Causality Tests Between the S&P 500 Cash and Futures Markets

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Abstract

This study examines whether the S&P 500 index cash and futures markets are causally related in the statistical sense of Granger (1969). Intraday minute-by-minute returns were examined over the period August to December 1987. A two stage filter technique was employed to reduce the raw returns to white noise and eliminate any autocorrelation in the regression residuals. Given the nonsynchronous trading in the index and the use of intraday data, this could be a serious problem that may invalidate any statistical inferences. The findings indicate a strong causal relationship, with the futures leading the cash. Different filtering mechanisms were explored that yielded similar results.

Introduction

Since the introduction of the Standard & Poor's (S&P) 500 index futures contract in April 1982, attention has focused on its relationship to the S&P cash (spot) index. Initial interest concentrated on the relative pricing between the two markets given arbitrage considerations. Modest and Sundaresan (1983) found that the prices in these two markets traded within acceptable ranges, given transactions costs and appropriate constraints on trading.

Subsequently, attention has focused on the increasing volatility in these markets. For example, Edwards (1988) found that the S&P 500 cash market volatility declined after 1982 when the futures contract was introduced. Aggarwal (1988) examined the S&P 500, Dow Jones Industrial Average (DJIA), and over-the-counter (OTC) indexes from 1982 to 1987 and found that volatility has increased for all of the indexes since the phenomenon of index arbitrage trading became important. Aggarwal, however, found that the S&P 500 index volatility declined relative to the OTC index volatility.

Conversely, Grossman (1988), using daily observations over a ten month period in 1987, found no relationship between stock market volatility and program trading on the New York Stock Exchange (NYSE). Theoretical support for these findings comes from Grossman (1988), who demonstrated that the

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futures markets provide additional information to the marketplace that cannot be observed through the use of synthetic trading strategies that simulate the derivative contracts. Therefore, real futures contracts should increase market efficiency and make the markets less volatile than is possible by synthetic trading strategies. In related work, Harris, Sofianos, and Shapiro (1990) found negligible intraday price movements in the S&P 500 index surrounding large (averaging $9 million each) program trades during the month of June 1989.

Recently, work has focused on the causal relationship between the S&P 500 cash and futures markets. In a study of the related Major Market Index (MMI), Finnerty and Park (1987) provide evidence that stock index futures price changes are correlated with the stock index cash price changes (i.e., "the tail wags the dog"). As noted by Gordon, Moriarty, and Tosini (1987) and confirmed by Finnerty and Park (1987), however, Finnerty and Park (1987) only report unidirectional results and never claim any evidence for a causal relationship. More recently, Kawaller, Koch, and Koch (1987), using intraday price data, found that the S&P 500 futures price movements consistently lead the index movements by 20 to 45 minutes. The cash movements, however, rarely lead the futures price movements. Therefore, they conclude that futures markets provide price discovery. They also note that their methodology does test Granger causality, except for the fact that they include lag zero coefficients.

In spite of the careful work that has been reported to date, causality tests possess one potentially serious flaw that has been recognized for some time. The S&P 500 cash index is an average of 500 stock prices. As such, it tends to lag movements in market sentiment due to the fact that not all 500 stocks trade simultaneously. Therefore, price movements in the cash index tend to be correlated over time, and the degree of correlation depends upon the size of the nontrading effect. Although this effect is well known, few studies have corrected for it. Kawaller, Koch, and Koch (1987) used an instrumental variables approach to eliminate autocorrelation in the regression residuals, while Harris (1989) derived a new index estimator that corrects for nonsynchronous trading effects. Even after this adjustment, Harris found that the S&P 500 cash index displayed more autocorrelation than the futures.

The persistence of autocorrelation in the data even after employing the Harris (1989) adjustment procedure should not be surprising. Atchison, Butler, and Simonds (1987) found that other price-adjustment delays may cause severe autocorrelation in the returns of stock index portfolios. Moreover, with the advent of intraday price data studies, the nonsynchronous trading problem has become even more acute.

In this light, this paper examines intraday data by employing a statistical causality procedure that adjusts for the autocorrelation in a data time series regardless of the source. Granger (1969) causality between the S&P 500 cash and futures markets is investigated by first prewhitening each original time series with the same filter. Then using both whitened series, lagged regression models that relate the two whitened series are estimated. By prewhitening each series, much of the unwanted autocorrelation is eliminated without regard to the source. More importantly, with both series prewhitened, the regression that tests for causality between the two series will tend to be void of serially correlated regression residuals as required.[1]

Recently, two related studies have reported causality tests on the S&P 500 index and MMI index. Keasler and Followill (1989), using daily closing prices, found unidirectional causality, with the S&P 500 futures market leading the spot. Chan and Chung (1989), using intraday data on the MMI, found no significant causal relation between the futures and the cash. Both of these studies employed the Haugh (1976) two stage cross-correlation test. That is, after prewhitening each time series, the cross-correlation function between the two whitened series was examined.

The current study also involves the use of a two stage technique; however, it differs from the above mentioned two stage tests in an important way. After prewhitening each series, rather than examining the cross-correlation function, this study employs a regression technique in the sense of Granger causality. As noted by Pearce and Haugh (1977), among others, this technique is a true test of Granger causality; the two stage Haugh (1976) technique is only an independence test and not a strict test of causality. (See Feige and Pearce (1979, p. 525)).

