DETECTING MANIPULATION IN FUTURES MARKETS: THE FERRUZZI SOYBEAN EPISODE

Stephen Craig Pirrong

John M. Olin School of Business
Washington University

Abstract: Market manipulation--the exercise of market power in a futures market--is a felony under US commodity law, but recent court and regulatory decisions have made conviction of a manipulator problematic at best. Instead, regulators attempt to prevent manipulation through various means. Deterrence is more efficient than prevention if manipulations can be detected ex post with high probability. This article examines a particular episode of attempted manipulation--the Ferruzzi soybean episode of 1989--to demonstrate how to detect manipulation in a commodity market. The analysis demonstrates that it is exceedingly unlikely that the price and quantity relations observed in May and July 1989 were the result of competition; they are instead reflective of market power. The ability to detect manipulation reliably suggests that existing regulation of manipulation in futures and securities markets is inefficient because it relies on costly preventative measures rather than ex post deterrence.

I. INTRODUCTION

A primary objective of federal regulation of commodity futures trading in the United States is the elimination of market manipulation. The primary form of "manipulation" explicitly identified in the relevant statute--the Commodity Exchange Act ("CEA")--is a corner, that is, the exercise of market power in a commodity futures market during the delivery period.[1] Reducing the frequency and severity of manipulation improves market efficiency because the exercise of market power induces wasteful distortions in commodity flows and production and storage decisions, and impairs the risk shifting and price discovery functions of futures markets.[2]

Despite the centrality of the antimanipulation goal to the purposes of the CEA, since the beginning of this regulation, court and regulatory decisions in market power manipulation cases have been notoriously confused and contradictory. As a result of this legal confusion, the deterrent effect of fines levied on manipulators after the fact has been undermined. Instead of relying upon harm-based sanctions, federal regulators and futures exchanges attempt to prevent the exercise of market power by large traders through a variety of other means, including position limits and emergency intervention. Emergency interventions include forcing large traders to sell ("liquidate") their positions when manipulation is suspected.

Reliance upon prevention in lieu of deterrence is inefficient if it is possible to detect manipulations after the fact with a high degree of accuracy. If the probability of detecting a harm is close to one, and malfeasors possess enough wealth to pay fines equal to the amount of damage inflicted, harm-based sanctions are less costly than preventative measures.[3] The second condition almost certainly holds in futures market manipulations. Therefore, the efficiency of the current regulatory structure in American futures markets depends on whether manipulations can be identified ex post.

Many of the important decisions in manipulation cases claim that it is difficult, if not impossible, to identify manipulations using data on futures and spot prices, and on the movements of commodities in interstate commerce. Prominent examples include In re Indiana Farm Bureau Cooperative Association and In re Cox.[4] Indiana Farm Bureau is especially important because it has been cited as a precedent in subsequent cases, including Cox and In re Abrams.[5] In this case, the majority decision argued that data on prices was insufficient to determine whether a manipulation had occurred, and instead mandated a wide-ranging examination of "the aggregate forces of supply and demand" and a "search for those factors which are extraneous to the pricing system."[6]

Many academics also argue that manipulation cannot be detected reliably ex post. Academic criticisms of ex post deterrence include: historical price data may themselves reflect manipulation; price data are unreliable; the definition of what constitutes a manipulated price is too vague; it is difficult to distinguish competitive markets operating under unusual supply and demand conditions from markets manipulated through the exercise of market power; and that it is difficult to distinguish manipulative intent from legitimate intent.[7]

If these arguments are correct, then it is likely to be more efficient to prevent manipulation than to deter it through fines levied ex post. Indeed, one legal scholar considers manipulation an "unprosecutable crime" and consequently recommends the creation of a vastly expanded preventative apparatus.[8]

Others, including Working, Easterbrook, and Pirrong, dissent from this view.[9] They argue that market power manipulation has distinctive effects on prices and quantities. Manipulated prices and quantities can be reliably distinguished, moreover, from competitive prices and quantities even if fundamental market conditions are "unusual." Furthermore, it is possible to determine whether an alleged manipulator intended to exercise market power from an analysis of his actions before, during, and after the alleged corner.

The efficient method of regulating futures markets depends crucially upon which view is correct. Unfortunately, heretofore the debate over this issue has involved primarily assertions and theoretical arguments, and has been notably devoid (with one modest exception)[10] of empirical analysis to determine the correctness of either view. This article attempts to address this difficulty by examining in detail an incident of alleged manipulation: Ferruzzi SA's alleged squeezes in the soybean market in the spring and summer of 1989. This analysis shows how time series and cross-sectional techniques can be used to detect price and quantity patterns symptomatic of manipulation, and to quantify the likelihood that price and quantity patterns observed during a period of alleged manipulation were actually the result of competitive market forces.

In order to carry out this exercise, I first draw upon a theoretical analysis of the effects of manipulation on price relations and commodity movements in futures markets in order to derive refutable hypotheses. These hypotheses demonstrate that prices and quantities in a manipulated market behave differently than in a competitive one. These hypotheses are then tested upon a variety of price and quantity data from the soybean market. In the Ferruzzi case, it is highly unlikely that the observed soybean price and quantity movements in May and July of 1989 resulted from chance in a competitive market. Furthermore, alternative, non-manipulative explanations for price and quantity movements in these months are examined and rejected. Moreover, Ferruzzi's actions are consistent with an intentional exercise of market power. That is, one can reject at extremely high confidence levels the null hypothesis that all market participants acted as price takers in the May and July 1989 soybean futures contracts in favor of the alternative that one firm--Ferruzzi--acted as a monopolist.

In essence, this analysis demonstrates that it is possible to quantify the probability that particular price and quantity movements in a futures market were generated by the same process generating historical data, or are instead consistent with the exercise of market power. This allows the determination of whether the evidence surpasses the burden of proof relevant in a manipulation case. In the Ferruzzi case, this probability is quite small. Furthermore, it is possible to test specific alternative, non-manipulative, explanations of these movements. Decisive rejection of the competitive null and non-manipulative explanations for price movements in favor of the alternative hypothesis of manipulation provides a strong basis for a finding of market power in a manipulation case. Finally, it is possible to demonstrate that Ferruzzi's actions were inconsistent with price taking behavior, but were consistent with specific intent to exercise market power. Thus, this analysis supports the view that used properly, empirical techniques can be used to quantify the probability that a particular trader intentionally exercised market power in order to determine whether a particular allegation of manipulation satisfies the required burden of proof.

The ability to use statistical techniques to detect manipulative price distortions ex post undercuts the notion that manipulation is inherently "unprosecutable." In this regard, it is also important to recognize that whatever the power of the tests employed here, for a given probability of false conviction (that is, for a given probability of type I error), these ex post tests must be more powerful than tests available to regulators trying to prevent manipulation through emergency intervention in the marketplace when a manipulation is suspected. Regulators contemplating emergency action must perforce rely upon a strict subset of the information employed to carry out the tests contemplated here. Regulators acting before the completion of a manipulation cannot know what happens to prices and quantities after the end of a manipulation, and what a suspected manipulator does with the deliveries he takes. For a given probability of wrongful intervention either ex ante or ex post, this additional information increases makes ex post deterrence less subject to error than ex ante restrictions on trader conduct or regulatory interventions into the marketplace

In sum, this analysis shows how economic and statistical analysis can be used to detect manipulation ex post. The decisive results this analysis produces suggest that current commodity and securities law is inefficient because (1) legal decisions have vitiated ex post deterrence, and (2) regulators rely upon costly preventative measures instead.

II. TESTING FOR THE EXISTENCE OF MARKET POWER IN FUTURES MARKETS

The model of Pirrong makes predictions concerning (1) the effects of market power on price relations in futures markets and on the movements of commodities, and (2) the behavior of traders that exercise market power.[11] These predictions distinguish price and quantity relations and trader behavior in manipulated markets from their counterparts in competitive markets. Specifically, the theory predicts that in a market power manipulation:

1. The price of the manipulated contract is abnormally high relative to the price of the contracts expiring later (that is, the price of the "front month" contract is artificially high relative to the deferred or "back month" contracts). This elevation should become evident sometime prior to the end of trading, and may become manifest only gradually as traders become progressively more aware of the possibility of a manipulation. The magnitude of the distortion is usually largest immediately prior to the time that the manipulator liquidates his position, as then other traders are most fully aware of the prospects for a squeeze.[12]

2. The expiring futures price and the spot price at the delivery market are abnormally high relative to prices at other, non-deliverable locations; the prices of related products; and prices of non-deliverable grades of the same commodity. Again, these distortions may manifest themselves gradually, and are typically largest immediately prior to the time that the manipulator liquidates. Thus, sometime prior to contract expiration the futures and deliverable spot prices rise abnormally relative to prices of comparable commodities.

3. The spot price in the delivery market declines both absolutely and relative to deferred month futures prices and spot prices at other locations around the end of futures trading or the delivery period. The timing of this decline may vary, depending upon when the manipulator liquidates and the time required to move stocks to the delivery point.

4. Large shipments of the commodity flow to the delivery point immediately prior to and during the delivery period. Moreover, shipments *from* the delivery point are abnormally small during the delivery period as traders amass stocks to make delivery.

5. Delivery point receipts are abnormally small *after* the delivery period because of the glut of the commodity at the delivery point that results from the artificially large receipts during the delivery period. Shipments from the delivery point increase after the end of a corner as some of the excess shipments are returned to their original sources and delayed shipments are released.

The intuition behind these results is straightforward. A manipulation may be profitable when (1) the incremental cost of augmenting deliverable supplies increases as shorts make more deliveries, and (2) a trader owns enough futures positions.[13] Under these circumstances, a large long (that is, the buyer of a large number of futures contracts) who stands for an excessive number of deliveries drives up the marginal cost shorts must incur to deliver even more of the commodity. Put differently, in spatial markets like those for most agricultural and many industrial products, the supply curve for a commodity in the delivery market is upward sloping because it is necessary to attract additional supplies from competing uses in other locations. Shorts must move up the supply curve in order to acquire more of the good for delivery. Shorts are willing to pay the long a price equal to this artificially inflated cost of delivering against another contract in order to settle (that is, buy back) the remainder of their positions. Thus, by calling for too many deliveries of the commodity (equivalently, by liquidating too few contracts), the large long induces shorts to repurchase their remaining positions at artificially high prices. The large long profits when he sells contracts at these high prices.

