The Park Place Economist

Volume 14 | Issue 1 | Article 9

4-2006

Drought's Affect on Soybean Prices

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Abstract

Droughts are among the most feared natural disasters. They can affect the lives of many people such as farmers, consumers, or commodity traders. Droughts have taken a year's work and salary away from farmers, led to higher prices for consumers, and taken the life savings away from some speculators. There has been a recent push in science to better understand the enigma of a drought. However, the research has not yet prevented people from losing a lot of money. The best way to protect people is by understanding how prices react to droughts. Agricultural prices are inherently unstable, primarily due to a combination of inelastic demand for food and production that is subject to the natural vagary of weather. The agricultural product on which this research focuses is soybeans. In particular, I will focus on the November futures contract because it has the most liquidity in the season after the crucial August weather.

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I. Introduction

Droughts are among the most feared natural disasters. They can affect the lives of many people such as farmers, consumers, or commodity traders. Droughts have taken a year's work and salary away from farmers, led to higher prices for consumers, and taken the life savings away from some speculators. There has been a recent push in science to better understand the enigma of a drought. However, the research has not yet prevented people from losing a lot of money. The best way to protect people is by understanding how prices react to droughts. Agricultural prices are inherently unstable, primarily due to a combination of inelastic demand for food and production that is subject to the natural vagary of weather. The agricultural product on which this research focuses is soybeans. In particular, I will focus on the November futures contract because it has the most liquidity in the season after the crucial August weather.

Understanding droughts is so important to recognizing price changes - as seen in a recent example from the summer of 2005. During the Midwest crop season, there was a drought that lasted up until the beginning of August driving up the price of many agricultural products, including soybeans. This caused the traders and speculators to panic and believe that soybean production would be greatly reduced and that the contract price would skyrocket. Into late July, the price of the November contract reached just under $8.00 per contract – up from around $6.00 earlier in the year (cbot.com, 2005). Knowing the growth pattern of soybeans, we know that August weather is crucial to the maturation of the plant (Hall, 2002).

Going into August 2005, the drought was still evident. Then, following a string of days with rain, the price of the November contract fell to under $5.70 within the next few weeks. If we knew ahead of time that this year's drought would not be very significant for soybeans, we may not have seen the spike in price. This is an example of a drought's *potential* effect. Looking at various levels of droughts in the past, it shows us that droughts will cause major changes in price for soybeans.

The goal of this paper is to measure the effective price change in the soybean contract that is caused by drought. I hypothesize that a drought during August will lead to a statistically significant increase in price, normal rainfall will not affect the price, and above average rain could lead to potential increases in price. An abundance of rain not only poses a threat of "drowning" the crop, but also increases the chance of pests or other diseases being brought to the plant (Kenyon, 1993). Using these predictions in combination with scientists' predictions of droughts, we can make a drought much less feared, and perhaps much more profitable.

II. Theory and review of Literature

Making a drought *profitable* would involve taking advantage of price discrepancies in the market caused when a drought occurs. The only way to do this is to understand how the market reacts to such problems. Looking at traditional agricultural economics, bad weather normally decreases the supply of grains and oilseeds, having a lower quantity of product being made available (Hall, 2002). With inelastic demand (i.e. demand is held constant), the supply shortage caused by the drought will force the supply curve to shift left to a higher equilibrium price (Kenyon, 1993). This fundamental supply theory explains why there is a sharp increase in soybean price during a drought season.

Ruby Mize, a University of Maryland agriculture professor, looks specifically at production and its relationship to price. Mize points out that in the years of significantly lower production, the soybean futures price, at some point, experienced a sharp increase (Mize, 2005). This observation succeeds in supporting the theory mentioned above. She also conducts an experiment simulating a drought at various stages of the soybean plant's life. She claims that, "soybeans are a more resilient crop than most, and are more capable of performing under stress of bad weather" (Mize, 2005). Through this experiment, Mize also confirms what agricultural economist Stanley Stevens asserts that the most vulnerable time for soybeans is in August when the crucial maturation, flowering, and pod filling, occurs (Stevens, 1997). In the other stages, each corresponding to a different month (see Table 1), the crop can still survive and mature in the presence of a drought.

