USING INTRADAY DATA TO TEST FOR EFFECTS OF INDEX FUTURES ON THE UNDERLYING STOCK MARKETS

HONG CHOI
AVANIDHAR SUBRAHMANYAM

INTRODUCTION

Since their introduction in 1982, stock index futures have become one of the most actively traded types of futures contracts. An issue of significant interest is the effect of such futures on the liquidity and volatility of the underlying stock markets. Index futures markets, by siphoning away trading from the underlying stocks, may lower market liquidity (increase bid–ask spreads) which may lead to decreased investor interest and participation in the stock market. Further, high levels of stock market volatility due to index futures trading may imply higher costs of capital for individual firms. Thus, examining the impact of index futures on the underlying stock spreads and volatilities is of considerable significance, both from a regulatory and practical perspective.

The authors thank Frank Edwards, Andrew Gardner, Larry Glosten, Larry Harris, Joel Hasbrouck, and especially two anonymous referees for extremely helpful comments and/or discussions. Financial support from the Center for the Study of Futures Markets is gratefully acknowledged.

- *Hong Choi is an Analyst at Bear Stearns and Co., New York.*
- *Avanidhar Subrahmanyam is an Associate Professor in the Finance Department, Anderson Graduate School of Management, University of California, Los Angeles.*

The Journal of Futures Markets, Vol. 14, No. 3, 293–322 (1994)

CCC 0270-7314/94/030293-30

Hypotheses on how underlying stock bid–ask spreads can be affected by index futures are formulated as follows. In the market microstructure literature, the bid–ask spread can be decomposed into three parts: the fixed cost, the inventory, and the asymmetric information component. The first component compensates market makers for fixed costs associated with making the market, the second compensates them for inventory holding costs due to risk aversion, and the third arises because market makers face the possibility of trading with individuals who possess superior information. Gammill and Perold (1989), Harris (1990), Gorton and Pennacchi (1993), and Subrahmanyam (1991) have discussed possible effects of the introduction of markets in "baskets" of stocks (i.e., index futures). In particular, these authors suggest that index futures markets may draw away uninformed traders from the underlying stock markets and may also stimulate additional trading on market-wide information, because firm-specific informational asymmetries are far lower in the index futures market. As the above authors point out, the migration of uninformed traders can exacerbate the asymmetric information problem between the market maker and the pool of potential traders in stock markets and may result in decreased stock market liquidity. Put another way, if uninformed portfolio traders shift to the index futures market, then to protect themselves from the increased probability of transacting with informed traders, market makers will widen their bid–ask spreads [see Glosten and Milgrom (1985)]. However, spreads may also increase if the futures contract stimulates additional trading on macroeconomic information, which spills over to the cash market through index arbitrage activities. If the migration of uninformed traders dominates, it should cause a concomitant reduction in trading volume, while if the effect of additional informed trading dominates, trading volume in the underlying stocks should increase. Another hypothesis is that the introduction of a futures market may provide market makers with an opportunity to more effectively hedge their inventory risk, thereby helping them lower the inventory cost component of the spread. Some of these hypotheses are examined in Jegadeesh and Subrahmanyam (1993), who analyze changes in *end-of-day* bid–ask quotes for S&P 500 stocks around the introduction of the S&P 500 futures contract.

Turning now to volatility, a prominent hypothesis is that index futures contracts "destabilize" the cash market by encouraging arbitrage-related activities which use controversial techniques such as program trading, thus increasing short-run price swings. In fact, since the 1987 crash, groups of regulators and practitioners have attempted to link the increased market volatility in this period to the index futures contracts and suggested tighter regulation of these markets. [See, for example, U.S. Securities and Exchange Commission (1988); the *Report of the Market Volatility and Investor Confidence Panel,* New York Stock Exchange (1990); and the *Presidential Task Force on Market Mechanisms* (1988).] A contrasting hypothesis is that if index futures lead to increased market-wide informed trading, prices may impound information more efficiently, so that volatility in the underlying stocks may decrease.

Considerable research [e.g., Harris (1989); Edwards (1988); Damodaran (1990)] has focused on the effect of the S&P 500 futures contract on cash market volatility. These studies have invariably used daily closing stock market data to compute and analyze volatility. However, much of the concern surrounding derivative markets appears to have an *intraday* flavor to it. For example, one does not expect the impacts of index arbitrage-related trades or the trades of large institutions to show up in daily volatility computations, because such impacts are short-run. For this reason, explicit usage of intraday data can potentially add considerable perspective to the issue of whether index futures markets can "destabilize" the underlying cash markets.

The most recent entrant into the category of index futures is the Major Market Index (MMI) futures contract, which was introduced by the Chicago Board of Trade in July 1984. This contract attracted considerable investor attention: The average daily dollar trading volume in the contract within five months of its inception amounted to about 78% of the dollar trading volume of the 20 stocks comprising the MMI during this period (see Table I). This article examines the impact of this futures contract on the bid–ask spread, the degree of asymmetric information, trading volume, and intraday volatility in the underlying stock markets, by analyzing intraday stock market data for the year 1984.

Given that the popular S&P 500 contract had been trading for about two years when the MMI was introduced, a natural question that arises is whether a priori, one can expect any effect of the MMI futures on the underlying stocks other than that induced by the introduction of the S&P 500 contract (note that all MMI stocks belong to the S&P 500 as well). For example, if the S&P 500 and MMI contracts are close substitutes as hedging vehicles, one could argue that the impact of the

TABLE I
Dollar Trading Volume of MMI Stocks and MMI Futures: July, 1984 to December, 1984 (Billions of Dollars)[a]

	Dollar Volume		
Month (1984)	*MMI Stocks*	*MMI Futures*	*Ratio (Futures/Stocks)*
July	2.92	1.73	0.59
August	8.85	8.37	0.95
September	8.88	5.55	0.63
October	9.78	6.29	0.64
November	7.92	6.61	0.83
December	7.68	7.51	0.98
Total	46.03	36.06	0.78 (mean)

[a]The daily dollar volume for MMI stocks is obtained by multiplying the daily total transaction volume by the average daily price. The monthly dollar volume for MMI futures is obtained by multiplying the monthly total transaction volume by 100 times the month-end closing MMI index value (as per the definition of the Major Market Index).

MMI futures on hedging opportunities would be marginal. The present study, however, is justifiable in several ways. First, the hypotheses on liquidity and volatility developed above are not invalidated by there being an extant index futures contract when a new one is introduced. For example, suppose that many investors held small portfolios that corresponded to popular blue-chip stocks when the MMI futures were introduced. These investors could well have preferred doing short-term adjustments to their portfolios in the MMI contract rather than the S&P 500 contract (which is based on a much larger portfolio), and could have migrated away to the futures market. One also expects index arbitrage to occur in both the MMI and the S&P 500 contracts. In fact since the MMI is presumably an easier index to replicate, one may make a case for *more* index arbitrage activity in the case of MMI futures. In addition, for market makers in blue chip stocks, the MMI contract may well be a more efficient hedging vehicle than the S&P 500 contract.

More support for the above motivation is provided by the fact that trading in MMI futures in relation to the spot market is significant in relation to the trading in the underlying stocks for the sample period considered. Table I presents the ratio of dollar trading volume in MMI futures and in the underlying stocks for the five months following the contract's introduction and indicates that it is actively traded throughout the sample period considered. In fact, it attained considerable popularity in a short time span, as evidenced by the average futures-cash daily dollar volume ratio of 98% five months following the introduction of the contract.

Finally, while reliable intraday quote and transaction data is available for the period surrounding the introduction of the MMI futures contract, the same is not true for the period around the introduction of the S&P contract. (The Institute for the Study of Security Markets (ISSM), the prime supplier of intraday data for research purposes, does not provide intraday data for the year 1982.) By examining the validity of the hypotheses developed above for the case of MMI futures, the study is able to take advantage of a finer set of data points, and thereby perform potentially more powerful tests.

The study initially uses intraday quote and transaction data to test for effects of the futures contract on the average quoted bid–ask spread in the underlying stock markets. A standard analysis-of-covariance regression methodology attempts to control for other spread determinants that may have changed around the time of the introduction of the MMI futures contract, using two industry-based control samples, one of S&P 500 stocks not on the MMI, and another of non-S&P 500 stocks. Barclay and Smith (1988) and Harris (1989) use similar methodologies to examine spread changes around stock repurchases and changes in S&P 500 stock volatilities following the introduction of S&P 500 futures, respectively.

