Effect of Weather Disturbances on Spring and Winter Wheat Price Spread

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Abstract

This study aims to understand the impact of weather disturbances, drought in particular, on the price relationship between spring and winter wheat in the US. Spring wheat is vulnerable to drought as its growing season often coincides with the timing of extreme drought events. This affects the production and pricing of spring wheat. Using the USDA crop progress and condition report as a proxy for extreme weather events, we show that weather events significantly affect the price relationship between spring and winter wheat. Estimation results support the notion that a lower percentage of spring wheat in good/excellent conditions leads to a higher price spread between spring and winter wheat. The effect of drought on spring wheat alone can raise the price of spring wheat by 2.16% to 4.2% above the hard red and soft red winter wheat, respectively.

JEL Classification: Q02, Q11, Q13
Keywords: wheat, price spread, drought, crop condition

1 Introduction

Agricultural production is significantly affected by weather disturbances. With the prediction of increasing frequency and severity of extreme weather events in the coming future (IPCC, 2014), it is important to understand their implications for agricultural production and the commodity markets.

Extreme weather events, droughts in particular, have significantly impacted wheat production over the past two decades. Drought is considered the most important climatic stressor of wheat (Zampieri et al., 2017). Spring wheat bears the major impact of the drought as its growing season coincides with the time of these extreme droughts. In 2021, the Northern Plains were hit by a severe drought, where 71% of the spring wheat in the US is produced. This led to a decline in spring wheat production from 531 million bushels in 2020/21 to 297 million in 2021/22, the lowest in recent years, as the yield in some areas dropped by over 50% compared to 2020 (WASDE, 2021). Meanwhile, hard red spring (HRS) wheat prices traded on the Minneapolis Grain Exchange (MGEX) rose from less than \$6/bushel at the beginning of 2021 to over \$9/bushel in July 2021. The increases in hard red winter (HRW) wheat and soft red winter (SRW) wheat prices, by comparison, are much milder. Nearby HRW wheat futures prices only increased from around \$6 to \$6.5/bushel, and SRW wheat futures prices increased from around \$6.5 to \$7/bushel during the same period.

Also, in 2017, the Northern Plains were affected by a lengthy spell of varying degrees of drought, ranging from abnormal dryness to exceptional drought. The crop condition ratings, which show the cumulative progress for each crop at key stages, suggest that only 36%, 10%, and 11% of North and South Dakota and Eastern Montana's hard red spring wheat acres in 2017 were rated good to excellent, respectively (Bond and Liefert, 2017). In 2012, 80% of the US agricultural land was under severe drought, which caused more than two-thirds of its counties to be declared disaster areas (National Integrated Drought Information System, 2022). These unprecedented drought events have always coincided with the spike in the price of spring wheat repeatedly, as suggested by the prices of HRS wheat traded on the MGEX. Though the effect is evident, surprisingly very few studies have empirically investigated the extent to which these drought events have affected the HRS prices.

Six major wheat classes are produced in the US, out of which three classes of wheat (HRS, HRW, and SRW) are actively traded on futures markets. These different classes of wheat, in a way, are substitutes as they are blended in different quantities to produce the desired protein content. The prices of all three classes of wheat move along in the same pattern most of the time, with HRS prices being a little higher than other winter wheat prices due to its higher protein content. But this pattern of price movement is broken in the years of extreme drought faced by the spring wheat, where spring wheat prices rose significantly higher than that of winter wheat. We suspect this difference in price spread is caused by supply shocks to the spring wheat.

This study aims to understand the impact of weather disturbances, drought in particular, on spring and winter wheat price spread in the US. Existing literature has extensively analyzed the impact of extreme weather on agricultural production (e.g., Kuwayama et al. (2019)). However, the study of the effect on commodity prices is more limited. Results from the present study will add compelling evidence on how weather disturbances affect commodity markets beyond production. Such information would be useful for policymakers to improve the design of federal disaster aid programs, as well as for market participants in selecting tools to mitigate the risks posed by droughts and extreme weather events. Our empirical analysis relies on regression models comparing spring and winter wheat prices, using crop progress and condition data of the USDA as the main indicator of weather disturbances. Preliminary estimation results show that crop conditions significantly affect the spread between spring and winter wheat prices, but the magnitude of the impact may be smaller than expected.