Empirical Methodology

The hypothesis investigated in this paper is whether the S&P 500 index cash and futures markets are causally related in the Granger (1969) sense. Letting P_t and F_t be the observed returns at time t on the S&P 500 index cash and futures contract, respectively, the Granger procedure involves estimating a regression of the form:

$$(1)\quad F'_t = \sum_{i=0}^{m} a_i P'_{t-i} + \sum_{j=1}^{n} b_j F'_{t-j} + \varepsilon_{ft}$$

where:

P'_t and F'_t = P_t and F_t whitened through the same appropriate filter;

a_i and b_j = coefficients;

[1]The details of this technique are discussed by Feige and Pearce (1979).

ε_{ft} = the error term; and

m and n = the number of lags in the causal relationship.

A statistically significant value for at least one of the a_i's indicates Granger causality from the cash to the futures markets.

Similarly, the causal relationship in the reverse direction (that is, from the futures to the cash) also can be examined by estimating the following equation:

$$(2)\quad P'_t = \sum_{i=1}^{m} c_i P'_{t-i} + \sum_{j=0}^{n} d_j F'_{t-j} + \varepsilon_{pt}$$

A statistically significant value for at least one of the d_j's indicates Granger causality from the futures to cash markets. Evidence of a causal relationship in both directions (i.e., a significant a_i coincident with a significant d_j) indicates feedback between the cash and futures markets.

The need to filter the two series arises because the regression residuals of the unfiltered series will tend to be autocorrelated. This is particularly true in this case due to the nonsynchronous trading of the index which induces autocorrelation in the series. The procedure used here is one method of resolving this problem.[2] To investigate causality using equations (1) and (2), the futures and cash series must be prewhitened using the same appropriate filter. The exact nature of an appropriate filter is controversial. In a seminal paper on causality, Sims (1972) reported that a (1-.75B)(1-.75B) filter, where B is the backward shift operator (i.e., $Bx_t = x_{t-1}$), works well in eliminating serial correlation in the regression residuals. Stokes and Neuburger (1979) and Feige and Pearce (1979), however, have criticized the use of the Sims filter in testing for causality. The latter authors note that a variety of filters will eliminate the undesirable serial correlation in the regression residuals and that these filters may provide widely varying results. They suggest investigators examine the robustness of any conclusions to alternative filtering procedures. The Sims procedure, however, has been used in a variety of studies investigating causality (e.g., Feige and Johannes (1981) and Jain and Gupta (1987)).

Given this discussion and the recommendations by Feige and Pearce (1979), this paper investigates the causal relationship between the S&P 500 index cash and futures markets using three different filtering procedures:

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[2]Other procedures such as generalized least squares (GLS) also may be useful in this regard.

(i) GRANGER: (1-B)	This is the simplest Granger filter and has obvious intuitive appeal.
(ii) SIMS: $(1-.75B)^2$	This has been the most widely used filter and, as Sims (1972) claims, it ". . . approximately flattens the spectral density of most economic time series."
(iii) ARIMA	Autoregressive integrated moving average filter. It has been used previously by others and provides significantly different results than the Sims filter. A comparison could be enlightening.

The empirical findings using this two stage technique of first filtering each series and then regressing one filtered series on the other are reported later.

Data

The database examined in this paper consists of over 39,000 observations during a five month period from August 10, 1987 through December 31, 1987. This period differs from the intraday study by Kawaller, Koch, and Koch (1987) who examined the years 1984 and 1985. It does include October 1987, the month of the stock market crash, and the period studied by Harris (1989). To circumvent the complications that may arise from the stock market crash, not only was the whole period studied, but also two separate periods before and after the crash were examined. The before period runs from August 10 to October 16, while the after period extends from October 26 to December 31.

Minute-by-minute observations were obtained from the Chicago Mercantile Exchange for the S&P 500 index cash and the nearest to expiration futures contract (front month only). The front month for the futures is used until the first trading day of the front month at which time the next contract expiration is used as the front month. For example, during November, the December futures contract is used as the nearest to expiration; however, on December 1, the March futures contract is used. Therefore, any expiration day and month effects are avoided.

During any given minute, multiple contract trades may occur. The last trade in any given minute was used as the observation for that minute. (This procedure is consistent with that used by Kawaller, Koch, and Koch (1987)). These trades then were matched with the most recently reported trade on the S&P 500 cash index. If for any minute a futures trade did not occur, the price for the previous minute was used. In all, there are 39,390 observations spanning 101 consecutive trading days.

Empirical Findings and Discussion

The investigation of a causal relationship between the S&P 500 cash and futures markets involves estimating equations (1) and (2). The two stage procedure employed in this study involves prewhitening the original series with an appropriate filter and then estimating equations (1) and (2). Estimating these equations requires the choice of an appropriate number of lags (n and m). There is no statistical procedure for determining an appropriate lag; however, this research examined up to 20 one minute lags for a number of reasons. First, Kawaller, Koch, and Koch (1987) found significant lags to 20 minutes and beyond. Second, intuitively it did not appear necessary or even desirable to go beyond 20 minutes in order to investigate a causal relationship. Finally, the matrix of residuals after filtering the raw data with ARIMA models was not of full rank when more than 20 lags were examined.

