PRICE VOLATILITY IN U.S. AGRICULTURE: IMPLICATIONS FOR COTTON PRODUCERS

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Abstract

The yields of the most major U.S. crops (barley, corn, cotton. sorghum, soybeans and wheat) have demonstrated declining growth rates over the last five decades. In addition, most of these crops have experienced increased yield volatility. The elimination of most of the Federal supply management programs may induce greater land use shifts among crops and between cropland and other major land uses, greater yield volatility and greater price instability.

Introduction

With the passage of the Federal Agricultural Improvement and Reform Act of 1996 (FAIR96) and the less than optimal weather patterns in both 1996 and 1997, price volatility has become a major topic of discussion. More specifically, the year-to-year variation in price will likely increase as a result of the passage of FAIR96. The purpose of this article is to identify the supply factors which influence price volatility and to measure the effect of these factors on the supply and price of cotton.

Prior to the passage of the Federal Agricultural Improvement and Reform Act of 1996 (FAIR96), federal commodity policies assisted in maintaining a level of total supply above the quantity that would clear the market at a price acceptable to both consumers and producers. Target prices provided production incentives in excess of market incentives, price support loan rates and marketing loans insured a price floor, and government held stocks assured that total supply would be sufficient to meet demands even in the event that production was reduced as a result of exogenous events. Thus, one could argue that government assisted in holding the price volatility associated with unexpected variation in supply within specific bounds.

The FAIR96 has eliminated the target price and land retirement programs and has reduced the likelihood of large CCC stocks as a result of price support loans being both capped and linked to 85 percent of the moving average market price. Because of these policy changes, future commodity supplies may become more susceptible to yield volatility, land-use shifts and the interaction of the two. This increasing supply volatility (increasing year-to-year variation in total output) would likely cause more price volatility.

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Discussion

Supply volatility is a result of yield growth rates, annual fluctuations in yields, land-use shifts in both acres planted and harvested and the varying level of carryover stocks. Trends in crop yields were analyzed using national average yields for the 1950-1995 time period (USDA,1997). Simple time trends were estimated for five periods including 1950-1995, 1960-1995, 1970-1995, 1980-1995 and 1986-1995. If the coefficient on time is positive and increases (decreases) from the 1950-1995 period to the 1986-1995 period than yields can be seen to be increasing at an increasing (decreasing) rate. Crop yields show three distinct patterns over the last five decades, increasing at an increasing rate, increasing at a decreasing rate, and no distinct trend over the time period (1950-1995). Corn, wheat, and barley yields have demonstrated continuously declining growth rates, while soybeans has demonstrated continuously increasing yield growth rate (Figure 1) . Cotton and sorghum have not shown a steady yield growth rate.

Two important factors have been identified as contributors to the reduced growth in national average crop yields over the last two decades; an increase in the occurrence of the exogenous factors adversely affecting yields (e.g. weather, pests) and shifts in land use. Maximum crop yields can be defined by the biological limits placed on the crop growth under optimal growing conditions. Factors which govern optimal growing conditions include planting time, depth of the seed, row spacing, geographic location, available moisture and temperature. Each of these factors contributes to yield potential and the failure to achieve the optimum level of any of the factors will adversely affect the optimal growing conditions leading to a deviation in yields from the potential maximum. Thus, the variation in yields can really be seen as the degree of adverse impacts each of these factors exerts on yields. The more adverse the impact, the lower the yield.

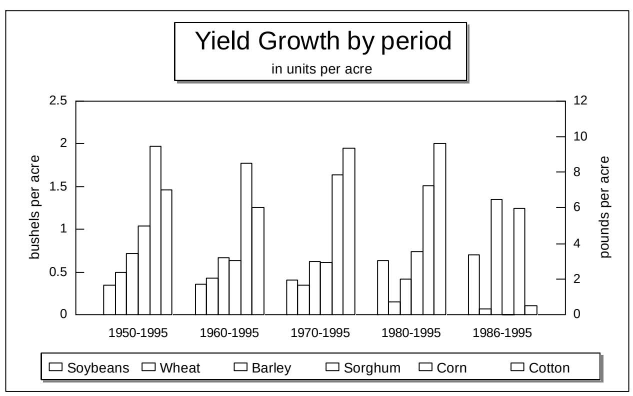

Figure 1. Yield growth for six major crops for periods between 1950 and 1995.

Yield Volatility

Yield volatility was measured as the deviation of observed yield from estimated trend. Predicted yield is estimated as either a simple linear function of time or where harvested acres have a significant effect on yield, predicted yield is estimated as a linear function of acres and time. Table 1 below provides the coefficeint of determination and T statistic for the coefficeint of time and acres.

