A Graphical and Beta Analysis of the Effect of Increased Ethanol Production on the Volatility of Corn Prices

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Abstract

Increased demand for corn-based ethanol puts upward pressure on prices of corn and other commodities, such as soybeans, and possibly worsens their price volatility. This paper investigates the changes in agricultural commodities' standard deviation and beta sizes due to ethanol production in the US. Standard deviations and beta estimations are compared for the ethanol pre-expansion and expansion periods. The results indicate a high level of price volatility in the second period, which could be attributed to ethanol expansion.

Keywords*:* Ethanol, Price volatility, Monthly price index, Beta, Corn, Soybeans.
JEL codes: Q12, Q14, P32

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1 .Introduction

Agriculture is risky because of production uncertainty and market volatility, and any market disturbance could exacerbate the volatility. It would not be an exaggeration to say that corn prices are volatile. In 2011, prices ranged from $4.81 in January to $6.93 in August; in 2012, prices ranged from $6.02 in January to $7.70 in August; and in October 2014, prices were down below $4.00. While numerous factors influence the price of corn, there is growing evidence that ethanol production has been a major contributor to the higher and more volatile price levels. The boom in US ethanol production results from government support through three energy Acts. The first Act changed ethanol subsidy from excise tax exemption to a blender tax credit of $0.51 per gallon of ethanol. The second and third Acts required ethanol use to reach 7.5 billion gallons by 2012 (EIA, 2006) and 36 billion gallons by 2022, respectively (EIA, 2008). Because corn is the primary feedstock used for ethanol production in the U.S., as ethanol production increases, the demand for corn also increases – which puts upward pressure on corn prices. This study uses graphical and beta approaches to investigate the potential impact of increased ethanol production on the level and volatility of corn and other commodities prices. There are numerous studies on the impact of ethanol expansion on local and national markets (Baker and Zahniser, 2007; Behnke and Fortenbery, 2011; McNew and Griffith, 2005); a local region relevant to the authors' location is Nebraska, the second leading producer of ethanol in the US.

2. Ethanol Production Expansion in Nebraska

Much of the state's ethanol production capacity has developed since 2006, going from 12 plants (1,181 million gallons per year (MGY) capacity) in 2006 to 20 plants (1,749 MGY capacity) in 2007 and 26 plants (2,006 MGY capacity) in 2008. Nebraska accounts for 14% of US ethanol production (Nebraska Energy Office). Increased ethanol production utilizes greater amounts of corn and positively impacts corn prices, which in turn impacts the land-use decisions of producers. To show a clearer impact on corn price volatility, other commodities relevant to Nebraska, such as soybeans and livestock, are included in the analysis. This is because market adjustments to expanded ethanol production go beyond the observed changes in corn prices. Higher corn prices improve the profitability of corn production relative to other crops providing incentives for producers to divert land from other crops – primarily soybeans, with lesser amounts from wheat, cotton, hay, and pasture (Baker and Zahniser, 2007; Hoffman et al., 2007; Dicks et al., 2009; Wilson et al., 2008; Wallander et al., 2011). Corn and soybeans share a common geographical production area, which makes them good substitutes, so as more acres were diverted to corn production to fulfill increased demand from ethanol, acres allocated to soybeans were reduced (Tejada and Goodwin, 2009; and Wright, 2011).

3. Methods

Like other annual crops, corn is planted in the spring, harvested in the fall, and is storable. The time lag between planting and harvesting means annual production levels heavily depend on weather and other factors that can negatively or positively impact production. Thus, yearly production swings influence price levels and can add to the variability of prices. In addition, crop prices also exhibit variability within the year due to the seasonality of production. Typically, prices are at their lowest in the fall during harvest when supplies are largest and highest in the late spring/early summer when supplies are the lowest. However, the ability to store corn does provide some mitigating impact – when prices are low at harvest, producers are incentivized to store the crop in expectation of higher prices later in the year. Thus, crop prices can be highly variable within a given year and from year to year. We use two approaches, graphical and estimation, to examine this variability.

3.1 Graphical Approach

The graphical approach uses monthly price index and marketing year standard deviation trends to illustrate whether the variability of Nebraska corn and soybean prices has increased due to increased ethanol production. The monthly price index is calculated as a ratio of the monthly crop price to the marketing year average crop price (Christian and Burgener, 2007). Its use removes the seasonal behavior of the commodity price series. While the monthly price index is used to illustrate (or capture) the seasonal price trends, the variability of the seasonal index values can be used to examine trends (or changes) in the volatility of the underlying price series. One way to measure this variability is to use the standard deviation of the monthly price index series. Graphs of monthly prices and standard deviations of corn and soybeans are examined for variability changes in the period before the rapid expansion of ethanol production and during the rapid expansion in Nebraska. The second approach for examining variability is explained below.

