Analysis of Multiple Structural Breaks in Relative Farm Prices in the United States, 1913-2003

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Abstract

We analyze the movement of farm prices relative to other commodity prices in the period 1913:1-2003:12, investigating the number and time of structural breaks and discussing likely causes of structural breaks in the relative farm prices. Bai and Perron's (1998, 2003) multiple structural change test with a dynamic programming algorithm is used. This test makes it possible to have an efficient computation of the estimates of the break points as global minimizers of the sum of squared residuals. We find 6 structural breaks when we consider only the mean process and 2 breaks when we consider the mean and autoregressive processes. Possible causes for these breaks are discussed.

JEL Classifications: Q11, C22
Key Words: Farm Prices, Other Commodity Prices, Multiple Structural Breaks

1. Introduction

High inflation has traditionally been one of the major concerns among economic policymakers around the world. But just as high inflation may be dangerous and disruptive to the normal functioning of an economy, the same can be said about very low inflation, which can lead at an extreme to deflation or a sustained decline in the aggregate price level. It was noticed that there is an increasing gap between all non-farm commodity prices and farm level agricultural commodity prices in the United States. For more than thirty years, agricultural prices grew at a rate below the growth rate of any other price index in the United States. This ultimately had to lead to the re-allocation of resources, especially labor, that moved from agriculture to the sectors of the economy exhibiting more opportunities (services, for example). On the other hand, during the period 1913-1973, farm level agricultural commodity prices were consistently above all non-farm commodity prices.

Traditionally, farm prices have been analyzed within the agricultural sector only. While sectoral type of analysis may answer many relevant questions, it is also of interest to analyze farm prices relative to other producer and consumer prices within the economy. That is the case because farm sector performance over a period of time cannot be meaningfully interpreted if it is isolated from the performance of other sectors or the economy overall.

This paper analyzes the movement of farm prices relative to other commodity prices in the United States during the period 1913-2003. While casual observation indicates both change in trend and structural break(s) in relative farm prices, the main goal of this paper is to determine the number and timing of structural breaks and discuss likely causes of structural breaks in relative farm prices.

The paper is organized as follows. The second section discusses the movement of farm and non-farm commodity prices between 1913 and 2003. The discrepancy between the two sectors' price movements is unusual by historical and international standards. The third section details the methodology introduced by Bai and Perron (1998, 2003) to measure the number and timing of structural breaks. In the fourth section, the number of structural breaks is determined in the series of the relative farm prices using the Bai-Perron method. The fifth section describes the likely causes of the structural breaks. The final section contains the implications and conclusions from the analysis.

2. Review of U.S. Farm Prices

It has been commonly emphasized that real farm prices were declining during the period 1920-1970 and 1974-current (c.f., Cochrane, 1958, 1985, 1986; Cochrane and Runge, 1992; Knutson, Penn, Flinchbaugh, 1998). It is further argued that even in nominal terms there were long periods of declining and depressed prices. For instance, the price of corn declined from $1.52 per bushel to $1.33 between 1950 and 1970, while the price of wheat fell from $2.00 per bushel to $1.33 during the same period (Bowens, Rasmussen, and Baker, 1984, p.45). The only time of prosperous and favorable farm prices, according to these and other sources, was the period of the early 1970s,[1] often compared to the golden years of agriculture (1910-1914).

However, it should be noted that farm prices in the United States traditionally have been analyzed and considered within agricultural sector, and their relationship with other producer prices has not received much attention. Compared to other sectors, relative farm prices have been declining only after 1973. Therefore, a question that one should ask here is "how did farm prices fare relative to other prices in the economy?" This is a relevant question because no sector performance over a long period of time can be interpreted meaningfully if it is isolated from the performance of other sectors or the economy overall. For instance, while real prices may be declining in a sector for long stretches of time, it is possible to observe similar trends in the rest of the economy or in some of the sectors, or maybe a completely opposite situation is possible. We see from figure 1 that farm prices did fairly well until the early 1970s. That trend changed in the mid 1970s, becoming especially worrisome in the 1980s and 1990s when the farm price index fell far below other producer prices.

(INSERT FIGURE 1)

Information from international data indicates that the decline in farm prices relative to other producer or commodity prices during the last thirty years is a U.S. phenomenon. Data for developed market economies, for example, Europe, Oceania, and Canada, show that farm and non-farm prices move together over time; the pattern is observed in Australia, Canada, EU countries, and New Zealand during the last 2-3 decades.[2] Although for some years these foreign economies experienced a falloff in inflation of farm commodities, they did not experience a long-term sustained gap of price levels between agricultural and non-agricultural sectors.

While change in trend in relative farm prices is an interesting question in itself, a casual observation also reveals possible multiple structural breaks in relative farm prices. That is really the problem concerning us here. Structural breaks in any time series are in general result of some external disturbances. Next section introduces the method used in analyzing the structural breaks in relative farm prices in the United States.

3. Methodology

Both statistics and econometrics literature contains a vast amount of work on issues related to structural change, most of it specifically designed for the case of a single change. Recently, the economic literature has witnessed an upsurge of interest in extending procedures to various models with an unknown change point. With respect to the problem of testing for structural change, recent contributions include the comprehensive treatment of Andrews (1993) and Andrews and Ploberger (1994). In comparison, the literature addressing the issue of multiple structural changes is relatively sparse. Recent developments include Andrews, Lee, and Ploberger (1996) who consider optimal tests in the linear model with known variance. Garcia and Perron (1996) study the sup Wald test for two changes in dynamic time series. In an independent study, Liu, Wu, and Zidek (1997) consider multiple shifts in a linear model estimated by least squares. They study the rate of convergence of the estimated break dates, as well as the consistency of a modified Schwarz model selection criterion to determine the number of breaks. Their analysis considers only the so-called pure-structural changes case where all the parameters are subject to shifts.

