CASH SETTLEMENT WHEN THE UNDERLYING SECURITIES ARE THINLY TRADED: A CASE STUDY

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INTRODUCTION

Cash settlement has been one of the most useful innovations in the futures industry. As Paul (1985) observes, it not only makes possible trading contracts for goods for which delivery is inconvenient, such the S&P 500 index, but also opens the door to trading contracts on goods like economic indexes, for which delivery is impossible. These benefits, however, do not come without some associated problems. The challenge involved in cash settlement is to make sure that the settlement process is fair and orderly so that futures prices properly reflect underlying market conditions during the final days of trading. If this does not occur, the hedging and price discovery functions of futures markets are compromised.

From the outset it was recognized by Jones (1982) and Garbade and Silber (1983), among others, that although cash settlement assures convergence to a cash index, it does not assure convergence to equilibrium cash prices. For future prices to properly reflect equilibrium prices, the exchange must also make sure that the cash price, or cash index, to which the futures contract settles is not distorted. As noted by Lien (1989a,

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1989b) there are three types of problems that can cause cash settling futures prices to diverge from true equilibrium prices.

First, because of sampling errors or lags in reporting, the cash index to which the futures contract settles may not accurately reflect cash market conditions. Henceforth, this will be referred to as the stale prices problem. This problem is likely to be exacerbated when the underlying cash securities on which the index is based are thinly traded. Without the spur of actual transactions, brokers, dealers, and other agents who provide the data on which the cash index is based may not update their quotes promptly.

Second, if the exchange relies on quotes provided by brokers, dealers, or other agents to construct the cash index rather than on publicly observable transaction prices, those agents may have an incentive not to provide accurate information. This is obviously true in the situation in which the agents providing the data have a position in the futures market. The extent to which agents can successfully mislead the exchange depends on the volume of trading in the underlying securities. If a security trades at the same time that a price quote is provided, a misleading quote would be obvious. On the other hand, if there is a large gap between the time of the quote and the last cash trade, it is difficult to determine whether the quote is accurate.

Finally, futures traders (including possibly the agents who provide the quotes) may have an incentive to attempt to manipulate the cash market to profit from futures positions. For instance, a trader with a large long position in municipal bond futures could make a profit on the futures position by buying enough of the underlying bonds to drive up the level of the cash index. Depending on the price elasticity of the cash bonds and transaction costs, profits on futures settlement could exceed the costs of buying and later reselling the cash securities.

As Cita and Lien (1992) stress, the manipulation problem involves particularly complex game-theoretic issues. To the extent that a relatively small volume of trading can affect the underlying security prices, both the shorts and the longs have an incentive to manipulate the cash market to profit on futures positions. Consequently, it is possible that competition between holders of short and long positions, both of whom hope to manipulate the market to their advantage, will drive up the volume of trading and push the cash price toward equilibrium, foiling all attempts at manipulation. This assumes, however, that holders of short and long positions are similar. If a few large traders dominate one side of the market, and the other side is characterized by a plethora of traders with small positions, the large traders are likely to have a distinct advantage. Simi-

larly, given the difficulty of taking short positions in many thinly traded cash securities, holders of short futures positions, who want to manipulate underlying prices downward, are likely to be at a disadvantage.

Although various theoretical models have been developed to elucidate the foregoing problems, particularly the possibility of manipulation, whether difficulties with cash settlement arise in practice remains largely an empirical question.[1] To help answer that question, this article presents a case study of the municipal bond futures market. The municipal bond futures market is ideal for such a case study because settlement in that market is based on the Bond Buyer Index (BBI) of 40 municipal bonds, virtually all of which are relatively thinly traded. The thin trading in the underlying securities makes it more likely that settlement problems will be observed. It is found that settlement risk is not an insignificant problem. The case study reveals that when interest rates moved sharply near the close of trading on December 19, 1995, the quoted prices for the cash securities included in the BBI did not respond fully. Consequently, there was a substantial divergence between the closing futures prices and the prices of other actively traded futures contracts and cash securities. As a result, some traders experienced windfall settlement losses, and others realized offsetting gains.

To explain and amplify these results, the remainder of the article is organized as follows. The next section describes the details of the municipal bond futures contract and the procedure for cash settlement, including how the cash index is constructed. Section 3 presents the empirical results that form the core of the case study. The implications of those results are discussed in the final section.

THE MUNICIPAL BOND FUTURES CONTRACT

The municipal bond futures contract, which began trading in June 1985, is written on the Bond Buyer Municipal Bond Index (BBI). The value of the contract is $1,000 times the level of the BBI. Prices on the exchange are quoted in dollars per hundred with the minimum tick being $\frac{1}{32}$ of a dollar.

For all but the final day of trading, daily settlements are based on trading during the settlement period, or, if there is no trading during that period (which is rare), on the bid and ask quotes during that interval. On the final trading day, however, the procedure is different in that settlement is based directly on the BBI. Specifically, the settlement price on the final day for all unliquidated positions is set equal to the level of the BBI at 2:00 p.m. This makes it critical that the BBI accurately reflects market conditions at that time.