Table 1. Affect of Harvest Acreage on Yield.

	Corn	Wheat	Cotton	Soy Beans	Barley	Sorghum
Yield =f(time)						
R squared	0.883	0.876	0.721	0.821	0.870	0.779
T statistic	18.232	17.645	10.661	14.212	17.145	12.446
Yield = f(acres)	Corn	Wheat	Cotton	Soy Beans	Barley	Sorghum
R squared	0.001	0.096	0.377	0.649	0.412	0.027
T statistic	-0.212	2.161	-5.164	9.012	-5.555	1.098
Yield = f (acres, time)						
R squared	0.885	0.881	0.754	0.826	0.875	0.832
T statistic						
Acres	0.815	-1.263	-2.435	-1.059	-1.308	3.679
Time	18.168	16.811	8.125	6.618	12.603	14.343

To test for an increasing trend in yield volatility the Harvey test for heteroskedacticity was used (Harvey, 1976). The Harvey test requires that the log of the squared error (difference between actual and predicted yield) be regressed against time. If the coefficient on time is positive and significant than yield volatility is increasing linerarly over time. Results of the Harvey test for each crop are presented in Table 2 below.

Table 2. Harvey Test Results

	Corn	Wheat	Cotton	Soybeans	Barley	Sorghum
R Squared	0.197	0.076	0.008	0.032	0.126	0.012
T statistic	3.287	1.903	0.594	1.214	2.517	0.721

Increases in yield volatility over time have been statistically significant for corn, wheat and barley. However the other major crops have not demonstrated an increasing yield variance over time. The results of the Harvey tests indicate that yield variance (volatility) has a positive relationship over time for corn, wheat and barley, but there appears to be no linear relationship between yield variance and time for the other major crops.

While the yield growth rate has generally declined in each decade since the 1950s, the difference in the yields for the seven major crops cannot be shown to be statistically different between each decade for all crops. However, yield variability differs considerably between the period from 1950-1972 and from 1973-1995 for the major crops. The period from 1950-1972 was a period of strong downsizing in agriculture production while the period from 1973-1995 can be characterized as a period of expansion. The increase in cropland acreage in the second period came at the same time the United States was losing about one-half million acres of prime farmland a year to urbanization, and pasture lands and forest lands were being shifted into new cropland acres. Thus, the land use shifts between the two periods provides a reason to expect differences in yield growth. The increasing acreage also occured in areas where weather variability is greater or has a greater impact on crop yields and thus yield volatility could also be expected to increase due to the land-use shifts.

When the standard deviations in yields between the two periods are compared, the second period demonstrates a larger standard deviation than the first period for all crops (Figure 2). This implies that the annual average variation in yield is larger in the second period than the first, even though for some of the crops there a linear relationship between yield volatility and time could not be found.

The annual average deviation in yield may be expected to increase over time as a result of yield growth . That is, the variation in bushels per acre could be expected to increase as the yield increases, but the percentage deviation should not be expected to change over time. To control for this affect, the annual deviation is divided by the predicted yield value. Even with this correction, the average annual deviation is greater in the second period for all crops except cotton and sorghum. Thus, increased volatility in soybean, wheat, barley and corn yields occurs in both absolute differences and percentage differences, reflecting the fact that the increase in the yields of these crops over time is not the only source of the increased volatility.

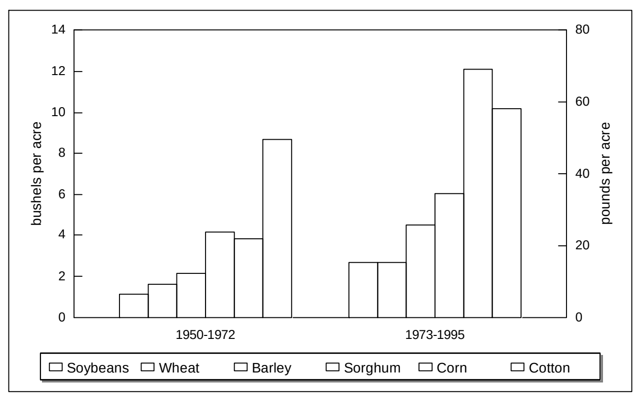

Figure 2. Deviation in yield for six major crops by time period.

