farmdoc DAILY

Are National Yield Declines Associated with Revenue Declines for U.S. Crops Over the Crop Insurance Coverage Period?

Carl Zulauf

Department of Agricultural, Environmental and Development Economics
Ohio State University

June 15, 2016

***farmdoc daily* (6):113**

Introduction

The relationship between percent change in U.S. yield and percent change in U.S. revenue per acre over the crop insurance coverage period is found to vary across the 6 crops examined: corn, upland cotton (subsequently referred to as cotton), rice, sorghum, soybeans, and wheat. For corn and soybeans, percent change in U.S. revenue per acre and U.S. yield are not associated. Thus, for corn and soybeans, it is incorrect to presume that a decline in national yield will led to lower U.S. revenue per acre. In addition, except for sorghum, percent change in revenue per acre is more strongly related to percent change in crop insurance price than percent change in yield. Thus, at the U.S. market level, crop revenue insurance is usually more about price risk than yield risk.
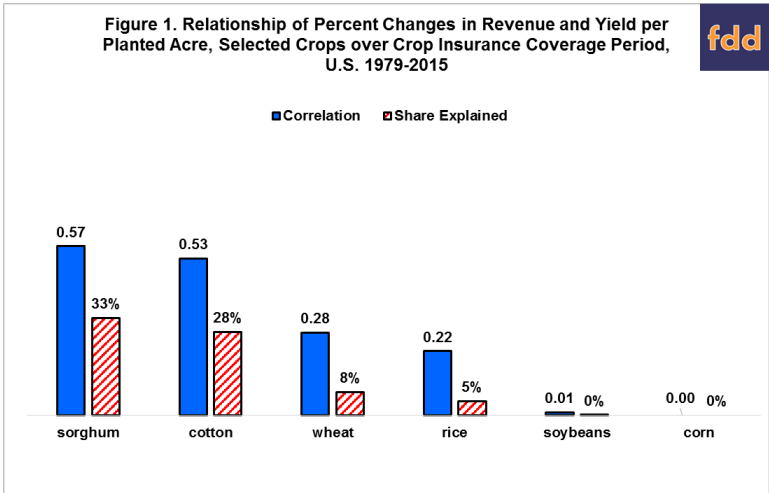
Data and Analysis

Revenue per acre is calculated as price time yield for the crop. Change in revenue is calculated as the percent change in revenue between the insurance pre-plant and harvest price discovery periods. Prices are the projected and harvest crop insurance prices for a crop year (see data note 1). Actual yield is U.S. average yield per planted acre for a crop year (see data note 2). Projected yield is the Olympic average of planted yield for the 5 prior crop years (see data notes 3 and 4). The data used to calculate yield per planted acre are from the U.S. Department of Agriculture (USDA), National Agricultural Statistics Service. Crop insurance prices are from the USDA, Risk Management Agency and a data set compiled by Art Barnaby of Kansas State University. Price and yield data are collected for the 1974 through 2015 crop years (see data note 5)