Recently, Bai and Perron (1998, 2003) extended Liu, Wu, and Zidek's work. Bai and Perron's model allows for general forms of serial correlation and heteroskedasticity in the errors, lagged dependent variables, trending regressors, as well as different distributions for the errors and the regressors across segments. In addition, they consider the more general case of a partial structural change model where not all parameters are subject to shifts. A partial change model is useful in allowing potential savings in the number of degrees of freedom, an issue particularly relevant for multiple changes. They also address the important problem of testing for multiple structural changes: a sup Wald type tests for the null hypothesis of no change versus an alternative containing an arbitrary number of changes and a procedure that allows one to test the null hypothesis of, say, l change(s), versus the alternative hypothesis of l+1 changes. The latter is particularly useful in that it allows a specific to general modeling strategy to consistently determine the appropriate number of changes in the data.

To explain Bai-Perron method, consider the following multiple linear regression with m breaks (m+1 regimes):

(1) $$y_t = x_t'\beta + z_t'\theta_j + e_t \qquad t = T_{j-1} + 1, \ldots, T_j \qquad \text{and } j = 1, \ldots, m+1,$$

where y_t is the observed dependent variable at time t; x_t ($p \times 1$) and z_t ($q \times 1$) are vectors of covariates; β and θ_j ($j = 1, \ldots, m+1$) are the corresponding vectors of coefficients; e_t is the disturbance at time t. To clearly understand the time index t in Equation (1), let's use the convention that $T_0 = 0$ and $T_{m+1} = T$. The indices ($T_1, \ldots, T_m$), or the break points, are explicitly treated as unknown. The purpose is to estimate the unknown regression coefficients together with the break points when T observations (on y_t, x_t, and z_t) are available. Note that this is a partial structural change model since the parameter vector β is not subject to shifts and is estimated using the entire sample.

When $p = 0$, we obtain a pure structural change model where all the coefficients are subject to change. The variance of e_t needs not be constant.[3]

The method of estimation considered by Bai-Perron is based on the least-squares principle. For each m-partition ($T_1, \ldots, T_m$), denoted $\{T_j\}$, the associated least-squares estimates of β and θ_j are obtained by minimizing the sum of squared residuals, $\sum_{j=1}^{m+1} \sum_{t=T_{j-1}+1}^{T_j} [y_t - x_t'\beta - z_t'\theta_j]^2$. Let $\hat{\beta}(\{T_j\})$ and $\hat{\theta}(\{T_j\})$ denote the estimates based on the given m-partition ($T_1, \ldots, T_m$). Substituting these in the objective function and denoting the resulting sum of squared residuals as $S_T(T_1, \ldots, T_m)$, the estimated break points ($\hat{T}_1, \ldots, \hat{T}_m$) are such that $(\hat{T}_1, \ldots, \hat{T}_m) = \arg\min_{T_1,\ldots,T_m} S_T(T_1, \ldots, T_m)$, where the minimization is taken over all partitions ($T_1, \ldots, T_m$) such that $T_i, \ldots, T_{i-1} \geq q$. Thus the break-point estimators are global minimizers of the objective function. The regression parameter estimates are the estimates associated with the m-partition $\{\hat{T}_j\}$, i.e. $\hat{\beta} = \hat{\beta}(\{T_j\})$ and $\hat{\theta} = \hat{\theta}(\{T_j\})$. Since the break points are discrete parameters and can only take a finite number of values, they can be estimated by a grid search. This method becomes rapidly computationally excessive when $m > 2$.

Of practical interest is a dynamic programming algorithm which makes it possible to have an efficient computation of the estimates of the break points as global minimizers of the sum of squared residuals. Bai and Perron (2003) use a method suggested by Guthery (1974) and Bellman and Roth (1969) whose models are for pure structural change models. The algorithm developed by Bai and Perron (2003) is a scheme that allows an estimation of more general partial change models. Their algorithm uses least-squares operations of order $0(T^2)$ for any number of structural changes m, unlike a standard grid search procedure which would require least squares operations of order $0(T^m)$. For more information about estimators and confidence intervals, refer to Bai and Perron (2003), pp 3-11.

4. Empirical Test of Multiple Structural Changes in Relative Farm Prices

4.1. Data

The data used in this study is the difference between agricultural & food commodity prices and all non-farm commodity prices in the United States. The source of the data is the Bureau of Labor Statistics. The data set is monthly and it starts from January 1913 and ends in December 2003, providing 1,092 total observations. Figure 1 presents a graph of the series. Summary statistics are displayed in Table 1. The figure shows that until the year 1973, there were a few changes in the mean process that were not remarkable. However, during and after 1973, the changes in the mean are more prominent while the relative price index keeps increasing. Figure 1 suggests that there should be multiple structural changes in the mean. As for the autoregressive process, the figure suggests that there could be at least two structural breaks (probably around the years 1955 and 1973), since we could observe different persistency in the series before and after the two time points, respectively.

(INSERT TABLE 1)

4.2. Empirical Results

In this empirical analysis, we perform two analyses related to multiple structural changes in the relative farm prices. The first analysis investigates structural changes in the mean process of the series. The second analysis evaluates structural changes in the mean and the first order autoregressive processes.

For the purpose of the first analysis, we apply only a constant as regressor. We allowed up to 8 breaks and used a trimming $\varepsilon = 0.10$; hence, each segment has at least 100 observations.[4] We also allowed serial correlation in the errors and different variances of the residuals across segments. Test results are displayed in Table 2. The first issue to be considered is the determination of the number of structural breaks. For this issue, we performed two different F-tests. The first one is $\text{SupF}_T(i)$ statistic which tests the null hypothesis of no structural break ($m = 0$) versus the alternative hypothesis $m = k$ breaks. This F-statistic is robust to serial correlation and heteroskedasticity.

Estimated $SupF_T(i)$ test statistics are all significant for i, where $i = 1, \ldots, 8$, at the 5 percent significance level, indicating that the null hypothesis of no structural breaks was rejected against all the alternative hypotheses of i breaks, where $i = 1, \ldots, 8$. This implies that there is at least one break and probably up to 8 breaks. The statistic is the highest when the alternative is 2 breaks.