As mentioned previously, the choice of an appropriate filter to whiten any economic time series is still a subject of much controversy. The most important function of the filter is to eliminate any serial correlation in the regression residuals. With residuals that are serially uncorrelated, inferences based on various test statistics (e.g., F-statistics) remain valid. As noted by Feige and Pearce (1979), this can be accomplished using a variety of filters which may provide widely varying results. Consequently, three filtering procedures were investigated in this study.

For sake of brevity, only the findings of the two most important filtering procedures are reported: the Sims and ARIMA filters.[3] After filtering both the S&P 500 cash and futures minute-by-minute returns using the Sims filter, equations (1) and (2) were estimated. Because the period of study includes the month of the stock market crash (October 1987), three periods were examined: the total period from August 10, 1987 to December 31, 1987; the period before the crash from August 10, 1987 to October 16, 1987; and the period following the crash from October 26, 1987 to December 31, 1987. The results are reported in Tables 1, 2, and 3.

For each lag, an estimated coefficient and its p-value (i.e., significance level) is reported. The R^2, F-statistic, and first order Durbin-Watson (DW) for each regression also are reported. Those estimated coefficients below the .05 significance level are not reported. Given the large number of observations, some

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[3]The simple (1-B) Granger filter provided similar results that are available upon request.

researchers have suggested using even higher significance levels. Examination of the total period (Table 1) indicates that the S&P 500 cash is influenced significantly by the futures movements over the prior 20 minutes (i.e., all coefficients are significant); prior cash movements influenced the futures for 15 minutes (each lag is one minute). Therefore, the futures leads the index by at least 20 minutes, whereas the index influences the futures for only 15 minutes. Notice also that the leading futures coefficients are much larger than the leading cash coefficients; thus, the magnitude of the futures influence is much larger than that of the cash. Examination of Tables 2 and 3 indicates that the approximate pattern persisted during the periods before and after the crash. For example, the cash movements influenced the futures for eight and ten minutes during the separate periods before and after the crash, respectively. The increase in R^2s after the crash may be due to the lower volatility and reported price staleness in both markets following the crash. The F-statistics and R^2s clearly indicate the significance of a causal relationship. The reason fcr filtering each time series was to eliminate serial correlation in the regression residuals. The reported DWs indicate that this procedure did well in eliminating first order autocorrelation. Further examination of the autocorrelation function of the regression residuals indicates no apparent serial correlation of higher order. (Notice that the Box-Ljung Q-statistic which would test the hypothesis that the residuals are white noise is not valid for large sample sizes--see Feige and Pearce (1979)). This implies that the reported F-statistics and other estimates are valid. These results suggest a strong causal relationship between the S&P 500 cash and futures, with the futures leading the cash by at least 20 minutes.

Alternatively, an ARIMA filtering procedure was examined. ARIMA models of up to five autoregressive and five moving average components were investigated. The ARIMA filters were chosen on their ability to reduce the original data to white noise as determined by observations of the autocorrelation function (the Box-Ljung Q-statistic does not apply for large samples) while using a minimal number of statistically significant components. The ARIMA model estimates for each of the three periods studied are reported in Appendix A. The models were extraordinarily successful in reducing the raw data to white noise.

Equations (1) and (2) were estimated using the ARIMA-filtered data. The results for the three periods studied are reported in Tables 4, 5, and 6. The ARIMA filters did well in providing uncorrelated regression residuals, as evidenced by the DW-statistic and observations of the autocorrelation function. The F-statistics indicate that there is a causal relationship between the cash and futures. The number of significant lag components contrasts dramatically with those using the Sims filter. For example, over the total period of analysis (Table 4), there is little evidence that the cash leads the futures, whereas the Sims filter results indicate significance to 15 minutes. Moreover, the ARIMA filter results indicate that the futures lead the index by at least 14 minutes, whereas the Sims filter found a leading relationship to at least 20 minutes. This general pattern persists over both periods before and after the crash. During the before period, however, the futures movements influenced the cash for only about seven minutes. During the after period, the influence persisted for at least 14 minutes. This could be one of the most interesting results reported in this study. A proper interpretation is difficult. One conjecture is that before the crash, the cash market was more responsive to futures movements than after the crash. This could be due to the much higher trading volume before the crash. Conversely, the cash market did not appear to influence the futures after the crash, while only influencing it for four minutes before the crash. These overall findings are summarized with lower R^2s and F-statistics for the ARIMA filter estimates. The conclusion of a significant causal relationship between the futures and cash, however, remains valid.

The examination of the autocorrelation function of the filtered residuals for each filter may shed some light on these findings. The ARIMA models did an excellent job of reducing the data to white noise. The Sims and Granger filters left the residuals with some autocorrelation, particularly from five to ten lags. This may be the reason why the R^2s are much larger for the Sims-filtered regressions versus the ARIMA-filtered regressions. That is, the reported relationships could be spurious.[4] Paradoxically, the reported DWs indicate otherwise.

These findings support the hypothesis of a causal relationship between the S&P 500 cash and futures markets. In particular, the findings clearly favor the futures leading the cash by approximately eight to 20 minutes, whereas the cash appears to influence the futures for only one to five minutes. These findings agree with those reported previously. The longevity of the futures movements on the cash movements was found to be less than those reported by Kawaller, Koch, and Koch (1987) who found the influence to extend well beyond 20 minutes.

