Market Integration:
Case Studies of Structural Change

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Paper presented at the NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management
St. Louis, Missouri, April 21-22, 2003

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Abstract

The grain/oilseed industry is undergoing considerable structural change in the form of mergers and the addition of new processing facilities to add value beyond commodity grade. The rapid structural changes in this industry call into question the relevance of previous research conducted in these areas. Focusing on two structural change events in northeast Missouri as case studies provides an incisive glimpse at the larger impact of structural change on the grain/oilseed industry. This study addresses the merger of Archer Daniels Midland and Quincy Grain, and the opening of a producer-owned ethanol plant in northeast Missouri to determine if these structural change events altered pricing patterns and linkages in Missouri grain/oilseed markets, and assess the need for re-specification of conventional economic models for price analysis in cases of potential structural change. This research utilizes a three-tier statistical analysis of cointegration tests, Flexible Least Squares analysis, and impulse response functions derived from Vector Autoregressive modeling to investigate the Law of One Price and price relationships among four Missouri grain/oilseed markets. The results are consistent with the Law of One Price, supporting the ideology that markets work, and implying that localized structural change may not significantly affect research shelf-life.

Key words: Ethanol, Consolidation, Structural Change

Introduction

The grain/oilseed industry is undergoing considerable structural change in the form of mergers and the addition of new processing facilities to add value beyond commodity grade. The rapid structural changes in this industry call into question the relevance of previous research conducted in these areas. Tomek (*b*) notes that confirmation and replication of applied econometrics is a critical component of furthering the agricultural economics profession. Due to the nature of structural change, sourcing accurate data prior to and following the event may be difficult. Furthermore, model re-specification and data updating may be needed if structural change causes inconsistent results.

Focusing on two structural change events in northeast Missouri as case studies, we attempt to provide an incisive glimpse at the larger impact of structural change on the grain/oilseed industry. This research investigates the impact of structural change in the grain/oilseed industry on pricing patterns and linkages in northeast Missouri prior to and following the January 1998 merger of Archer Daniels Midland (ADM) and the Quincy Grain Company, and the opening of a producer-owned ethanol plant in Macon, Missouri on April 29, 2000. The objectives of this research are to determine what measures may be necessary to ensure consistent and accurate price analysis over periods in which structural change occurred, and if pricing patterns and linkages in the grain/oilseed industry change in correspondence to the two identified structural change events.

Price analysis research is rich within the agricultural economics profession. Extensive literature exists on price analysis of commodities, such as corn, soybeans, and wheat (Alexander; Brorsen, Coombs, and Anderson; Eales, Engel, Hauser, and Thompson; Elam and Woodworth; Jackson, Irwin, and Good; Kastens, Schroeder, and Plain; Kenyon; Townsend, and Brorsen; Wisner, Blue, and Baldwin; Zulauf and Irwin). The use of futures markets, especially for hedging is another topic often visited by the literature (Bond and Thompson; Garcia, Hudson, and Waller; Just and Rausser; Kahl; Kastens and Schroeder; Lapan and Moschini; Tomek (*a*); Zulauf, Irwin, Ropp, and Sberna). Inconsistent and inaccurate results may be the product of price analyses that do not account for structural changes occurring over the analyzed period. Model re-specification may be necessary to account for structural changes in such cases. Additionally, past research may no longer be relevant in post-structural change environments. While this thesis provides only two examples of localized structural change, the two structural change events investigated here represent the most likely types of structural change to occur within in the grain/oilseed industry at the present time.

The merger of ADM and Quincy Grain allows ADM to own most of the elevators in the northeast Missouri. Northeast Missouri Grain Processors (NEMO), Limited Liability Company (LLC) provides a value-added outlet for producer-owners' corn through operation of its ethanol plant. Structural changes such as these raise questions regarding to what extent, if any, the entrance and exit of competitors, the structure and ownership characteristics of firms, and even the number of buyers in a given region impact pricing patterns and linkages.

Northeast Missouri is the region of interest for these case studies, with a particular focus on the areas where the ADM-Quincy Grain merger resulted in the transfer of elevator ownership and the 70-mile radius surrounding the NEMO ethanol plant, where most of its producer-owners' operations are located. The region of interest includes major points of trade along the Missouri and Mississippi Rivers. The statistical analysis incorporates corn and soybean price data from Macon and Hannibal elevators, two markets within the mapped region, and from St. Louis and Kansas City elevators, two primary markets outside of the mapped region. The St. Louis and Kansas City locations are included to assess if changes in pricing patterns and linkages between these locations and the ones in Northeast Missouri coincide with the observed structural changes.

This research may justify or refute concerns regarding consolidation in the grain/oilseed industry. If it is true that structural changes such as these do significantly alter pricing patterns and linkages, there are significant implications for research based on data from periods that contain occurrences of structural change.

The Merger of ADM and Quincy Grain

There has been considerable debate regarding issues of consolidation in the agricultural sector. Research in the area of consolidation has generally been motivated by concerns regarding the exertion of market power. Accusations of market power abuse were directed at ADM following the merger between them and Quincy Grain in 1998. Previously, the two companies had operated competing elevators in northeast Missouri. Following the merger, ADM owned most of the elevators in the area. Given that the merger occurred simultaneously with low commodity prices, and ADM's history of litigation concerning market power abuse (e.g., the lysine price fixing ruling against ADM, Connor), the question arises as to whether the merger decreased soybean prices in northeast Missouri. The motivation for this case study was whether or not the observed structural change (i.e., the merger) altered pricing patterns and linkages, as exhibited by the level of integration between selected Missouri soybean markets.

The NEMO Ethanol Plant

Financial support for ethanol production has grown since the 1970's, with the introduction of state and federal legislation, as well as regulations requiring the use of oxygenates, such as ethanol, in automotive fuels. Corn is the primary source of ethanol production in the US (Fuel Cell Buses). NEMO was incorporated as Missouri's first new generation cooperative under Chapter 274 of Missouri state statutes in March 1995. The NEMO ethanol plant created a value-added market for its producer-owners when it began purchasing corn on May 1, 2000. The introduction of the ethanol plant provided a new source of demand for corn in northeast Missouri, representing a structural change to the corn markets within close proximity to the plant. The NEMO producer-owners, who previously delivered their production to local grain elevators or river markets, were located within a 70-mile radius of the ethanol plant. Thus, the effects of the structural change on corn markets were expected to be at least as far reaching as that radius. The motivation for this case study was whether or not the observed structural change altered pricing patterns and linkages, as exhibited by the level of integration between Missouri corn markets.

Literature Review

Numerous producers (sellers) and relatively fewer buyers dispersed over geographic regions are general characteristics of agricultural markets (Faminow and Benson). Given the structure of agricultural markets, the process of price discovery is often influenced by the spatial and intertemporal aspects of the markets. Market competition and efficiency varies with these spatial and intertemporal influences. Thus, the study of the interdependence of markets, as measured by price relationships is justifiably important. The following is an overview of selected literature on the subject.

Faminow and Benson noted that studies of spatial price relationships for agricultural commodities have been widely used to indicate market performance, without consideration of intraregional transport costs. The authors offered an alternative theory assuming that intraregional transport costs are significant, which implies that the market is a linked oligopsony. Their theoretical implications are illustrated in an analysis of weekly hog prices in five Canadian cities from January 9, 1965 to December 20, 1975, that tested for short-run integration, and long-run integration over two partitioned data periods.[1] Their results indicated possible market

[1] Markets perform efficiently when they are integrated (i.e., when the price in the importing market equals the price in the exporting market plus the transportation and other transfer costs associated with trade).

inefficiencies in the second period, which the authors suggested likely resulted from substantial institutional change in the industry.