Next, motivated by the arguments of Gammill and Perold (1989); Gorton and Pennacchi (1993); and Subrahmanyam (1991), the study tests for changes in the degree of asymmetric information and trading volume around the introduction of the MMI contract. A vector autoregressive (VAR) approach recently developed by Hasbrouck (1991), and another technique developed by Glosten and Harris (1988) and extended by Madhavan and Smidt (1991), are used to estimate the degree of asymmetric information in the stock samples before and after the introduction of the MMI contract. The advantage of these approaches is that they are relatively easy to implement on intraday data and have appealing intuitive interpretations.[1]

In the final part of the analysis, the study examines whether the introduction of MMI futures affects the intraday volatility level of MMI stocks, as measured by the intraday standard deviation of quote midpoints, to account for bid–ask bounce effects.

[1] It would also be of interest to analyze changes in average depth, i.e., the number of shares for which quotes are valid, around the introduction of MMI futures. Unfortunately, depth data in the ISSM tapes for the year 1984 contain serious errors and do not lend themselves to a satisfactory analysis.

DESCRIPTION OF SAMPLES AND DATA

Trading in MMI futures commenced on July 23, 1984. The analysis is conducted on intraday data for the year 1984 and uses three samples of stocks. The first sample consists of the 20 stocks in the MMI. The second sample consists of stocks on the S&P 500 but not on the MMI, and the third of stocks neither on the MMI nor on the S&P 500. Each stock in the second and third samples is chosen to mimic a particular stock in the MMI sample, as described in the two following paragraphs. Thus the two control groups also consist of 20 stocks each. The usage of two (i.e., S&P 500 and non-S&P 500) control samples is justified because the literature has documented the anomalous behavior of S&P 500 stocks. This behavior (e.g., significant price moves when stocks are added or dropped from the index) is often attributed to disproportionate institutional interest in such stocks, simply because they belong to a widely popular index. [See Harris and Gurel (1986); Shleifer (1986); Pruitt and Wei (1989).] Since all MMI stocks also belong to the S&P 500, and because well-diversified institutional portfolios are often good substitutes for each other, any change in institutional investing behavior due to the introduction of the index futures contract could also have spilled over the S&P 500 stocks.

The two control groups are matched based on industry and firm size. Intertemporal and cross-sectional variations in industry-specific news flows can be expected to create variations in spreads and volatility, which the matching attempts to control. Further, one expects size to be a significant factor affecting cross-sectional variation in spreads [because trading volume in large firms is generally higher—see Stoll (1978b) and Benston and Hagerman (1974)] and volatility [larger firms are generally well-diversified and less subject to catastrophic events—see Harris (1989)]. In the actual analysis, the study also uses other spread determinants in a further attempt to control for cross-sectional and intertemporal spread variations.

The mechanics of the matching procedure are as follows. First, MMI stocks are classified into various industry groups using SIC codes. Then, among the stocks in the S&P 500 index, the largest NYSE listed firm in each industry category corresponding to the MMI stocks is selected for the S&P 500 stock group.[2] However, if the candidate firm

[2]The candidate firms are required to be listed on the New York Stock Exchange (NYSE), because all the MMI firms are traded on the NYSE, and trading protocols and the extent of competition vary on other exchanges and in the over-the-counter market.

is not present on the index at any time during the sample period, it is excluded from consideration. The 20 non-S&P 500 index stocks are selected in a similar way. In this case, for a firm to be a candidate for inclusion, it should never have been listed on the S&P index during the sample period (i.e., the year 1984). In some cases firms in the proper matching categories are not available. In those instances, control firms are selected from closely related industries. The ticker symbols of the firms in the three stock groups, their industry categories, SIC codes, and market values are listed in the Appendix.

The analysis is conducted using intraday data provided by the Institute for the Study of Security Markets (ISSM) for the calendar year 1984. This data set provides intraday bid–ask quotes as well as transaction prices and quantities for each stock traded on the NYSE or the American Stock Exchange. Within each security, the processing of raw transaction data is performed as follows. First, quotations and transactions reported out of sequence are excluded. Second, the overnight price change and the closing quotes are replaced with missing values to control for differences with the opening and closing procedures, dividends, and overnight news arrival. Third, to control for reporting errors, an error filter is employed. The filter discards a trade or a quote if the price (or the midpoint of the quote) is more than four times the width of the range beyond the bounds of the range for three successive trades (or quote updates). For example, if XYZ stock's quote midpoint is 9.5, and the midpoints of the next two posted quotes are 12 and 10, respectively, then the range is 0.5 (10.0 minus 9.5). The quote midpoint of 12 is two points from the upper boundary which is not more than four times 0.5, so the trade is not discarded. However, if the quote midpoint following the midpoint of 12 is 9.875 rather than 10, then the range width is 0.375 and the quote of 12 is discarded. An analogous filter holds for transaction prices. These filters discard fewer than 1 in 40,000 observations in the sample considered and the estimates documented are virtually unchanged with and without the filters.

EMPIRICAL TESTS AND RESULTS

This section tests the hypothesis that index futures contracts, either by causing uninformed traders to migrate away from the stock market or by stimulating additional informed trading on market-wide factors, can increase bid–ask spreads in the markets for the underlying stocks. A contrasting hypothesis is that index futures markets can decrease spreads by facilitating inventory hedging by market makers. The inventory hedging hypothesis also implies that the sensitivity of stock market spreads to volatility may decline because of more efficient hedging by market makers. This issue is also analyzed and some hypotheses are tested—derived from Gammill and Perold (1989); Harris (1990); Gorton and Pennacchi (1993); and Subrahmanyam (1991)—that index futures can draw away uninformed portfolio traders and/or stimulate macro-informed trading, and thereby increase informational asymmetry in the underlying stock markets. This section also tests for changes in trading volume around the introduction of the index futures contract, because the hypotheses advanced by the above authors have volume implications as well. Finally, the "destabilization" hypothesis is tested by examining whether the introduction of the MMI futures contract leads to an increase in the intraday volatility level of the MMI sample.

The Bid–Ask Spread

The regression model for analyzing changes in the bid–ask spread pools time-series and cross-sectional data, adjusting for time-series and cross-sectional variations in three firm-specific variables: price, return volatility, and volume. Several studies, e.g., Benston and Hagerman (1974), Stoll (1978b), and Barclay and Smith (1988), have estimated spread models based on these three variables and found that they explain a significant portion of the cross-sectional and intertemporal variation in bid–ask spreads. Demsetz (1968) and Stoll (1978a) discuss the intuition behind why these variables should affect spreads. Demsetz (1968, p. 45) argues that raw spreads should be higher for larger priced stocks to equate costs of transacting per dollar traded in equilibrium. Stoll (1978) argues that a larger volatility level implies greater inventory risk as well as greater potential profits for informed traders and hence implies higher spreads. Further, a higher trading volume facilitates the offsetting of inventory imbalances and hence should result in a lower spread. A trend variable is included in the regression model to capture intertemporal patterns in spreads which are not captured by changes in the three variables above.[3] The regression model allows for heterogeneity in the slope coefficients across the three samples, as well as heterogeneity in the pre- and post-futures period *within* each sample. Tests for evidence of the latter are of particular relevance. Thus, the regression model is

[3]The trend variable is not very crucial to the analysis. Qualitatively similar, but slightly weaker results are obtained when the trend variable is excluded.

as follows:

$$
\begin{aligned}
SP_{it} = {} & \alpha_0 + b_0 STD_{it} + b_1\mathrm{PRICE}_{it} + b_2\mathrm{VOL}_{it} + DM_{it}(\gamma_0 \\
& + b_3 STD_{it} + b_4\mathrm{PRICE}_{it} + b_5\mathrm{VOL}_{it}) \\
& + DS_{it}(\delta_0 + b_6 STD_{it} + b_7\mathrm{PRICE}_{it} + b_8\mathrm{VOL}_{it}) + D_{it}\{(\alpha_1 \\
& + b_9 STD_{it} + b_{10}\mathrm{PRICE}_{it} + b_{11}\mathrm{VOL}_{it}) \\
& + DM_{it}(\gamma_1 + b_{12} STD_{it} + b_{13}\mathrm{PRICE}_{it} + b_{14}\mathrm{VOL}_{it}) + DS_{it}(\delta_1 \\
& + b_{15} STD_{it} + b_{16}\mathrm{PRICE}_{it} + b_{17}\mathrm{VOL}_{it})\} + b_{18} T_{it} + e_{it} \qquad (1)
\end{aligned}
$$

where SP_{it} is the average spread (the ask quote minus the bid quote) of stock i during day t, STD_{it} is the intraday return standard deviation (calculated on the basis of changes in quote midpoints) of stock i during trading day t, VOL_{it} is the total trading volume in stock i during day t, PRICE_{it} is the closing price of stock i on day t, D_{it} is 1 for the post-MMI period and zero otherwise, DM_{it} is 1 for the MMI stocks and zero otherwise, DS_{it} is 1 for the S&P 500 control sample and zero otherwise, and T_{it} is a trend variable which takes on the value t in period t. To control for serial correlation and heteroskedasticity, a Generalized Least Squares (GLS) technique is employed, the technical details of which are available from the authors.[4]

In the above regression specification, the estimates of $\alpha_1 + \gamma_1$, $\alpha_1 + \delta_1$, and α_1 are of primary interest. $\alpha_1 + \gamma_1$ is the average difference between MMI stock spreads in the pre- and post-futures periods, and $\alpha_1 + \delta_1$ and α_1 have similar interpretations for the S&P 500 and non-S&P 500 groups, respectively. Table II presents simple tests for shifts in mean intraday spreads and shows that spreads for MMI stocks do not change significantly in the post-MMI futures period ($t = 0.29$) while those for the other two groups decrease significantly ($t = -2.99$ and -5.30 respectively).[5] As a further check, Table III presents the average spread during the 7 months preceding the introduction of the

[4]Though the regression results reported for the spread and volatility analyses are for the pooled sample consisting of all three subsamples (i.e., MMI, non-MMI S&P 500, and non-S&P 500), qualitatively similar results are obtained upon running separate regressions (with dummy variables for the pre- versus post-futures periods) for each of the three subsamples. These results are available from the authors upon request.