The second F-test is a sequential test, $SupF_T(l+1|l)$, where the null hypothesis is l number of structural break(s) and the alternative hypothesis is l+1 number of breaks. The method amounts to the application of (l+1) tests of the null hypothesis of no structural change versus the alternative hypothesis of a single change. The test is applied to each segment containing the estimated breaks points $\hat{T}_{i-1}$ and $\hat{T}_i$ ($i = 1, \ldots, l+1$). A rejection is made in favor of a model with (l+1) breaks if the overall minimal value of the sum of squared residuals (over all segments where an additional break is included) is sufficiently smaller than the sum of squared residuals from l break model. The break date thus selected is the one associated with this overall minimum.[5] The results show that the sequential $SupF_T(l+1|l)$ test statistics could not reject the null hypothesis of $l = 1$ break, which means that the test selects 1 break at the 5 percent significance level. On the contrary, it rejects the null hypothesis of $l = 4$, which suggests that it also supports 5 breaks at the 5 percent level. Therefore, the sequential $SupF_T(l+1|l)$ test statistic itself does not provide any conclusive result. Furthermore, the number of structural breaks, i.e., 1 break or 5 breaks, suggested by the sequential test does not coincide with the number of breaks, i.e., 2 breaks, suggested by the $SupF_T(i)$ test. This implies that with the discordant results from the two different F-statistics, it is not conclusive how many breaks the mean process has.

(INSERT TABLE 2)

For this reason, we need to rely upon information criteria to select the number of breaks. A common procedure to select the dimension of a model is to consider an information criterion. Yao (1988) suggests the use of the Bayesian information criterion (BIC) while Liu, Wu, and Zidek (1997) propose a modified Schwarz criterion (LWZ). Perron (1997) presented a simulation study of the behavior of these two information criteria and of the AIC in the context of estimating the number of changes in the trend function of a series in the presence of serial correlation. The results first show the AIC to perform very badly. The BIC and LWZ perform reasonably well in the absence of serial correlation in the errors but choose a much higher value than the true one in the presence of serial correlation. When no serial correlation is present in the errors but a lagged dependent variable is present, the BIC performs badly if the coefficient on the lagged dependent variable is large. In such cases, the LWZ performs better under the null of no break but underestimates the number of breaks when some are present.[6] Note that model selection procedures based on information criteria cannot take account into potential heterogeneity across segments, unlike the sequential method. Thus, if such a feature is present in the time process, the sequential procedure works better than information criteria. However, in our analysis the sequential $\text{SupF}_T(l+1|l)$ test does not provide a clear answer. Results of both the BIC and LWZ statistics in Table 2 accord each other; they suggest six breaks. Thus, based on the statistics, we finally select 6 structural breaks with the mean as a regressor for the series.

Of direct interest are the estimates obtained under global optimization. Outputs from the global optimization indicate that the most significant break was at August 1981, and the next significant breaks are in turn at June 1994, October 1942, July 1972, November 1954, and June 1930. The reason for having August 1981 and June 1994 as the first and second significant breaks would be the prominent changes in the mean after 1973. Figure 2 shows structural changes in the mean process of the series.

(INSERT FIGURE 2)

The structural breaks test, with the mean as a regressor, suggests approximately the number and the timing of breaks, but since there are notable changes also in other time processes beyond the mean, the test including the mean and autoregressive processes in one framework will provide better insights about structural changes. For structural changes in the mean and the first order autoregressive processes, we apply a constant and one period lagged variable as regressors as follows:

(2) $$p_t = a + b\, p_{t-1} + \zeta_t,$$

where p_t is relative farm prices at time t. Here, a parameter of importance is b which is interpreted as measuring persistency of the time series of the relative farm price level. A feature of substantial importance at the graph of the relative price level series is different variability in different periods with distinct dissimilar shapes before and after 1973. To that effect, we have investigated the stability of the relative price process allowing different variances for the residuals across segments.

Preliminary results suggest that there are less than 5 breaks. Therefore, we allowed up to 5 breaks and used a trimming $\varepsilon = 0.15$; hence, each segment has at least 150 observations. This is a relatively large trimming relative to our sample size. This trimming is relevant because we allowed serial correlation in the errors and different variances of the residuals across segments. Test results are displayed in Table 3. $SupF_T(i)$ tests are all significant for $i = 1$ through $i = 5$ at the 5 percent significance level, indicating that the null hypothesis of no structural breaks was rejected and the alternative hypotheses of i breaks, where $i = 1, \ldots, 5$, was supported. This implies that there is at least one break and there may be more than one break (up to 5 breaks). The statistic is the highest when the alternative is 2 breaks. The sequential test results, $SupF_T(l+1|l)$, reject the null hypothesis of $l = 1$ and could not reject the null of $l = 2$ at the 5 percent significance level, indicating that the statistic selects 2 breaks. Therefore, the two $SupF_T$ test statistics coincide to suggest 2 structural breaks. The BIC statistic suggests 2 breaks while the LWZ statistic suggests no break. Bai and Perron (2003) state that selecting the break point using the BIC works well when breaks are present but less so under the null hypothesis of no break. Since the two $SupF_T$ tests suggest two breaks, we use the BIC to support it. Therefore, based on the two $SupF_T$ tests and the BIC, we select 2 breaks in the mean and autoregressive processes of the series.

(INSERT TABLE 3)

Outputs from the global optimization indicate that the most significant break was at June 1973, and the next is at December 1959. The autoregressive parameter *b* is significantly higher in the second period. This is likely because, as we can observe from Figure 1, variability is weak and persistency is strong during the period. Figure 3 shows structural changes in the mean and autoregressive processes of the series. As we can see from Table 3, the goodness of fit of the mean and autoregressive processes with two breaks is 0.99 (adjusted R^2), which means that the two processes with two regime changes effectively explain movements of the relative farm price series. Therefore, in the figure, one can hardly differentiate the dotted line (the mean and autoregressive processes with three different regimes) from the dashed line (relative farm prices).

