The Impact of Market-Specific Public Information on Return Variance in an Illiquid Market

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I. INTRODUCTION

Numerous studies have examined return volatility during trading and nontrading periods. Early studies focused on the market for common stock and observed that return variance during trading periods when exchanges are open far exceeds return variance during nontrading periods when exchanges are closed [Fama (1965), Granger and Morgenstern (1970), Oldfield and Rogalski (1980), French and Roll (1986), Barclay, Litzenberger, and Warner (1990)]. More recently, studies by Lauterbach and Monroe (1989) and Hill, Schneeweis, and Yau (1990) have detected similar effects in the futures markets. French and Roll (1986) identify three potential determinants of this greater variance: the more frequent arrival of public information during trading periods, the impact of private information when informed investors trade, and the impact of trade-induced noise. Their empirical evidence suggests that return variance is influenced primarily by the trading of informed investors with private

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information. Trade-induced noise accounts for no more than 12% of observed variance, and public information has little or no impact. A related study of Japanese stocks by Barclay et al. (1990) similarly concludes that informed traders who possess private information have the greatest impact.

In a more recent study, Jones, Kaul, and Lipson (1994) depart from the standard characterization of trading and nontrading periods and designate trading periods as times when exchanges are open and traders endogenously choose to trade, and nontrading periods as times when exchanges are open, but traders endogenously choose not to trade. Under this classification, a large portion of the daily stock return volatility occurs without trades, especially for the largest firms. In contrast to earlier research, the arrival of public information, and not trading by investors with private information, is the major source of short-term return volatility.

This study provides additional evidence on the impact of public information on return volatility by comparing return volatility across trading and nontrading periods in the market for municipal bond futures (MBF). It extends prior research along two key dimensions. First, the impact of the purest form of market-specific public information, the formal announcement of the price of the underlying contract on which trading is based, is examined. Only at this announcement is the spot price known with certainty. Second, the impact of information in a market that is well known for its relative illiquidity is detailed. The MBF market is presumably composed of relatively few informed traders with precise knowledge of price information, and a few uninformed traders. Thus, the arrival of public information in this relatively illiquid market could have a greater impact on trading activity. This enables better examination of the impact and importance of public versus private information. In addition, this study examines informational impacts with the use of a testing procedure that is robust to underlying distributional assumptions. In direct contrast to prior studies, the empirical results indicate that the release of market-specific public information reduces both trading and nontrading variance. Similar tests carried out as a control in the Treasury bond futures market reveal no such effect.

The remainder of this article is organized as follows. Section II describes the features of the MBF contract pricing and the possible impact on return volatility. Section III presents the data and describes test procedures. Section IV provides the empirical results of tests that compare return variance across trading and nontrading periods with the use of daily data; in Section V the results of tests of trading variance using intraday data are detailed. Conclusions are given in Section VI.

II. MUNICIPAL-BOND FUTURES AND MARKET-SPECIFIC PUBLIC INFORMATION

Public information can be broadly classified into two types. The first type, such as news releases of price indexes and employment data, has economy-wide implications and thus simultaneously influences a broad range of trading activity and markets. Most studies that investigate public information [such as Ederington and Lee (1993)], detect a price impact associated with the release of such macroeconomic data. The second type pertains to the pricing of a specific asset or contract. Examples include the U.S. Agriculture Department's announcement of hog farrowing intentions, and the announcement of prices of municipal bonds that make up the Bond Buyer Index (BBI) on which the MBF is priced.[1]

This study uses the unique features of the MBF contract that existed during the early period of MBF trading (June 11, 1985 to October 4, 1993) to directly test the impact of market-specific public information on return variance. The BBI is an index composed of 40 bonds that represent a cross section of the most actively traded municipals. Bonds that are included in the BBI are subject to change every 2 weeks to ensure a representative sample of liquid municipals. This process allows market watchers and participants to use the index as a gauge to track the performance of the municipal bond market in general. The bonds are selected to represent the diversity of issues and are screened with the use of a strict set of rules before inclusion.[2] Thus, on revision days, the 15th and the last business day of each month, bonds are deleted from the BBI and new ones added to keep the index current. From inception of the contract in 1985 through October 4, 1993 during nondelivery months, the underlying bonds in the BBI were formally priced daily only near the close of trading with the calculated BBI then announced.[3] The release of this market-specific public information could thus directly affect nontrading variance as designated by French and Roll (1986). In delivery months during this period, another formal pricing occurred at 11 a.m.

[1]Runkle (1992) analyzes whether live-hog futures prices incorporate information about the government announcement of hog-farrowing intentions and predictable errors in the announcement. Hamilton, Hein, and Koch (1994) apply a cash-and-carry model to determine the theoretically fair price of MBF contracts and determine that revisions to the BBI do not affect the pricing of the MBF.

[2]A complete listing of rules can be found in handbooks on the MBF market issued by the CBOT. See Hamilton, et al. (1994) for a discussion of the revision process and tests of its impact on the pricing of MBF futures.

[3]Several changes have been made in terms of constructing and reporting the BBI. For a summary of these changes see the CBOT publication "A Guide to the Modifications to the Municipal Bond Index Futures Contract," 1995, Reference EM31-9, Board of Trade of the City of Chicago. The term *nondelivery* designates months in which the nearby futures contract does not expire, whereas *delivery* indicates the expiration month.

each trading day, such that information on the release of the computed BBI could also directly affect trading variance. Shown below is time line indicating the mechanics of pricing during delivery and nondelivery months, where trading began at 7.20 a.m. and ended at 2:00 p.m. (CST).[4]

The time line shows the once-a-day pricing in nondelivery months at the close of trading and the twice-a-day pricing in delivery months at midday (11 a.m.) and close of trading. This procedure was changed on October 5, 1993, when the Chicago Board of Trade (CBOT) also started pricing the BBI during nondelivery months at 11 a.m. and at the close. The presumption was that the twice-daily pricing would make the MBF futures contact more attractive and consequently increase trading activity.