[5]The question arises as to whether it is feasible to expect any spread decrease for the MMI sample, given that all these stocks trade in very liquid markets. Note, however, that the "theoretical" minimum for spreads on the NYSE is 12.5¢, given the minimum tick size restriction. From Table II, the average spread for this sample is close to 20¢, leaving ample room for a further decrease.

TABLE II

Changes in Average Daily Spreads for MMI Stocks, the S&P 500 Control Group, and the Non-S&P 500 Control Group in 1984[a]

MMI Stocks	
Pre-futures	0.20739
Post-futures	0.20776
t-statistic	0.29
Prob > |*t*|	0.77
S&P 500 Group	
Pre-futures	0.24489
Post-futures	0.23757
t-statistic	−2.99
Prob > |*t*|	0.00
Non-S&P 500 Group	
Pre-futures	0.29555
Post-futures	0.28181
t-statistic	−5.30
Prob > |*t*|	0.00

[a]Quote-by-quote data is used to obtain daily average spreads. These numbers are then averaged over each period.

MMI futures contract and compares it with the average spread in each of the five months following the introduction of the futures contract. The results obtained are qualitatively similar.

Table IV lists the parameter estimates obtained from running the regression (1). The signs of the estimates for the coefficients of volatility, trading volume, and the price level are as expected. The coefficient on the trend variable, which captures spread shifts due to changes in macroeconomic variables, is significant ($t = -3.88$), indicating that spreads tend to shift downward during the sample period. Table V tests for changes in the spread after accounting for changes in the explanatory variables and indicates that the t-value of the change in the intercept for MMI stocks is 2.32. This implies that the average spread, after accounting for changes in the explanatory variables, increases significantly in the post-futures period for the MMI sample. The t-value for the change in the intercept for the S&P 500 group is 1.94, which is suggestive of a weak spillover effect of introducing futures on the S&P 500 group. The spread in the non-S&P 500 sample exhibits markedly different behavior: it *declines*

TABLE III

Month-by-Month Changes in Average Daily Spreads for MMI Stocks, the S&P 500 Control Group, and the Non-S&P 500 Group in 1984[a]

MMI Stocks	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*
Pre-futures[b]	0.20739	0.20739	0.20739	0.20739	0.20739
Post-futures[c]	0.21126	0.21152	0.20798	0.20122	0.20597
t-statistic	1.78	1.65	0.28	−3.01	−0.65
Prob > $\|t\|$	0.08	0.10	0.78	0.00	0.52
S&P 500 Group	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*
Pre-futures	0.24489	0.24489	0.24489	0.24489	0.24489
Post-futures	0.24719	0.23631	0.23467	0.22976	0.23781
t-statistic	0.57	−2.12	−2.53	−3.77	−1.63
Prob > $\|t\|$	0.57	0.03	0.01	0.00	0.10
Non-S&P 500 Group	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*
Pre-futures	0.29555	0.29555	0.29555	0.29555	0.29555
Post-futures	0.28488	0.27932	0.27983	0.27940	0.28515
t-statistic	−2.63	−3.72	−3.66	−3.47	−2.19
Prob > $\|t\|$	0.01	0.00	0.00	0.00	0.03

[a]Quote-by-quote data are used to obtain daily average spreads. These numbers are then averaged over each period.
[b]The pre-futures period is the 7-month period from January to July 1984.
[c]The post-futures period is a particular month in the post-futures period (Aug., Sep., Oct., etc.).

significantly after accounting for changes in other spread determinants ($t = -4.53$). None of the point estimates appear *economically* significant: Table V indicates average increases of less than a cent each for the MMI and the S&P samples, and an average decrease of about two cents for the non-S&P 500 sample.[6] The results appear to be broadly consistent with those of Jegadeesh and Subrahmanyam (1993), who analyze changes in end-of-day bid–ask quotes for the S&P 500 stocks around the introduction of the S&P 500 contract,

[6]Using volume as a control variable in the regression (1) should be viewed with some caution. If the introduction of futures indeed causes many uninformed traders to move from the stock market to the futures market or causes increased informed trading on market-wide factors, volume in the stock market may change following the introduction of the futures contract. However, the results from running a regression similar to (1) that excludes trading volume as one of the explanatory variables are almost identical to the ones described above. These results are available from the authors upon request. Note, however, that if index futures cause uninformed portfolio traders to migrate away from the stock market or increase informed trading on market-wide factors, then, even after controlling for trading volume, spreads of MMI stocks should show an increase. This is because in either event, the proportion of informed traders in the market increases following the introduction of index futures. [See Glosten and Milgrom (1985) for a demonstration that the bid–ask spread is increasing in this proportion.]

TABLE IV

Parameter Estimates of Regression Model (6): (Pooled Cross-Sectional Time-Series Regression)[a]

Variable		*Parameter*	*T-Value*	*Prob* > |*T*|
Constant	(α_0)	0.2602	23.22	0.00
STD	(b_0)	1.903	12.52	0.00
PRICE	(b_1)	0.00123	7.70	0.00
VOL	(b_2)	−7.11E-6	−3.78	0.00
DM	(γ_0)	−0.0693	−4.15	0.00
DM * *STD*	(b_3)	−1.845	−10.68	0.00
DM * PRICE	(b_4)	−0.00083	−3.95	0.00
DM * VOL	(b_5)	7.05E-6	3.70	0.00
DS	(δ_0)	−0.0620	−3.85	0.00
DS * *STD*	(b_6)	−1.322	−5.64	0.00
DS * PRICE	(b_7)	−2.59E-4	−1.36	0.17
DS * VOL	(b_8)	6.47E-6	3.36	0.00
D	(α_1)	−0.0198	−4.53	0.00
D * *STD*	(b_9)	3.277	10.35	0.00
D * PRICE (b_{10})		7.59E-6	0.06	0.95
D * VOL (b_{11})		1.55E-6	0.66	0.51
D * *DM*	(γ_1)	0.0289	5.63	0.00
D * *DM* * *STD* (b_{12})		−3.326	−10.11	0.00
D * *DM* * PRICE (b_{13})		−4.02E-5	−0.31	0.76
D * *DM* * VOL (b_{14})		−1.63E-6	−0.69	0.49
D * *DS*	(δ_1)	0.0291	4.99	0.00
D * *DS* * *STD* (b_{15})		−3.827	−10.38	0.00
D * *DS* * PRICE (b_{16})		−1.44E-4	−1.04	0.30
D * *DS* * VOL (b_{17})		−2.02E-6	−0.84	0.40
T (b_{18})		−7.21E-5	−3.88	0.00

[a] $SP_{it} = \alpha_0 + b_0\mathrm{STD}_{it} + b_1\mathrm{PRICE}_{it} + b_2\mathrm{VOL}_{it} + DM_{it}(\gamma_0 + b_3\mathrm{STD}_{it} + b_4\mathrm{PRICE}_{it} + b_5\mathrm{VOL}_{it})$
$+ DS_{it}(\delta_0 + b_6\mathrm{STD}_{it} + b_7\mathrm{PRICE}_{it} + b_8\mathrm{VOL}_{it}) + D_{it}\{(\alpha_1 + b_9\mathrm{STD}_{it} + b_{10}\mathrm{PRICE}_{it} + b_{11}\mathrm{VOL}_{it})$
$+ DM_{it}(\gamma_1 + b_{12}\mathrm{STD}_{it} + b_{13}\mathrm{PRICE}_{it} + b_{14}\mathrm{VOL}_{it}) + DS_{it}(\delta_1 + b_{15}\mathrm{STD}_{it} + b_{16}\mathrm{PRICE}_{it} + b_{17}\mathrm{VOL}_{it})\}$
$+ b_{18}T_{it} + e_{it}$

where

- SP_{it} = (ask price − bid price) of stock *i* during time *t*.
- D_{it} = dummy variable that takes 1 for the post-MMI futures period and 0 otherwise.
- STD_{it} = standard deviation of returns for stock *i* during time *t*.
- PRICE_{it} = average price of stock *i* during time *t*.
- VOL_{it} = total trading volume of stock *i* during time *t*.
- D_{it} = dummy variable that takes a value of 1 for post-MMI period and 0 otherwise.
- DM_{it} = dummy variable that takes a value of 1 for MMI stocks and 0 otherwise.
- DS_{it} = dummy variable that takes a value of 1 for the S&P 500 group and 0 otherwise.
- T_{it} = trend variable which has a value of *t* during period *t*.

