Investigation of the Cost-Price Squeeze for Individual Agricultural Commodities

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Investigation of the Cost-Price Squeeze for Individual Agricultural Commodities

Abstract

The relationship between prices paid and prices received by farmers for individual agricultural commodities was examined using cointegration analysis. A Johansen and Juselius cointegration test between prices paid and prices received for barley, corn, wheat, and sorghum indicated that the series were cointegrated. Therefore, we do not reject a long-run correspondence between prices paid and prices received for these commodities. The results of this study validate the authors’ previous findings at the aggregate farm price level.
Introduction

Over the past three decades, economists have become increasingly concerned about the effect of inflation on agriculture. Inflation, as defined by an increase in the general price level, may have a minimal effect on farm income if prices received and prices paid by farmers increase proportionately. However, the concern is that inflation has had a greater impact on prices paid by farmers than prices received by farmers, which has resulted in a declining ratio of prices received to prices paid. Economists often refer to this declining ratio as the cost-price squeeze. The cost-price squeeze theory, as explained by Tweeten and Griffin (1976), says that when inflation is present, prices paid by farmers increase more than prices received by farmers. Since farmers are price-takers, they have no direct means to pass higher input costs on to consumers. Therefore, they must adjust their input use and output as the ratio of prices received to prices paid declines (Tweeten, 1980).

Several authors have examined the impact of inflation on prices received and prices paid by farmers. Tweeten (1980) found that at high inflation rates, a cost-price squeeze is imposed on the farm sector since prices paid increase considerably faster than the inflation rate. Gardner (1981) also found similar results when he examined the effect of inflation on prices received and prices paid by farmers when excluding macroeconomic variables. However, when macroeconomic variables were included in the model, Gardner (1981) found that inflation did not have a direct effect on the cost-price squeeze.

Moss (1992) also found comparable results to Tweeten (1980) and Gardner (1981) using cointegration analysis to examine the relationship between farm prices paid and prices received. Moss (1992) concluded that prices paid and prices received by farmers were not cointegrated, therefore, a cost-price squeeze could not be rejected in the long-run. In a recent study,
cointegration techniques were used to examine the relationship between aggregate farm prices paid and prices received using more recent data than used in similar studies involving cointegration analysis. Our findings were not completely consistent with previous research. Results of our sector level study indicated that a cost-price squeeze is not present in agriculture and aggregate farm prices received and prices paid do move together in the long-run.

Objectives

The objective of this research is to estimate the impact of inflation on prices paid and prices received by farmers for individual agricultural commodities. Our previous research on aggregate farm prices indicated that a one-for-one correspondence between prices paid and prices received could not be rejected in the long run. Therefore, for this study, we were interested in validating our previous findings by testing the hypothesis that prices received and prices paid for individual agricultural commodities were also cointegrated in the long-run. This analysis differs from earlier studies as we are estimating the impact of inflation on prices received and prices paid for individual agricultural commodities versus aggregate farm prices.

Methodology

For this study, a time series cointegration approach was used to determine if a long-run cost-price squeeze exists for individual agricultural commodities. Several methods are available to test for cointegration between variables. Two commonly used techniques are the Johansen and Juselius approach and the Engle Granger approach (Engle and Granger 1987). The Engle Granger approach is widely used in testing for cointegration in single equations. However, according to Harris (1995), when more than 2 variables are included in the model, more than one
cointegration vector may be present. Using the Engle Granger approach, one can only show that a cointegration vector is unique when 2 variables are included in the model. Assuming that only one cointegration vector is present and more than one exists, one would not be able to obtain a valid estimate of the long-run relationships between the variables in the model. The estimation of a single equation, even when only one cointegration relationship exists, is inefficient because it does not result in the minimum variance against alternative methods (Harris, 1995).

Since this study included the analysis of more than 2 variables, along with the possibility of multiple cointegration relationships, the Johansen and Jesulius cointegration method was utilized. A multivariate model was estimated to determine if prices received or prices paid by farmers for individual agricultural commodities are cointegrated with each other or with the general price level.

If prices received and prices paid are cointegrated, this implies that prices received and prices paid move together in the long-run, so a cost-price squeeze does not exist. The Johansen and Juselius approach involves a multivariate autoregressive model that provides a method of estimating multiple cointegration relationships (Johansen (1988), Johansen and Juselius (1990)). The following model in vector error-correction form was used for the present study.

\[
\Delta z_t = \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_{k-1} \Delta z_{t-k+1} + \Pi z_{t-k} + u_t^1
\]

The estimate of \( \Gamma_i \) measures the short-run adjustment to changes in the endogenous variables, while \( \Pi \) contains information on the cointegrating relationships between variables in the model. Testing for cointegration involves testing the rank of \( \Pi \). If \( \Pi \) has full rank, the variables are stationary. If the rank of \( \Pi \) is zero, no cointegration relationships are present. If \( \Pi \) has reduced rank, we can divide \( \Pi \) into \( \Pi = \alpha \beta^\top \), where \( \alpha \) represents the short-run speed of adjustment...
following a shock to the system and $\beta$ represents the long-run structural relationships between variables (Johansen and Juselius (1990)).

