	-0.05	0.96
Logan_D_wheat_fp	1	-4.09	4.64	-0.88	0.38	2.52	-1.62	0.11
McHenry_D_wheat_fp	1	2.75	4.78	0.57	0.57	1.52	1.81	0.07
McIntosh_D_wheat_fp	1	-3.67	4.77	-0.77	0.44	2.32	-1.58	0.11
McKenzie_D_wheat_fp	1	0.55	4.88	0.11	0.91	0.95	0.58	0.56
McLean_D_wheat_fp	1	0.85	4.84	0.17	0.86	1.18	0.71	0.48
Mercer_D_wheat_fp	1	3.28	5.03	0.65	0.51	1.52	2.16	0.03
Morton_D_wheat_fp	1	0.78	4.87	0.16	0.87	1.46	0.54	0.59

Mountrail_D_wheat_fp	1	0.54	4.98	0.11	0.91	1.01	0.54	0.59
Nelson_D_wheat_fp	1	3.32	4.72	0.7	0.48	2.08	1.6	0.11
Oliver_D_wheat_fp	1	3.04	5.17	0.59	0.56	1.77	1.72	0.09
Pembina_D_wheat_fp	1	-2.04	4.6	-0.44	0.66	1.69	-1.21	0.23
Pierce_D_wheat_fp	1	1.73	4.88	0.36	0.72	1.63	1.06	0.29
Ramsey_D_wheat_fp	1	9.31	4.85	1.92	0.06	2.78	3.35	0
Ransom_D_wheat_fp	1	5.71	4.85	1.18	0.24	3.07	1.86	0.06
Renville_D_wheat_fp	1	1	4.74	0.21	0.83	1.28	0.78	0.44
Richland_D_wheat_fp	1	1.22	4.63	0.26	0.79	4.45	0.28	0.78
Rolette_D_wheat_fp	1	0.71	4.83	0.15	0.88	1.2	0.6	0.55
Sargent_D_wheat_fp	1	0.1	4.75	0.02	0.98	5.93	0.02	0.99
Sheridan_D_wheat_fp	1	0.46	4.74	0.1	0.92	2.2	0.21	0.83
Sioux_D_wheat_fp	1	-1.04	4.76	-0.22	0.83	1.9	-0.55	0.59
Slope_D_wheat_fp	1	0.08	4.89	0.02	0.99	1.03	0.08	0.94
Stark_D_wheat_fp	1	1.32	5.04	0.26	0.79	1.13	1.17	0.24
Steele_D_wheat_fp	1	13.34	4.84	2.75	0.01	6.71	1.99	0.05
Stutsman_D_wheat_fp	1	3.73	4.75	0.79	0.43	3.82	0.98	0.33
Towner_D_wheat_fp	1	2.29	4.81	0.48	0.63	1.44	1.59	0.11
Trail_D_wheat_fp	1	21.85	4.64	4.71	0	7.85	2.78	0.01
Walsh_D_wheat_fp	1	2.08	4.87	0.43	0.67	2.05	1.01	0.31
Ward_D_wheat_fp	1	1.17	4.97	0.23	0.81	1.09	1.07	0.29
Wells_D_wheat_fp	1	3.65	4.85	0.75	0.45	2.87	1.27	0.2
Williams_D_wheat_fp	1	0.62	5.08	0.12	0.9	0.97	0.64	0.52
hay_sp	1	1.01	1.48	0.69	0.49	0.64	1.58	0.11
Barnes_D_hay_sp	1	5.04	3.04	1.66	0.1	3.28	1.54	0.12
Benson_D_hay_sp	1	0.95	2.86	0.33	0.74	1.51	0.63	0.53
Billings_D_hay_sp	1	-1.3	2.3	-0.57	0.57	0.64	-2.02	0.04
Bottineau_D_hay_sp	1	1.04	2.2	0.47	0.64	0.97	1.07	0.28
Bowman_D_hay_sp	1	-0.98	2.45	-0.4	0.69	0.67	-1.46	0.15
Burke_D_hay_sp	1	-1.28	2.33	-0.55	0.58	0.66	-1.94	0.05
Burleigh_D_hay_sp	1	-0.7	2.68	-0.26	0.79	1.03	-0.68	0.5
Cass_D_hay_sp	1	8.97	2.87	3.12	0	3.54	2.53	0.01
Cavalier_D_hay_sp	1	-0.83	2.25	-0.37	0.71	0.67	-1.24	0.22
Dickey_D_hay_sp	1	-1.4	2.78	-0.51	0.61	3.79	-0.37	0.71
Divide_D_hay_sp	1	-0.71	2.29	-0.31	0.76	0.67	-1.06	0.29
Dunn_D_hay_sp	1	-0.59	2.64	-0.22	0.82	0.68	-0.86	0.39
Eddy_D_hay_sp	1	1.54	2.5	0.62	0.54	1.39	1.1	0.27
Emmons_D_hay_sp	1	3.37	2.62	1.29	0.2	2.22	1.52	0.13
Foster_D_hay_sp	1	0.92	2.7	0.34	0.73	2.52	0.37	0.71
Goldenvalley_D_hay_sp	1	-0.98	2.17	-0.45	0.65	0.67	-1.47	0.14
GrandForks_D_hay_sp	1	4.09	2.72	1.5	0.13	2	2.04	0.04
Grant_D_hay_sp	1	1.69	2.21	0.76	0.45	0.98	1.73	0.08
Griggs_D_hay_sp	1	0.52	2.79	0.19	0.85	1.69	0.31	0.76
Hettinger_D_hay_sp	1	0.59	2.39	0.25	0.8	0.92	0.64	0.52
Kidder_D_hay_sp	1	-0.34	3.2	-0.1	0.92	1.02	-0.33	0.74
LaMoure_D_hay_sp	1	0.54	3.04	0.18	0.86	4.21	0.13	0.9
Logan_D_hay_sp	1	-1.01	2.64	-0.38	0.7	1.62	-0.62	0.53
McHenry_D_hay_sp	1	1	2.64	0.38	0.71	1.04	0.96	0.34
McIntosh_D_hay_sp	1	-3.65	2.85	-1.28	0.2	1.71	-2.13	0.03
McKenzie_D_hay_sp	1	-1.01	2.37	-0.43	0.67	0.63	-1.59	0.11
McLean_D_hay_sp	1	-0.87	2.74	-0.32	0.75	0.97	-0.9	0.37
Mercer_D_hay_sp	1	1.73	2.44	0.71	0.48	0.98	1.76	0.08

