INTRADAY STOCK INDEX FUTURES ARBITRAGE WITH TIME LAG EFFECTS

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The following individuals provided helpful information concerning the institutional aspects of arbitrage trading: Ira Kawaller (CMEX), Ted Doukas (CBT), Gary Katz (NYSE), Bill Toy (Goldman Sacks), and Bill Mullen (Loomis-Sayles).

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ABSTRACT

Previous research concludes that stock index arbitrage provides risk-free profits on a consistent basis. However, these studies employed end of the day data and/or do not consider the effect of lags in the cash price on the results. This study examines potential stock index arbitrage opportunities by using five minute intervals for the S&P 500, MMI, and NYFE contracts. Realistic cost, interest rate, and dividend yield data are employed to provide reliable results. When only end of the day or early morning data are used then large arbitrage profits are recorded. Smaller profits are available for intraday data. The effect of time lags related to making cash market trades or inactivity for smaller stocks eliminates the apparent intraday arbitrage profits, except for the October-December 1987 time period.

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The literature on the price behavior of stock index futures in relation to the underlying cash index has concentrated on two related issues: (1) the lead-lag relationship between the futures and cash prices, which also relates to the ability of futures to "predict" subsequent cash index prices, and (2) the pricing and arbitrage of stock index futures markets.

Section I of this paper includes a summary of the research concerning these two issues. The studies on the lead-lag/price discovery relationship which uses intraday data provides consistent conclusions that futures do lead cash prices during most time periods. This lead effect of futures implies that the use of matched futures-cash prices may provide biased results for arbitrage studies.

The pricing and arbitrage studies of stock index futures typically employ daily data. Using the cost of carry model, these studies usually conclude that arbitrage profits are frequent and relatively large for the time periods studied. Recently, MacKinlay and Ramaswamy (1988) use 15 minute intraday periods to examine the mispricings of stock index futures from their fair prices, as well as to examine if stock index futures prices violate an arbitrary arbitrage transactions boundary. They determine that once the mispricing value crosses one transaction boundary, e.g. the upper bound, then it is less likely to cross the opposite boundary. Moreover, these violations tend to persist for long periods of time.

The existence of arbitrage profits raises the question of the source of these profits. Are arbitrage profits available in these markets due to a limited supply of arbitrage capital? Or are these reported profits illusionary because of the lag effect of the cash index prices and the end of day timing difference between the futures and cash indices? Are there other factors affecting these reported profits, such as the risk involved when a subset of the index is used to undertake the arbitrage transaction? Now that the stock index futures market has matured, are such profits still available? To what extent did the market volatility in the third quarter of 1987 affect stock index arbitrage opportunities?

The purpose of this paper is to investigate stock index arbitrage opportunities with intraday data and to examine the reasons for any apparent risk-free profits from this arbitrage. This paper differs from most previous research in that it employs intraday data to examine stock index arbitrage, uses a realistic cost structure, determines the effect of lags, and compares arbitrage results across the three major futures contracts (S&P 500, MMI, and NYFE). In addition, intraday results are compared to the apparent arbitrage profits existing at the end of the day and the beginning of the day. The differing contract characteristics and liquidity of the three futures contracts provide a useful comparison to investigate the aforementioned questions concerning stock index arbitrage.

Section I provides an overview of the stock index futures lead-lag and pricing issues found in the literature. Section II examines the factors affecting arbitrage transactions, such as the cost and risk aspects of executing an arbitrage trade. Section III relates the methodology of this paper, and Section IV provides the results of using intraday data for stock index futures arbitrage. Section V provides conclusions and implications.

I. ISSUES IN THE LITERATURE

The lead-lag and arbitrage/pricing issues are interrelated. If futures price changes lead cash index changes then this lead may affect reported arbitrage results. Likewise, the matching of prices for arbitrage purposes by using end of day data implicitly assumes that there is no lead effect for futures and that futures do <u>not</u> provide any price discovery mechanism, since futures close 15 minutes later than the cash markets.