TABLE V

Tests for Changes in the Intercept and for Structural Shifts Based on Regression (1)

I. Changes in the Intercept

Group	*Parameters*	*t-Value*	*Prob* > |*t*|
$MMI_A - MMI_B$	$\alpha_1 + \gamma_1 = 0.0091$	2.32	0.02
$S\&P_A - S\&P_B$	$\alpha_1 + \delta_1 = 0.0093$	1.94	0.05
$N\text{-}S\&P_A - N\text{-}S\&P_B$	$\alpha_1 = -0.0198$	−4.53	0.00

II. Changes in the Coefficients of Explanatory Variables

1) STD

Group	*Parameters*	*t-Value*	*Prob* > |*t*|
$MMI_A - MMI_B$	$b_9 + b_{12} = -0.0486$	−0.54	0.58
$S\&P_A - S\&P_B$	$b_9 + b_{15} = -0.550$	−2.91	0.00
$N\text{-}S\&P_A - N\text{-}S\&P_B$	$b_9 = 3.277$	10.35	0.00

2) PRICE

Group	*Parameters*	*t-Value*	*Prob* > |*t*|
$MMI_A - MMI_B$	$b_{10} + b_{13} = -3.27E\text{-}5$	−0.60	0.53
$S\&P_A - S\&P_B$	$b_{10} + b_{16} = -1.37E\text{-}4$	−1.93	0.05
$N\text{-}S\&P_A - N\text{-}S\&P_B$	$b_{10} = 7.59E\text{-}6$	0.06	0.95

3) VOL

Group	*Parameters*	*t-Value*	*Prob* > |*t*|
$MMI_A - MMI_B$	$b_{11} + b_{14} = -7.90E\text{-}8$	−0.24	0.82
$S\&P_A - S\&P_B$	$b_{11} + b_{17} = -4.73E\text{-}7$	−0.78	0.45
$N\text{-}S\&P_A - N\text{-}S\&P_B$	$b_{11} = 1.55E\text{-}6$	0.66	0.51

and also find a statistically significant but economically insignificant increase in S&P 500 bid–ask quotes following the introduction of the S&P 500 contract.

Turning now to the structural changes in the relations between the spread and the independent variables, Table V suggests that while there is no significant structural change for the MMI sample, the sensitivity of the spread to volatility decreases for the S&P 500 sample and increases for the non-S&P 500 sample (t-values for the three samples are −0.54, −2.91, and 10.35, respectively). These results do not seem consistent with any plausible hypothesis. For example, the hypothesis that index futures facilitate inventory hedging and cause market makers to decrease the sensitivity of spreads to volatility predicts a decrease in volatility sensitivity for the MMI sample, which the study does not find. The increase in the volatility sensitivity for the non-S&P 500 sample is also quite puzzling. The authors have not been able to obtain a satisfactory explanation for the nature of these structural shifts; however, the shifts do not appear to be related to the introduction of the MMI futures contract.

The Amount of Private Information Conveyed by a Trade

As noted earlier, if an index futures contract does draw away uninformed portfolio traders from the underlying stocks, one expects the degree of asymmetric information in the underlying stock markets to increase following its introduction. However, the degree of asymmetric information may also increase if the introduction of the futures contract stimulates additional informed speculation on macroeconomic factors in the futures market, which could spill over to the cash market, either because market-wide informed traders use both the cash and futures market to exploit their information, or because of index arbitrage activities.[7] Within the context of the present study, if the migration effect, rather than the informed-trading effect dominates, one expects to see a decrease in trading volume in the MMI (and possibly the S&P) samples to accompany an increase in the degree of asymmetric information in the stock market. On the other hand, if the macroeconomic informed trading effect dominates, one expects an *increase* in trading volume for the MMI sample to accompany an increase in the degree of asymmetric information. The analysis below examines changes in both the degree of asymmetric information and average trading volume to shed light on which hypothesis is best supported by the data.

Several approaches have been used in the literature to estimate the degree of asymmetric information. The approaches of Stoll (1989) and George, Kaul, and Nimalendran (1991) do not explicitly consider the possibility that large trades could convey more information than small trades. Specifically, these authors use *daily* (rather than intraday) data, and consequently are not able to analyze the effect of transaction quantities on intraday transaction prices and quote revisions. This study uses two approaches recently developed by Hasbrouck (1991) and Madhavan

[7]The authors thank a referee for mentioning this possibility.

and Smidt (1991) [which are improvements over Glosten and Harris (1988)] to measure changes in the degree of asymmetric information around the introduction of the MMI contract. These approaches are easy to implement on intraday data and they explicitly model the effects of trade size on price and quote revisions.

Hasbrouck uses a Vector Autoregression (VAR) representation of the quote revision and trade process to estimate the degree of asymmetric information. Part of the exposition from Hasbrouck is briefly repeated here for coherence. The starting point is a two-variable VAR specification of quote revisions and order flow attributes:

$$r_t = a_1 r_{t-1} + a_2 r_{t-2} + \cdots + b_0 x_t + b_1 x_{t-1} + \cdots + v_{1,t} \qquad (2)$$

$$x_t = c_1 r_{t-1} + c_2 r_{t-2} + \cdots + d_1 x_{t-1} + d_2 x_{t-2} + \cdots + v_{2,t} \qquad (3)$$

where x_t is a vector of trade attributes and r_t is the period t quote revision denoted by

$$r_t = (q_t^b + q_t^a)/2 - (q_{t-1}^b + q_{t-1}^a)/2$$

q_t^b and q_t^a being the bid and ask quotes in time t, respectively. As in Hasbrouck, $x_t = \{h_t, h_t^0, h_{t2}\}$ where h_t is the signed transaction volume, h_t^0 is the sign of a trade, and h_{t2} is given by $\mathrm{sign}(h_t)h_t^2$ and is designed to take into account nonlinearities in the price impact of a trade.

The disturbance $v_{1,t}$ reflects public information arrivals and $v_{2,t}$ the unanticipated component of the trade. Let the moving average representation corresponding to (2)–(3) be given by

$$r_t = v_{1,t} + a_1^* v_{1,t-1} + \cdots + b_0^* v_{2,t} + b_1^* v_{2,t-1} + \cdots \qquad (4)$$

$$x_t = c_1^* v_{1,t-1} + c_2^* v_{1,t-2} + \cdots + v_{2,t} + d_1^* v_{2,t-1} + d_2^* v_{2,t-2} + \cdots \qquad (5)$$

The quote midpoint can be written as

$$q_t = m_t + s_t$$

where m_t is the "true" or "efficient" price and s_t embodies microstructure imperfections such as fixed cost and lagged inventory control effects. Now suppose that m_t evolves as a random walk, i.e.,

$$m_t = m_{t-1} + w_t$$

where w_t is white noise. Denote $\text{var}(v_{2,t}) = \Omega$, $\text{var}(v_{1,t}) = \sigma_1^2$ and $\text{var}(w_t) = \sigma_w^2$. Further, let $\sigma_{w,x}^2$ denote the variance of the impact of the trade innovation on the efficient price innovation, i.e.,

$$\sigma_{w,x}^2 = \text{var}(E(w_t \mid x_t - E(x_t \mid \phi_{t-1})))$$

where ϕ_{t-1} denotes the public information set at time $t - 1$. Then, Proposition 1 in Hasbrouck demonstrates that

$$\sigma_w^2 = \sigma_{w,x}^2 + \sigma_u^2$$

where $\sigma_{w,x}^2 = \sum b_i^* \Omega \sum b_i^{*'}$ and $\sigma_u^2 = (\sum a_i^*)^2 \sigma_1^2, a_0^* = 1$.