Pricing Diagram: Time Line from the Inception of the MBF Contract through October 4, 1993

Nondelivery months

Open		Close BBI Pricing *
7:20 a.m.		2:00 p.m.

Delivery Months	BBI Pricing *	BBI Pricing *
7:20 a.m.	11:00 a.m.	2:00 p.m.

Market Microstructure and the Announcement of the BBI

The microstructure that prevailed in the MBF market prior to October 5, 1993 provides an avenue to examine the impact of public information on variance in an illiquid market. To assess the impact of public information on trading variance, return variance from open to the close of trading day is compared between delivery months and nondelivery months. Formally, trading periods are designated as the time from the opening to the close of the CBOT, and nontrading periods as the time from the close of the CBOT on a given day to the opening of the CBOT on the next business day.[5]

[4]See Catania, Andrews, and Keefer (1987) for a detailed discussion of the MBF contract and pricing rules. The quoted BBI is determined from price data obtained from six dealers for each of the 40 bonds.

[5]Unlike the Jones et al. (1994) study, traders' actions do not determine trading and nontrading periods.

Both information and market liquidity influence return variance. Due to the relative illiquidity of the MBF market, it seems reasonable to surmise that trading prior to the release of the BBI is dominated mostly by informed traders. At these times only a small subset of participants, primarily dealers who make a market in bonds included in the BBI, have substantive private information regarding individual bond prices and the likely value of the BBI.[6] However, with the formal release of the BBI, liquidity traders are more likely to enter the market. As suggested by Admati and Pfleiderer (1988), liquidity traders prefer to trade when the market has depth, such that trades have a minimal impact on price. Release of information on the BBI should thus coincide not only with a reduction in the relative impact of informed traders but also with an increase in the activity of liquidity traders. Given the timing of BBI announcements, liquidity traders should thus have a greater impact after 11 a.m. in delivery months.

MBF Return Variance between Delivery and Nondelivery Months

The preceding discussion suggests that the twice-daily release of information on the BBI during delivery months should affect MBF return variance in both trading and nontrading periods differently than the once-a-day release of the BBI during nondelivery months. Given the relative illiquidity of the MBF market and the likely entry of liquidity traders after the 11 a.m. release of pricing information in delivery months, it is reasonable to expect the second release of pricing information on the BBI at the close of trading in delivery months to be better anticipated by the market. As Amihud and Mendelson (1991) point out, the value discovery process is facilitated by the ability of traders to observe a sequence of recent events that provide information. Therefore, it follows that the release of the first announcement will most likely reduce noise and allow for a more efficient price discovery process. Consequently, nontrading returns in delivery months should exhibit lower volatility than in nondelivery months.

The difference in return variance during trading periods in delivery and nondelivery months is less predictable because there are competing effects associated with the 11 a.m. trading time announcement. Specif-

[6]Pricing is provided by six dealer-to-dealer municipal bond brokers. The six pricing brokers are composed of the following firms: Cantor Fitzgerald Municipal Brokers, Inc.; Chapdelaine & Co., Inc.; J. F. Hartfield & Co., Inc.; J. J. Kenny Drake, Inc.; Municipal Partners, Inc.; and Titus & Donnelly, Inc.

ically, the release of the BBI could increase return variance as liquidity traders enter the market, due to an increase in liquidity trading variance, but could also decrease return variance with the relative reduction in informed trading. If informed trading associated with private information has a greater effect, MBF trading variance will be less in delivery months. If the impact of liquidity traders is greater, trading variance will be greater in delivery months. This leads to the following conjectures:

1. MBF return variance during nontrading periods in delivery months is less than MBF return variance during nontrading periods in nondelivery months.
2. MBF return variance during trading periods differs across delivery months and nondelivery months.

Relative Illiquidity of the MBF Market

The previous discussion suggests that the impact of BBI announcements depends on the volume of trading by both informed and uninformed traders. To provide a measure of the relative illiquidity of the MBF market, daily trading volume between the MBF and Treasury bond futures (TBF) contract is compared. Importantly, there are no pricing disparities in the TBF market between delivery and nondelivery months, as the price of the cheapest-to-deliver bond is widely known at all times Treasury bonds are traded, including all trading hours for the MBF.

Table I presents summary statistics regarding daily trading volume and open interest for the nearby MBF and TBF contracts from the inception of the MBF contract on June 11, 1985 through September 21, 1993 for the entire sample period and subsamples of just delivery months and nondelivery months. The results indicate wide differences between the two markets. For instance, the mean value for TBF volume in the overall sample period is almost 70 times the mean value of MBF volume, and the mean value of TBF open interest is almost 20 times the mean value of MBF open interest. These multiples drop to 20 and 10 for volume and open interest, respectively, in delivery months. Although both volume and open interest drop from nondelivery to delivery months, the decline for TBF contracts is considerably greater. The results of tests for differences in liquidity between the two markets (not reported) demonstrate substantially greater trading activity in TBF contracts in both delivery and nondelivery months.

TABLE I

Summary Statistics: Daily Data for the Municipal Bond Futures and Treasury Bond Futures (June 11, 1985–Sept 21, 1993)

Summary statistics are provided for the municipal bond futures (MBF) and Treasury bond futures (TBF). The entire sample covers the period June 11, 1985 to September 21, 1993. MBF and TBF volume is designated as VOLM and VOLT, and MBF open interest and TBF open interest as OPENM and OPENT, respectively. The entire sample consist of 2094 observations. Any observation that contains a missing value for one of the four variables is removed. This results in 20 observations being deleted. In Panel A summary statistics for all days in the sample period are reported. Panel B contains statistics for days in delivery months, and in Panel C statistics for days in nondelivery months are reported.