In future analyses, we also intend to evaluate the incidence of the 2021 wheat price spike in the northern US, i.e., did the price increase occur more at the elevator level so that the producers received significantly higher prices, or conversely, more at market hubs so that the other factors further aggravated the price spike.

2 Literature Review

We review two strands of relevant literature: 1) the economic impact of drought; and 2) the interdependencies between the prices of different classes of wheat.

Economic Impact of Drought

Many studies show that climatic anomalies and extreme weather events lead to variances in crop yield. Droughts and extreme heat conditions are found to be significant in lowing cereal production due to the reduction of both harvested areas and yields (Lesk, Rowhani, and Ramankutty, 2016). A recent study by Kuwayama et al. (2019) shows that drought negatively affected crop yields in the United States. Using panel data models with fixed effects, they show that each additional week of drought led to a reduction of 0.1% to 1.2% for corn and soybean yield in dryland and 0.1% to 0.5% in irrigated lands, respectively. Despite the toll on crop yield, they concluded additional weeks of drought did not affect measures of farm income.

For wheat, heatwaves and droughts are considered the most critical climatic stressors (Zampieri et al., 2017). For instance, the 2010 droughts in Russia and Ukraine reduced the wheat harvest by 32.7% and 19.3%, respectively, severely diminishing the worldwide wheat supply (Sternberg, 2011). From 1980 to 2008, a 5.5% reduction of global wheat production can be attributed to climatic stress, despite the increase of wheat productivity by 50% due to improved management and higher-yielding crop varieties (Lobell et al., 2015).

On the other side, limited studies have been conducted on the economic cost incurred due to drought in the agricultural sector. Quiggin (2007) estimated that food prices in Australia increased by 4.4% in 2002-2003 and by 12% in 2005-2007 due to drought and other severe weather events. Horridge, Madden, and Wittwer (2005) simulated the short-run effects of the Australian Drought of 2002-2003 by aggregating the values from 38 sectors and 45 regions. They found that despite the small share of agriculture in Australian GDP, the drought led to income losses of up to 20% and a reduction in GDP by 1.6%. Wheaton et al. (2008) evaluated the economic cost of the 2001-2002 drought in Canada, finding that depending on the region, the drought led to $1.7 to 2.4 billion in crop production losses. However, the impact of the drought on the cash receipts was smaller due to inventory adjustments.

Several studies analyzed the economic cost associated with the 2014 drought, which had a prominent impact on Californian agriculture (Howitt et al., 2014; Medellín-Azuara et al., 2016). It is estimated that the drought resulted in a loss of $810 million in crop revenue, $203 million in dairy and other livestock value, and $454 million of additional groundwater pumping costs due to a net water shortage of 1.5 million acre-feet. Along with the loss of 17,100 seasonal and part-time jobs, the economic costs of drought totaled $2.2 billion. Losses continued to accumulate as the drought spanned into the following years, resulting in a total of $2.7 billion loss in 2015 and a $603 million loss in 2016 (Medellín-Azuara et al., 2016).

Despite the significant discussion on how prices respond to natural disasters (Huang and Etienne, 2021), very few attempts have been made to explain the impacts of drought on prices. Schaub and Finger (2020) used the structural vector autoregressive model (SVAR) to analyze the effect of drought on the feed prices in Germany and showed that regional and national droughts caused substantial increases in hay prices (up to +15%). In contrast, the feed grain prices were not affected by the droughts. Maystadt and Ecker (2014) noted that drought results in an increase in livestock prices which in turn positively affected the violent conflicts in Somalia. In this study, we attempt to address this gap in the literature and examine how drought has affected wheat prices in the US.

Price Relationship between Different Classes of Wheat

Six different major wheat classes are being produced in the USA: Hard Red Spring, Hard Red Winter, Soft Red Winter, Soft White, Hard White, and Durum Wheat. Hard Red Winter (HRW), Hard Red Spring (HRS), and Soft Red Winter (SRW) wheat are the major crops in terms of production area and exports, accounting for 40%, 25% and 15% of total production, respectively (Economic Research Service, 2022). Also, these three classes of wheat play prominent roles in the commodity market and are traded in three different markets: MGE (Minneapolis Grain Exchange), KCBT (Kansas City Board of Trade) and CBOT (Chicago Board of Trade). The main deliverables of MGEX, KCBT and CBOT wheat futures contract are Hard Red Spring (HRS) with a protein content of 13.5%, Hard Red Winter (HRW) with a protein content of 11%, and #2 Soft Red Winter (SRW) wheat, respectively. Premium and discounts are offered for different protein contents. Along with several subtle differences, these markets are highly interdependent with each other and share many common features. These classes of wheat are substitutable, although not perfect substitutes due to their protein differences (Wilson and Chan, 1987). The prices of the three types of wheat are highly correlated, but show differences that reflect the underlying fundamentals of the respective grades of wheat.