This description shows that a cornerer artificially increases demand for the commodity at the delivery point during the delivery period in order to earn a supercompetitive profit. This artificial demand stimulus explains the five listed effects of manipulation. Since the demand increase is confined to the delivery market, the price in that market rises relative to the prices in other markets. (Prices rise in these other markets too because the manipulator bids supplies away from them, but these price increases are smaller than the price rise in the delivery market.) Moreover, this relative price increase in the delivery market (1) attracts additional supplies to that point, and (2) induces some traders to hold stocks at that point that they would have shipped elsewhere but for the manipulation. Together these actions inflate receipts and stocks in the delivery market. The demand increase is also confined to a narrow time interval surrounding the delivery period. This raises the price in the delivery market during this period relative to the prices for deferred delivery. (This distortion in temporal pricing patterns may be even more evident when one controls for the size of the stocks in the delivery market.) In a competitive market, the spot price is high relative to the deferred futures price only when deliverable stocks are unusually small. Therefore, if the current spot price is high relative to the deferred futures price at the same time deliverable stocks are very large, it is unlikely that all traders were acting competitively at contract expiration. Finally, the cornerer abruptly terminates the artificial demand stimulus when the corner ends (either due to the manipulator's actions or regulatory intervention). This sudden decrease in demand, combined with the artificial inflation in stocks causes the spot price to plunge in the delivery market. The spot price declines both absolutely and relative to (1) prices in other markets, (2) the deferred futures price, and (3) the but-for-manipulation competitive spot price.[14] Market participants refer to this post-delivery price collapse as the "burying the body (or corpse)" effect.[15] The decline in demand at the end of the delivery period demand also leads to an increase in shipments from, and a reduction in shipments to, the delivery market.

It is important to note that these price and quantity effects are quite distinct from the price and quantity effects of other "unusual" events in futures markets.[16] Most important, the effects of manipulation are readily distinguishable from systemic demand or supply shocks.[17] For example, it is sometimes argued that an export boom or a crop failure could produce the same economic symptoms as a manipulation. It is indeed true that shocks of this sort can lead to a large increase in prices and changes in commodity flows, but the pattern of these price and quantity changes can be distinguished from those resulting from a manipulation.

Take, for instance, the case of an export boom in soybeans. During the typical boom, demand increases at the major export points, including the Gulf of Mexico, Toledo, the East Coast of the U.S., as well as Chicago, the primary delivery point for the Chicago Board of Trade ("CBT") soybean futures contract. This increase in demand cause prices to vary at all of these points, and at the points tributary to them (such as, the growing regions of Iowa). Although prices rise at all locations, relative prices between the various export ports should not change much because demand is rising at all points. In particular, the relative price at the futures delivery point does not *necessarily* rise during an export boom. Indeed, it may fall. During a squeeze, in contrast, demand increases only at the delivery point, and thus the price in Chicago should rise significantly relative to the prices in the other important soybean markets. Put another way, during an export boom the relative price in Chicago would increase dramatically only if the boom were confined to that point. This would be peculiar, to say the least.

Manipulation has other tell-tale signs that distinguish it from systemic shocks. For example, the “burying the body” effect is unique to manipulation.[18] Furthermore, during an export boom shipments from the delivery market should increase, whereas during a manipulation shipments from the delivery market should decline. Similar arguments hold for other systemic shocks. In sum, therefore, one can distinguish a large manipulation from other unusual events that affect commodity prices and flows. Only a large surge in demand confined to the delivery market during the delivery period can explain the price and quantity effects of manipulation; absent a squeeze such a demand shock is highly unusual, and hence should be readily identifiable.

The theory also predicts how a manipulator should behave. Most important, a manipulator must both take a large number of deliveries and liquidate (sell) contracts during the same delivery period. He must take excessive deliveries in order to drive up the futures price, but he must sell some contracts to profit from this price rise. Moreover, if the manipulator is a commercial firm (such as an exporter or processor), he takes deliveries of the commodity against futures at prices that are higher than the cost of obtaining the commodity elsewhere, or at later times, to meet the firm’s processing or exporting needs.

The following section tests these implications in a specific case of alleged manipulation--the Ferruzzi soybean episode of 1989. This analysis demonstrates that testing for the existence of market power in futures markets is considerably easier than in other product markets because the temporary nature of a corner allows one to exploit information about price changes (rather than price levels) in order to test for the existence of market power.

III. EMPIRICAL TESTS OF MARKET POWER MANIPULATION:

THE FERRUZZI CASE

A. Background

Ferruzzi is a large Italian conglomerate. In 1989 it was a major participant in the world grain and oilseed markets as a merchandiser and as a processor. Commencing in late 1988 and continuing through mid-1989, the firm accumulated large long positions in soybean futures and took delivery of substantial amounts of beans against those futures contracts. By May, 1989 the firm owned a large fraction of warehouse receipts granting title to stocks of soybeans deliverable against Chicago Board of Trade soybean futures contracts. By mid-May, the US regulator of futures markets--the Commodity Futures Trading Commission ("CFTC")--and the Chicago Board of Trade had become deeply concerned about Ferruzzi's accumulation of such large physical stocks of soybeans and its massive long position in May soybean futures. The firm was able to accumulate such positions only after obtaining a hedge exemption from the speculative position limits imposed by the exchange and the CFTC. The CFTC and the CBT requested that Ferruzzi liquidate its May futures position, and clarify its intentions.[19] The firm claimed it had legitimate needs for the physical stocks and the futures contracts, and did not liquidate its position. Finally, on the last day of trading of the May future, the firm's hedging exemption was revoked. This order came too late, however, to have a pronounced effect on the liquidation of the May contract.

After the termination of trading of the May future, the conflict between the CFTC and the CBT on the one side and Ferruzzi on the other shifted to the July contract. Ferruzzi again amassed a huge position. By June 30 the firm owned 23.6 million bushels of July futures contracts, representing 40.8 percent of the total open interest. This substantial concentration was particularly troublesome to the exchange and the regulator because Ferruzzi owned a substantial portion of the deliverable stocks of soybeans. It therefore could demand delivery of far more soybeans outside of its control than were available in deliverable locations. Shorts would have had to make additional deliveries by shipping beans from other locations to Chicago, engendering costly distortions in the timing and direction of commodity flows.

Responding to this situation, immediately after the end of trading on 11 July, 1989, the CFTC revoked Ferruzzi's exemption from speculative position limits, and the CBT ordered all large market participants to liquidate their positions in an orderly fashion over the five trading days remaining on the July contract. This order followed six weeks of frequent contact between the CBT, the CFTC, and Ferruzzi.[20] In disciplinary proceedings following the emergency action, the CBT levied the largest fine in its history on Ferruzzi (although the firm admitted to no wrong doing as part of the settlement).

There is widespread controversy over whether Ferruzzi's activities increased the May or July soybean futures prices above the competitive level. The firm has steadfastly defended its actions. Some parties--especially farmers--have criticized the July liquidation as an unwarranted interference in the marketplace that favored shorts, penalized longs, and caused prices of soybeans to fall throughout the Midwest.[21] The following sections attempt to resolve this controversy by rigorously testing the hypothesis that prices in May and July, 1989 were not markedly above the competitive level against the alternative hypothesis that these prices were artificially inflated through the exercise of market power.

B. The May, 1989 Soybean Futures Contract

1. The Behavior of the May Futures Price Relative to Deferred Futures and Spot Prices

In this section I employ an event study methodology to determine whether the May, 1989 soybean futures price was manipulated. The event study is used to test predictions 1 and 2 described in section II above. Regressions on historical data are used to quantify the "typical" relations between the May futures price and deferred futures prices, a spot soybean price, and the prices of soybean product futures. Forecast errors from these regressions are cumulated over key periods in May, 1989 to determine whether the May futures price rose by more than one would expect given movements in the other prices. Statistical tests are then applied to quantify the probability of observing cumulative forecast errors of this magnitude.

In order to quantify the typical relation between the May futures price and (1) deferred month futures prices, and (2) a non-deliverable spot price, I estimate several regressions. The first regresses the daily percentage change in the May futures price ($r_{K,t} = \ln P_{K,t} - \ln P_{K,t-1}$) against the daily percentage change in the September futures price ($r_{U,t} = \ln P_{U,t} - \ln P_{U,t-1}$) and a constant.[22] Settlement prices are used to estimate these daily returns. The second regresses the daily percentage change in the May futures price against the daily percentage change in the November futures price ($r_{X,t} = \ln P_{X,t} - \ln P_{X,t-1}$) and a constant. The third regresses percentage change in the May futures price against the daily percentage change in the Central Illinois spot soybean price.[23] The last regression is of the May return against the return of a portfolio consisting of soybean oil and soybean meal. When processed, soybeans yield a relatively stable amount of oil and meal; each bushel typically yields 11 pounds of oil and 48 pounds of meal. The portfolio value equals the price per pound of May soybean oil multiplied by 11 plus the price per pound of May soybean meal multiplied by 48. I refer to this as the "crush" portfolio, as it represents the value of a bushel of soybeans after they are crushed (that is, processed).

The regressions are estimated on a pooled data set consisting of the relevant returns for a period beginning March 1 and ending on the last day of trading of the May futures contract for each year from 1982 through 1995. (Central Illinois cash price data are available only beginning in 1982; extending the September and November futures regressions data sets to 1969 has no effect on the reported tests for manipulation in the May, 1989 contract.) That is, daily returns from 14 different years are stacked to form a single data set, and the regression coefficients are estimated using this pooled data.

The regressions are estimated using OLS. Given the estimated coefficients and observed September 89, November 89, and Central Illinois spot returns, fitted returns for the May 89 contract are calculated for each day from 15 March, 1989 to 19 May, 1989. (19 May was the last trading day for May 89 soybean futures.) These fitted returns are then subtracted from the actual May 89 returns to determine the residual returns. The residual returns are added daily beginning on 15 March, 1989 to determine cumulative residuals, that is, the cumulative unexpected percentage changes in the May 89 futures price.

Figure 1 plots the cumulative residuals, commencing on 3 April, 1989. The cumulative residuals calculated from the September and November return regressions increase slightly from 15 March to 1 May, and then rise steeply from 2 May to 8 May. This means that the May futures price rose sharply relative to both the September and November soybean futures prices over this period. Specifically, the May price rose 4.45

percent relative to the September price and 4.86 percent relative to the November price over these five trading days. These cumulative residuals are large relative to their standard errors. Assuming the residuals are i.i.d., the *t*-statistic for the cumulative residual based on the September futures return equals 4.78, and the *t*-statistic for the cumulative residual based on the November futures return equals 4.40. Each of these *t*-statistics is significant at the 1 percent level. The May futures price also rose relative to the spot price of soybeans in Central Illinois. The cumulative residual from the May-Central Illinois regression over the 2 May, 1989-8 May, 1989 period equals 1.90 percent, with a *t*-statistic of 2.67. Finally, the May soybean futures price rose 2.78 percent relative to the price of the oil-meal portfolio. The *t*-statistic is 3.50.