Morton_D_hay_sp	1	1.2	2.39	0.5	0.62	1.05	1.15	0.25
Mountrail_D_hay_sp	1	-1.15	2.24	-0.52	0.61	0.63	-1.83	0.07
Nelson_D_hay_sp	1	1.62	3.11	0.52	0.6	1.26	1.29	0.2
Oliver_D_hay_sp	1	1.54	2.79	0.55	0.58	1.19	1.3	0.2
Pembina_D_hay_sp	1	-4.36	2.74	-1.59	0.11	1.26	-3.47	0
Pierce_D_hay_sp	1	1.46	2.71	0.54	0.59	1.31	1.11	0.27
Ramsey_D_hay_sp	1	0.49	2.88	0.17	0.87	1.95	0.25	0.8
Ransom_D_hay_sp	1	2.97	2.55	1.17	0.24	2.61	1.14	0.26
Renville_D_hay_sp	1	-0.11	2.28	-0.05	0.96	0.78	-0.14	0.89
Richland_D_hay_sp	1	-3.97	2.51	-1.58	0.11	3.06	-1.3	0.19
Rolette_D_hay_sp	1	-0.92	2.2	-0.42	0.68	0.73	-1.27	0.21
Sargent_D_hay_sp	1	1.16	2.63	0.44	0.66	3.76	0.31	0.76
Sheridan_D_hay_sp	1	0.84	2.64	0.32	0.75	1.1	0.76	0.45
Sioux_D_hay_sp	1	-1.24	2.15	-0.58	0.56	0.99	-1.25	0.21
Slope_D_hay_sp	1	-0.56	2.47	-0.23	0.82	0.67	-0.84	0.4
Stark_D_hay_sp	1	-0.12	2.52	-0.05	0.96	0.76	-0.16	0.87
Steele_D_hay_sp	1	5.75	2.99	1.93	0.05	4.06	1.42	0.16
Stutsman_D_hay_sp	1	2.23	2.99	0.75	0.46	2.2	1.01	0.31
Towner_D_hay_sp	1	-1.04	2.22	-0.47	0.64	0.86	-1.21	0.23
Trail_D_hay_sp	1	10.48	2.82	3.72	0	5.05	2.07	0.04
Walsh_D_hay_sp	1	0.99	2.72	0.36	0.72	1.26	0.79	0.43
Ward_D_hay_sp	1	-0.72	2.43	-0.3	0.77	0.69	-1.04	0.3
Wells_D_hay_sp	1	2.5	2.67	0.94	0.35	1.84	1.36	0.17
Williams_D_hay_sp	1	-0.89	2.45	-0.36	0.72	0.64	-1.38	0.17
eth_price	1	0.62	1.83	0.34	0.74	0.54	1.15	0.25
Barnes_D_eth_price	1	5.32	2.76	1.93	0.05	2.83	1.88	0.06
Benson_D_eth_price	1	2.16	2.71	0.8	0.43	1.18	1.83	0.07
Billings_D_eth_price	1	-0.39	2.63	-0.15	0.88	0.56	-0.69	0.49
Bottineau_D_eth_price	1	-0.39	2.57	-0.15	0.88	0.67	-0.58	0.56
Bowman_D_eth_price	1	-0.83	2.64	-0.31	0.75	0.65	-1.27	0.2
Burke_D_eth_price	1	0.31	2.71	0.12	0.91	0.59	0.53	0.6
Burleigh_D_eth_price	1	0.79	2.75	0.29	0.77	0.72	1.1	0.27
Cass_D_eth_price	1	2.55	2.73	0.93	0.35	2.26	1.13	0.26
Cavalier_D_eth_price	1	0.1	2.58	0.04	0.97	0.61	0.17	0.87
Dickey_D_eth_price	1	7.67	2.62	2.93	0	2.22	3.45	0
Divide_D_eth_price	1	0	2.72	0	1	0.59	0	1
Dunn_D_eth_price	1	-0.4	2.74	-0.14	0.88	0.59	-0.68	0.5
Eddy_D_eth_price	1	2.66	2.69	0.99	0.32	1.23	2.17	0.03
Emmons_D_eth_price	1	1.28	2.76	0.46	0.64	1.69	0.76	0.45
Foster_D_eth_price	1	6.58	2.78	2.37	0.02	2.46	2.67	0.01
Goldenvalley_D_eth_price	1	-0.64	2.64	-0.24	0.81	0.7	-0.91	0.37
GrandForks_D_eth_price	1	0.83	2.64	0.32	0.75	1.06	0.78	0.43
Grant_D_eth_price	1	0.43	2.81	0.15	0.88	0.88	0.48	0.63
Griggs_D_eth_price	1	2.85	2.67	1.07	0.29	1.63	1.75	0.08
Hettinger_D_eth_price	1	0.3	2.66	0.11	0.91	1.19	0.25	0.8
Kidder_D_eth_price	1	0.34	2.75	0.12	0.9	0.69	0.49	0.62
LaMoure_D_eth_price	1	9.71	2.69	3.61	0	3.16	3.08	0
Logan_D_eth_price	1	2.25	2.72	0.82	0.41	1.06	2.12	0.03
McHenry_D_eth_price	1	0.52	2.71	0.19	0.85	0.78	0.67	0.5
McIntosh_D_eth_price	1	1.67	2.66	0.63	0.53	0.99	1.68	0.09
McKenzie_D_eth_price	1	-0.6	2.71	-0.22	0.83	0.53	-1.14	0.26
McLean_D_eth_price	1	0.3	2.94	0.1	0.92	0.8	0.38	0.71

