PRICE FORMATION IN THE OTC CORPORATE BOND MARKETS: A FIELD STUDY OF THE INTER-DEALER MARKET

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Abstract

Despite its importance the market-micro structure of the secondary market for corporate bonds remains something of a mystery. The major reason for this has been the OTC inter-dealer nature of this market. As far as we are aware this paper presents the first exploratory field study of the U.S. inter-dealer OTC corporate bond market. We construct a primary data-base from the trades of a major bond dealer and document the competitive structure of the market in terms of the number of active dealers and market trading mechanism. We find that the trading mechanism closely resembles a first–price sealed bid auction. We also examine the potential differences between segments of the market and develop a measure of competition based on the theory of auctions. Our measure indicates that competition is highest in US investment grade corporate bonds and lowest in junk bonds. We also examine the effect of the size of a trade on pricing and spreads.

1. Introduction

While the U.S. corporate bond market had a value close to $3 trillion in 1998, empirical research into price and return formation in this market has been relatively sparse compared to research on equity markets. There are two reasons for this. First, while some corporate bonds trade on the NYSE and AMEX exchanges, they tend to be odd-lots accounting for no more than 2% of market volume [see Nunn et al (1986), Warga and Welch (1993)]. Second, data quotes on OTC trades tend to be diffuse and based on matrix valuation rather than on actual trades such as those produced by IDC (in association with S & P and Moody's).

While a few studies have sought to use real quotes from dealers such as Lehman Bros. [see, Warga and Welch (1993)], and find quite surprising disparities between matrix prices and actual dealer quotes, no study, thus far, has analyzed the dynamics of price formation in the U.S. corporate bond OTC market. Specifically, questions such as how many dealers bid for large blocks of OTC-placed corporate bonds? Is there a difference in the bidding behavior for investment-grade versus non-investment grade bonds? What is the link between price determination and the number of bidders -- i.e., how competitive is the market, have yet to be analyzed.[1] Indeed, while we know a lot about the competitive structure of US equity markets, we know very little

[1] A few recent studies have examined bid-ask spreads in the OTC market. For example, Schultz (2000) finds that spreads are lower for larger size trades. Hong and Warga (1999) compare trades on the NYSE to dealer trades and find no significant differences between these two. Chakravarty and Sarkar (1999) compare spreads in the corporate, municipal and government bond markets. Hotchkiss and Ronen (1998) find that the dealer market for a given bond incorporates information as quickly as the underlying stock market. Alexander et al (1999) examine the determinants of the trading volume for a small sample of high yield bonds. None of these studies examine the nature of bidding in this market.

about the competitive structure and pricing dynamics of the US corporate bond markets. The lack of transparency in pricing has been of great concern to the SEC, especially in periods of high volatility as have recently occurred.[2]

As a first step in closing this knowledge gap we carried out a field study of price determination in the OTC corporate bond market with the support of a major corporate bond trader.[3] In Section 2, we provide a general description of the OTC bond market. In Section 3, we describe our database and in Section 4 we provide descriptive statistics of the sample. In Section 5, we report our results on the competitive structure of the market.

2. Description of the market

Most of the participants in the OTC bond market are large institutional traders, usually money managers who trade on behalf of their institutional clients such as pension funds. There are also inter-dealer brokers who operate on both the buy and sell sides of the market and essentially act in a way similar to market-makers in the stock market. These broker-dealers provide anonymity to the traders, who in turn can bypass the inter-dealer brokers and trade directly with other institutional traders for issues in which they know that a given counterparty has an interest.

The following description applies to the asset manager who provided the trading data. Clients of the asset management firm, along with the individual asset managers, decide on a portfolio strategy regarding risk and return. This includes decisions on

[2] At the SEC's request, NASD is planning to set up an electronic network to report and distribute prices on the OTC corporate bond trades. See, New York Times "NASD to set up network to report data on bonds," September 10, 1998.

what type of bonds to hold (high risk, low risk, foreign, domestic, etc.). Once a decision on the general portfolio strategy has been set, the client gives the asset manager complete discretion in executing trading decisions. The asset manager then decides which bonds to buy or sell, as well as which type and maturity (duration) to hold. Periodically, the client reviews the account's performance and indicates to the asset manager any desired change in the risk/return characteristics.

All of the asset manager's trades are on behalf of clients, with the asset manager remunerated by a fee based on the amount of assets managed. The performance of the portfolio (account) is usually benchmarked to appropriate bond indices. The asset manager decides on the names and maturity of the bonds that are needed in different accounts. These are given to a trader, who executes the trades. The trader has discretion with respect to the timing and the price of the trade. It is the trader who decides whether an issue is worth buying at a particular price or not. In a few cases, the desired issues may not be available in the market, in which case the trader, with the consent of the account manager, can buy alternative bonds with similar risk, return and maturity characteristics.

The trader has access to various data providers. These providers (such as Telerate and Bloomberg) supply data on treasury rates and prices, including actual trades of treasury bonds, spot and future rates, and stock market information. In addition, they also have access to proprietary trading models to calculate matrix prices for different bonds. A few traders in the market (together with the major broker-dealers) have a screen based information system for actual trades of corporate bonds as well.