The size ordering of these residuals is what one would expect to observe during a manipulation. Manipulation elevates the nearby (May) price and depresses the deferred (September and November prices) relative to their competitive values; the latter effect is due to the inflation in deliverable stocks manipulation causes. Manipulation also elevates prices in non-delivery markets such as Central Illinois because stocks are bid away from these markets to enhance deliverable supplies. This elevation in prices in non-delivery markets also increases input prices for processors of soybeans. This increases the prices of soybean products, but by a lesser amount than the rise in input prices because the demand curves for processed products slope down. Thus, during a manipulation one expects to observe that the manipulated price rises most relative to deferred futures prices, and least relative to spot prices in other markets; the rise relative to soy product prices should lie between these bounds. This is exactly what occurred in May, 1989.

After May 8, the May futures price continued to rise relative to the September and November futures prices, and the Central Illinois spot price, but at a slower rate. The cumulative residuals over the 2 May-19 May period equal 5.16 percent (t=2.76), 5.03 percent (t=2.24); 2.08 percent (t=1.67); and 4.99 percent (t=3.27) for the residuals calculated from the September, November, Central Illinois, and crush portfolio regressions, respectively. Thus, the residuals imply that the May price was approximately 5 percent higher than expected conditional upon observation of the September and November futures returns, the crush return, and the Central Illinois spot return.

The rise in the May futures price relative to the September futures price, the November futures price, and the Central Illinois spot price is consistent with the anticipated exercise of market power by Ferruzzi

Basing inferences on residuals from individual regressions ignores important information because the joint distribution of returns allows more discriminating tests for market power. Specifically, a regression of the May return against the September and November futures returns, the Central Illinois spot return, and the crush return permits the calculation of residual returns conditional on the movements of all of these control variables. In such a regression, all coefficients are statistically significant, indicating that each variable contributes some power to explain variations in May futures returns.

The standardized May cumulative return over the 2 May-8 May period equals 2.83 percent. The t-statistic on this increase is 5.82. Under the assumption that the residuals from this regression are i.i.d. normal variates, the probability of observing a cumulative return of this size or larger equals 2.94E-9. Thus, under the normality and independence assumptions, the information included in the distribution of the joint returns of the futures and spot prices, the null is rejected at an extremely high confidence level. These results are consistent with the hypothesis that Ferruzzi exercised market power in the May soybean futures contract.

The specific *p*-value reported in the previous paragraph is predicated on the assumptions of independence and normality. These assumptions are common in empirical work on financial markets, but may lead to biased *p*-values if they are violated. For example, to the extent that the residuals exhibit leptokurtosis the normal distribution understates the probability mass in the tails; in this case, the *p*-value is biased downwards. Such downward bias could lead to "false positive" identification of manipulation. Moreover, any serial dependence in the residuals (in the first or higher moments) can cause cumulative residuals to have a distribution that differs from the normal with mean zero and standard deviation equal to the regression standard error times the square root of the number of trading days over which the residuals are cumulated (as was assumed when calculating the *p*-values reported above).

This issue can be addressed in various ways, depending on the context and the nature of the data. One common source of leptokurtosis is conditional heteroskedasticity. This can be accounted for using standard GARCH techniques (as are employed in the next section) but this approach is problematic when applied to a specific delivery month futures contract for a seasonal commodity. An alternative method is to estimate the density of residuals non-parametrically. This approach imposes no distributional assumptions and can handle substantial deviations from normality. Due to this flexibility, I employ the non-parametric approach to the study of the cumulative May residuals.

To implement this approach to measure the probability of observing a 5 day residual May return of 2.83 percent, I (1) generate a sample of all 5 day cumulative May residuals derived from the regression of the May return on the September, November, CIL, and crush returns for the 1982-1995 period (excluding 1989) and (2) use this sample to estimate the 5 day cumulative residual probability density function non-parametrically.[24] Given the density estimate, I integrate numerically (using Gauss-Legendre quadrature) over this density from .0283 (the observed cumulative return over 2 May-8 May) to the density's upper support. This integral gives the probability of observing a 5 day cumulative return in excess of 2.83 percent.

The value of this probability is effectively zero because the 5 day cumulative residual from 2-8 May, 1989 is 4 standard deviations above the largest other 5 day cumulative residual observed in the sample of all 5 day May cumulative residuals.[25] Thus, the conclusion that the observed runup in the May futures price over the 2 May-8 May time period was highly anomalous is not an artifact of any particular assumption about the probability distribution of 5 day cumulative May soybean residuals. This is very strong evidence that the May, 1989 futures price was manipulated.

2. The Behavior of the Chicago Spot Price Relative to Spot Prices in Other Markets

In order to determine whether the Chicago spot price was affected by market power, I compare changes in the Chicago spot price to changes in spot prices in other markets. These spot prices are not transactions prices *per* se. Instead, they are bids made to purchase soybeans by elevator operators. Since they are bids, they may be imperfect measures of true spot prices. The resulting "noise" in the price data should make it more difficult to identify manipulative distortions precisely.

Spot prices for nine non-deliverable markets are available for the period January 1988-March, 1996.[26] The markets are St. Louis/Southern Illinois River, Central Illinois, Eastern Iowa, Central Iowa, Western Iowa, Kansas City, Minneapolis, New Orleans (the “Gulf” market or “NOLA”), and Mississippi River barge loading stations in Iowa. Each of these points is a major production location or terminal market. For each date for which prices are available for each market, the bid prices from these markets are averaged to determine the price of a “portfolio” of non-deliverable soybeans. This portfolio price is denoted P_P. The daily log price changes in this portfolio are calculated as well. Call this portfolio return r_P. Similarly, the change in the log of the bid posted by elevator operators in Chicago is calculated. Call the Chicago bid P_C and the return r_C.

Given these returns, the following error correction model (“ECM”) is estimated:

(1) $$r_{C,t} = a + \sum_{i=1}^{5} [g_i r_{C,t-i} + w_i r_{P,t-i}] + m(P_{C,t-1} - P_{P,t-1}) + x_t$$

(2) $$r_{P,t} = v + \sum_{i=1}^{5} [k_i r_{C,t-i} + y_i r_{P,t-i}] + V(P_{C,t-1} - P_{P,t-1}) + e_t$$

The lagged price difference is included in the equations because Augmented Dickey-Fuller tests indicate that the Chicago and portfolio prices are non-stationary, but that these prices are cointegrated. This last result is sensible. It means that if a temporary disturbance (such as a demand shock at the Gulf) drives Chicago prices and prices elsewhere apart, they tend to move back together after the shock. This convergence reflects the long run equilibration of a spatial market.

The residuals from this ECM are assumed to be jointly conditional normal, with conditional variances and covariances of the residuals following a bivariate GARCH process. Assuming GARCH residuals permits me to capture potential heteroskedasticity and "fat tails" in the spot return distributions. Formally:

(3) $$h_{C,t} = a + bh_{C,t-1} + cx_{t-1}^2$$

(4) $$h_{P,t} = k + mh_{P,t-1} + qe_{t-1}^2$$

(5) $$h_{C,P,t} = q + uh_{C,P,t-1} + vx_{t-1}e_{t-1}^2$$

where $h_{C,t}$ is the variance of the residual from the Chicago spot return equation on day *t*, $h_{P,t}$ is the variance of the residual from the portfolio return equation on day *t*, and $h_{C,P,t}$ is the covariance between these residuals on day *t*.[27] Together, these time varying variances and covariance allow the determination of a time varying joint probability distribution of the daily residuals from the Chicago return and out-of-position portfolio return regressions. The ECM model is estimated using OLS and the GARCH model is estimated using quasi-maximum likelihood.

The model is fitted on a sample of daily price data extending from 2 January, 1988 through 31 March, 1996. Given the estimated coefficients, the residuals and the variance-covariance matrix are computed for each day commencing with 16 March, 1989 and ending 21 July, 1989. Since the residuals are assumed jointly normal with zero means, conditional upon observing e_t, the expected value of the Chicago residual is $Ex_t = be_t$ where $b = h_{C,P,t} / h_{P,t}$. The variance of this conditional residual is $h_{C,t}(1 - r^2)$ where $r = h_{C,P,t} / \sqrt{h_{C,t}h_{P,t}}$ is the correlation between the Chicago return and the portfolio return. Given these numbers, it is possible to calculate the difference between the observed Chicago residual and the expected value of this residual conditional upon the observed portfolio residual. Formally, this difference is $x_t - be_t$. The ratio of this difference to the standard deviation of the conditional residual is a standard normal variate, and can be used to calculate the probability of observing a residual of this magnitude. A conditional standardized residual that is large in absolute value represents a change in the Chicago spot price relative to the change in the spot price in other locations that is unlikely to be a chance event. Conditional residuals can also be cumulated and their significance tested.

Over the period 3 May-9 May, the cumulative conditional Chicago residual equals 2.38 percent; the standardized cumulative residual equals 3.37 (*p*-value=.000378).[28] Over the 3 May-16 May period, the cumulative conditional Chicago residual equals 3.44 percent; the standardized residual equals 3.36 (*p*-value=.000395). Thus, the spot price data provide evidence of a rise in the price of soybeans in Chicago relative to the price of soybeans in other locations. This rise is statistically significant, and is consistent with the exercise of market power in the May contract.

The Chicago spot price's rise relative to spot prices in other markets is smaller than the rise in the May futures price relative to deferred futures prices. Also recall that the rise in the May futures price relative to the Central Illinois spot price is smaller than the rise in the May price relative to deferred futures. This is what one would expect to observe during a market power manipulation because the exercise of market power at the delivery point tends to raise prices in non-delivery markets as well, though by less than it raises the price in the delivery market. Therefore, the cumulative conditional Chicago spot price residual is a downward biased measure of the effect of market power on the Chicago soybean price relative to the no-manipulation competitive price.[29]

The Chicago spot price declined relative to non-deliverable spot prices in late May, but there was no precipitate collapse symptomatic of burying the body. From the end of trading on 19 May through 31 May, the cumulative residual equals -2.8 percent (t=-1.42, p-value=.0778).