In general, the price of HRS wheat is the highest, followed by HRW and SRW. Several studies explain the differences in their prices and their relationships. Wilson (1983) pointed out that market fundamentals explain most of the variations in the relationships between HRS and HRW prices. The size of the crop yield, the carry-in stocks, and the average protein percentage in the HRW crop were noted as important in explaining the price differences, whereas the protein of HRS does not affect the price. McNew (1991) determined that the fundamental factors explaining the price spread between HRW and SRW wheat include production, beginning stocks, domestic use, and export of the wheat.

Meunier (1988) studied the relationship between the HRW and White wheat (WW) by applying the Granger's causality test on average monthly cash prices and daily Free on Board (FOB) prices. The result showed that the adjustment on one wheat instantaneously causes the adjustment on another, i.e., a feedback relationship exists between the price of HRW and the price of WW. This result is in line with the observed strong relationship between different wheat classes in the US market.

Bekkerman (2021) argued that the spread between HRS and HRW wheat is indicative of the market demand for higher-protein wheat relative to the baseline winter wheat. In years when the average protein level for winter wheat is low, demand for higher-protein spring wheat would be higher due to the higher demand for spring wheat to be blended with winter wheat to achieve the desired protein level. This means that the spread between spring and winter wheat would increase in years when winter wheat has low protein. Bekkerman, Brester, and Taylor (2016) noted that in 2004-2010, the HRS-HRW price spread increased throughout the marketing year, suggesting that the market is willing to pay a higher premium for higher protein spring wheat as the harvest season approaches. While not directly estimating the drivers of the spread, they noted that transportation costs, availability of wheat in different regions, differences between end-uses, and other supply and demand factors unique to the two wheat classes may significantly affect the spread.

The existing literature on the price relationship between different classes of wheat focuses mostly on the differences in protein content. As noted by Bekkerman, Brester, and Taylor (2016), many other factors may play a role in driving the spread between spring and winter wheat prices. In the present study, we link the two strands of the literature discussed, and examine how the drought events in the United States had altered the price relationship between spring and winter wheat.

3 Data and Empirical Approach

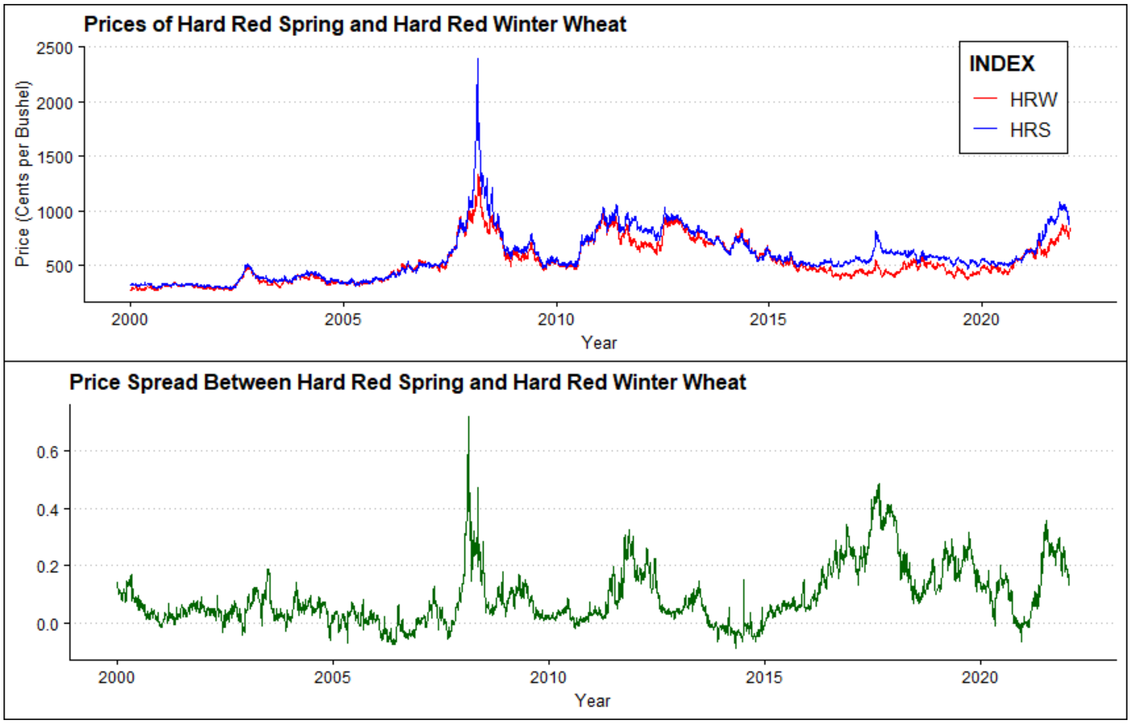
Our main model lies in comparing the prices of spring and winter wheat. In the US, spring wheat is typically planted in March-May, and harvested in late summer and early fall. Due to the production cycle, spring wheat is vulnerable to drought incidence as its growth stage closely coincides with the season most prone to drought. Meanwhile, winter wheat is typically planted in fall, and harvested in the summer or early fall of the following year. Having many characteristics in common, spring and winter wheat prices are close substitutes for each other, and their prices tend to mimic the behavior of the other. However, with the occurrence of drought, the prices spread between the two classes of wheat can deviate from the average differences suggested by the protein content. We link the price spread with drought conditions.