Goodwin and Schroeder evaluated spatial price linkages in regional fed cattle markets. The objective of the paper was to, "…empirically evaluate cointegration and spatial price linkages for regional slaughter cattle markets and to determine the impacts on cointegration of several market characteristics" (p. 452).[2] Highly cointegrated markets follow similar pricing patterns, implying strong spatial market linkages. Cointegration tests were run on spatial price relationships among 11 regional slaughter cattle markets. Findings indicated that several markets were not cointegrated between 1980 and 1987. However, increased cointegration in several regional livestock markets paralleled significant structural changes to the livestock industry in the 1980's. Although the results did not provide conclusive evidence that increased concentration of markets implies increased cointegration of markets, the authors suggest that it is a reasonable expectation, since trade and information costs would decrease and packers could coordinate price behavior across regions, as market concentration increases.

Goodwin (*a*) used VAR models to allow parameters to vary when forecasting national average quarterly cattle prices from 1970 to 1990, noting that standard forecasting models may ignore structural change and produce biased and misleading forecasts. Other variables included in the analysis were national average prices for hogs and broilers, total cattle on feed, corn prices, and nominal disposable personal income. Changes in US meat consumption patterns, geographic shifts in marketing patterns, and consolidation in the beef slaughter and packing industry were cited as indicators of possible structural change in cattle price relationships. Goodwin noted, "In light of the observed changes in beef demand and supply relationships, it is important that the potential for structural change be recognized in forecasting models" (p. 12). Unlike standard tests for structural change (e.g., Chow tests), the flexibility of the VAR model permitted the identification of gradually occurring structural change without *a priori* specification of the timing of the change. The empirical results confirm the existence of a structural change beginning in 1974 and lasting through the early 1980s. Impulse response functions, created by converting the gradually switching VAR model to an equivalent moving-average representation using Choleski decompostion, indicated greater exogeneity and faster adjustment of cattle prices since the structural change.

Goodwin and Piggott also examined price linkages in spatially separate markets using VAR and cointegration models. Their analysis of daily price linkages for four corn and soybean markets in North Carolina utilized VAR and cointegration models to account for "neutral bands" that represent the effects of transaction costs on price relationships. Impulse response functions were used to investigate dynamic patterns of adjustments to shocks. Price equalizing arbitrage activities were found to occur in response to localized shocks that exceeded the thresholds of the neutral band. In many cases, smaller shocks within these neutral bands did not result in price movements that were consistent with stable price adjustments. Overall, the results were consistent with long-run market integration, as positive shocks elicited positive responses and negative shocks elicited negative responses. The analysis confirms the significance of

[2] When a long-term equilibrium exists between price series, they are cointegrated.

transaction costs on spatial price linkages, as threshold models consistently suggested faster adjustments in response to deviations from equilibrium than when threshold behavior is ignored.

Thompson, Wul, and Bohl investigated the degree of spatial equilibrium between wheat markets in France, Germany, and Great Britain, and the effects of EU policy reform on the speed of convergence to the long-run relationship, using quarterly domestic and world (border) wheat price data from 1976 to 1999. As the authors hypothesized that the LOP would hold in all three wheat markets based on charting of the price data. Additionally, they expected that world prices would be weakly exogenous (i.e., meaning deviations from the LOP would not affect the world price) and that domestic prices would be endogenous (i.e., meaning domestic prices would adjust to eliminate deviation from the LOP). The authors tested for the Law of One Price (LOP) using an iterative seemingly unrelated regression-augmented Dickey-Fuller (SURADF) test, and assessed short-run price adjustment dynamics with a seemingly unrelated regression error correction model (SURECM). These results were compared to results obtained by running ordinary augmented Dickey-Fuller (ADF) and Error Correction Model (ECM) tests on the data. The LOP held in markets in France and Great Britain, but not in Germany according to the ADF test. In contrast, when the SURADF test was applied, the LOP was found to hold in all three markets. Thompson, Wul, and Bohl render this as "… strong evidence for LOP in the long run …" (p. 1051).

Empirical Model

As illustrated, an extensive literature has employed time series procedures appropriate for analyses of market integration. A three-tier technique is used to empirically analyze the effects of the merger of ADM and Quincy Grain in 1998 and the opening of the NEMO ethanol plant in 2000 on the price linkages and pricing patterns observed between Kansas City, Macon, Hannibal, and St. Louis, Missouri soybean and corn markets.

Prior to this analysis, tests were performed on the time series to determine if data transformation was necessary to purge potential statistical issues. Dickey-Fuller (DF) tests of stationarity were performed on each of the corn and soybean price series as follows:

(1) $$P_t = \rho P_{t-1} + u_t ,$$

where P_t and P_{t-1} are the commodity prices at time t and t-1, respectively, ρ is the coefficient on P_{t-1}, and u_t is a white noise error term. Finding that $\rho = 1$ means that P_t has a unit root (i.e., the time series is nonstationary). Summary statistics for the tests are displayed in Table 1. In all cases, the null hypothesis of nonstationarity could not be rejected at a 10% confidence level, as the absolute values of the DF test statistics were between zero and the DF absolute critical value of 2.57. Thus, the price series were deemed nonstationary (i.e., unit root problems existed). Nonstationarity was corrected for by first-differencing the data. DF tests verified that the first-differenced time series were stationary.

The first component of the three-tier approach uses cointegration tests. The LOP is investigated among Kansas City, Macon, Hannibal, and St. Louis, Missouri locations for both, corn and soybean markets using OLS. The LOP holds when prices at paired locations are cointegrated (i.e., when a long-run equilibrium relationship exists between prices at paired locations). Cointegration necessitates that each of the time series be integrated of the same order. Recall that tests of stationarity found that each time series was integrated of order 1, denoted I(1), meaning that differencing the nonstationary time series once yielded stationary, or I(0), time series. If the time series were integrated of different orders, then the conclusion would be that they were not cointegrated (Gujarati).

Given that each time series was found to be I(1), cointegration between prices at the specified locations is tested for corn and soybean markets by running OLS cointegrating regressions on the price series P_{it} and P_{jt} as follows:

(2) $$\Delta P_{it} = \beta \Delta P_{jt} + \varepsilon_t ,$$

and testing whether the residuals are stationary. Subscripts i and j represent elevator locations ($i \neq j$). The ΔP_{it} variable is the first-differenced commodity price at location$_i$ at time t ($t = 1, \ldots, T$), while β is the coefficient on ΔP_{jt}, the first-differenced commodity price at location$_j$ at time t, and ε_t is a residual or random disturbance term. If ΔP_{it} and $\Delta P_{jt,}$ are not cointegrated, any linear combination of them and thus, $\hat{\varepsilon}_t$ is nonstationary (i.e., $\hat{\varepsilon}_t$ has a unit root). Therefore, Cointegrating Regression Durbin-Watson (CRDW), DF, and ADF tests are run on the residuals to evaluate the null hypothesis that the time series are not cointegrated (i.e., $\phi_1 = 0$), as follows from estimation of equation (2) (Enders):

(3) $$\Delta \hat{\varepsilon}_t = \phi \hat{\varepsilon}_{t-1} + \mu_t ,$$

where Δ is the first-difference operator, $\hat{\varepsilon}_t$ is the estimated residual error from equation (2), ϕ is the cointegrating parameter, $\hat{\varepsilon}_{t-1}$ is the estimated residual error from equation (2) lagged one observation, and μ_t is a white noise residual error.