[1]See, for example, Lien (1989b), Cita and Lien (1992), and Kumar and Seppi (1992).

The BBI index on which the contract is written is composed of 40 tax-exempt municipal bonds that pay semiannual interest at a fixed rate. To be included in the index, the bonds must satisfy the following five criteria:

1. Must have a principal value outstanding of at least $50 million. (Housing bonds must have a minimum principal of $75 million.)
2. Must be rated A- or higher by Standard & Poor's or A or higher by Moody's at the time of inclusion in the index.
3. Must have a remaining maturity of at least 19 years on the date of inclusion.
4. Must either be noncallable or have a time to call of at least 16 years as of the date of inclusion.
5. Must be eligible for secondary trading at least one business day prior to inclusion in the index. At the time of inclusion, the bond must be quoted at a price between 85 and 105.

The Bond Buyer also requires that no single issuer have more than two bonds in the index.

To assure that the rating, maturity, and prices of bonds in the index remain relatively constant over time, the Bond Buyer frequently revises composition of the BBI. After the close of trading on the 15th of the month (or the first business day preceding the 15th if the 15th is not a business day) and on the last business day of the month, the BBI is typically revised. On revision dates, bonds that no longer meet the five criteria are deleted and replaced with new bonds. This frequent revision schedule, although useful for maintaining a constant composition, causes two problems. First, bonds entering and leaving the index typically have different prices. Without adjustment, therefore, revisions in the sample would alter the level of the index.

The Bond Buyer makes two adjustments to assure that revisions in the sample do not produce discontinuities in the index. First, the index is not based on the raw prices of the constituent bonds, but rather on their converted prices. The converted price for a bond is calculated by dividing the raw price by a conversion factor. The conversion factor equals the price at which $1 in principal of the bond yields 8%. Because of this adjustment, converted prices are approximately equal to what the dollar price of the bond would be if it had an 8% coupon. As a result, bonds of comparable rating and maturity tend to have comparable converted prices so that substituting one for another does not have a major impact on the index.

Second, although use of converted prices tends to reduce price differentials between bonds entering and leaving the index, discrepancies still exist. Consequently, the Bond Buyer employs a procedure similar to that used by Dow Jones to assure that the industrial index of 30 common stocks is not altered when one stock is substituted for another. In the case of the BBI, the index is set equal to the average converted price of the included bonds multiplied by a coefficient. The coefficient is determined so that the when old bonds are deleted and new bonds are added, the index remains unchanged. For example, assume that prior to revision the average converted price of bonds in the index is 100 and that the coefficient is 0.95, so that the BBI is 95. If after deletions and additions the average converted price of the new sample rises to 101, the coefficient would be changed to 0.9406 to keep the BBI at 95. In this fashion, adjustments in the coefficient eliminate discontinuities in the index.

The combination of price conversion, the averaging of prices, and the application of the coefficient means that there is no straightforward way to duplicate the behavior of the BBI by investing in the underlying bonds. Although this may cause some inconvenience for hedgers and speculators, as long as the procedures by which the BBI is computed are well documented, traders can develop accurate models that relate changes in the level of the BBI to changes in the value of the municipal bond portfolios in which they are interested. It is critical, however, that the prices of the underlying bonds on which the BBI is based reflect current market conditions. Whether bond prices reflect market conditions depends on the frequency with which the underlying cash bonds are traded, the fashion in which quotes are updated, and the manner in which dealers provide price data to the Bond Buyer and the Chicago Board of Trade.

The Price Data Collection Process

Recognizing the importance of accurate cash pricing during the delivery month, the Bond Buyer and the Chicago Board of Trade (CBOT) have developed a detailed procedure for collecting data and constructing the BBI. Each day between 10:45 and 11:00 a.m. and between 1:45 and 2:00 p.m. (Chicago time) the Bond Buyer contacts at least six municipal bond brokers to get price evaluations.[2] As described by the CBOT, the brokers chosen are firms that do not take positions in either the cash or the futures markets so as to minimize any incentive for them to provide mis-

[2]All the times reported in this article refer to Chicago time.

leading quotes. The Bond Buyer asks each broker to estimate the price for which a $100,000 block of each cash bond could be sold. From these quotes, the raw price for each bond is calculated by dropping the high and low quotations and computing the mean of the remaining estimates. Next, these mean raw prices for each bond are transformed into converted prices. Finally, the converted prices are averaged and multiplied by the appropriate coefficient to arrive at the index.