Although not directly addressed in this study, given the size, leverage, and transactions costs in the futures markets relative to the spot, it should not be surprising that the futures lead the cash, as the futures market may react more quickly to new information. As for the cash leading the futures, a plausible explanation is that program selling in the futures market can drive the cash quickly, causing the cash to overreact and lead the futures.

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[4]See C.W. Granger and P. Newbold, "Spurious Regressions in Econometrics," *Journal of Econometrics*, 2 (July 1974), pp. 111-120.

Concluding Remarks

The findings reported in this paper clearly suggest a causal relationship, in the Granger (1969) sense, between the S&P 500 cash and futures markets. In agreement with past studies, the futures appear to lead the cash by eight to 20 minutes. In this sense, the futures market does act as a vehicle for price discovery which has been its anticipated function from the outset.

In reporting these findings one must be reminded that the causal relationship identified is causal only in a statistical sense as defined by Granger (1969). The relationship between statistical causality and that of philosophers and physicists has not yet been established.

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Table 1
Estimates of Equations (1) and (2) Using Sims Filter on Return Series
Time Period: 8/10/87 - 12/31/87

Dependent Variable: Futures			Dependent Variable: Index		
Variable	Estimate	p-value	Variable	Estimate	p-value
Index-Lag00	0.02865	.0001	Future-Lag00	0.13375	.0001
Future-Lag01	-1.59170	.0001	Future-Lag01	.32140	.0001
Future-Lag02	-1.79933	.0001	Future-Lag02	.51394	.0001
Future-Lag03	-1.82704	.0001	Future-Lag03	.66737	.0001
Future-Lag04	-1.77906	.0001	Future-Lag04	.81835	.0001
Future-Lag05	-1.70986	.0001	Future-Lag05	.94704	.0001
Future-Lag06	-1.57228	.0001	Future-Lag06	1.05807	.0001
Future-Lag07	-1.31368	.0001	Future-Lag07	1.10098	.0001
Future-Lag08	-1.08640	.0001	Future-Lag08	1.13148	.0001
Future-Lag09	-.94463	.0001	Future-Lag09	1.13846	.0001
Future-Lag10	-.82906	.0001	Future-Lag10	1.07937	.0001
Future-Lag11	-.69211	.0001	Future-Lag11	1.02512	.0001
Future-Lag12	-.58235	.0001	Future-Lag12	.99943	.0001
Future-Lag13	-.48504	.0001	Future-Lag13	.99030	.0001
Future-Lag14	-.40320	.0001	Future-Lag14	.91829	.0001
Future-Lag15	-.30231	.0001	Future-Lag15	.74823	.0001
Future-Lag16	-.21725	.0001	Future-Lag16	.57498	.0001
Future-Lag17	-.17990	.0001	Future-Lag17	.42485	.0001
Future-Lag18	-.11134	.0001	Future-Lag18	.26731	.0001
Future-Lag19	-.04699	.0001	Future-Lag19	.16792	.0001
Future-Lag20	-.03127	.0001	Future-Lag20	.07007	.0001
Index-Lag01	.05663	.0001	Index-Lag01	-2.34543	.0001
Index-Lag02	.07498	.0001	Index-Lag02	-3.65893	.0001
Index-Lag03	.08567	.0001	Index-Lag03	-4.74237	.0001
Index-Lag04	.09586	.0001	Index-Lag04	-5.50882	.0001
Index-Lag05	.10160	.0001	Index-Lag05	-5.94529	.0001
Index-Lag06	.09330	.0007	Index-Lag06	-6.07720	.0001
Index-Lag07	.08472	.0055	Index-Lag07	-5.94850	.0001
Index-Lag08	.08834	.0066	Index-Lag08	-5.61621	.0001
Index-Lag09	.08708	.0099	Index-Lag09	-5.14292	.0001
Index-Lag10	.07844	.0217	Index-Lag10	-4.57381	.0001
Index-Lag11	.06906	.0407	Index-Lag11	-3.95811	.0001
Index-Lag12	.06837	.0353	Index-Lag12	-3.33101	.0001
Index-Lag13	.06190	.0417	Index-Lag13	-2.71400	.0001
Index-Lag14	.05720	.0377	Index-Lag14	-2.12567	.0001

Table 1 (continued)
Estimates of Equations (1) and (2) Using Sims Filter on Return Series
Time Period: 8/10/87 - 12/31/87

Dependent Variable: Futures

Variable	Estimate	p-value
Index-Lag15	.05116	.0325
Index-Lag16	****	****
Index-Lag17	****	****
Index-Lag18	****	****
Index-Lag19	****	****
Index-Lag20	.00504	.0305

F = 3045.97* R^2 = .76 DW = 2.002
**** = not significant at .05 level

Dependent Variable: Index

Variable	Estimate	p-value
Index-Lag15	-1.58108	.0001
Index-Lag16	-.09832	.0001
Index-Lag17	-.69848	.0001
Index-Lag18	-.39170	.0001
Index-Lag19	-.17764	.0001
Index-Lag20	-.05263	.0001

F = 8815.57* R^2 = .90 DW = 2.008
* = significant at .01 level

Table 2
Estimates of Equations (1) and (2) Using Sims Filter on Return Series
Time Period: 8/10/87 - 10/16/87