The second tier of the analysis uses Flexible Least Squares estimator tests for parameter stability over time, which may indicate possible structural change in the analyzed variable. Dorfman and Foster, Lutkepohl, and Tesfatsion and Veitch provide a detailed explanation of the FLS estimator. The FLS estimator minimizes the loss function derived from equations (2) and (3), and accounts for the presence of cointegration by allowing the coefficients β and ϕ to vary over time. The FLS estimator is represented as follows:

(4) $$\sum_{t=1}^{T} (\Delta P_{it} - \beta_t \Delta P_{jt} - \phi_t \hat{\varepsilon}_{t-1})^2 + \lambda \sum_{t=1}^{T-1} (\beta_{t+1} - \beta_t)' \boldsymbol{D} (\beta_{t+1} - \beta_t) + \lambda \sum_{t=1}^{T-1} (\phi_{t+1} - \phi_t)' \boldsymbol{D} (\phi_{t+1} - \phi_t),$$

where β_t and ϕ_t are T x 1 vectors of time-varying parameter estimates, λ is a value between zero and one [λ ε (0,1)], and $\boldsymbol{D}$ is a T x T weighting matrix. The first term is the sum of squared errors, and the second term is the sum of squared parameter variations over time. The matrix $\boldsymbol{D}$ has been specified as a positive definite diagonal unit matrix with diagonal elements $d_{ii} = 1$ to ensure a minimum is obtained in the loss function. A large λ penalizes parameter variability and a small λ allows for greater parameter variability. Charting the price integration coefficient, resulting from equation (4), over time is constructive in assessing possible structural change.

Visual inspection of the time paths of FLS coefficients is useful, but conclusions drawn from visually inspecting these time paths alone may be fallible. Thus, a more rigorous quantitative analysis is performed by regressing the FLS coefficients against a trend variable and a trend-structural change interaction variable as follows:

(5) $$\hat{\beta}_t = \sigma_0 + \sigma_1\delta_t + \sigma_2\psi_t + \omega_t ,$$

where $\hat{\beta}_t$ is the estimated time varying FLS coefficient from equation (4), σ_0 is an intercept term, σ_1 and σ_2 are the coefficients on the trend variable (δ_t) and the trend-structural change interaction variable (ψ_t), respectively, and ω_t is a random disturbance term. The sign on and the magnitude of σ_1 and σ_2 represent the trend in the FLS coefficient over time and how that trend may be altered by the structural change events, correspondingly. This adds statistical rigor to the visual interpretation of FLS time paths.

The third tier of the analysis employs estimated vector autoregressive (VAR) models in the generation of impulse response functions to determine whether price responsiveness among locations differs before and after the identified structural change events. Introduced by Sims, initially as a forecasting method using macroeconomic data in 1980, VAR modeling has since found microeconomic applications, e.g., Goodwin (*a*), and Goodwin and Piggott. The general form of the VAR model is as follows:

(6) $$\Delta P_{it} = \alpha_0 + \alpha_1\hat{\varepsilon}_{t-1} + \sum_{k=1} \alpha_{11}(k)\Delta P_{it-k} + \sum_{k=1} \alpha_{12}(k)\Delta P_{jt-k} + \alpha_{13}\boldsymbol{U}_t + \lambda_t ,$$

where *t* refers to time (t = 1, 2, . . ., T), which for this study is days; *i* and *j* refer to elevator location ($i \neq j$); *k* is the number of lag lengths; $\boldsymbol{U_{ijt}}$ is a matrix containing the intercept term and other included exogenous variables, for instance diesel prices; and λ_{it} is an n x 1 vector of normally distributed random errors.

The VAR model was applied to corn and soybean prices at Kansas City, Macon, Hannibal, and St. Louis locations. The diesel price, as a proxy for transportation costs was a pre-determined variable included in the VAR model. VAR models have been criticized for a lack of economic interpretation in their parameters (Enders). However, impulse response functions, which are derived from VAR modeling, are useful in interpreting the relationships between data series (Goodwin and Piggott, and Sims).

Data

This analysis utilizes daily primary-level local elevator corn and soybean price data for four Missouri elevators (i.e., Kansas City, Macon, Hannibal, and St. Louis locations) from January 1996 through January 2003. Price data were obtained from DTN AgDayta. Weekly average

United States retail diesel prices from the US Department of Energy, Energy Information Administration were also incorporated into the empirical model over the same time period.

As previously indicated each of these time-series were first-differenced to correct for nonstationarity. The weekly diesel price data was transformed to correspond to daily corn and soybean price data by first-differencing the diesel price data, and then extending each resulting weekly observation to five daily observations of the same value. Summary statistics are listed in Table 2 for corn and soybean price data before and after the structural change events, prior to the application of differencing and transportation adjustment techniques described in the following paragraphs. The average, standard deviation, maximum, and minimum for 376 observations of diesel prices are \$1.21, \$0.18, \$1.77, and \$0.95, respectively.

Corn and soybean price data were adjusted for transportation prior to statistical analyses performed in *SHAZAM* 9.0, including tests of stationarity and cointegration, the generation of and time paths of price integration coefficients via FLS regressions. Goodwin (*b*) notes that when two price series vary in a nonsynchronous manner within a band created by transportation costs, any value of ϕ from equation (3) could be consistent with adherence to the LOP, negating the reliability of conventional hypothesis tests. Thus, the price data were adjusted for transportation as follows:

$$(7) \qquad P_{it}^{*} = P_{it} + \left[\frac{\$1.10 + \left[\frac{\left(Diesel_t - \overline{Diesel} \right)}{4} \right]}{800} \right] * \mathrm{M}_{ij} ,$$

where P_{it}^{*} is the adjusted commodity price at location$_i$ at time t, P_{it} is the actual price at location$_i$ at time t, $Diesel_t$ is the diesel price at time t, $\overline{Diesel}$ is the average diesel price over the recorded time series, M_{ij} is the distance in miles between location$_i$ and the location for which P_{it} is adjusted to for transportation costs (i.e., location$_j$). The loaded-truck hauling rate is \$1.10 per mile. A truckload generally holds 800 bushels of corn or soybeans, and the number four is chosen for weighting purposes. Preliminary semi-accurate latitudinal and longitudinal coordinates for the ethanol plant and elevator locations were obtained from Switchboard.com and refined using the Center for Agricultural, Resource, and Environmental Systems (CARES) interactive mapping website. *ArcGIS* 8.1's distance tool was used to measure the distance between locations in meters, and the values were converted to miles in *Microsoft Excel*. VAR analysis was conducted in *EViews* 4, using soybean and corn price data that were not adjusted for transportation costs, and incorporating diesel prices as an exogenous variable.

Results

As previously illustrated, the time-series data used for this study exhibited statistical issues, i.e., nonstationarity, which was corrected for by first-differencing the data. The soybean and corn price data were adjusted for transportation costs between locations prior to performing tests of stationarity and cointegration, and generating time path charts of price integration coefficients via FLS regressions. The VAR analysis utilized first-differenced price data that was not adjusted for transportation costs, as diesel prices were incorporated as an exogenous variable in VAR analysis. The results for the three tiers of statistical analysis follow.

The first tier of the analysis investigated the Law of One Price (LOP) using OLS to determine if prices at paired locations in corn (i.e., Kansas City and Macon, St. Louis and Macon, and Hannibal and Macon) and soybean (i.e., Kansas City and Hannibal, St. Louis and Hannibal, and Macon and Hannibal) markets were cointegrated. OLS cointegrating regressions were performed to assess whether the linear combinations of the price series were nonstationary (i.e., whether the residuals possessed a unit root). If the price series were cointegrated, any linear combination of them, and thus the estimated residuals from the regression, would be stationary (i.e., the estimated residuals do not have a unit root).

Statistical results for the tests of cointegration are presented in Table 3. A large R-squared (R^2) and a small Cointegrating Regression Durbin-Watson (CRDW) test statistic generally indicate cointegration. Given the resulting Dickey-Fuller (DF) τ-test statistics, the null hypothesis of no cointegrating vector was rejected at a 10% confidence level for each of the relationships, as the absolute values of τ-test statistics were large relative to the absolute critical value of 3.04. This strongly suggests that the LOP holds for each of the paired price series tested, as a long-run relationship was found among these locations. Thus, as detailed in the empirical model, the presence of a cointegrating vector was accounted for using an Error Correction Model (ECM) term in the estimation of the FLS estimator, and the generation of impulse response functions through VAR modeling.