Table 1 - Soybean Growth Process

Stage	Month
Planting	May
Emerging	June
Blooming	July
Pod Setting	August
Leaf Dropping	September
Harvest	October, November

The degree to which the supply curve shifts as a result of a drought depends on the severity of the drought. Drought is a difficult word to define mainly because: drought, unlike flood, is not a distinct event, and drought often has neither a distinct start nor end. Researchers, therefore, have devised a way of categorizing different types of droughts. The drought types that can cause damage to the crop are either moderate or severe droughts spread out over a large geographic region. A moderate drought is said to occur when an area receives 45 to 60% of the expected precipitation while a severe drought involves less than 44% of rain within a three month time frame (Changnon, 1987). The Department of Energy and Natural Resources calculates that the average rainfall in soybean producing areas is between 35 and 48 inches per year (Changnon, 1987). This means that a year with rainfall in the range of 16 to 24 inches is a year that had a moderate drought while less than 16 inches of rain is considered a severe drought.

Researchers at the National Oceanic and Atmospheric Administration (NOAA) state that the only important weather statistic is the August rainfall. On average, they peg the soybean producing regions to receive 3.57" of rain in August alone (ncdc.noaa.gov, 2006). A moderate drought would then have rainfall between 1.61" and 2.14" and a severe drought would have less than 1.60" in August. Through this, it is established that the lack of rain, especially in August, can hinder the growth of soybeans. This decrease in production is reflected in the futures price. However, I measure the magnitude of this effect on the varying degree of drought.

III. Data

I use the November contract for soybeans because it best represents the crop life through the crucial August weather. The August contract is not used because it expires mid-month and would not fully include a late August drought. The September contract is rejected simply due to its lack of liquidity and volume.

The dataset spans 35 years allowing for a wide variety of drought and non drought years to be compared. All of the years in which there was not a drought are used to formulate an average price (adjusted for inflation) of the November futures contract throughout its market activity. There has been a trend in globalization of the soybean market recently; however, with South America being the only other *major* producer, their crop conditions are reflected in a different commodity – *Brazilian Soybeans (BS)*. This commodity correlates with, but is not the same as, U.S. soybeans; therefore, South American weather will not interfere with the U.S. data used in this research. Bunge Chicago, a commercial farmer and drought researcher, provides the drought data necessary for this research. The key weather to observe is that which occurs during August; these are likely to have the largest impact on production and also price (Stevens, 1996).

IV. Empirical Model

This study tests the hypothesis that different levels of drought have a significant influence on the price of soybeans. This model goes about measuring the various effects by a simple comparison of prices of the November contract during different years. In order for the data not to be skewed, one must control for demand (i.e. have similar export levels), acreage planted, and normal precipitation levels within the observed years.

The next step is to find the years in which there were similar levels of August rainfall in the bean producing regions. I came up with four possible levels of rainfall that the region may encounter: *Above average rainfall, average rainfall, below average rainfall, and drought*. The measurements for each category are given in Appendix 1 and were derived from the NOAA website.

To test *above average rainfall* years, I gather the years in which there was August rainfall exceeding 4.2", but less than 6.0". The reason for the cap is to make sure that flood effects are not factored into the price. Perhaps in further research, the effects of a flood during the growing season could be measured; however, this research focuses mainly on drought effects. Also, all of the years in this category, as well as in all categories, must have similar exports and acreage used. Once the years are gathered, the price changes are considered. By comparing the point in which the high and the low prices occur, I derive a percent change in November futures price over the month of August. This process is repeated for the other categories above.

By looking at the final results, one can make the distinctions between each category's affect on soybean price. For each varying amount of rainfall, there is a different percentage that represents the net effect of the August rain.

V. Results

The results from the *average rainfall* years are found in Table 2. The like years gathered in order to test the model are shown. The high/low ranges are given in dollars per contract (5,000 bu.), and the sign in front of the percent change figure indicates the price's direction. A positive change indicates an increase in price while a negative change indicates a price decrease. The results for *average rainfall* are as expected; the cumulative change in price was a minute .04%. This shows that when the weather acts as expected, there is not much panic in the markets. It is also interesting to point out that there is a varying degree of impact over the years. One explanation is that in the years with large decreases in price (1988 & 2001) July was a very dry month. There were expectations that the dryness would continue into August. However, August received the average rainfall and the soybean plant was able to survive, driving the price back down to normal levels. The reason for the other years being positive may simply be explained by the fact that the contract is approaching expiration, and this generally means

Table 2 - Average Rainfall's Effect on Price

Year	Low	High	Percent change
1987	4.9175	5.145	4.42%
1988	8.12	8.955	-10.28%
1989	5.61	5.995	6.42%
1992	5.3825	5.55	3.02%
1994	5.5325	5.755	3.87%
1998	5.285	5.43	2.67%
2001	4.735	5.2	-9.82%
		Average Change	0.04%

Calculations made by author; based off historical prices a slight increase in price, *ceteris paribus*.