3.2 Estimation Approach: Beta

At the national level, ethanol's impact on volatility in the commodities futures market is estimated using beta, a common tool in finance. It is a part of the Capital Asset Pricing Model (CAPM) and is used creatively to estimate risk levels tolerable in a portfolio (Harrington, 1983). It measures financial stock volatility/risk, and many studies attest to that. The study by Harrington (1983) shows that the accuracy of beta values varies by the forecast horizon and that longer horizons tend to be more accurate. Campbell and Vuolteenaho (2004) used the type of market news to break a stock's beta into two components. They found that discount rates news had a higher beta than news about future cash flows.

Beta is a relative measure of specific stock volatility with respect to general market volatility. For instance, if Apple stock (AAPL) has a beta of 1.3, it implies AAPL is 30% more volatile, hence risky, than the overall market, such as NASDAQ QQQ or SPDR S&P. The farm/agricultural industry has a beta of 1.14 compared to 0.98 for the oil/gas industry (Damodaran, 2023). While stocks of agricultural firms may have betas, agricultural commodities traded on the futures market do not have betas. We apply the stock beta concept to agricultural futures commodities.

A corn beta will measure corn volatility with respect to the agricultural commodities in the futures market. The Bloomberg Commodity Index (BCOM), which is analogous to the stocks QQQ, includes commodities such as corn, soybeans, wheat, cotton, sugar, coffee, cocoa, cattle, and hogs. Unfortunately, the available BCOM data includes energy, precious and industrial metals, and agriculture. Hence, we calculated an agricultural-only "BCOM" index based on the nine commodities above using monthly prices. The average self-index of the nine commodities is used as the market index. The beta estimation uses returns, and these were calculated for each commodity and market indices as:

$$Return_t=Index\_tIndex\_t-1-1 \; Returnt=Index\_tIndex\_t-1-1$$

Beta is then estimated using the regression model below:

$$\text{Commodity Return}_t=\beta_0+\beta_1\text{BCOM Return}_t+\varepsilon_t \quad \text{Commodity Return}_t=\beta_0+\beta_1\text{BCOM Return}_t+\varepsilon_t$$

where

$$\beta_1 \beta_1$$

is beta with potential values as

- Between 0 and 1: The commodity is less volatile than the market
- Equal to 1: similar volatility as the market
- Greater than 1: The commodity is more volatile than the market.

It is worth noting that beta can be 0 (no relationship) or negative (inverse relationship), but these are uncommon since the specific commodity is captured in the market index.

3.3 Data

To evaluate the potential impact of increased ethanol production on the level and volatility of corn and soybean prices, monthly prices for corn and soybeans for Nebraska were obtained from the National Agricultural Statistics Service (NASS) for the marketing years 2000/01 through 2012/13 and used to construct a monthly price index. The marketing year (MY) for corn and soybeans is September 1 through August 31. This definition is used to construct the seasonal price index. Monthly futures data used in the beta estimation was obtained from Yahoo Finance, but the original source is CME Group. Table 1 presents the statistical description of the futures market data used. Cattle and hog have fewer observations due to the lack of data in 2000-2001. Five commodities have negative kurtosis, indicating their distributions are less heavy-tailed. Except for the livestock, all commodities are slightly skewed rightward.

Table 1 Descriptive Statistics of Data Used, September 2000 to August 2013

	Corn	SB	Wheat	Cotton	Sugar	Coffee	Cocoa	Cattle	Hog
Mean	383	906.58	506.20	67.37	0.86	118.95	2034.34	100.12	99.76
Std. Dev.	185	365.28	205.31	30.16	0.17	56.84	679.82	10.84	14.84
Kurtosis	-0.86	-1.22	-0.81	7.29	-0.66	1.02	-0.80	0.02	0.35
Skewness	0.73	0.37	0.58	2.42	0.07	1.06	0.30	-0.65	-0.43
Minimum	188	423.75	244.75	29.90	0.56	42.60	704.00	72.85	49.55
Maximum	803	1764.50	1073.00	205.14	1.27	299.35	3757	122.88	126.91
Count	134	133	134	134	134	134	134	118	118

Since much of the US ethanol production capacity developed since 2006, this study focuses on price volatility from 2000 to 2013. This period allows three sub-periods to be compared: Pre-expansion (2000-2006), Rapid-expansion (2006-2009), and Post-rapid expansion (2009-2013). The beta was estimated for three sub-periods:

- Pre-ethanol expansion: September 2000-August 2006
- Rapid-ethanol expansion: September 2006-August 2009
- Post-rapid expansion: September 2009-August 2013

The commodity indices were calculated for each sub-period with respect to the sub-period's average price as the base period price.