Mercer_D_eth_price	1	0.47	2.63	0.18	0.86	0.79	0.59	0.56
Morton_D_eth_price	1	0.24	2.72	0.09	0.93	0.73	0.33	0.74
Mountrail_D_eth_price	1	-0.31	2.71	-0.11	0.91	0.55	-0.56	0.57
Nelson_D_eth_price	1	1.76	2.64	0.66	0.51	1.05	1.68	0.09
Oliver_D_eth_price	1	1.27	2.68	0.47	0.64	0.94	1.35	0.18
Pembina_D_eth_price	1	2.17	2.61	0.83	0.41	1.09	1.99	0.05
Pierce_D_eth_price	1	1.05	2.61	0.4	0.69	0.82	1.27	0.2
Ramsey_D_eth_price	1	4.27	2.62	1.63	0.1	1.95	2.19	0.03
Ransom_D_eth_price	1	2.94	2.78	1.06	0.29	1.53	1.92	0.06
Renville_D_eth_price	1	0.07	2.62	0.03	0.98	0.71	0.1	0.92
Richland_D_eth_price	1	5.84	2.65	2.2	0.03	1.81	3.23	0
Rolette_D_eth_price	1	-0.28	2.7	-0.1	0.92	0.62	-0.44	0.66
Sargent_D_eth_price	1	5.38	2.68	2.01	0.04	2.04	2.64	0.01
Sheridan_D_eth_price	1	2.32	2.61	0.89	0.38	1.01	2.29	0.02
Sioux_D_eth_price	1	1.15	2.75	0.42	0.68	1.02	1.13	0.26
Slope_D_eth_price	1	-0.74	2.62	-0.28	0.78	0.57	-1.3	0.19
Stark_D_eth_price	1	0.05	2.78	0.02	0.99	0.77	0.06	0.95
Steele_D_eth_price	1	5.69	2.73	2.09	0.04	3.78	1.5	0.13
Stutsman_D_eth_price	1	3.71	2.8	1.33	0.19	1.76	2.1	0.04
Towner_D_eth_price	1	0.6	2.59	0.23	0.82	0.75	0.8	0.42
Trail_D_eth_price	1	6.21	2.71	2.29	0.02	4.15	1.5	0.14
Walsh_D_eth_price	1	0.64	2.59	0.25	0.8	0.86	0.75	0.45
Ward_D_eth_price	1	-0.44	2.64	-0.17	0.87	0.58	-0.75	0.45
Wells_D_eth_price	1	3.4	2.64	1.29	0.2	1.51	2.26	0.02
Williams_D_eth_price	1	-0.59	2.67	-0.22	0.83	0.54	-1.1	0.27
renfuel_vol	1	0.1	0.11	0.93	0.35	0.04	2.59	0.01
Barnes_D_renfuel_vol	1	0.63	0.27	2.32	0.02	0.28	2.23	0.03
Benson_D_renfuel_vol	1	0.07	0.28	0.26	0.8	0.14	0.54	0.59
Billings_D_renfuel_vol	1	-0.1	0.17	-0.56	0.58	0.04	-2.32	0.02
Bottineau_D_renfuel_vol	1	0.07	0.23	0.29	0.77	0.06	1.18	0.24
Bowman_D_renfuel_vol	1	0.03	0.18	0.19	0.85	0.05	0.75	0.45
Burke_D_renfuel_vol	1	-0.13	0.18	-0.73	0.46	0.04	-3.36	0
Burleigh_D_renfuel_vol	1	0.24	0.27	0.87	0.39	0.08	2.88	0
Cass_D_renfuel_vol	1	0.78	0.27	2.88	0	0.33	2.33	0.02
Cavalier_D_renfuel_vol	1	-0.1	0.17	-0.59	0.56	0.04	-2.63	0.01
Dickey_D_renfuel_vol	1	0.84	0.25	3.32	0	0.36	2.31	0.02
Divide_D_renfuel_vol	1	-0.14	0.19	-0.73	0.46	0.04	-3.32	0
Dunn_D_renfuel_vol	1	-0.13	0.24	-0.53	0.59	0.05	-2.78	0.01
Eddy_D_renfuel_vol	1	0.16	0.24	0.65	0.52	0.11	1.4	0.16
Emmons_D_renfuel_vol	1	0.76	0.2	3.83	0	0.21	3.61	0
Foster_D_renfuel_vol	1	0.95	0.28	3.43	0	0.29	3.23	0
Goldenvalley_D_renfuel_vol	1	-0.05	0.17	-0.31	0.76	0.04	-1.31	0.19
GrandForks_D_renfuel_vol	1	0.16	0.25	0.61	0.54	0.14	1.09	0.28
Grant_D_renfuel_vol	1	0.07	0.21	0.34	0.73	0.1	0.71	0.48
Griggs_D_renfuel_vol	1	0.48	0.25	1.91	0.06	0.14	3.54	0
Hettinger_D_renfuel_vol	1	0.15	0.2	0.72	0.47	0.07	2.04	0.04
Kidder_D_renfuel_vol	1	0.1	0.26	0.38	0.7	0.07	1.5	0.13
LaMoure_D_renfuel_vol	1	1.21	0.26	4.65	0	0.4	3.05	0
Logan_D_renfuel_vol	1	0.65	0.19	3.39	0	0.14	4.59	0
McHenry_D_renfuel_vol	1	0.01	0.25	0.05	0.96	0.07	0.17	0.87
McIntosh_D_renfuel_vol	1	0.87	0.24	3.61	0	0.15	5.69	0
McKenzie_D_renfuel_vol	1	-0.13	0.19	-0.7	0.49	0.04	-3.64	0