The Squared Ranks Test was used to test the statistical significance of the difference in the volatility of yields between periods (Conover, 1980). This test for variances assigns ranks to the values determined by the difference between the actual and the predicted yield. The rank is squared and then summed across all observations in the sample. The null hypothesis is that the variances in the two periods are equal while the alternative hypothesis is that the yield variance in the 1950-1972 period is less than the yield variance in the 1973-1995 period. The null hypothesis is rejected if the sum of the squared ranks is less than the its alpha quantile. Thus, small values would imply that the null hypothesis is rejected and the alternative hypothesis may be accepted. Table 3 below provides the value of the squared ranks for testing the alternative hypothesis listed above for each crop. The null hypothesis is rejected at the 99 percent confidence level (***) for corn, soybeans and sorghum, and at the 90 percent level for wheat, cotton and barley (*). Clearly, yield volatility is significantly increasing for corn, soybeans, wheat and barley given the results of the Harvey and Squared Ranks tests and the difference in standard deviations between the two periods. However, for cotton and sorghum the case is less clear.

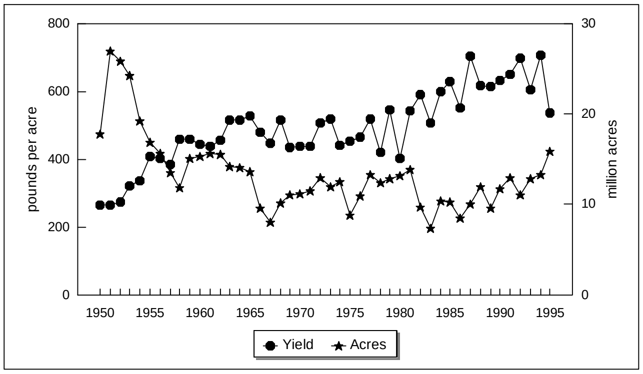

Figure 3. Cotton Yield and Acreage, 1950-1995

Table 3. Squared Ranks Test for Yield Variance

Squared Ranks Test	Corn	Wheat	Cotton	Soybeans	Barley	Sorghum
T statistic	10052 ***	13769 *	13884 *	10634 ***	13468 *	11338 ***

For both cotton and sorghum the standard deviation of yield is significantly greater in the first period than the second for actual yields but is greater in the second period when the size of the variation is adjusted for yield growth. Also, no linear relationship between yield variation and time was identified. However, because the yield volatility is measured as the difference between the actual yield and the trend yield, how trend yield is estimated will affect the degree of volatility. Cotton and sorghum had poorest fit for a linear yield trend and thus presents the greatest difficulty in measuring a trend in yield volatility.

Land Use Shifts

Regional land use changes affect national average yields as a result of the wide disparity in yield potential that is associated with differing land qualities and climatic conditions. Within regions, the expansion of crop acreage usually occurs through the returning of idled cropland acres to crop production or the conversion of pasture land or forest land. These lands are less productive and thus lower the average yield for the location. While land use changes occurred in the past, their scope was often constrained by the need to maintain commodity base acreage. With the new planting flexibility offered under FAIR96, land use will likely be more responsive to the relative profitability of alternative uses.

Harvested acreage of cotton has ranged from nearly 27 million acres in 1951 to only 7.3 million acres in 1983. Cotton is also one of only two major crops that demonstrates a statistically significant and negative relationship between acreage and yield. In fact, roughly 38 percent of the variation in yield can be explained by the variation in acreage. The annual variation in acreage affect yield due to regional land use shifts. For instance, since 1960 Texas has produced between 31 percent and 53 percent of U.S. cotton. Texas cotton yields have varied from 265 pounds per acre to the recent 522 pounds per acre. In each year, Texas yields are well below the average yield for cotton producing states. Thus, the larger the share of U.S. cotton acres accounted for by Texas, the lower the national average cotton yields are likely to be. Offsetting the negative impact on national cotton yields of increased Texas acreage is the increase acreage in high yielding states such as Arizona, California, Mississippi and Georgia.
During the period from 1967 to 1981 cotton yield growth was relatively flat (Figure 3). This period was characterized by a more than doubling of Texas cotton acreage, from 3.5 million (41 percent of U.S. total cotton acres) to 7.2 million acres (52 percent of U.S. total cotton acres). In contrast, during the period from 1981 to 1992 cotton yield growth increased and Texas cotton acreage declined from 52 percent to 32 percent of national cotton acreage. The percent of the national cotton acreage accounted for by Texas and Mississippi has a statistically significant negative affect on national average yield. The amount of cotton acreage in Georgia and California has a statistically significant positive affect on national average yield. These four states account for two-thirds to three-quarters of total U.S. cotton acreage.

Land use shifts affect yield volatility, both the total amount of land devoted to cotton and the location of that land. The major land use shifts which occurred over the last two decades have clearly had an impact on both yield growth and volatility. Furthermore, local and regional land use changes may continue to occur between major land use categories (forest land and cropland) and within categories as a result of increased planting flexibility.

