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Analysis of the Soybean-to-Corn Price Ratio and its Impact on Farmers' Planting Decision-Making in Indiana

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Abstract

In Indiana agricultural land is used mostly for corn and soybean harvesting. Rotated corn is a common practice, but in recent years, essentially due to the “ethanol boom” and increased profitability of corn production, many farmers have switched to continuous corn. Corn price increase affects the soybean-to-corn (STC) ratio, however, it is hypothesized that over time market effects will be felt, and return the ratio to its stable range. The threshold autoregressive model is used to analyze the monthly time series of STC ratio in Indiana. Results suggest that exogenous shocks will not have permanent effect on the STC price ratio, but will require, however, a reasonably long time to die out.

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1 Introduction

More farmers in Midwest consider growing continuous corn, mainly due to higher existing and expected profits derived from the relatively higher prices of corn. Soybean and corn being the competing crops in this area, and considering that cropland acres are relatively fixed, this means increase in corn production in expense to reduction in soybean production. According to the expert estimations if there were 5.5 million corn and 5.7 million soybean acres planted in 2006 in Indiana, and estimated 6.2 million corn and 5.0 million soybean acres in 2007, by 2010 it is expected to be about 7.1 million corn acres and only 4.5 million soybean acres (Erickson, Alexander and Theller, 2007).

During the last six decades the acreage of planted corn in Indiana increased from about 4.5 million acres to 5.5 million acres. There was more dramatic growth in soybean acreage - from 1.5 million acres to 5.5 million acres. During the past ten years both corn and soybean acreage has been maintained at around 5.5 million acres on average.

Crop rotation have been a common practice in the Midwest, benefiting farmers with its aid in plant nutrition, pest-management, input cost reduction, and increasing yields (Erickson, Alexander and Theller, 2007). However, contrary to expectations of experts, farmers utilizing continuous corn seem to be “happier”, and this is mainly due to the factors such as: better yields of corn compared to soybean in recent years, soybeans suffering from an array of pest problems, and unavailability of rotation to solve corn rootworm problems (Erickson and Lowenberg-DeBoer, 2005). On the other hand, even though corn usually provides higher gross returns compared to soybean, it is also more costly to produce and harvest. This is especially true for continuous corn, with about 10 percent yield penalty, and additional fertilizer and pesticide costs (Erickson and Lowenberg-DeBoer, 2005).

The adoption of either rotating or continuous corn by farmer is largely determined by expected prices of corn and soybean. Large number of literature has examined past market prices (e.g. Houck and Ryan, 1972), or futures prices (e.g. Peck, 1975; Gardner, 1976) as a measure of expected prices. Together with this, the government programs are also considered affecting farmers' price expectations (Chavas, Pope and Kao, 1983).

This paper analyzes the effects of the lagged soybean-to-corn (STC) ratios on current period ratio, based on the monthly time series information of the crop prices received by Indiana farmers. STC ratio is defined as the ratio of soybean cash price over corn cash price. The main objective of the paper is to find the length of the effect of the exogenous shock on price ratio. The hypotheses are that 1) the STC will return to its stable range after the external shock, and 2) the STC cycles have a non-linear pattern. Monthly data were obtained from USDA NASS web-site, and information from 1975-2006 years is used in the estimation.

2 Theoretical Model and Data Analysis

Farmer's decision about whether to adopt or not continuous corn, may be derived from his profit maximizing behavior. It can be hypothesized that crop planting decision of an individual farmer is a factor of lagged crop prices (expected prices) and costs of production, government support, and the type of the harvested crop in the lagged year(s). In this paper we direct our attention to the corn and soybean prices, as the factors of crop planting decision, and their cyclic relationship over the time.

The importance of the STC cycle analysis, with respect to planting decision making, can be presented with a following example: if a soybean-to-corn price ratio in previous period(s) was low (because of high corn price, for example) farmers might decide to deviate from the adopted corn rotation and

switch to the continuous corn. Then, in the following periods, most likely price of the soybean will increase (in the short run because it is, at some extend, substitute to corn as a livestock feed, and in the medium run as a result of reduced overall soybean supply). Also, possibly corn price will decrease (as a result of increased corn supply). This will increase the STC ratio (e.i. relative profitability of soybean production will improve, *ceteris paribus*) and farmers will be motivated to plant soybean now. With this example we hypothesize that there is some kind of a pattern in the STC cycle, which can be explored in a time series estimation context. The theoretical model of corn-soybean cycle can be expressed as follows:

$$PR_t = f \left(PR_{t-1}, \dots, PR_{t-p}; G, Y, C, \tilde{Z} \right)$$

where PR_t is a soybean-to-corn price ratio at a time t , p is the lag length, G , Y , and C respectively represent government support, crop yield, and cost of crop production, \tilde{Z} is a vector of other exogenous factors. In the time series specification the exogenous factors do not directly enter the equation, however, presumably they do affect the prices, and, consequently, the price ratio of crops.