McLean_D_renfuel_vol	1	0.07	0.28	0.24	0.81	0.1	0.69	0.49
Mercer_D_renfuel_vol	1	-0.06	0.21	-0.3	0.77	0.09	-0.73	0.47
Morton_D_renfuel_vol	1	-0.01	0.23	-0.06	0.95	0.08	-0.16	0.87
Mountrail_D_renfuel_vol	1	-0.13	0.18	-0.72	0.47	0.04	-3.36	0
Nelson_D_renfuel_vol	1	-0.12	0.31	-0.4	0.69	0.12	-1.02	0.31
Oliver_D_renfuel_vol	1	-0.12	0.27	-0.46	0.65	0.1	-1.22	0.22
Pembina_D_renfuel_vol	1	0.06	0.25	0.22	0.82	0.11	0.5	0.62
Pierce_D_renfuel_vol	1	0.1	0.3	0.32	0.75	0.11	0.83	0.41
Ramsey_D_renfuel_vol	1	-0.13	0.28	-0.48	0.63	0.2	-0.67	0.5
Ransom_D_renfuel_vol	1	0.22	0.23	0.95	0.34	0.16	1.33	0.18
Renville_D_renfuel_vol	1	-0.07	0.19	-0.34	0.73	0.05	-1.42	0.16
Richland_D_renfuel_vol	1	0.79	0.25	3.16	0	0.24	3.32	0
Rolette_D_renfuel_vol	1	-0.07	0.17	-0.39	0.69	0.04	-1.59	0.11
Sargent_D_renfuel_vol	1	0.9	0.24	3.74	0	0.25	3.52	0
Sheridan_D_renfuel_vol	1	0.02	0.25	0.1	0.92	0.1	0.24	0.81
Sioux_D_renfuel_vol	1	0.01	0.2	0.05	0.96	0.07	0.13	0.89
Slope_D_renfuel_vol	1	-0.05	0.19	-0.26	0.8	0.04	-1.22	0.22
Stark_D_renfuel_vol	1	-0.09	0.22	-0.43	0.67	0.06	-1.5	0.13
Steele_D_renfuel_vol	1	0.77	0.25	3.1	0	0.34	2.26	0.02
Stutsman_D_renfuel_vol	1	0.64	0.26	2.43	0.02	0.24	2.65	0.01
Towner_D_renfuel_vol	1	0	0.18	-0.01	0.99	0.05	-0.03	0.98
Trail_D_renfuel_vol	1	-0.01	0.24	-0.04	0.97	0.49	-0.02	0.98
Walsh_D_renfuel_vol	1	0.03	0.25	0.11	0.92	0.1	0.25	0.8
Ward_D_renfuel_vol	1	-0.07	0.2	-0.35	0.73	0.04	-1.73	0.08
Wells_D_renfuel_vol	1	0.41	0.27	1.53	0.13	0.19	2.23	0.03
Williams_D_renfuel_vol	1	-0.12	0.23	-0.5	0.61	0.04	-3.17	0
max_temp	1	2.22	5.28	0.42	0.67	1.8	1.23	0.22
Barnes_D_max_temp	1	7.91	10.92	0.72	0.47	11.75	0.67	0.5
Benson_D_max_temp	1	3.17	11.74	0.27	0.79	6.62	0.48	0.63
Billings_D_max_temp	1	0.88	8.44	0.1	0.92	2.06	0.43	0.67
Bottineau_D_max_temp	1	1.53	10.36	0.15	0.88	3.11	0.49	0.62
Bowman_D_max_temp	1	0.72	7.51	0.1	0.92	2	0.36	0.72
Burke_D_max_temp	1	0.01	9.32	0	1	1.9	0.01	0.99
Burleigh_D_max_temp	1	3.97	8.59	0.46	0.64	2.73	1.46	0.15
Cass_D_max_temp	1	7.44	10.1	0.74	0.46	14.1	0.53	0.6
Cavalier_D_max_temp	1	-0.32	8.92	-0.04	0.97	2.05	-0.16	0.88
Dickey_D_max_temp	1	-0.86	11.32	-0.08	0.94	15.95	-0.05	0.96
Divide_D_max_temp	1	-1.89	9.34	-0.2	0.84	1.98	-0.95	0.34
Dunn_D_max_temp	1	-2.25	7.82	-0.29	0.77	1.97	-1.14	0.25
Eddy_D_max_temp	1	4.06	10.69	0.38	0.7	5.54	0.73	0.46
Emmons_D_max_temp	1	5.36	8.88	0.6	0.55	8.51	0.63	0.53
Foster_D_max_temp	1	11.97	11.26	1.06	0.29	10.89	1.1	0.27
Goldenvalley_D_max_temp	1	0.3	7.57	0.04	0.97	1.86	0.16	0.87
GrandForks_D_max_temp	1	8.69	9.57	0.91	0.36	6.92	1.26	0.21
Grant_D_max_temp	1	-1.58	7.48	-0.21	0.83	2.6	-0.61	0.54
Griggs_D_max_temp	1	6.33	10.18	0.62	0.53	5.96	1.06	0.29
Hettinger_D_max_temp	1	-1.4	7.6	-0.18	0.85	2.85	-0.49	0.62
Kidder_D_max_temp	1	3.04	11.1	0.27	0.78	3.29	0.92	0.36
LaMoure_D_max_temp	1	6.66	11.78	0.57	0.57	16.07	0.41	0.68
Logan_D_max_temp	1	3.91	8.65	0.45	0.65	3.91	1	0.32
McHenry_D_max_temp	1	0.11	10.97	0.01	0.99	3.65	0.03	0.98
McIntosh_D_max_temp	1	15.77	9.9	1.59	0.11	4.77	3.3	0