The second tier analysis used the FLS estimator to visually detect possible evidence that structural changes altered grain/oilseed prices by graphically representing the time paths of corn and soybean inter-location price relationships from 1996 through 2002. Time paths of inter-location relationships for soybean and corn prices are illustrated in Figures 1 through 3 and Figures 4 through 6, respectively, using the weighting coefficient λ = 0.001 to give the model the most flexibility. The LOP suggests that FLS coefficients should revert to one soon after any deviations from one.

The time path illustrated in Figure 1 suggests that the merger of ADM and Quincy Grain did not change the price relationship between soybean markets in Kansas City and Hannibal. Similarly, there is no apparent indication that the merger changed price relationships between St. Louis and Hannibal soybean markets in the time path exhibited in Figure 2. No change in pricing relationships between Macon and Hannibal soybean markets is discernable from the time path plotted in Figure 3.

In contrast, the time paths for corn markets provide some evidence of a change following the introduction of the NEMO ethanol plant. The time path of the price relationship between Kansas City and Macon corn markets presented in Figure 4 appears stable, until a slight upward trend following the introduction of the NEMO ethanol plant. Likewise, Figures 5 and 6 illustrate a slightly increasing time path in the corn price relationships between St. Louis and Macon, and Hannibal and Macon, respectively after the introduction of the ethanol plant. This suggests changing inter-location corn price relationships following the introduction of the ethanol plant.

Regressing the estimated FLS coefficients ($\hat{\beta}_t$) against a trend variable and an interaction variable provides statistical support for inferences drawn from visual analysis of the charted time paths. As evidenced in Table 4, the quantitative analysis provided inconclusive results for the soybean markets, as analysis of different price relationships yielded conflicting results with varying degrees of statistical significance. The three price relationships examined in the corn markets corroborate with each other, suggesting interesting results. In each case, the long-run trend in the estimated FLS coefficient is decreasing by a small amount over time, as indicated by the coefficient, σ_1, on the trend variable. With the introduction of the NEMO ethanol plant, the positive value of the coefficient, σ_2, on the interaction variable slightly offsets the decreasing long-run trend. Thus, the introduction of the ethanol plant brings corn markets more inline with the LOP by adding a new source of demand and mitigating the trend in the FLS coefficients of diverging from one.

For the third tier of analysis, impulse response functions were created using Choleski decompostion to convert the VAR models to an equivalent moving-average representation of inter-market price relationships. Impulse response functions simulate the effect of a shock in one time-series on itself and another time-series in a system over time. Thus, impulse response functions are examined to determine how quickly prices at one location adapted to shocks in prices at another location prior to and following the identified structural changes for soybean and corn markets. The impulse response functions for soybean markets, presented in Figures 7 through 9, and for corn markets, presented in Figures 10 through 12, illustrate the level of variation (in cents per bushel) and duration (in days) of responses to shocks in market prices.

Figure 7 illustrates little change in how Hannibal and Kansas City soybean markets respond to shocks within each market. The perforated line in the upper two charts displayed in Figure 7 represents the response of the Hannibal soybean market to a one standard deviation shock in the Kansas City soybean market prior to and following the merger of ADM and Quincy Grain. The continuous line in the lower two charts represents the response of the Kansas City soybean market to a one standard deviation shock in the Hannibal soybean market. The duration of responses to shocks prior to the merger appeared to last nearly 60 days, while following the merger the responses had been completed in closer to 50 days. Thus, the diagram suggests that if anything, the Hannibal and Kansas City soybean markets responded to shocks in each other by returning to a long-run equilibrium quicker following the merger than prior, as the two post-merger charts flat-lined sooner than the two pre-merger charts.

The perforated line in the upper two charts of Figure 8 represents how the Hannibal soybean market responded to a one standard deviation shock in the St. Louis soybean market prior to and following the merger. The continuous line in the lower two charts represents the response of the St. Louis soybean market to a one standard deviation shock in the Hannibal soybean market prior to and following the merger. The diagram illustrates little change in speed of response by the St. Louis and Hannibal markets to shocks in each other following the structural change event. In each case, pre- and post-merger responses appear to be relatively complete by 50 days.

The perforated line in the upper two charts of Figure 9 represents how the Hannibal soybean market responded to a one standard deviation shock in the Macon soybean market prior to and following the merger. Alternatively, the continuous line in the lower two charts represents the response of the Macon soybean market to a one standard deviation shock in the Hannibal soybean market prior to and following the merger. The diagram illustrates little change in speed of response by the Macon and Hannibal soybean markets to shocks in each other following the structural change event. In each case, pre- and post-merger responses are completed in approximately 40 days.

The impulse response functions for corn markets likewise show little evidence of changing price relationships among Missouri corn markets as a result of the operation of the NEMO ethanol plant. The perforated line in the upper two charts displayed in Figure 10 represents the response of the Macon corn market to a one standard deviation shock in the Kansas City corn market prior to and following the opening of the NEMO ethanol plant. The continuous line in the lower two charts represents the response of the Kansas City corn market to a one standard deviation shock in the Macon corn market. Although the change seems relatively small, it appears that in each case, the variation and the duration of the responses increase slightly after the ethanol plant is operating.

The perforated line in the upper two charts displayed in Figure 11 represents the response of the Macon corn market to a one standard deviation shock in the St. Louis corn market prior to and following the opening of the NEMO ethanol plant. The continuous line in the lower two charts represents the response of the St. Louis corn market to a one standard deviation shock in the Macon corn market. Again, the variation for each response appears to have increased slightly following the opening of the ethanol plant. However, the responses are generally complete within 50 days, both prior to and following the opening of the ethanol plant.

The perforated line in the upper two charts displayed in Figure 12 represents the response of the Macon corn market to a one standard deviation shock in the Hannibal corn market prior to and following the opening of the NEMO ethanol plant. The continuous line in the lower two charts represents the response of the Hannibal corn market to a one standard deviation shock in the Macon corn market. The diagram illustrates little change in speed of response by the Hannibal and Macon markets to shocks in each other following the structural change event. In each case, pre- and post-merger responses appear to be relatively complete within 50 days of the shock.

Conclusion

The purpose of this research was to analyze how soybean and corn pricing patterns and linkages respond to the presence of structural changes in their respective markets. This study used a three-tier statistical analysis to investigate whether or not the 1998 merger of AMD and Quincy Grain, and the opening of the NEMO ethanol plant altered pricing patterns and linkages in northeast Missouri soybean and corn markets. After correcting for statistical issues (i.e., nonstationarity), the data was transformed, when appropriate.

Tests of cointegration and FLS analysis were performed (i.e., tiers one and two, respectively) using soybean and corn price data that were adjusted for transportation costs between locations. The soybean and corn price data used to generate impulse response functions for tier three analysis were not adjusted for transportation costs, as diesel prices were incorporated into the VAR analysis as an exogenous variable.

The findings of this study generally support the ideology that markets work. Tests of cointegration performed on prices at paired locations in corn (i.e., Kansas City and Macon, St. Louis and Macon, and Hannibal and Macon) and soybean (i.e., Kansas City and Hannibal, St. Louis and Hannibal, and Macon and Hannibal) markets provided strong evidence that the LOP holds across these markets. Additionally, the time paths of inter-location corn and soybean price relationships provide no conclusive evidence to suggest that pricing patterns and linkages were detrimentally altered by the observed structural changes in the grain/oilseed industry. While the quantitative analysis of FLS coefficients for soybean markets provided inconclusive results, the results for the corn markets suggest that the introduction of the NEMO ethanol plant is further evidence that markets work, as the operation of the plant appears to have benefited market integration. The impulse response functions illustrate little evidence that pricing patterns and linkages may have changed, following the structural changes. In most cases, the duration of a response for one market location to a shock in another market location was nearly the same length prior to and following the structural change events.