(INSERT FIGURE 3)

5. Discussion About the Causes of Structural Breaks

As we could see in the previous section, the test results of the structural changes in the mean process indicate six structural breaks. In this section, we will discuss possible causes for these breaks. Our goal is not to develop an economic model to test and determine causes for each of the structural breaks, but to point in the direction to follow if one is to pursue this issue further.

5.1. Structural Break in 1994

Input costs are of great importance in the pricing decisions of companies. Given the markup of prices over the cost of production, changes in input costs may lead to changes in output prices in two basic ways. In the simplest case, a firm may respond to a cost increase by passing the increase along directly to the output price. Another way is that a firm may mitigate the input cost increase by substituting an alternative input and then passing the smaller cost increase on to its output price. The basic inputs to production are labor, capital, and materials, and several structural changes in the economy during the early 1990s may have affected the behavior of the costs of these inputs.

Among all inputs to production, labor constitutes the largest portion of total costs for most goods and services produced. For the U.S. economy as a whole, labor costs measured as total compensation account for approximately 60 percent of total value-added costs in the economy (Jorgensen, Gollop, and Fraumeni, 1987). Labor costs, broadly defined, fall into two categories: wages and salaries paid to workers and benefits. During the late 1980s and early 1990s, benefits paid to workers increased significantly to reach the peak of 11 percent of GDP in 1993. Many benefits, such as dental and health insurance, are identical for all employees at a firm. The average annual real increase in employer costs per hour worked for health insurance between 1982 and 1993 was 7.3 percent, while real wages and salaries rose only 2.4 percent annually (Willis, 2003). This rapid increase in insurance costs led to large increases in benefit costs of all employees.

The difference between farm sector and other sectors in the U.S. economy is that many of the farm operators do not have health or dental insurance or any other benefits. Also, the number of temporary (seasonal) laborers in the farm sector is relatively large compared to the number of temporary laborers in other sectors. A vast majority of temporary laborers do not have any health or dental insurance or benefits of any sort. Finally, many farm operators hold other jobs apart from farming that give them benefits they need. All this leads to the conclusion that labor costs in the non-farm sector increased at a much higher rate than in the farm sector. Assuming that this cost was passed on to output prices, this seems to be one of the obvious reasons for the structural break in non-farm relative to farm prices in 1994. Finally, to make the matters more obvious, this increase in labor cost was coupled with a booming economy. What this means is that unemployment reached record lows in 1994. According to the Bureau of Labor Statistics (BLS) data, non-farm payroll employment increased by an average of 294,000 per month, representing the highest percentage increase in payroll employment since 1988. We speculate that the effects of increased labor cost on relative farm prices would have been even more pronounced had the Federal Reserve not become correctly concerned about an increase in inflation. A booming economy at full employment cannot be sustained for a long period of time and will eventually drive up inflation as the economy overheats. In order to slow down the booming economy, the Federal Reserve engineered the so-called "soft landing" by tightening the monetary policy by raising interest rates. This preemptive attack on inflation led to a moderate slow-down of the economy in 1995 that included an increase in unemployment, hence a decrease in the cost of labor.

5.2. Structural Breaks in 1954 and 1981

Both of these structural breaks in farm relative to non-farm price indices have to do with surges in the price of oil.[7] Viewed from a long-term perspective, inflation, measured by the rate of change in the consumer price index (CPI), tracks movements in the world oil price. Not only do oil and other energy prices constitute a portion of the actual CPI, but they impact other commodity prices as well. The sustained high level of oil prices begins to affect core inflation (minus energy and food) through continued pressure on prices of other commodities. Furthermore, their downstream impacts on other commodity prices will have a lagged effect on the CPI inflation (*e.g.*, Hamilton, 1996; Herrera and Hamilton, 2004). If we notice the relative importance of energy and oil in the U.S. economy, the increase in energy prices becomes easier to understand as a cause of inflation. Prior to the embargo of 1973-74, total energy expenditures constituted 8 percent of U.S. gross domestic product (GDP), the share of petroleum expenditures was just under 5 percent and natural gas expenditures accounted for 1 percent. The price shocks of the 1970s and early 1980s resulted in these shares rising dramatically to 14 percent, 8 percent, and 2 percent, respectively, by 1981.[8] To summarize, the structural break in farm relative to non-farm commodity prices in 1954 and 1981 was due to a jump in energy and crude oil prices that further led to a sharper increase in non-farm commodity prices than in farm prices. The reason of why farm prices were less affected by oil and energy price boom is that farm sector was more labor intensive rather than capital intensive at that time (especially in 1954) if compared to most other sectors and industries.

5.3. Structural Break in 1972

The only time of prosperous and favorable farm prices, according to several sources (*e.g..*, Knutson, Penn, and Flinchbaugh, 1998; Lucier, Chesley, and Ahearn, 1986), was the period of the early 1970s, often compared to the golden years of agriculture (1910-1914). This increase in farm prices came about due to reduced feed grain production (due to early frosts and corn blight) and increased export demand. Increased export demand occurred due to a combination of factors: falling value of the dollar (following the adoption of the floating exchange rate), the opening of the Soviet Union's borders to U.S. grain, and an increase in income in OPEC countries. All this happened while the overall inflation was soaring due to the oil shock. Inflation and the energy crisis of the early to mid 1970s drove up industrial costs. Production input prices in agriculture increased by 146 percent between 1970 and 1974. However, reduced feed grain production and increased export demand led crop prices to increase by 224 percent during the same time period (Lucier, Chesley, and Ahearn, 1986). Thus, the character of this structural break is different from all other breaks in that it occurred during the time of overwhelming overall inflation. The increase in farm prices was exacerbated further due to especially favorable export demand and bad weather conditions.