Now looking at Table 3, the same explanation applies for the interpretation of the chart. The interesting issue for *above average rainfall* is the fact that every year it happens, the net effect on price is negative. The average change is about a 15% decrease in price for these types of rainy months. There is a similar explanation for the larger percentages as there is for *the average rainfall* decreases. In the larger change years (1974, 1975, 2005), there was a fear of a drought in July carrying over into August. Again, this was not the case, and the price of soybeans suffered. It appears that an (unexpected) above average amount of rain has a greater effect on price than just the average, given a previous possibility of drought.

Table 3 - Above Average Rainfall's Effect on Price

Year	Low	High	Percent change
1974	7.12	8.9	-25.00%
1975	5.495	6.525	-18.74%
1977	4.97	5.75	-15.69%
1982	5.505	6.145	-11.63%
1985	5.03	5.335	-6.06%
1993	6.48	7.09	-9.41%
2005	5.955	7.09	-19.06%
		Average Change	-15.09%

Calculations made by author; based off historical prices

Lastly I looked at droughts. Looking at Table 4, one may notice that there are two types of droughts; there are drought periods with rainfall simply below the desired amount for soybeans, and then there are more severe droughts where there is a definite water shortage. The average change *for below average rainfall* is 10.85% while a more severe drought causes an average of a 15.06% increase in contract price. The discrepancy in different drought years is due to the timing of the drought. For example, if a drought already was evident before August, the effect of a continued drought multiplies the price increase. This example is seen in 1983 when a July drought continued to become a severe August drought thus magnifying the price change (Ellis, 2005). Similarly, if July was a relatively wet month, then August became drier, such as in the case of the 1986 crop season, there is a lag period where it is difficult to determine if there really is a drought going on. This effectively slows the market's reaction to drier weather and the futures price is not as drastically affected. Finally, the percentages may vary if the drought occurs late in August; the result of this case is the mitigation of the drought effects. Evidence supporting this view is exemplified in the crop season of 1999. In this year, there was in fact a mid to late month drought spell during August where the effects were

Table 4: Drought's Effect on Price

Year	Low	High	Percent change
1999	4.45	5.03	11.53%
1996	**7.205**	**8.02**	**10.16%**
1991	5.29	5.985	11.61%
1986	4.6525	4.8	3.07%
1984	**6.04**	**6.64**	**9.04%**
1983	**7.21**	**9.67**	**25.44%**
1976	**5.9**	**6.99**	**15.59%**
1973	7.345	9.29	20.94%
1971	3.1375	3.3775	7.11%
	Below Average Rainfall		10.85%
	Severe Drought		**15.06%**

Calculations made by author; based off historical prices barely captured in the market, given the size of the drought. By the time the drought had taken its toll, a vast majority of the crop was past its crucial stage of growth and not as prone to damage as it would have been one month earlier. Therefore the change in price was about average for that type of drought.

These results support my hypothesis. Since drought plays a large role in determining production for a given season, it in turn causes fluctuation in the commodity price. Also, the stronger a drought is or the longer it persists, the larger the effect will be on the price.

Overall, the results of this model were very close to what I expected. The most surprising aspect, however, was how strong an impact the *above average rainfall* has on price. It has a little larger effect on price than a severe drought. However, the data may be skewed from the wash-over effects of the previous month's weather. Or it can also be explained by the fact that soybean plants are referred to as *desert* plants; they have more of a resiliency to dryness than they do to wetness. The fact that the price went down also shows that the plant can prosper with rain, and cannot grow properly without it in August.