Variable	*N*	*Mean*	*Std Dev*	*Minimum*	*Maximum*
		Panel A: All Months			
VOLM	2074	2794.47	2165.08	0	18109.00
VOLT	2074	195836.55	131224.74	2201.00	640004.00
OPENM	2074	10289.43	5464.18	0	26390.00
OPENT	2074	198001.43	96707.36	4379.00	376334.00
		Panel B: Delivery Months			
VOLM	469	1196.95	986.22	33.00	6752.00
VOLT	469	23178.66	35683.24	2201.00	365167.00
OPENM	469	5011.29	3079.10	0	18692.00
OPENT	469	50688.48	36313.08	4379.00	292711.00
		Panel C: NonDelivery Months			
VOLM	1605	3261.28	2193.21	0	18109.00
VOLT	1605	246289.24	103052.81	5165.00	640004.00
OPENM	1605	11831.77	5029.43	454.00	26390.00
OPENT	1605	241048.02	59183.58	14808.00	376334.00

Limited Number of Informed Traders in the MBF Market

In addition to its relative illiquidity, there are presumably few informed traders in the MBF market due to the limited number of firms that make a market in municipal bonds and the wide range of municipal securities that are traded. Specifically, there are few firms that have a national market presence in underwriting municipal securities and stand willing to buy and sell municipals in the secondary market. When calculating the BBI, prices from only six brokers are obtained, with the high and low dropped from each bond. Given this limited involvement, it seems logical to infer that relatively few individuals or firms trade sufficiently to accurately price each of the 40 bonds in the BBI before it is formally announced to the public.

Main Hypotheses

The arrival of information and market liquidity both influence the variance of returns. It is therefore hypothesized that trading prior to the release of price information on the BBI is undertaken mostly by informed traders, and that with the release of price information, liquidity traders tend to enter the market such that informed traders contribute a reduced share of market activity. The formal midday announcement during delivery months allows direct testing of differences in trading and nontrading return variances when there are substantive differences in informed and liquidity trading. This leads to the following two hypotheses.

For nontrading return variance (σ^2_{NT}), it is hypothesized:

$$\mathbf{H}_1: \quad \sigma^{2\,(\text{Delivery})}_{NT} < \sigma^{2\,(\text{Nondelivery})}_{NT}$$

For trading return variance (σ^2_T), it is hypothesized:

$$\mathbf{H}_2: \quad \sigma^{2\,(\text{Delivery})}_{T} \neq \sigma^{2\,(\text{Nondelivery})}_{T}$$

where the superscripts refer to observations segmented by delivery months and nondelivery months.

H_1 follows from the contention that nontrading variance is affected by market-specific public information in the MBF market due to both the relative illiquidity of the MBF market and the two pricing announcements for the BBI in delivery months. With a midday pricing in delivery months, the second announcement should be better anticipated by the market than the single announcement at the close of trading in nondelivery months. Therefore, the announcement of prices at market close in delivery months should exhibit lower (nontrading) variance in comparison to the announcement in nondelivery months at the close of trading.

H_2 is not signed because it reflects the unpredictable magnitudes of two competing effects. Only in delivery months is there a midday price announcement during trading hours. If public information affects variance, trading variance in delivery months should differ from trading variance in nondelivery months. If the increase in trading return variance due to the public announcement is greater (lesser) than the reduction in trading return variance due to the reduction in informed trading (i.e., trading associated with private information) as a result of the announcement itself, then the variance in returns will increase (decrease). The difference in variance is therefore dependent on the magnitudes of the two competing effects.

In later empirical work (Section V), additional hypotheses that delineate the impact of the announcements on trading variance are developed and tested with the use of intraday data.

III. DATA AND METHODOLOGY

The Data

The empirical tests are carried out in two stages. In the first stage, the two previous hypotheses outlined are tested with the use of daily data obtained from the CBOT. The daily data consist of opening and closing prices, volume, and open interest for the nearby MBF contract from the introduction of the MBF contract on June 11, 1985 to September 21, 1993. Terminating the daily data with the September 1993 contract avoids the twice-daily pricing of the BBI in nondelivery months that began on October 5, 1993. At expiration of the nearby contract the data series shifts to the next-to-expire contract. Trading and nontrading periods are identified as periods when the CBOT is open and closed, respectively. This sample is used to compare return variances across days and consists of 2090 observations. Of the 2090 observations, 1622 relate to nondelivery months and 468 relate to delivery months.[7] In the second stage hypotheses are formulated based on the introduction on October 5, 1993 of a second pricing announcement in nondelivery months. These hypotheses are then tested with the use of intraday data.

Comparison of Returns

Returns used to calculate trading and nontrading variance across an interval t are measured with the use of the continuously compounded returns formula:

$$R_t = \ln\left(\frac{P_{te}}{P_{tb}}\right) \tag{1}$$

where

P_{te} = the closing price at the end (te) of a trading or nontrading interval

P_{tb} = the opening price at the beginning (tb) of a trading or nontrading interval

Trading time returns ($R_{T,d}$) within any given day d are given by

[7]Initially, the data set had 2094 observations, but 4 observations were removed because of missing data. Returns for these days were thus eliminated.

$$R_{T,d} = \ln\left(\frac{P_{2\ \mathrm{p.m.},d}}{P_{7:20\ \mathrm{a.m.},d}}\right), \tag{2}$$

and nontrading time returns ($R_{\mathrm{NT,d}}$) on any given day d are given by

$$R_{\mathrm{NT},d} = \ln\left(\frac{P_{7:20\ \mathrm{a.m.},d}}{P_{2\ \mathrm{p.m.},d-1}}\right) \tag{3}$$

Tests of normality for the data, such as Jarque–Bera (not reported), indicate that returns in the full sample and in the subsamples (delivery and nondelivery months) are not normally distributed. Therefore, differences in return variance across periods and samples are analyzed with the use of the Brown–Forsythe (1974) modified Levene (1960) (henceforth BFL) statistic,[8]

$$F = \left[\frac{\sum_{j=1}^{J} n_j (\bar{D}_{\cdot j} - \bar{D}_{\cdot\cdot})^2}{\sum_{j=1}^{J}\sum_{i=1}^{n_j} (D_{ij} - \bar{D}_{\cdot j})^2}\right]\left[\frac{(N - J)}{(J - 1)}\right] \tag{4}$$

where $D_{ij} = |R_{ij} - M_{\cdot j}|$; R_{ij} is the return for day I, period j, $M_{\cdot j}$ is the sample median return for period j, computed over the n_j days included in the test; $\bar{D}_{\cdot} = \Sigma$ is the mean absolute deviation (from the median) over the n_j days for a given period j; $\bar{D}_{\cdot\cdot} = \Sigma\,\Sigma\, D_{ij}/N$, where the D_{ij} is summed over the j periods and n_j days; and N is the grand mean (computed as $N = \Sigma\, n_j$ over the j periods). The F statistic is $F_{J-1,N-J}$ under the null hypothesis. This methodology has been widely used in the stock markets and to a lesser extent in the futures markets. [As examples, see Lockwood and Linn (1990) and Ederington and Lee (1993).]