[3] For proprietary and competitive reasons, names of specific dealers cannot be disclosed in this paper.

The typical procedure would be for the trader to initiate contact with other institutional traders' brokers or broker-dealers who he or she knows are interested in buying or selling a given bond. Those counter-parties that are interested submit quotes to the dealer. These quotes are not legally binding. However, reputational reasons prevent dealers from making bids that they cannot honor. The dealer has a fiduciary responsibility to get the best quote and to treat all accounts equally.[4] He or she does not know the client's identity. The dealer only knows the account number(s) for which a given trade is made. A buy or sell trade can be initiated by any dealer. If initiated by another dealer, the trader decides whether the issue fits the needs of at least some of his/her clients. For example, in case of buying bonds of companies that the trader is unfamiliar with, the research department assists the trading desk in this evaluation. Once this has been done, the dealer consults the asset managers. If the go-ahead to buy is given, the trader accepts the trade.

A typical counterparty submits a buy or sell bid (not both) within 1-2 minutes of getting a sell or buy request from the dealer. This happens in many trades when both sides are familiar with the details of the particular issue and the security is a straight bond with no special provisions. However, in the case of trades where the bonds have complex features such as call or put provisions or sinking fund provisions, the submission time for a bid by a given counterparty after being requested is usually about 10 minutes. In the case of very illiquid bonds, a trade can take as long as a day. This may also be the case if the amount to be traded is large, where "large" is defined

[4] The Employee Retirement Security Income Act (ERISA), which governs defined benefit retirement money invested in the United States requires this fiduciary duty. Since such retirement assets are primarily

as greater than $10 million. One of the reasons for the difficulty in trading large blocks is the relatively low level of short selling in this market. Dealers and even broker-dealers are reluctant to short more than $10 million in notional amounts. Trading is mostly conducted in terms of a spread over comparable-maturity treasuries. A typical quote for an issue would thus be “IBM Series A 5-year maturity for 80 basis points over 5-year treasury yield.” Most of the market participants follow this convention.

3. The Data Base

The analysis is based on a randomly - selected sample of bond trades conducted by a major dealer in the OTC corporate bond market during the period January 1, 1997 to November 28, 1997. The following data were collected from the dealer's trading book:

- Name of the issuer.
- Face value of the trade.
- Coupon.
- Time to maturity.
- Bid/offer prices.
- Trade date and time.
- Settlement date.
- Name of winning counterparty.
- Price of winning bid/offer, hereafter referred to as "best bid".
- Names of other bidders.
- Prices quoted by other bidders.

Trading occurred in the form of successive auctions during any given day. For example, a block of corporate bonds of a specific issuer was posted for sale by one or

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invested in the bond market, it is plausible to assume that this fiduciary requirement holds for most dealers in the market.

more portfolio managers, typically, and telephone bids were received from broker-dealers. The highest bidder received the block.[5] [An offer is defined as an offer to sell securities to the dealer. Thus, the lowest among the submitted prices is chosen].

The method of transaction-selection examined every fifth trade from the dealer's trade book. The choice of every fifth trade was not based on data availability but rather to provide a sufficiently large sample given the cost of hand collecting and analyzing these OTC data which mitigated against the use of every single trade. There were two exceptions to this data-selection rule:

- If the fifth trade in sequence was part of a bond swap contract.
- If the fifth trade involved only one bid/offer price -- *i.e.*, only one trader showed an interest in the transaction.[6]

In such cases, the trade was excluded from the sample and the next trade that satisfied the above criteria was selected.

4. Descriptive Statistics of the Sample

The characteristics of the sample of trades is shown in Table 1. As noted above, the sample comprises every fifth trade (with more than one bid) conducted by the asset manager's corporate bond trading desk over an 11-month period from January to November 1997. A total of 987 trades were analyzed that received more than a single bid. As can be seen in Table 1, there were an average of 2.44 additional bids per trade over and above the winning bid, with the most frequent number of additional bids

[5] In the case of an offer to buy, the lowest bid would be accepted. In the case of an offer to sell the highest bid would be accepted.

[6] We randomly selected one month, the month of November 1997 and found that the percentage of single bid trades in this month was about 30% of the total number of trades in this month.

being 2 - *i.e.,* three bidders in all, with one winning bidder and two unsuccessful bidders. The histogram in Figure 1 shows the distribution of additional bidders.

The total number of trades encompassed three different types of bonds: Corporate investment-grade bonds, emerging market bonds, and high-yield bonds - defined as those corporate bonds with yields 2% or more above similar-maturity Treasury bonds. The sample consists of 373 corporate bond trades, 478 emerging market bond trades and 136 high-yield securities trades. Measured by number of additional bids (to the winning bid) received per trade, corporate bond trades were the most competitive (2.8 additional bids per trade), followed by emerging market bonds (2.32) and high-yield bonds (1.9).