5.4. Structural Break in 1942

As the United States entered World War II, so called "preparedness" programs gave way to a war economy. The War Production Board and other agencies managed the production and distribution of key fuels and materials. The Office of Price Administration controlled pricing, and basic commodities were rationed. Rationing ended in 1947. Furthermore, the government took temporary control of the railroads, while the Lend-Lease program funded arms exports to the Allies.[9]

Rationing of tires and gasoline, as well as many other non-agricultural commodities, meant that producers could not raise their prices since major buyer became the military. The government forbade nearly all non-military construction, and prices of commodities used in the construction industry were controlled as well. Price controls and rationing meant that consumers had to spend time standing in lines or searching for sellers willing to sell goods at the controlled prices. The quality of many goods deteriorated as sellers, forbidden to raise prices, adjusted to increased demands by selling lower quality goods at the controlled prices (Hughes and Cain, 2002).

At the same time, many agricultural and food products were rationed and prices controlled (*e.g.*, meats, butter, canned, bottled and frozen fruits and vegetables, dry beans, lentils, sugar). But most of the basic food products and farm commodities were not rationed and subject to price control (*e.g.*, eggs, fresh fruits and vegetables, dried and dehydrated fruits, breads and cereals, milk, perishable cheeses, spaghetti, macaroni, poultry, jams, mayonnaise). That allowed agricultural prices to increase relative to non-agricultural prices during World War II.

5.5. Structural Break in 1930

Most economists of the 1920s believed that the stock market--not new housing, sales of durable goods, or the financial health of banks--was the chief indicator of the fiscal health of the United States. In September of 1929, stock prices began to fluctuate, but market analysts dismissed this as temporary. What many of these analysts did not realize--or refused to admit--however, was that stock prices were totally out of proportion to actual profits. Sales of goods and the construction of factories were falling rapidly while stock values continued to climb. Still, very few were worried; they still accepted Adam Smith's "self-adjusting economy" as dogma and believed the problems would correct themselves (Hughes and Cain, 2002).

October 29, 1929, "Black Tuesday," is considered the beginning of the Great Crash. "Black Tuesday" was the single most devastating financial day in the history of the New York Stock Exchange. Within the first few hours the stock market was open, prices collapsed and wiped out all the financial gains of the previous year. Since most Americans viewed the stock market as the chief indicator of the health of the American economy, the Great Crash shattered public confidence.

Between October 29 and November 13, the day when stock prices hit their lowest point, over $30 billion disappeared from the American economy. This amount was comparable to the total amount of money the federal government had spent to fight the First World War.

The Great Depression hit farmers especially hard. Many had gone into debt to buy machinery and land and now could not make their payments. Low crop prices wiped out potential profits. Fact of the matter is, farm prices dropped even more than other commodity prices. Low wages, high unemployment, and the lack of storage ability forced farmers to sell their products at very low prices.[10]

6. Summary and Conclusions

A gap between all non-farm commodity prices and farm level agricultural commodity prices in the United States has been increasing during the last thirty years. Agricultural prices grew at a rate below the growth rate of any other price index. In the period between 1913 and 1973, however, prices of agricultural commodities were always higher than prices of non-farm commodities. This paper analyzed the movement of farm prices relative to other commodity prices during the period 1913-2003. The main goal was to determine the number and time of structural breaks and discuss likely causes of structural breaks in relative farm prices.

We used Bai and Perron's (1998, 2003) multiple structural change test. This methodology allows for general forms of serial correlation and heteroskedasticity in the errors, lagged dependent variables, trending regressors, as well as different distributions for the errors and the regressors across segments. This model is a more general case of a partial structural change model where not all parameters are subject to shifts. It also addresses the important problem of testing for multiple structural changes: a sup Wald type tests for the null hypothesis of no change versus an alternative containing an arbitrary number of changes and a sequential test that allows one to test the null hypothesis of, say, l change(s), versus the alternative hypothesis of l+1 changes. A dynamic programming algorithm is used to have an efficient computation of the estimates of the break points as global minimizers of the sum of squared residuals.

For the first analysis investigating structural changes in the mean process of the relative farm prices, we could find 6 structural breaks based on the BIC and LWZ statistics. Outputs from the global optimization indicate that the most significant break was at August 1981, and the next significant breaks are in turn at June 1994, October 1942, July 1972, November 1954, and June 1930. For the second analysis investigating structural changes in the mean and autoregressive processes of the series, we could find 2 structural breaks based on the $SupF_T(l+1|l)$ statistic, sequential $SupF_T(l+1|l)$ statistic, and the BIC. Outputs from the global optimization indicate that the most significant break was at June 1973 and the next significant break is at December 1959.

As historical circumstances changed, the causes of the structural breaks in relative farm prices changed with them. The common denominator for all of the structural breaks is that factors likely to have caused them are exogenous stresses on either macroeconomic or global level. Given a distinctive nature of the farm sector due to the nature of sectoral product or production process (*e.g.*, production dependent on weather and climate conditions, asset -primarily land - fixity), these exogenous shocks exposed the vulnerability of the farm sector in the United States. Policy makers in the United States always reacted to these exogenous shocks with changes in macroeconomic policies that were intended to maintain stable conditions for operating in leading or mainstream industries. Farm policies coordinated with macroeconomic policy seem to be the sole tool available to the farm sector in order to level relative agricultural prices and help farmers gain more control over their future.