The importance of land use shifts is that they affect supply directly through changes in acres harvested and indirectly by changing the average yield and the volatility of that yield. The effect on yield is important to cotton as yield volatility explains 16 percent of the variability in real prices. The linear relationship was estimated as:

Actual real price-trend real price = .12 * (actual yield-trend yield)

Thus, a deviation from trend of 10 pounds will cause a deviation in trend price of 1.2 cents per pound.

The trend in real cotton price has been negative since 1950 (Figure 4). As with most other crops, only the mid-1970s period shows a reversal of this trend. Using the Standard

Ranks Test, price volatility is not significantly different between the two periods (1950-1972, 1973-1995). However, measuring price volatility as the percent of the variation (actual - predicted / predicted), the volatility in the second period is significantly greater than the first period. The volatility in price can be seen to be similar to the volatility in yield, with a significantly greater percentage variation in the second period but not a significantly greater difference between the actual level of volatility.

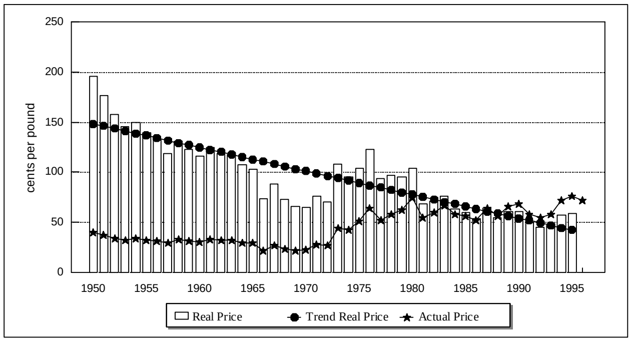

Figure 4. Actual and real price (1987=100) of cotton, 1950-1995.

Stocks have also contributed to price variability, although it may be argued that the affect has been negative. Stocks were considerably greater in the 1950-1972 period than in the 1973-1995 period. However, the mean total use was not statistically different between the two periods. Thus, the stock-to-use ratio was significantly greater in the first period compared to the second period. As the stock-to-use ratio increases price declines and price volatility declines as the price elasticity increases as total supply declines.

Conclusions and Policy Implications

Growth rate in yields for most of the major food, feed and fiber crops is declining and this decline will reduce the ability of U.S. farmers to produce in excess of what the market will demand at an acceptable price in the future. In addition to the declining rate of growth in yields, yield volatility is also increasing. This trend in yields will increase crop prices and lead to increased price volatility. The last two decades trend in falling yield growth may be reversed as new technology may again surface which propels yields upward (e.g boll wevil resistant cotton). Most importantly, the decline in yield growth should not be taken as a cry of impending scarcity, but as a warning that the commodity supply road ahead may not be as smooth as it has been in the past . In addition, there are technologies now coming on board which may increase the utilization efficiency of these crops, reducing their demand. The high-oil corn is a case in point. If cattle feeders can obtain twice the energy from the same amount of corn they will use less.

Government held stocks are declining as a result of the changes in government loan rate policy. Coupled with the continuous growth in demand in a major export crop like corn and a declining yield growth rate and increasingly volatile yields, an end to the decades-long downward trend in real prices may be near. However, high prices or increasing real prices would certainly change many industry practices such as the holding of more stocks and would provide a positive incentive to expand production in other areas of the world. Because real crop prices continue to follow the falling trend of the past 5 decades, agribusinesses would be unwise to hold year to year stocks. If real prices were to rise, agribusiness firms would be more likely to hold stocks.

Land use shifts are likely to increase as a result of the elimination of government payments tied to crop base acreage. An increase in land use shifts may increase yield volatility and thus price volatility. The changing relative prices between the commodities resulting from increased yield volatility, the differences between crops in yield growth, reduced stocks and increased land use shifts, may further hasten land use shifts.

Cotton producer revenues will be affected by the relative profitability of their crop. The relative profitability will depend on the comparable growth rates in yields, yield volatility, land use shifts and industry's willingness to hold stocks. Increased volatility in the other major crops will be transmitted to cotton.

The effect of the yield growth rate, yield volatility, land use shifts, and stocks on price trends and volatility has been measured for the major U.S. crops. Each of these factors has been shown to significantly affect prices. Because of the difference in the magnitude of the change in each of the factors and the affect of this change on price, relative prices of the commodities are likely to be more volatile over the next decade. Producers and other agribusiness dependent on these crops should develop strategies to effectively deal with increased volatility in supply and price.

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