The sample can also be broken down in terms of the maturity of the bonds traded. The number of short-term (less than 1-year maturity) securities transactions analyzed was 21, medium-term securities (1 year to 10 years) 552, and longer-term securities (maturities greater than 10 years) 414. In terms of additional bids per trade, they varied from an (average) high of 2.71 for short-term securities to a low of 2.39 for medium-term securities. Figure 2 shows that over 92% the trades were below $10 million in size. Because of the limited number (21) of short-term securities in our sample, we decided to include them in the tests, although arguably most instruments with less than 1 year maturity trade in the money market.

5. **Competitive Structure**

One way to analyze the competitive structure of the OTC corporate bond market is to examine bid-spreads. The bidding mechanism in the OTC market for block

trades in corporate bonds approximates the first-price sealed - bid auction mechanism. It has been shown that the English auction, the Dutch auction, the second-price sealed bid auction and the first-price auction yield (on average) the same revenue to the seller [see Vickery revenue equivalence theorem (1961)]. We also know that for second-price auctions, increasing the number of bidders increases the average revenue of the seller [Holt (1979), Harris and Raviv (1981)]. Further, as the number of bidders increases, the second highest bidder tends to use the highest possible valuation - *i.e.*, the price difference between best and second best bidder gets smaller. Since an increase in the number of bidders increases the level of competition and also reduces the price spread, or difference, between the first and second best bids, this latter spread appears to be the most appropriate measure of the competitiveness of the auction-like OTC corporate bond market.

In Table 2, we report the differences between (i) the best (winning) bid and the next best bid (ii) the best (winning) bid and the average of the non-winning bids and (iii) the best (winning) bid and the worst bid.

We also compute the percentage difference between the best-to-second-best, the best-to-average and best-to-worst bids. These percentage differences are computed in two ways. First, we compute a value weighted spread, which is defined as the ratio of two weighted sums - The numerator is the sum over all trades of the product of the notional amount of each trade with the difference between the best and second-best prices of that trade. The denominator is the sum over all trades of the product of the notional amount of each trade with the best price of that trade. Thus, the value weighted spread is a measure of the actual dollar loss that would result if the best

bidder were removed in all trades as a percentage of the total trade amount of all trades. We also compute a value weighted spread for the best-to-average and best-to-worst prices. As a basis for comparison, we also compute an equally weighted spread, which is computed as the ratio of the difference between the best and second best price to the best price. This equally weighted spread is a measure of the percentage loss (not weighted) that would result if the best bidder were removed from all trades. As before, we also compute the equally weighted spread for the best-to-average and best-to-worst bids.

From Table 2, it is evident that the value weighted percentage difference between the winning bidder and the second-best bidder is an average of 15.3 basis points (or 0.153%). In terms of dollars per trade, this averages $5,271. Aggregated over the 987 trades in the field sample, this amounted to $5,202,372 during the 11-month period examined. The value weighted percentage differences between the best-to-average losing bids and best-to-worst bids were, respectively, 23.7 and 34.9 basis points. All of these spreads are significantly different from zero at conventional levels of significance.

The equally weighted spreads for the best-to-second-best, best-to-average and best-to-worst were 18.4, 36.2 and 60.4 basis points respectively. Although these are somewhat greater than the value weighted spreads, the values themselves are not significantly different from zero. The variability of this ratio seems to be significantly larger than the variability of the value weighted average. Given that the value weighted average is an actual dollar loss, it is more appropriate to use this for

evaluating competitiveness of this market. From here onwards, we shall focus on this measure of spread for detailed examination.

Table 3 breaks these data down by type of bond, while Table 4 breaks the data down by maturity. As can be seen from Tables 1 and 3, the high-yield bond market is by far the thinnest in terms of number of bidders and has the widest price dispersion across bids. Interestingly, emerging market price formation and bidding activity appears to be closer to that of investment-grade corporate bonds than high-yield domestic bonds.

An alternative way to analyze these data is to examine the correlation between the number of additional bidders and the difference between the winning bid and the second-best bid. In particular, do price differences between the first and second-best bid fall in the presence of a larger, as opposed to a smaller, number of alternative bidders? The correlation matrix shown in Table 5 indicates that there is a correlation coefficient of - .154 between the number of bidders and the dollar-amount difference between the winning and second-best bids. Moreover, an increase of one additional bidder reduces the price difference between the best and second best bids by 23.6%.

This generally inverse relationship between the number of bidders and the difference between the best and the next best bid is also confirmed by regression tests. Table 6a shows a linear regression of the number of bidders on the best-second-best bid differential. It can be inferred that an increase of one bidder reduces this price spread by $1,673 per trade. We also tested various non-linear specifications of the relationship between bid spreads and number of bidders -- for example, a log-log model and a power function model. Both showed an inverse relationship between the

number of bidders and the (winning bid-second-best bid) measure. We also test the same hypothesis by looking at the percentage difference between the best and second-best bids, while controlling for effects resulting from trade size. The relationship continues to be negative. Interestingly, the best to second-best spread is negatively related to the size of the trade. These results are shown in Table 6b.

To further investigate the impact of large trades, we split the sample into trades less than or equal to $10 million and trades greater than $10 million. This division is admittedly arbitrary. It is based on conversations with traders, who felt that trades of less than $10 million in size were definitely not “large blocks.” We then conducted t-tests of differences in mean values of the number of bids, the spread between the best and second-best bids and the spread between the best and the worst bids. The results are shown in Table 7.