Trading Variance versus NonTrading Variance

In previous research, trading variance has generally systematically exceeded nontrading variance by significant margins [French and Roll (1986), Barclay, Litzenberger, and Warner (1990), Lauterbach and Monroe (1989)]. Results of tests for trading and nontrading variance in both the MBF and TBF markets are reported in Table II. Panel A of Table II reports summary statistics for trading and nontrading variance in the

[8]Conover, Johnson, and Johnson (1981) compare over 50 methods for testing differences in variances. They conclude that the modified Levene (1960) test is among the most powerful and is robust to departures from normality.

TABLE II

Comparison of Trading and Nontrading Variance for Municipal Bond Futures and Treasury Bond Futures

Table II reports BFL (Brown–Forsythe–Levene) tests for homoskedasticity with the use of daily data from June 11, 1985 through September 21, 1993. In Panel A results of differences in trading and nontrading variance across all months in the test period are reported; in Panel B results across nondelivery months are reported; in Panel C results across delivery months are reported. Returns are measured with the use of the continuously compounded returns formula, $R_t = \ln(P_{tc}/P_{tb})$, where P_{tc} is the closing price at the end of a designated trading or nontrading interval, and P_{tb} is the opening price at the beginning of a designated trading or nontrading interval. The BFL F statistic is given below, where $D_{ij} = |R_{ij} - M_j|$; R_{ij} is the return for day I, period j. M_j is the sample median return for period j computed over the n_i, days included in the test. $D_j = \Sigma(D_{ij}/n_j)$ is the mean absolute deviation (from the median) over the n_j days for a given period j, $\bar{D}_{..} = \Sigma\,\Sigma\, D_{ij}/N$, where the D_{ij} is summed over the j periods and n_j days; and N is the grand mean (computed as $N = \Sigma n_j$ over the j periods). The F statistic is distributed $F_{J-1,N-J}$ under the null hypothesis:

$$F = \left[\frac{\sum_{j=1}^{J} n_j(\bar{D}_{.j} - \bar{D}_{..})^2}{\sum_{j=1}^{J}\sum_{i=1}^{n}(D_{ij} - \bar{D}_{.j})^2}\right]\left[\frac{(N - J)}{(J - I)}\right].$$

Period	*MBF Variance*	*TBF Variance*
	Panel: Trading and Nontrading Variance (All Months)	
Nontrading	0.00001481	0.00001269
Trading	0.00002183	0.00004084
$\mathbf{H}_{10}$: Variances are equal	BFL F: 103.71, p value: 0.000	BFL F: 551.640, p value: 0.000
	Panel B: Trading and Nontrading Variance (Nondelivery Months)	
Nontrading	0.00001697	0.00001371
Trading	0.00002301	0.00003874
$\mathbf{H}_0$: Variances are equal	BFL F: 72.120, p value: 0.000	BFL F: 402.170, p value: 0.000
	Panel C: Trading and Nontrading Variance (Delivery Months)	
Nontrading	0.00000725	0.00000911
Trading	0.00001757	0.00004801
$\mathbf{H}_0$: Variances are equal	BFL F: 38.550, p value: 0.000	BFL F: 150.440, p value: 0.000

MBF market with the use of daily observations over the entire period. In the MBF market we observe that the BFL statistics indicate that mean daily trading variance significantly exceeds nontrading variance (at the 0.0001 level) over the entire sample period. Similar results are evident in the TBF market. Given the nature of this study, the sample is subdivided into delivery and nondelivery month observations, and then investigated for homoskedasticity across trading and nontrading periods. Results for the subsamples, presented in Panels B and C, yield identical results that show that trading variance exceeds nontrading variance and that the number of months before contract expiration has no impact on this result.

The overall results thus provide evidence that MBF return trading variance systematically exceeds MBF nontrading return variance and therefore appears to follow the same variance patterns documented in the stock market and a variety of futures markets. A key implication is that the increased trading variance over nontrading variance could possibly be caused by the flow of private information during trading hours, as suggested by French and Roll (1986). Again, the results of the tests in the TBF market mimic the results in the MBF market.

IV. EMPIRICAL RESULTS: TRADING VARIANCE AND NONTRADING VARIANCE

To investigate hypotheses H_1 and H_2 BFL tests are used to test for homoskedasticity across trading and nontrading periods in delivery and nondelivery months in the MBF market. The same tests are also conducted in the TBF market for comparison. The first set of tests examine differences in nontrading variance between delivery and nondelivery months, whereas the second set examines differences in trading variance between delivery and nondelivery months.

Tests for Nontrading Variance

In Panel A of Table III results from the BFL tests for nontrading variance related to H_1 are reported. These results are consistent with the hypothesis that nontrading variance is significantly less in delivery months than in nondelivery months for MBFs. Specifically, the variance in delivery months is 43% of the variance in nondelivery months. The F statistic is 12.906, and is significant at the 0.001 level. This evidence suggests that market-specific public information on the BBI affects nontrading variance in the MBF market and that the announcement of prices in delivery months is associated with lower variance. On the other hand, variance in delivery months in the TBF market, which is 66% of the variance in nondelivery months, is not significantly different from variance in nondelivery months.