Reasons Cash Prices in the BBI Might Be Stale

As discussed in the introduction, there are three basic reasons why the cash price data collected by the Bond Buyer and the CBOT may fail to reflect true equilibrium prices. First, the quotes might be stale. The possibility of stale prices is enhanced by the fact that municipal bonds are not actively traded in the secondary market compared to government bonds. If the level of interest rates changes, but a specific bond does not trade, the onus is on the broker to make sure that the quoted price is properly adjusted. There is little doubt that the quote would be adjusted if it were sought as part of a trade, but it is less clear that brokers would always take the time to make sure that the 2:00 p.m. quotes given to the Bond Buyer are up to date. Consequently, if there have been no recent inquires regarding purchases or sales, the prices on broker screens at 2:00 p.m. may not reflect that state of the market at that time, at least for some of the bonds in the BBI. In addition, the procedure by which the price data are accumulated by the brokers may lead to a price lag. For example, a broker may appoint someone to write down the prices for the 40 BBI bonds in anticipation of the 2:00 p.m. call. If the market moves sharply just before 2:00 p.m., the list may not be properly updated.

It is also possible that the quoted price may either be purposely misleading or manipulated. As noted previously, the Bond Buyer and the CBOT attempt to minimize the incentive to provide misleading prices by collecting quotes from brokers who do not have positions in the market. This does not, unfortunately, reduce the incentive of traders with large futures positions to manipulate the cash price.

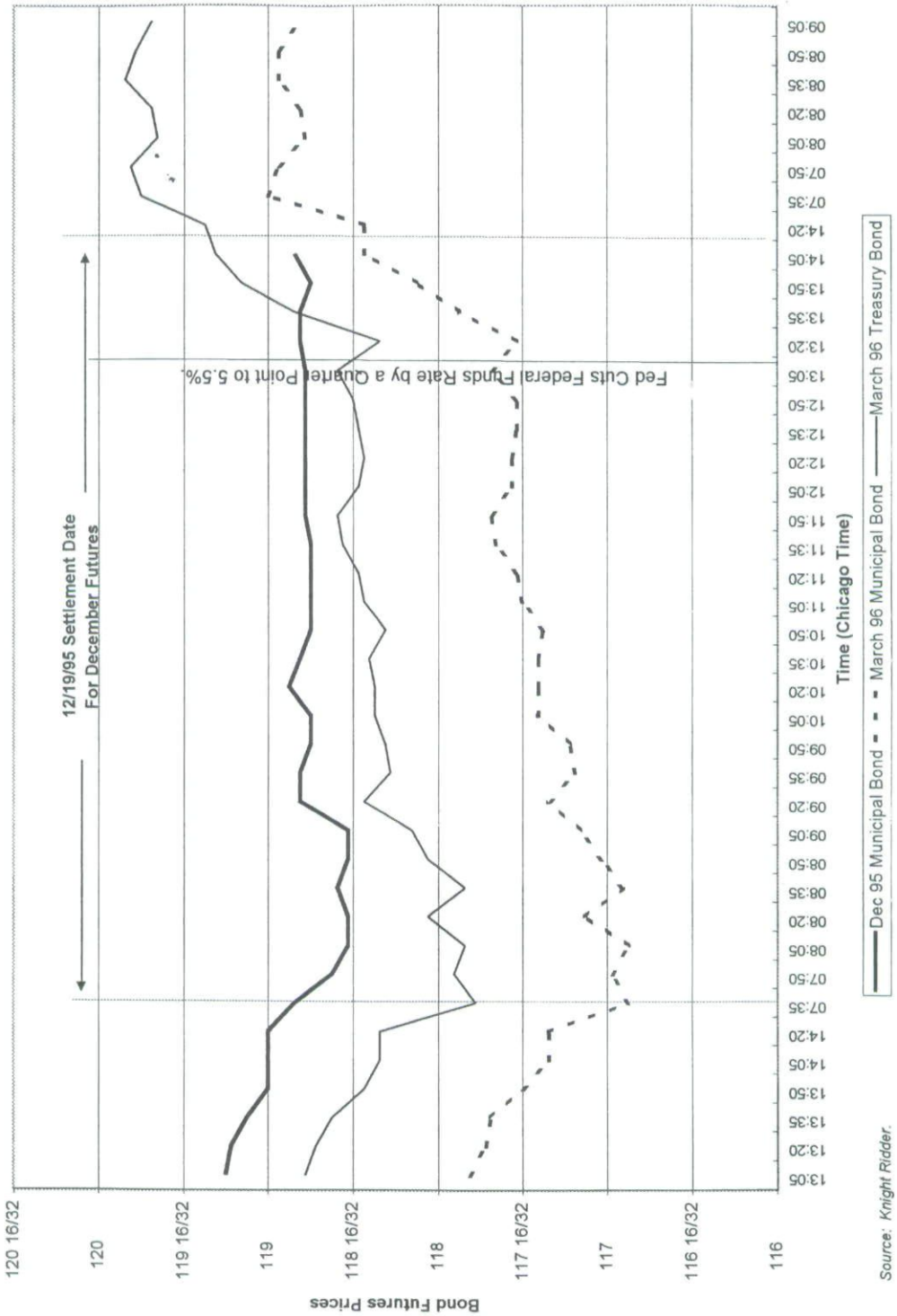
Whether or not the foregoing concerns are real problems is an empirical question. One way to evaluate the extent of the problem is to find a situation in which interest rates moved sharply just prior to 2:00 p.m. on the final day of trading and examine how the expiring futures contracts settled in comparison to other futures contracts and actively traded cash securities. Fortunately, there is such an instance that provides an ideal case study.