A. The Lead-Lag Relationship

The lead-lag/price discovery issue has been investigated in several different ways. Kawaller, Koch, and Koch (1987) use a three stage least squares model on minute by minute S&P 500 futures and cash data for six days during 1984 and 1985; they determine that the futures contract leads the cash index for as long as 20 to 45 minutes. Laatsch and Schwarz (1988) find simultaneous pricing for minute by minute data with the Major Market Index (MMI). However, Finnerty and Park (1987) conclude that a significant lead-lag relationship exists for minute by minute MMI data from August 1984 to August 1986. Herbst, McCormack, and West (1987) use spectral analysis cross correlations to determine that futures lead the cash index for the S&P 500 and Value Line futures contacts, with the lead varying from 0 to 16 minutes. Stoll and Whaley (1988a) employ correlation coefficients to examine various multiples of a five minute interval lag for the S&P 500 and MMI contracts. They determine that futures provide a price discovery function with a lead time of 5 minutes on average and up to 15 minutes or more occasionally, although the futures and cash prices are often contemporaneous. Stoll and Whaley attribute the lag effect to infrequent trading for the cash stocks. Swinnerton, Curcio, and Bennett (1988) use five minute intervals for four MMI expirations in 1986 to determine that a mispriced futures value based on the cost of carry model is only a <u>modest</u> predictor of the future underlying cash index, and that a lead time of five minutes is the best predictor of the cash index, although the futures provided some predictive ability up to 30 minutes later.

The reasons that futures lead the cash index are threefold: (1) opinions concerning the market are registered first in the futures market due to the significantly lower transactions cost of futures over cash, (2) the greater liquidity in the futures market, and (3) futures price <u>appear</u> to lead the cash index because the smaller stocks in the index do not trade frequently.

B. Arbitrage and Pricing

Cornell and French (1983) and Modest and Sundaresan (1983) completed early studies of stock index futures pricing and arbitrage with daily data by employing the cost of carry model. Cornell and French found that mispricing did exist, attributing the mispricing to a tax timing option for the stock. However, Cornell (1985) shows empirically that the tax timing hypothesis does not affect the results and the mispricings began to disappear as the contract matured. Modest and Sundaresan calculated no-arbitrage bands based on assumed transactions costs, finding that the daily futures versus cash relationships fell within the bands for the December 1982 contract. However, the transactions costs used by Modest and Sundaresan are much higher than institutions pay, and their assumption that long futures arbitrage (short cash stocks) is costly because of the uptick short sale rule does not conform to the industry practice of pension funds that initiate long arbitrage. Saunders and Mahajan (1988) adjust for several restrictive assumptions made in other arbitrage studies and then employ regression analysis on daily data from late 1982 to 1984 to examine the pricing relationships between futures and cash for the S&P 500 and NYSE contracts. They conclude that stock index futures have matured over time, although arbitrage profits are not calculated.

Finnerty and Park (1989) employ intraday data on the MMI contract from August 1984 to August 1986 to examine dynamic program trading strategies. The standard deviation of the percentage difference from the theoretical cost of carry value is calculated to develop a filter model that identifies profitable trades. However, no transactions costs are employed and potential lag effects are ignored.

Merrick (1989) examines early unwindings and rollovers of arbitrage positions to determine if such dynamic strategies affect the profits of such transactions. Although only daily S&P 500 data are employed, Merrick finds that the effective total transactions cost is only 73% of the original transactions cost when unwindings and rollovers are employed as part of a complete arbitrage strategy.

MacKinlay and Ramaswamy (1988) perform the only cost of carry pricing study involving intraday data. Using the S&P 500 contract from June 1983 to June 1987, they examine the mispricing of futures contracts from their fair value by using 15 minute intervals. MacKinlay and Ramaswamy determine that a positive or negative persistence in mispricing exists when autocorrelations are measured for eight lags of 15 minutes each. They also find that mispricings are a function of time by using a regression analysis on the average absolute daily mispricing versus the time to expiration of the futures.

MacKinlay and Ramaswamy also provide some arbitrage results, although their choice of the size of the transactions bands seems to be arbitrary at .6% of the value of the cash index. They find that the average time above the upper transaction band is two hours and the average time below the lower bound is 36 minutes (using 15 minute interval data). Further analysis of the arbitrage violations leads MacKinlay and Ramaswamy to conclude that the arbitrage violations are path dependent, i.e. once an arbitrage boundary is crossed it is less likely for the mispriced value to cross the opposite arbitrage boundary. They also state that stale prices are not a major cause of the arbitrage boundary violations; however, they do not provide any substantiation for this conclusion since they do not directly test if arbitrage profits are affected by lags. Finally, MacKinlay and Ramaswamy do not provide information on the size of the average arbitrage profits.

While the relevance of the issues raised by these studies becomes clearer in the next section, several critical factors are apparent. The use of daily data to examine the pricing and arbitrage of stock index futures markets creates difficulties in determining true arbitrage profits; these difficulties are caused by the 15 minute non-simultaneous nature of the end of the day futures/cash prices and the potential lag effects. Furthermore, assumptions concerning the cost structure for the marginal arbitrageur are critical in determining the existence of arbitrage profits; previous studies do not consider the true cost structure of arbitrage. Finally, how the arbitrage market was affected by the 1987 market crash is not addressed by these previous studies.