Cointegration methods are useful when time series data are non-stationary and conventional econometric methods would encounter the problem of spurious regression (Harris, 1995). Spurious regression may appear to indicate significant long-run relationships between variables, when it is actually not the case. Therefore, the first step in the Johansen approach is to determine which variables are stationary and non-stationary in levels. For this study, the Augmented Dickey-Fuller Test (ADF) developed by Dickey and Fuller (1979, 1981) and Said and Dickey (1984) was used to test each variable for a unit root. The null hypothesis of a unit root is rejected if the variable is stationary.

To determine if cointegration relationships exist between the variables, the cointegration rank ($r$) must be determined. The $Cats$ programming package was used to determine the cointegration rank by examining the eigenvalue matrix. Johansen proposes two methods for determining the cointegration rank, the $\lambda_{\text{max}}$ test and the trace test. In this study, the $\lambda_{\text{max}}$ test was used to find the number of cointegrating vectors. The Schwartz Information Criteria (SIC) is then used to find the lag length based on the appropriate number of cointegrating vectors.

Once the cointegration rank and number of lags are estimated, the next step in the cointegration analysis is to conduct hypotheses testing. In $Cats$, this involved testing linear restrictions on the cointegration space by inputting restrictions on each of the $\beta$ vectors. We must then identify a set of unique cointegrating vectors corresponding to a set of restrictions on $\beta$ that are not rejected using a likelihood ratio test.

After determining the appropriate cointegrating relationships, tests for weak exogeneity are conducted. A variable is weakly exogenous to the system if it does not respond to changes in
the long-run relationship. To test for weak exogeneity, we test the hypothesis that $\alpha$ was equal to zero by placing row restrictions on $\alpha$. The non-zero columns of $\alpha$ include information on the speed of the short-run adjustment to disequilibrium and which cointegration vectors enter each short-run equation (Harris, 1995).

**Data and Results**

To analyze prices paid for agricultural commodities, actual annual production costs for barley, wheat, corn, rice, oats, sorghum, cotton, and soybeans were obtained from the Food and Agricultural Policy Research Institute (FAPRI) for the 1980-2005 time period. Annual prices received for each of these commodities over the 1980-2005 time frame were also obtained from FAPRI. A multivariate model was estimated to determine if prices received or prices paid by farmers were cointegrated with each other or with the general price level. For this study, the general price level is measured by the personal consumption expenditures (GPL) component of the gross domestic product obtained from the Bureau of Economic Analysis. The GPL component is a nation-wide indicator of the average increase in prices for all domestic personal consumption.

To perform cointegration analysis, it is generally recommended for each data series to include more than 25 observations. However, in this case, consistent cost of production data for agricultural commodities prior to 1980 is simply not available. While researchers do not generally encourage the use of a small number of observations, previous authors have pointed out that when testing for unit roots, the length of the time series is much more important than the data frequency (Hakkio and Rush 1991, Shiller and Perron 1985). Both Bahmani-Oskooee (1996) and Hakkio and Rush (1991) suggest that testing the long-run relationships of data using
less than 30 annual observations provides the same results as using monthly or quarterly data over the same time period. In this case, it would not make sense to use monthly or quarterly data for agricultural commodities due to the annual production cycles.

The prices received and prices paid data series for each commodity were tested for stationarity using ADF tests. The ADF tests indicated that corn, sorghum, barley, and wheat prices paid and prices received data were nonstationary in levels and stationary in first differences (integrated of order one). Since cointegration relationships can only occur between variables integrated of the same order, we were able to proceed with the Johansen and Jesulius procedure for corn, sorghum, barley, and wheat. The ADF tests were also computed for rice, oats, cotton, and soybeans. However, nonstationarity could not be rejected for these data series so rice, oats, cotton, and soybeans were excluded from the study. Figure 1 shows the relationship between prices received and prices paid for each commodity included in the study.

The cointegration rank test was performed on the data series for corn, sorghum, barley, and wheat and the results are shown in Table 1. The tests indicated that 2 cointegration vectors were present for corn and wheat and 1 cointegration vector existed for barley and sorghum. The appropriate lag length was determined using the Schwartz Information Criterion (Table 2). One lag was selected for barley, corn, and sorghum, while 2 lags were selected for wheat. A set of unique cointegrating vectors was identified for each commodity that were not rejected by a likelihood ratio test (Table 3). The first cointegrating vector included prices received, prices paid, and a trend variable representing technology improvements and efficiency gains. For all four commodities, results indicated that prices received and prices paid do move together in the long run. Therefore, prices received and prices paid for corn, sorghum, barley, and wheat are cointegrated. These results are consistent with our previous findings regarding aggregate farm
prices received and prices paid. The tests for weak exogeneity indicated that no variables were weakly exogeneous.

