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The Journal of Finance, Vol. 48, No. 4. (Sep., 1993), pp. 1403-1419.

Stable URL:
http://links.jstor.org/sici?sici=0022-1082%28199309%2948%3A4%3C1403%3ATABATS%3E2.0.CO%3B2-N

The Journal of Finance is currently published by American Finance Association.

THE JOURNAL OF FINANCE • VOL. XLVIII, NO. 4 • SEPTEMBER 1993

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ABSTRACT

Recent press accounts claim that collusion is common practice in Treasury auctions and that as a result the auction profits are excessive. But, this paper finds that the auction prices are on average marginally higher than the secondary market bid prices. The auction profits, however, are systematically related to the total fraction of winning bids tendered by banks and dealers. The postauction prices of the two-year notes in which Salomon Brothers had a 94 percent holding are also examined. The secondary market prices of these notes were significantly higher than the estimated competitive prices in the four-week postissue period.

THE MARKET FOR U.S. Treasury notes and bonds is widely considered as one of the most active and liquid markets in the world. The recent revelation that Salomon Brothers accumulated a large position in the two-year notes issued in the May 1991 auction and allegedly manipulated the price of this issue has led many investors to question the price efficiency in this market. For instance, one of the lead articles in the *Wall Street Journal* dated August 19, 1991 (p. A1) reports that "Collusion and price fixing in the $2.3 trillion Treasury securities market have been routine for more than a decade, according to traders and top Wall Street executives."

Such assertions have led to calls for changes in the auction rules and tighter regulation of the market for Treasury securities and evidently, such measures are being contemplated by the Treasury. For instance, the same issue of the *Wall Street Journal* (p. A5) reports that the "Treasury is considering significant changes in how it sells government debt," and the *Wall Street Journal* dated August 26, 1991 (p. A1) quotes the Fed Vice Chairman David Mullins as saying "We need to examine mechanisms to improve the efficiency of the market, (and) reduce the cost of Treasury finance..." While it is possible that technicalities such as position limits were violated in Treasury auctions, models of rational economic behavior predict that collusion cannot be sustained in a market with as many participants as in the Treasury auctions. It is therefore important to investigate

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whether or not these theory-based predictions are borne out in practice in order to evaluate the need for new, potentially costly, government regulations.

The regulators, naturally, attempt to continuously monitor whether bids in Treasury auctions are fixed as a result of collusion among the primary dealers or other participants. For instance, an ongoing Securities and Exchange Commission probe seeks to investigate whether bids in any of the auctions were "collusive, prearranged or concerted."[1] Establishing whether there were collusive, prearranged, or concerted bids in any given auction is an elaborate legal endeavor and is clearly beyond the scope of this paper. This paper pursues a more general objective and measures the profits of the winning bidders in Treasury auctions and investigates whether these profits are systematically related to the proportion of winning bids tendered by commercial banks and nonbank primary dealers (hereafter "banks and dealers")[2] in order to evaluate whether there is prima facie evidence of pervasive price fixing.

The expected economic profits to winning the auctions are estimated as the average change in the differences between the prices of newly issued bonds and matched seasoned bonds on the auction dates and on selected dates following the auctions.[3] The evidence indicates that on average the primary dealers buy bonds in the auctions at prices marginally higher than the prices that they are willing to pay in the secondary markets after the auctions.

The next test examines whether the postauction price changes are systematically related to the percentage of new issues won by banks and dealers. If they routinely collude then it is likely that when they collectively bid less aggressively, or when the percentage of winning bids tendered by this group is low, the profits to the winning bids will be high. Interestingly, it is found that the allocation to banks and dealers are negatively related to auction profits. This result is consistent with the collusion hypothesis and suggests that further analysis using data on bids by individual dealers is warranted.

Finally, the validity of claims that the secondary market prices of the two-year Treasury notes issued in the May 1991 auction were manipulated is investigated. Salomon Brothers admitted to having controlled 94 percent of

[1] See the *Wall Street Journal*, August 27, 1991, page C6.

[2] Ideally, I would have liked to examine the relation between auction profits and allocations to primary dealers while banks and dealers includes nonprimary dealer commercial banks. The allocations to primary dealers, however, are not publicly available and the Treasury Department indicated that this is proprietary information. The average proportion of winning bids from commercial banks is 14.60 percent while that from nonbank primary dealers is 58.78 percent (see Table IV). These statistics suggest that the allocation to nonprimary dealer commercial banks, which is a fraction of the total allocation to commercial banks, is small relative to the allocation to primary dealers. Therefore, I expect that any association that may exist between auction profits and primary dealer allocations will likely be evident when allocation to banks and dealers is used as a proxy, although there may be a loss of power due to the inclusion of allocations to nonprimary dealer commercial banks in this proxy.

[3] The auction data are obtained from the *Treasury Bulletin* and the secondary market bond prices are collected from the *Wall Street Journal*.

the two-year notes issued in this auction in violation of the Treasury regulation that no bidder may bid for more than 35 percent of the issues in any single auction. Although the holding of Salomon Brothers appears large, the analysis in Kyle (1984) suggests that any position less than 100 percent will not result in a market squeeze. Contrary to this prediction, however, it is found that the prices of the two-year notes issued in May 1991 were significantly higher than the estimated competitive prices in the four-week postissue period.

The rest of the paper is organized as follows. Section I describes the institutional aspects of the Treasury note and Treasury bond auctions. Section II presents estimates of the profits to winning allocations in Treasury auctions. Section III examines the relation between auction profits and allocations to banks and dealers. Section IV examines the secondary market prices of the two-year notes issued in May 1991 and Section V concludes.