McKenzie_D_max_temp	1	-1.05	7.8	-0.13	0.89	1.8	-0.58	0.56
McLean_D_max_temp	1	-0.47	11.82	-0.04	0.97	3.9	-0.12	0.9
Mercer_D_max_temp	1	-0.29	10.36	-0.03	0.98	3.86	-0.07	0.94
Morton_D_max_temp	1	-1.9	8.23	-0.23	0.82	2.94	-0.65	0.52
Mountrail_D_max_temp	1	-0.67	9.16	-0.07	0.94	1.83	-0.37	0.71
Nelson_D_max_temp	1	-1.76	11.26	-0.16	0.88	5.05	-0.35	0.73
Oliver_D_max_temp	1	-2.32	8.19	-0.28	0.78	2.62	-0.89	0.38
Pembina_D_max_temp	1	7.63	11.12	0.69	0.49	4.47	1.71	0.09
Pierce_D_max_temp	1	-2.44	11.96	-0.2	0.84	5.4	-0.45	0.65
Ramsey_D_max_temp	1	10.94	10.13	1.08	0.28	8.31	1.32	0.19
Ransom_D_max_temp	1	-8.21	9.84	-0.83	0.4	7.02	-1.17	0.24
Renville_D_max_temp	1	-1.38	9.77	-0.14	0.89	2.42	-0.57	0.57
Richland_D_max_temp	1	19.28	10.7	1.8	0.07	13.34	1.44	0.15
Rolette_D_max_temp	1	0.07	8.77	0.01	0.99	2.28	0.03	0.98
Sargent_D_max_temp	1	5.3	10.61	0.5	0.62	13.27	0.4	0.69
Sheridan_D_max_temp	1	-0.19	10.6	-0.02	0.99	3.73	-0.05	0.96
Sioux_D_max_temp	1	7.24	7.6	0.95	0.34	3.19	2.27	0.02
Slope_D_max_temp	1	-1.17	7.46	-0.16	0.88	1.88	-0.62	0.53
Stark_D_max_temp	1	-1.91	7.69	-0.25	0.8	2.11	-0.91	0.37
Steele_D_max_temp	1	19.51	9.89	1.97	0.05	14.5	1.35	0.18
Stutsman_D_max_temp	1	2.85	10.29	0.28	0.78	7.32	0.39	0.7
Towner_D_max_temp	1	4.05	10.12	0.4	0.69	2.73	1.49	0.14
Trail_D_max_temp	1	15.58	10.46	1.49	0.14	21.67	0.72	0.47
Walsh_D_max_temp	1	5.8	11.52	0.5	0.61	5.99	0.97	0.33
Ward_D_max_temp	1	-1.22	9.31	-0.13	0.9	2.11	-0.58	0.56
Wells_D_max_temp	1	2.8	9.56	0.29	0.77	6.09	0.46	0.65
Williams_D_max_temp	1	-1.45	8.45	-0.17	0.86	1.8	-0.8	0.42
min_temp	1	1.39	2.42	0.57	0.57	0.75	1.84	0.07
Barnes_D_min_temp	1	-18.28	11.7	-1.56	0.12	11.91	-1.54	0.13
Benson_D_min_temp	1	-7.51	10.17	-0.74	0.46	5.36	-1.4	0.16
Billings_D_min_temp	1	-2.89	7.74	-0.37	0.71	1.07	-2.7	0.01
Bottineau_D_min_temp	1	0.37	4.82	0.08	0.94	1.43	0.26	0.79
Bowman_D_min_temp	1	-1.86	8.71	-0.21	0.83	1.44	-1.3	0.2
Burke_D_min_temp	1	-2.58	5.26	-0.49	0.62	0.88	-2.95	0
Burleigh_D_min_temp	1	0.49	10.9	0.04	0.96	3.06	0.16	0.87
Cass_D_min_temp	1	-22.95	10.42	-2.2	0.03	15.28	-1.5	0.13
Cavalier_D_min_temp	1	-1.76	4.91	-0.36	0.72	1.06	-1.66	0.1
Dickey_D_min_temp	1	13.29	10.47	1.27	0.2	14.75	0.9	0.37
Divide_D_min_temp	1	-2.06	5.98	-0.34	0.73	0.96	-2.15	0.03
Dunn_D_min_temp	1	-1.42	9.93	-0.14	0.89	1.63	-0.87	0.38
Eddy_D_min_temp	1	-1.3	10.71	-0.12	0.9	5.93	-0.22	0.83
Emmons_D_min_temp	1	0.78	11.65	0.07	0.95	10.12	0.08	0.94
Foster_D_min_temp	1	5.63	11.57	0.49	0.63	12.22	0.46	0.64
Goldenvalley_D_min_temp	1	-1.22	7.62	-0.16	0.87	1.19	-1.02	0.31
GrandForks_D_min_temp	1	-20.43	9.77	-2.09	0.04	6.14	-3.33	0
Grant_D_min_temp	1	5.2	6.03	0.86	0.39	2.35	2.21	0.03
Griggs_D_min_temp	1	-0.74	10.74	-0.07	0.95	6.79	-0.11	0.91
Hettinger_D_min_temp	1	0.36	9.3	0.04	0.97	2.68	0.13	0.89
Kidder_D_min_temp	1	0.19	11.05	0.02	0.99	2.96	0.06	0.95
LaMoure_D_min_temp	1	-1.4	10.58	-0.13	0.89	15.35	-0.09	0.93
Logan_D_min_temp	1	8.67	9.62	0.9	0.37	6.4	1.36	0.18
McHenry_D_min_temp	1	-5.06	9.48	-0.53	0.59	2.79	-1.81	0.07