The summary measure of information asymmetry is then

$$R_{w,x}^2 = \frac{\sigma_{w,x}^2}{\sigma_w^2}$$

This measure is computed in the pre- and post-futures period for each of the 60 stocks in the three samples, and tests are performed to examine its behavior across the three samples in the period surrounding the introduction of the MMI futures contract.[8]

The VAR model is truncated at five lags and the VMA at 30 lags, as in Hasbrouck (1991). The sign test used is similar to that in Lee and Ready (1991). That is, if a transaction occurs at or above the prevailing ask quote, it is regarded as a buy, and if it occurs at or below the prevailing bid quote, as a sale. If it occurs at the quote midpoint, it is signed using the previous transaction price and the "tick" test, which entails assigning a positive sign to the trade if the price move from the previous transaction price is downward, and vice versa. When the price is the same as the previous transaction price, one applies the "tick" rule using the last price following which there was a move.

In the actual empirical test, for each of the 60 firms, the four-variate VAR model described by (2)–(3) is estimated in the pre- and post-MMI futures periods. Table VI documents how the $R_{w,x}^2$ measure changes for the three stock groups on a stock-by-stock basis, and provides average values of the measure in the pre- and post-futures period for each of the three samples. The measure increases from an average of 22% to about 31% for the MMI sample, from 20% to 29% for the non-MMI

[8]At this point, a limitation of the VAR methodology should be pointed out. The model is based on the assumption that the coefficients of the quote revision and the trade process are constant over time, which is questionable if the time period under consideration is long. However, since the sample period for the estimation of the VAR parameters (seven months in the pre-MMI futures period and five months in the post-futures period) is fairly short, the stability issue does not appear to be very relevant.

TABLE VI

Changes in the Proportional Contribution of Trade Innovations to Quote Innovations for MMI Stocks, S&P 500 Group, and Non-S&P 500 Group in 1984 (the First and Second Numbers Represent the Contribution in the Pre- and Post-Futures Periods, Respectively).[a]

Four-Variable VAR Model Represented by (3)–(4) in the Text					
MMI Stocks		*S&P 500 Group*		*Non-S&P 500 Group*	
AXP	0.234	ABT	0.233	ALX	0.224
	0.193		0.287		0.410
CHV	0.231	AET	0.256	AMA	0.393
	0.237		0.331		0.187
DD	0.148	AHP	0.055	ARV	0.268
	0.344		0.205		0.080
DOW	0.248	ARC	0.234	ASH	0.277
	0.336		0.272		0.251
EK	0.290	BMY	0.230	BBC	0.306
	0.307		0.310		0.301
GE	0.373	DEC	0.232	BHW	0.262
	0.401		0.394		0.383
GM	0.078	EMR	0.377	CKE	0.218
	0.346		0.332		0.330
IBM	0.352	F	0.200	DIG	0.233
	0.480		0.277		0.222
IP	0.284	HWP	0.311	DSN	0.226
	0.376		0.362		0.050
JNJ	0.012	LLY	0.223	GRN	0.351
	0.258		0.213		0.505
KO	0.254	MTC	0.021	IMO	0.397
	0.362		0.340		0.270
MMM	0.348	PEP	0.270	LZ	0.212
	0.436		0.363		0.310
MO	0.271	PFE	0.276	MUR	0.315
	0.380		0.347		0.345
MOB	0.174	RJR	0.086	MX	0.029
	0.215		0.261		0.366
MRK	0.310	RD	0.250	NPH	0.023
	0.418		0.029		0.290
PG	0.260	SN	0.014	OLN	0.260
	0.364		0.338		0.283
S	0.101	TX	0.145	RAH	0.246
	0.288		0.238		0.310
T	0.009	UM	0.174	SNG	0.248
	0.189		0.295		0.341
X	0.187	WMT	0.070	TSO	0.343
	0.292		0.393		0.384
XON	0.149	WY	0.216	UB	0.278
	0.021		0.292		0.293
Average	0.217		0.194		0.255
	0.312		0.294		0.295
(*t*-stat.)	(2.88)		(3.48)		(1.24)

[a] $R^2_{w,x}$ is the proportion of the variance in the quote revision that is explained by the trade innovation. The first number denotes the $R^2_{w,x}$ in the pre-futures period and the second number denotes the $R^2_{w,x}$ in the post-futures period. See the text for details.

S&P 500 sample, and from 26% to 30% for the non-S&P 500 sample. On the basis of the simple t test reported at the bottom of Table VI, only the increases for the MMI and the non-MMI S&P 500 samples are significant. In an attempt to counter the somewhat ad hoc distributional assumption inherent in the choice of the t-statistic in Table VI, a sign test is presented in Table VII. This test appears consistent with the results of Table VI, in the sense that it indicates a significant number of firms experiencing $R^2_{w,x}$ increases for the MMI and the S&P 500 group.

The Price Response to a Trade

An additional test based on Madhavan and Smidt (1988) is used to evaluate the robustness of the results obtained from the VAR analysis. The basic idea behind the Madhavan–Smidt approach is as follows. Under the assumption that a representative market maker uses Bayes' rule to update beliefs, the expected value of the stock can be expressed as a weighted sum of the prior mean and the information conveyed by the order flow. The weight placed on the prior mean then provides an inverse measure of the degree of asymmetric information in the market. Madhavan and Smidt derive an estimating equation which allows the estimation of this weight.

Define P_{jt} as the transaction price, q_{jt} the unsigned transaction size, and D_{jt} as the indicator variable which equals $+1$ for a buy and -1 for a sale (as per the tick test), where the subscripts t and j refer to the time and the particular stock, respectively. Then, as per eq. (11) in Madhavan and Smidt (1991, p. 105), the specification is[9]

$$\Delta P_{jt} = \beta_{1j} q_{jt} + \beta_{2j} D_{jt} - \beta_{3j} D_{j,t-1} + \eta_{jt}$$

TABLE VII

A Sign Test for Changes in $R^2_{w,x}$ for Each Group

Four-Variable VAR Model Represented by (3)–(4) in the Text

	MMI Stocks	*S&P 500 Group*	*Non-S&P 500*
No. of firms with R^2 increases	18[a]	17[a]	13
No. of firms with R^2 decreases	2	3	7

[a]Denotes significance at the 5% level.

[9]Madhavan and Smidt (1991) include an inventory component in their specification. However, they find that the inventory component is statistically insignificant. The present analysis, therefore, deletes the inventory component.

where

$$\beta_{1j} \equiv \text{RISK}_j * \frac{1 - \text{PRIOR}_j}{2 * \text{PRIOR}_j - 1}$$

$$\beta_{2j} \equiv \frac{\text{COST}_j}{\text{PRIOR}_j}$$

$$\beta_{3j} \equiv \text{COST}_j$$

Here, PRIOR is the weight placed by the market maker on his prior observation (e.g., public information), as opposed to the order flow, so that larger values of PRIOR imply a smaller weight on the order flow and, consequently, lower information asymmetry. Further, COST denotes the fixed cost of executing a trade, and RISK denotes the risk faced by an investor.[10] The error term is assumed to follow the process

$$\eta_{jt} = \epsilon_{jt} + Z_j \epsilon_{j,t-1}$$

where the ϵ's are white noise terms and Z_j is treated as a parameter for estimation. In the specification above, the variable of interest is PRIOR, which, as pointed out earlier, is an inverse measure of the degree of asymmetric information.

To discern differences in the PRIOR parameter before and after the introduction of the MMI futures, an additional parameter, denoted by INCR, is introduced. This parameter is defined as follows.

$$\text{PRIOR} = \text{PRIOR}_{\text{pre-futures}} + I_{\text{post-futures}} * \text{INCR}$$

where $I_{\text{post-futures}}$ is an indicator variable which returns the value of 1 for the post-futures period and zero otherwise. To jointly estimate the parameters RISK, PRIOR, COST, and INCR, the maximum-likelihood estimation of the model is performed for each of the 60 stocks in the three subsamples, for the entire year 1984. The goodness-of-fit of the model is reasonable (R^2's range from 40%–60%) and all the coefficients are significant, as in Madhavan and Smidt (1991). However, for reasons of brevity and to focus on the issue at hand, rather than presenting the estimates of the entire model, only the estimates of the increment in the inverse measure of asymmetric information, i.e., INCR, are presented. Before interpreting the results, the reader should bear in mind that a

[10]In eq. (11) of Madhavan and Smidt (1991), the coefficient β_{1j} is defined as $(1 - \pi)/(\alpha\pi)$. However, the Appendix of that paper (p. 133) defines $\alpha = 1/(\rho\sigma^2 + \beta_{1j})$, where ρ is the risk aversion parameter and σ^2 is the risk faced by the investor. The quantity $\rho\sigma^2$ is defined as the RISK parameter in the present maximum likelihood estimation. The expression for β_{1j} above is obtained by substituting for α in Madhavan and Smidt's definition.

negative value for INCR implies a smaller PRIOR and consequently, larger information asymmetry, in the post-futures period. Table VIII presents the estimated values of the INCR parameter, ordered by t-statistics, for each stock in the three subsamples, together with the average values of INCR and the average t-statistics for each subsample. (The averages are not directly comparable across the subsamples because the base level of information asymmetry is lower in MMI stocks.) It can be seen that the average t-statistic for the MMI sample is -1.60, with a p-value of 0.89, while the average t-statistics for the S&P and non-S&P samples are $+0.88$ and $+1.68$, respectively (the latter is significant at the 10% level).