These findings are important examples of support for the LOP and for the ideology that markets work. First, this research does not substantiate claims that ADM abused market power when it increased the size of its local oligopsony in northeast Missouri through the acquisition of Quincy Grain Company. Second, this research finds little change in Missouri corn price relationships that coincides with the introduction of the NEMO ethanol plant to northeastern Missouri. Together, these cases suggest significant implications for future price analyses performed over periods that comprise structural change events. Considerable model re-specification may be unnecessary in many cases, and the addition of a simple dummy variable may be adequate to obtain consistent and accurate results.

When considering these results, two points should be noted. First, this research merely provides observations of market performance prior to and following localized structural change events, and that the results cannot conclusively indicate causality. Other factors, such as decreased information asymmetry from technological advances, may contribute to market efficiency, offsetting detrimental factors, such as market power abuse. Second, the two structural changes examined here may be relatively small. The magnitude of the structural changes considered may partially explain for the lack of need for model re-specification implied by these results. Thus, the magnitude of potential structural changes may be important when considering the necessary level of model re-specification, as the magnitude of the change affects the degree to which pre- and post-structural change environments differ.

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Table 1. Summary of Statistical Results for the Tests of Stationarity (Constant, No Trend)

H_o: $\rho_i = 0$	Soybean Markets										
	KC	H	H1	H2	H3	M	M1	M2	M3	StL	D
DF (τ-test)[a]	-1.56	-1.64	-1.64	-1.64	-1.64	-1.56	-1.56	-1.56	-1.56	-1.59	-1.55

H_o: $\rho_i = 0$	Corn Markets										
	KC	H	H1	H2	H3	M	M1	M2	M3	StL	D
DF (τ-test)[a]	-2.03	-2.06	-2.06	-2.06	-2.06	-2.15	-2.15	-2.15	-2.15	-2.06	-1.55

Note: Number of observations = 1,826. Number of lags = 22. KC = Kansas City. H = Hannibal. M = Macon. StL = St. Louis. H1 = Hannibal adjusted for transportation to KC. H2 = Hannibal adjusted for transportation to StL. H3 = Hannibal adjusted for transportation to M. M1 = Macon adjusted for transportation to KC. M2 = Macon adjusted for transportation to StL. M3 = Macon adjusted for transportation to H. D = diesel prices, which are of course reported at the same value under the soybean and corn markets headings.

[a] Dickey-Fuller asymptotic critical value = -2.57.

Table 2. Summary Statistics for Corn and Soybean Price Data

	Pre-Merger[a]				Post-Merger[b]			
Soybean Prices ($/bushel)	Average	Standard Deviation	Maximum	Minimum	Average	Standard Deviation	Maximum	Minimum
Kansas City	$7.56	$0.58	$8.93	$6.10	$5.09	$0.66	$6.93	$4.11
Hannibal	$7.53	$0.58	$8.90	$6.21	$5.03	$0.65	$6.88	$3.97
Macon	$7.41	$0.57	$8.75	$6.02	$4.86	$0.68	$6.70	$3.83
St. Louis	$7.67	$0.55	$8.99	$6.29	$5.17	$0.66	$7.01	$4.08
	Pre-NEMO[c]				**Post-NEMO[d]**			
Corn Prices ($/bushel)	Average	Standard Deviation	Maximum	Minimum	Average	Standard Deviation	Maximum	Minimum
Kansas City	$2.68	$0.87	$5.51	$1.70	$2.06	$0.27	$2.83	$1.53
Hannibal	$2.64	$0.83	$5.26	$1.60	$2.01	$0.25	$2.72	$1.45
Macon	$2.48	$0.86	$5.20	$1.45	$1.89	$0.28	$2.55	$1.30
St. Louis	$2.76	$0.82	$5.32	$1.73	$2.13	$0.26	$2.88	$1.56

[a] 523 observations.
[b] 1,326 observations.
[c] 1,130 observations.
[d] 719 observations.

Table 3. Summary of Statistical Results for the Tests of Cointegration (Constant, No Trend)

	Soybean Markets					
	Pre-Merger[b]			Post-Merger[c]		
	KC-H	StL-H	M-H	KC-H	StL-H	M-H
R^2	0.55	0.66	0.50	0.45	0.43	0.36
CRDW	2.56	2.76	2.94	2.57	2.58	2.84
DF (τ-test)[a]	-5.78	-6.60	-5.66	-9.32	-8.00	-8.24

	Corn Markets					
	Pre-NEMO[d]			Post-NEMO[e]		
	KC-M	StL-M	H-M	KC-M	StL-M	H-M
R^2	0.18	0.23	0.31	0.18	0.15	0.20
CRDW	2.27	2.46	2.35	2.39	2.36	2.25
DF (τ-test)[a]	-7.85	-8.82	-8.41	-5.75	-5.17	-4.90

Note: Number of lags = 22. For corn markets, KC-M = the Kansas City, Macon relationship; StL-M is the St. Louis, Macon relationship; H-M is the Hannibal, Macon relationship. For soybean markets, KC-H is the Kansas City, Hannibal relationship;
StL-H is the St. Louis, Hannibal relationship; M-H is the Macon, Hannibal relationship.

[a] Asymptotic critical value = -3.04.
[b] Number of observations = 522.
[c] Number of observations = 1,326.
[d] Number of observations = 1,129.
[e] Number of observations = 719.

Table 4. Summary Statistics for the Analysis of Flexible Least Squares Coefficients

	Soybean Markets			Corn Markets		
	KC-H	StL-H	M-H	KC-M	StL-M	H-M
Intercept (σ_0)	0.78600	0.84337	0.90944	0.96620	0.97568	1.00191
	(< .01)[a]	(< .01)	(< .01)	(< .01)	(< .01)	(< .01)
Trend (σ_1)	0.00036	0.00006	-0.00020	-0.00054	-0.00059	-0.00046
	(< .01)	(0.61)	(0.08)	(< .01)	(< .01)	(< .01)
Trend-Structural Change Interaction (σ_2)	-0.00028	-0.00002	0.00014	0.00026	0.00031	0.00019
	(< .01)	(0.82)	(0.15)	(< .01)	(< .01)	(< .01)

[a] P-values reported in parentheses.