McIntosh_D_min_temp	1	9.13	9.67	0.94	0.35	4.65	1.96	0.05
McKenzie_D_min_temp	1	-1.7	9.14	-0.19	0.85	0.89	-1.9	0.06
McLean_D_min_temp	1	2.35	10.53	0.22	0.82	2.94	0.8	0.42
Mercer_D_min_temp	1	-5.74	10.7	-0.54	0.59	3.22	-1.78	0.07
Morton_D_min_temp	1	-1.35	10.02	-0.13	0.89	3.23	-0.42	0.68
Mountrail_D_min_temp	1	-2.04	6.18	-0.33	0.74	0.84	-2.44	0.02
Nelson_D_min_temp	1	-8.07	10.91	-0.74	0.46	3.98	-2.03	0.04
Oliver_D_min_temp	1	-7.18	10.37	-0.69	0.49	3.91	-1.84	0.07
Pembina_D_min_temp	1	-7.24	8.9	-0.81	0.42	3.77	-1.92	0.06
Pierce_D_min_temp	1	-1.42	9.83	-0.14	0.89	3.45	-0.41	0.68
Ramsey_D_min_temp	1	-18.02	11.11	-1.62	0.11	7.07	-2.55	0.01
Ransom_D_min_temp	1	8.9	11.22	0.79	0.43	9.22	0.97	0.33
Renville_D_min_temp	1	-1.49	5.07	-0.29	0.77	1.16	-1.28	0.2
Richland_D_min_temp	1	-1.71	9.86	-0.17	0.86	14.66	-0.12	0.91
Rolette_D_min_temp	1	-2.23	4.98	-0.45	0.65	1.08	-2.07	0.04
Sargent_D_min_temp	1	-6.22	10.08	-0.62	0.54	15.79	-0.39	0.69
Sheridan_D_min_temp	1	1.99	5.88	0.34	0.74	2.06	0.96	0.34
Sioux_D_min_temp	1	-8.22	6.47	-1.27	0.2	1.86	-4.41	0
Slope_D_min_temp	1	-0.66	8.82	-0.08	0.94	1.25	-0.53	0.6
Stark_D_min_temp	1	-1.71	8.98	-0.19	0.85	1.65	-1.03	0.3
Steele_D_min_temp	1	-27.37	11.26	-2.43	0.02	14.18	-1.93	0.05
Stutsman_D_min_temp	1	1.72	11.4	0.15	0.88	10.08	0.17	0.86
Towner_D_min_temp	1	-2.54	4.91	-0.52	0.61	1.2	-2.11	0.03
Trail_D_min_temp	1	-60.48	9.61	-6.29	0	20.68	-2.92	0
Walsh_D_min_temp	1	-7.81	9.79	-0.8	0.43	3.21	-2.43	0.02
Ward_D_min_temp	1	-0.9	8.93	-0.1	0.92	1.29	-0.7	0.49
Wells_D_min_temp	1	-1.39	10.32	-0.14	0.89	6.27	-0.22	0.82
Williams_D_min_temp	1	-1.57	10.72	-0.15	0.88	1.12	-1.39	0.16

The dependent variable "corn_acre" represents a total area planted with corn in a specific county for a given period. The corn expected revenue variable is assumed to be positively correlated with corn acreage, although the sign is instead negative. The future price for corn crops is positively correlated with the corn planted acreage, as expected. Also, the competing crop price variables of the hay spot price and the soybean future price are negatively correlated with corn planted acreage, as expected. As corn stocks volume from the previous year increases, the total planted corn acre in the next year decreases. So, we expect corn stocks to correlate with the total corn planted acre negatively. However, the sign is instead positive.