I. The Process of Treasury Auctions

Treasury notes and bonds of various maturities are issued periodically through discriminatory price auctions. The Treasury announces the quantities of notes and bonds of different maturities that will be sold in upcoming auctions and accepts competitive and noncompetitive tenders until 1:00 P.M. eastern standard time on the auction date. The competitive bidders, mainly designated primary dealers[4] and commercial banks, submit bids for yield-quantity pairs. The noncompetitive bidders submit tenders for quantities that they are willing to purchase at the quantity-weighted price of the accepted competitive bids. Bidders other than the primary dealers and commercial banks are required to deposit 2 percent of the amount bid along with their tenders. These deposits do not earn interest and may be held for up to two weeks. Therefore, the deposit requirement makes it costly for many investors to bid directly and provides incentives for them to bid through the primary dealers. In addition to these bidders, the Fed also places a noncompetitive bid for a quantity announced prior to the auction.

The Fed collects the bids and nets out the noncompetitive bids and allocates the balance to the highest bidders among the competitive bidders. The coupon rate is set at the highest bid below the quantity-weighted average yield in the auction, rounded off to the nearest one-eighth. The winning bidders make the payments for their allocations on the issue date, which is typically a week from the auction date.

Table I presents the summary statistics for Treasury notes and bonds issued during the January 1986 to June 1991 sample period. The Treasury

[4] The primary dealers are members of the Primary Dealer Association whose membership is conferred by the Federal Reserve Bank of New York. The primary dealers have the responsibility to bid in all Treasury auctions and to actively make secondary markets in the Treasury securities, among other things. See Bollenbacher (1988), for example, for further details on the role of primary dealers.

Table I

Issues of Treasury Notes and Treasury Bonds—January 1986 to June 1991

This table presents summary information on Treasury notes and bonds of different maturities issued through public offerings. Subscription is the average of the ratio of total bids in an auction to the amount issued, Price and Yield Ranges are the differences between the maximum and minimum accepted bid prices (dollars) and yields to maturity (percentages) respectively.

Years to Maturity	Number of Issues	Amount ($ Millions)	Subscription	Range: Price	Range: Yield
2	66	771960	2.63	0.0497	−0.028
3	22	289976	2.52	0.0657	−0.026
4	20	168958	3.08	0.0554	−0.017
5	26	221910	2.87	0.0902	−0.022
7	22	165411	2.67	0.1752	−0.035
10	23	275409	2.16	0.2378	−0.037
20	1	4753	2.72	0.8950	−0.100
30	21	199385	2.27	0.3134	−0.030
All	201	2097767	2.61	0.1243	−0.028

raised about $2.1 trillion through these issues. The two-year notes were issued monthly and the other securities were generally issued quarterly during this sample period. There was, however, only one issue of twenty-year bonds in this sample period.

The amounts of bids tendered are on average 2.61 times the amounts of bonds issued. The yield range of accepted bids is typically about three basis points for all maturities. The price range, however, is generally higher for longer term bonds and it ranges from 4.97 cents for the two-year notes to 31.34 cents for the thirty-year bonds. The yield and price ranges for the single issue of the twenty-year bonds, however, are substantially higher.

II. Profits to Winning Bids

This section first examines the average ex post profits to winning bids in Treasury auctions. The sample used in this section comprises all two-, five-, seven-, and ten-year notes issued in the January 1986 to June 1991 period.[5] This sample contains 67.7 percent of the issues and 68.3 percent of the value of the bonds issued in this period.

The ex post profit to winning a bid in an auction and holding the newly issued bond till time t, denoted as π_t, is:

$$\pi_t = P_t - (P_A + \text{Holding cost}_t), \tag{1}$$

[5] The Treasury offered one issue of foreign-targeted ten-year notes in February 1986, within my sample period. This issue is excluded from the sample.

where P_A is the value-weighted average of the prices paid by the winning bidders for the newly issued bonds in the auction, as reported in the *Treasury Bulletin*. P_t is the average of the bid and ask prices of these bonds quoted at the close of date t plus accrued coupon; $t = 0$ denotes the issue date, $t = 1$ denotes one week from the date of issue and so on. These price quotations, which are for payment two business days after the quote date, are obtained from various issues of the *Wall Street Journal*. Holding cost is the cost of financing the investment in the bond from the date of issue to two business days after t.[6] The auction date interest rate on the Treasury bill that matures in about a week after that date is used as the rate at which the bidder can finance his investment in the bond.[7] The Treasury bill interest rates (r_A) are also obtained from the *Wall Street Journal*. π_t is computed as:

$$\pi_t = P_t - P_A(1 + r_A)^{n/365}, \tag{2}$$

where n is the number of calendar days from the issue date to two business days after date t.

Table II presents the average profit to purchasing a bond at the auction and holding it till the issue date and also for holding periods of one to four weeks from the issue date. Table II also presents the average changes in the yields-to-maturity from the auction date to date t. The average profits for the two-year notes over these holding periods range from 13.93 cents to 21.30 cents per \$100 face value and they are significantly positive. For the five-, seven-, and ten-year Treasury notes, however, the average profits are not reliably different from zero.

These average ex post profits, however, need not measure the economic profits to bidding since they potentially include compensation for bearing interest rate risk from the auction date until date t. Moreover, interest rates generally declined over this sample period which was probably not anticipated. For example, the yield to maturities of the two-year notes issued in January 1986 and June 1991 were 8.17 and 7.06 percent respectively. Consequently, the ex post profits measured here may overstate the expected holding period profits at the time of bidding.