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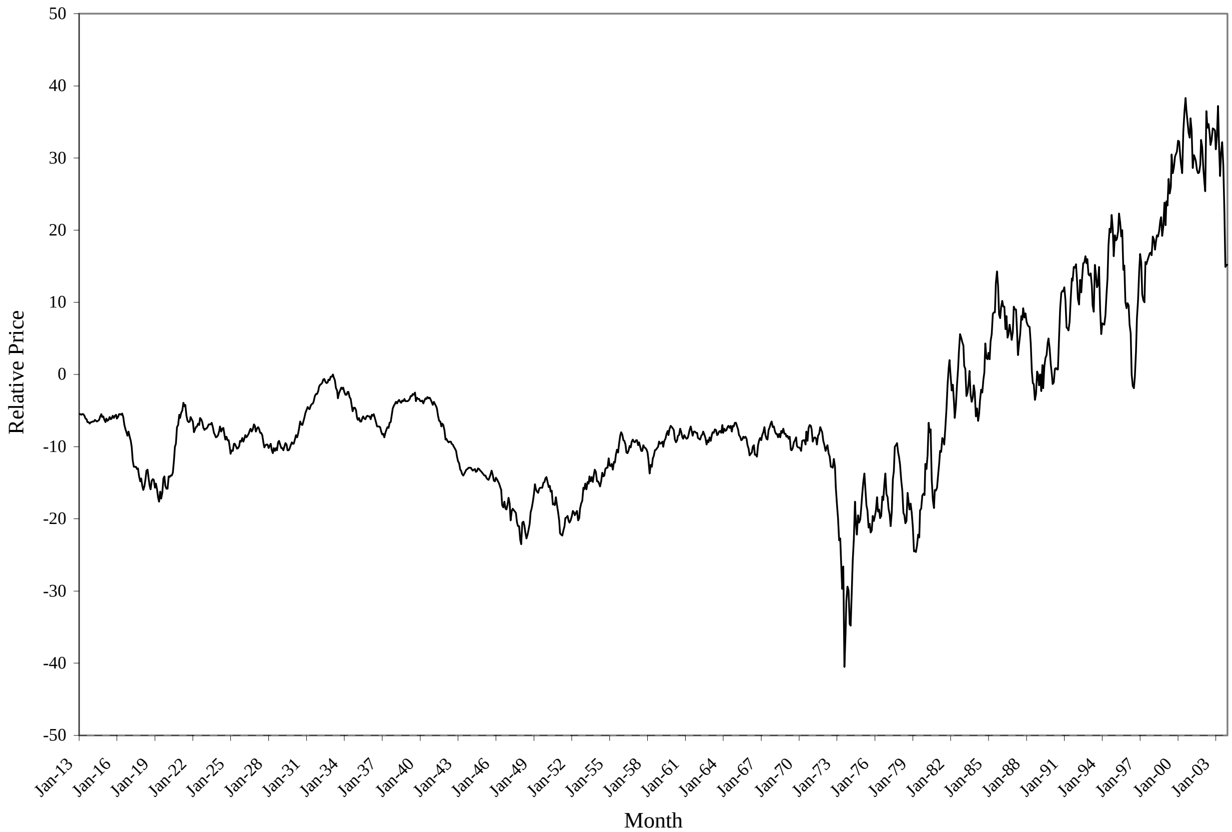
Figure 1
All Commodity Prices less Farm Commodity Prices in the United States, 1913-2003.



Source: Bureau of Labor Statistics and authors' calculations.

Figure 2
All Commodity Prices less Farm Commodity Prices in the United States and Structural Changes in the Mean Process, 1913-2003.

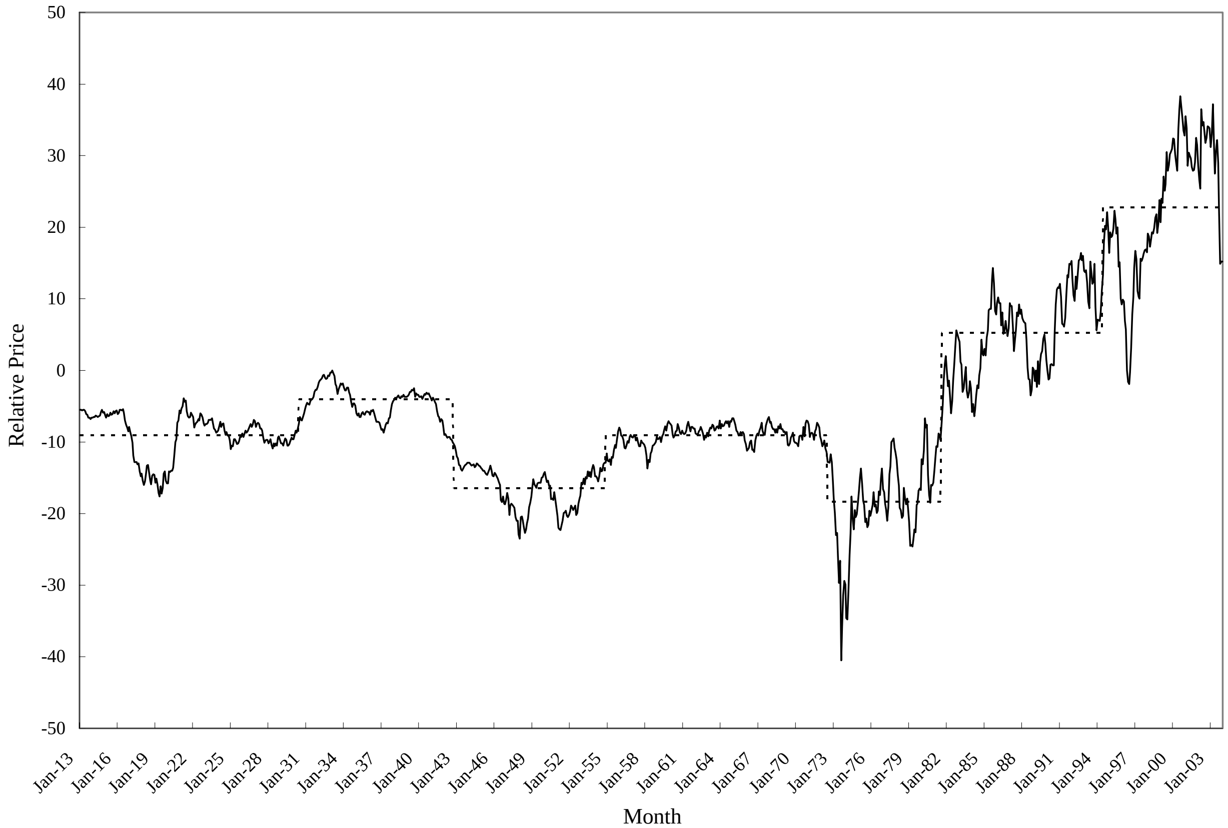
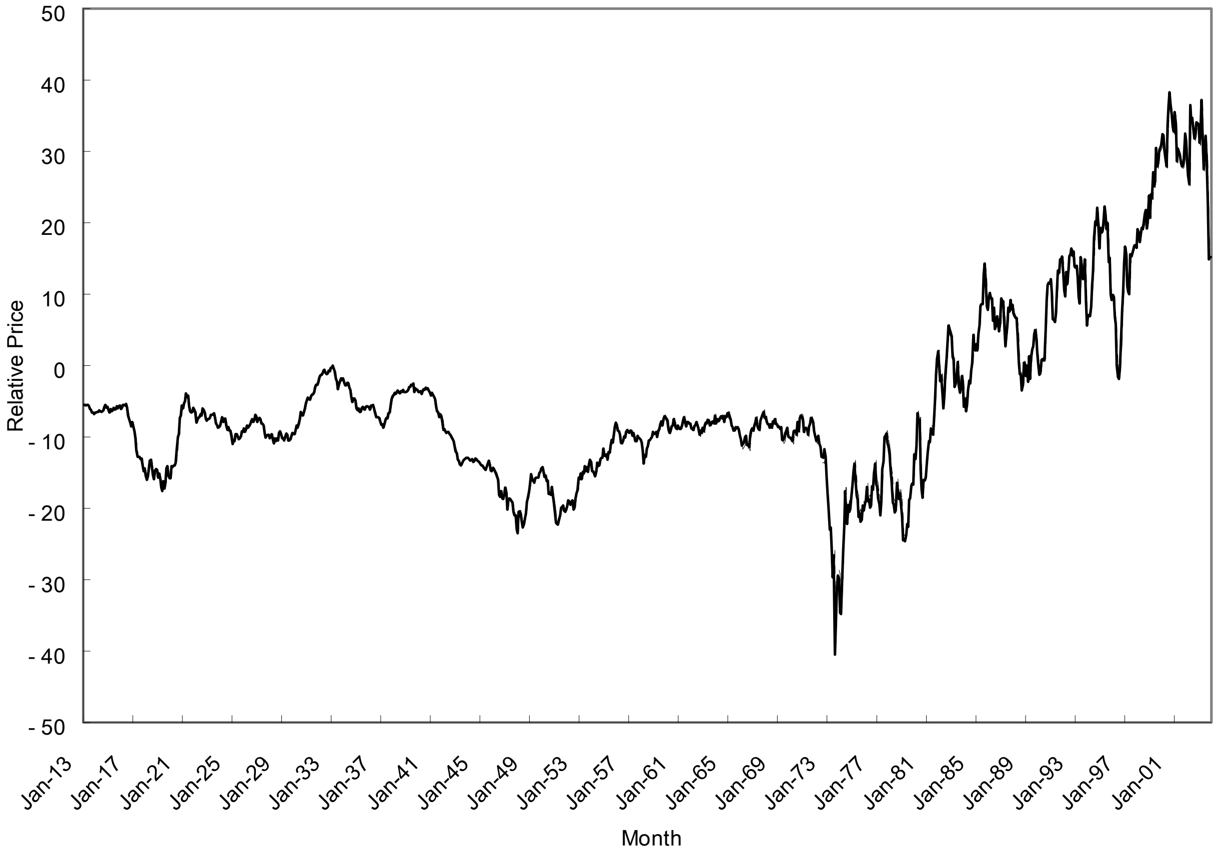