We use nearby futures prices of hard red spring (HRS), hard red winter (HRW) and soft red winter (SRW) wheat, traded on MGEX, KCBT, and CBOT, respectively. The dataset consists of weekly nearby futures prices of the three wheat classes from 2000/01 to 2021/22, retrieved from the Bloomberg terminal. We use futures instead of cash prices for two reasons. First, futures prices are subject to immediate changes in the underlying supply and demand conditions; this gives us a good measure for understanding the price implications of ongoing drought conditions in various parts of the nation. Also, futures contracts deal with the specified protein level of a given class of wheat, which helps us remove the variation caused by the differences in protein levels within the different wheat classes. For instance, the reference protein level for MGEX HRS wheat is 13.5%, and for KCBT HRW wheat, the reference level is 11%. By contrast, cash prices are often quoted for different protein levels.

Figure 1 plots the prices of HRS vs. HRW wheat, while figure 2 plots the trajectories of HRS vs. SRW wheat prices. Summary statistics are presented in table 1. Prices of all three classes of wheat, in general, move close to each other. In most of the times, HRS wheat has the highest price, followed closely by HRW and SRW. On average, HRS is priced at a 55 cents/bushel, and 76 cents/bushel premium above HRW and SRW wheat, respectively. As noted earlier, a large portion of the price differences can be attributed to the differences in protein levels. In addition to the protein levels, other variables (stocks, production, etc.) have a significant role in determining the price spread (Wilson, 1983; Wilson and Chan, 1987; McNew, 1991).