Therefore, the expected economic profits to the winning bids are estimated as the average change in the differences between the prices of newly issued bonds and matched seasoned bonds on the auction dates and on selected dates following the auctions. The method used for measuring the prices of matched seasoned bonds is as follows. In the first step, for each newly issued bond the market price of a comparable seasoned bond, denoted as P^c, is estimated using the secondary market prices of maturity matched bonds. The matched bonds are two seasoned bonds with maturity dates closest to that of the newly issued bond. The maturity dates of the matched seasoned bonds

[6] Recall that the payment for the purchase of bonds in Treasury auctions has to be made on the issue date.

[7] The time to maturities of the Treasury bills used in the empirical analysis varied from seven to ten days from the date of the auction.

Table II

Ex Post Profits to Winning Bids in Treasury Note Auctions

This table presents average ex post profits to purchasing two-, five-, seven-, and ten-year notes in Treasury auctions in the January 1986 to June 1991 period. π_t denotes the average profit to purchasing notes at the auctions and holding them up to t; $t = 0$ denotes the issue date, $t = 1$ denotes one week from the date of issue and so on. The ex post profit in an auction is computed as follows:

$$\pi_t = P_t - (P_A + \text{Holding cost}_t),$$

where P_t and P_A are the bond price including accrued coupon at time t and the auction prices respectively. Holding cost_t is the cost of holding a bond from the auction date to date t, computed at the Treasury bill rate. π_t is expressed as dollars per \$100 face value. The average differences between the yields to maturity (expressed in percentages) on the auction date (Y_A) and on date t (Y_t) are also presented. N is the number of observations for which price data on date t were available in the *Wall Street Journal*. The t-statistics are reported in parentheses.

Years to Maturity		Week 0	1	2	3	4
2	π_t	0.1393	0.1732	0.2130	0.1904	0.2010
		(3.95)	(3.46)	(3.04)	(2.49)	(2.30)
	$Y_t - Y_A$	−0.0732	−0.0782	−0.0851	−0.0557	−0.0456
		(−3.64)	(−2.69)	(−2.09)	(−1.25)	(−0.89)
	N	52	64	66	66	66
5	π_t	0.1296	0.2453	0.3422	0.1963	0.3469
		(0.90)	(1.05)	(1.48)	(0.83)	(1.20)
	$Y_t - Y_A$	−0.0284	−0.0471	−0.0614	−0.0146	−0.0423
		(−0.79)	(−0.81)	(−1.06)	(−0.24)	(−0.59)
	N	25	26	26	26	26
7	π_t	−0.0099	0.4212	0.6653	0.4007	0.3829
		(−0.04)	(1.50)	(1.57)	(0.87)	(0.77)
	$Y_t - Y_A$	0.0074	−0.0777	−0.1191	−0.0615	−0.0491
		(0.13)	(−1.39)	(−1.43)	(−0.68)	(−0.50)
	N	17	20	22	22	22
10	π_t	0.2675	0.2836	0.3237	0.5246	0.4742
		(0.87)	(0.74)	(0.66)	(0.85)	(0.77)
	$Y_t - Y_A$	−0.0394	−0.0334	−0.0324	−0.0573	−0.0430
		(−0.81)	(−0.55)	(−0.42)	(−0.59)	(−0.44)
	N	20	22	22	22	22
All	π_t	0.1374	0.2434	0.3288	0.2796	0.3025
		(1.84)	(2.66)	(2.80)	(2.06)	(2.11)
	$Y_t - Y_A$	−0.0454	−0.0645	−0.0775	−0.0490	−0.0451
		(−2.70)	(−2.90)	(−2.68)	(−1.52)	(−1.26)
	N	114	132	136	136	136

are also constrained to straddle the maturity date of the newly issued bond. The comparable bond yield is then obtained by linearly interpolating between the yields of the matched bonds. Specifically, let N_1, N_2, and N_n be the number of days to maturity of the two seasoned bonds and the newly issued bond respectively and let Y_1 and Y_2 be the yield to maturities of the seasoned bonds. The comparable bond yield Y^c is computed as:

$$Y^c = \frac{N_2 - N_n}{N_2 - N_1} Y_1 + \frac{N_n - N_1}{N_2 - N_1} Y_2. \tag{3}$$

P^c is the price at which the yield to maturity of the comparable bond equals Y^c. P^c provides an estimate of the price at which a seasoned bond with the same maturity as the newly issued bond will trade. Let ΔP_t be the difference between the prices of the newly issued bond and the comparable seasoned bond on date t, i.e., $\Delta P_t \equiv P_t - P_t^c$ and let ΔP_A denote this difference on the auction date.

Newly issued bonds usually command a "liquidity premium" relative to comparable seasoned bonds because they are more actively traded.[8] The components of ΔP_t can therefore be written as:

$$\Delta P_t = \lambda_t + e_t, \tag{4}$$

where λ_t is the liquidity premium at time t and e_t is the error in using P^c as an estimate of the equivalent seasoned bond price. The error term e_t has two components. The first component is the measurement error in quoted bond prices due to factors such as nonsynchronous trading of the matched seasoned bonds and the newly issued bond. The measurement error component of e_t is assumed to be zero on average. In addition, e_t also potentially contains a model misspecification error. Specifically, since bonds need not be priced so that yields are linear functions of time to maturity, expression (3) may be a biased estimator of comparable seasoned bond yields. The potential magnitude of this misspecification error is assessed in the Appendix and it is fairly small.