THE DECEMBER 1995 CONTRACT SETTLEMENT: A CASE STUDY

What makes the December 1995 contract ideal for a case study was an unexpected announcement by the Federal Reserve on the final day of trading, December 19, 1995. At 1:15 p.m. (Chicago time) on December 19 the Federal Open Market Committee cut the target federal funds rate from $5\frac{3}{4}$ to $5\frac{1}{2}\%$. As reported by Bloomberg, Dow Jones, Reuters, and other news services, the response of the market was strong and immediate. The magnitude of that response is illustrated in Figures 1 and 2, which are based on data collected from Knight–Ridder. Figure 1 presents price data at 15-minute intervals for the three futures contracts that are of interest here: the December municipal bond contract, the March municipal bond contract, and the March Treasury bond contract. (The December Treasury bond contract is not presented because it expired at 12:00 p.m., prior to the Fed announcement.) To provide a slightly larger frame of reference, Figure 2 presents price data 15-minute intervals for the same three contracts over the 5-trading-day period from December 15 to December 21.

Figure 2 shows clearly that the December and March municipal bond futures contracts and the Treasury contract moved closely together in the $4\frac{1}{2}$ days preceding the Fed announcement. This is to be expected because changes in the level of interest rates are the primary determinant of the price of movements for all the contracts. More specifically, the basic cost-of-carry model predicts that the two municipal futures contracts should move virtually lockstep. This lockstep behavior is observed, but only until the afternoon of December 19. The more detailed picture in Figure 1 demonstrates that the divergence begins immediately following the Fed announcement. Whereas the March contracts for both municipal bonds and Treasury bonds jump approximately one point in response to the Fed announcement, the December municipal bond contract fails to move at all.

It is possible that the divergence between the December municipal bond futures and the other futures contracts is evidence that the other contracts, rather than the December futures, are behaving anomalously. Cash market data collected from Bloomberg for individual Treasury bonds and bond indexes reported in Tables I and II show that such is not the case. Table I presents price data for the on-the-run 30-year Treasury bond at 30-minute intervals from the close of futures trading on December 18 through the close on December 20. The table shows that movements in the long bond price mirror movements in prices of the actively traded futures contracts depicted in Figures 1 and 2. Most importantly, the price rises sharply after 1:00 p.m. in response to the Fed announcement and



Source: *Knight Ridder.*

FIGURE 1
Fifteen-minute interval prices for municipal bond and treasury bond futures—December 19, 1995.