Figure 3
All Commodity Prices less Farm Commodity Prices in the United States and Structural Changes in the Mean and Autoregressive Processes, 1913-2003.



Note: The dotted line is the mean and autoregressive processes in three different regimes with two structural breaks.

Table 1
Summary Statistics for the U.S. Relative Farm Price Index Series.

Summary Statistics						
Mean	Standard Deviation	Max	Min	Skewness	Kurtosis	Normality Test
-5.024	12.633	38.300	-40.500	1.274	4.738	433.11(0.00)

Q(5)	5176.0**
Q(20)	17774.0**
Q(100)	47190.0**
$ARCH_6$	3971.67**
ADF	-1.040

Notes: The normality test was completed using the Jarque-Bera statistic, where the null hypothesis is the normal distribution and the values in the parenthesis are *p*-values. The Q(*k*) is the Box-Pierce Q-statistic at lag *k* for residual series. The null hypothesis is no autocorrelation up to lag *k*. $ARCH_6$ denotes the test of autoregressive conditional heteroskedasticity up to lag 6. The lag 6 was chosen by the AIC and SIC statistics. The null hypothesis of ARCH test is no ARCH effects up to lag *k*. The superscript ** denotes rejection of the null hypothesis in each test at the 5 percent significance level. The number of optimal lag in the ADF unit-root test equation was determined by the AIC and SIC statistics.

Table 2
Test Results of the Structural Changes Test in the Mean Process:
Relative to U.S. Farm Prices.

Specifications						
Z_t={1}	q = 1	p = 0	M = 8	h = 10		

Test Results

Number of Breaks	BIC	LWZ	$SupF_T(i)$ Test		$SupF_T(i+1\|i)$ Test	
0	5.072	5.073				
1	3.971	3.994	$SupF_T(1)$	14.19**		
2	3.681	3.725	$SupF_T(2)$	17.10**	$SupF_T(2\|1)$	4.57
3	3.483	3.548	$SupF_T(3)$	14.27**	$SupF_T(3\|2)$	2.59
4	3.395	3.482	$SupF_T(4)$	13.15**	$SupF_T(4\|3)$	1.74
5	3.241	3.350	$SupF_T(5)$	14.18**	$SupF_T(5\|4)$	17.90**
6	**3.187**	**3.318**	$SupF_T(6)$	12.31**	$SupF_T(6\|5)$	0.39
7	3.200	3.352	$SupF_T(7)$	11.09**	$SupF_T(7\|6)$	0.00
8	3.214	3.387	$SupF_T(8)$	9.94**	$SupF_T(8\|7)$	0.00

Estimates with Six Breaks

α_1	α_2	α_3	α_4	α_5	α_6	α_7
-9.068**	-4.602**	-16.459**	-9.064**	-18.346**	5.258**	22.782**
(-27.66)	(-11.78)	(-41.72)	(-27.78)	(-40.31)	(13.74)	(51.20)