Consider the components of ΔP_A.

$$\Delta P_A = -\gamma + \lambda_A + e_A, \tag{5}$$

where γ is the expected profit to a winning bid in the auction. From expressions (5) and (4),

$$\delta_t \equiv \Delta P_t - \Delta P_A = \gamma + (\lambda_t - \lambda_A) + (e_t - e_A). \tag{6}$$

I assume that $E(e_t - e_A) = 0$. If the misspecification error at the auction date is systematically different from that at time t then this assumption will not be valid. The experiment described in the Appendix, however, indicates that

[8] For instance, Amihud and Mendelson (1991) document that the prices of newly issued Treasury bills are generally higher than the prices of seasoned bonds with the same maturity and attribute this price difference to the liquidity of the Treasury bills.

the magnitude of misspecification error is likely to be small and the misspecification error on the auction date is virtually the same as that four weeks after the auction.

Therefore, $E(\delta_t)$ equals the expected auction profits less the expected change in the liquidity premium from the auction date to date t. When t is close to the auction date the change in liquidity premium will likely be small. The volume of trade for a given bond issue generally declines over time as more and more of that issue are used in dedicated portfolios and taken out of circulation. Therefore, as the time between the auction date and t increases the expected holding period profit will likely decrease.

Table III presents the estimates of expected profits to winning bids in the two-, five-, seven-, and ten-year note auctions. The average profit to winning bids is 4.17 cents per $100 face value when the bonds are held till the issue date.[9] The winning bids for ten-year notes earn the highest profit of 12 cents (t-statistic = 2.35) while the winning bids for seven-year notes lose 4.27 cents (t-statistic = −0.60). The profits to winning bids dissipate entirely if the bonds are held for four weeks after the issue, probably because of the declining liquidity premia in the prices.[10]

To put the magnitude of the auction profits in perspective the quoted bid-ask spreads for these Treasury notes are examined. The total spread was on average 9.35 cents per $100 face value. The average auction profit is therefore less than half the bid-ask spread. In other words, on average the primary dealers purchase bonds in the auctions at prices that are marginally higher than the prices that they are willing to pay for the same bonds in the secondary markets soon after the auctions. Therefore, using the postauction secondary market prices as benchmarks, the auction prices on average do not seem to be particularly low.[11]

III. Auction Profits and Allocations to Banks and Dealers

Press accounts claim that primary dealers exploit their preferential status and collude in the bidding process. If these investors collude then it can be expected that when they collectively tender lower bids the profits for the winning bids will be higher. Of course, it is not possible for an outsider to

[9] When the May 1991 issue of the two-year note is excluded the average profit is 3.96 cents per $100 face value.

[10] In addition to estimating P_c using maturity matched bonds, the comparable seasoned bond prices were also computed using Macaulay duration-matched bonds. These matched bonds were selected so that their durations straddled that of the newly issued bonds. The results using duration-matched bonds were similar to those reported here with maturity-matched bonds and are therefore not reported. The time series standard errors of $\Delta P_t - \Delta P_A$, however, were larger using duration-matched bonds than when using maturity-matched bonds.

[11] One may argue that the primary dealers make markets in the Treasury bonds and hence sell their auction purchases at the ask prices and hence this price is the appropriate benchmark. However, the profits due to buying at the bid and selling at the ask are returns to market making and not profits as a result of winning auction bids.

Table III

Expected Profits to Winning Bids in Treasury Note Auctions

This table presents estimates of average expected profits to purchasing two-, five-, seven-, and ten-year notes in Treasury auctions in the January 1986 to June 1991 period. The expected profit to purchasing a note at the auction and holding it up to time t, denoted as δ_t, is estimated as follows. Let P_t denote the price of a newly issued bond at time t, and P_t^c the price of a comparable seasoned bond. Subscript $t = A$ denotes the auction date, $t = 0$ denotes the issue date, $t = 1$ denotes one week from the date of issue and so on. Let $\Delta P_t \equiv P_t - P_t^c$.

$$\delta_t = \Delta P_t - \Delta P_A.$$

δ_t is expressed in dollars per \$100 face value.

The average changes in the yield differences (expressed in percentages) between the newly issued bond and a comparable seasoned bond on the auction date (ΔY_A) and on date t (ΔY_t) are also presented for reference. N is the number of observations for which matched and newly issued bond prices on the auction date and on date t were available in the *Wall Street Journal*. The t-statistics are reported in parentheses.

Years to Maturity		Week 0	1	2	3	4
2	δ_t	0.0502	0.0392	0.0104	0.0061	−0.0022
		(4.66)	(3.17)	(0.95)	(0.57)	(−0.17)
	$\Delta Y_t - \Delta Y_A$	−0.0286	−0.0227	−0.0063	−0.0040	0.0007
		(−4.68)	(−3.18)	(−1.01)	(−0.65)	(0.10)
	N	51	64	66	66	66
5	δ_t	0.0181	0.0026	0.0049	−0.0337	−0.0267
		(0.50)	(0.06)	(0.13)	(−0.77)	(−0.58)
	$\Delta Y_t - \Delta Y_A$	−0.0053	−0.0014	−0.0022	0.0072	0.0053
		(−0.60)	(−0.15)	(−0.23)	(0.67)	(0.47)
	N	24	25	26	26	26
7	δ_t	−0.0427	0.0313	0.0345	−0.0064	−0.0097
		(−0.60)	(0.51)	(0.57)	(−0.12)	(−0.16)
	$\Delta Y_t - \Delta Y_A$	0.0087	−0.0062	−0.0062	0.0009	0.0015
		(0.60)	(−0.50)	(−0.51)	(0.08)	(0.13)
	N	17	20	22	22	22
10	δ_t	0.1200	0.1454	0.0931	0.1708	0.1069
		(2.35)	(2.91)	(1.52)	(2.66)	(1.27)
	$\Delta Y_t - \Delta Y_A$	−0.0184	−0.0224	−0.0146	−0.0264	−0.0167
		(−2.29)	(−2.85)	(−1.51)	(−2.65)	(−1.26)
	N	20	22	22	22	22
All	δ_t	0.0417	0.0488	0.0266	0.0231	0.0096
		(2.43)	(3.02)	(1.61)	(1.32)	(0.48)
	$\Delta Y_t - \Delta Y_A$	−0.0161	−0.0161	−0.0068	−0.0047	−0.0011
		(−3.66)	(−3.51)	(−1.59)	(−1.07)	(−0.22)
	N	112	131	136	136	136