II. THE FACTORS AFFECTING ARBITRAGE

A. Cost of Carry Pricing

Without transaction costs, stock index futures prices are forced to equilibrium by the cost of carry model given in (1):

$$P_{f,t} = P_{s,t}\, e^{(r-d)(T-t)/365} \quad (1)$$

Where:

$P_{f,t}$ = the forward price determined from the cost of carry model at time t

P_s = the spot cash index price at time t

r = the risk-free interest rate or opportunity rate of return continuously compounded

d = the dividend yield on the cash securities for the index continuously compounded

T = the expiration date of the futures contract

t = the current date.

Mispricing exists when the futures price differs from the forward price:

$$X_t = P_{F,t} - P_{f,t} \quad (2)$$

Where:

X_t = the size of the mispricing

$P_{F,t}$ = the futures price at time t.

In general, arbitrage profits exist when the mispricing of the futures contract is larger than the transaction bands created when the arbitrage trade is undertaken:

$$|X_t| > TR \quad (3)$$

Where:

TR = the total transactions costs for the arbitrage trade.

When $P_{F,t} > P_{f,t}$ then a basket of stocks representing the cash index are purchased and the futures contract is sold (long cash arbitrage). The dividend yield of d is earned and reinvested continuously, and funds are borrowed at r or the opportunity cost of r is earned over the holding period. At expiration, the futures contract price is set equal to the cash index value by design, i.e. stock index futures have cash settlement. Those who hold cash securities may cover their positions by selling stock with a "market on close" order (or "market on open" order since June 1987) in order to avoid any price risk at futures expiration.

When $P_{F,t} < P_{f,t}$ then stocks may be sold short and the futures contract purchased. However, due to the risk involved from the "uptick rule" for short sales, most short cash arbitrage transactions are instituted by financial institutions that already own stocks. Thus, these stocks are sold and the funds are invested in risk-free assets, guaranteeing a return above the risk-free rate because of the arbitrage profits obtained.

Long cash arbitrage may be either financed at the appropriate cost of funds r (pure arbitrage) or initiated by financial institutions as an alternative to a risk-free investment (quasi arbitrage). Short cash arbitrage is almost exclusively instituted by quasi-arbitrageurs because of the uptick rule. In the stock market the brokerage houses act as the only pure arbitrageurs, since their financing costs are lower than other pure arbitrageurs and their marginal commissions are zero. However, Stoll and Whaley (1987) state two reasons why brokerage house arbitrage activity may be limited for stocks: (1)

the availability of capital to institute such trades may be constrained by net capital requirements, and (2) they may have more profitable uses for their borrowed funds. In addition, after October 1987 there were public relations issues that caused may brokerage houses to suspend their program trading activities for their own accounts.

B. Operational Issues

The operational and implementation issues related to stock index futures arbitrage are critical in determining if any forward mispricing is large enough to cross an arbitrage transactions boundary, and if other factors such as risk affect these apparent profits. The cost and risk factors are considered below. Operational issues include the size of the arbitrage trade, the time interval to employ in the analysis, and the choice of the risk-free rate and dividend yield in the analysis.

The size of a typical arbitrage trade depends upon the size of the potential profits, the liquidity in the futures and cash markets, and the minimum size needed to avoid cash odd-lot charges. The S&P 500 futures contract is very liquid and therefore can absorb large trades in a relatively short time period. Initiating an arbitrage transaction with the S&P 500 cash stocks requires $25 million in order to avoid odd-lot charges or the tracking risk resulting from trading a basket of stocks that does not exactly match the cash index. A smaller basket of stocks may be used to execute a "risky arbitrage" trade with about $10 million. Arbitrageurs typically use a complete

$25 million portfolio, since smaller baskets have created significant tracking risk. MMI arbitrage trades may be completed with baskets of $3 million in stocks. While traders often would like to engage in larger transactions, the MMI futures contract does not always have the liquidity needed to institute significantly larger sizes. NYFE contracts can not be effectively arbitraged without risk because of the large number of stocks making up the index and their relative weights in the index. Moreover, trades for NYFE contracts often are much smaller than $25 million because of the lack of liquidity in the futures market. Typically there is no liquidity problem for the cash stocks for any of these arbitrage trades, since the smaller capitalized stocks are only traded in 100 share lots, and the larger capitalized stocks have sufficient liquidity to allow for large program trades.

The appropriate time interval to conduct an analysis of arbitrage trading is approximately five minutes. One reason for this choice is the time it takes for an order to reach the floor of the stock exchange and be executed once it is entered into the DOT system (Designated Order Turnaround system). While most trades entered into the DOT system are executed within two minutes, a five minute interval is reasonable once the delay time for the last trades from stocks plus the decision time for the arbitrage is considered. Moreover, the studies on the lag effects of stock index futures generally conclude that at least a five minute lag time is appropriate. Finally, time intervals of less than five minutes often provide an insufficient number of trades for the MMI and NYFE contracts to obtain accurate arbitrage profit figures.