Relationship between Percent Change in U.S. Yield and Revenue
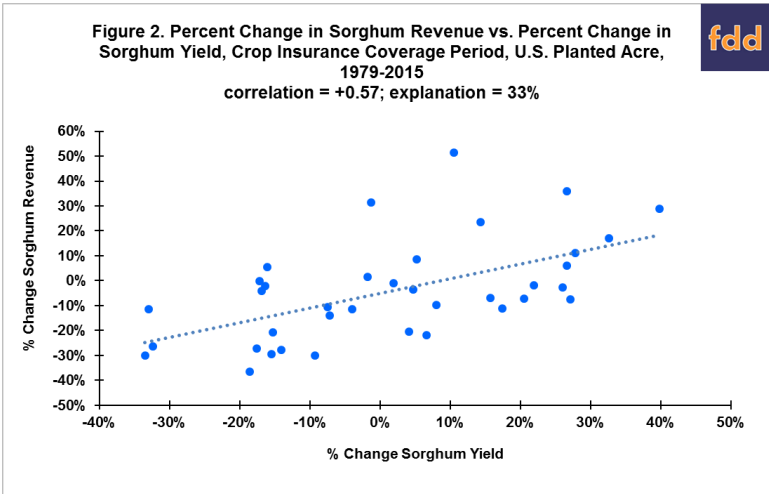
The relationship between percent change in U.S. yield per planted acre and U.S. revenue per planted acre over the crop insurance coverage period varies notably across the 6 crops analyzed. The correlation between these two variables ranges from +0.55 for sorghum to +0.01 for soybeans and 0.00 for corn (see Figure 1). Statistical confidence that the correlation differs from 0 is 99% for sorghum and upland cotton,
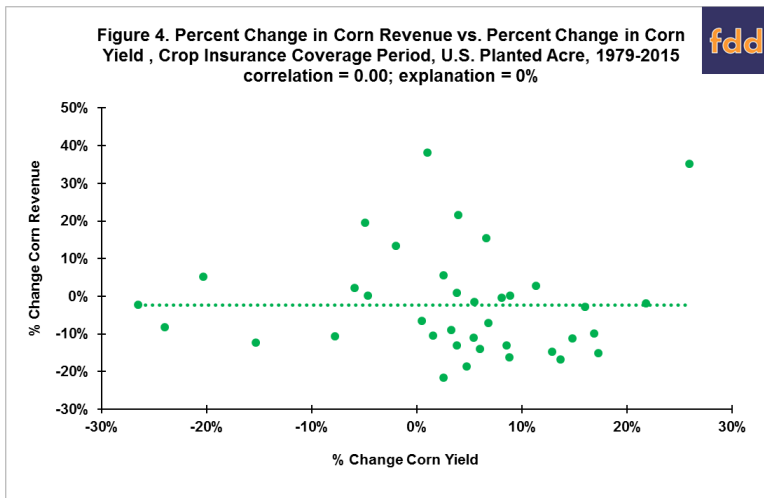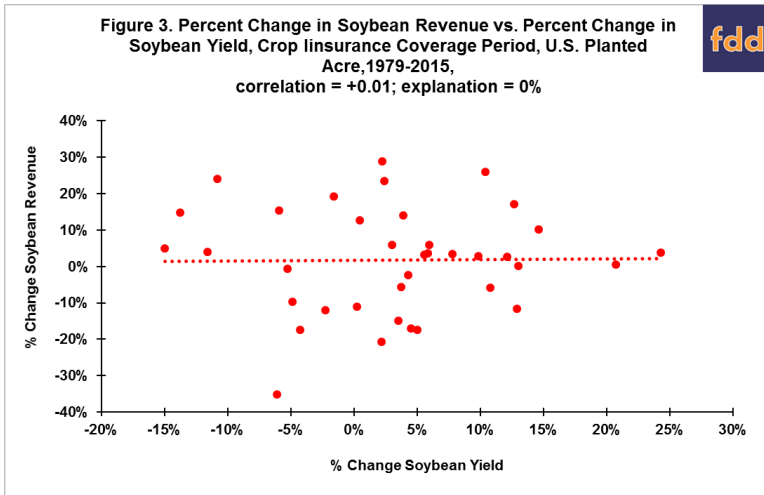
91% for wheat, 74% for rice, 4% for soybeans, and 1% for corn. Thus, at the conventional 90% confidence test level, only 3 crops (sorghum, cotton, and wheat) have a statistically significant relationship between percent change in yield and revenue per acre over the crop insurance coverage period.

Figure 1. Relationship of Percent Changes in Revenue and Yield per Planted Acre, Selected Crops over Crop Insurance Coverage Period, U.S. 1979-2015

To illustrate the difference in correlation values, a scatter chart of the percent change in revenue observed for a given percent change in yield of sorghum, soybeans, and corn are presented in Figures 2, 3, and 4. The figures also contain the linear line associated with the correlation value. Only the line for sorghum visually differs from a horizontal line. A horizontal line is associated with a correlation of 0.00.

Figure 2. Percent Change in Sorghum Revenue vs. Percent Change in Sorghum Yield, Crop Insurance Coverage Period, U.S. Planted Acre, 1979-2015
correlation = +0.57; explanation = 33%

Figure 3. Percent Change in Soybean Revenue vs. Percent Change in Soybean Yield, Crop Iinsurance Coverage Period, U.S. Planted Acre,1979-2015, correlation = +0.01; explanation = 0%

Figure 4. Percent Change in Corn Revenue vs. Percent Change in Corn Yield , Crop Insurance Coverage Period, U.S. Planted Acre, 1979-2015 correlation = 0.00; explanation = 0%

To focus on the observations with the largest percent decline in yield, Figure 5 presents the average percent decline in yield and average percent change in revenue for the 4 years with the largest percent decline in yield (see data note 6). Only for sorghum and cotton does the decline in revenue approach the decline in U.S. yield. For the 4 years with the largest decline in corn yield, the average decline in revenue per planted acre is only 4% despite an average 22% decline in yield. For rice, soybeans, and wheat; the average percent change in revenue per planted acre is positive, implying the percent increase in crop insurance price more than offset the percent decline in U.S. yield.