The gradual decline in the Chicago spot price relative to spot prices in other markets represents the weakest rejection of the competitive null, and thus the weakest evidence against a market power manipulation of the May contract. All in all, however, the spot price evidence confirms the futures price evidence examined in the previous section. Moreover, the lack of a precipitate decline in the Chicago spot price may reflect concerns that another, larger manipulation was impending in July.[30] Finally, there is strong evidence that there were abnormal flows of soybeans to Chicago in late May, and abnormal flows of soybeans out of Chicago in early June. These shipment and receipt patterns provide clear evidence that the true spot price of soybeans in Chicago relative to prices in other markets was abnormally high in May, and abnormally low in early June. The next section considers this evidence in detail.

3. The Behavior of Shipments and Receipts in the Chicago Market in May and June

To test whether the patterns of shipments and receipts of soybeans in Chicago in May, 1989 are consistent with the exercise of market power, I estimate models of shipments and receipts on weekly data reported in the Chicago Board of Trade Statistical Annual from the 7 January, 1982 to March 30, 1989. Specifically, the following equations are estimated:

(6) $$\Delta R_t = c + b\Delta R_{t-1} + \sum_{i=1}^{5} l_i \Delta PS_{t-i} + fR_{t-1} + e_t$$

(7) $$\Delta S_t = w + h\Delta S_{t-1} + \sum_{i=1}^{5} q_i \Delta PS_{t-i} + j S_{t-1} + n_t$$

Here ΔR_t is the change in receipts of soybeans in Chicago from other markets from week t-1 to week t; ΔS_t is the change in shipments from Chicago to other markets from week t-1 to week t; and ΔPS_t is the change in the shipments of soybeans to primary markets (other than Chicago) from week t-1 to t. The lagged value of the level of receipts (in the receipt equation) and the lagged value of the level of shipments (in the shipment equation) reflects the statistical result that receipts and shipments are mean reverting. That is, if the previous week's receipts were high, *ceteris paribus* one would expect this week's receipts to decline.[31]

Given the parameter estimates, values of the shipments and receipts are forecast for each week from 26 May, 1989 (the last week of the delivery period) to 16 June, 1989. Forecast errors are calculated by subtracting forecast receipts (shipments) from actual receipts (shipments).

The forecast errors from the receipt equation are positive for the last week of May, 1989 (that is, the last week during which longs could deliver against May contracts), and negative for the first two weeks in June. Specifically, receipts of soybeans in Chicago during the week ending 26 May, 1989 were 1.320 million bushels greater that expected conditional on past shipments, receipts, and other primary market receipts, whereas receipts in the weeks of 2 June and 9 June were .832 million bushels and .368 million bushels smaller, respectively, than one would expect (conditional upon lagged shipments, receipts, and primary market receipts). Conversely, shipments from Chicago were .149 million bushels smaller than expected during the week ending 26 May, but were 3.09

million bushels higher than predicted over the next three weeks. The pattern of shipments and receipts is therefore consistent with the exercise of market power; receipts were larger (smaller) than normal before (after) the end of the delivery period, whereas shipments were smaller (larger) than normal before (after) the close of the delivery month.[32]

It is highly unlikely that these patterns resulted from chance in competitive marketplace. Given the standard errors of the forecast errors, it is possible to calculate the joint probability of observing the residual shipment and receipt patterns just documented. Specifically, the probability that receipts would be at least 1.320 (t=4.50, p-value=3.40E-6) million bushels greater than predicted and shipments would be at least .149 million bushels (t=-.51, p-value=.305) less than predicted during a given week is 1.04E-6. The probability that receipts would be at least 1.254 million bushels (t=-2.47, p-value=.0068) less than predicted during the same three week period as shipments are at least 3.09 million bushels (t=6.00, p-value=9.87E-10) more than forecast is 4.83E-13. Since the residuals from (6) and (7) are serially uncorrelated, the probability that one would observe the reversals in shipments and receipts that occurred in the 26 May, 1989-16 June, 1989 period is the product of these two probabilities, 5.02E-19.[33]

Thus, the shipment and receipt data provide strong evidence of manipulative distortions in the Chicago Board of Trade soybean contract in May, 1989. The observed pattern of bean movement into and out of Chicago in the weeks surrounding the end of the delivery period is symptomatic of the exercise of market power. Moreover, the observed movements are unlikely to have resulted from chance. Finally, the observed movements are consistent with the unusual behavior of spot and futures price relations during the delivery month, and therefore support the inferences drawn from the price data.[34] In sum, one can reject decisively the hypothesis that the movements of soybeans during May and June, 1989 were produced by competitive behavior by participants in the CBT soybean contract in favor of the alternative that a large trader--Ferruzzi--exercised market power.

4. Ferruzzi's Behavior During the Delivery Period

During May, 1989, 7.495 million bushels of soybeans were delivered in Chicago against CBT contracts, and another 1.6 million bushels were delivered in Toledo, the "safety-valve" delivery point for the soybean contract. Ferruzzi allegedly took a substantial fraction of these deliveries. By May 18, 1989, Ferruzzi owned most of the deliverable stocks, and by July 1 owned approximately 85 percent of these stocks.[35] The ownership of large quantities of warehouse receipts at the end of a delivery period is exactly what would be observed during a market power manipulation. In essence, the manipulator has the highest willingness to pay for receipts, and therefore ends up them.

The firm also liquidated a substantial proportion of its position in May soybeans. As late as May 16, Ferruzzi was long 16 million bushels. Since total deliveries against the May were about 9 million bushels, Ferruzzi necessarily liquidated at least 7 million bushels (and probably much more, as it could have liquidated some of its position prior to May 16). This simultaneous sale of large quantities and acceptance of large number of deliveries is consistent with the exercise of market power; a manipulator must take large numbers of deliveries to elevate the price, but must liquidate large quantities in order to profit from this elevation. Given the price structure in the market (namely, the fact that the May price exceeded the July price during May) it is difficult to view this as competitive price taking behavior.[36]

5. Summary and Conclusions

The evidence on prices and quantities allows a decisive rejection of the hypothesis that the May 1989 futures price was competitive during the delivery month in favor of the alternative hypothesis that the price was supercompetitive due to the exercise of market power. Moreover, the behavior of Ferruzzi--specifically, its acceptance of substantial deliveries, its ownership of a substantial portion of the deliverable stock after the end of the delivery period, and its liquidation of a substantial portion of its position--is exactly what one would expect from a firm intending to exercise market power. Thus, the data provide overwhelming evidence that Ferruzzi intentionally artificially inflated the price of the May soybean future. An examination of the July futures price provides even stronger evidence of the manipulation of that contract. The next section considers this evidence.

C. The July, 1989 Soybean Futures Contract

1. The Behavior of the July Futures Price Relative to Deferred Futures Prices and Spot Prices

To evaluate whether the behavior of soybean prices during June and July, 1989, I estimate regressions for July futures like those for May futures described above. The regressions are estimated using a pooled data set of returns for the years 1982 through 1995. In each year, the data from 1 May through the end of trading of the July future are included. The residuals from regressions of July futures returns on September futures returns, July futures returns on November futures returns, July futures returns on CIL cash returns, and July returns on crush return returns, are examined to determine whether the July futures price rose relative to (1) deferred old crop and new crop futures prices, (2) the Central Illinois spot price, and (3) soybean product prices. As before, these models are estimated using OLS.

Figure 2 depicts cumulative residuals over the 1 May-20 July period. An examination of these residuals reveals a substantial rise in the July futures price (relative to the other prices considered) commencing immediately after the end of trading of the May soybean future. In the five trading day period starting 23 May and ending 30 May, the cumulative residual from the July-September regression equals 5.58 percent (t=3.83); the cumulative residual from the July-November regression equals 7.25 percent (t=4.23); the cumulative residual from the July-CIL spot regression equals 2.07 percent (t=1.95); and the residual from the July-crush portfolio equals 2.27 percent (t=1.88). The cumulative residuals remained positive and actually increased somewhat after the initial run-up; by 10 July, the November cumulative residual (cumulating beginning on 22 May) was 7.6 percent. The size ordering of the residuals is again consistent with manipulation.[37]

Residuals produced by a multiple regression of the July return on the September and November futures returns, the Central Illinois cash return, and the crush return imply that over the 23 May-30 May period the July price rose 3.20 percent more than one would expect given the movements in the control variables over this period. Assuming that the residuals are i.i.d. normal variates, the probability of observing 5 day July cumulative residual of 3.20 percent equals 9.57E-5. Thus, it is highly unlikely that the observed rise in the July relative price resulted from chance interaction of competitive forces. One can reject the hypothesis that the observed price relations are competitively determined in favor of the market power alternative.

As noted before, the probability reported in the prior paragraph is predicated on distributional assumptions that may be violated in practice. A non-parametric estimate of the density of 5 day July cumulative residuals implies that the probability of observing 3.20 percent cumulative residual is 4.39E-4. Thus, the conclusion that the run-up in July soybean futures prices relative to other soybean prices over this period was unusually large is robust to alternative means of estimating the relevant probability.

Other price movements during July, 1989 also provide evidence that the July futures price was above the competitive level. Consider the price response on 12 July to the announcement of the emergency liquidation which was made after the close of trading on 11 July. The residual implied by the July-September regression coefficients and the September futures return on 12 July equals -2.92 percent (t=-4.46). The residual implied by the July-November regression and the November futures return on 12 July equals -3.72 percent (t=-4.84). The residual implied by the July-Central Illinois regression and the Central Illinois spot return on 12 July equals -.87 percent (t=-1.82). Finally, the July-crush residual is -2.69 percent (t=-4.99).

The 12 July residual from the regression of the July return against the September, November, Central Illinois, and crush returns is –1.75 percent. Assuming that this residual is a normal variate implies that the probability of observing such large relative price change at random is extremely small, equaling only 4.09E-10.[38] A non-parametric estimate of the density of one day residual returns implies a probability of observing such a relative price move is only 8.01E-5.

The price response to the liquidation order is consistent with the hypothesis that the futures price prior to 11 July was artificially high because the liquidation order reduced the probability that Ferruzzi would be able to exercise market power in the July contract. (Alternative explanations are discussed--and rejected--in Section III.C.3 below.)