More striking is the evidence in Table IX, which lists the results of a sign test within each sample, restricting itself to the stocks which experienced significant information asymmetry increases or decreases (measured by absolute t-statistics greater than 1.645). The sign test shows that of the 12 MMI firms which experience significant changes in informational asymmetry in the post-futures period, nine experience increases and only three experience decreases.[11] In sharp contrast, four firms in the S&P sample experience significant increases, and ten experience significant decreases, while *no* firms experience significant increases in the non-S&P sample, and 12 experience significant decreases. In sum, the evidence is suggestive that firms in the MMI experience increases in information asymmetry in the post-futures period.

Thus, while the tests based on the VAR methodology and the Madhavan–Smidt methodology support the notion that the degree of asymmetric information increases for the MMI sample, other tests indicate that the spread itself does not significantly change for the MMI sample, and decrease significantly for the S&P 500 and non-S&P 500 samples (see Table II). This finding is consistent with an effect which tends to decrease spreads uniformly across the three samples during the sample period. For example, the significant negative coefficient of the trend variable in Table IV suggests that an extraneous factor causes spreads across the three samples to shift downward throughout the sample period. In this case, because of the increase in the degree of asymmetric information, one would expect the extent of the spread decline to be lower for the MMI sample. Since this is

[11]From Table VI, it can be verified that eight of these nine firms experience considerable increases in the $R^2_{w,x}$ measure as well. The exception is Exxon (ticker symbol XON) which experiences a considerable decrease in $R^2_{w,x}$, but has a significant negative value for INCR. The authors attribute this discrepancy to noise in the estimation process.

TABLE VIII

Estimate of Changes in the Estimate of the Weight Placed on Public Information in the Post-Futures Period for Each Sample (t-statistics in Parentheses)[a]

MMI Stocks		*S&P 500 Group*		*Non-S&P 500 Group*	
PG	−0.072	TX	−0.030	MX	−0.016
	(−10.31)		(−9.87)		(−1.37)
IBM	−0.022	BMY	−0.030	TSO	−0.009
	(−8.31)		(−5.56)		(−0.76)
JNJ	−0.039	AHP	−0.021	CKE	−0.009
	(−7.76)		(−4.22)		(−0.73)
T	−0.011	PEP	−0.020	UB	−0.008
	(−7.02)		(−3.58)		(−0.54)
XON	−0.008	SN	−0.012	SNG	−0.008
	(−4.95)		(−1.41)		(−0.4)
MO	−0.020	WY	−0.010	IMO	−0.003
	(−2.79)		(−1.35)		(−0.29)
CHV	−0.026	EMR	−0.010	OLN	−0.001
	(−2.51)		(−1.08)		(−0.03)
MMM	−0.018	LLY	−0.005	LZ	0.022
	(−2.44)		(−1.5)		(−1.34)
X	−0.010	HWP	0.007	NPH	0.033
	(−2.01)	HWP	(1.49)		(2.01)
KO	−0.016	DEC	0.008	DIG	0.041
	(−1.56)		(1.59)		(2.12)
S	−0.003	AET	0.022	DSN	0.044
	(−0.72)		(2.06)		(2.24)
EK	−0.001	PFE	0.014	ALX	0.057
	(−0.20)		(2.7)		(2.40)
GM	0.001	WMT	0.025	AMA	0.079
	(0.3)		(2.8)		(2.69)
DOW	0.002	RD	0.026	RAH	0.045
	(0.46)		(2.86)		(2.78)
DD	0.0055	RJR	0.023	GRN	0.031
	(0.96)		(3.15)		(2.82)
GE	0.0053	ABT	0.023	MUR	0.049
	(1.03)		(3.47)		(3.02)
AXP	0.0089	UM	0.146	BBC	0.046
	(1.5)		(3.93)		(3.19)
MOB	0.0069	F	0.016	BHW	0.071
	(1.84)		(4.62)		(3.22)
MRK	0.046	ARC	0.030	ASH	0.046
	(5.88)		(5.54)		(3.22)
IP	0.052	MTC	0.106	ARV	0.108
	(6.68)		(11.05)		(6.64)
Average	−0.006		0.015		0.031
	(−1.60)		(0.884)		(1.68)

[a]The first number (the second number) denotes the estimate (the t-statistic) of the increase in the weight placed on the public signal by the market maker in the post-futures period (the weight is an inverse measure of information asymmetry). Negative numbers for the increase thus imply an increase in the amount of asymmetric information in the post-futures period. See the text for details.

TABLE IX
A Sign Test for Changes in the Amount of Asymmetric Information for each Group, Based on Table VIII

	MMI Stocks	*S&P 500 Group*	*Non-S&P 500*
No. of firms with significant increases	9[a]	4	0
No. of firms with significant decreases	3	10	12[a]

[a]Denotes significance at the 5% level.

consistent with the findings summarized in Table II, the tests appear to be internally consistent.

Trading Volume

To determine which factor, the migration of uniformed traders or the increase in "macro" informed trading, causes an increase in the degree of asymmetric information, one needs to examine changes in trading volume. To this end, daily average transactions volume for the three samples is compared in Table X. The table indicates that trading volume in the months following the futures introduction is consistently higher than the pre-futures average for both the MMI and the S&P group. For the entire year, the MMI and non-S&P group show a significant increase at the 10% level.

In sum, the evidence suggests that for the stocks in the MMI, trading volume in the post-futures period tends to be at higher levels relative to the pre-futures period in 1984. This evidence supports the hypothesis that the increase in asymmetric information documented earlier is due to additional macro-informed trading in the futures market which spills over to the cash market and, consequently, increases the degree of asymmetric information. One can argue that, rather than siphoning off trading volume from the underlying stocks, the futures contract actually *increases* trading activity in the stock market and increases efficiency by way of additional informed trading on macro-economic factors. This conclusion is similar to that reached by Froot, Gammill, and Perold (1990) in a very different context. These authors found that the short-run autocorrelation in the S&P 500 index changed from being highly positive in 1983 to practically zero in 1989. They attribute this to "market-wide information [being] more efficiently impounded into the price of individual stocks" (p. G1–3).

TABLE X

Changes in Average Daily Transaction Volume for MMI Stocks, the S&P 500 Control Group, and the Non-S&P 500 Control Group in 1984[a]

MMI Stocks	*2-Month*	*4-Month*	*6-Month*	*8-Month*	*Whole Year*
Pre-futures[b]	3463	3962	4003	3902	4105
Post-futures[c]	4772	4708	4579	4397	4337
t-statistic	4.40	3.40	3.42	3.56	1.89
Prob > $\|t\|$	0.00	0.00	0.00	0.00	0.06
S&P 500 Group	*2-Month*	*4-Month*	*6-Month*	*8-Month*	*Whole Year*
Pre-futures	1880	2169	2261	2217	2327
Post-futures	2575	2472	2534	2465	2380
t-statistic	4.54	2.92	3.12	3.35	0.80
Prob > $\|t\|$	0.00	0.00	0.00	0.00	0.43
Non-S&P 500 Group	*2-Month*	*4-Month*	*6-Month*	*8-Month*	*Whole Year*
Pre-futures	284	302	298	297	303
Post-futures	281	307	333	328	334
t-statistic	−0.08	0.19	1.43	1.57	1.76
Prob > $\|t\|$	0.94	0.85	0.15	0.12	0.08

[a]Transaction-by-transaction data is used to obtain daily total volume. Then, this volume is averaged over each period.
[b]The numbers shown above are in terms of 100 shares.
[c]2–month: One month before futures (July 1984) versus one month after (August 1984).
4–month: 2 months before (June, July) versus 2 months after (Aug., Sept.), etc.
Whole year: January through July versus August through December.