As demand for ethanol increases, we expect an increase in corn planted acreage, which will ultimately lead to an increase in renewable fuel volume. Ethanol price variables are likely to be positively correlated with corn acreage. However, all four biofuel energy variables including the price of oil, ethanol, the volume of ethanol, and the renewable fuel mandated volume are not significant according to our multiple regression results.

We also expect farmers to make crop planting acreage decisions based on the relative dryness and wetness of crop and soil moisture levels (PDSI) at the time of planting. The crop/soil moisture variables are expected to correlate with corn planted acreage positively. The result indicates if the moisture in the soil is less during March, then the farmer will plant more corn in the upcoming year. Also, the maximum temperature variable is positively correlated with corn acreage, as expected, and includes the total precipitation for April, May, June, and July. Higher minimum temperatures from previous seasons encourage farmers to allow more land to be planted with corn crops. Our expected sign between minimum temperature and corn acreage is positive, and even though this matches our expectation, the result is not significant.

From Table 4 we see that the output elasticities of corn expected revenue and corn stocks were -8.8864 and 47.7563, respectively, and are statistically significant. However, the sign of the coefficients does not match our expectations. Further, the output elasticities of corn future price, wheat spot price, hay spot price, and soybean future price are 61.3228, 48.6787, -20.1952, and -49.2227, respectively. In other words, for the 53 counties, holding everything constant, a 1% increase in the corn future price led to a 0.6133% increase on average in the corn planted acreage. Also, a 1% increase in the hay spot price led to a 0.2019% decrease on average in the corn planted acreage. Finally, a 1% increase in soybean future price resulted in a 0.4923% decrease on average in corn planted acreage.

Table-4. Elasticity (e^y) of corn acreage with respect to prices (continued)

County	e^y _Corn price	e^y _Wheat price	e^y _Hay price	e^y _Ethanol price	e^y _Soybean price
Adams	-0.109	-0.144	0.016	0.267	0.119
Barnes	0.329	1.407	0.082	3.011	0.119
Benson	-0.292	0.719	0.028	1.373	0.119
Billings	-0.154	-0.094	-0.004	0.077	0.119
Bottineau	-0.893	0.289	0.029	0.05	0.119
Bowman	-0.092	-0.303	0.001	-0.139	0.119
Burke	-0.226	0.022	-0.002	0.471	0.119
Burleigh	-0.905	-0.243	0.003	0.679	0.119
Cass	2.661	1.752	0.141	1.547	0.119
Cavalier	-0.331	0.143	0.004	0.337	0.119
Dickey	1.453	-0.684	-0.003	4.29	0.119
Divide	-0.233	0.072	0.005	0.299	0.119
Dunn	-0.225	0.036	0.006	0.062	0.119
Eddy	-0.741	0.236	0.035	1.641	0.119
Emmons	-1.144	-0.644	0.062	0.933	0.119
Foster	-2.071	0.372	0.02	3.662	0.119
Goldenvalley	-0.255	-0.012	0.002	-0.039	0.119
GrandForks	0.73	0.641	0.064	0.745	0.119
Grant	0.091	-0.308	0.037	0.507	0.119
Griggs	-0.995	0.518	0.017	1.795	0.119
Hettinger	-0.202	-0.228	0.022	0.426	0.119
Kidder	-0.538	-0.134	0.009	0.428	0.119
LaMoure	1.895	-0.085	0.028	5.252	0.119
Logan	-0.66	-0.893	0.004	1.354	0.119
McHenry	-0.586	0.408	0.027	0.548	0.119
McIntosh	-1.872	-0.887	-0.031	1.128	0.119
McKenzie	-0.165	0.022	0.001	-0.017	0.119
McLean	-0.477	0.042	0.003	0.423	0.119
Mercer	-0.649	0.487	0.04	0.513	0.119
Morton	-0.148	0.046	0.031	0.403	0.119
Mountrail	-0.204	0.024	0	0.127	0.119
Nelson	0.088	0.603	0.029	1.219	0.119
Oliver	-0.269	0.487	0.035	0.929	0.119
Pembina	0.124	-0.536	-0.044	1.357	0.119
Pierce	-0.449	0.213	0.033	0.82	0.119
Ramsey	-0.697	1.643	0.01	2.568	0.119
Ransom	-0.555	1.01	0.053	1.854	0.119
Renville	-0.353	0.094	0.013	0.338	0.119
Richland	1.476	0.184	-0.035	3.278	0.119
Rolette	-0.298	0.038	0.003	0.147	0.119
Sargent	0.789	-0.015	0.034	2.944	0.119
Sheridan	-0.155	-0.005	0.027	1.469	0.119
Sioux	-0.314	-0.286	-0.002	0.877	0.119
Slope	-0.175	-0.088	0.007	-0.092	0.119
Stark	-0.22	0.147	0.013	0.333	0.119
Steele	0.143	2.596	0.091	3.313	0.119
Stutsman	0.283	0.668	0.046	2.189	0.119
Towner	-0.546	0.358	0.001	0.61	0.119
Traill	3.454	4.47	0.166	3.638	0.119
Walsh	-0.091	0.359	0.024	0.615	0.119