Tests for Trading Variance

The results of similar tests comparing trading variance in nondelivery months with trading variance in delivery months are reported in Panel B of Table III. Again, the results suggest that MBF trading variance is affected by public information with variance in delivery months, when the release of information takes place, equal to approximately 70% of the

TABLE III

Comparison of Nontrading Variance between Delivery and Nondelivery Months and Trading Variance between Delivery and Nondelivery Months for the Municipal Bond Futures and the Treasury Bond Futures

Table III reports BFL (Brown–Forsythe–Levene) tests for homoskedasticity in nontrading and trading periods. In Panel A results of tests for differences in variance in delivery and nondelivery months for nontrading periods are reported, and in Panel B results of tests that examine differences in variance in delivery and nondelivery months for trading periods are reported. Returns are measured with the use of the continuously compounded returns formula $R_t = \ln(P_{tc}/P_{tb})$, where P_{tc} is the closing price at the end of a designated trading or nontrading interval and P_{tb} is the opening price at the beginning of a designated trading or nontrading interval. The BFL F statistic is given below, where $D_{ij} = |R_{ij} - M_j|$; R_{ij} is the return for day, I, period j. M_j is the sample median return for period j computed over the n_j days included in the test. $\bar{D}_j = \Sigma(D_{ij}/n_j)$ is the mean absolute deviation (from the median) over the n_j days for a given period j; and $\bar{D}_{..} = \Sigma\,\Sigma\, D_{ij}/N$, where the D_{ij} is summed over the j periods and n_j days; and N is the grand mean (computed as $N = \Sigma n_j$ over the j periods). The F statistic is distributed $F_{J-1,N-J}$, under the null hypothesis:

$$F = \left[\frac{\sum_{j=1}^{J} n_j(\bar{D}_j - \bar{D}_{..})^2}{\sum_{j=1}^{J}\sum_{i=1}^{n_j} (D_{ij} - \bar{D}_j)^2}\right]\left[\frac{(N - J)}{(J - 1)}\right]$$

Period	*MBF Nontrading Variance*	*TBF Nontrading Variance*
	Panel A: Nontrading Variance (Delivery and Nondelivery Months)	
Delivery	0.00000725	0.00000911
Nondelivery	0.00001697	0.0001371
H₁: $\sigma^{2\,(\text{Delivery})} < \sigma^{2\,(\text{Nondelivery})}$	BFL F: 12.906, p value: 0.000	BFL F: 1.569, p value: 0.210
	Panel B: Trading Variance (Delivery and Nondelivery Months)	
Delivery	0.00001757	0.00004801
Nondelivery	0.00002301	0.00003874
H₂: $\sigma^{2\,(\text{Delivery})} \neq \sigma^{2(\text{Nondelivery})}$	BFL F: 9.140, p value: 0.000	BFL F: 0.671, p value: 0.413

variance exhibited in nondelivery months. In the case of the TBF market trading variance in delivery months is actually higher than trading variance in nondelivery months, but the differences are not significant. It must be noted that although the expiration effects could be a possible explanation for the reduction in variance, the overall evidence suggests otherwise. In general, the announcement of price information on the BBI appears to lower trading variance in delivery months in the MBF market. This is consistent with the conjecture that market-specific public information not only impacts trading variance but also reduces variance in this relatively illiquid market. To further examine the effect of the announcement in the MBF market, a two-step procedure is now adopted. In the first step, variance in the MBF market on weekdays and on weekends is

TABLE IV

Comparison of Nontrading Variance on Weekdays and on Weekends between Delivery and Nondelivery Months for Municipal Bond Futures

Table IV reports BFL (Brown–Forsythe–Levene) tests for homoskedasticity in nontrading periods. Results of tests for differences in variance in delivery and nondelivery months for weekdays are reported in column 2, and in column 3 similar tests for weekends are reported. Returns are measured with the use of the continuously compounded returns formula, $R_t = \ln(P_{te}/P_{tb})$, where P_{te} is the closing price at the end of a designated trading or nontrading interval and P_{tb} is the opening price at the beginning of a designated trading or nontrading interval. The BFL F statistics given below, where $D_{ij} = |R_{ij} - M_j|$; R_{ij} is the return for day I, period j. M_j is the sample median return for period j computed over the n_j days included in the test. $\bar{D}_j = \Sigma(D_{ij}/n_j)$ is the mean absolute deviation (from the median) over the n_j days for a given period j; and $\bar{D}_{..} = \Sigma\Sigma D_{ij}/N$ where the D_{ij} is summed over the j periods and n_j days and N is the grand mean (computed as $N = \Sigma n_j$ over the j periods). The F statistic is distributed $F_{J-1,N-J}$ under the null hypothesis:

$$F = \left[\frac{\sum_{j=1}^{J} n_j(\bar{D}_j - \bar{D}_{..})^2}{\sum_{j=1}^{J}\sum_{i=1}^{n}(D_{ij} - \bar{D}_j)^2}\right]\left[\frac{(N-J)}{(J-1)}\right]$$

Period	*MBF Nontrading Variance Weekdays*	*MBF Nontrading Variance Weekends*
	MBF Nontrading Variance (Weekdays and Weekends)	
Delivery	0.00000745	0.00000668
Non-Delivery	0.00001690	0.00001699
H₁: $\sigma^{2(\text{Delivery.})} < \sigma^{2(\text{Nondelivery})}$	BFL F: 7.140, p value: 0.007	BFL F: 6.700, p value: 0.010

examined, and in the second step, variance before and after the first revision day in delivery months is examined.

Weekends versus Weekdays

With the additional time between trading over weekends versus weekdays, the relative impact of midday pricing should be more evident on weekends, although the impact could be tempered due to other weekend informational effects. Tests that examine differences in nontrading variance between delivery and nondelivery months from Monday through Thursday (weekdays) and nontrading variance in delivery and nondelivery months from Friday to Monday (weekends) are carried out to assess whether any differential impact appears. The results, reported Table IV, are consistent with a reduction in nontrading variance over weekdays as well as weekends. Variance in delivery months during weekdays amounts to about 44% of the variance in nondelivery months, and for weekends the comparative value is around 40%. The F values for the weekday and weekend variances are 7.14 and 6.70, respectively, and are both significant at the 0.01 level. The basic premise that market-specific information reduces nontrading variance is well supported, with virtually the same effect on weekdays and weekends.