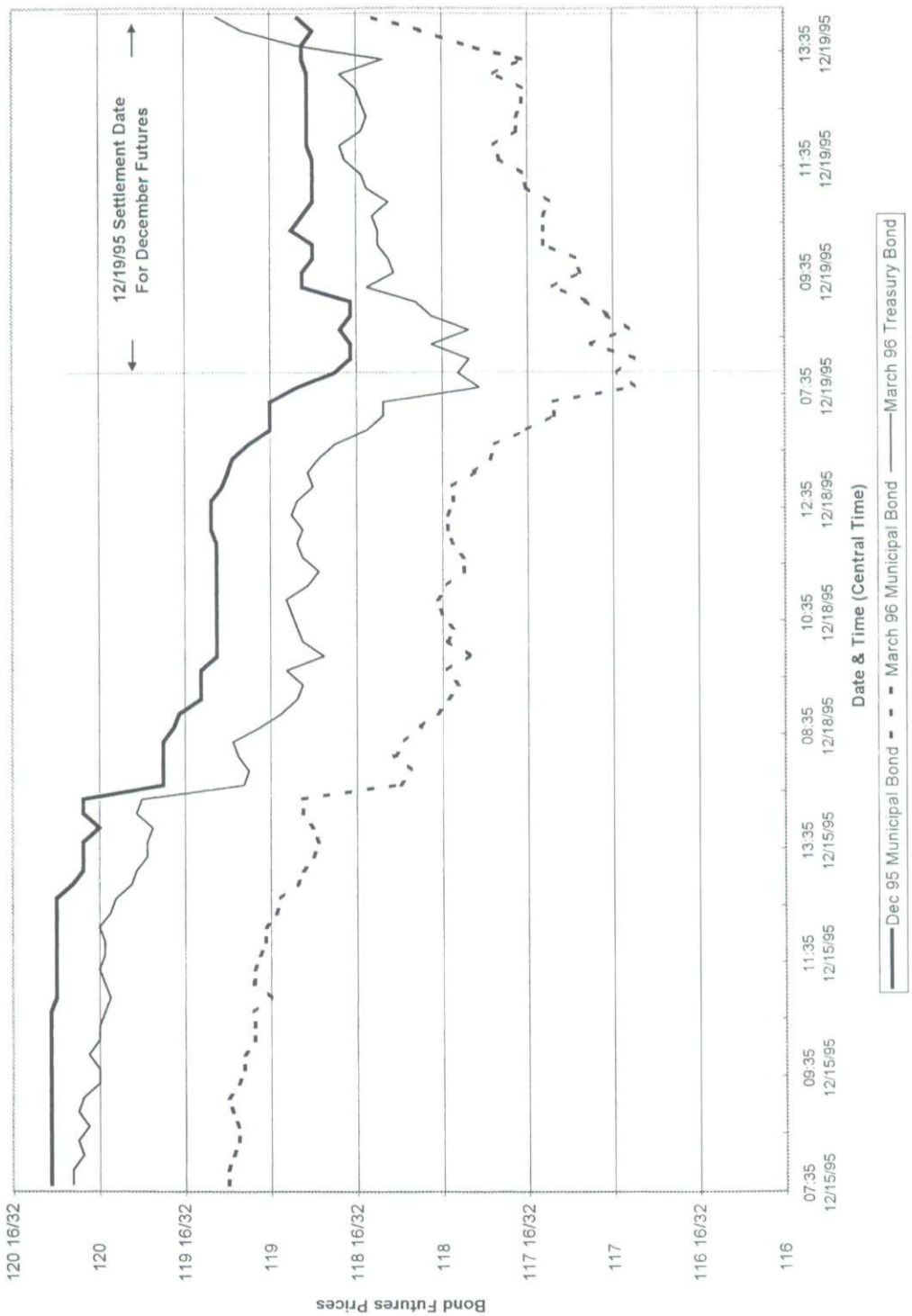


FIGURE 2

Fifteen-minute interval prices for municipal bond and treasury bond futures—December 15, 1995–December 21, 1995.

TABLE I

Half-Hour Interval Prices for the Most Recently Issued 30-Year Treasury Bond—December 19, 1995–December 20, 1995

Date	*Chicago Time*	*30-Year Treasury Bond Price*	*Cumulative Price Change orm 12/18 Close*
12/18/95	Close	118 11/32	
12/19/95	7:30	117 24/32	19/32
	8:00	117 30/32	13/32
	9:00	118 2/32	9/32
	9:30	118 10/32	1/32
	10:00	118 14/32	3/32
	10:30	118 12/32	1/32
	11:00	118 13/32	2/32
	11:30	118 17/32	6/32
	12:00	118 14/32	3/32
	12:30	118 13/32	2/32
	1:00	118 19/32	8/32
	1:30	118 25/32	14/32
	2:00	119 11/32	1 11/32
12/20/95	7:30	119 22/32	1 11/32
	8:00	119 24/32	1 13/32
	9:00	119 24/32	1 13/32
	9:30	119 24/32	1 13/32
	10:00	119 24/32	1 13/32
	10:30	119 27/32	1 16/32
	11:00	119 22/32	1 11/32
	11:30	119 19/32	1 8/32
	12:00	119 19/32	1 8/32
	12:30	119 17/32	1 6/32
	1:00	119 14/32	1 8/32
	1:30	119 18/32	1 1/32
	2:00	119 10/32	31/32

in sync with the futures market. By 2:00 p.m. the price adjustment is largely complete. The next day the market opens about where it closed the day before and prices remain flat throughout the morning before falling in the afternoon.

For other cash bonds and for bond indexes, intraday data are not available. Nonetheless, the daily price changes are consistent with those reported for the long bond and the actively traded futures contracts. In particular, Table II shows that both the Lehman Brothers long-term index and other Treasury bond prices rose about 1% from the close on December 18 to the close on December 19 and then remained largely unchanged from the close on December 19 to the close on December 20. This is

TABLE II

Comparison of Price Change in Fixed Income Cash Markets—December 19, 1995–December 20, 1995

	Price Level			*% Price Change*	
Description	*12/18/95*	*12/19/95*	*12/20/95*	*12/19/95*	*12/20/95*
Bond Buyer Municipal Bond Index	119 9/32	118 26/32	119 30/32	−0.39%	0.95%
Lehman Bros. Government Bond Index (Long-term bonds)	1590.81	1603.51	1604.38	0.80%	0.05%
Treasury bond maturing 2/15/2020	126 24/32	127 25/32	127 30/32	0.81%	0.13%
Treasury bond maturing 8/15/2022	111 31/32	113 3/32	113 3/32	1.00%	0.00%
Treasury bond maturing 11/15/2022	117	118 5/32	118 5/32	0.99%	0.00%

exactly the same daily pattern that is observed for the long bond and for the actively traded futures contracts.

The foregoing makes it clear that the behavior of the expiring December municipal bond futures contract is anomalous. Because the contract cash settles to the BBI, this implies that there must be a problem with the index. Table II highlights the problem. Between the 11:00 a.m. and 2:00 p.m. surveys, the BBI increases only $\frac{2}{32}$. During that same time, prices of actively traded futures contracts and cash bonds jump nearly a point, primarily in response to the Fed announcement. The evidence therefore, supports the hypothesis that bond prices included in the 2:00 p.m. BBI were stale and failed to reflect the Fed announcement.