The crop prices, as well as the price ratio, covering the period between 1925 and 2006, are represented on the Figure 1. It is obvious, that STC cycle pattern significantly altered starting from mid 1970s. Moreover, in the earlier period, prior to the food processing industry’s “discovery of the soybean” and its extensive use in livestock feed, soybean did not have a large share in the cropland. Midwestern farmers were more diversified, devoting more acreage to lower yielding wheat, oats, rye, vegetables, etc. So, it does make more sense to analyze STC ratio, as a factor of farmers’ planting decision starting from the period when it became the “acreage competing” crop to corn. Therefore, in our analysis we use only 384 observations of last 32 years of the data.

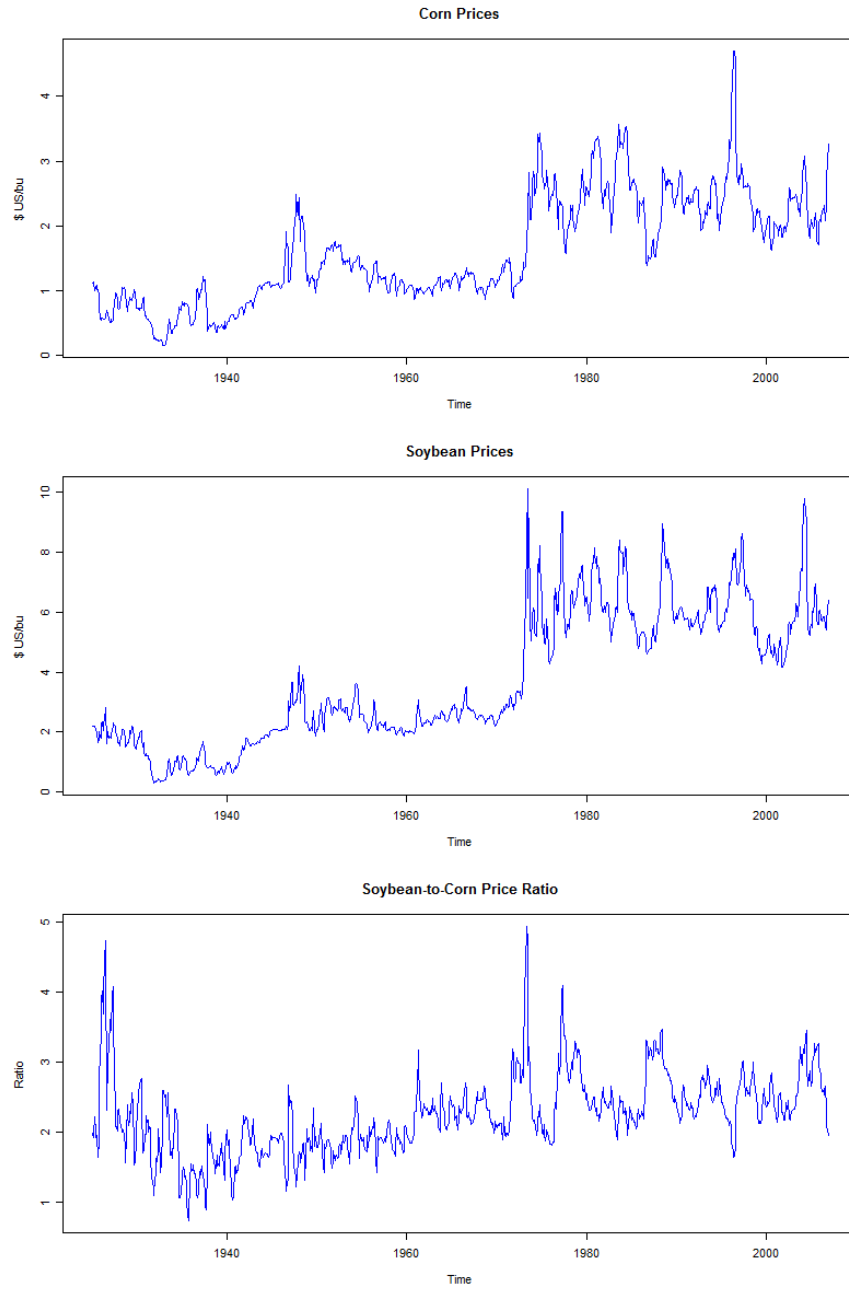


Figure 1: Time Series of Prices and Ratio

3 Empirical Model and Results

The TAR model used in this research is modeled as:

$$\begin{aligned} \Delta y_t = & \phi \left(\alpha_1 + \beta_1 y_{t-1} + \sum_{i=1}^l \gamma_{i,1} y_{t-i} + \sum_{j=1}^{11} \delta_{j,1} S_{j,t} \right) \\ & + (1 - \phi) \left(\alpha_2 + \beta_2 y_{t-1} + \sum_{i=1}^m \gamma_{i,2} y_{t-i} + \sum_{j=1}^{11} \delta_{j,2} S_{j,t} \right) + \epsilon_t \end{aligned}$$

where ϕ is 1 if $y_{t-1} \geq \tau$ and 0 otherwise, τ being a threshold value. Δy_t is a first difference of the price ratio in the period t , β_k is a coefficient of the lagged price ratio, $\gamma_{i,k}$ are coefficients of the lagged differences of the price ratio, and $\delta_{j,k}$ are the coefficients of the monthly dummy variables, the latter defined as $S_{j,k} = D_{j,k} - D12, k$, $D_{j,k}$ being the monthly dummy variable. With this specification of the model we do not include the trend variable in the model, since there is no significant trend observed in the estimated period.