4. Results

We examine the potential impact of increased ethanol production on the level and variability of Nebraska corn and soybean prices using a graphical approach and an estimation approach. We first present the graphical results and then the estimation results.

4.1 Graphical Illustration of Commodity Price Volatility

The seasonal pattern of Nebraska corn prices is illustrated in Figure 1. As can be seen, corn prices fluctuate from month to month and have exhibited a strong upward trend over time. This upward trend has strengthened dramatically since 2006/07 MY and corresponds to the most recent expansion period of the ethanol industry (Nebraska's ethanol production capacity increased from 1,181 MGY in 2006 to 2,006 MGY in 2008).

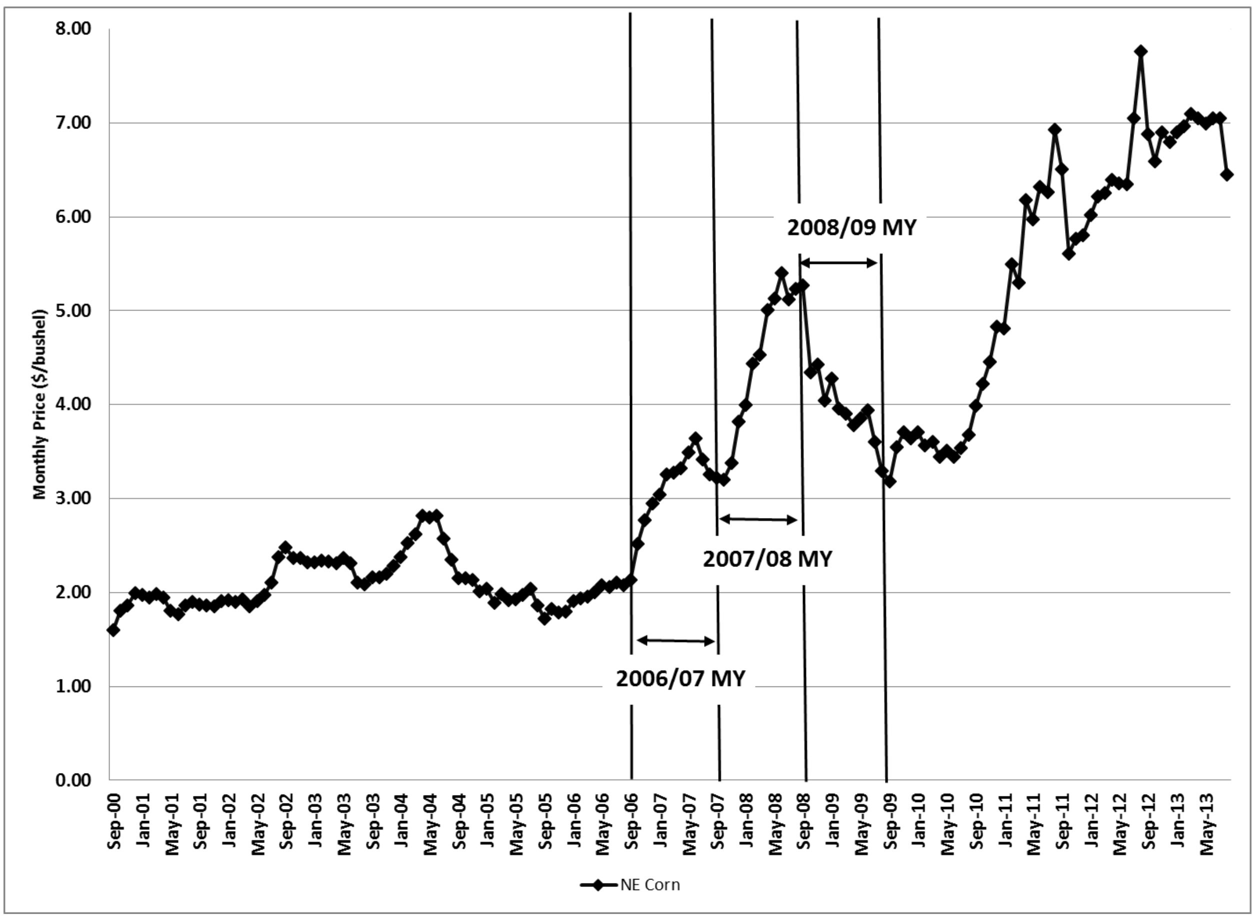

Figure 1. Monthly Corn Prices ($/bushel) for Nebraska 2000/01 – 2012/13 MY.

As discussed earlier, corn prices are seasonal during the marketing year.

As illustrated in Figure 1, corn prices tend to be at their lowest at harvest (September/October), the beginning of the marketing year, and then rise through the late spring/early summer (April/May/June) before declining to harvest-time lows. This seasonal pattern can be illustrated using the 2006/07 – 2008/09 MY period highlighted in Figure 1. During the 2006/07 MY, prices rose from $2.30 in September to $3.64 in June before declining to $3.26 in August. A similar pattern occurred in the 2007/08 MY with September corn prices at $3.22, June prices at $5.40, and August prices at $5.23. However, the 2008/09 MY did not follow the typical seasonal pattern; the marketing year began with a season-high corn price of $5.27, which then declined throughout the entire MY, ending at $3.29 in August. Although 2008/09 MY followed an atypical pattern, corn prices were substantially higher at the close of the 2008/09 MY ($3.29 in August 2009) than at the beginning of the 2006/07 MY ($2.30 in September 2006).

As illustrated in Figure 2, soybean prices exhibit a seasonal pattern similar to corn, fluctuating from month to month and showing a strong upward trend over the 2000/01 – 2012/13 MY period. To illustrate, consider the 2006/07 – 2008/09 MY period highlighted in Figure 2. Soybean prices rose from $5.14 in September to $7.38 in July, declining to $7.33 in August 2006/07 MY. This pattern was repeated in 2007/08 MY with September soybean prices at $7.96, peaked in July at $13.30, and then fell to $12.80 in August. The 2008/09 MY began with soybean prices at $10.40 in September, then peaked at $11.20 in June before falling to $10.80 in August. Like corn, soybean prices were much higher at the close of the 2008/09 MY ($10.80 in August 2009) than at the beginning of the 2006/07 MY ($5.14 in September 2006).