To determine whether the failure of the BBI to react to the Fed announcement was caused by a few outliers, Table III presents disaggregated data on the movement of all 40 bonds in the BBI between the morning and afternoon surveys. The table shows that most of the bond prices rose between 0.1 and 0.3% compared to the 1.0% move for actively traded futures contracts and Treasury bonds. None of the 40 rose by more than 0.5%, and one fell. This demonstrates that the behavior of the index is not an artifact of a few outliers. As a group, the prices of the bonds in the BBI 40 were not updated to take account of the changed market conditions brought about by the Fed announcement.

Further evidence in support of the stale price hypothesis is provided by the behavior of the BBI on December 20. Whereas the long bond and actively traded futures contracts rise by about $\frac{10}{32}$ during the interval from the close on December 19 to 11:00 a.m. on December 20, the BBI jumps by a full point. This indicates that by 11:00 a.m. on the 20th brokers had adjusted the quotes they were reporting to the Bond Buyer and the CBOT,

TABLE III

Analysis of Price Changes for Bonds in the Bond Buyer Municipal Index on December 19, 1995

	Moody's	Coupon	Maturity	Bond Price on 12/19/95 Midday (Bid) (12:00 EST)	Bond Price on 12/19/95 Close (Bid) (3:00 EST)	% Chg in Bond Price
Palm Beach Co Sch Bd FL COPs Series 1995A	Aaa	5.375	8/1/15	97 4/32	97 12/32	0.3%
Florida St Bd Ed public educ capital outlay refunding bds 1995 Series C	Aa	5.5	6/1/21	97 12/32	97 17/32	0.2%
Philadelphia SD PA go bonds Series B of 1995	Aaa	5.5	9/1/25	96 7/32	96 15/32	0.3%
NYS Dorm Auth consolidated 3rd general resolution rev bds (City Univ) Ser 1995-1	Aaa	5.375	7/1/25	96 3/32	96 1/32	−0.1%
Florida St Bd Ed public educ capital outlay refunding bds 1995 Series D	Aa	4.75	6/1/22	88 7/32	88 11/32	0.1%
Puerto Rico Pub Bldgs Auth government facilities revenue bonds	Aaa	5.5	7/1/21	98 3/32	98 5/32	0.1%
NYS Urban Dev Corp correctional capital fac rev bds Series 5	Aaa	5.5	1/1/25	97 10/32	97 11/32	0.0%
Allegheny Co Hosp Dev Auth Pa hlth ctr rev bds Ser 1995 (Univ of Pittsburg Med)	Aaa	5.375	12/1/25	94 7/32	94 15/32	0.3%
Birmingham Spl Care Fac Fin Auth AL hosp rev bds (St Vincent & Providence Hosp)	Aa	5	11/1/25	88 19/32	88 27/32	0.3%
Michigan State Hosp Fin Auth hosp rev & ref bds (Henry Ford Hlth Sys) Ser 95	Aa	5.25	11/15/25	91 23/32	91 28/32	0.2%
Alaska Hsg Fin Corp govt purp 95 Ser A	Aaa	5.875	12/1/30	98 12/32	98 20/32	0.3%
Martin Co Ind Fac & Poll Cntrl Fin Auth NC solid waste disp rev bds Series 1995	A2	6	11/1/25	99 8/32	99 12/32	0.1%
PR Elec Pwr Auth pwr rev bds Ser X	Baal	5.5	7/1/25	95 6/32	95 16/32	0.3%
PR Elec Pwr Auth power rev ref bds Series Z	Baal	5.25	7/1/21	92 19/32	92 30/32	0.4%
North Carolina Muni Pwr Agy No 1 Catawba electric rev bds Ser 1995 A	Aaa	5.375	1/1/20	96 3/32	96 18/32	0.5%
Dade Co FL aviation rev (Miami Intl Airport)	Aaa	6	10/1/24	101 1/32	101 5/32	0.1%
Dallas-Fort Worth Regional Airport TX jt rev ref bonds Ser 1995	Aaa	5.625	11/1/15	98 26/32	98 31/32	0.2%
Denver CO airport system revenue bonds Series 1995 A	Aaa	5.7	11/15/25	98 15/32	98 21/32	0.2%
Port Authority of NY & NJ consolidated bonds 100th Series	A1	5.75	6/15/30	99 15/32	99 14/32	0.0%
Clark Co NV passenger fac char rev bds 1995 Ser A (Las Vegas-Macarran Intl Arpt)	Aaa	5.75	7/1/23	97 14/32	97 17/32	0.1%

TABLE III (continued)

Analysis of Price Changes for Bonds in the Bond Buyer Municipal Index on December 19, 1995