The remaining operational issues for an arbitrage transaction are the choices of the risk-free rate and the dividend yield for computing the cost of carry forward rate. Arbitrageurs use the T-bill rate, or the T-bill plus a premium, in order to decide whether to initiate a transaction. Some researchers have employed the CD rate or the broker's call rate as an opportunity rate and financing rate, respectively. The dividend yield should be the dividend yield on the underlying index over the life of the futures contract.[1] The potential risk factor relating to the dividend yield is discussed below.

B. Transactions Costs

Calculating an accurate valuje for the costs of transacting an arbitrage trade are critical to determine if the trade will be profitable. Previous researchers have tended to pick an arbitrary percentage amount, or an arbitrary total cost, choosing values which are too high in comparison to actual institutional costs.

The total costs for a program arbitrage trade involve two cash stock commissions, a round turn futures commission, and one-half the bid-ask spread for both the cash and futures trades. The cash commissions and cash bid-ask spread are the critical factors affecting the total cost of the trade, since they comprise approximately 90% of the total cost. While 7 cents per share each way has been mentioned in the academic literature for the cash commission, the true cost of trading cash stocks for institutions ranges between 3 and 6 cents per share. Three to four cents per share is common when an agency trade is made, i.e. when "best efforts" are attempted to secure the best stock price, while 5 to 6 cents per share is appropriate when the price spread between the futures and cash index is guaranteed. Here we use 3 cents per share each way as the appropriate cost for a low cost arbitrageur. Commissions for futures trades are $12 per round turn for institutions.

The bid-ask spread for cash stocks depend upon the liquidity of the stock. The large capitalization stocks that make up the MMI contact have bid-ask spreads of 1/8 of a point. The largest 250 stocks in the S&P 500 index also have 1/8 spreads, but the smaller 250 stocks have spreads of 1/4 to 3/8. Other stocks on the NYSE have spreads of 3/8 to 1/2. The bid-ask spread found in Stoll and Whaley (1983) of .69% for the largest decile of NYSE stocks is based on 1975-79 data and therefore is too large given the significant increase in trading volume and the general increase in per share price which has occurred since that time. Bid-ask spreads for the futures contracts also depend on liquidity. The S&P 500 contract has a bid-ask spread of 1 tick ($25), while the MMI and NYFE futures have spreads of 2 to 3 ticks (an average of $31 and $62 respectively for the MMI and NYFE contracts).

Arbitrage transaction cost bands need to consider only one-half of the bid-ask spread, since only one side of the transaction has a price risk. The closing transaction for an arbitrage trade is made on a market on close/market on open order, guaranteeing the price of the cash trades which will correspond to the ending futures index. Such orders are appropriate since the futures expiration value is set equal to the market close/open on the expiration day of the futures contract.

C. Risk

Five potential types of risk exist for a stock index futures arbitrage transaction: tracking risk, non-constant dividend payments, dividend uncertainty, mark-to-market effects, and short sale restrictions. Tracking risk exists when the basket of stocks employed as the cash portfolio does not exactly match the cash index composition, either because fewer stocks are purchased or because the weights of the stocks in the cash portfolio differ from those in the cash index. It is simple to generate a portfolio which is equivalent to the MMI index, hence no tracking risk exists for this type of arbitrage. While a no risk arbitrage for the S&P 500 portfolio is more costly to generate, a trade of $25 million provides an exact match to the composition of this cash index. Smaller arbitrage transactions may be generated with a smaller basket of stocks, but such trades are risky. The NYSE index is too costly to duplicate exactly for an arbitrage trade and therefore possesses significant tracking risk.

Dividends are <u>not</u> a constantly decreasing function of time, i.e. dividend payments tend to occur in spikes during each quarter. Specifically, 75% of the dividends for the S&P 500 index are paid during the last seven weeks of the quarter. About 70% of the dividends on MMI stocks are paid in the second month of each quarter. Thus, there is a "seasonality" to dividend payments. In fact, it is possible to have stock index futures selling at a discount to the cash index, which occurs when the actual dividend yield until the settlement of the futures contract exceeds the risk-free rate. Dividend payment uncertainty is another type of risk, although the effect of this risk is minimal since dividends tend to be very predictable over short periods of time. An unexpected dividend increase will increase the profits for the long cash arbitrage and decrease the short arbitrage profits, and vice-versa. These biases associated with the dividend payment schedule have a relatively minor effect in most circumstances (see Saunders and Mahajan (1988, p. 212)). Moreover, temporary intraday arbitrage opportunities would not be significantly affected by these dividend factors.