observe whether or not the primary dealers tender low collusive bids. However, if they collectively bid less aggressively in certain auctions then the allocations that they are likely to receive in those auctions will be less than that in the other auctions. Therefore, the collusion hypothesis implies that the auction profits will be negatively related to the proportion of winning bids tendered by the primary dealers and this hypothesis is tested in this section.

Table IV presents the average percentage of winning bids tendered by various groups of investors in the two-, five-, seven-, and ten-year Treasury note auctions. The commercial banks and nonbank primary dealers tendered 14.60 and 58.78 percent of the winning bids on average in these auctions.[12] The combined average percentage of the winning bids submitted by banks and dealers ranged from a low of 68.16 percent in the two-year note auctions to 81.13 percent in the ten-year note auctions.

Tests to examine whether the expected auction profit δ is systematically related to the proportion of winning bids tendered by banks and dealers are carried out next.[13] These tests control for differences in the level of competition in the auctions and differences in the extent of dispersion of opinion among the bidders regarding the bond value. Auction models of Reece (1978), Milgrom and Weber (1982), and Bikhchandani and Huang (1989) predict that the auction profits will be related to these variables.[14] These predictions are fairly intuitive. When there are a finite number of bidders who can each bid for finite quantities then each bidder optimally bids below the expected bond value conditional on his information set and on his bid winning the auction.

Table IV

Treasury Note Allocations

This table presents the average percentage of the newly issued two-, five-, seven-, and ten-year Treasury notes that were issued to different investor classes in the January 1986 to June 1991 period. The column headings denote the investor classes. N is the number of observations for which the investor class breakdown was available in the *Treasury Bulletin*.

Years to Maturity	N	Fed	Individuals	Corporations	Commercial Banks	Nonbank Primary Dealers	Others
2	64	8.04	7.28	5.60	16.74	51.42	10.92
5	25	0.58	4.86	11.71	11.60	62.53	8.72
7	22	1.60	4.74	7.74	14.25	66.31	5.35
10	20	3.31	3.37	8.29	11.75	69.38	3.90
All	131	4.82	5.80	7.54	14.60	58.78	8.46

[12] These data are obtained from various issues of the *Treasury Bulletin*. Although the *Treasury Bulletin* groups the allocations to brokers with nonbank dealers, in private communication the Treasury Department indicated that virtually all the allocation in this group is to primary dealers.

[13] See footnote 2.

[14] See Cammack (1991) for a discussion of the predictions of auction theory in the context of Treasury bill auctions, which are conducted in a manner similar to the Treasury note auctions examined here.

Since a bidder's marginal probability of losing an auction by lowering his bid increases with the level of competition the equilibrium bids on average increase, and the expected profits decrease, as the number of bidders increases. When there is an increase in the dispersion of opinion about the value of the bond, however, the marginal probability of losing an auction by lowering the bid decreases. Therefore, the bids will on average be lower and the expected profits to winning bids will be higher when there is larger dispersion of opinion than otherwise.

The ratio of the amount of bids tendered in an auction to the total value of bonds offered (denoted as SUBS below) is used as the proxy for the level of competition. The price range of accepted bids (RANGE-P) is used as the proxy for dispersion of opinion. The following regression is fitted to examine whether there is any systematic relation between the expected auction profits δ and the percentage of winning bids tendered by the banks and dealers after controlling for the other variables discussed above:

$$\delta_t^i = a_{1t}\,\text{SUBS}^i + a_{2t}\,\text{RANGE-P}^i + a_{3t}\,\text{FRAC}^i + \sum_{j=1}^{4} d_j D^i + e_t^i \qquad (7)$$

where the superscript i denotes the ith auction, FRAC is the fraction of winning bids tendered by banks and dealers and the dummy variables D_1, D_2, D_3, and D_4 equal 1 if the time to maturity of the bond offered in auction i is two, five, seven, and ten years respectively and zero otherwise. Regression (7) is fitted using the weighted least squares procedure. The standard deviations of δ_t for bonds of a given maturity are estimated and the inverse of these standard deviations are used to weight the respective observations.

Table V presents the regression estimates. The slope coefficients on SUBS in regression (7) are reliably positive, contrary to theoretical predictions. Since this variable includes both the expected and the unexpected levels of participation in an auction, it is possible that its positive relation with auction profits may be due to the ex post information that the unexpected component conveys. The sign of the slope coefficient on RANGE-P is positive as predicted but it is not reliably different from zero except for $t = 1$.