Specifically, there is no significant difference in the number of bids between the large-block (over $10 million) and small trading block sample. Secondly, both the best to second-best and the best to worst spreads are significantly lower for the large block sample. Thus, it appears that large trades in this market are not at a significant competitive disadvantage relative to smaller sized trades. That is, a large trade does not appear to convey any special adverse market information or impose liquidity constraints on dealers.[7]

Finally, we analyzed the effects on prices and bidding of successively excluding each of the nine largest counterparties to the dealer's trading desk -- "largest counterparties" being defined as firms that “won” more than 5% of the bids over the

sample period. The estimated effects on bid spreads from this "successive-exclusion" scenario are shown in Table 8. The exclusion of broker-dealers is one way to measure the potential cost to institutional asset managers and, ultimately, their fiduciary clients, from prohibitions on transactions between them and affiliated broker-dealers under the US Employee Retirement Security Income Act.[8] Specifically, in the absence of being able to disclose the names and association (if any) of each of the bidders with the asset manager, it provides benchmark results of the range of effects of the ERISA restrictions have if the asset manager's affiliated broker-dealer was indeed a major player (bidder) in the OTC market.

In the sample of trades used Bidder 1 was the most successful bidder, winning 150 out of the 987 trades. Excluding Bidder 1 as a counterparty in these 150 trades (and taking the next best bid as the winning bid) results in a value-weighted additional cost of 16.1 basis points per trade. Excluding Bidder 2 (100 winning trades) results in an additional cost of 15.1 basis points per trade. The ninth most successful bidder (Bidder 9) won 55 bids, with an average additional cost of 13.2 basis points from exclusion. Thus, exclusion of Bidder 1 from this market would on average result in an increase in the execution costs of 0.025%, calculated as 150/987 times 0.161%.

[7] This is in contrast to the equity markets where larger trades (both on the exchange floor and in the upstairs market) generally have higher price impact. See, for example, Madhavan and Cheng (1997)

[8] The Employee Retirement Income Security Act of 1974 (ERISA) prohibits an asset-management affiliate of a financial institution involved in a fiduciary capacity in managing qualified pension funds covered by the Act from having an "economic interest" - via a related securities affiliate - in capital market transactions involving securities that give rise to pension assets. This includes transactions in seasoned security issues as those covered in this study.

6. **Conclusion**

This is the first paper to analyze the market micro-structure and price formation in the US corporate bond market. It is unique in that it utilizes *actual* transaction prices submitted for large and small blocks of corporate bonds.

The institutional features of this market are characterized by: (i) a few large traders acting mostly on behalf of institutional clients, (ii) an inter-dealer market (similar to the one in government bonds) and (iii) a trading mechanism that closely resembles a first price (English) sealed bid auction.

Using the trading book of a major dealer over an 11-month period in 1997, we analyzed the competitive structure of the market both in terms of the number of bids received for each trade the difference between the best and second best bids on any trade. It was found that the average number of bidders is quite small, with nine major counterparties accounting for the major proportion of trades and that spreads were on average 0.15% between the best and second best bids over the whole sample. Interestingly, the OTC market for emerging market bonds appeared to have lower spreads than the domestic high yield bond market. Additional bidders appeared to have a material pro-competitive effect on the observed difference between the best and second best bids. And, large trades did not seem to suffer from the disadvantages that are now well documented for large block trades in the equity market. Indeed, the difference between the best and second-best bids decreased with increased trade size.

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Table 1

Number of trades with 'n' bids, other than winning bid

Number of Additional Bids	Full Sample	Corporates	Emerging	Junk
1	215	73	86	56
2	354	97	206	51
3	269	102	148	19
4	92	56	29	7
5	35	27	5	3
greater than 5 bids	22	18	4	0
Additional Bids per trade	2.44	2.80	2.32	1.90
Total Number of Additional Bids	2409	1043	1108	258

Number of Additional Bids	less than 1 year	1 year to 10 years	greater than 10 years
1	4	130	81
2	5	201	148
3	8	145	116
4	2	44	46
5	1	18	16
greater than 5 bids	1	14	7
Additional Bids per trade	2.71	2.39	2.50
Total Number of Additional Bids	57	1319	1033

Table 1 (continued)

Bin	*Frequency*	*Cumulative %*
1	215	21.78%
2	354	57.65%
3	269	84.90%
4	92	94.22%
5	35	97.77%
More	22	100.00%