The marking-to-market of the futures contract creates a cash flow during the life of the arbitrage, causing daily resettlement for traders. However, the effect of marking-to-market on profits is minor in relative terms and therefore is ignored by most researchers (see MacKinlay and Ramaswamy (1988)).

Short sale restrictions create risk for a leveraged arbitrageur who must sell short the individual stocks and buy the futures contract. Since each every stock in the index must trade on an uptick before all of the short sales may be completed, short cash arbitrage is risky for the leveraged arbitrageur.

Consequently, almost all short arbitrage is conducted by quasi-arbitrageurs who sell stocks <u>currently</u> in their portfolio while simultaneously buying futures in order to create a synthetic risk-free transaction. Such transactions are often called stock replacement strategies.

D. The Lag Effect

The literature examined in Section I states that the cash index may lag the futures price by five to 30 minutes. Consequently, <u>apparent</u> arbitrage profits calculated by using simultaneous futures and cash prices may not be the appropriate prices to employ in the analysis. Futures adjust before cash index values for two reasons: the lower costs and higher liquidity in the futures market cause new information to be reflected in the futures prices first, and infrequent trading in smaller stocks in the cash index create timing differences between futures and cash index reported prices. Lag effects would indicate that apparent arbitrage profits exist, when in fact such profits are only illusionary.

III. METHODOLOGY

A. Model and Data

The cost of carry model with transactions bands described in equations (1) to (3) is employed to examine the potential profits from stock index futures arbitrage. Five minute interval data on the three major stock index futures from January 1987 through

June 1988 are used to determine if arbitrage profits exist, as well as to examine the lag effect on arbitrage profits. The five minute interval is chosen in conjunction with the studies on the lead-lag effect and as the typical period for a trader to execute a transaction. Moreover, a five minute interval reduces significantly the chance that any interval for the MMI or NYFE contracts will have zero entries.[2] Correspondingly, only the nearby contracts are employed because of severe liquidity problems for all of the deferred futures contracts. Expiration days are eliminated from the data in order to avoid the adverse effects of expirations on the volatility of the market, as shown in studies of the "triple witching hour" (See Stoll and Whaley (1986, 1988)).

A $25 million portfolio of stocks is used for the arbitrage trade. This corresponds to a S&P 500 arbitrage basket that avoids tracking risk, or alternatively avoids complications relating to odd-lot costs. While $25 million for a MMI or NYFE arbitrage may entail futures liquidity risk, the $25 million size is only employed for comparison purposes; the arbitrage profits for smaller portfolios for these contracts would be a direct proportion of the $25 million portfolio.[3]

The T-bill yield is used as the risk-free interest rate in order to correspond to industry practice. The T-bill rate is changed monthly. The dividend yield on the relevant cash index is employed for the analysis, with the yield changing on a monthly basis.

B. Transactions Costs and Lag Effects

Transactions costs for a low cost arbitrageur are used to determine the transactions bands. Commissions on cash stock transactions are three cents per share each way, with futures commissions being $12 per contract round turn. Bid-ask spreads are determined based on the discussion in the previous section. Lags are examined by employing a five minute lag structure to determine the effects of lags on potential arbitrage profits.

IV. RESULTS

Table 1 shows the average arbitrage profits for a $25 million portfolio, using end of the day and early morning cost of carry comparisons after transactions costs for all three stock index futures contracts. The end of the day results compare futures prices which close 15 minutes later than the cash prices and are shown in column (2).[4] The number of days for the three month futures period for which such profits are available are in column (3). Column (4) gives the results for the early morning contemporaneous prices five minutes after the stock market opens (with no lags in the cash index), while columns (5) and (6) show the effect of a 5 and 15 minute cash index lag. Column (7) presents the number of no lag, five minute intervals with positive arbitrage profits for the early morning results.

TABLE 1 ABOUT HERE

Table 1 shows that using the end of day prices, when the futures close 15 minutes later than the cash market closes, generates apparently large arbitrage profits after transactions costs. Early morning results with no cash lags imply even larger apparent profits. However, the early morning profits decline significantly with a 5 and 15 minute cash lag, i.e. once all stocks in the index trade then the apparent arbitrage profits shown in the early morning disappear. Correspondingly, the large end of day profits are the result of the 15 minute difference in closing times between the futures and cash markets. The significance of these timing effects becomes clearer when the intraday results are examined in Table 3. Table 2 shows the standard deviations for the end of the day and early morning results.