Impact of Revisions in the BBI

Bonds that comprise the BBI are subject to change every 2 weeks to ensure a representative sample of liquid municipals. This allows market watchers and participants to use the index as a gauge to better discern the performance of the municipal bond market in general. The bonds are selected to represent the diversity of issues and are screened with the use of a strict set of rules before inclusion. Thus, on revision days, the 15th and last business day of each month, bonds are deleted from the BBI and new ones are added to keep the index current.

This process provides another way of testing the impact of market-specific information on trading variance. Comparison of trading variance after the last revision on the BBI with variance prior to the last revision can lead to an estimate of the impact of BBI-specific information revealed by the addition of the new bonds and the removal of the old bonds on return variance. Given the mechanics of the revision process, there is no uncertainty concerning the composition of the BBI after the last revision in the delivery month prior to expiration. With this reduced uncertainty, trading variance after the last revision in delivery months should be lower than trading variance in prior periods. The lower variance results from the more precise information regarding the final composition of the BBI at futures contract expiration, and the corresponding reduction in risk premia associated with cash-and-carry trading. To test this, observations during delivery months are separated into pre-last-revision and post-last-revision samples. If uncertainty is reduced, trading variance before the last revision should exceed trading variance after the last revision.

The results of these tests, reported in Table V, lend further support to the notion that trading variance in the MBF market is reduced by market-specific public information. Specifically, post-last-revision trading variance is approximately 41% of pre-last-revision trading variance in delivery months, and the difference in variance is significant at the 0.05 level. Interestingly, given the F values and the levels at which the differences are significant, it seems that the release of revision information has a smaller impact than the release of pricing information. The same tests are conducted for nontrading variance because the reduction in uncertainty may also affect daily closing and opening prices. The results, re-

TABLE V

Comparison of Pre- and Post–Last-Revision Variance in Delivery Months for Municipal Bond Futures

Table V reports BFL (Brown–Forsythe–Levene) tests for homoskedasticity in trading and nontrading periods during delivery months. The delivery month is segmented into two groups based on the first revision day of the month, usually the 15th business day of the month (the day when new bonds are added to the BBI and the old ones deleted). In column 2 results of tests for differences in trading variance in pre and postrevision periods are reported, and in Column 3 the results for nontrading periods are reported. Returns are measured with the use of the continuously compounded returns formula, $R_t = \ln(P_{tc}/P_{tb})$, where P_{tc} is the closing price at the end of a designated trading on nontrading interval and P_{tb} is the opening price at the beginning of a designated trading or nontrading interval. The BFL F statistic is given below, where $D_{ij} = |R_{ij} - M_j|$; R_{ij} is the return for day I, period j. M_j is the sample median return for period j computed over the n_j days included in the test $D_j = \Sigma(D_{ij}/n_j)$ is the mean absolute deviation (from the median) over the n_j days for a given period j; and $\bar{D}_{..} = \Sigma\,\Sigma\, D_{ij}/N$ where the D_j is summed over the i periods and n_j days, and N is the grand mean (computed as $N = \Sigma n_j$ over the j periods). The F statistic is distributed $F_{J-1,\,N-J,}$ under the null hypothesis:

$$F = \left[\frac{\sum_{j=1}^{J} n_j(\bar{D}_j - \bar{D}_j)^2}{\sum_{j=1}^{J}\sum_{i=1}^{n_j}(D_{ij} - \bar{D}_j)^2}\right]\left[\frac{(N-J)}{(J-1)}\right]$$

Period	*Trading Variance*	*Nontrading Variance*
	Pre and Postrevision Variance in Delivery Months	
Prerevision	0.00002516	0.00001044
Postrevision	0.00001025	0.00000676
H$_0$: $\sigma^{2(\text{Postrevision.})} < \sigma^{2(\text{Prerevision})}$	BFL F: 4.820, p value: 0.029	BFL F: 0.920, p value: 0.340

ported in the same table, show that post-revision nontrading variance is only 65% of prerevision nontrading variance, but indicate that the differences are insignificant at conventional levels. The impact of revision information thus appears to be relatively weak.

V. INTRADAY TESTS OF PUBLIC INFORMATION EFFECTS ON TRADING VARIANCE

On October 5, 1993, the CBOT changed pricing procedures from once-a-day pricing at the close of trading in nondelivery months to twice daily, with the initial pricing at 11 a.m. The CBOT's intent was to provide users with more timely, intraday pricing information in all months. This change in microstructure provides another clear means of testing the impact of market-specific public information on return variance during trading periods. To do this intraday (tick) data are obtained from Tick Data Inc. Given the seeming reduction in daily return variance due to the release of market-specific public information, the (new) midday announcement of the BBI in nondelivery months should also affect trading variance immediately thereafter. The evidence so far points to a reduction in variance subsequent to the release of information. On this basis the following hypotheses (H_3–H_6) are postulated: For trading variance in the nondelivery months prior to October 5, 1993:

$$H_3: \quad \sigma_T^{2\,(\text{Open-11 a.m.})} \simeq \sigma_T^{2\,(\text{11 a.m.-close})}$$

For trading variance in the nondelivery months subsequent to October 5, 1993:

$$H_4: \quad \sigma_T^{2\,(\text{Open-11 a.m.})} \neq \sigma_T^{2\,(\text{11 a.m.-close})}$$

For trading variance in the delivery months prior to October 5, 1993:

$$H_5: \quad \sigma_T^{2\,(\text{Open-11 a.m.})} \neq \sigma_T^{2\,(\text{11 a.m.-close})}$$

For trading variance in the delivery months subsequent to October 5, 1993:

$$H_6: \quad \sigma_T^{2\,(\text{Open-11 a.m.})} \neq \sigma_T^{2\,(\text{11 a.m.-close})}$$

These hypotheses reflect the impact of the additional announcement of prices for bonds in the BBI instituted on October 5, 1993, during nondelivery months. Prior to October 5, 1993, the twice-daily pricing in delivery months remained in force, while no announcement was made during trading hours in nondelivery months. Hence, the comparison of trading variance before and after 11 a.m. in nondelivery months prior to October 5, 1993 should have no measurable statistical difference (H_3). In contrast, H_4 reflects the fact that the additional pricing instituted by the CBOT should provoke a measurable difference in trading variance if market-specific information has an impact. H_5 and H_6 similarly reflect the fact that information on the BBI has always been announced during delivery months at 11 a.m., such that trading variance from open to 11 a.m. and from 11 a.m. to close should differ.