	Moody's	Coupon	Maturity	Bond Price on 12/19/95		% Chg in Bond Price
				Midday (Bid) (12:00 EST)	Close (Bid) (3:00 EST)	
Florida Dept of Trans tpke rev bonds Ser 1995 A	Aaa	5.5	7/1/21	97 25/32	97 28/32	0.1%
NYS Thruway Auth highway & bridge trust fund rev bds Ser 1995 A	Aaa	5.5	4/1/15	98 17/32	98 16/32	0.0%
Philadelphia PA airport rev bonds Ser 1995A (Philadelphia Airport Sys)	Aaa	6.1	6/15/25	101 24/32	102	0.2%
Austin TX airport sys prior lien rev Ser 95A	Aaa	6.125	11/15/25	101 30/32	102 6/32	0.2%
Denver CO airport system rev bds (Denver Intl Aiport) Ser 1995 C	Aaa	5.6	11/15/25	95 18/32	95 28/32	0.3%
Long Beach CA harbor rev bds Series 1995	Aaa	5.375	5/15/20	94 7/32	94 7/32	0.0%
NYS Thruway Auth highway & bridge trust fund bds Series 1995 B	Aaa	5.125	4/1/15	94 26/32	94 26/32	0.0%
San Francisco Arpts Comm GA arpt rev bds (San Francisco Intl Airport)	Aaa	5.9	5/1/25	101 6/32	101 8/32	0.1%
Delaware River Port Auth PA rev bds Series 1995	Aaa	5.5	1/1/26	97 17/32	97 26/32	0.3%
Texas Tpke Auth Dallas North tollway sys rev bds Ser 95 (Pres George Bush Tpke)	Aaa	5.25	1/1/23	94 9/32	94 16/32	0.2%
Texas Tpke Auth Dallas North tollway sys rev bds Ser 95 (Pres George Bush Tpke)	Aaa	5	1/1/25	91 3/32	91 9/32	0.2%
NYC Muni Wtr Fin Auth wtr & swr sys rev bds Fiscal 1996 Ser A	A	5.5	6/15/23	95 12/32	95 14/32	0.1%
Dade Co FL water and sewer rev bds Series 1995	Aaa	5.5	10/1/25	97 7/32	97 15/32	0.3%
Detroit MI water supply sys rev 2d lien Ser 95A	Aaa	5.5	7/1/25	96 18/32	96 20/32	0.1%
Chicago IL wastewater transmission rev bds Series 1995	Aaa	5.125	1/1/25	91 16/32	91 25/32	0.3%
MA Wtr Resources Auth general revenue bds 1995 Series B	Aaa	5	12/1/25	90 23/32	90 30/32	0.2%
PR Aqueduct & Swr Auth refunding bds Series 1995	Baal	5	7/1/19	90 10/32	90 17/32	0.2%
San Diego Pub Fac Fin Auth CA sewer rev bds Series 1995	Aaa	5	5/15/25	91 9/32	91 14/32	0.2%
San Diego Pub Fac Fin Auth CA sewer revenue bds Series 1995	Aaa	5	5/15/20	92 2/32	92 7/32	0.2%
Upper Occoquan Sewage Auth VA regional sewage sys rev bds	Aaa	4.75	7/1/29	85 18/32	85 27/32	0.3%
Upper Occoquan Sewage Auth VA regional sewage sys rev bds	Aaa	5	7/1/25	90 27/32	91 10/32	0.5%
					AVERAGE	0.2%

Source: Thompson Municipal Group.

either in response to trades in the underlying bonds or in recognition of the changed market conditions.

There is one added facet of the price behavior of the December futures that is particularly curious and seems to suggest the possibility of misleading price quotations or manipulation. Specifically, the failure of the December futures contract to rise after the Fed announcement at 1:15 p.m. appears to imply that market participants anticipated that final settlement would be based on stale prices. Had futures traders assumed that the BBI would rise in conjunction with other bond prices, presumably the December futures would have risen as well. Consequently, the data seem to imply that at least some traders knew in advance that the BBI would not properly reflect market conditions at 2:00 p.m.

Although the misleading quotes and/or manipulation are possible explanations for the preceding scenario, there is a simpler explanation that is also consistent with the data. Between 1:15 and 2:00 p.m., only one December futures contract traded. It is possible, therefore, that the price during this time interval was essentially meaningless and conveyed no information to traders who had already concluded that the best way to minimize transaction costs was to cash settle rather than to attempt to liquidate outstanding positions in a highly illiquid market. Unfortunately, this is an issue that cannot be resolved without information regarding the knowledge and intent of traders who held significant positions in the December futures at 1:15 p.m. Consequently, although it can be concluded that the December futures price and the BBI were distorted at 2:00 p.m., it cannot be determined whether this distortion was a result of incomplete and/or inaccurate reporting, or was the result of a conscious effort to deceive or manipulate prices.