TABLE 2 ABOUT HERE

Table 3 provides the intraday arbitrage results. Column (2) presents the simultaneous futures and cash prices. These profits are significantly smaller than those found in Table 1, especially when the October-December 1987 period is eliminated from the results. In addition, when cash prices are used with a five minute lag (column 3), then the apparent intraday arbitrage profits shown in column (2) of Table 3 essentially disappear for the S&P 500 and MMI contracts (except for the December 1987 period), and the arbitrage profits are reduced substantially for the NYFE contract. In fact, the averages for all periods show that with a 15 minute cash index lag then all three contracts have negative results when the December 1987 period is eliminated. Thus, in general, the lag effect of the cash index explains the simultaneous average arbitrage profits giaven in column (2). In particular, note that the NYFE contract takes a longer time (15 minutes) for the lag effect to take effect. This result is consistent with the liquidity and non-trading effects for smaller stocks on the NYSE.

TABLE 3 ABOUT HERE

Column (5) in Table 3 shows the number of intervals where apparent arbitrage profits exist without a lag. Column (6) presents the average number of time and sales trades per five minute interval for the profitable transactions in the quarter (no lag). Table 3 shows that all three contracts have a large number of apparent arbitrage possibilities per three month period, i.e. prices temporarily deviate outside the transactions bounds, but these deviations are due to the lag effect of the cash index. Table 4 provides the standard deviations for the intraday results. The large standard deviations show that some large potential arbitrage profits exist in some time periods; hence, while on average the cash lag effect indicates that the arbitrage profits are illusionary, some time periods may still provide arbitrage profits.

TABLE 4 ABOUT HERE

V. CONCLUSIONS AND IMPLICATIONS

Several studies on stock index arbitrage have employed end of day data. The results in Tables 1 and 3 show that the end of day results imply that large arbitrage profits exist, when in reality the non-simultaneous nature of the timing mismatch between the futures and cash prices is the dominant factor driving these results. MacKinlay and Ramaswamy (1988) conclude that intraday arbitrage profits are available on a consistent basis. Here we have shown that apparent intraday arbitrage profits are due to the lag between the futures and cash indices. A lag as short as five minutes eliminates apparent profits that seem to exist when simultaneous prices are employed.

FOOTNOTES

[1] MacKinlay and Ramaswamy (1988) use the NYSE yield as a proxy for the S&P 500 yield. They also use CD rates rather than the T-bill rate.

[2] Time and sales data are employed to generate the last price for each five minute interval. Prices in the time and sales record are only recorded when a change in price occurs. Moreover, the number of "trades" in the time and sales record is actually the number of price recordings, not the volume.

[3] Of course, smaller NYFE trades create a greater tracking risk or larger odd-lot commission costs.

[4] Futures stop trading at 4:15 Eastern time while the cash market ends trading at 4:00.

BIBLIOGRAPHY

Cornell, B. "The Weekly Pattern in Stock Returns: Cash Versus Futures: A Note," Journal of Finance Vol. 40, June 1985, pp. 583-588.

Cornell, B., and K. French, "The Pricing of Stock Index Futures," Journal of Futures Markets, Spring 1983a, pp. 1-14.

Cornell, B., and K. French, "Taxes and the Pricing of Stock Index Futures," Journal of Finance, Vol. 38, June 1983b, pp. 675-694.

Finnerty, J.E., and H.Y. Park, "Empirical Evidence on Stock Index Arbitrage: The Case of Program Trading," Journal of Portfolio Management, 1989.

Finnerty, J.E., and H.Y. Park, "Stock Index Futures: Does the Tail Wag the Dog?", Financial Analysts Journal, Vol. 43 No. 2, March-April 1987, pp. 57-61.

Herbst, A.F., J.P. McCormack, and E.N. West, "Investigation of a Lead-Lag Relationship Between Spot Stock Indices and Their Futures Contracts," Journal of Futures Markets, Vol. 7 No. 4, 1987, pp. 373-381.

Kawaller, I., P. Koch, and T.Koch, "The Temporal Relationship Between S&P Futures and the S&P 500 Index," Journal of Finance, Vol. 42, December 1987, pp. 1309-1329.

Laatsch, F.E., and T.V. Schwarz, "price Discovery and Risk Transfer in Stock Index Cash and Futures Markets," Review of Futures Markets, Vol. 7 No. 2, 1988, pp. 272-289.

MacKinlay, C., and K. Ramaswamy, "Index-Futures Arbitrage and the

Behavior of Stock Index Futures Prices," Review of Financial Studies, Summer 1988, pp. 137-158.

Merrick, J. Jr., "Early Unwindings and Rollovers of Stock Index Futures Arbitrage Programs: Analysis and Implications for Predicting Expiration Day Effects," The Journal of Futures Markets, Vol. 9 No. 2, April 1989, pp. 101-112.