The estimate (t-statistic) of the slope coefficient on FRAC using issue date profits is -0.2336 (-2.32) which indicates a reliable negative relation between the proportion of winning bids tendered by banks and dealers. In order to assess the economic significance of this result, the sample of bonds of each maturity is partitioned into three roughly equal groups (labelled "Low," "Medium," and "High") based on the proportion of winning bids tendered by banks and dealers. Table VI presents the average profits to winning the auction and holding the bond till the issue date for each group. The average profits for the Low groups are larger than that for the High groups for two-, seven-, and ten-year notes. The differences in profits, however, are not reliably different from zero when five-, seven-, and ten-year notes are considered separately. For the entire sample, the average profit for the Low group is 8.14 cents per $100 which is more than that for the High group by 4.57 cents

Table V

Association between Auction Profits, Bids Tendered, Price Range, and Allocations to Banks and Dealers

This table presents the estimates of the following regression:

$$\delta_t^i = a_{1t}\,\text{SUBS}^i + a_{2t}\,\text{RANGE-P}^i + a_{3t}\,\text{FRAC}^i + \sum_{j=1}^{4} d_j D^i + e_t^i$$

where δ_t^i is the profit to purchasing a Treasury note in auction i and holding it until time t. (See Table III for details on the computation of δ_t^i.) $t = 0$ denotes the issue date, $t = 1$ denotes one week from the date of issue and so on. SUBS is the ratio of the total amount of bids to the amount issued; RANGE-P is the difference between the prices of the maximum and minimum accepted bids; and FRAC is the ratio of the winning bids tendered by banks and dealers to the amount issued. D_1, D_2, D_3, and D_4 are dummy variables that equal 1 if the year to maturity of the bond is two, five, seven, and ten years respectively and zero otherwise. The sample consists of all two-, five-, seven-, and ten-year Treasury notes issued in the January 1986 to June 1991 period. N is the number of observations. The t-statistics are reported in parentheses.

t	SUBS	RANGE-P	FRAC	N
0	0.0713	0.1771	−0.2336	108
	(2.89)	(0.83)	(−2.32)	
1	0.0475	0.5301	−0.2764	126
	(1.74)	(2.18)	(−2.43)	
2	0.0581	0.1546	−0.0630	131
	(2.20)	(0.63)	(−0.57)	
3	0.0606	0.2418	−0.1398	131
	(2.30)	(1.02)	(−1.26)	
4	0.0739	0.1544	−0.2192	131
	(2.48)	(0.56)	(−1.73)	

Table VI

Auction Profits and Allocations to Banks and Dealers

This table presents the average auction profits (δ) to purchasing a Treasury note in an auction and holding it until issue date within three groups sorted based on the ratio of winning bids tendered by banks and dealers (FRAC) to the amount issued.

Years to Maturity		Allocation to Banks and Dealers		
		Low	Medium	High
2	δ	0.0825	0.0473	0.0253
	FRAC	56.43%	69.02%	76.60%
5	δ	0.0701	−0.1164	0.1094
	FRAC	61.36%	75.20%	85.00%
7	δ	−0.0135	−0.0464	−0.0632
	FRAC	71.73%	79.09%	85.18%
10	δ	0.1709	0.1719	0.0629
	FRAC	73.14%	81.79%	87.88%
All	δ	0.0814	0.0210	0.0357
	FRAC	62.65%	74.26%	81.78%

per \$100. While there does not seem to be a natural benchmark that can be used to evaluate the economic significance of this difference, the fact that it is roughly the same as the average profits in Treasury auctions suggests that it is nontrivial.

The evidence presented in this section is consistent with the implications of the collusion hypothesis. However, it is also possible that the association between FRAC and auction profits is due to banks and dealers *legitimately* sharing information, such as their forecasts of macroeconomic variables that may not be available to other bidders. It is not possible to determine conclusively which of these explanations is more appropriate based on analysis of publicly available data. These results, however, suggest that a more detailed analysis to resolve these issues is warranted.

IV. Secondary Market Prices of Two-Year Notes Issued in May 1991

The total amount of the two-year notes auctioned in May 1991 was \$12.25 billion. Salomon Brothers admitted to having controlling interest over 94 percent of this issue, well in excess of the 35 percent statutory ceiling.[15] The claims by the other investors that Salomon Brothers manipulated the secondary market prices of this issue led to widespread calls for overhauling the auction rules.[16]

Kyle (1984) examines theoretically how a large investor can potentially corner a market by taking large positions in the spot and forward (or when-issued) markets and squeeze the short investors. In his model, the dominant investor can manipulate the market prices and effect a short squeeze only if he controls more than 100 percent of the asset supply. In Kyle's model investors other than the dominant player act competitively. Therefore, when the net holding of the small investors is positive, the short sellers can all close out their positions by purchasing assets from the competitive investors at fair market prices and avoid a short squeeze. In this setting the 94 percent position held by Salomon Brothers in the May 1991 issue is not sufficient to manipulate the market prices. This section examines the secondary market prices of the May 1991 issue in order to test whether the allegations of price manipulations are true or whether the market prices are competitively set as in Kyle's model.

[15] The controlling interest held by Salomon Brothers included a \$590 million dollar long position in the when-issued market, \$4.2 billion purchased in its own account in the auction, and \$500 million transferred from a customer account due to unauthorized bids. Salomon purchased an additional \$5.92 billion of this issue in the auction on behalf of different customers (the source is U.S. Department of Treasury, *Joint Report* (1992)) which also seems to have been considered as a part of Salomon's controlling interest.

[16] While there have been widespread allegations that the price of this note was manipulated by Salomon Brothers, none of the published accounts that I am aware of, including the *Joint Report* (1992), document evidence that the market price during the postauction period was abnormally high.