The relative price increases on 18-19 July are also consistent with the view that Ferruzzi could exercise market power. On 13 July, 1989 Ferruzzi filed suit requesting an injunction stopping the CBT's liquidation order. Although the firm's request was denied, there was some uncertainty regarding how Ferruzzi would behave during the liquidation period. News accounts from the 18th and 19th state that traders were concerned that Ferruzzi would defy the CBT. The cumulative residual implied by the July-September regression and the September futures returns on 18-19 July equals 5.75 percent (t=6.23). The cumulative residual implied by the July-November regression and the November futures returns on 18-19 July equals 6.89 percent (t=6.38). In addition, the cumulative residual implied by the July-Central regression and the 18-19 July Central Illinois spot returns equals 2.98 percent (t=4.43). Finally, the cumulative residual from the July-crush regression equals 3.12 percent (t=4.63). Moreover, on 18-19 July the July price rose 3.16 percent more than one would have expected conditional upon the September, November, spot, and crush returns on these dates. Assuming the independence and normality of the residuals, the p-value for a 3.16 percent 2 day cumulative residual is 5.85E-14. Based on the non-parametric estimate of the density of two day cumulative residuals, the p-value is 4.75E-15. Again, this evidence strongly suggests that Ferruzzi's position and market anticipations of the firm's actions, rather than exogenous competitive factors, were driving the July soybean futures price.

Finally, the relative price movement on 20 July is highly unlikely to have resulted from chance, and is instead consistent with the hypothesis that the July futures price was substantially affected by market power on the preceding days. By 20 July, Ferruzzi had complied with the liquidation order and sold almost all of its remaining position. In response to the termination of Ferruzzi's ability to demand additional deliveries, the July price collapsed relative to other prices. The residual implied by the July-September regression and the September return on 20 July equals -4.87 percent (*t*=-7.44). The residual implied by the July-November regression and the November return on 20 July equals -5.33 percent (*t*=-6.95). The residual implied by the July-Central Illinois regression and the Central Illinois spot return on 20 July equals -5.50 percent (*t*=-11.58). The July-crush residual is -8.50 percent (*t*=-15.77). The abnormal July return for 20 July implied by the regression of the July return on the September, November, Central Illinois, and crush returns is –6.38 percent (*t*=-22.9). This is by far the largest observed residual July price decline observed in the data set. Therefore, regardless of the method of estimating *p*-values (including non-parametric methods that do not make distributional assumptions), the probability of observing such a large negative July residual is effectively zero. One can therefore overwhelmingly reject the null hypothesis of competitive pricing in favor of the market power alternative.

This price collapse after the liquidation of the lion's share of Ferruzzi's position is a classic example of the "burying the corpse" phenomenon. The magnitude of the collapse provides a point estimate of the effect of market power on the July soybean price. Based on these residuals, one can infer that the July price was at least 5 percent above the competitive price.

In sum, the behavior of the July soybean price relative to the prices of deferred futures, soybean products, and non-deliverable soybeans is clearly consistent with the exercise of market power by a large long trader. The probability that the price movements documented above were produced by normal competitive forces is vanishingly small. The next section examines spot price relations. This analysis confirms that based on futures prices.

2. The Behavior of the Chicago Spot Price Relative to Prices in Other Markets

The Chicago spot price also exhibits substantial evidence of market power manipulation in June and July, 1989. Using the methodology described in section III.B.2, it can be shown that spot bids for soybeans by Chicago elevator operators rose relative to spot bids in the other markets studied commencing on around 20 June. From 20 June to 11 July, the Chicago spot price rose 4.70 percent relative to out-of-position soybean prices. This rise is highly significant; the *t*-statistic equals 2.75 (*p*-value=.00287). On July 12-14 the Chicago spot price fell 2.58 percent (*t*=-2.88, *p*-value=.0019) relative to non-deliverable prices. On 18-19 July, the Chicago spot price rose 3.48 percent (*t*=3.84, *p*-value=6.13E-5) percent relative to the other spot prices. On 20 July, the Chicago spot price fell 4.70 percent relative to non-deliverable spot prices (*t*=-4.83, *p*-value=6.71E-7). The price decline on 20 July is particularly revealing. The differences between the Chicago spot price and the New Orleans, St. Louis/southern Illinois River, Central Illinois, Eastern Iowa, Central Iowa, Western Iowa, Iowa barge loading terminals, Minneapolis, and Kansas City spot prices each fell by a larger amount on this date than on any other day in the sample period. Thus, the behavior of the Chicago spot price relative to non-deliverable spot prices in June and July, 1989 provides additional evidence of the influence of market power on soybean prices. The magnitudes of the price runup from 20 June to

11 July and the decline observed on 20 July suggests that the manipulative price distortion was approximately 5 percent.[39]

3. The Behavior of Shipments and Receipts in the Chicago Market in July and August

There is some evidence that (1) Chicago receipts were inflated in the last two weeks of July, (2) Chicago shipments were depressed in the last two weeks of July, (3) Chicago receipts were depressed in the first week of August, and (4) Chicago shipments were higher than expected in the first week of August. These patterns are consistent with the exercise of market power, but the abnormalities in the movements of soybeans to and from Chicago in July and August are less pronounced than those found in May and June. Specifically, in the two week period ending 28 July, receipts were .599 million bushels (t=1.44, p-value=.075) greater than predicted by (6) and shipments were .265 million bushels (t=-.64, p-value=.2610) less than predicted by (7). The probability of deviations of at least this size equals .0196. During the week of 4 August, Chicago receipts were .699 million bushels (t=-2.38, p-value=8.66E-3) less than predicted by (6) and shipments were .092 million bushels (t=.32, p-value=.374) more than predicted by (7). The probability of observing these deviations simultaneously equals .0032. The probability of observing this rise and fall (fall and rise) in receipts (shipments) equals 6.35 E-5. Thus, it is highly unlikely that this pattern resulted from a chance in a competitive market.

The anomalous behavior of soybean movements to and from the delivery market during July and August is less pronounced than occurred in May and despite the fact that price distortions in July appear more extreme than in May (although the deviations in shipments and receipts from their expected values are still statistically significant). This is most likely due to the emergency intervention. By law, trading of a futures contract stops 8 business days before the end of the delivery month. Operators of delivery facilities have the ability to load unit trains of soybeans in Iowa and Illinois and ship them to Chicago within a week. Therefore, they can wait until after the end of trading of a particular future before shipping additional supplies to the delivery point. The liquidation of the bulk of Ferruzzi's position by July 20 sharply reduced the need for these additional deliveries. As a result, it was unnecessary to distort commodity movements during late July and early August to the same degree as had occurred in May.

4. Alternative Explanations of Price Movements During July, 1989

The events examined in this article occurred in the year following the massive drought of 1988. As a result of the drought, stocks of soybeans were low (relative to historical averages) during 1989. Moreover, weather patterns the during early summer 1989 led some observers to fear another drought. However, beginning on 10 July, 1989, enough rain fell in the soybean belt to alleviate these fears, and government and private forecasts were predicting cooler, wetter weather patterns during the crucial pollinating period.

In order to rule out non-manipulative explanations of behavior of prices in June and July, 1989, it is necessary to examine whether the combination of weather-related news and low stocks can account for the rise in the July futures price in late May and in early July, the fall in the July futures price in the period surrounding the announcement of the emergency action on July 11, the rapid rise in the July price on 18 and 19 July, and the collapse in the price on 20 July.

There are several news stories (reported on the Dow Jones wire as well as several agricultural news services) in late the spring and early summer of 1989 that discuss or mention concerns of a renewed drought. This would explain a rise in the July soybean futures price, but cannot account for four phenomena documented in Section above: (1) the rise of the July (old crop) price relative to the November (new crop) price, (2) the rise of the July futures price relative to the September futures price, (3) the rise of July soybean price relative to the value of Central Illinois soybeans, and (4) the rise of Chicago spot soybean prices relative to spot prices in other markets. The rise in the July price relative to the November price is especially revealing. Drought related information affects market expectations regarding the size of the new crop. The release of information relating to the size of the new crop should have a larger effect on the price of new crop futures prices than on old crop prices.[40] Specifically, the increased probability of drought should raise both old crop (July) and new crop (November) futures prices, but new crop prices should rise more than old crop prices. The intuition behind this result is straightforward. When the expected size of the new crop declines, it is desirable to increase carryover of the old crop in order to satisfy future consumption needs. That is, current consumption should fall and the amount kept in storage should rise. It is necessary to increase the rewards to storage to induce this response from competitive market participants. A rise in new crop prices relative to old crop prices increases the profitability of storage and thereby induces the efficient response. Similarly, in order to induce market participants to store rather than consume soybeans in the remainder of the old crop year, the September futures price must rise relative to the July futures price. Thus, the observed rise in the July price *relative to* the September and November soybean prices is inconsistent with an increased probability of drought. Indeed, conditional upon this news, one would have expected a *fall* in the July price (relative to later futures prices). The observed rise in the July price (relative to these deferred prices) therefore *underestimates* any manipulative price distortion resulting from Ferruzzi's activities.

Weather related information cannot explain the rise in Chicago prices relative to prices elsewhere either. The price in Chicago should rise relative to prices in other locations if and only if it is desirable to attract additional stocks of soybeans to the city. Chicago serves primarily as a residual storage location that absorbs stocks of soybeans in the Autumn, and then releases these soybeans to exporters as the crop year progresses. There are no processors of soybeans in Chicago. Moreover, in 1989 most remaining stocks of soybeans in Iowa (which had the largest stocks in the country) were far closer to the processors and the Mississippi export route than is Chicago. Thus, if adverse weather shocks made it desirable to carry over stocks of soybeans for longer periods, it was more efficient to store these stocks in Iowa (or other Midwestern locations) than to move them to Chicago. As a consequence, there was no need for the relative price in Chicago to rise to attract soybeans to that point.

Similar results obtain for the other price moves already documented; they cannot be attributed to the weather. The price decline of 12 July is particularly informative. On 10 July through 12 July, the news wires and agricultural news services reported (1) rainfall throughout the soybean growing region, and (2) changes in government and private weather forecasts predicting cooler, rainy weather in place of hot, dry conditions. This information indeed alleviated drought fears to a considerable degree, and the prices of the entire soybean complex fell on 10 July-12 July. What is important to note, however, is that on 12 July the July price fell by more than one would expect conditional upon the observed movements in the September and November futures prices and the Central Illinois cash price. Information leading to an upward revision in the size of the impending harvest would have the exact opposite effect. New crop prices should be affected more acutely by new crop-related information than old crop prices. Anticipation of a larger harvest reduces the benefits of carrying stocks of soybeans until or through the harvest. A *rise* in the nearby (that is, July) price relative to deferred prices (that is, November or September) induces the required supply and consumption responses. Therefore, the observed *fall* in the July soybean futures price on 12 July relative to the prices of November and September beans is inconsistent with the weather-based explanation. Given the news of rain, one would expect the residuals from the July-September and July-November regressions to be positive, rather than negative. Thus, the observed negative residual *understates* the market's response to the liquidation order alone, as this response is confounded by the response to the weather related news.