Modest, D., and M. Sundaresan, "The Relationship Between Spot and Futures Prices in Stock Index Futures Markets: Some Preliminary Evidence," Journal of Futures Markets, Summer 1983, pp. 15-41.

Stoll, H.R. and R.E. Whaley, "The Dynamics of Stock Index and Stock Index Futures Returns," Working paper, 1988a.

Stoll, H.R., "Index Futures, Program Trading and Stock Market Procedures," Journal of Futures Markets, Vol. 8 August 1987, pp. 391-412.

Stoll, H.R. and R.E. Whaley, "Expiration Day Effects of Index Options and Futures," Monograph Series in Finance and Economics, Vol. 3, 1986, 89 pp.

Stoll, H.R. and R. E. Whaley, "Futures and Options on Stock Indexes: Economic Purpose, Arbitrage, and Market Structure," The Review of Futures Markets, Vol. 7 No. 2, 1988b, pp. 224-249.

Stoll, H.R. and R.E. Whaley, "Program Trading and Expiration Day Effects," Financial Analysts Journal, Vol. 43, March-April 1987, pp. 16-28.

Stoll, H.R. and R.E. Whaley, "Transaction Costs and the Small Firm Effect," The Journal of Financial Economics, Vol. 12

No. 1, 1983, pp. 57-80.

Swinnerton, E.A., R.J. Curcio, and R.E. Bennett, "Index Arbitrage Program Trading and the Prediction of Intraday Stock Price Change," Review of Futures Markets, Vol. 7 No. 2, 1988, pp. 300-323.

TABLE 1
AVERAGE ARBITRAGE PROFITS PER $25 MILLION PORTFOLIO:
END OF DAY AND EARLY MORNING RESULTS
(PROFITS IN THOUSANDS)

Expiration Intervals	End of Day Profits	No. of Days	Early Morning Profits: No Lag	Early Morning Profits: 5 Min Lag	Early Morning Profits: 15 Min Lag	No. of Profitable Intervals (No lag)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. S&P 500						
Mar 87	36.4	13	36.1	- 7.0	-32.6	36
Jun 87	52.0	23	98.4	33.4	0.4	42
Sep 87	42.6	18	29.2	-16.8	-28.1	36
Dec 87	98.5	24	333.3	235.0	178.8	73
Mar 88	74.9	15	91.9	12.8	-20.1	38
Jun 88	57.0	24	56.2	10.8	-11.7	40
B. MMI						
Mar 87	30.8	9	40.7	-4.6	-20.6	29
Jun 87	36.5	27	74.2	12.6	- 3.2	50
Sep 87	22.6	22	29.1	-2.1	- 8.4	47
Dec 87	159.5	22	363.2	266.7	182.2	65
Mar 88	52.6	17	87.9	16.6	-14.5	33
Jun 88	25.5	19	53.9	2.3	-19.4	36
C. NYFE						
Mar 87	69.2	6	50.1	.3	-27.4	59
Jun 87	82.4	19	110.7	53.1	10.5	39
Sep 87	42.5	6	37.0	-10.8	-39.0	16
Dec 87	85.6	21	329.7	233.7	124.6	69
Mar 88	96.1	13	119.9	37.2	-21.2	

28

Jun 88	54.4	17	59.6	13.9	-13.5
					39
D. AVERAGES					
S&P 500					
with Dec87	60.2	29.5	107.5	44.7	14.4
					44.2
w/o Dec87	52.6	18.6	62.4	6.6	-18.4
					38.4
MMI					
with Dec87	54.6	19.3	108.2	48.6	19.4
					43.3
w/o Dec87	33.6	18.8	57.2	5.0	-13.2
					39.0
NYFE					
with Dec87	71.7	13.7	117.8	54.6	5.7
					41.7
w/o Dec87	68.9	12.2	75.5	18.7	-18.1
					36.2

TABLE 2
STANDARD DEVIATIONS FOR THE END OF DAY AND
EARLY MORNING ARBITRAGE RESULTS
PER $25 MILLION PORTFOLIO
(IN THOUSANDS)