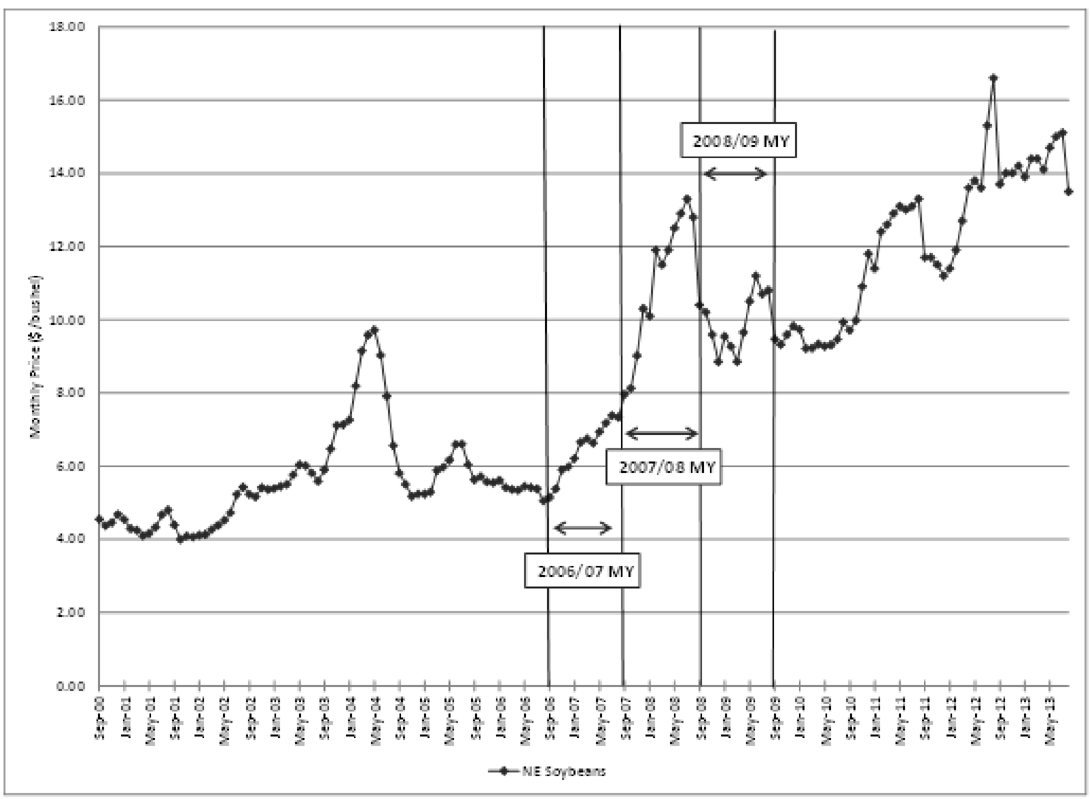

Figure 2. Monthly Soybean Prices ($/bushel) for Nebraska 2000/01 – 2012/13 MY.

As stated earlier, annual crop prices tend to follow a seasonal pattern due to the annual production process and storability; this pattern can be illustrated (or viewed more easily) using a monthly price index for the crop's marketing year. The monthly prices for corn and soybeans presented in Figures 1 and 2 were used to construct monthly price indices for the 2000/01 to 2012/13 MY period. The monthly price index for corn is presented in Figure 3 and for soybeans in Figure 4.