The finding that a decline in U.S. corn, soybean, and wheat yield over the crop insurance coverage period does not necessarily result in a decline in U.S. revenue per acre is consistent with the author's assessment of forecasts in USDA's May *World Agricultural Supply and Demand Estimates*. This assessment, published in the June 8, 2016 *farmdoc daily*, found that a decline in U.S. corn, soybean, and wheat yield from the May forecast value is not necessarily associated with lower revenue per acre.

Figure 5. Percent Changes in Yield and Revenue for 4 Years with Largest Percent Decline in Yield, U.S. Crop Insurance Coverage Period, 1979-2015
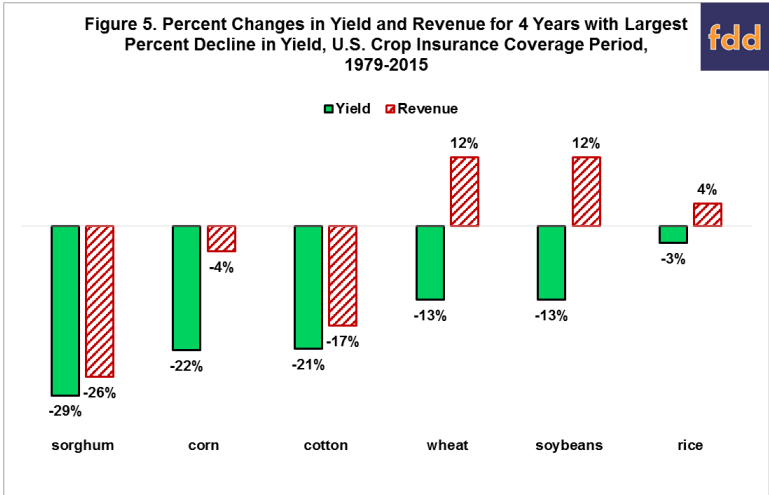
Last, even for sorghum, percent change in yield explains only 33% of the percent change in revenue per acre over the crop insurance coverage period (see Figure 1 and data note 7). Thus, for none of the 6 crops does percent in yield explain a majority of the percent change in revenue per acre over the crop insurance coverage period.

Relationship between Percent Change in U.S. Revenue and Price

The relationship between percent change in U.S. revenue per planted acre and percent change in U.S. crop insurance price over the insurance coverage period is much stronger for 5 of the 6 crops (see Figure 6). The higher explanatory power of price is particularly striking for rice, soybeans, and wheat. For sorghum, explanatory power is similar for percent change in price and yield (see data note 8).

Figure 6. Share of Change in Revenue over Crop Insurance Coverage Period Explained by Change in Yield and Price, U.S. Planted Acre, 1979-2015
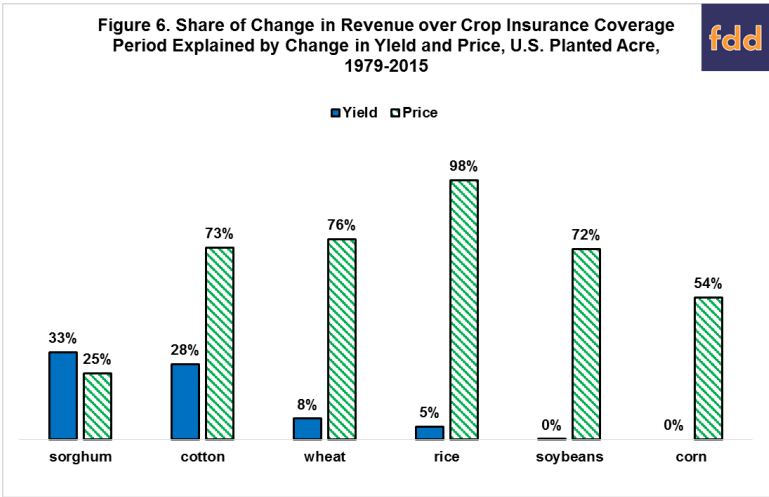
Summary Observations

- Characteristics of U.S. market level risk over the crop insurance coverage period varied notably across the 6 crops analyzed.