Expiration	End of Day	Early Morning		
		No Lag	5 Min Lag	15 Min Lag
(1)	(2)	(3)	(4)	(5)
A. S&P 500				
Mar 87	31.0	37.3	30.6	26.2
Jun 87	42.0	113.4	94.5	57.5
Sep 87	47.2	24.1	24.5	22.6
Dec 87	98.5	814.1	807.2	747.1
Mar 88	75.8	143.5	99.5	64.9
Jun 88	80.3	63.6	36.7	39.4
B. MMI				
Mar 87	25.1	45.5	38.6	36.0
Jun 87	32.0	77.5	61.0	32.0
Sep 87	14.1	26.4	29.4	30.2
Dec 87	499.5	602.4	581.9	496.3
Mar 88	42.3	133.0	89.5	56.2
Jun 88	16.2	82.1	47.8	30.2
C. NYFE				
Mar 87	39.2	32.9	27.7	26.5
Jun 87	80.3	134.6	113.7	77.4
Sep 87	29.8	25.2	23.3	34.2
Dec 87	74.4	647.2	633.8	583.8
Mar 88	91.6	154.7	122.2	68.4
Jun 88	61.4	68.8	51.6	51.5
D. AVERAGES				
S&P 500				
with Dec87	62.5	199.3	182.2	159.7
w/o Dec87	55.2	76.4	57.2	42.1
MMI				
with Dec87	104.9	161.2	141.4	113.5
w/o Dec87	25.9	72.9	53.3	36.9
NYFE				
with Dec87	62.8	177.2	162.1	140.3
w/o Dec87	60.5	83.2	67.7	51.6

TABLE 3
AVERAGE ARBITRAGE PROFITS PER $25 MILLION PORTFOLIO:
INTRADAY RESULTS
(PROFITS IN THOUSANDS)

Expiration	Intraday Results			Number of Profitable Intervals (No lag)	Number of Trades Per Column (5) Interval
	No Lag	5 Min Lag	15 Min Lag		
(1)	(2)	(3)	(4)	(5)	(6)
A. S&P 500					
Mar 87	21.3	-2.5	-10.7	280	31
Jun 87	24.8	6.9	- 2.3	735	35
Sep 87	11.5	-7.3	-16.1	474	29
Dec 87	194.0	167.6	146.5	1339	32
Mar 88	24.1	-1.8	-13.8	508	30
Jun 88	26.4	13.0	.9	930	28
B. MMI					
Mar 87	18.8	3.3	-6.4	571	16
Jun 87	17.7	-1.3	-11.0	788	21
Sep 87	18.9	8.8	1.2	1053	19
Dec 87	250.2	225.8	205.0	1268	17
Mar 88	24.8	5.8	- 4.0	695	13
Jun 88	17.2	.5	- 8.8	583	14
C. NYFE					
Mar 87	35.1	6.1	- 3.7	140	13
Jun 87	38.0	21.3	7.5	655	18
Sep 87	13.1	-12.7	-23.9	111	13
Dec 87	138.3	116.7	94.6	1229	16
Mar 88	42.2	22.5	8.2	452	14
Jun 88	31.0	19.2	7.6	708	14
D. AVERAGES					
S&P 500					
with Dec87	50.4	29.3	17.8	711	30.8
w/o Dec87	21.6	1.7	- 7.9	585	30.6
MMI					
with Dec87	57.9	40.5	31.5	826	16.7
w/o Dec87	19.5	3.4	- 3.2	738	16.6
NYFE					
with Dec87	49.6	28.9	15.7	549	14.7
w/o Dec87	31.9	11.3	- .1	413	14.4

TABLE 4
STANDARD DEVIATIONS FOR THE INTRADAY ARBITRAGE RESULTS
PER $25 MILLION PORTFOLIO
(IN THOUSANDS)

Expiration	Intraday Results		
	No Lag	5 Min Lag	15 Min Lag
(1)	(2)	(3)	(4)
A. S&P 500			
Mar 87	34.1	30.4	34.2
Jun 87	26.1	28.6	30.3
Sep 87	11.8	19.4	22.3
Dec 87	338.3	333.0	316.6
Mar 88	30.9	34.8	38.7
Jun 88	38.5	39.8	44.3
B. MMI			
Mar 87	17.5	22.0	25.6
Jun 87	29.9	27.2	25.2
Sep 87	17.6	22.0	24.8
Dec 87	389.9	386.6	378.4
Mar 88	26.7	30.6	33.3
Jun 88	17.6	21.6	25.4
C. NYFE			
Mar 87	63.9	55.1	53.4
Jun 87	40.8	38.6	42.8
Sep 87	12.4	21.8	26.9
Dec 87	242.9	233.0	220.2
Mar 88	44.9	42.5	50.0
Jun 88	34.2	34.4	40.6
D. AVERAGES			
S&P 500			
with Dec87	79.9	81.0	81.1
w/o Dec87	28.3	30.6	34.0
MMI			
with Dec87	83.2	85.0	85.4
w/o Dec87	21.9	24.7	26.9
NYFE			
with Dec87	73.2	70.9	72.3
w/o Dec87	39.2	38.5	42.7