The Valuation Impact of Stale Cash Prices

A relatively straightforward way to assess the impact of settlement based on stale cash prices is to use the March futures price to estimate the true equilibrium December futures price at 2:00 p.m. on December 19. As Figure 1 makes clear, the March municipal bond futures responded to the Fed announcement in the same fashion as the Treasury bond futures and cash markets. This supports the view that when the underlying securities are thinly traded, actively traded futures contracts provide important price discovery information regarding the cash market. If it is assumed that the response of the March futures is rational, a basic regression model can be used to predict how the December futures should have moved on December 19. The regression takes the form

$$\text{daily \% change December} = a + b^*(\text{daily \% change March}). \quad (1)$$

When eq. (1) is estimated over the period from October 1, 1994 to November 30, 1995, a clean period during which both futures contract traded actively, the intercept is 0.0003, with a t statistic of 0.04, and the slope coefficient is 0.975 with a t-statistic of 55. The R^2 is 0.99. Considering that daily log first differences are used, this is a remarkably tight fit that confirms the impression produced by Figure 2 that the two futures contracts move lockstep during normal periods. The fact that the regression is estimated in terms of log first differences of asset prices also eliminates any problems that could arise from nonstationarity or autocorrelation. Both the independent and the dependent variable are close to white noise and the autocorrelation of the residuals is insignificant at all lags up to 10.

When eq. (1) is applied the predicted change in price for the December futures contract from the close on December 18 to the close on December 19 is an increase of 0.87% or about $1\frac{1}{32}$. The actual price change for the December futures contract was $\frac{1}{32}$. Consequently, on the expiration day the December futures contract settled about 1 point below its equilibrium level. This would have resulted in windfall gains or losses of $1,000 per contract for traders, depending on whether they were long or short. This is an important consideration because the open interest at expiration was not negligible. One institutional investor alone reported having a position of over 3,400 contracts.

Comparison with Historical Data: A Basic Bootstrap Analysis

Despite the strong results, there remains the possibility that the anomalous events on the afternoon of December 19 were due to random fluctuations in prices. Given the sharp divergence between prices of closely related futures contracts, one would suspect that the probability that it could be attributed to random fluctuations is small. Nonetheless, an examination of the historical record is a useful bootstrap test of that suspicion.

What makes the December 19 price movements so unique is that the March 1996 municipal bond and Treasury bond futures both rose by one point or more, whereas the December 1995 futures contract remained unchanged. To assess how frequently such an event occurs, daily data for the municipal and Treasury bond futures market are analyzed between the initiation of municipal bond futures trading in June 1985

and the end of 1995 using data provided by TickData Corporation. The question asked is how frequently do daily price changes in the nearby municipal contract differ from price changes in the next deferred Treasury bond or municipal bond futures contract by one point or more. Regarding the comparison with the deferred Treasury bond contract, only three instances of such divergences are found. All three occurred in 1986, when the municipal bond contract was new and the volume of trading was small. For comparison with the deferred municipal bond contract, there was only one that approached the divergence observed on December 19. That event also occurred on an expiration date in June of 1991.[3] In short, the historical data support the view that the price divergence observed on December 19 was not the result of random fluctuations, but the result of the failure of the underlying cash index to properly reflect market conditions.

SUMMARY AND CONCLUSIONS

Cash settlement is an extremely useful innovation because it makes possible futures trading on indexes and baskets of securities for which delivery is not economically feasible. For cash settlement to function properly, it is critical that the index used to settle expiring contracts accurately reflects market conditions. When the index is composed of actively traded securities, such as the equities in the S&P 500, this is not a significant problem. When the index is based on relatively illiquid securities, like the Bond Buyer Municipal Bond Index, a potential problem arises. If the prices of the cash prices quoted are stale, or perhaps even manipulated by large futures traders, settlement at expiration can fail to reflect market conditions, which may result in windfall gains or losses.

This article demonstrates that the foregoing concerns are not idle worries. In the case of the December 1995 municipal bond futures contract, the evidence clearly shows that the index on which settlement is based was distorted. Whereas all actively traded cash securities and comparable interest rate futures contracts rose sharply after the Fed announcement at 1:15 p.m. on December 19, both the Bond Buyer Index and the December municipal bond futures contract failed to move. As a result, traders and hedgers with open positions experienced windfall gains or losses, depending upon whether they were short or long. Although the BBI did respond the next morning and move back into line with the prices of actively traded cash securities and futures contracts, the belated re-

[3]Unfortunately, a search of several electronic databases uncovered no information regarding the cause of the divergence.

action was of little solace to futures traders whose positions were settled the previous day.

In light of this finding, it seems appropriate to suggest that the futures exchanges take steps beyond simply collecting data on the underlying index during the expiration day of a cash settling futures contract that is tied to illiquid securities. Tests using prices of actively traded cash securities and other futures contracts should be conducted to ensure that the level of the index on which settlement is based is reasonable. In some cases, it may be necessary to expand the sample of securities on which the index is based, alter the manner in which the data are collected, or improve the process by which the index is computed. All of these issues are interesting topics for future research.

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