Table VII, Panel A, presents the average estimates of ΔP_t, the differences between the prices of newly issued bonds and comparable seasoned bonds, for all two-year note issues in the 1986 to 1991 sample period except the May 1991 issue. The auction prices are on average 2.55 cents per \$100 higher than the matched bond prices. The matched price differences range from 6.82 cents on the issue date to 1.74 cents four weeks from the issue date and the yields to maturity of the newly issued bonds are on average 1.09 to 3.94 basis points below that of comparable seasoned bonds over this period.

Table VII, Panel B, presents the price and yield comparisons for the May 1991 two-year notes. The auction price is 4.98 cents higher than the comparable seasoned bond price, which is not statistically different from the corresponding price difference in Panel A. The postauction matched price differences, however, are significantly higher than the corresponding price differences in Panel A. The average matched price difference for this two-year note from the date of issue to four weeks after the issue is 31.36 cents per \$100 face value and this difference is significantly larger than the average difference of 4.23 cents for the other two-year notes. In addition, the matched price difference of 31.36 cents is the largest average matched price difference for the two-year notes in the sample. Therefore, contrary to

Table VII

Relative Prices of Two-Year Notes

This table presents a comparison of the prices and the yields of newly issued two-year Treasury notes issued in the January 1986 to June 1991 period with that of comparable seasoned bonds. Panel A presents the comparison for all two-year notes except the May 1991 issue and Panel B presents the comparison for the two-year note issued in the May 1991 auction. ΔP_t and ΔY_t are the differences between prices (expressed in dollars per \$100 face value) and yields (expressed in percentages) of the newly issued bonds and that of matched seasoned bonds on date t. t = *Auction* denotes the auction date, $t = 0$ denotes the issue date, $t = 1$ denotes one week from the date of issue and so on.

	Auction	0	1	2	3	4
	Panel A. All Two-year Notes Other than May 1991 Issue					
ΔP_t	0.0255	0.0682	0.0642	0.0331	0.0285	0.0174
	(2.48)[a]	(5.74)	(5.42)	(3.33)	(3.39)	(2.11)
ΔY_t	−0.0150	−0.0394	−0.0374	−0.0198	−0.0173	−0.0109
	(−2.57)	(−5.83)	(−5.49)	(−3.44)	(−3.51)	(−2.23)
	Panel B. Two-year Note Issued in May 1991					
ΔP_t	0.0498	0.3277	0.3163	0.2387	0.2561	0.4294
	(0.29)[b]	(3.09)	(2.68)	(2.56)	(3.35)	(6.17)
ΔY_t	−0.0286	−0.1853	−0.1819	−0.1386	−0.1497	−0.2519
	(−0.29)	(−3.06)	(−2.67)	(−2.57)	(−3.34)	(−6.11)

[a]The t-statistics under the hypothesis that mean ΔP_t and ΔY_t are different from zero are presented in Panel A.

[b]The t-statistics in Panel B indicate the number of standard deviations away from the sample mean reported in Panel A.

the implications of Kyle's model, the evidence indicates that the market prices were reliably higher than the estimated competitive prices although Salomon Brothers held less than 100 percent of the outstanding two-year notes.

V. Concluding Remarks

Recent press accounts claim that collusion in Treasury auctions is common practice and that the bidders profit at the expense of the Treasury. Such assertions have instigated the Treasury into considering new auction regulations. This paper examined the profits of the winning bids in Treasury auctions and investigated whether these profits are systematically related to the proportion of winning bids tendered by banks and dealers in order to evaluate whether there was prima facie evidence of price fixing.

The average profit to winning bids in the two-, five-, seven-, and ten-year Treasury note auctions is 4.17 cents per $100 face value. This profit is less than half the average bid-ask spread in the secondary markets and it indicates that on average the primary dealers purchase bonds at marginally higher prices in the auctions than in the secondary markets. It was found, however, that the auction profits are negatively related to the proportion of winning bids tendered by commercial banks and nonbank dealers. While this result is consistent with the collusion hypothesis, further analysis using finer data is required in order to draw more conclusive inferences.

This paper also examined the secondary market prices of the two-year notes issued in the May 1991 auction in which Salomon Brothers admitted to having violated auction regulations. The evidence here indicates that the prices of these notes were reliably higher than the estimated competitive prices in the four-week period after issue. This finding indicates that the concerns of bond market participants about potential squeezes are justified.[17] The possibility of price manipulation could potentially have an adverse effect on bond market liquidity. For example, if a squeeze were a real possibility, it may not be possible to purchase large amounts of bonds in the market without moving the prices away from the competitive levels. Since the evidence indicates that liquidity is priced in the bond market,[18] reduced liquidity will adversely affect market prices. Therefore, steps to curb potential price manipulations will likely be beneficial.

To alleviate this problem the Treasury has announced that it will reopen an issue in the event of "an acute, protracted squeeze." The practicality of this policy was tested when the *Wall Street Journal* (dated August 20, 1992)

[17] The *Wall Street Journal* also reported that there was a squeeze in the April 1992 two-year note issue. The profit from the auction date to the issue date for this note was 22.87 cents per $100 which, among all two-year notes, was second only to the May 1991 issue.

[18] The five-, seven- and ten-year newly issued notes were on average priced 46, 41, and 39 cents per $100 face value higher than comparable seasoned bonds on the issue date.

reported that there was a squeeze in the $5\frac{1}{2}$ percent July 1997 Treasury note. Although the New York Fed launched an investigation in response to these allegations, the Treasury declined to reopen this issue. This episode illustrates one of the problems with this policy of selectively reopening issues when the criteria for judging whether or not there is a squeeze are not clear cut.