Dependent Variable: Futures			Dependent Variable: Index		
Variable	Estimate	p-value	Variable	Estimate	p-value
Index-Lag00	.29730	.0001	Future-Lag00	.03806	.0001
Future-Lag01	-1.50258	.0001	Future-Lag01	.08790	.0001
Future-Lag02	-1.69270	.0001	Future-Lag02	.18773	.0001
Future-Lag03	-1.73422	.0001	Future-Lag03	.30846	.0001
Future-Lag04	-1.69837	.0001	Future-Lag04	.40356	.0001
Future-Lag05	-1.59569	.0001	Future-Lag05	.46363	.0001
Future-Lag06	-1.43797	.0001	Future-Lag06	.48317	.0001
Future-Lag07	-1.27827	.0001	Future-Lag07	.47181	.0001
Future-Lag08	-1.09491	.0001	Future-Lag08	.43353	.0001
Future-Lag09	-.93693	.0001	Future-Lag09	.38707	.0001
Future-Lag10	-.78778	.0001	Future-Lag10	.32714	.0001
Future-Lag11	-.66310	.0001	Future-Lag11	.27479	.0001
Future-Lag12	-.53891	.0001	Future-Lag12	.22077	.0001
Future-Lag13	-.41473	.0001	Future-Lag13	.17351	.0001
Future-Lag14	-.30848	.0001	Future-Lag14	.13346	.0001
Future-Lag15	-.23288	.0001	Future-Lag15	.09902	.0001
Future-Lag16	-.17422	.0001	Future-Lag16	.07295	.0001
Future-Lag17	-.12309	.0001	Future-Lag17	.05215	.0001
Future-Lag18	-.06632	.0015	Future-Lag18	.03602	.0001
Future-Lag19	****	****	Future-Lag19	.01993	.0002
Future-Lag20	****	****	Future-Lag20	.00578	.0401
Index-Lag01	.55458	.0001	Index-Lag01	-1.33730	.0001
Index-Lag02	.70657	.0001	Index-Lag02	-1.30837	.0001
Index-Lag03	.78029	.0001	Index-Lag03	-1.14456	.0001
Index-Lag04	.74053	.0001	Index-Lag04	-.95945	.0001
Index-Lag05	.65669	.0001	Index-Lag05	-.75278	.0001
Index-Lag06	.51943	.0001	Index-Lag06	-.60857	.0001
Index-Lag07	.42651	.0001	Index-Lag07	-.46099	.0001
Index-Lag08	.32935	.0001	Index-Lag08	-.32604	.0001
Index-Lag09	.23887	.0001	Index-Lag09	-.23065	.0001
Index-Lag10	.14176	.0112	Index-Lag10	-.17156	.0001
Index-Lag11	****	****	Index-Lag11	-.14334	.0001
Index-Lag12	****	****	Index-Lag12	-.09740	.0001
Index-Lag13	****	****	Index-Lag13	-.09001	.0001
Index-Lag14	-.10282	.0370	Index-Lag14	-.06588	.0002

Table 2 (continued)
Estimates of Equations (1) and (2) Using Sims Filter on Return Series
Time Period: 8/10/87 - 10/16/87

Dependent Variable: Futures

Variable	Estimate	p-value
Index-Lag15	-.09501	.0424
Index-Lag16	****	****
Index-Lag17	****	****
Index-Lag18	****	****
Index-Lag19	****	****
Index-Lag20	****	****

F = 1210.31* R^2 = .72 DW = 2.000

Dependent Variable: Index

Variable	Estimate	p-value
Index-Lag15	-.03637	.0299
Index-Lag16	****	****
Index-Lag17	****	****
Index-Lag18	****	****
Index-Lag19	****	****
Index-Lag20	****	****

F = 964.93* R^2 = .68 DW = 2.001

**** = not significant at .05 level
* = significant at .01 level

Table 3
Estimates of Equations (1) and (2) Using Sims Filter on Return Series
Time Period: 10/26/87 - 12/31/87