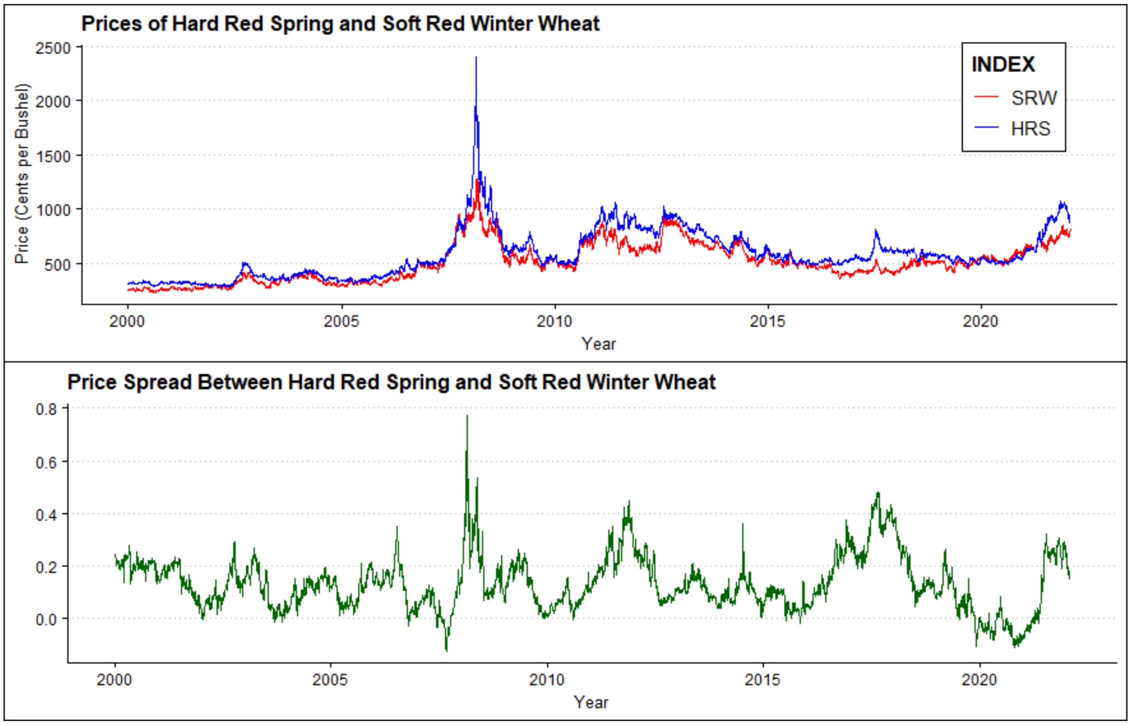
Figures 1 and 2 show that the spread between HRS and HRW, and between HRS and SRW wheat (computed as logarithmic price differences) fluctuated around 8% and 12%, respectively, during the sample period. In both plots, the spread showed sharp increases in 2008, 2012, 2017, and 2021.

Figure 1: Price spread between hard red spring and hard red winter wheat prices.



In particular, in 2008, HRS wheat prices were almost 80% higher than HRW wheat prices, and about 70% higher than the SRW wheat price. This period coincides with the rapid run-ups in commodity prices and the subsequent financial crisis. As can be seen in the figures, all three wheat markets experienced large volatility in 2008, reaching their all-time highs. HRS wheat rose over 300% from $6 per bushel to $24 per bushel on February 28, 2008. Meanwhile, HRW and SRW reached $13.35 and $13.70, respectively, on February 27, 2008. Janzen et al. (2014) indicate that the heightened price volatility around this time can largely be attributed to supply disruptions. They estimated that 40-62 % of the rise in wheat prices in 2008 were attributed to supply shocks, whereas broad-based demand shocks associated with fluctuations in global economic activity had a 9-12% price impact. Etienne, Irwin, and Garcia (2015) note that there may be short-lived bubble periods in HRS wheat market in 2008 due to the increasing participation of index traders in commodity markets. However, the spread between spring and winter wheat prices was a noticeably short run, quickly plummeting to the level in average years.

Figure 2: Price spread between hard red spring and soft red winter wheat prices.



Prices of Hard Red Spring and Soft Red Winter Wheat

Price Spread Between Hard Red Spring and Soft Red Winter Wheat

Another spike in the price spread was observed in 2017, when extreme heat and drought took a toll on the spring wheat crop in Northern US. Spring wheat prices were priced above HRW and SRW wheat prices by almost 50%. The most recent spike in the price spread occurred in 2021. In 2021, 99% of the hard red spring wheat growing region in the Northern Plains was under the area experiencing a drought, which greatly affected the spring wheat supply. HRW and SRW wheat prices were below the HRS wheat prices by almost 40% in the summer of 2021.

Table 1: Summary Statistics

Variables	Mean	SD	Min	Max
HRS Wheat Prices (cents/bu.)	583.33	221.93	286.25	2,400
HRW Wheat Prices (cents/bu.)	528.63	183.47	274.75	1,337
SRW Wheat Prices (cents/bu.)	507.78	174.68	233.5	1,280
Spread: HRS-HRW (%)	8.19	8.75	-9.01	51.36
Spread: HRS-HRW (cents/bushel)	54.70	77.60	-68.75	1,232.75
Spread: HRS-SRW (%)	11.97	78.29	-13.03	53.77
Spread: HRS-SRW (cents/bushel)	75.55	83.55	-90.5	1,290.5
HRS Stocks-to-Use (%)	35.16	10.63	10.64	66.20
HRW Stocks-to-Use (%)	36.20	15.47	9.31	69.22
SRW Stocks-to-Use (%)	34.80	17.57	6.89	78.04
Spring Wheat Crop Condition (G+E %)	61.78	13.87	9	86.0
Winter Wheat Crop Condition (G+E %)	51.67	10.38	27	78.0