Figure 1. Time Path of Kansas City-Hannibal Soybean Price Relationship

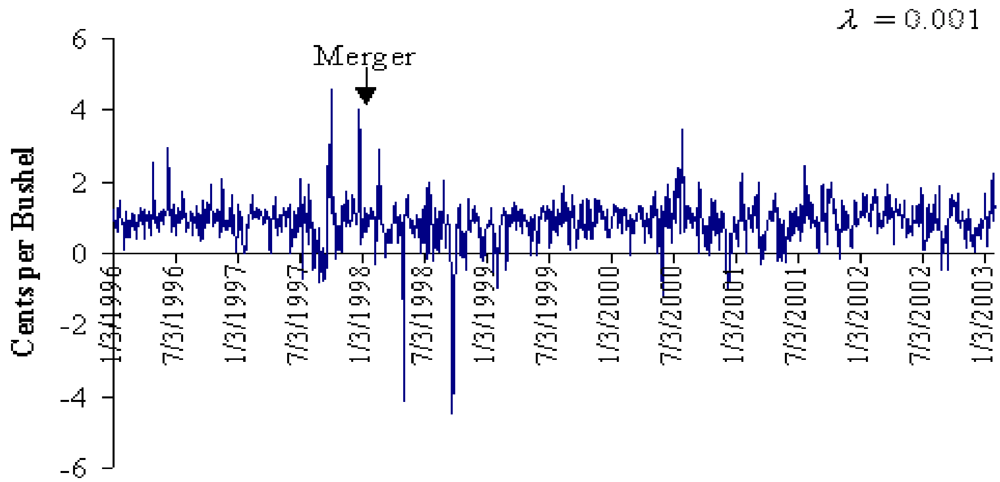

Figure 2. Time Path of St. Louis-Hannibal Soybean Price Relationship

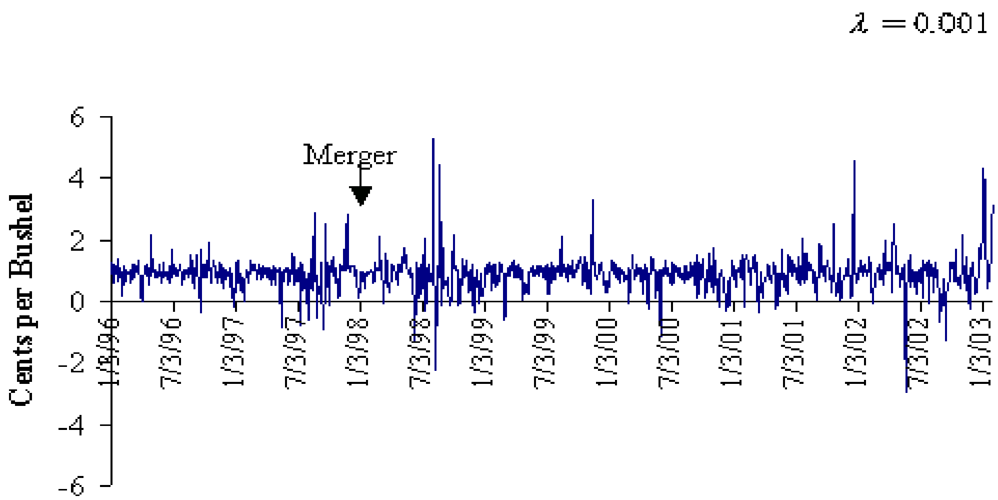

Figure 3. Time Path of Macon-Hannibal Soybean Price Relationship

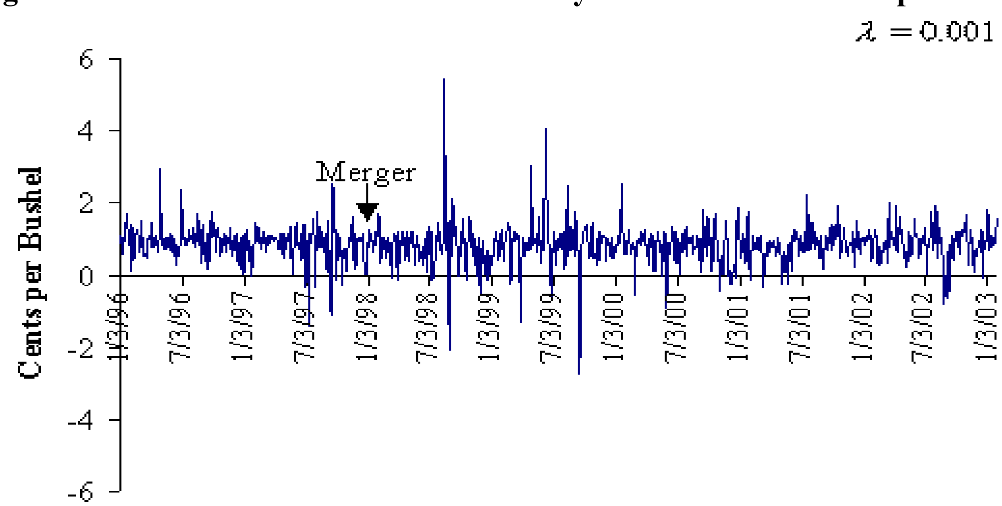

Figure 4. Time Path of Kansas City-Macon Corn Price Relationship

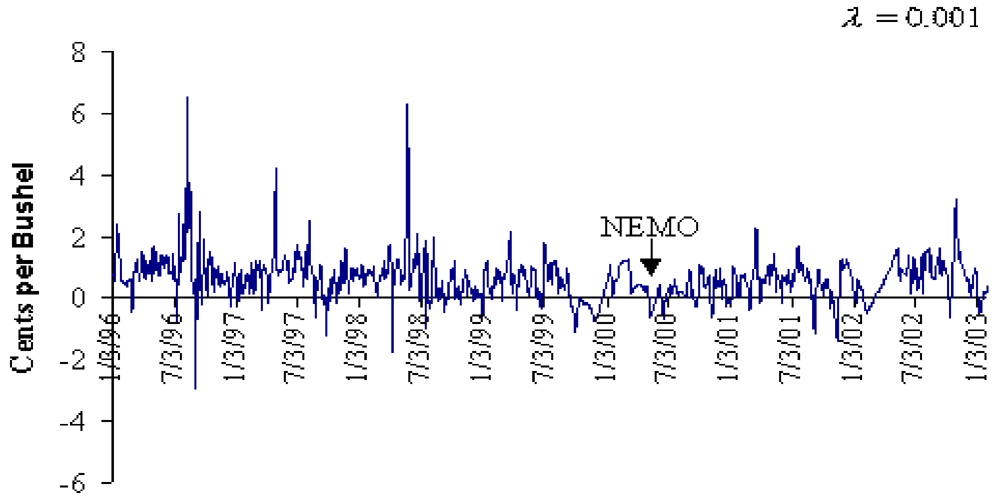