Following Tong and Lim (1980) the optimal number of lags for the each of two parts of TAR is selected based on minimized AIC. The procedure implies finding the minimized sum of the two AIC for each equation given the array of potential lag lengths and threshold values.

$$AIC_{k_i}^* = \min_{k_i} \left\{ \ln \left(\frac{RSS_i}{n_i} \right) + 2 \frac{k_i}{n_i} \right\}, \quad i = 1, 2$$

$$AIC_{\tau_j}^* = \min_{t_j} \left\{ AIC_{\hat{k}_1}^* + AIC_{\hat{k}_2}^* \right\}, \quad j = 1, \dots, r$$

where k is a candidate lag length, τ is a candidate threshold value, r is the total number of the candidate thresholds.

The candidate threshold values were obtained as follows: initially the mean value of y_t was obtained, then the range $\bar{y} \pm \sigma_y$ is determined, where σ_y

is the standard deviation of y_t (with this the range covering the two thirds of the observations was considered as a potential source for threshold values). Ten potential thresholds were examined, allowing up to 36 lags, to obtain the optimal TAR model as specified above. AIC_{τ}^{*} was minimized at $\hat{\tau} = 2.24$, the optimal length of lags were 28 and 3 for $\hat{\phi} = 1$ and $\hat{\phi} = 0$ respectively.

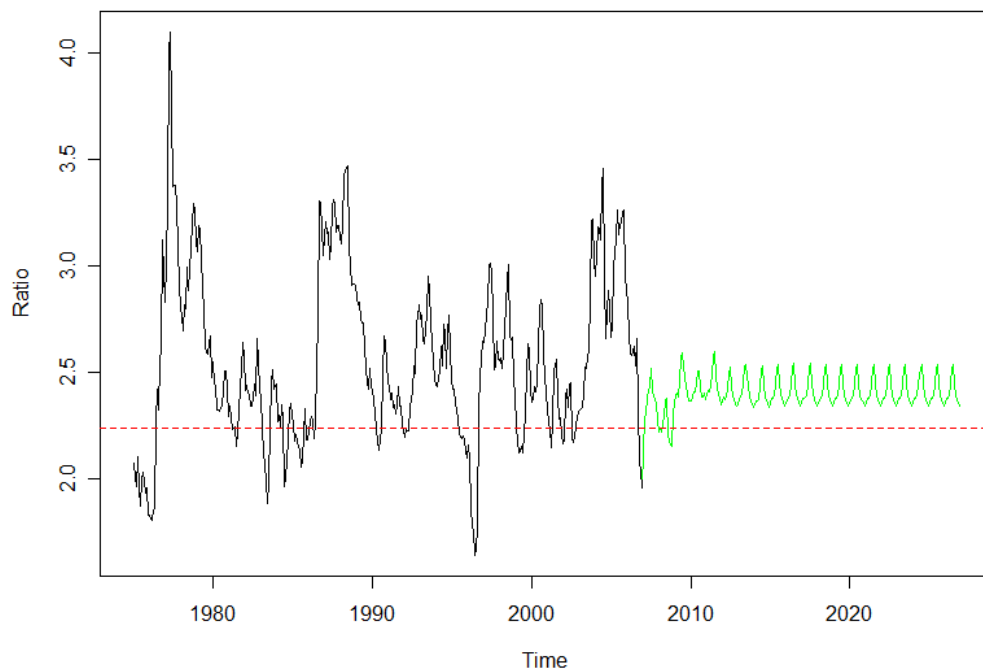


Figure 2: Actual and Predicted Time Series of STC Ratio

The obtained results suggest that it takes about 7 years for the time series to converge to a stable long-run seasonal pattern. In other words, the external shocks will not have a permanent effect on STC ratio, but it will require a reasonably long period for the effects of the shock to die out. This agrees with the theoretical model presented earlier: in the short and medium run the relationship between corn and soybean prices is derived from the demand

and supply on crop market, affected by the changes in relative crop acreage. In the long run however, given no additional impulses of the external shock, the STC ratio will reach the point of its dynamic stability. Note, however, that long-run stable level of the ratio can be reached at different price levels of crops. Moreover, at different price levels the long-run stable level of the STC ratio may be different as well.

4 Conclusions

Increased corn prices, due to the “ethanol boom”, have motivated many farmers to switch to a continuous corn. This was primarily the effect of increased relative profitability of corn production versus soybean production in the Midwest. The results of the threshold autoregressive analysis of monthly crop price data in Indiana suggest that over the time, market factors will bring the STC ratio to its stable pattern. This latter, however, is conditional on the absence of the external shocks like subsidies, yield, input costs, etc. Although it is not possible to take into account these exogenous shocks, the main finding of this paper is that the STC ratio has nonlinear pattern, and that it takes quite a long time for the shock effect to die out.

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