Figure 1
Histogram of Number of Additional Bids

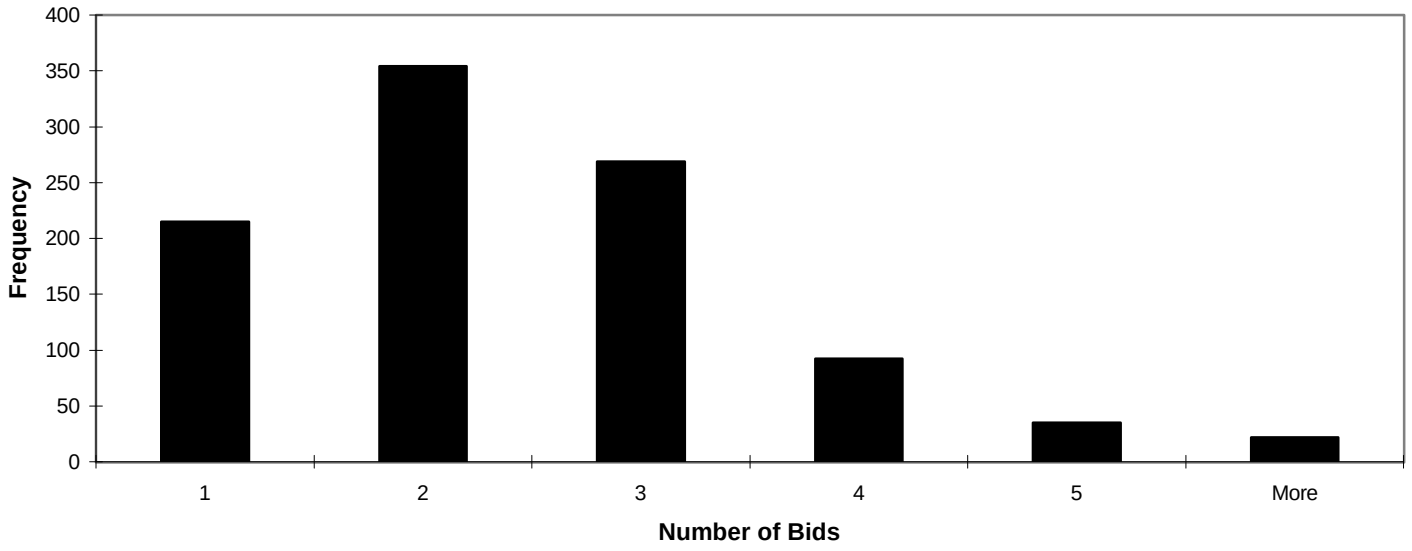

Figure 2

Bin	*Frequency*	*Cumulative %*
5.00E+05	158	16.01%
1.00E+06	170	33.23%
2.00E+06	223	55.83%
5.00E+06	218	77.91%
1.00E+07	140	92.10%
2.00E+07	60	98.18%
More	18	100.00%

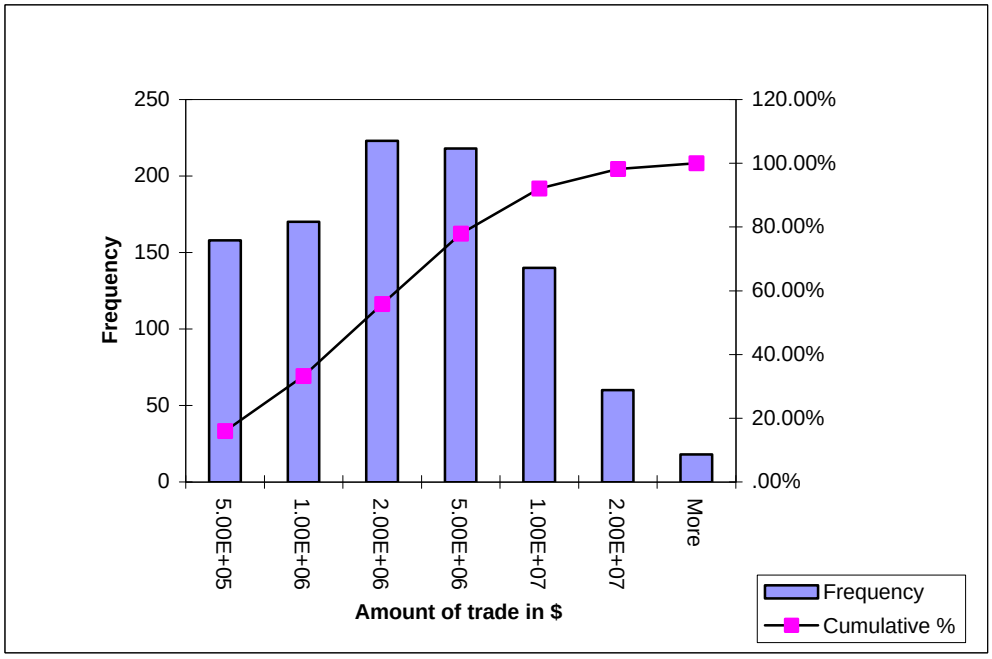

Table 2 - results for whole sample

Value weighting[1]	Best - Second best	Best - Average	Best - Worst
% change in price	0.153%	0.237%	0.349%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$5,271	$8,207	$12,077
Total $ in sample	$5,202,327	$8,100,221	$11,919,723
Equal Weighting			
% change in price	0.184%	0.362%	0.604%
Significance level for spread[2]	0.28	0.42	0.44
$ per trade	$6,369	$12,513	$20,886
Total $ in sample	$6,285,939	$12,350,528	$20,613,995
Average Value per trade	$3,455,642		
Aggregate value per trade	$3,410,718,907		
Number of trades in sample	987		

[1]Please refer to appendix I,note 1 for details on how each quantity is calculated.