While most of the spreads are positive, reflecting the protein premium between spring and winter wheat prices, it is interesting to note that negative spreads occurred rather frequently during the sample period. For instance, HRS wheat prices were priced at a discount relative to HRW wheat for most of 2014. Data from the USDA shows that the HRW crop production was low in 2013 compared to historical standards, while HRS crop production had been high. Emslie (2014) notes that the negative price spread was further triggered by the large Canadian wheat production confirmed in December 2013. In December 2013, estimates showed that Canadian wheat yield would surpass the previous record by 21%.

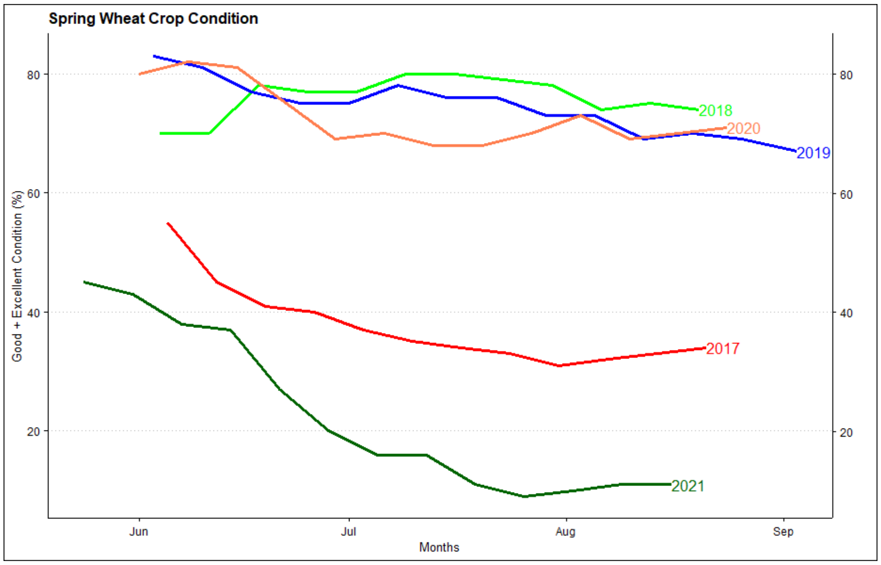
Since Canadian wheat is largely equivalent to the HRS wheat in the US and Canada is one of the world's largest wheat exporters, the HRS wheat prices in the US significantly dropped following the news on the yield. Meanwhile, Argentina, which exports a significant amount of wheat in the region, had a poor crop. The additional demand for HRW wheat from Brazil strengthened the HRW wheat prices in the US, further contributing to the negative spread between HRS and HRW wheat.

Previous studies note that supply shocks play a role in the price spread between different classes of wheat (Wilson, 1983; Wilson and Chan, 1987; McNew, 1991). To examine the supply shock caused by weather disturbances, in particular drought, we use the data derived from the Crop Progress and Condition report published by the USDA Economics, Statistics and Market Information System. The report provides information on the progress and qualitative condition ratings of important crops based on field surveys. Crop condition data is expressed as a percentage of crops in excellent, good, fair, poor, and very poor condition. Winter wheat progress and condition report is available starting from week 14 of a calendar year (March), and ends until the harvest season in week 27 (July). For Spring wheat, the data is available from week 20 (May), and ends in week 33 (August). Since the report shows the state of a crop at the regional or national level, it has been used to anticipate the positive or negative anomalies in production and forecast yield (Beguería and Maneta, 2020). Even though the weather data is readily available, we prefer using the crop progress and condition data because it depicts the real scenario from the fields.

Following previous studies (Bekkerman, 2021), we combine the "good" and "excellent" ratings to indicate the proportion of wheat crops in higher quality groups, and the remaining three ratings as lower quality groups. In general, the value of this crop condition variable is high for good crop years and is low for years impacted by the weather events such as drought. Bekkerman (2021) argued that higher quality ratings (based on crop conditions) may be associated with either higher yield (which is often associated with lower protein levels) or higher protein. In the case of the former for spring wheat, this suggests that its prices should decrease relative to winter wheat. For the latter, spring wheat prices may increase given the higher protein content.