Ferruzzi also argued that a dock strike in Brazil during June raised the demand for US soybeans and therefore caused the increase in the July futures price. This argument fails to explain salient relative price movements. In particular, it fails to explain why the Chicago price rose relative to prices at other export points (most notably NOLA and river locations tributary to NOLA). Indeed, given that NOLA is the major export point for US soybeans, the dock strike should have caused the NOLA price to rise relative to Chicago, rather than the reverse.

5. Alternative Explanations of Ferruzzi's Actions

In news releases made in July and August of 1989, and in subsequent statements in the press, Ferruzzi offers alternative explanations for its conduct. In particular, it argues that its position in July soybean futures, and its large holdings of deliverable soybeans were legitimate commercial activities. The firm claims that it was holding beans and bean futures to ensure that it had access to supplies for its soybean processing plants and its export business (especially with the Soviets). An examination of the “delivery economics” implied by price relations and Ferruzzi’s behavior makes these claims untenable.

In particular, it is abundantly clear that #2 soybeans in Chicago were not the lowest cost source of soybeans for Ferruzzi’s processing and exporting activities in early-to-mid July, 1989. Consider the viability of using deliverable soybeans for export via the Gulf (the primary export point for US grains and oilseeds). During the 1984-1989 period, the price of #1 soybeans (the standard quality on export contracts) for Gulf delivery averaged 30 cents/bu over the price of #1 soybeans in Chicago. On 11 July, 1989, the price of Gulf soybeans was only 5 cents/bu above the July soybean futures price. On 19 July, the July futures price exceeded the Gulf price by 1 cent. In addition to paying the futures price to obtain beans in Chicago, in order to market these soybeans in the Gulf Ferruzzi would have had to incur other costs. On 11 July, the cost of barge freight from Chicago to the Gulf was 21.5 cents per bushel. Moreover, a long taking delivery would also have had to pay 6 cents per bushel to load out beans from a Chicago warehouse onto a barge for shipment down the Illinois and Mississippi rivers. Since the par grade for soybeans deliverable against CBT contracts is #2, but the standard grade for Gulf delivery is #1, Ferruzzi would have incurred approximately 6 cents/bu in cost above the July futures to reflect the grade differential. Finally, Ferruzzi would have had to pay approximately 3 cents per bushel for weighing, stevedoring, and interest and storage prior to loadout to execute July bean receipts for Gulf delivery. Thus, the total costs of acquiring soybeans via delivery and shipping them to New Orleans would have exceeded the cost of buying soybeans in barges already in the Gulf by between 31.5 cents/bu (on 11 July) and 37.5 cents/bu (on 19 July). Similarly, the firm could have acquired soybeans in St. Louis for between 18 cents/bu and 20.5 cents/bu less than the Chicago futures price in July, 1989, and at Central Iowa Mississippi River points for between 19 and 21 cents less than the July futures price. Since barge freight costs, load-out costs, and grade differential costs would have been smaller for beans acquired at these river points than for beans acquired via delivery in Chicago, standing for delivery of soybeans in Chicago did not minimize the costs of acquiring soybeans for export via the Gulf. Indeed, the firm would have paid about 5 percent more than necessary to execute delivery receipts for export. Thus, if Ferruzzi were in fact a price taker in the Chicago market, it would have filled its export orders more economically by (1) selling soybean futures and (2) buying beans in the Gulf.

A similar analysis obtains for domestic processing. Ferruzzi's subsidiary, Central Soya, has processing plants in Central Illinois (Gibson City) and Central Indiana (Decatur). On 10 July, Central Soya was bidding 9.75 cents/bu above the July futures price for delivery of beans at its Decatur facility and 15 cents/bu *below* the July future for delivery of beans at Gibson City. On 19 July, Central Soya was bidding only 2.5 cents/bu above the July futures price in Decatur. However, Ferruzzi would also have had to pay loadout, weighing, interest, storage, freight, and grade upgrade costs of approximately 40 cents/bu to transport and transform deliverable beans for processing in its plants. Thus, given the futures prices in July, 1989, to take delivery against CBT contracts and ship the beans thus obtained to Decatur, IN cost between 30.25 cents/bu and 37.5 cents/bu more than Ferruzzi was willing to pay for locally procured soybeans. These differences are on the order of 5 percent of the Decatur price. Therefore, the argument that Chicago warehouse receipts were an economical source of raw material for its processing facilities is clearly implausible.[41]

Ferruzzi has also argued that given the drought-reduced stocks of soybeans, it was prudent for the firm to hold large stocks of deliverable beans to ensure that it had enough soybeans to operate its plants continuously until the harvest of the new crop. As noted above, given the very high prices of July soybeans, it would have been cheaper to acquire soybeans in the country near its plants rather than to acquire them via delivery at the July futures price. Moreover, Ferruzzi's high market share of warehouse receipts and July futures demonstrates that the firm's strategy differed dramatically from the strategies employed by other processors and exporters such as ADM, Cargill, Continental, Dreyfus, or Bunge. Ferruzzi held a substantial portion of the deliverable soybeans. Ferruzzi's share of the long futures open interest also equaled 59 percent on 11 July; the next two largest longs accounted for only 6.5 percent of the open interest, and the largest commercial (other than Ferruzzi) held a net long position equal to .5 percent of the open interest.[42] These facts raise the question: if amassing claims on deliverable stocks was a prudent response to anticipated shortages of soybeans, why was Ferruzzi the only firm that resorted to this strategy? The stark difference between Ferruzzi's actions and those of other exporting and processing firms undermines the credibility of the argument that the firm's actions were routine response of a commercial firm to a problem common to all market participants--the small supply of available soybeans due to the 1988 drought. In addition, there is no evidence that Ferruzzi had fixed price sales of oil and meal even approximating the size of their futures position; only fixed price ("flat price" in trade vernacular) sales impose price risk on a firm. This implies that the long soybean position *increased* the price risk the firm faced, rather than serving to off-set short flat price risk in soy products. This is inconsistent with a hedging rationale for Ferruzzi's actions.[43]

Moreover, the difference between the value of processed soybeans implied by the futures prices of oil and meal and the value of unprocessed soybeans was extremely small during July, 1989. During the 1969-1989 period, the difference between the value of the July crush portfolio and the price of July soybean futures (the "Board processing margin") averaged 4.3 percent of the value of the crush portfolio. On 10 July, 1989, however, the processing margin equaled only .5 percent of the value of the crush portfolio. It was therefore atypically unprofitable to process delivered soybeans during the period of the alleged manipulation. This further undermines the contention that acquiring deliverable soybeans was a prudent act for a processor during July, 1989.

Altogether, Ferruzzi's actions are not consistent with the hypothesis that during July, 1989 the firm was a price taker attempting to minimize the cost of acquiring soybeans to satisfy its export and processing requirements. A price taker would have achieved Ferruzzi's purported goals at lower cost by selling expiring soybean futures and buying soybeans at non-deliverable locations or buying futures for deferred delivery. Instead, the firm's actions are consistent with an attempt to exercise market power. A manipulator would rationally stand for delivery of soybeans in Chicago at prices that exceed prices at non-deliverable locations because completion of a manipulation requires the long to demand enough deliveries so as to raise the price in the delivery location relative to both the competitive price in that market, and prices in other markets. Thus, this behavior provides strong evidence of specific intent to exercise market power.

It has also been argued that Ferruzzi could not have exercised market power because there were large stocks of soybeans within ready transport distance of Chicago. Geographic proximity does not imply that it was efficient to transport these soybeans to Chicago, however. If it was economically efficient to ship some of these soybeans elsewhere, or to continue to store them in their present locations, rather than to send them to Chicago, the marginal cost of shipping them to Chicago would have exceeded the competitive price in Chicago. Moreover, since shorts would have had to obtain soybeans from progressively less economical sources, if these conditions had existed, Ferruzzi would have faced a downward sloping demand curve for the futures contracts it held; that is, Ferruzzi would have possessed market power. Thus, the relevant question is not whether soybeans were geographically proximate to Chicago, but whether they were *economically* proximate; these two concepts are not equivalent in a spatial market.[44] The observed rise in the relative spot price in Chicago during both May and July, the decline in this relative price after Ferruzzi's liquidations in these months, and the observed behavior in shipments and receipts during these months, are consistent with the hypothesis that it was uneconomical to ship additional soybeans into Chicago then despite the apparent nearness of supplies. Indeed, Iowa was the largest reservoir of soybeans in early summer 1989. On 1 June, 1989, prices at the points in Iowa closest to Chicago (on the Mississippi) were 2 to 5 cents above Chicago prices. As late as 14 June, before the Chicago spot price rose dramatically relative to prices in other locations, eastern Iowa prices were 1.5 to 2.5 cents above Chicago prices. Since it was also necessary to incur rail costs to ship soybeans from these river points to Chicago, Iowa was not an economical source of soybeans for Chicago through mid-June.[45]

The existence of a “backwardation” in Chicago is also inconsistent with the assertion that soybeans held in other locations were supplied elastically to the Chicago market. A backwardation exists when the futures price for immediate delivery exceeds the futures price for later delivery (net of storage costs). The soybean market was in a pronounced backwardation in July, 1989; the July price exceeded the price for August delivery. The theory of storage implies that the cost of supplying the marginal bushel of soybeans to the delivery market is at least as large as one-half the backwardation.[46] The July-August storage-cost-adjusted backwardation in July, 1989 was approximately 50 cents per bushel, indicating that the cost of shipping the *marginal* bushel of soybeans to Chicago from elsewhere was approximately 25 cents per bushel; additional bushels would have been even costlier to ship. (Note that 25 cents is approximately the level of artificiality implied by the spot price and futures price analysis presented above.) This implies that it was costly to obtain soybeans outside of Chicago and ship them to the delivery market; therefore, the existence of large supplies outside of Chicago does not imply that Ferruzzi was powerless to corner the market. The spatial segmentation of the soybean market reflected in the large backwardation created the conditions in which a large long could have exercised market power.

D. Conclusions

The data analyzed herein reject decisively the null hypothesis that Ferruzzi, SA was acting as a price taker on the May and July 1989 soybean futures contracts in favor of the alternative that the firm exercised market power. Moreover, alternative non-manipulative explanations for (1) price movements during this period and (2) Ferruzzi's actions cannot withstand scrutiny. The point estimates imply that the price distortion resulting from Ferruzzi's actions was approximately 5 percent in the May contract and as much as 10 percent in the July contract.