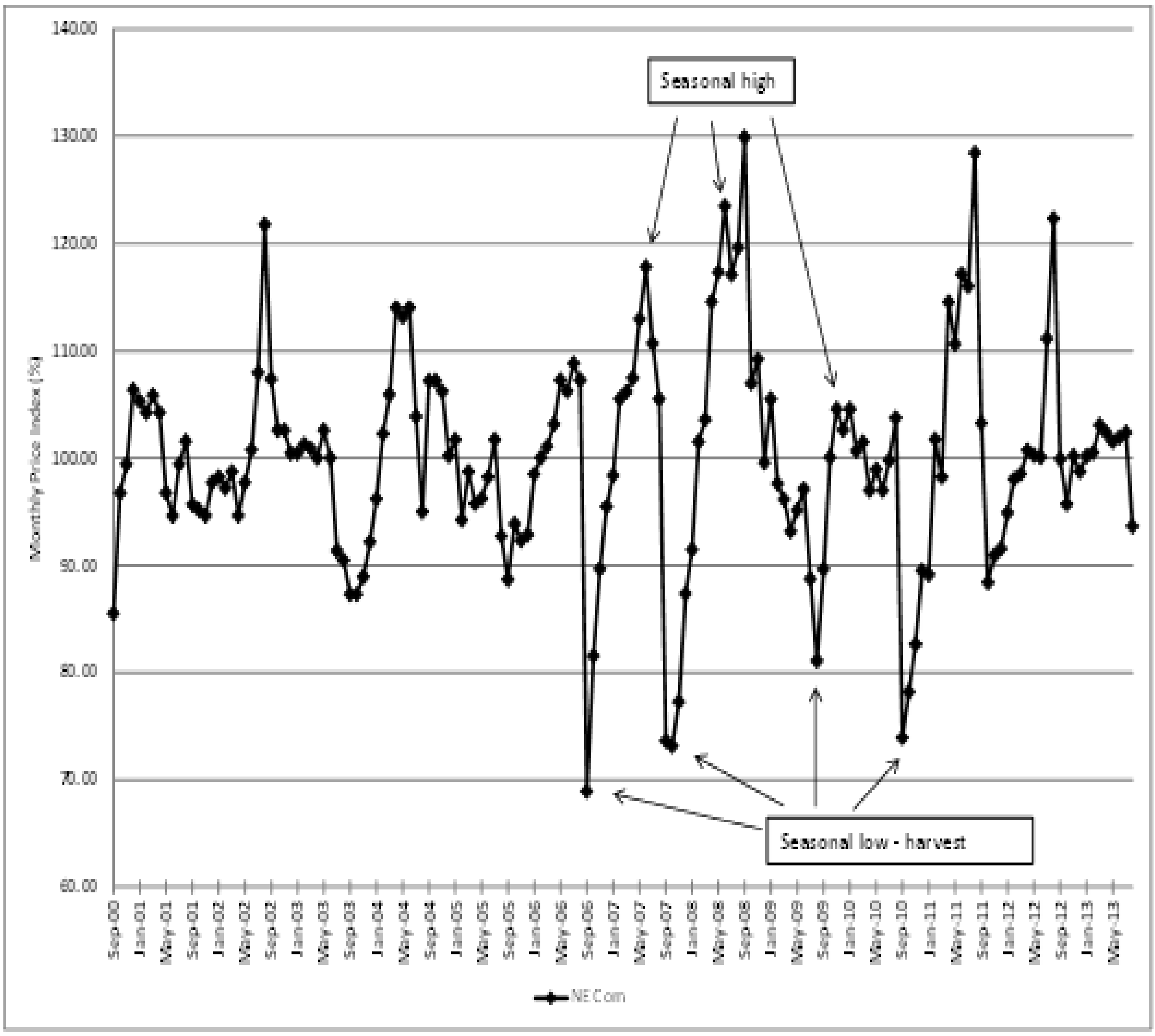

Figure 3. Monthly Price Index for Nebraska Corn 2000/01 – 2012/13 MY.