As suggested by table 1, the average good plus excellent crop conditions in spring wheat is 61.78%, whereas for winter wheat it is 51.67%. However, spring wheat crop conditions show higher variability, with the lowest value reaching 9%. Figure 3 shows spring wheat crop conditions from 2017 to 2021. In the years with normal weather conditions, the good plus excellent percentage of spring wheat is in the range of 70-80% during the harvest, whereas in the years with drought, the percentage of crops in higher-quality conditions drops to as low as 10%. 2017 and 2021 were the years experiencing severe drought where the percentage of high quality crop was 34% and 11%, respectively. This shows a strong correlation between the crop condition and the severity of drought during the respective periods. In other words, the crop condition variable we constructed should at least partially capture the effect of drought on the yield of the crop.

Figure 3: Spring Wheat Crop Condition for Five Years



The other main explanatory variable used is the ending stocks-to-use ratio of each class of wheat, which depicts the market-specific fundamentals of the respective wheat class. It measures carryover stock as a percentage of total demand to use, which shows the tightness of the current supply-demand relationship of the wheat market. The variable has been extensively used in previous studies to estimate the impact of market-specific shocks on the prices of storable commodities (Etienne, Irwin, and Garcia, 2018; Lawson, Alam, and Etienne, 2021). The stocks and use data for each class of wheat are obtained from the monthly USDA WASDE report.

We run the following regression models to understand the effect of supply shocks on the price spread.

$$Spread_{HRW} = \beta_0 + \beta_1 SC + \beta_2 WC + \beta_3 HRWsu + \beta_4 HRSsu \tag{1}$$

$$Spread_{SRW} = \beta_0 + \beta_1 SC + \beta_3 WC + \beta_3 SRWsu + \beta_4 HRSsu \tag{2}$$

where $SpreadHRW$ and $SpreadSRW$ are the price spread of HRS wheat relative to HRW and SRW wheat, respectively (i.e., the log price difference between the respective classes of wheat). SC and WC are the percentage of good plus excellent crop conditions for spring and winter wheat, respectively. $HRSsu$, $HRWsu$ and $SRWsu$ are the stock-to-use ratio of the HRS, HRW, and SRW wheat, respectively. Weekly data from 2000 to 2021 are used for the analysis.

4 Results

Table 2 shows the regression results for equations (1) and (2). Our main focus here is the relation of crop conditions to the price spread. The impact of spring wheat crop conditions is negatively significant. All else equal, when the percentage of spring wheat in good and excellent condition increases by one percentage point, the price spread between the HRS and HRW wheat on average decreases by 0.036 percent, and the spread between HRS and SRW wheat prices decreases by 0.070 percent. This suggests that in the years when a higher percentage of spring wheat is in good/excellent condition, or spring wheat crop is not affected by extreme weather events, spring wheat prices decrease relative to winter wheat prices. Conversely, when the spring wheat is affected by some extreme events, a lower percentage of spring wheat crops in good/excellent condition. This will lead to an increase in spring wheat prices relative to winter wheat, i.e., a larger price spread.

Table 2: Estimation results for equations (1) and (2)

	Price Spread	
	HRS-HRW	HRS-SRW
	(1)	(2)
Spring Crop Condition	-0.036^{***}	-0.070^{***}
	(0.007)	(0.007)
Winter Crop Condition	0.012	0.052^{***}
	(0.009)	(0.009)
HRW Stocks-to-Use	0.234^{***}	
	(0.008)	
SRW Stocks-to-Use		0.126^{***}
		(0.006)
HRS Stock to Use	-0.180^{***}	-0.132^{***}
	(0.013)	(0.011)
Intercept	2.901^{***}	7.034^{***}
	(0.606)	(0.661)
Observations	1,110	1,110
Adjusted R^2	0.511	0.428
Residual Std. Error (df = 1105)	2.790	3.060
F Statistic (df = 4; 1105)	290.331^{***}	208.290^{***}
Note:	*p<0.1; **p<0.05; ***p<0.01	

In years affected by drought, the percentage of spring wheat in good/excellent condition is 40-60 percentage points lower than the normal crop year. In the case of 2021, the crop condition is 60 percentage points lower than that of 2020 when the crop did not experience any significant weather disturbances. This 60-percentage point reduction in crop condition results in the rise of the price of HRS by 2.16 percent and 4.2 percent above the price of HRS and SRW, respectively.