Figure 5. Time Path of St. Louis-Macon Corn Price Relationship

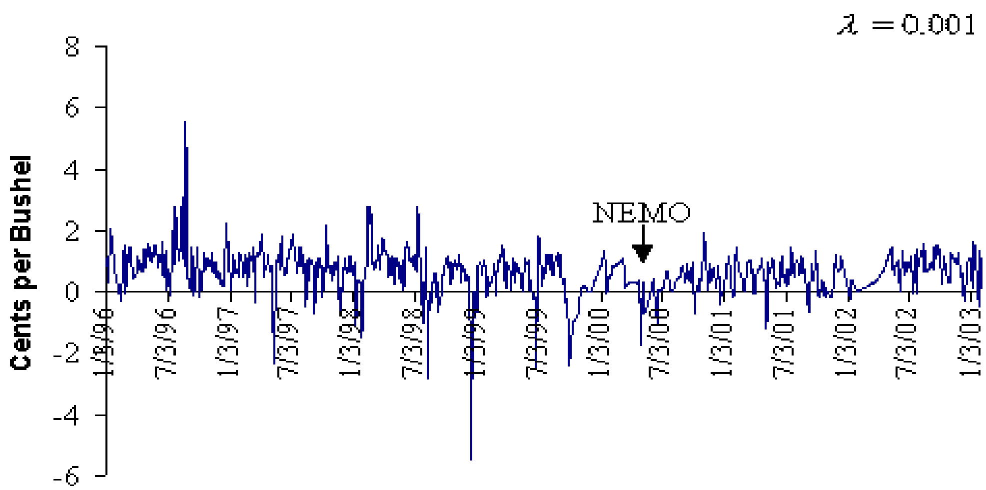

Figure 6. Time Path of Hannibal-Macon Corn Price Relationship

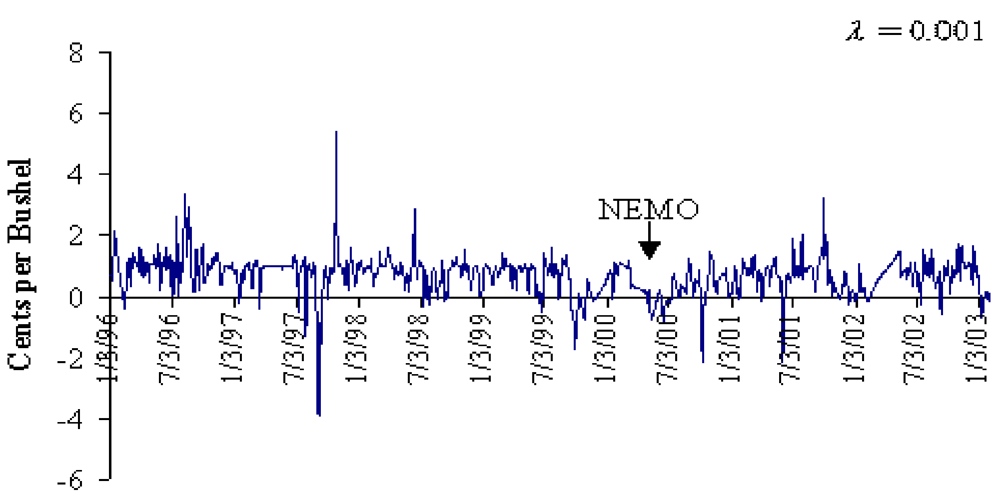

Figure 7. Impulse Responses for Hannibal-Kansas City Soybean Price Relationships

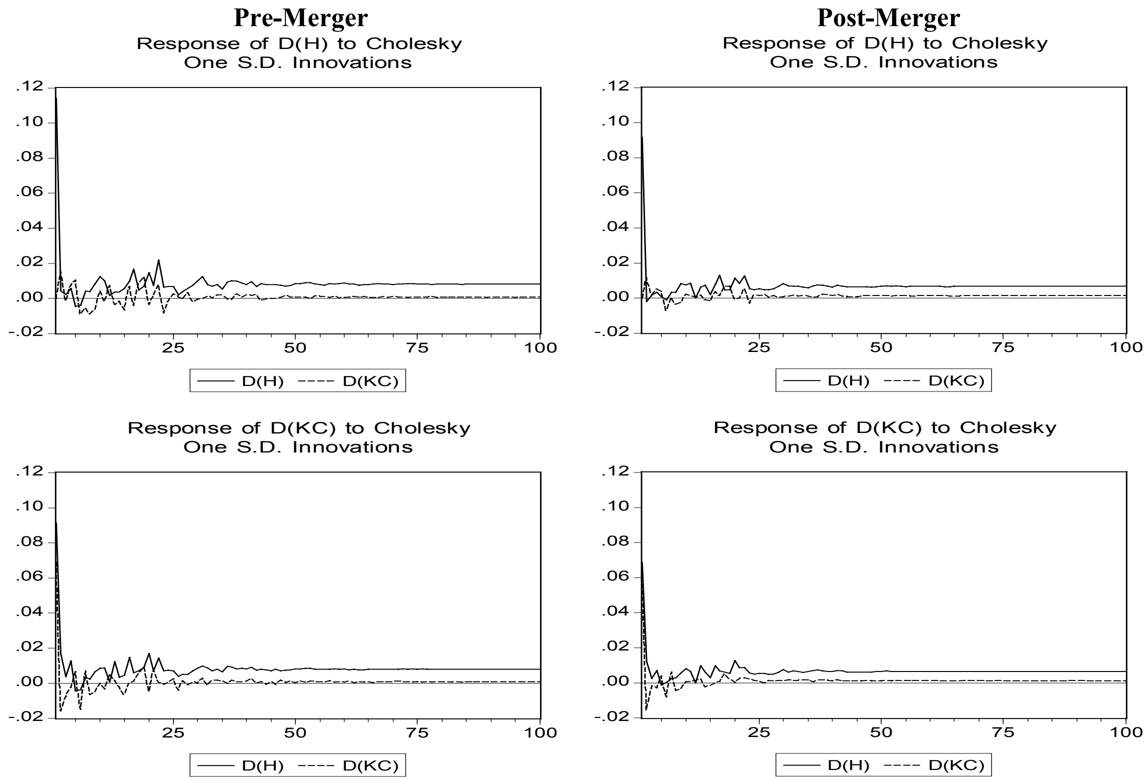

Figure 8. Impulse Responses for Hannibal-St. Louis Soybean Price Relationships

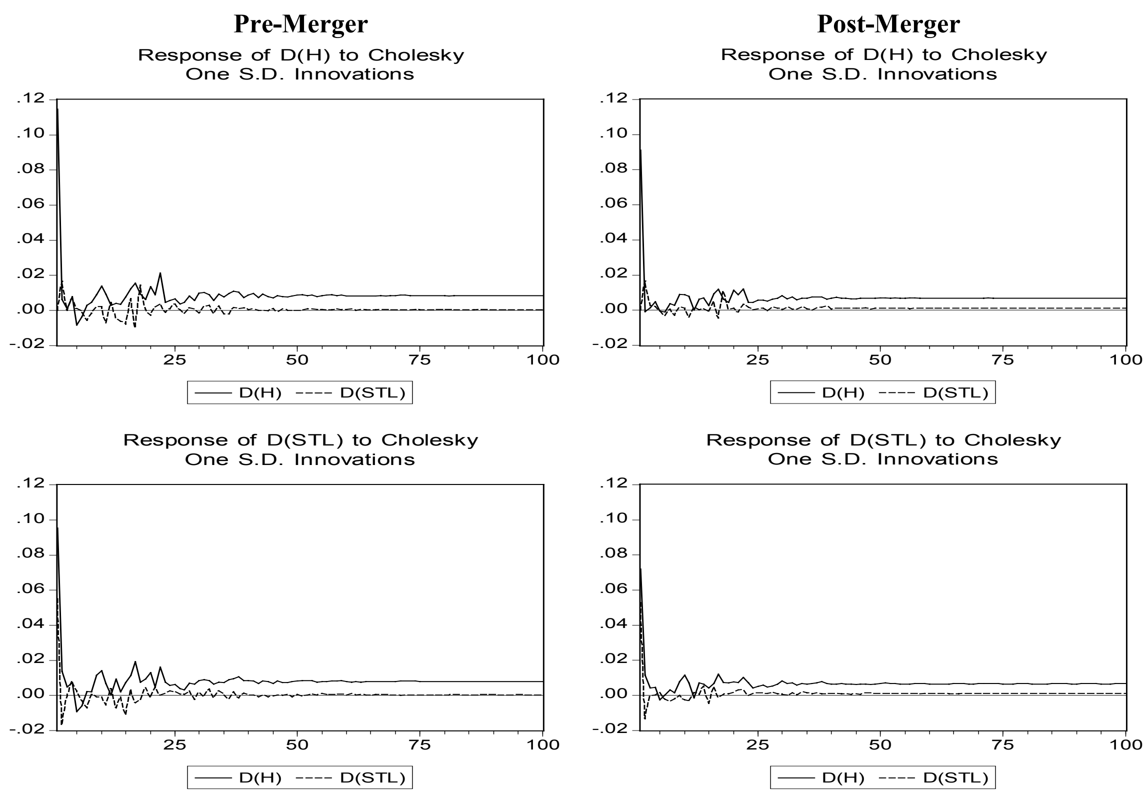