To test H_3–H_6, return variances are calculated using tick-by-tick prices. The data are purposely assembled to straddle the October 5th event date.[9] To simplify the analysis, only prices for nearby contracts are

[9]The trading period was divided into twenty-seven 15-minute intervals. Prior to 11 a.m. there are 14 such intervals and after 11 a.m. 13 such intervals. The first interval after 11 a.m. (11:05) contains returns from 10:50 to 11:05. This was done in order to capture price leakage that could occur prior to the announcement. Most CBOT manuals indicate that prices of the bonds in the BBI will be evaluated between 10:45 a.m. and 11 a.m. Chicago time. The process of including returns between 10:50 a.m. and 11:05 into the postannouncement period should capture any price leakage that may take place.

used. For example, to compare trading return variance under H_3, prices for the June 1993 and September 1993 contracts are used to construct returns in the nondelivery months preceding October 5, 1993 (i.e., for May 1993 and August 1993). The sample consists of prices for each 15-minute interval from the open of trading to the close of trading. This interval is selected to avoid empty intervals, as the MBF contract is not highly liquid. The sample is then divided into a preannouncement period (open–11 a.m.) and a postannouncement period (11 a.m.–close), even though no announcement takes place in the period before October 5, 1993. This is done to match the analysis for H_4. Results of the BFL test for differences in variance related to H_3 are reported in Panel A of Table VI. In absolute terms, variance after 11 a.m. is not much different from variance before 11 a.m. The F values are 0.02 and 0.65 for May 1993 and August 1993, suggesting that there is no meaningful difference in variance. The results not only provide strong evidence that variance does not differ before and after 11 a.m., but also support the contention postulated in H_3. On the other hand, results of the test of H_4 (see Panel B of Table VI) with the use of the December 1993 and March 1994 contracts and prices in the preceding nondelivery months of November 1993 and February 1994, show strong evidence that the variance in returns differs before and after the newly introduced 11 a.m. announcement in nondelivery months and provide support for H_4. The F values, reported in Table VI, in this case are 13.01 and 4.82. Variance after the announcement ranges between 40% and 60% of the variance prior to the announcement. The overall results strongly support the conjecture that public information impacts trading variance.

To test H_5 and H_6 returns in June 1993 and September 1993 and in December 1993 and March 1994, respectively, are examined for differences in variances before and after the 11 a.m. announcement. Given that pricing announcements on the BBI in delivery months were reported twice a day from the inception of the contract, variance between these periods should differ in all months. Results of the tests of H5 and H6, reported in Panels A and B of Table VII, provide support for this conjecture. The September postannouncement variance is 37% of the preannouncement variance, whereas the December postannouncement to preannouncement figure is approximately 20%. The March 1994 postannouncement to preannouncement figure is approximately 28%. The June 1993 postannouncement variance is also lower, although not significantly different from the preannouncement variance. However, in all other cases the difference in variance is significant at the 0.05 level.

TABLE VI

Intraday Tests of Trading Variance for the Municipal Bond Futures Nondelivery Months

Table VI reports BFL (Brown–Forsythe–Levene) tests for homoskedasticity with the use of intraday data in trading periods during nondelivery months. These tests examine variance in nondelivery months before and after the second pricing announcement was introduced on October 5th, 1993. Each sample is composed of prices at 15-minute intervals. The samples are divided into two periods: open to 11 a.m. (preannouncement sample), and 11 a.m. to close (postannouncement sample). In Panel A results of tests for differences in trading variance in pre- and post-11 a.m. periods for May 1993 and August 1993 are reported. In May 1993 and August 1993 no formal announcement of the BBI was made at 11 a.m. However, this basis is used to divide the sample so that a clear comparison can be made with November 1993 and February 1994 (when a formal announcement at 11:00 a.m. was in effect). In Panel B the results for November 1993 and February 1994 are reported. Returns are measured with the use of the continuously compounded returns formula $R_t = \ln(P_{te}/P_{tb})$, where P_{te} is the closing price at the end of a designated trading or nontrading interval and P_{tb} is the opening price at the beginning of a designated trading or nontrading interval. The BFl F statistic is given below, where $D_{ij} = |R_{ij} = M_j|$; R_{ij} is the return for day l, period j. M_j is the sample median return for period j computed over the n_j days included in the test $D_j = \Sigma(D_{ij}/n_j)$ is the mean absolute deviation (from the median) over the n_j days for a given period j; $\bar{D}.. = \Sigma\Sigma D_{ij}/N$, where the D_{ij} is summed over the j periods and n_j days, and N is the grand mean (computed as $N = \Sigma n$ over the j periods). The F statistic is distributed $F_{J-1,N-J}$ under the null hypothesis:

$$F = \left[\frac{\sum_{j=1}^{J} n_j(\bar{D}_j - \bar{D}_j)^2}{\sum_{j=1}^{J}\sum_{i=1}^{n}(D_{ij} - \bar{D}_j)^2}\right]\left[\frac{(N-J)}{(J-1)}\right]$$

Period	*Trading Variance in May 1993*	*Trading Variance in August 1993*
Panel A: Trading Variance before and after 11:00 a.m. in Nondelivery Months before October 5th, 1993		
Open–11.00 a.m.	0.00000036	0.00000031
11.00 a.m.–Close	0.00000028	0.00000034
H$_3$: $\sigma^{2(\text{Open-11:00 a.m.})} = \sigma^{2(\text{11 a.m.-close})}$	BFL F: 0.021, p value: 0.884	BFL F: 0.650, p value: 0.421
Period	*Trading Variance in November 1993*	*Trading Variance in February 1994*
Panel B: Trading Variance before and after 11:00 a.m. in Nondelivery Months after October 5th, 1993		
Open–11.00 a.m.	0.00000090	0.00000092
11.00 a.m.–Close	0.00000039	0.00000055
H$_4$: $\sigma^{2(\text{Open-11:00 a.m.})} \neq \sigma^{2(\text{11 a.m.-close})}$	BFL F: 13.010, p value: 0.000	BFL F: 4.822, p value: 0.029

The primary implication is that strong support exists for an information effect.