Intraday Volatility Tests

A simple t-test initially compares the mean intraday volatility before and after the introduction of the MMI contract by employing straightforward t-tests. Intraday volatility is measured as the simple intraday standard deviation of returns based on *bid–ask quote midpoints,* to control for spurious volatility due to bid–ask bounce effects. Next, to control for variations in volatility due to variations in price levels and general trends, a pooled time-series cross-sectional regression model is again employed. Controlling for the price level helps control for spurious return variances due to stock price discreteness [see Harris (1989)], which is a greater problem for low price levels. As in the analysis of spreads, a trend variable is included to capture general trends in volatility not captured by changes in the price level (e.g., due to changes in macroeconomic news flows). The regression again allows for structural heterogeneity across the three samples, as well as in the pre- and post-futures period within each sample. Thus, the regression model is given by

$$\begin{aligned} STD_{it} = {} & \alpha_0 + b_0\text{PRICE}_{it} + DM_{it}(\gamma_0 + b_1\text{PRICE}_{it} + DS_{it}(\delta_0 \\ & + b_2\text{PRICE}_{it} + D_{it}\{(\alpha_1 + b_3\text{PRICE}_{it}) \\ & + DM_{it}(\gamma_1 + b_4\text{PRICE}_{it}) \\ & + DS_{it}(\delta_1 + b_5\text{PRICE}_{it})\} + b_6T_{it} + e_{it} \end{aligned} \tag{6}$$

where STD, PRICE, D, T, DM, and DS have interpretations identical to those in eq. (1).

As in the spread tests, GLS techniques are used to obtain regression estimates. The parameter estimates $\alpha_1 + \gamma_1$, $\alpha_1 + \delta_1$, and α_1 capture the effects of futures on the MMI group, the S&P group, and the non-S&P group, respectively, and are thus of primary interest. Table XI presents the results of simple t-tests of changes in intraday volatility. The volatility of MMI and S&P 500 stocks do not change significantly in the post-futures period, while the volatility of the non-S&P 500 group shows a significant decrease in this period. Table XII presents results from the regression (6). This table indicates that the

TABLE XI

Changes in the Average Intraday Standard Deviation of Returns for MMI Stocks, the S&P 500 Control Group, and the Non-S&P 500 Control Group in 1984[a]

MMI Stocks	
Pre-futures	0.00216
Post-futures	0.00213
t-statistic	−0.06
Prob > $\|t\|$	0.95
S&P 500 Group	
Pre-futures	0.00220
Post-futures	0.00205
t-statistic	−20.42
Prob > $\|t\|$	0.67
Non-S&P 500 Group	
Pre-futures	0.00500
Post-futures	0.00443
t-statistic	−3.74
Prob > $\|t\|$	0.00

[a]The midpoint of each intraday bid–ask quote for a particular stock is used to obtain a standard deviation of the intraday return. These numbers are then averaged over each period and a simple t-value is calculated.

TABLE XII
Parameter Estimates of the Regression Model (6)[a]

Variable		*Parameter*	*T-Value*	*Prob* > $\lvert T \rvert$
Constant	(α_0)	0.00706	8.67	0.00
PRICE	(b_0)	−0.000076	−2.83	0.00
DM	(γ_0)	−0.00304	−2.80	0.01
DM * PRICE	(b_1)	0.000041	1.37	0.17
DS	(δ_0)	−0.00392	−3.20	0.00
DS * PRICE	(b_2)	0.000060	1.87	0.06
D	(α_1)	−0.000042	−0.04	0.97
D * PRICE	(b_3)	−0.000014	−0.39	0.70
D * *DM*	(γ_1)	−0.000175	−0.12	0.90
D * *DM* * PRICE	(b_4)	0.000023	0.56	0.57
D * *DS*	(δ_1)	0.00038	0.23	0.82
D * *DS* * PRICE	(b_5)	0.000009	0.20	0.84
T	(b_6)	−0.000002	−0.43	0.67

[a] $STD_{it} = \alpha_0 + b_0\text{PRICE}_{it} + DM_{it}(\gamma_0 + b_1\text{PRICE}_{it})_{\text{ZDS}_{it}}(\delta_0 + b_2\text{PRICE}_{it}) + D_{it}\{(\alpha_1 + b_3\text{PRICE}_{it}) + DM_{it}(\gamma_1 + b_4\text{PRICE}_{it}) + DS_{it}(\delta_1 + b_5\text{PRICE}_{it})\} + b_6T_{it} + e_{it}$

where

STD_{it} = standard deviation of stock *i*'s return during time *t*.
PRICE_{it} = average price of stock *i* at time *t*.
D_{it} = dummy variable that takes a value of 1 for post-MMI period and 0 otherwise.
DM_{it} = dummy variable that takes a value of 1 for the MMI stocks and 0 otherwise.
DS_{it} = dummy variable that takes a value of 1 for the S&P 500 group and 0 otherwise.
T_{it} = trend variable which has a value of *t* during period *t*.

coefficient on the trend variable is not significantly different from zero (its *t*-value is 0.43); whereas, as expected, price has a negative effect on volatility. Test results for changes in intraday volatility are summarized in Table XIII. The *t*-values of the changes in intercept for the MMI, S&P 500, and non-S&P 500 groups are 0.20, 0.25, and −0.04, respectively, and, therefore, present no evidence that the average intraday volatility (after accounting for changes in price) is affected by the introduction of the futures contract. Table XIII also suggests that the sensitivity of return volatility to the price of a stock does not change in any of the three groups in the post-MMI period. *t*-values associated with the estimates $b_3 + b_4$, $b_3 + b_5$, and b_3 are 0.5, −0.07, and −0.39, respectively.

In summary, the above tests suggest that the introduction of MMI futures does not have any perceptible effect on the average intraday volatility level in the underlying stock markets. One can construe this as evidence against the "destabilization" hypothesis which contends that index futures cause excessive short-run price swings by encouraging speculation and automated index arbitrage strategies.

TABLE XIII
Tests for Changes in the Intercept and for Structural Shifts, Based on Regression (6)

I. Changes in the Intercept

Group	*Parameters*	*t-Value*	*Prob > |t|*
$MMI_A - MMI_B$	$\alpha_1 + \gamma_1 = -2.17E\text{-}4$	−0.20	0.84
$S\&P_A - S\&P_B$	$\alpha_1 + \delta_1 = 3.36E\text{-}4$	0.25	0.81
$N\text{-}S\&P_A - N\text{-}S\&P_B$	$\alpha_1 = -4.20E\text{-}5$	−0.04	0.97

II. Changes in the Coefficients of the Price Level

Group	*Parameters*	*t-Value*	*Prob > |t|*
$MMI_A - MMI_B$	$b_3 + b_4 = 8.46E\text{-}6$	0.50	0.60
$S\&P_A - S\&P_B$	$b_3 + b_5 = 5.47E\text{-}6$	−0.07	0.95
$N\text{-}S\&P_A - N\text{-}S\&P_B$	$b_3 = -1.43E\text{-}5$	−0.39	0.70

CONCLUDING REMARKS

This article uses intraday data to investigate the effect of the introduction of the MMI futures contract in 1984 on the bid–ask spread, the asymmetric information contained in a trade, the trading volume, and the intraday volatility in the underlying stocks. The study represents the first attempt at using intraday data to test for effects of introducing index futures on the underlying stocks.

The lack of availability of reliable intraday data for 1982 limits the power of tests which attempt to examine the effect of the S&P 500 futures contract on the liquidity and volatility of the underlying stocks. Further, the nature of the hypotheses and the considerable initial investor interest in the MMI contract following its introduction provide motivation for the premise of the study, namely, that the MMI contract has an effect on the liquidity and volatility of the underlying stocks distinct from that generated by the 1982 introduction of the S&P 500 contract.

Since any effect of futures on the MMI stocks could spill over to the S&P 500 index because of heavy institutional demand in such stocks, two industry-based control groups of stocks are used for the study, one comprised of stocks on the S&P 500 index but not on the MMI and one of stocks neither on the S&P 500 nor on the MMI index. Results from the analysis can be summarized as follows. The average intraday bid–ask spread in the post-MMI futures period, after accounting for general trends and changes in volatility, price, and trading volume, shows a statistically significant increase for the MMI and S&P groups, and a statistically significant decrease for the non-S&P group. In addition, measures of the degree of asymmetric information show a significant increase for the MMI (and, to a lesser extent, the S&P) sample, but no significant change for the non-S&P sample. Finally, the introduction of the futures contract appears to have stimulated additional trading volume in the MMI and the S&P samples.

The results do not support the hypothesis that index futures markets can reduce spreads in the stock market by creating liquidity and facilitating inventory hedging by market makers. They lend some support for the hypothesis that these markets may increase trading volume and asymmetric information by stimulating additional informed speculation on market-wide factors, which spills over to the cash market. The spread increase, however, does not appear to be economically significant. Finally, there is no significant change in intraday volatility (controlling for bid–ask bounce effects) in the underlying stock markets around the introduction of the MMI futures. This evidence does not support the hypothesis that index futures can destabilize the underlying stock markets by encouraging nonrational speculation and index arbitrage-related trading.

Overall, it seems reasonable to conclude that spread or volatility changes caused by the introduction of the MMI futures contract are quite small, if any. In addition, the introduction of the futures contract appears to have increased trading volume and the flow of information to the underlying stock markets, thus possibly enhancing their efficiency.