Dependent Variable: Futures			Dependent Variable: Index		
Variable	Estimate	p-value	Variable	Estimate	p-value
Index-Lag00	.08920	.0001	Future-Lag00	.32465	.0001
Future-Lag01	-1.87754	.0001	Future-Lag01	.67195	.0001
Future-Lag02	-2.37415	.0001	Future-Lag02	.97293	.0001
Future-Lag03	-2.52491	.0001	Future-Lag03	1.22533	.0001
Future-Lag04	-2.43412	.0001	Future-Lag04	1.44063	.0001
Future-Lag05	-2.21762	.0001	Future-Lag05	1.64701	.0001
Future-Lag06	-1.94998	.0001	Future-Lag06	1.81905	.0001
Future-Lag07	-1.66252	.0001	Future-Lag07	1.89221	.0001
Future-Lag08	-1.39164	.0001	Future-Lag08	1.92756	.0001
Future-Lag09	-1.16812	.0001	Future-Lag09	1.91753	.0001
Future-Lag10	-.97145	.0001	Future-Lag10	1.85638	.0001
Future-Lag11	-.82152	.0001	Future-Lag11	1.77787	.0001
Future-Lag12	-.69000	.0001	Future-Lag12	1.66573	.0001
Future-Lag13	-.55239	.0001	Future-Lag13	1.49460	.0001
Future-Lag14	-.42721	.0001	Future-Lag14	1.30262	.0001
Future-Lag15	-.31771	.0001	Future-Lag15	1.08051	.0001
Future-Lag16	-.20550	.0001	Future-Lag16	.82438	.0001
Future-Lag17	-.15483	.0001	Future-Lag17	.60445	.0001
Future-Lag18	-.10068	.0001	Future-Lag18	.38499	.0001
Future-Lag19	-.05921	.0001	Future-Lag19	.19830	.0001
Future-Lag20	-.03113	.0001	Future-Lag20	.05668	.0001
Index-Lag01	.17416	.0001	Index-Lag01	-2.27792	.0001
Index-Lag02	.23239	.0001	Index-Lag02	-3.44507	.0001
Index-Lag03	.25664	.0001	Index-Lag03	-4.31642	.0001
Index-Lag04	.25315	.0001	Index-Lag04	-4.79505	.0001
Index-Lag05	.22812	.0001	Index-Lag05	-4.92757	.0001
Index-Lag06	.18755	.0001	Index-Lag06	-4.77986	.0001
Index-Lag07	.13501	.0001	Index-Lag07	-4.39616	.0001
Index-Lag08	.09754	.0310	Index-Lag08	-3.86056	.0001
Index-Lag09	****	****	Index-Lag09	-3.28990	.0001
Index-Lag10	****	****	Index-Lag10	-2.71444	.0001
Index-Lag11	****	****	Index-Lag11	-2.18265	.0001
Index-Lag12	****	****	Index-Lag12	-1.70544	.0001
Index-Lag13	****	****	Index-Lag13	-1.27090	.0001
Index-Lag14	****	****	Index-Lag14	-.89494	.0001

Table 3 (continued)
Estimates of Equations (1) and (2) Using Sims Filter on Return Series
Time Period: 10/26/87 - 12/31/87

Dependent Variable: Futures			Dependent Variable: Index		
Variable	Estimate	p-value	Variable	Estimate	p-value
Index-Lag15	-.07093	.0416	Index-Lag15	-.56471	.0001
Index-Lag16	-.07299	.0131	Index-Lag16	-.28248	.0001
Index-Lag17	-.05542	.0166	Index-Lag17	-.11471	.0001
Index-Lag18	-.03619	.0262	Index-Lag18	****	****
Index-Lag19	****	****	Index-Lag19	****	****
Index-Lag20	****	****	Index-Lag20	-.01521	.0389

F = 2320.65* R^2 = .84 DW = 2.001 F - 3961.34* R^2 = .90 DW = 2.004
**** = not significant at .05 level * = significant at .01 level

Table 4
Estimates of Equations (1) and (2) Using ARIMA Filter on Return Series
Time Period: 8/10/87 - 12/31/87

Dependent Variable: Futures			Dependent Variable: Index		
Variable	Estimate	p-value	Variable	Estimate	p-value
Index-Lag00	.03060	.0001	Future-Lag00	.14116	.0001
Future-Lag01	****	****	Future-Lag01	.12102	.0001
Future-Lag02	****	****	Future-Lag02	.11184	.0001
Future-Lag03	-.02821	.0001	Future-Lag03	.08798	.0001
Future-Lag04	-.05453	.0001	Future-Lag04	.12414	.0001
Future-Lag05	-.06950	.0001	Future-Lag05	.11015	.0001
Future-Lag06	****	****	Future-Lag06	.12198	.0001
Future-Lag07	.07417	.0001	Future-Lag07	.07336	.0001
Future-Lag08	-.01525	.0028	Future-Lag08	.10990	.0001
Future-Lag09	-.06168	.0001	Future-Lag09	.09914	.0001
Future-Lag10	-.02822	.0001	Future-Lag10	.05316	.0001
Future-Lag11	****	****	Future-Lag11	.10387	.0001
Future-Lag12	-.02580	.0001	Future-Lag12	.12489	.0001
Future-Lag13	-.01374	.0074	Future-Lag13	.13115	.0001
Future-Lag14	-.01901	.0002	Future-Lag14	.07086	.0001
Future-Lag15	****	****	Future-Lag15	****	****
Future-Lag16	-.01391	.0064	Future-Lag16	.06313	.0001
Future-Lag17	-.04360	.0001	Future-Lag17	.06764	.0001
Future-Lag18	.01931	.0001	Future-Lag18	.03529	.0013
Future-Lag19	****	****	Future-Lag19	.07993	.0001
Future-Lag20	-.03698	.0001	Future-Lag20	****	****
Index-Lag01	****	****	Index-Lag01	-.20318	.0001
Index-Lag02	****	****	Index-Lag02	-.27333	.0001
Index-Lag03	.00996	.0001	Index-Lag03	-.36990	.0001
Index-Lag04	.00899	.0007	Index-Lag04	-.17641	.0001
Index-Lag05	****	****	Index-Lag05	-.18031	.0001
Index-Lag06	****	****	Index-Lag06	-.16034	.0001
Index-Lag07	.01022	.0002	Index-Lag07	-.10120	.0001
Index-Lag08	.01506	.0001	Index-Lag08	-.08953	.0001
Index-Lag09	****	****	Index-Lag09	-.07446	.0001
Index-Lag10	****	****	Index-Lag10	-.04693	.0001
Index-Lag11	****	****	Index-Lag11	-.04487	.0001
Index-Lag12	.00712	.0083	Index-Lag12	-.03318	.0001
Index-Lag13	-.00844	.0017	Index-Lag13	-.01677	.0037
Index-Lag14	****	****	Index-Lag14	****	****