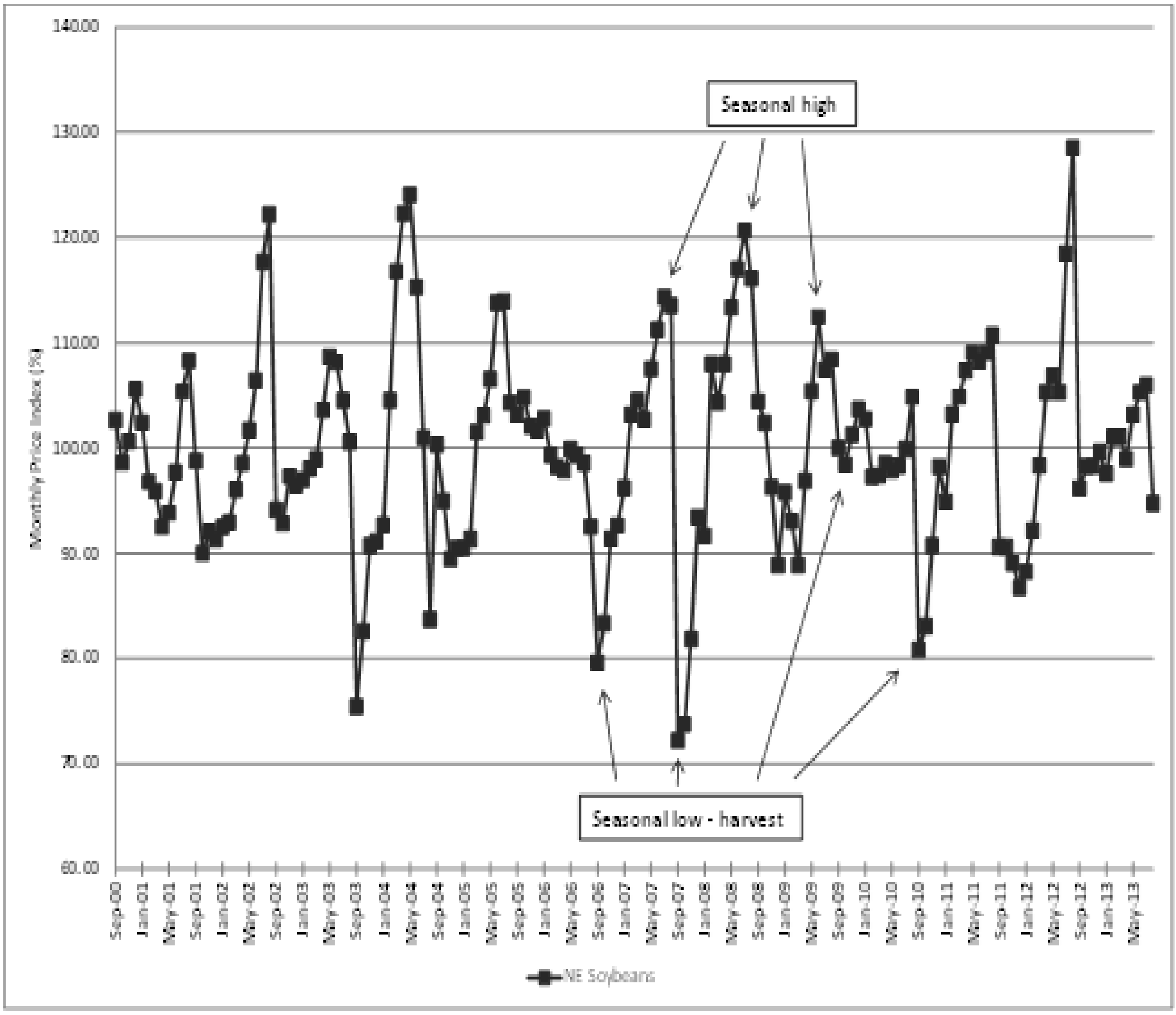

Figure 4. Monthly Price Index for Nebraska Soybeans 2000/01 – 2012/13 MY.