[2]Please refer to note 2 in Appendix 1 for the statistical test used.

Table 3 - Results for subsamples - corporate, junk, emerging

Emerging markets

Value weighting[1]	Best - Second best	Best - Average	Best - Worst
% change in price	0.160%	0.248%	0.347%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$5,729	$8,888	$12,437
Total $ in sample	$2,738,357	$4,248,493	$5,944,973
Equal Weighting			
% change in price	0.173%	0.413%	0.714%
Significance level for spread[2]	0.31	0.44	0.45
$ per trade	$6,197	$14,815	$25,590
Total $ in sample	$2,962,036	$7,081,731	$12,231,925
Average Value per trade	$3,585,940		
Aggregate value per trade	$1,714,079,258		
Number of trades in sample	478		

Corporates (spread over treasury less than 2%)

Value weighting[1]	Best - Second best	Best - Average	Best - Worst
% change in price	0.120%	0.205%	0.340%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$4,573	$7,805	$12,959
Total $ in sample	$1,705,582	$2,911,237	$4,833,592
Equal Weighting			
% change in price	0.152%	0.280%	0.499%
Significance level for spread[2]	0.25	0.35	0.43
$ per trade	$5,795	$10,678	$19,035
Total $ in sample	$2,161,355	$3,982,817	$7,100,148
Average Value per trade	$3,814,488		
Aggregate value per trade	$1,422,804,208		
Number of trades in sample	373		

Table 3 (continued)

Junk (spread over treasury greater or equal to 2%)

Value weighting[1]	Best - Second best	Best - Average	Best - Worst
% change in price	0.277%	0.343%	0.417%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$5,576	$6,915	$8,391
Total $ in sample	$758,389	$940,492	$1,141,158
Equal Weighting			
% change in price	0.315%	0.411%	0.514%
Significance level for spread[2]	0.24	0.20	0.19
$ per trade	$6,340	$8,285	$10,344
Total $ in sample	$862,204	$1,126,730	$1,406,842

Average Value per trade	$2,013,496
Aggregate value per trade	$273,835,441
Number of trades in sample	136

Table 4 - Results for subsample based on time to maturity

Maturity less than 1 year

Value weighting[1]	Best - Second best	Best - Average	Best - Worst
% change in price	0.046%	0.075%	0.107%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$2,112	$3,437	$4,874
Total $ in sample	$44,358	$72,177	$102,348
Equal Weighting			
% change in price	0.070%	0.106%	0.152%
Significance level for spread[2]	0.26	0.21	0.21
$ per trade	$3,175	$4,861	$6,938
Total $ in sample	$66,678	$102,089	$145,698
Average Value per trade	$4,565,069		
Aggregate value per trade	$95,866,448		
Number of trades in sample	21		

Maturity between 1 and 10 years

Value weighting[1]	Best - Second best	Best - Average	Best - Worst
% change in price	0.151%	0.229%	0.329%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$4,729	$7,187	$10,307
Total $ in sample	$2,610,366	$3,967,423	$5,689,410
Equal Weighting			
% change in price	0.184%	0.394%	0.658%
Significance level for spread[2]	0.28	0.43	0.45
$ per trade	$5,761	$12,343	$20,596
Total $ in sample	$3,180,015	$6,813,066	$11,369,180
Average Value per trade	$3,131,920		
Aggregate value per trade	$1,728,819,727		
Number of trades in sample	552		

Table 4 (continued)

Maturity greater than 10 years

Value weighting[1]	Best - Second best	Best - Average	Best - Worst
% change in price	0.161%	0.256%	0.386%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$6,154	$9,808	$14,802
Total $ in sample	$2,547,604	$4,060,620	$6,127,965
Equal Weighting			
% change in price	0.191%	0.332%	0.556%
Significance level for spread[2]	0.29	0.33	0.42
$ per trade	$7,305	$12,734	$21,311
Total $ in sample	$3,024,105	$5,271,773	$8,822,878
Average Value per trade	$3,830,997		
Aggregate value per trade	$1,586,032,732		
Number of trades in sample	414		

Table 5 - Correlation analysis

	min $ amt	*avg $ amt*	*max $ amt*	*trade size*	*nbid*	*diffprmin*	*diffpravg*	*diffprmax*
min $ amt	1							
avg $ amt	0.7520878	1						
max $ amt	0.4446312	0.9002228	1					
trade size	0.4129909	0.3602834	0.2435601	1				
nbid	-0.154008	-0.032402	0.0513446	0.0553536	1			
diffprmin	0.5577716	0.3932062	0.2116068	-0.068577	-0.23612	1		
diffpravg	0.0895803	0.5808352	0.6810842	-0.048133	-0.01755	0.1702012	1	
diffprmax	0.029495	0.5556557	0.7313724	-0.042858	0.01846	0.0645673	0.966871	1

Table 6a
Sensitivity Analysis
Regression of min$ on nbid
Linear Model

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.154008
R Square	0.023718
Adjusted R	0.022727
Standard E	12632.65
Observatio	987

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	3.82E+09	3.82E+09	23.93028	1.17E-06
Residual	985	1.57E+11	1.6E+08		
Total	986	1.61E+11			