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Table 4 (continued)
Estimates of Equations (1) and (2) Using ARIMA Filter on Return Series
Time Period: 8/10/87 - 12/31/87

Dependent Variable: Futures

Variable	Estimate	p-value
Index-Lag15	****	****
Index-Lag16	-.01202	.0001
Index-Lag17	****	****
Index-Lag18	-.00590	.0161
Index-Lag19	****	****
Index-Lag20	****	****

F = 29.75* R^2 = .03 DW = 1.999
**** = not significant at .05 level

Dependent Variable: Index

Variable	Estimate	p-value
Index-Lag15	****	****
Index-Lag16	****	****
Index-Lag17	****	****
Index-Lag18	****	****
Index-Lag19	****	****
Index-Lag20	****	****

F = 174.40* R^2 = .15 DW = 2.000
* = significant at .01 level

Table 5
Estimates of Equations (1) and (2) Using ARIMA Filter on Return Series
Time Period: 8/10/87 - 10/16/87

Dependent Variable: Futures			Dependent Variable: Index		
Variable	Estimate	p-value	Variable	Estimate	p-value
Index-Lag00	.30080	.0001	Future-Lag00	.03849	.0001
Future-Lag01	-.01965	.0069	Future-Lag01	.03189	.0001
Future-Lag02	-.03483	.0001	Future-Lag02	.07952	.0001
Future-Lag03	-.04384	.0001	Future-Lag03	.07943	.0001
Future-Lag04	-.05389	.0001	Future-Lag04	.05132	.0001
Future-Lag05	-.02945	.0002	Future-Lag05	.03643	.0001
Future-Lag06	****	****	Future-Lag06	.01852	.0001
Future-Lag07	-.02477	.0017	Future-Lag07	.01120	.0001
Future-Lag08	****	****	Future-Lag08	****	****
Future-Lag09	-.02102	.0081	Future-Lag09	****	****
Future-Lag10	****	****	Future-Lag10	-.00630	.0267
Future-Lag11	-.01836	.0208	Future-Lag11	.00575	.0431
Future-Lag12	****	****	Future-Lag12	****	****
Future-Lag13	****	****	Future-Lag13	****	****
Future-Lag14	****	****	Future-Lag14	****	****
Future-Lag15	-.01747	.0283	Future-Lag15	****	****
Future-Lag16	****	****	Future-Lag16	.00653	.0219
Future-Lag17	****	****	Future-Lag17	****	****
Future-Lag18	****	****	Future-Lag18	.00570	.0455
Future-Lag19	****	****	Future-Lag19	****	****
Future-Lag20	****	****	Future-Lag20	****	****
Index-Lag01	.19938	.0001	Index-Lag01	-.13000	.0001
Index-Lag02	.17506	.0001	Index-Lag02	-.14258	.0001
Index-Lag03	.13464	.0001	Index-Lag03	****	****
Index-Lag04	.05290	.0107	Index-Lag04	-.01672	.0241
Index-Lag05	****	****	Index-Lag05	.03351	.0001
Index-Lag06	****	****	Index-Lag06	-.01583	.0330
Index-Lag07	****	****	Index-Lag07	.02868	.0001
Index-Lag08	****	****	Index-Lag08	.02425	.0011
Index-Lag09	****	****	Index-Lag09	****	****
Index-Lag10	****	****	Index-Lag10	****	****
Index-Lag11	-.07067	.0007	Index-Lag11	-.02150	.0038
Index-Lag12	****	****	Index-Lag12	****	****
Index-Lag13	****	****	Index-Lag13	-.03489	.0001
Index-Lag14	****	****	Index-Lag14	****	****

Table 5 (continued)
Estimates of Equations (1) and (2) Using ARIMA Filter on Return Series
Time Period: 8/10/87 - 10/16/87

Dependent Variable: Futures			Dependent Variable: Index		
Variable	Estimate	p-value	Variable	Estimate	p-value
Index-Lag15	****	****	Index-Lag15	****	****
Index-Lag16	****	****	Index-Lag16	****	****
Index-Lag17	****	****	Index-Lag17	****	****
Index-Lag18	****	****	Index-Lag18	-.01578	.0268
Index-Lag19	****	****	Index-Lag19	****	****
Index-Lag20	****	****	Index-Lag20	****	****
F = 10.25* R2 = .02 DW = 1.999			F = 66.89* R2 = .13 DW = 1.999		

**** = not significant at .05 level
* = significant at .01 level

Table 6
Estimates of Equations (1) and (2) Using ARIMA Filter on Return Series
Time Period: 10/26/87 - 12/31/87