As shown in Figures 3 and 4, monthly price indices for both corn and soybeans tend to reach seasonal lows at harvest time (September/October), then rise through the late spring/early summer (April/May/June) before declining to harvest-time lows; however, these highs and lows vary over time due in part to factors other than seasonality, such as increased demand for corn for ethanol production. The recurring seasonal price pattern is shown by the fluctuations of the monthly index above and below the value of 100 (by construction, an index number of 100 means that the price in that month is exactly equal to the marketing year average). Furthermore, the value of the index in each month tends to be similar in magnitude over time (e.g., October corn price index is 96.7 and 95.1 in 2000 and 2001, respectively). Given this, it is possible to identify periods when factors other than seasonality are impacting price levels by comparing the current monthly price index to the previous 5-year average of the index for that month. For example, between 2006 and 2008, Nebraska's ethanol production capacity increased from 1,181 to 2,006 MGY; during this same time period, the monthly corn price index for September increased from 68.93 in 2006 to 73.63 in 2007 and 129.88 in 2008; the monthly index for June increased from 117.80 in 2007 to 123.48 in 2008. Comparing these values to the previous 5-year average of monthly price indices for September (97.2) and June (103.84) provides another indication that this price movement was due to factors other than seasonal and suggests that corn prices were lower than normal in September 2006 and 2007 but much higher in 2008; likewise, June prices in 2007 and 2008 were much higher than typical seasonal factors would indicate. Further, the increased differences in the monthly index numbers suggest greater volatility of prices during this time period.

As evidenced in Figure 4, soybean prices exhibit a seasonal pattern similar to corn. During the most recent ethanol expansion period (2006/07 – 2008/09 MY), the September soybean price index increased from 79.6 in 2006 to 104.4 in 2008, and the July price index rose from 114.30 in 2007 to 120.63 in 2008. Compared to the previous 5-year average of monthly price indices for September (91.2) and July (108.5) suggests that soybean prices in 2006 were much lower than typical seasonal factors would suggest and much higher in 2008.

While the monthly price index is useful for examining trends in the seasonal pattern of commodity prices, the standard deviation of the monthly price index series is typically used to examine the volatility of commodity prices over time. The standard deviation of the monthly price index series for corn and soybeans for the 2000/01 – 2012/13 MY period is presented in Figure 5. The variability measured by the monthly price index standard deviation for both crops has been trending upward from 2000/01 to 20012/13. Interestingly, the price variabilities of both crops are positively correlated; however, given that the two crops are produced in the same geographic area and experience the same types of growing conditions, this is not unexpected.