APPENDIX TABLE AI

Composition of the Three Sample Groups (SIC Codes)

Industry	*MMI Stocks*		*S&P 500 Group*		*Non-S&P 500 Group*	
Financial	AXP	(6211)	AET	(6311)	GRN	(6331)
Automobile	GM	(3711)	F	(3711)	ARV	(3714)
Food, Drinks	KO	(2080)	PEP	(2080)	CKE	(100)[a]
Chemical	DOW	(2800)	MTC	(2800)	OLN	(2800)
	DD	(2820)	BMY	(2834)	LZ	(2890)
Computer systems	IBM	(3570)	DEC	(3570)	BHW	(3579)
Drugs	MRK	(2834)	PFE	(2834)	RAH	(2834)
	JNJ	(2834)	ABT	(2834)	BBC	(5122)[a]
Electronics	GE	(3600)	EMR	(3621)	NPH	(3640)
Household prod.	PG	(2840)	LLY	(2834)	DIG	(5141)

(continued)

TABLE AI. (Continued)
Composition of the Three Sample Groups (SIC Codes)

Industry	*MMI Stocks*		*S&P 500 Group*		*Non-S&P 500 Group*	
Oil	CHV	(2911)	RD	(2911)	ASH	(2911)
	XON	(2911)	ARC	(2911)	MUR	(2911)
	MOB	(2911)	SN	(2911)	TSO	(2911)
	X	(2911)	TX	(2911)	IMO	(2911)
Retails	S	(5311)	WMT	(5331)	ALX	(5311)
Tobacco & others	MO	(2111)	RJR	(2052)	UB	(2011)
Paper and forest products	IP	(2600)	WY	(2421)	DSN	(2670)
Communications	T	(4813)	HWP	(3570)[a]	SNG	(4813)
Misc. manufacturing	EK	(3861)	UN	(2000)	MX	(3823)
Conglomerates	MMM	(2670)	AHP	(2834)	AMA	(5311)[a]

[a](1) JNJ, ABT, and BBC are classified as "Medical & Dental Equip. & Supplies" in *Moody's Industry Review Index*, (2) MMM and AMA are classified as "Conglomerates" in *Moody's Industry Review Index*, (3) CKE produces agricultural products, and is related to the "Food and Drinks" category, (4) T and HWP are classified as "Miscellaneous" in *Moody's Industry Review Index*.

TABLE AII
Market Values of the Three Sample Groups

MMI Stocks		*S&P 500 Group*		*Non-S&P 500 Group*	
AXP	8387	AET	3621	GRN	2682
GM	22348	F	7219	ARV	195
KO	7292	PEP	3514	UB	248
DOW	6214	MTC	4042	OLN	695
DD	12022	BMY	5970	LZ	884
IBM	70579	DEC	4986	BHW	266
MRK	6867	PFE	5852	RAH	526
GE	24209	EMR	4292	NPH	967
JNJ	7365	ABT	5511	BBC	319
PG	8730	LLY	4512	CKE	452
CHV	12265	RD	12894	ASH	958
XON	33674	ARC	11667	MUR	1205
MOB	12022	SN	15283	TSO	303
X	3585	TX	9270	IMO	4743
S	12638	WMT	5348	ALX	91
MO	8472	RJR	7219	DIG	79
IP	2792	WY	4423	DSN	319
T	42382	UM	2656	SNG	1017
EK	11436	HWP	9843	MX	136
MMM	9363	AHP	7899	AMA	462

The market value for each firm is calculated as the average of the quantity (number of shares outstanding * stock price) at the beginning and end of the period (Jul. 83–Jul. 84).
Values in the tables are in millions of dollars.

BIBLIOGRAPHY

Barclay, M.J., and Smith, C.W. Jr. (1988): "Corporate Payout Policy: Cash Dividends versus Open-Market Repurchases," *Journal of Financial Economics,* 22:61–82.

Benston, G., and Hagerman, R. (1974): "Determinants of Bid–Ask Spreads in the Over-the-Counter Market," *Journal of Financial Economics,* 1:353–364.

Damodaran, A. (1990): "Index Futures and Stock Market Volatility," *Review of Futures Markets,* 9:442–457.

Demsetz, H. (1968): "The Cost of Transacting," *Quarterly Journal of Economics,* 82:33–53.

Edwards, F.R. (1988): "Does Futures Trading Increase Stock Market Volatility?," *Financial Analysts Journal,* January–February: 63–69.

Froot, K.A., Gammill, J.F., Perold, A.F. (1990): "New Trading Practices and the Short-Run Predictability of the S&P 500," in *Market Volatility and Investor Confidence,* New York: New York Stock Exchange, G1-1–G1-27.

Fuller, W.A., and Battese, G.E. (1974): "Estimation of Linear Models with Cross-Error Structure," *Journal of Econometrics,* 2:67–78.

Gammill, J.F., and Perold, A.F. (1989): "The Changing Character of Stock Market Liquidity," *Journal of Portfolio Management,* Spring: 13–18.

George, T., Kaul, G., and Nimalendran, M. (1991): "Estimating the Components of the Bid–Ask Spread: A New Approach," *Review of Financial Studies,* 4:623–656.

Glosten, L.R., and Harris, L. (1988): "Estimating the Components of the Bid–Ask Spread," *Journal of Financial Economics,* 21:123–142.

Glosten, L.R., and Milgrom, P.R. (1985): "Bid, Ask, and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders," *Journal of Financial Economics,* 14:71–100.

Gorton, G., and Pennacchi, G. (1993): "Security Baskets and Index-Linked Securities," *Journal of Business,* 66:1–28.

Harris, L. (1989): "S&P 500 Cash Stock Price Volatilities," *Journal of Finance,* 44:1155–1175.

Harris, L. (1990): "The Economics of Cash Index Alternatives," *The Journal of Futures Markets,* 10:179–194.

Harris, L., and Gurel, E. (1986): "Price and Volume Effects Associated with Changes in the S&P 500 List: New Evidence of Price Pressures," *Journal of Finance,* 41:815–829.

Hasbrouck, J. (1991): "The Summary Informativeness of Stock Trades: An Econometric Analysis," *Review of Financial Studies,* 4:571–595.

Ho, T.S.Y., and Stoll, H.R. (1981): "Optimal Dealer Pricing under Transactions and Return Uncertainty," *Journal of Financial Economics,* 9:47–73.

Jegadeesh, N., and Subrahmanyam, A. (1993): "Liquidity Effects of the Introduction of the S&P 500 Index Futures Contract on the Underlying Stocks," forthcoming, *Journal of Business,* April.

Lee, C.M.C., and Ready, M.J. (1991): "Inferring Trade Direction from Intraday Data," *Journal of Finance,* 46:733–746.

Madhavan, A. and Smidt, S. (1991): "A Bayesian Model of Intraday Specialist Pricing," *Journal of Financial Economics,* 30:99–134.

The Presidential Task Force on Market Mechanisms (1988): report.

Pruitt, S. W., and Wei, K. C. J. (1989): "Institutional Ownership and Changes in the S&P 500," *Journal of Finance,* 44:509–513.

Report of the Market Volatility and Investor Confidence Panel (1990): New York: New York Stock Exchange.

Roll, R. (1984): "A Simple Implicit Measure of the Effective Bid–Ask Spread in an Efficient Market," *Journal of Finance,* 39:1127–1139.

Searle, S. R. (1971): *Linear Models.* New York: Wiley.

Shleifer, A. (1986): "Do Demand Curves for Stocks Slope Down?" *Journal of Finance,* 41:579–590.

Silber, W. L. (1985): "The Economic Role of Financial Futures," in *Futures Markets: Their Economic Role,* Peck, A. E. (ed.), Washington, DC: American Enterprise for Public Policy Research, pp. 83–114.

Stoll, H. R. (1978a): "The Supply of Dealer Services in Securities Markets," *Journal of Finance,* 33:1133–1151.

Stoll, H. R. (1978b): "The Pricing of Dealer Services: An Empirical Study of NASDAQ Stocks," *Journal of Finance,* 33:1152–1173.

Stoll, H. R. (1989): "Inferring the Components of the Bid–Ask Spread: Theory and Empirical Tests," *Journal of Finance,* 44:115–134.

Stoll, H. R., and Whaley, R. E. (1987): "Expiration Day Effects of Index Options and Futures," *Financial Analysts Journal,* March, 16–28.

Subrahmanyam, A. (1991): "A Theory of Trading in Stock Index Futures," *Review of Financial Studies,* 4:17–51.

U.S. Securities and Exchange Commission (1988): "The October 1987 Market Break," Washington, D.C.: Report by the Division of Market Regulation.