This analysis demonstrates that it is possible to use economic theory to devise refutable hypotheses regarding the exercise of market power in commodity markets, and then use standard empirical techniques to test these hypotheses. In the Ferruzzi case, the results are striking. Standard statistical techniques detect price and quantity movements that are symptomatic of manipulation. Moreover, these price and quantity movements were highly unlikely to have been observed by chance. This conclusion is robust to the method used to calculate the relevant *p*-values, so the results are not dependent on distributional assumptions. Finally, examination of Ferruzzi's behavior and market conditions prevailing at the time (1) rules out non-manipulative explanations of these price movements, and (2) provides evidence of Ferruzzi's specific intent to manipulate the market. Moreover, these disparate analyses reinforce each other. All tell a consistent story, namely, that prices were manipulated during July of 1989 by Ferruzzi, SA.

IV. SUMMARY AND CONCLUSIONS

This article analyzes the anti-manipulation component of US commodity law through the lens of a particular case--the alleged Ferruzzi manipulation of soybean futures in 1989. Building on a foundation of the economic theory of market power in futures markets, I derive several refutable hypotheses about the behavior of prices and quantities during a manipulation. I then employ these tests to soybean price and quantity relations in May and July 1989. These tests imply that one can reject with extremely high probabilities the null hypothesis that Ferruzzi acted as a competitive firm during these delivery months.

Although the analysis in this article focuses on a single alleged manipulation, similar methods can be employed to study other episodes such as the alleged 2 year Treasury note squeeze in 1992, and the alleged Sumitomo copper corner in 1995. Implementation details will differ depending on the nature of available data and the specific trading mechanisms involved, but the basic method of testing for relative price and quantity movements for evidence of manipulation is generally applicable.

The methods employed herein rely extensively on analysis of historical data. It should be recognized that exceptional events that disrupt financial markets (such as the Russian default of 1998) can occur, and that using historical data to estimate the probability that a particular futures was manipulated during such a period is problematic, though not impossible. However, such extreme events are (almost by definition) quite rare, and therefore they seldom compromise the utility of the methods I employ. Furthermore, historical price data need not be examined in a vacuum; one can determine whether price and quantity movements during an alleged manipulation were attributable to some other cause, as I do in section III.C.4 above. Furthermore, an analysis of the delivery economics (analyzed in section III.C.5) is not predicated on historical price data, but instead relies solely on contemporaneous price relations to determine intent of the alleged manipulator. A finding that it was costlier to obtain supplies via delivery than through other means bolsters evidence of price distortions symptomatic of manipulation derived from historical comparisons. Thus, I do not advocate a mechanical implementation of statistical tests to find manipulation. The statistical tests provide a rigorous framework that can--and should--be augmented with other economic analysis to determine whether a manipulation has occurred.

These results suggest that the existing regulatory framework in US commodity futures markets is inefficient. Court and regulatory decisions have undermined the efficacy of ex post deterrence that could rely on tests like those employed here. Instead, US regulators and exchanges rely upon preventative measures to reduce the frequency of manipulation. Since the results of this article show that it is possible to use statistical methods to detect manipulation ex post, harm-based deterrence is likely less costly and more powerful than preventive alternatives. Therefore, the existing regulatory framework is almost the exact opposite of the efficient one.

[1] The Commodity Exchange Act, 7 U.S.C. Section 9 of the CEA makes manipulation or attempted manipulation a felony. Section 5 requires exchanges to prevent "the manipulation or cornering of any commodity." The CEA also proscribes the spreading of false reports as manipulative.

[2] Stephen Craig Pirrong, Manipulation of the Commodity Futures Market Delivery Process, 66 J. of Bus. 335 (1993) ("Delivery Process" hereafter). Stephen Craig Pirrong, Mixed Manipulation Strategies in Commodity Futures Markets, 15 J. of Futures Markets 13 (1995) ("Mixed Manipulation" hereafter).

[3] Steven Shavell, The Optimal Structure of Law Enforcement, 36 J. of Law and Econ. 255 (1993).

[4] In re Indiana Farm Bureau Cooperative Association, [1982-84 Transfer Binder] Commodity Futures L. Rep. (CCH) 21,796 (CFTC 1982), In re Cox, [1985-1987 Transfer Binder] Commodity Futures L. Rep (CCH) 23,786 (CFTC 1987).

[5] In re Abrams, 2 Commodity Futures L. Rep. (CCH) 24,408 (CFTC 1989).

[6] In re Indiana Farm Bureau, *supra* note 4, at 27,288 n. 2.

[7] See especially, Daniel Fischel and David Ross, Should the Law Prohibit Manipulation in Financial Markets, 105 Harvard L. Rev. 503 (1991); Wendy Collins Perdue, Manipulation of Futures Markets: Redefining the Offense, 56 Fordham L. Rev. 345 (1987); Edward T. McDermott, Defining Manipulation in Commodity Futures Trading: The Futures "Squeeze," 74 NW. U. Law. Rev 202 (1979); and Robert C. Lower, Disruptions of the Futures Markets: A Comment on Dealing with Market Manipulation, 8 Yale J. on Reg. 391 (1991).

[8] Jerry Markham, Manipulation: The Unprosecutable Crime, 8 Yale J. on Reg. 281 (1991).

[9] Frank Easterbrook, Monopoly, Manipulation, and the Regulation of Futures Markets, 59 J. of Bus. S103 (1986); Stephen Craig Pirrong, Commodity Market Manipulation Law: A (Very) Critical Appraisal and a Proposed Alternative, 51 Washington and Lee L. Rev. 945 (1994); Holbrook Working, Price Relations Between May and New Crop Wheat Futures at Chicago since 1885, 10 Wheat Studies 183 (1934).

[10] Pirrong, *supra* note 9, at 995-1000. Kenneth Cone, Review of Grain Futures Contracts: An Economic Appraisal, 32 J. of Econ. Lit. 1893 (1994) also criticizes the lack of rigorous analysis of data pertaining to specific manipulations.

[11] Pirrong, *supra* note 9.

[12] It is possible that the distortion may not be largest immediately before liquidation because fundamental factors can influence the degree of market power a large long possesses. For example, a reduction in demand for the commodity at other locations makes the delivery market supply curve more elastic, which reduces the monopoly price.

A related testable implication is suggested by the supply of storage curve. This curve relates the spread between futures prices of different maturities and the contemporary level of inventories of the commodity. Specifically, in a competitive market the spread between a deferred futures price and an expiring futures price (net of interest and warehousing costs) is an increasing, concave function of inventories. The supply of storage curve has been analyzed by Working, The Theory of the Inverse Carrying Charge in Futures Markets, 39 J. Farm Econ. 1 (1948), Telser, Futures Trading and the Storage of Cotton and Wheat, 66 J. Pol. Econ. 233 (1958), Williams, The Economic Function of Futures Markets (1986), and Wright and Williams, Storage and Commodity Markets (1991). In a manipulation, the observed spread-inventory pair should lie substantially below the supply of storage curve. In both May and July, 1989, the spread is extremely wide for the level of stocks in the market, when compared to years 1974-1988. These results are not especially clear-cut, however, because the data from the soybean market for the years 1974-1988 do not conform closely to the predictions of the supply of storage theory. Nonetheless, for the months studied they stocks-spread relation is consistent with the exercise of market power. For example, adjusting for warehousing and interest costs, the July-August spread in early July, 1989 was 35 cents/bu. Stocks in Chicago at this time were 9.24 million bushels. In the 6 years in the 1974-1988 period in which Chicago stocks were in excess of 9 million bushels, the average adjusted July-August spread was 3.7 cents. Similarly, in July, 1989 the adjusted July-September spread was 81 cents; in other years when Chicago stocks exceed 9 million bushels, this spread averaged 17.4 cents. The July-November spread in July, 1989 was 113.9 cents per bushel; in earlier years when stocks were of a comparable magnitude, this spread averaged 34 cents. Thus, there is evidence that futures calendar spreads were very wide given the magnitude of stocks held in the market. This is consistent with manipulation.

[13] Marginal costs of delivery are typically increasing for "spatial commodities;" that is, commodities which are (1) produced and consumed over a wide geographical area, and (2) costly to transport. Examples of such goods include grains and industrial metals. The marginal cost of delivery is increasing for such commodities because it is necessary to acquire additional supplies from progressively less economical locations. Manipulation is not limited to spatial commodities, however. Any transaction cost which makes it costly to increase deliverable supply can facilitate manipulation. Thus, a corner may occur in a financial market, although the conditions in such markets are typically less conducive to manipulation than is the case in physical commodity markets.

[14] The post-manipulation spot price is below the no-manipulation spot price because the corner increases supplies in the delivery market.

[15] This phrase is attributed to the noted grain trader and meat magnate P. D. Armour. He was once asked whether it was easy to manipulate the market. Armour replied that the manipulator faced the same problem as a murderer: "It is easy to commit the murder, but difficult indeed to dispose of the corpse." That is, it is easy to drive the price up by buying huge quantities, but hard to sell what you buy at a profit.

[16] Easterbrook, *supra* note 9, at S107 also argues that the price and quantity effects of manipulation are distinctive. For an alternative view, see Fischel and Ross, *supra* note 7.

[17] A systemic shock is one that affects all markets in common in a similar fashion. That is, a systemic shock is not concentrated in the delivery market alone.

[18] Unless, of course, one was willing to believe that the export boom collapsed on a single day which just happened to correspond with the expiration of a futures contract.

[19] Testimony of Kalo A. Hineman, Commissioner, Commodity Futures Trading Commission, Before the Committee on Agriculture, Nutrition, and Forestry of the United States Senate, 8 September, 1989.

[20] *Id.*

[21] A farmers group sued the CBT for its actions. American Agricultural Movement v. Chicago Board of Trade, 977 F.2d 1147 (7th Circuit, 1992).

[22] US exchanges use a letter code to indicate delivery month. For example, letter K indicates May contracts, letter N indicates July contracts, letter U stands for September, and letter X indicates November contracts.

[23] Kenneth French, Detecting Spot Price Forecasts in Futures Prices, 59 J. of Bus. S39 (1986), shows that the elasticity of one futures price with respect to another futures price may depend upon the spread between these prices. In order to capture this possibility, I also regressed the May log price change against the September log price change and another variable equal to the product of the September log price change and the spread between September and May prices. This new interaction term allows the elasticity of the May price with respect to the September price to depend upon the spread as theory suggests. Similar regressions were estimated for November futures and Central Illinois spot. All of the results reported in the main text hold using the projected residuals from these alternative regression specifications.