- Only sorghum and cotton consistently align with the common presumption that a decline in U.S. yield over the crop insurance coverage period results in a decline in U.S. revenue per acre.

- For the other 4 crops (corn rice, soybeans, and wheat), a decline in U.S. yield can result in higher revenue for U.S. producers of the crop as a group. Such an outcome occurred in the 2012 drought for corn and soybeans. In other words, for these 4 crops at the U.S. market level, a physical loss does not necessarily translate into a financial loss relative to the decision to plant the crop.

- Except for sorghum, percent change in revenue per acre over the crop insurance coverage period is more strongly related to percent change in crop insurance price than yield. Thus, at the U.S. market level for corn, cotton, rice, soybeans, and wheat; revenue insurance is more about price risk than yield risk. This finding is consistent with the historical policy observation that insurance did not became a widely-used risk instrument across U.S. crops until revenue insurance was introduced.

- Even if a decline in U.S. yield increases average U.S. revenue per acre relative to the value expected at planting, a reduction in yield for an individual producer can reduce the producer's revenue per acre if the producer's individual yield reduction is large enough.

- Despite the importance of the preceding point, it is also important to understand market level risks because crop insurance payments are highest when a market level risk occurs.

- Last, this analysis examines the change in revenue over the crop insurance coverage period. It does not examine the change in revenue that can occur across crop years. Both within crop year risk and multiple crop year risk are important risks for U.S. farms.

References and Data Sources

Art Barnaby, Kansas State University, Personal Communication.

U.S. Department of Agriculture, National Agricultural Statistics Service. *QuickStats*. June 2016. http://quickstats.nass.usda.gov/

U.S. Department of Agriculture, Risk Management Agency. *Summary of Business*. June 2016. http://www.rma.usda.gov/.

Zulauf, C. "Assessment of May WASDE Price and per acre Revenue Forecasts." *farmdoc daily* (6):108, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, June 8, 2016.

Data Notes

1. The crop insurance prices are for Illinois corn, soybeans, and wheat, Texas cotton, Arkansas rice, and Kansas sorghum. With the exception of wheat, each state is the largest or second largest producer of the crop. For wheat, the insurance price based on Chicago futures is used because the Chicago wheat futures contract is historically considered to be the most general wheat futures contract. Kansas City, Minneapolis, and Portland are other wheat insurance contracts for hard red winter, hard red spring, and white wheat, respectively.

2. For cotton, rice, soybeans, and wheat, yield per planted acre is calculated as crop year production divided by acres planted to the crop in the crop year. For corn and sorghum, acres harvested for silage are subtracted from planted acres. Production is divided by the adjusted planted acres. This calculation assumes all non-harvested corn and sorghum acres are intended for grain production.

3. An Olympic average removes the low and high values before calculating the average.

> **Commented [C1]:** Removed first bullet point.
> Added last bullet point.
> Edited several bullet points to reflect removal of first bullet point.

4. Projected yield is also measured as the yield derived from a linear trend-line of planted yields over the 1974-2015 period. Results are similar for both measures of projected yield.

5. For the analysis measuring projected yield as a 5 year Olympic average, number of observations is 37 (1979 through 2015). Since revenue insurance was not offered for rice until the 1987 crop year, it has 29 observations.

6. Four years is 10% of 37 (number of observations) rounded to the nearest whole number. Other subsamples were also examined, including alternative shares of observations and observations more than one standard deviation from the average change in yield for a crop over the crop insurance coverage period. The chart in Figure 5 is consistent across the different subsamples.

7. For 2 variables, share of explanation, which ranges from 0% to 100%, is the square of the correlation coefficient, which ranges from -1.0 to +1.0.

8. The reader may be interested in the correlation between percent change in price and percent change in yield since this correlation is often discussed. The price-yield correlation over the crop insurance coverage period by crop is: cotton, +0.02; corn, -0.67; rice, +0.08; sorghum, -0.41; soybeans, -0.51; and wheat, -0.22.