Ward	-0.267	0.112	0.005	0.06	0.119
Wells	-0.468	0.615	0.047	2.018	0.119
Williams	-0.168	-0.006	0.003	-0.026	0.119

The output elasticities of the soil moisture index (PDSI), the monthly maximum temperature, and the total rainfall were 14.8583, 132.5554, and 21.4212, respectively. In other words, a 1% increase in soil moisture in May led to a 0.1486% increase in corn acreage expansion. Similarly, as maximum temperature increased during the planting season, corn planted acreage expanded significantly. Also, the total rainfall variable is positively correlated with corn planted acreage such that a 1% increase in total rainfall led to a 0.2143% increase in total corn planted acreage.

The corn future price variable is expected to correlate with corn planted acreage positively. From Table 4, we see that the elasticity of corn future price with respect to corn planted acreage is (0.10) for Adams County. In other words, there is a 0.10% change in corn acreage due to a 1 unit change in the corn expected price on average over the previous 26 years. In addition, a 1% increase in the soybean price led to a 0.14% decrease on average in the corn planted acreage (for Adams County), holding everything else constant as before. The value of the corn price elasticity is 2.66 representing that the corn acreage increased by 2.66% (Cass County) due to a 1 unit increase in the corn price on average. Further, corn price elasticities with respect to corn planted acreage are positive and greater than 1 for counties including Cass, Dickey, Lamour, Richland, Trail. For these, a 1 unit increase in corn price led to more than 1% change in corn planted acreage on average from 1990 to 2015. These counties' corn planting decisions are more responsive to the corn expected price as compared to other counties. However, counties such as Barnes, Grant, Nelson have corn price elasticity values ranging from 0.02 to 0.09. Thus, corn planted acreage in these counties are less responsive to corn prices. Also, counties known as Pembina, Steele, Stutsman, GrandForks have corn price elasticity values fall between 0.10 to 0.80.

Wheat future price variables are expected to correlate with corn planted acreage negatively. For the soybean future price elasticity, a 1% increase led to less than 1% decrease on average in the corn planted acreage for counties Adams, Bowman, Burleigh, Dickey, Emmons, Hettinger, McIntosh, Sheridan, and Slope. The corn planted acreage in these counties was more responsive to the wheat future price as compared to other counties. Also, Adams, Barnes, Dickey, Dunn, Eddy, Grant, Lamoure, Mclean, Morton, Mountrail, and Nelson Counties were moderately responsive to the wheat price with respect to corn planted acreage.

Hay price variables are expected to correlate with corn planted acreage negatively. A 1% increase in the hay price led to less than 1% decrease on average in the corn planted acreage for counties like Billings, Dickey, Pembina. However, a majority of counties (totaling 46) have a positive hay price elasticity value with respect to corn planted acreage. For hay price elasticity, a 1% increase led to a 0.001 to 0.17% increase on average in the corn planted acreage throughout North Dakota counties. The corn planted acreage in majority counties was less responsive to hay price as compared to other crop prices.

The ethanol price variable is expected to correlate with corn planted acreage negatively. The ethanol price elasticities have negative values with respect to corn planted acreage for some counties including Bowman, Goldenvalley, Mckenzie, Slope, and Williams. In other words, a 1% increase in the ethanol price led to 0.01 to 0.13% decrease in the corn acreage expansion. These counties were more responsive to ethanol price as compared to other counties. However, the majority of counties (totaling 48) have a positive ethanol price elasticity value with respect to corn planted acreage.

Finally, the soybean future price variables are expected to correlate with corn planted acreage positively. Also, the value of soybean future price with respect to corn acreage remain constant (0.119) for all counties of North Dakota.

9. Conclusion

This article examines the local crop selection decisions of ND farmers in response to changes in major crop prices, expected revenue, biofuel policy mandates, climate, and other economic factors. This research identifies the driving factors of crop acreage response focusing on North Dakota agriculture. Moreover, we ask how and why agricultural producers respond to different challenges as their crop mix became more destined for ethanol production and less for food consumption. Here, this research presents producers' corn planting decisions and how these vary over time due to various factors. The long-run trend of corn acreage expansion is expected to interconnect with changes in major crops, ethanol prices, climate, and renewable fuel policy mandates. Key findings indicate corn planted acres increased by 1.2 million acres in North Dakota. Different counties are characterized by various crop rotation schemes due to climatic conditions and other economic factors. Also, the value of crop price elasticities indicates a significant impact of major crop prices on corn planted acreage decisions.

The local producer's responses on their decisions to plant corn due to econometric, biophysical, and biofuel policy factors have yet to be fully documented. Further information on farms, such as topography and soil quality, and socio-demographic factors, such as farmers education and farm practices, is required to better understand farmers' corn planting choices and to develop our modeling framework further. In this article, we focus on producers' decision-making drivers at a regional scale (county level). We leave it to future research to perform a national level study on decision making mechanism to find the extent of price and climate variables on acreage were due to input usage, land allocation among crops, and extensive margin changes. It would help quantify process by which price and other factors affect crop acreage. Nevertheless, our analysis does reveal the importance of climate variables to examine climate change impact on crop acreage change.

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