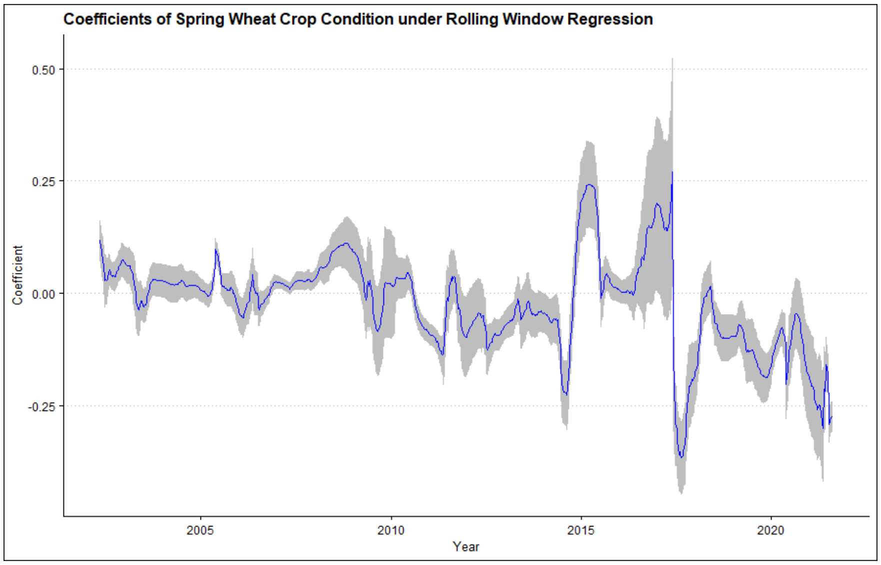
The winter wheat good/excellent crop condition variable is positive in both regression equations, but only significant when modeling the HRS-SRW spread. When a higher percentage of winter wheat is in good/excellent condition, the price of winter wheat is expected to decrease due to the expectation of good crops. All else equal, this will increase the spread between spring and winter wheat prices. As suggested by Table 2, a one percentage point increase in winter wheat good/excellent crop acreage increases the HRS-HRW price spread by 0.052%.

The stock-to-use ratio of HRS wheat is negatively significant with the price spread in both equations. This indicates that, when the supply of the spring wheat is high, its prices go down and thus decrease the price spread. For winter wheat, both stocks-to-use ratio of HRW and SRW are positively significant in explaining the price spread. This suggests that, when the stocks of winter wheat is high, the prices of winter wheat go down that in turn increases the price spread between spring and winter wheat. This result is in line with the result found by Wilson (1983); Wilson and Chan (1987); McNew (1991).

With this model, only 51 and 43 percent of the price spread of HRS with HRW and SRW is explained, respectively, suggesting that this model does not completely describe the price spread. There may be many other factors responsible for the change in price between different classes of wheat. Also, there may exist the possibility of structural breaks in the price relationship, because a single coefficient cannot represent the whole data set.

Figure 4 shows the coefficients of spring wheat crop conditions obtained from rolling window regression. The window size is 2 years. Here, we see the sudden change of coefficient from positive magnitude to negative significant around 2017. This changing magnitude of

Figure 4: Coefficients of Spring Wheat Crop Condition under Rolling Window Regression



spring wheat crop condition reveals that it is not always significant in explaining the price spread but we can at least get an impression that during the years impacted by drought as in 2012, 2017 and 2021, the coefficients of spring wheat condition are negative and significant.

5 Preliminary conclusions

This study aims to understand the impact of weather disturbances, drought in particular, on spring and winter wheat price spread in the US. Spring wheat is vulnerable to drought as its growing season often coincides with the time of extreme drought. This affects the production and prices of spring wheat. Using the USDA crop progress and condition report as a proxy for extreme weather events, we show that weather events significantly affect the price relationship between different classes of wheat. Estimation results support the notion that a lower percentage of spring wheat in good/excellent condition leads to a higher spread between spring and winter wheat prices. The effect of drought on spring wheat alone can raise the price of spring wheat by 2.16% to 4.2% above the hard red and soft red winter wheat, respectively. The estimated effect appears to be smaller than anticipated.

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