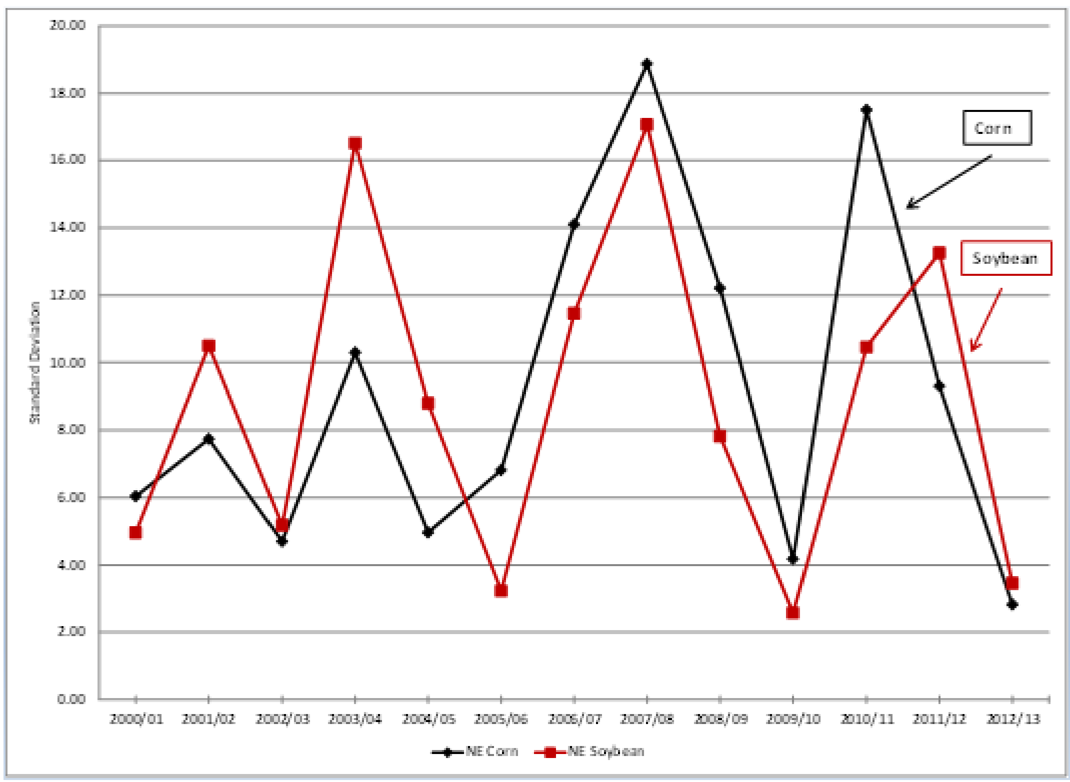

Figure 5. Standard Deviation of Monthly Price Index for Nebraska Corn and Soybeans 2000/01 – 2012/13 MY.

The graphical approach shows the volatility of corn and soybean prices increased in the ethanol rapid expansion period. We now present the results of the beta estimation for statistical confirmation of potential increased volatility.

4.2 Beta Estimation

Overall, the results (Table 2) show that the crop futures commodity prices are more volatile than the market volatility (beta >1), while the livestock prices are less volatile (beta<1). The estimated betas of corn and soybean support the graphical analysis results.

Table 2. Beta of Selected Agricultural Commodities

Period	Corn	Soybean	Wheat	Live Cattle	Lean Hog
Pre-Expansion (2000-06)	1.111***	1.283***	0.695***	0.381	1.191***
Adjusted R Squared	*0.348*	*0.333*	*0.126*	*0.031*	*0.127*
Rapid Expansion (2006-09)	1.394***	1.402***	1.607***	0.204*	0.530**
Adjusted R Squared	*0.583*	*0.778*	*0.678*	*0.078*	*0.164*
Post Rapid Expansion (2009-13)	1.645***	1.230***	1.239***	0.328***	0.479**
Adjusted R Squared	*0.709*	*0.688*	*0.449*	*0.184*	*0.071*

***p value <0.01, **p value <0.05, *p value < 0.1

The volatility of corn, soybean, and wheat prices increased in the rapid ethanol expansion period. Wheat, about 30% less volatile than the market, became 60% more volatile. Corn's volatility increased by about 28 percentage points, and soybean about 12 percentage points. Corn, the main feedstock for US ethanol, continued to experience increased volatility during the post-rapid expansion phase with a beta of 1.645. The volatility of live cattle prices was relatively stable across the periods, ranging between 0.20 and 0.40. Similar to live cattle, lean hog prices showed consistent volatility across periods.

5. Summary and conclusions

This study examines the potential impact of increased ethanol production on the level and volatility of corn prices. Corn prices fluctuate monthly and have exhibited a strong upward trend over time. They follow a seasonal pattern due to the annual production process and storability. Examination of the standard deviation of the monthly price index and evaluation beta results for corn and other crops indicate that price volatility continued to be greater than the market over the entire period (2000/01 – 2012/13), but it was corn's that increased substantially throughout the study period. While there is a strong connection between the impact of ethanol on corn and soybeans, the initial impact on wheat was due to the overall disruption to the commodities market during the rapid expansion phase. U.S. policies have contributed to the rapid expansion of ethanol, and the resulting higher commodity prices boost farm incomes, but the increased commodity price volatility is an unintended consequence that makes farming more risky. This calls for a more comprehensive approach to the U.S. pursuit of biofuel expansion. Finally, while it wasn't a goal of this research, beta results underscore the need for agricultural producers to diversify using crops and livestock to minimize their risk exposure.

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