VI. SUMMARY AND CONCLUSIONS

This study provides direct evidence of the impact of market-specific public information on trading and nontrading variance in the municipal bond

TABLE VII

Intraday Tests of Trading Variance for the Municipal Bond Futures Delivery Months

Table VII reports BFL (Brown–Forsythe–Levene) tests for homoskedasticity with the use of intraday data in trading periods during delivery months. These tests examine variance in delivery months before and after the second pricing announcement was introduced October 5th, 1993. Each sample is composed of prices at 15-minute intervals. The samples are divided into two periods: open to on 11 a.m. (preannouncement sample) and 11 a.m. 10 close (postannouncement sample). In Panel A results of tests for differences in trading variance in pre- and post-11 a.m. periods for June 1993 and September 1993 are reported. Because June and September are delivery months, a formal announcement of the BBI is made at 11 a.m. (prior to October 5th, 1993). In Panel B the results for December 1993 and March 1994 are reported. Returns are computed with the continuously compounded returns formula, $R_t = \ln(P_{te}/P_{tb})$, where P_{te} is the closing price at the end of a designated trading or nontrading interval and P_{tb} is the opening price at the beginning of a designated trading or nontrading interval. The BFL F static is given below, where $D_{ij} = |R_{ij} = M_{.j}|$; R_{ij} is the return for day I period j. M_{ij} is the sample median return for period j, computed over the n_j days included in the test $D_{.j} = \Sigma(D_{ij}\, n_j)$ is the mean absolute deviation (from the median) over the n_j days for a given period j; $D_{.} = \Sigma\,\Sigma\, D_{ij}\, N$, where the D_{ij} is summed over the j periods and n_j days and N is the grand mean (computed as $N = \Sigma n_j$ over the j periods). The F statistic is distributed $F_{J-1,N-J}$ under the null hypothesis.

$$F = \left[\frac{\sum_{j=1}^{J} n_j(\bar{D}_j - \bar{D}_.)^2}{\sum_{j=1}^{J}\sum_{i=1}^{n_j}(D_{ij} - \bar{D}_j)^2}\right]\left[\frac{(N-J)}{(J-1)}\right]$$

Period	*Trading Variance in June 1993*	*Trading Variance in September 1993*
Panel A: Trading variance before and after 11:00 a.m. in Delivery Months before October 5th, 1993		
Open–11.00 a.m.	0.00000012	0.00000019
11.00 a.m.–Close	0.00000009	0.00000007
H₅: $\sigma^{2(\text{Open-11:00 a.m.})} \neq \sigma^{2(\text{11 a.m.-close})}$	BFL F: 1.091, p value: 0.297	BFL F: 5.920, p value: 0.015
Period	*Trading Variance in December 1993*	*Trading Variance in March 1994*
Panel B: Trading Variance before and after 11:00 a.m. in Delivery Months after October 5th, 1993		
Open–11.00 a.m.	*0.00000036*	*0.00000079*
11.00 a.m.–Close	*0.00000007*	*0.00000022*
H_6: $\sigma^{2(\text{Open-11:00 a.m.})} \neq \sigma^{2(\text{11 a.m.-close})}$	BFL F: 12.250, p value: 0.000	BFL F: 5.21, p value: 0.023

futures (MBF) market. This market is particularly interesting given its unique features—the existence of few informed traders and its relative illiquidity compared with other markets. During the sample period for daily data the prices of the underlying cash instruments used to construct the BBI upon which the futures contract is based are publicly announced once a day during nondelivery months, and twice a day, with a midday announcement during trading hours, in delivery months. The announcement of the BBI is viewed as market-specific public information that should affect return variance.

The study reports results of empirical tests for differences in return variance with the use of a methodology that is robust to distributional assumptions. Initial comparisons that use daily data over the entire June 11, 1985 through September 21, 1993 period indicate that trading variance in the MBF market significantly exceeds nontrading variance. A breakdown of the sample into observations from delivery and nondelivery months yields the same results, consistent with patterns documented in the stock and other futures markets. However, additional empirical tests indicate that the announcement of the BBI reduces nontrading variance and trading variance in delivery months relative to nondelivery months. Corresponding tests in the market for Treasury bond futures reveal no such effects. Further investigation of the MBF market reveals that this effect persists across both weekdays and weekends. The same effects are evident after the last revision of the BBI versus prior periods.

The institution of twice-a-day pricing of the BBI by the CBOT on October 5, 1993 provides a means of further testing the effects of information on trading variance with the use of intraday data. Prior to the introduction of the pricing announcement at 11 a.m. in nondelivery months (before October 5th, 1993), trading variance before and after 11 a.m. exhibits no statistically measurable difference. However, following the introduction of the 11 a.m. announcement in nondelivery months, trading variance after 11 a.m. is significantly less than trading variance before 11 a.m. These tests provide strong evidence that market-specific public information affects trading variance in an illiquid market. The overall results of the analysis could help traders formulate trading strategies given that there is less variance in an illiquid market after information releases. Traders seeking to hedge cash market positions or trade when the market has depth should consider trading in postannouncement periods. On the other hand, the higher variance prior to announcements should attract speculators.

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