	Coefficients	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Upper 95.0%*
Intercept	9355.876	926.8343	10.09444	7.23E-23	7537.078	11174.67	7537.078	11174.67292
nbid	-1673.69	342.1381	-4.89186	1.17E-06	-2345.09	-1002.29	-2345.09	-1002.2877

Table 6b:Regression of best-second best spread vs trade size and nbid

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.242576
R Square	0.058843
Adjusted R	0.05693
Standard E	0.003129
Observatio	987

min %spread vs size and nbid

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	2	0.000602	0.000301	30.76081	1.1E-13
Residual	984	0.009634	9.79E-06		
Total	986	0.010236			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Upper 95.0%*
Intercept	0.003523	0.000237	14.85886	3.29E-45	0.003057	0.003988	0.003057	0.003988
trade size	-3.68E-11	2.04E-11	-1.797534	0.072557	-7.69E-11	3.37E-12	-7.69E-11	3.37E-12
nbid	-0.000639	8.49E-05	-7.523616	1.2E-13	-0.000805	-0.000472	-0.000805	-0.000472

Table 7:t-Test: Two-Sample Assuming Unequal Variances

	nbid		minimum % spread		maximum % spread	
	<=10 million	*>10 million*	*<=10 million*	*>10 million*	*<=10 million*	*>10 million*
Mean	2.43344334	2.525641	0.001892829	0.00118745	0.00635561	0.002088457
Variance	1.30090674	2.3564769	1.10466E-05	2.208E-06	0.001889	3.34846E-06
Observations	909	78	909	78	909	78
Hypothesized Mean Difference	0		0		0	
df	84		155		941	
t Stat	-0.518305		3.506758802		2.92998132	
P(T<=t) one-tail	0.30280404		0.000296787		0.00173586	
t Critical one-tail	1.66319751		1.654743755		1.64647417	
P(T<=t) two-tail	0.60560807		0.000593574		0.00347172	
t Critical two-tail	1.98861017		1.975386112		1.96248948	

Table 8 - exclusion of individual bidders

Name of Company Excluded	Bidder 1		
Value Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.161%	0.230%	0.300%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$6,648	$9,494	$12,416
Total $ in sample	$997,170	$1,424,000	$1,862,400
Equal Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.173%	0.273%	0.401%
Significance level for spread[2]	0.30	0.28	0.31
$ per trade	$7,164	$11,290	$16,575
Total $ in sample	$1,074,500	$1,693,500	$2,486,200
Average Value of Trades	$4,132,700		
Aggregate Value of trades	$619,900,000		
Number of trades in sample	150		
Name of Company Excluded	Bidder 2		
Value Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.151%	0.337%	0.658%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$3,980	$8,901	$17,351
Total $ in sample	$398,020	$890,080	$1,735,100
Equal Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.22%	0.90%	1.85%
Significance level for spread[2]	0.31	0.43	0.43
$ per trade	$5,696	$23,633	$48,794
Total $ in sample	$569,620	$2,363,300	$4,879,400
Average Value of Trades	$2,637,700		
Aggregate Value of trades	$263,770,000		
Number of trades in sample	100		

Table 8 (continued)

Name of Company Excluded	Bidder 3		
Value Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.137%	0.264%	0.434%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$4,083	$7,904	$12,982
Total $ in sample	$404,210	$782,510	$1,285,200
Equal Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.151%	0.484%	1.041%
Significance level for spread[2]	0.26	0.42	0.44
$ per trade	$4,505	$14,472	$31,122
Total $ in sample	$446,030	$1,432,700	$3,081,100
Average Value of Trades	$2,989,400		
Aggregate Value of trades	$295,950,000		
Number of trades in sample	99		
Name of Company Excluded	Bidder 4		
Value Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.140%	0.171%	0.212%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$6,540	$8,018	$9,912
Total $ in sample	$595,120	$729,610	$902,000
Equal Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.143%	0.203%	0.264%
Significance level for spread[2]	0.24	0.17	0.15
$ per trade	$6,705	$9,486	$12,371
Total $ in sample	$610,160	$863,190	$1,125,700
Average Value of Trades	$4,682,400		
Aggregate Value of trades	$426,100,000		
Number of trades in sample	91		

Table 8 (continued)

Name of Company Excluded	Bidder 5		
Value Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.248%	0.360%	0.496%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$6,117	$8,864	$12,230
Total $ in sample	$489,360	$709,140	$978,370
Equal Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.247%	0.357%	0.493%
Significance level for spread[2]	0.23	0.21	0.21
$ per trade	$6,100	$8,801	$12,162
Total $ in sample	$487,980	$704,090	$972,930
Average Value of Trades	$2,465,100		
Aggregate Value of trades	$197,210,000		
Number of trades in sample	80		
Name of Company Excluded	Bidder 6		
Value Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.103%	0.145%	0.200%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$3,770	$5,314	$7,318
Total $ in sample	$241,250	$340,080	$468,370
Equal Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.121%	0.169%	0.226%
Significance level for spread[2]	0.29	0.23	0.20
$ per trade	$4,417	$6,191	$8,273
Total $ in sample	$282,660	$396,210	$529,500
Average Value of Trades	$3,662,800		
Aggregate Value of trades	$234,420,000		
Number of trades in sample	64		