Conclusion

Results of this study indicate that prices received and prices paid for individual agricultural commodities are cointegrated. Due to the small number of observations in each data series, we expected to have limited power to reject the hypothesis that prices received and prices paid for individual agricultural commodities move together in the long-run. However, since we were unable to reject the null hypothesis of cointegration between prices paid and prices received for each commodity tested, this study further supports the previous finding that a long-run cost-price squeeze is not present in agriculture.
Footnotes

1 The vector \( z_t \) is defined as a vector of \( n \) possible endogenous variables and models \( z_t \) as an unrestricted vector autoregression model including \( k \)-lags of \( z_t \).

2 \( \lambda_{\text{max}} \) test = \(-T \log (1 - \lambda_{r+1}), r = 0, 1, 2, \ldots, n-2, n-1 \) where \( T \) is the sample size and \( \lambda_{r+1} \) is the eigenvalue corresponding to \( r + 1 \) cointegration vectors. Test the null hypothesis of \( r \) cointegration vectors vs. the alternative of \( r + 1 \) cointegration vectors.
References


Figure 1. Prices Received and Prices Paid

Barley

Corn

Wheat

Sorghum
Table 1. Cointegrating Rank

<table>
<thead>
<tr>
<th></th>
<th>Barley</th>
<th></th>
<th>Wheat</th>
<th></th>
<th>Corn</th>
<th></th>
<th>Sorghum</th>
<th></th>
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<td>Test Statistic</td>
<td>Ho: r</td>
<td>Critical Value</td>
<td>Test Statistic</td>
<td>Ho: r</td>
<td>Critical Value</td>
<td>Test Statistic</td>
<td>Ho: r</td>
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<td>16.13</td>
<td>25.56</td>
<td>0</td>
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<td>27.82</td>
<td>0</td>
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<td></td>
<td>6.21</td>
<td>2</td>
<td>10.56</td>
<td>4.16</td>
<td>2</td>
<td>10.56</td>
<td>6.78</td>
<td>2</td>
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</table>

r is the number of cointegrating vectors
Fail to reject Ho when test statistic < critical value
Table 2. Lag Length Selection

<table>
<thead>
<tr>
<th></th>
<th>Barley</th>
<th>Wheat</th>
<th>Corn</th>
<th>Sorghum</th>
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<tr>
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<td>Lags, r=1</td>
<td>SIC</td>
<td>Lags, r=2</td>
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<td></td>
<td>1</td>
<td>2.06</td>
<td>1</td>
<td>3.34</td>
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<td></td>
<td>2</td>
<td>2.48</td>
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<td>3.31</td>
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<td></td>
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<td>3.52</td>
<td>3</td>
<td>3.60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SIC</td>
<td></td>
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<tr>
<td>Minimize</td>
<td>Schwartz Criteria</td>
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### Table 3. Cointegration Results

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Likelihood Ratio Test</th>
<th>CHISQ(2)</th>
<th>p-value</th>
<th>Cointegrating Vectors</th>
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</thead>
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<tr>
<td><strong>Barley</strong></td>
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<td>3.47</td>
<td>0.18</td>
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<td></td>
<td>PR</td>
<td>PP</td>
<td>GPL</td>
<td>Trend</td>
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<td></td>
<td>2.827</td>
<td>2.827</td>
<td>0.000</td>
<td>0.074</td>
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<tr>
<td><strong>Wheat</strong></td>
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<td>2.70</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PR</td>
<td>PP</td>
<td>GPL</td>
<td>Trend</td>
</tr>
<tr>
<td></td>
<td>5.023</td>
<td>-5.023</td>
<td>0.000</td>
<td>0.055</td>
</tr>
<tr>
<td></td>
<td>0.000</td>
<td>10.684</td>
<td>-0.001</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Corn</strong></td>
<td></td>
<td>1.82</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PR</td>
<td>PP</td>
<td>GPL</td>
<td>Trend</td>
</tr>
<tr>
<td></td>
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<td>2.563</td>
<td>0.000</td>
<td>0.086</td>
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<td></td>
<td>0.000</td>
<td>7.702</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
<td><strong>Sorghum</strong></td>
<td></td>
<td>3.71</td>
<td>0.16</td>
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<tr>
<td></td>
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<td>PP</td>
<td>GPL</td>
<td>Trend</td>
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<td>-1.986</td>
<td>1.986</td>
<td>0.000</td>
<td>-0.044</td>
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</table>

PP = prices paid for each agricultural commodity  
PR = prices received for each agricultural commodity  
GPL = general price level