Figure 9. Impulse Responses for Hannibal-Macon Soybean Price Relationships

Pre-Merger **Post-Merger**

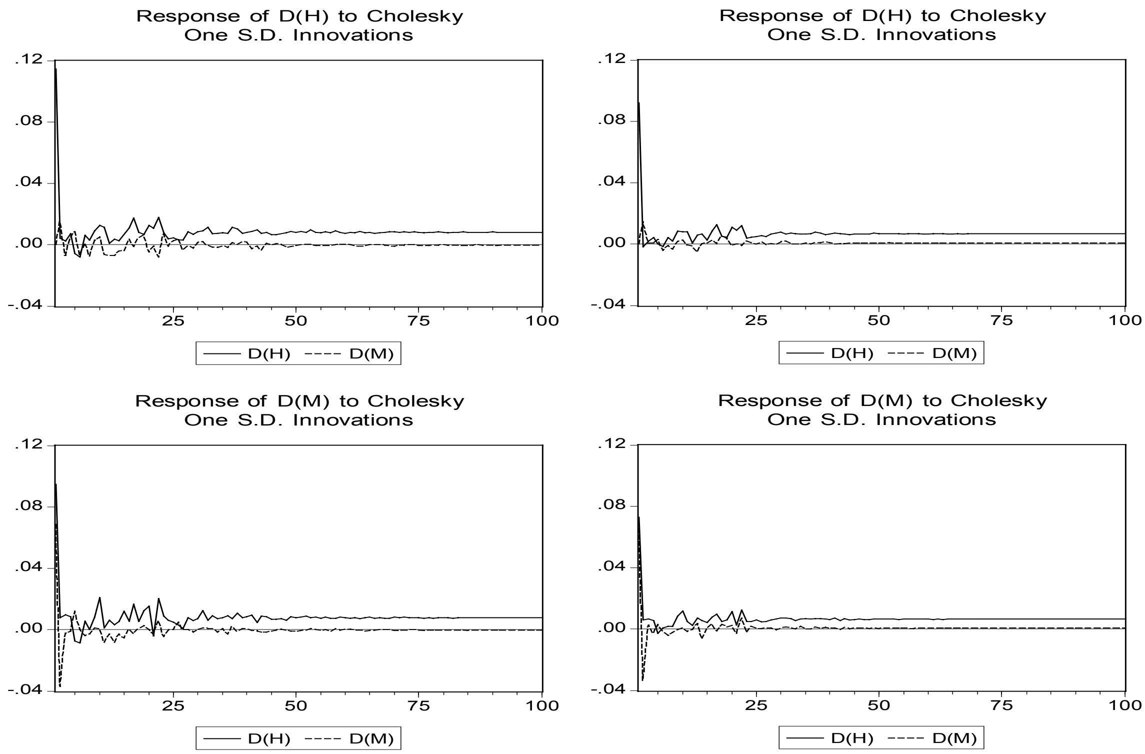

Figure 10. Impulse Responses for Macon-Kansas City Corn Price Relationships

Pre-NEMO **Post-NEMO**

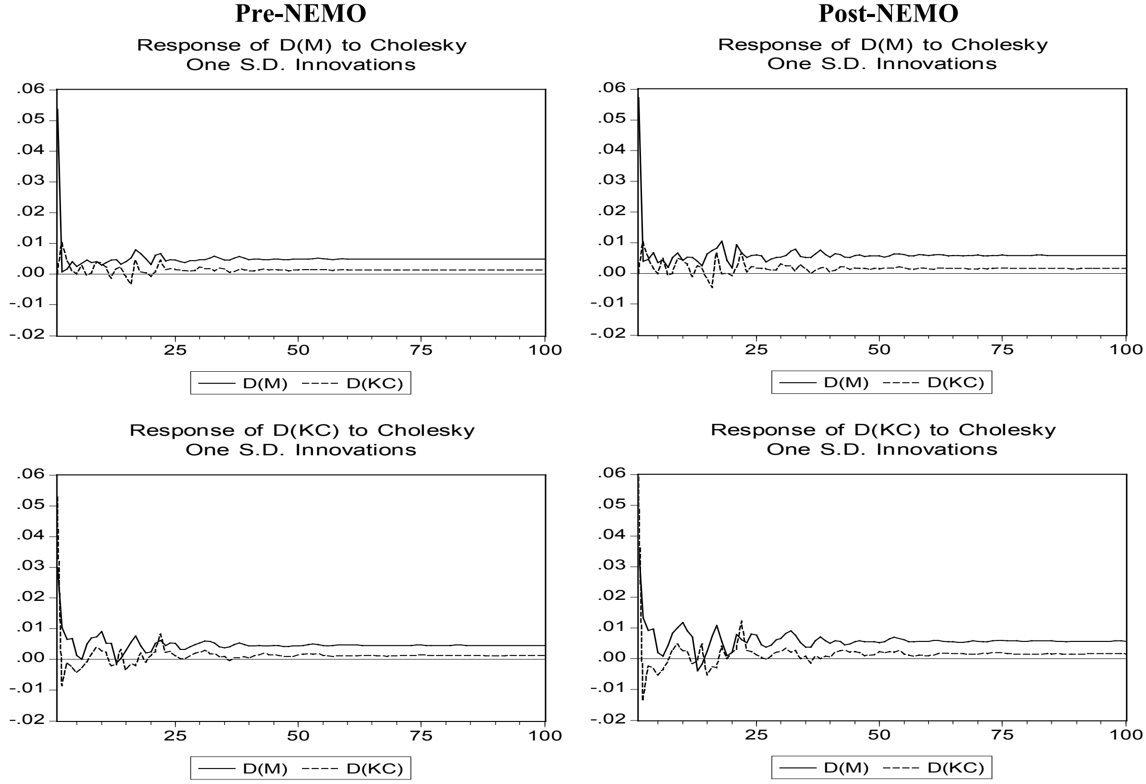

Figure 11. Impulse Responses for Macon-St. Louis Corn Price Relationships

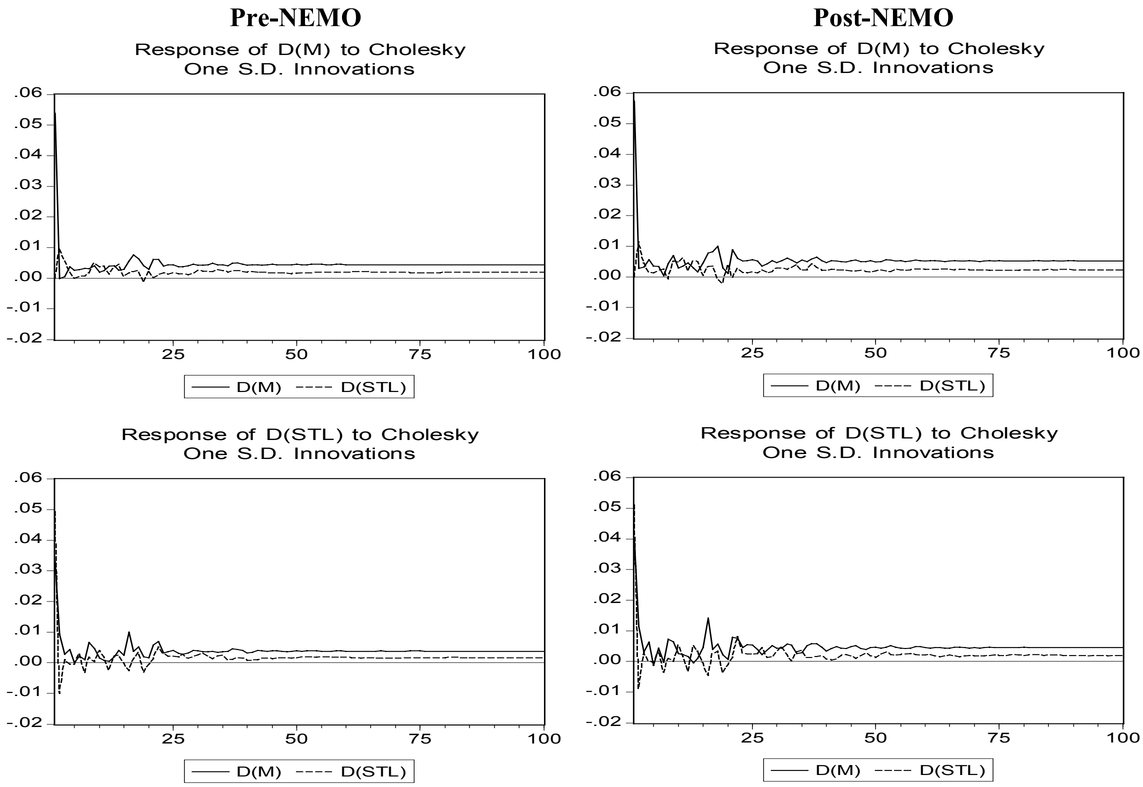

Figure 12. Impulse Responses for Macon-Hannibal Corn Price Relationships