Table 8 (continued)

Name of Company Excluded	Bidder 7		
Value Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.115%	0.181%	0.253%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$3,540	$5,601	$7,821
Total $ in sample	$223,030	$352,870	$492,700
Equal Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.162%	0.233%	0.309%
Significance level for spread[2]	0.20	0.16	0.14
$ per trade	$5,009	$7,189	$9,542
Total $ in sample	$315,540	$452,910	$601,140
Average Value of Trades	$3,089,200		
Aggregate Value of trades	$194,620,000		
Number of trades in sample	63		
Name of Company Excluded	Bidder 8		
Value Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.211%	0.288%	0.383%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$8,621	$11,743	$15,631
Total $ in sample	$500,000	$681,110	$906,620
Equal Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.189%	0.291%	0.396%
Significance level for spread[2]	0.27	0.24	0.24
$ per trade	$7,712	$11,871	$16,173
Total $ in sample	$447,310	$688,490	$938,010
Average Value of Trades	$4,079,500		
Aggregate Value of trades	$236,610,000		
Number of trades in sample	58		

Table 8 (continued)

Name of Company Excluded	Bidder 9		
Value Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.132%	0.176%	0.226%
Significance level for spread[2]	0.00	0.00	0.00
$ per trade	$5,387	$7,185	$9,210
Total $ in sample	$296,290	$395,180	$506,570
Equal Weighting	Best-Second Best	Best-Average	Best-Worst
% change in price	0.195%	0.252%	0.312%
Significance level for spread[2]	0.23	0.17	0.15
$ per trade	$7,953	$10,293	$12,754
Total $ in sample	$437,440	$566,140	$701,490
Average Value of Trades	$4,082,600		
Aggregate Value of trades	$224,540,000		
Number of trades in sample	55		

Appendix 1 - Details of Cost Calculation

[1] The details of calculation of all items are provided below. Our benchmark calculations are based on the following data . The total sample consists of 3 bonds - labelled A,B and C. All three are bids, and the prices at which they are transacted are as follows:
A: 99.00, other bids - 98.5,98.0, emerging,1million face value, transaction value = 990,000
B: 100.1, other bids - 100.05,100.02, corporate, 1million face value, transaction value = 1,001,000
C: 87.5, other bids - 87, junk, transaction value = 875,000

Calculation for Value weighting:
In this method, we first calculate the $ value loss in each trade, aggregate this to find a total $ value loss of going from the best to the second best in all bids. Using this figure, we find an average $ value loss per trade. We multiply the average loss per trade by the total number of trades per year (assumed here to be 5000) to find the total $ value loss per year. In addition, we also find a percentage loss per trade by dividing the average $ value per trade by the face value per trade.
Total Number of trades = 3
Average Value of trade = (990,000 + 1001000 + 875000)/3 =$958,333
Aggregate Value of Trade = $2,875,000

Best - second best Total $ in sample = 0.01*((99-98.5)*1e6 + (100.1 - 100.05)*1e6 + (87.5-87)*1e6) = $10,500
Best - Average Total $ in sample = 0.01*((99-98.25)*1e6+(100.1-100.035)*1e6+(87.5-87)*1e6) = $13,150
Best - Worst Total $ in sample = 0.01*((99-98)*1e6+(100.1-100.02)*1e6+(87.5-87)*1e6) = $15,800

$ per trade Best - Second best = 10500/ 3 = $3,500
$ per trade Best - Average = 13150 /3 = $4383
$ per trade Best - Worst = 15,800/3 = $5267

% change in price best - second best = 3500 / Average Face value of trade = 3500 / 958333 = .365%%
% change in price best - average = 4383/958333 = .457%
% change in price best - worst = 5267/958333 = .549%

Number of trades in sample = 3
Total $ value of sample = $3,000,000
$ value per trade = $1,000,000

Appendix 1 (Continued)

Calculation for equal weighting:

In the previous section, we calculated all values based on the notional amount of the trade. In this section, we recalculate all values based on the actual value of the trade. The approach used is somewhat different than the previous section. Instead of value weighting, we use an equally weighted approach, the details of which are enumerated:

First, we calculate the percentage loss in each trade and average these to find an aggregate % loss per trade.

% change in price best - second best =1/3*((100.1 - 100.05)/100.1 + (99-98.5)/99 + (87.5-87)/87.5)
= .375%
% change in price best - average = 1/3*((100.1 - 100.035)/100.1 + (99-98.25)/99 + (87.5-87)/87.5)
= .465%
% change in price best - worst = 1/3*((100.1-100.02)/100.1 + (99-98.0)/99 + (87.5 - 87)/87)
= .555%

$ per trade best - second best = .00375 * 958,333 = $3594
$ per trade best - average = .00465 * 958,333 = $4456
$ per trade best - worst = .00555 * 958,333 = $5319

[2] The test used was a standard two sided z test to check if the spread was significantly different from zero. For both the equal and the value weighted average, the percentage spreads as calculated above were used in the statistical test.