T_1	T_2	T_3	T_4	T_5	T_6
06/30	10/42	11/54	07/72	08/81	06/94
(05/30 – 11/30)	(09/42 – 11/42)	(06/54 – 06/62)	(06/72 – 08/72)	(06/79 – 08/83)	(10/77 – 02/97)

Adjusted R^2	0.86
F(7,1085)	947.11 (0.00)

Notes: The null hypothesis of $SupF_T(i)$ test is zero structural break and the alternative hypothesis is *i* structural breaks. The null hypothesis of $SupF_T(i+1|i)$ test is *i* breaks and the alternative hypothesis is *i*+1 breaks. The six breaks were chosen based on BIC and LWZ statistics. The parentheses under the break points are 95 percent confidence interval for the estimated break points. The superscript ** denotes statistical significance at the 5 percent level.

Table 3
Test Results of the Structural Changes Test in the Mean and AR(1) Processes: Relative to U.S. Farm Prices.

Specifications

Z_t={1} q = 2 p = 0 M = 5 h = 15

Test Results

Number of Breaks	BIC	LWZ	$SupF_T(i)$ Test		$SupF_T(i+1\|i)$ Test	
0	0.841	**0.843**				
1	0.844	0.878	$SupF_T(1)$	11.92**		
2	**0.839**	0.906	$SupF_T(2)$	23.64**	$SupF_T(2\|1)$	39.91**
3	0.846	0.944	$SupF_T(3)$	17.91**	$SupF_T(3\|2)$	5.93
4	0.864	0.995	$SupF_T(4)$	14.59**	$SupF_T(4\|3)$	3.45
5	0.882	1.046	$SupF_T(5)$	12.52**	$SupF_T(5\|4)$	2.13

Estimates with Six Breaks

a_1	a_2	a_3
-0.082	1.403**	0.234**
(-0.60)	(4.06)	(2.88)
b_1	b_2	b_3
0.992**	1.170**	0.982**
(80.87)	(33.91)	(215.16)

T_1	T_2
12/59	07/73
(12/55 – 04/60)	(01/73 – 12/74)

Adjusted R^2	0.99
$F(7,1085)$	12771.57 (0.00)

Notes: The null hypothesis of $SupF_T(i)$ test is zero structural break and the alternative hypothesis is i structural breaks. The null hypothesis of $SupF_T(i+1|i)$ test is i breaks and the alternative hypothesis is i+1 breaks. The six breaks were chosen based on BIC and LWZ statistics. The parentheses under the break points are 95 percent confidence interval for the estimated break points. The superscript ** denotes statistical significance at the 5 percent level.

Endnotes

[1] This increase in farm prices came about due to reduced feed grain production (due to early frosts and corn blight) and increased export demand (Knutson, Penn, and Flinchbaugh, 1998). Increased export demand occurred due to a combination of factors: falling value of the dollar (following the adoption of floating exchange rate), the opening of the Soviet Union's borders to U.S. grain, and an increase in income in OPEC countries.

[2] Figures for Australia, Canada, EU countries, and New Zealand are not displayed here, but they are obtainable from the authors upon request.

[3] Breaks in variance are permitted provided they occur at the same dates as the breaks in the parameters of the regression. The existence of breaks in the variance could be exploited to increase the precision of the break data estimators. However, Bai and Perron (1998, 2003) do not pursue this avenue and instead treat the variance as a nuisance parameter and focus on breaks in the conditional mean of y_t. Bai and Perron (2003), while permitting breaks in the variance, do not make use of it other than to estimate the variance segment by segment when such changes are permitted.

[4] In a practical test, one needs to ensure that the specifications are such that the size of the test is adequate under the hypothesis of no break. If serial correlation and/or heterogeneity in the data or errors across segments are not allowed, using any value of the trimming ε will lead to tests with adequate sizes. However, if such features are allowed, a higher trimming is needed. Since our sample data observations amount to 1,092, the trimming with $\varepsilon = 0.10$ should be enough for both serial correlation and/or heterogeneity features.

[5] The estimates $\hat{T}_i$ need not be the global minimizers of the sum of squared residuals, and one can also use sequential one at time estimates, which allow the construction of a sequential procedure to select the number of breaks.

[6] Selecting the break point using the BIC works well when breaks are present but less so under the null hypothesis of no break, especially if serial correlation is present. The method based on the LWZ criterion works better under the null hypothesis (even with serial correlation) by imposing a higher penalty. However, this higher penalty translates into a very bad performance when breaks are present.

[7] The surge in the price of oil during 1972-1973 has been even more dramatic than the two considered here (*i.e.*, 1954 and 1981). However, agricultural prices in the United States at that time increased significantly and the reasons for that and the structural break of 1972 is discussed in the next subsection.

[8] If one would like to learn more about the causes of crude oil price increases, Hamilton (1983) nicely summarized the principal causes of crude oil and energy price increases in the period 1947-1981. In 1952-1953, crude oil and energy prices increased due to the Iranian nationalization of oil companies, and strikes by oil, coal, and steel workers in the United States. Between 1970 and 1974, there was a rupture of the trans-Arabian pipeline, Libya cut back its oil production, the OPEC embargo, coal prices increased due to increased coal exports, strikes by coal workers, and the

introduction of more stringent environmental legislation. Finally, the 1981 hike in oil prices was preceded with the Iranian revolution, Iran-Iraq war, and removal of U.S. price controls.

[9] There is a deep division among economists about the success of this kind of economy. Keynesians maintain how the World War II economy of the United States is a prime example of success of the Keynesian concept while many non-Keynesians questioned this interpretation. Hughes and Cain (2002) and Higgs (1990) offer a prime example of the debate on this issue.

[10] Even if farmers could not make a profit by selling their products, at least they could still eat, so most stayed put. In contrast to popular images of farmers leaving the land, the 1930s actually had the lowest rate of migration from farms to cities (Hughes and Cain, 2002).