The Treasury may want to consider other market-based approaches to deter potential squeezes, such as standardizing the bond issues. One way to standardize bonds would be to issue all bonds of a given year to maturity with the same coupon and maturity date. For example, all two-year notes issued in, say 1993, may be issued with the same coupon and with December 1995 maturity. Alternatively, all bonds may be issued as pure discount bonds that mature at the end of selected months, say June and December, over a twenty- or thirty-year period.[19,20] Standardization of bond issues will periodically bring to the market a new supply of bonds of any given maturity and hence will make it more difficult for any investor to corner the market. There are likely to be other benefits to standardization as well. For instance, increasing the supply of the standardized bonds will increase the liquidity of these issues and hence possibly increase the prices that investors are willing to pay for them. In addition, auction theory indicates that a decrease in uncertainty about the value of bonds sold in the auctions will likely increase auction revenues. If bonds identical to that sold in the auctions are publicly traded at the time of the auctions then the extent of differences of opinion about their values will likely be less than otherwise, which in turn will potentially increase auction revenues.

Appendix

This appendix evaluates the potential magnitude of the misspecification error due to pricing comparable seasoned bonds using yields interpolated between the yields to maturity of matched bonds.

The prices of discount bonds with maturities ranging from one to eleven years are generated using the Cox, Ingersoll, and Ross (1985) (CIR) single factor model. Under the CIR model, the short interest rate is generated by the following diffusion process:

$$dr_t = \kappa(\mu - r_t)\,dt + \sigma\sqrt{r_t}\,dz,$$

[19] The first approach may pose a problem if a particular bond trades at a discount at the time of scheduled reissue. Then, under the current tax treatment of original issue discounts, the reissued bond will not be a substitute for a bond with the same maturity and coupon issued earlier at par or at a premium. I would like to thank Jerome Powell of the Treasury for pointing this out. This problem also applies to the reopening policy currently used by the Treasury. This tax issue, however, does not arise in the case of the second alternative suggested above since under the current regulations that apply to STRIPS, whenever the pure discount bonds are purchased they are treated as newly issued discount securities.

[20] Currently, certain designated issues are stripped by primary dealers and the principal and coupons are traded separately as discount bonds. This practice, however, is not intended to and does not serve the purpose of standardization.

where r_t is the instantaneous interest rate at time t, μ is the mean rate, κ is the speed of adjustment parameter and $\sigma^2 r_t$ is the instantaneous variance of the changes in the short rate. The parameter values used in the experiment are $\kappa = 0.8$, $\mu = 0.08$ and $\sigma = 0.06$. The experiment was conducted with two values for the short rate, one above μ with $r_t = 0.1$, and one below μ with $r = 0.06$. The local expectations hypothesis is assumed.

Bonds with maturities of $T - 1/4$ years and $T + 1/4$ years were used as the maturity-matched bonds to compute the comparable yields of bonds with maturities of two, five, and seven years and bonds with maturities of $T - 1$ years and $T + 1$ years were used as the maturity-matched bonds to compute the comparable yields of bonds with maturities of ten years.[21] The maximum difference between the model and the interpolated yields of less than 1 basis point was observed for the two-year discount bonds and the maximum difference between the model prices and the respective prices based on interpolated yields was less than 1 cent per $100. These results indicate that the magnitude of the misspecification errors are likely to be small. Moreover, the differences in these yields at the time of the auction and four weeks after the bond issue ($t = 4$) (the differences between the misspecification errors) were virtually zero for bonds of all maturities.

[21] For the two-, five-, and seven-year notes the maximum differences between the maturities of the newly issued bonds and matched bonds were 42, 60, and 126 days respectively, and for the ten-year notes the maximum differences on the short and long sides of maturity were 126 and 1838 days respectively. Using longer matched bond maturity differences for the ten-year bonds did not make much difference since the term structure under the CIR model was fairly flat at long horizons.

REFERENCES

Amihud, Yakov, and Haim Mendelson, 1991, Liquidity, maturity, and the yields on Treasury securities, *Journal of Finance* 46, 1411–1426.

Bikhchandani, Sushil, and Chi-Fu Huang, 1989, Auctions with resale markets: An exploratory model of Treasury bill markets, *Review of Financial Studies* 2, 311–340.

Bollenbacher, George M., 1988, *The Professional's Guide to the U.S. Government Securities Markets* (New York Institute of Finance, New York).

Cammack, Elizabeth B., 1991, Evidence on bidding strategies and the information in Treasury bill auctions, *Journal of Political Economy* 99, 100–130.

Cox, John, C., Jonathan E. Ingersoll, and Stephen A. Ross, 1985, An intertemporal general equilibrium model of asset prices, *Econometrica* 53, 385–408.

Kyle, Albert, 1984, A theory of futures market manipulations, in R. Anderson, ed.: *The Industrial Organization of Futures Markets* (Lexington Books, Lexington, Mass.).

Milgrom, Paul R., and Robert J. Weber, 1982, A theory of auctions and competitive bidding, *Econometrica* 50, 1089–1122.

Reece, Douglas K., 1978, Competitive bidding for offshore petroleum leases, *Bell Journal of Economics* 9, 369–384.

U.S. Department of Treasury, Securities and Exchange Commission, and Board of Governors of the Federal Reserve System, 1992, *Joint Report on the Government Securities Market* (U.S. Government Printing Office, Washington, D.C.).