Dependent Variable: Futures			Dependent Variable: Index		
Variable	Estimate	p-value	Variable	Estimate	p-value
Index-Lag00	.09038	.0001	Future-Lag00	.32692	.0001
Future-Lag01	****	****	Future-Lag01	.06440	.0001
Future-Lag02	****	****	Future-Lag02	.09274	.0001
Future-Lag03	-.01738	.0192	Future-Lag03	.10793	.0001
Future-Lag04	.02236	.0026	Future-Lag04	.10839	.0001
Future-Lag-05	****	****	Future-Lag05	.13528	.0001
Future-Lag06	****	****	Future-Lag06	.11473	.0001
Future-Lag07	****	****	Future-Lag07	.05892	.0001
Future-Lag08	****	****	Future-Lag08	.10861	.0001
Future-Lag09	-.02164	.0038	Future-Lag09	.07693	.0001
Future-Lag10	****	****	Future-Lag10	.06345	.0001
Future-Lag11	-.02650	.0004	Future-Lag11	.08523	.0001
Future-Lag12	****	****	Future-Lag12	.05642	.0001
Future-Lag13	****	****	Future-Lag13	.02978	.0362
Future-Lag14	****	****	Future-Lag14	.05197	.0003
Future-Lag15	****	****	Future-Lag15	****	****
Future-Lag16	.01819	.0148	Future-Lag16	****	****
Future-Lag17	-.04553	.0001	Future-Lag17	.05031	.0004
Future-Lag18	.01908	.0104	Future-Lag18	****	****
Future-Lag19	****	****	Future-Lag19	****	****
Future-Lag20	****	****	Future-Lag20	****	****
Index-Lag01	-.01615	.0001	Index-Lag01	-.14243	.0001
Index-Lag02	****	****	Index-Lag02	-.20020	.0001
Index-Lag03	.00997	.0163	Index-Lag03	-.27550	.0001
Index-Lag04	****	****	Index-Lag04	-.04524	.0001
Index-Lag05	****	****	Index-Lag05	-.07969	.0001
Index-Lag06	****	****	Index-Lag06	-.05757	.0001
Index-Lag07	-.00963	.0207	Index-Lag07	.02126	.0072
Index-Lag08	.01263	.0024	Index-Lag08	****	****
Index-Lag09	****	****	Index-Lag09	.03050	.0001
Index-Lag10	****	****	Index-Lag10	****	****
Index-Lag11	****	****	Index-Lag11	-.01613	.0409
Index-Lag12	-.01029	.0129	Index-Lag12	****	****
Index-Lag13	-.01025	.0130	Index-Lag13	****	****
Index-Lag14	****	****	Index-Lag14	****	****

Table 6 (continued)
Estimates of Equations (1) and (2) Using ARIMA Filter on Return Series
Time Period: 10/26/87 - 12/31/87

Dependent Variable: Futures

Variable	Estimate	p-value
Index-Lag15	****	****
Index-Lag16	****	****
Index-Lag17	.01130	.0055
Index-Lag18	-.00863	.0290
Index-Lag19	****	****
Index-Lag20	****	****

F = 18.50* R^2 = .04 DW = 2.000
**** = not significant at .05 level

Dependent Variable: Index

Variable	Estimate	p-value
Index-Lag15	.01744	.0254
Index-Lag16	.02006	.0098
Index-Lag17	-.03673	.0001
Index-Lag18	****	****
Index-Lag19	.02612	.0004
Index-Lag20	.02297	.0017

F = 71.62* R^2 = .14 DW = 2.003
* = significant at .01 level

Appendix A
ARIMA Model Filters

Period: 8/10/87-12/31/87 Series: Futures No. of Observations: 39390
Model: $(1 + .0902\ B - .016\ B^2)\ y_t = -.00001123 + \varepsilon_t$
(17.91) (3.17) (.95)

Residuals: Sum of Squares: .215369
Mean Square Error: .000005 Degrees of Freedom: 39387

Period: 8/10/87-12/31/87 Series: Index No. of Observations: 39390
Model: $(1 + .6579\ B - .3260\ B^2)\ y_t = -.00001641 + \varepsilon_t$
(138.11) (68.43) (.61)

Residuals: Sum of Squares: 1.13859
Mean Square Error: .00003 Degrees of Freedom: 39387

Period: 8/10/87-10/16/87 Series: Futures No. of Observations: 19110
Model: $(1 + .0155\ B - .0314\ B^2)\ y_t = -.000007754 + \varepsilon_t$
(2.15) (4.34) (1.87)

Residuals: Sum of Squares: .00628244
Mean Square Error: .00000033 Degrees of Freedom: 19107

Period: 8/10/87-10/16/87 Series: Index No. of Observations: 19110
Model: $(1 + .2904\ B - .2380\ B^2)\ y_t = -.000002457 + \varepsilon_t$
(41.32) (33.82) (1.57)

Residuals: Sum of Squares: .000900333
Mean Square Error: .000000047 Degrees of Freedom: 19107

Period: 10/26/87-12/31/87 Series: Futures No. of Observations: 18330
Model: $(1 + .3830\ B - .1134\ B^2)\ y_t = -.00000224 + \varepsilon_t$
(52.18) (15.45) (.20)

Residuals: Sum of Squares: .0402486
Mean Square Error: .0000022 Degrees of Freedom: 18327

Period: 10/26/87-12/31/87 Series: Index No. of Observations: 18330
Model: $(1 + .6434\ B - .3114\ B^2)\ y_t = -.000006625 + \varepsilon_t$
(91.66) (44.36) (.30)

Residuals: Sum of Squares: .160287
Mean Square Error: .000009 Degrees of Freedom: 18327