To further demonstrate that there is statistical significance in the data, I used a simple t-test to test the differences in means from the tables above. The output for this test is in Appendix 2. To perform this test, I compare all of the non-average data to the average data set. To summarize, I found significance in the difference of the average rainfall and drought with a sig. value of .001 which is highly significant. For average rainfall compared to above average rainfall, the differences are again significant, this time with a .002 sig. value. However, the final comparison of average rainfall to below average rainfall did not prove to be as significant as the other mean comparisons, only having a .024 sig. value. This number is not terrible; however, to undoubtedly claim significance between the means, the sig. value should be closer to zero.

VI. Conclusion

The results of the model indicate that droughts have a significant role in determining soybean prices. It also appears that August weather is not the only month to consider when studying prices. In many cases, it is the combination of previous month's weather patterns and August's weather that lead to more drastic outcomes for price. Another important conclusion is that a surplus of rain can cause just as much volatility as a shortage of rain.

I have also drawn the same conclusions that past researchers have. For example, through my research, I confirm what Kenyon and Hall argue about agriculture economics in that, a significant decrease in supply will indeed cause the price of the good to rise greatly. I also validate Mize's and Stevens' claim that August weather is the crucial month for soybean production. The importance of this is that perhaps in the future, the markets will be less volatile until the month of August, meaning less risk in the market.

Looking at the data in the tables, there is rarely a set of years that contains a closely related change in price due to the same effect. This can only mean that what really matters in the market are the current conditions for the year. With such a wide range of possible weather outcomes, there is no certainty to these numbers; however, they are fairly persuasive and consistent. Scientists are recently making the attempt to research droughts more thoroughly by attempting to figure out when droughts will occur by studying their cycles. They are also trying to approximate the severity of the drought and the length of the drought. Understanding more about droughts can have a tremendous impact on the markets and the people affected by them. With the application of the figures derived from this model to the knowledge of droughts, people can make droughts less scary and perhaps more profitable.

Appendix 1: Rainfall Levels by Year

Year	ENCR	CR	Avg
1971	2.3	2.8	2.63
1973	3.5	2.5	2.83
1974	**4.3**	**5.6**	**5.17**
1975	**5**	**4.9**	**4.93**
1976	**1.5**	**2.3**	**2.03**
1977	**5.4**	**5.8**	**5.67**
1982	**5**	**4.4**	**4.60**
1983	**3.6**	**2.1**	**2.60**
1985	**4.5**	**5.4**	**5.10**
1984	**2.5**	**2.5**	**2.50**
1986	3.6	2.9	3.13
1987	3.5	3.9	3.77
1988	4	3.3	3.53
1989	3.8	4.2	4.07
1991	2.7	2.8	2.77
1992	3.3	3.3	3.30
1993	**5.2**	**3.8**	**4.27**
1994	3.9	3.8	3.83
1996	**2.7**	**2.5**	**2.57**
1998	4	2.8	3.20
1999	3.4	2.4	2.73
2001	3.7	3.8	3.77
2005	**4.5**	**4.2**	**4.30**

Above average	**4.2 < rainfall < 6.0**
Average rainfall	3.2 < rainfall < 4.2
Below average	2.6 < rainfall < 3.2
Severe drought	**0 < rainfall < or = 2.6**

Calculations made by author; based off the NOAA figures and ranges
ENCR = Eastern Northern Central Region (IA, MN, WI)
CR = Central region (IL, IN, OH, MO, KY, TN)

Appendix 2: T-test Output

Average Rainfall versus Severe Drought:

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	avgrain	.0429	7	7.00092	2.64610
	drought	15.0586	7	5.29584	2.00164

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	avgrain & drought	7	.488	.267

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	avgrain - drought	-15.01571	6.39552	2.41728	-20.93059	-9.10084	-6.212	6	.001

Average Rainfall versus Below Average Rainfall:

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	avgrain	.0429	7	7.00092	2.64610
	belowavg	10.8514	7	5.43697	2.05498

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	avgrain & belowavg	7	-.170	.716

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	avgrain - belowavg	-10.80857	9.56518	3.61530	-19.65488	-1.96226	-2.990	6	.024

Average Rainfall versus Above Average

Rainfall:

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	avgrain	.0429	7	7.00092	2.64610
	aboveavg	-15.0843	7	6.49905	2.45641

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	avgrain & aboveavg	7	.328	.473

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	avgrain - aboveavg	15.12714	7.83877	2.96278	7.87749	22.37680	5.106	6	.002

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