Since the Central Illinois price is a bid price, rather than a transaction price, it is plausible that it is a noisy estimate of the true price. If so, using the Central Illinois return as the independent variable could provide biased coefficient estimates. To address this possibility, a reverse regression was also estimated. For the 1982-1989 sample period, a comparison of the original and reverse regressions reveals little evidence of an error in variables problem. Moreover, the estimated inflation in the Chicago spot price relative to the Central Illinois price differs little between the two specifications. Therefore, for clarity all Central Illinois residuals are estimated from the model with the Central Illinois return on the right-hand-side. The same is true for the July models estimated in Section III.C.

[24] Jorion states that “historical data display fatter tails than in normal distributions,” and that bootstrap methods of this sort are “ideally suited” to “capture fat tails.” Philippe Jorion, Value at Risk 239 (1997). The density is produced by a Rosenblatt-Parzen kernel estimator using a Gaussian kernel. The bandwidth is calculated using Silverman’s formula. For details, see Adrian Pagan and Aman Ullah, Nonparametric Economics ch. 2 (1999).

[25] The sample standard deviation of the 5 day cumulative residuals in the bootstrap sample is used to make this calculation. The estimated probability of observing the 2.83 percent cumulative runup is on the order of 1E-50.

[26] An earlier draft of this article presented results based on spot price data from five markets for the 1984-1989 period. The results based on that data set are almost identical to those presented in the text.

[27] This methodology is employed in Victor Ng and Stephen Craig Pirrong, Fundamentals and Volatility: Storage, Spreads, and the Dynamics of Metals Prices, 67 J. of Business 203 (1994) and Stephen Craig Pirrong, Metallgesellschaft: A Prudent Hedger Ruined, or a Wildcatter on NYMEX?, 17 J. of Futures Markets 543 (1997).

[28] All of the reported *p*-values are for the relevant one-tailed tests.

[29] Pirrong, *supra* note 2, at 347-348.

[30] The Chicago spot bid fell substantially relative to the bids in St. Louis, NOLA, and Iowa after the end of trading of the May contract; in the 19 May-25 May period, the Chicago price fell over 20 cents relative to the prices at these other locations. However, the price in Chicago did not fall substantially relative to the price in Central Illinois. There is some evidence to support the view that there was concern about further trouble in the July contract. Specifically, by May 30 (and continuing through 11 July) several country elevators set their bids to buy soybeans based off of the November futures price. This is highly unusual behavior (as bids are usually based on the next-to-expire futures price).

[31] The model was also estimated over the 1973-1989 period. The shorter time period was chosen because the last soybean processor in Chicago ceased operation in 1982. Moreover, the Staggers Act of 1981 eliminated the through-rate privilege for Chicago storage. Prior to the Act's passage, a firm that shipped grain via rail to Chicago, stored it, and then shipped it via rail to some other point paid the lower through rail rate rather than the sum of two point-to-point rates. In 1982, the CFTC approved a CBT proposal to eliminate the exchange's requirement that warehouse receipts include this through-rate privilege. The elimination of this feature from rail pricing made it less attractive to ship grain to Chicago for storage. These developments changed the nature of the Chicago cash soybean market. Results based on the longer sample period are very close to those reported. Moreover, I experimented with different lag lengths on shipments and receipts, and with including lagged shipments (receipts) in the receipts (shipments) equation. The coefficients on the longer lags, and on lagged shipments (receipts) in the receipt (shipment) equations are jointly statistically insignificant, so I omit them. Again, manipulation hypothesis test results are robust to these specifications. Finally, since it is possible that shipments and receipts are subject to common, unobserved shocks, I also estimated the model using GLS-SURM. Since the correlation between residuals is around .003, common shocks are unimportant. As a result, I base hypothesis tests on OLS estimates of (6) and (7).

[32] The pattern of soybean movements during this period was also highly unusual, and symptomatic of a distortion of commodity flows consistent with the exercise of market power. For instance, operators of Chicago warehouses eligible for delivery against CBT soybean futures contracts barged grain *up* the Illinois River *to* Chicago; normally, virtually all Illinois River traffic in soybeans (and grains) travels downriver towards the Mississippi. Chicago warehouses are frequently the origination point for barges of soybeans, but almost never the destination for them. During the same period, barges were shipped from Chicago down the Illinois. Thus, barges were moved upriver to Chicago, unloaded into delivery warehouses, reloaded into barges, and shipped downriver virtually simultaneously!

[33] The *p*-values are based on the assumption that the relevant residuals are normally distributed. *P*-values based on a non-parametric density estimator are slightly larger than those reported in the main text, but even then the probability of observing such a pattern of movements in stocks is vanishingly small.

[34] The CEA makes it clear that one of its clear antimanipulation objectives is to reduce distortions in commodity flows. § 5a requires exchanges to choose delivery points and delivery differentials to prevent such disruptions.

[35] Letter dated May 16, 1989 from CFTC to Colm Cronin, Ferruzzi USA. Attached as appendix 7 to Heineman testimony, *supra* note 19. Chicago Board of Trade, Emergency Action, July 1989 Soybeans: The Story Behind the Action, 11 (1989).

[36] Pirrong, *supra* note 9, at 1008-1010.

[37] July soybeans also rose in price by a statistically significant amount relative to August soybeans. Ferruzzi was also a buyer of August soybean futures, and there were considerable concerns that the firm would squeeze that contract too. Thus, the increase in the July-August spread underestimates the effect of Ferruzzi on the July contract alone.

[38] There were allegations that news of the liquidation order leaked prior to the close of trading on 11 July. Bruce Ingersoll, As Congress Returns, Will CFTC Feel the Squeeze on Soybean Flap?, Wall St. J., Aug. 22, 1989 and C1. Scott Kilman and Sue Shellenbarger, Soybeans Sink as CBOT Acts to Avoid Squeeze, Wall St. J. July 13, 1989, at C1. There is some evidence consistent with these assertions. The residuals on 11 July were -1.10 percent (July-September regression), -1.50 percent (July-November regression), -.57 percent (Central Illinois-July regression). The 11 July residual from the regression of the July return on the September, November, Central Illinois, and crush returns is -.5 percent. The *p*-value for this return (based on the more conservative non-parametric density estimate) is .03.

[39] There are two conflicting source of bias involved in using the 4.5 percent price decline on 20 July as a measure of the price distortion. First, recall that a manipulation raises both the delivery market price and non-delivery market prices, although the former rises by a larger amount than the later. The end of a manipulation causes both prices to fall. Thus, for this reason, the decline in the Chicago price relative to prices in other markets is an underestimate of how far market power drove the Chicago price above the competitive level. Second, due to the inflation in deliverable stocks caused by the artificially high price in Chicago, the competitive price after a manipulation is lower than the competitive price would have been in the absence of a manipulation. This implies that the post-manipulation decline is larger than the manipulation-induced inflation in the Chicago price.

[40] Kenneth French, *supra* note 23. It is also possible to demonstrate this result in the context of a different model of commodity price spreads. Specifically, the model of Jose Scheinkman and Jack Schectman, A Simple Competitive Model With Production and Storage, 50 Rev. Econ. Stud 427 (1983) makes the same prediction. The Scheinkman-Schectman theory is based on the solution of an intertemporal optimization problem in a model with production risk and storage, whereas the French model is based on the concept of the convenience yield.

[41] Information on Central Soya's bidding activity and execution costs obtained from Chicago Board of Trade, *supra* note 35, at 13-15, and Keith Schap and Charles Flory, Ferruzzi vs. the CBOT: Who is Right, 9 Futures Magazine, 16-18 (September, 1989).

[42] Hineman, *supra* note 19.

[43] This increase in risk was substantial. Without its long futures position, Central Soya's risk was limited to the variability in the crush spread (i.e., its processing margin). With the long futures position, it bore flat price risk. The crush portfolio regressions reported earlier imply that the correlation between changes in the crush portfolio value and changes in the price of July soybean futures is approximately .95. Thus, the variance of the daily change of the difference between the value of the crush portfolio and the price of July soybeans is one-tenth of the variance of the daily change in the price of July soybeans (1-.(.95)(.95)). This implies that the July soybean position was approximately 10 times as risky as the crush spread. If it was concerned about extreme price rises, the firm could have bought out of the money soybean calls. This would have given the firm protection against price increases without exposing it to substantial risk on the downside, as the strategy the firm actually followed did.

[44] Locations A and B are economically proximate if the price in market A is equal to the price in market B plus transport and handling costs. Unless the commodity flows from A to B in a competitive equilibrium, A and B are not economically proximate even if they are geographically close. Also note that this "economic metric" is not symmetric: if A is proximate to B, then B cannot be proximate to A. There is also a temporal dimension that must be considered. If the marginal cost of increasing the rate of flow between B and A is increasing, then even if A and B are economically proximate, the supply curve for deliveries at A from B is upward sloping. This upward sloping supply curve translates into a downward sloping demand curve for the holder of a large long futures position in a contract requiring delivery at A. That is, a large long can exercise market power by forcing an acceleration of commodity flows as well as distorting their direction.

[45] It should be noted that this implies that the marginal cost of delivering the first bushel of soybeans from Iowa exceeded the futures price. Since in a spatial market the supply curve for Iowa soybeans (delivered to Chicago) is upward sloping, this implies that attracting soybeans from Iowa for delivery to Chicago would have necessitated a distortion in commodity flows. Further analysis supports this conclusion. Even if Iowa was the most economical source of soybeans for Ferruzzi/Central Soya uses, the firm incurred additional costs to obtain these soybeans through delivery on futures as opposed to acquiring them via cash market channels. Movement through Chicago required 2 additional handlings--loading

from railcars into a delivery elevator, and loading from a delivery elevator into railcars. This involved a cost of at least 6 cents. Ferruzzi would have had to pay grade upgrades as well. Furthermore, shipment distance from Iowa to Central Illinois or Central Indiana via Chicago is greater than shipment distance direct from Iowa to the latter locations. Thus, it would have been cheaper to obtain Iowa beans direct in order to supply Central Soya's crushing needs. It is clearly inane for a firm desiring to minimize costs to ship beans from a point on the Mississippi (e.g., Davenport, IA) to Chicago and then down the Illinois and Mississippi to the Gulf. Thus, even if it were necessary for Ferruzzi to obtain Iowa soybeans for its processing and export requirements, it was clearly inefficient to obtain these soybeans via the delivery process.

[46] Williams and Wright, *supra* note 12 at ch. 9.